HOW THE WORLD WORKS

THE STORY OF HUMAN LABOR FROM PREHISTORY TO THE MODERN DAY

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Preface for the General Reader

This book has an ambitious scope, ranging as it does from pre-history to a future post–fossil fuel era.

I wrote it because there is a lack, as far as I am aware, of a recent introduction to the materialist theory of history. Although it is not a history book, it is about the successive economic and social forms within which our history has taken place. I follow the approach pioneered by Adam Smith and Karl Marx of seeing history as being structured by the successive forms of economy within which people have worked to win their survival. I draw on the work of generations of historians, economists, and social theorists who have contributed to this materialist view of history, and I attempt to summarize their results for the non-specialist reader.

There are certain broad themes in my account: the interaction of human reproduction with technology, social domination, and the division of labor. In chapter 2 I look at the biggest change human society ever went through as we developed from being hunters to becoming farmers. We will see how, according to modern research, this transition was neither easy nor immediately beneficial, so the problem is to understand why it took place at all. But, once the transition took place, the additional food resources that became available allowed a dramatic rise in population density and to a process of migration and colonization that have left their marks in the languages we still speak.

While archaeology shows that the first agricultural societies retained an egalitarian structure, this had by the era of classical civilization thoroughly broken down. In area after area, freedom gave way to slavery. Slaves were forced to produce surplus goods for sale giving rise to international trade, money, and banking. I explain in chapter 3 the internal structure of slave economies, their markets and processes of reproduction and how their limited markets and their squandering of human resources led them to stagnate.

Since it was slave economies that invented money chapter 3 explains the classical theory of price, according to which the prices of commodities tend to be proportional to the amount of labor expended making them. In the process I explain how the classical theory is more scientific than the supply and demand theory that most social science students have been taught.

Slave economies have arisen at different times in various parts of the world, but in the end they have given way to peasant economies. In these, relatively self-sufficient family farms are subject to the exploitation a landlord or military class. In chapter 4 I look at the basic reproduction process of such economies, the degree of exploitation to which the peasants were subjected, and the efficiency of the overall economic model. In particular I am concerned to counter the modern prejudice that assumes feudal society to have been inefficient and irrational compared to modern capitalism.

Most of the world now lives in the capitalist economic system. Chapter 5, the longest in the book, explains how capitalism works. I show that the classical theory of price still applies under capitalism, and that this, combined with the existence of private firms, necessarily implies that goods will be sold at a markup or profit over the wage cost of their production. I show that it was ultimately the development of technology, particularly powered machinery, that enabled the owners of such machines to become the new dominant class. A large part of the chapter is devoted to the interaction between technology, profits, and real wages. I show that a freer and better paid workforce led to a more rapid rate of technical progress.

The next big theme of chapter 5 is how capitalism has interacted with population growth and family structure. Early and late capitalist societies have radically different demographics. An exploding population in the nineteenth century fueled European settler colonialism. Now, in contrast, developed capitalist states are scarcely able to reproduce their workforces. This shift has led to chronically depressed profit rates and stagnant levels of investment. It presages an existential crisis for capitalism.

One of the more controversial points I make is that far from the early twenty-first century being a period of very rapid technical change, such advances are now much slower than they were in the twentieth century. This slowdown in technical progress is a mark of capitalism having passed its heyday.

For a century now, socialist economies have existed as an alternative to capitalism. Chapter 6 examines the basic structure of socialism. I start with technology. Electricity, and lots of it, was seen as one leg of socialist transformation. The other leg was people and the number of people depended on birth rates, death rates, and family structures, all of which are covered in section 6.3.

In capitalist economies the surplus available for investment depends on private profits; in a socialist system it depends on the planned division of output between consumer goods and investment goods. In classical Marxist terms, socialist economies have a historically unique mechanism for the extraction of a surplus product. This mechanism underlay the very fast growth rates achieved by the USSR before the 1970s and by China right up until to the present. Section 6.5 presents the basic theory of socialist growth developed by Feldman in the 1920s and shows that his theory gives a good explanation of what was achieved over the next fifty years. What is not widely appreciated in the West was just how successful the USSR was in the production of mass consumption goods. Why, if it was producing so much, was there an impression of continuous shortages?

It comes down in the end to how the Soviets managed the consumer market, and, more fundamentally, to why there still was a market in consumer goods. The later parts of the chapter deal with why the socialist economies still retained money, and why it was impossible for them to escape what Marxists term "the law of value." The chapter finishes with an examination of the processes that led to the final disintegration of the European socialist countries.

I finish with a chapter on future economies. I look at the constraints that will be imposed by a shift to carbon-neutral economics. I ask whether future economies will be communist and whether communism has some specific technical basis on which it must rest. This chapter is inevitably slightly speculative!

COMMENTS FOR MORE TECHNICAL READERS

Although this book is written from a perspective strongly influenced by Marx, there are a number of points on which my presentation will differ significantly from what has become common in Marxism.

The first difference is on the role assigned to technology. Back in the mid-nineteenth century Marx put forward a bold, technologically determinist view of society. But this view came to be seen as something of an embarrassment by the late twentieth century, particularly by European and American theorists. Western Marxist theory was dominated by people with a training in the humanities or social studies. Exceptions like Bernal, Bordiga, Pannekoek, or Machover were so few that their very existence was noteworthy. The specialized educational background of Western Marxists had a number of effects: slow adoption of new concepts from the sciences, hostility to what is seen as technical determinism and reluctance to use mathematical and quantitative methods.

From the mid-1980s a new type of Marxism has gradually developed that has been more sympathetic to the hard sciences and to quantitative analysis. Here I apply this approach to the general history of modes of production. In the process I give the term “mode of production” a much more literal, technological interpretation than most recent Marxists have done. For each historical form of economy, I focus first on its underlying technology and then its demography. In my view, technology and population constrain everything else.

I have long been critical of the “value form” school of economists [Heinrich and Locascio, 2012] who, in my opinion [Cockshott, 2013a], unduly restrict the idea of value and abstract labor to modern capitalist society. I think that the idea of abstract labor is critical to the analysis of all forms of economy, not just to capitalism. Abstract labor denotes an attribute of the human species being, our plasticity and adaptability. I lay out this approach right at the start of chapter 1. Along with a misapprehension about labor, the value form school has tended to see value as a concept that only applies to capitalist economies. I think this view gets the history all wrong. I thus chose, with some deliberation, to introduce my analysis of value in chapter 3.5 where I am examining classical slave civilizations. I am also concerned to correct the illusion that value relations, seen as something specifically capitalist, have no relevance to socialist economies. In section 6.8 I show why, even in socialist economies, value relations still operated. Officially, the Soviets accepted that the “law of value” still applied to them. Despite the theoretical acceptance, political pressures were such as to make socialist governments act as if value relations could be simply ignored. The consequences were unfortunate. It would be an even worse misfortune were a future socialist government, influenced perhaps by value form theory, to repeat that mistake.

Althusser et al. [2006] criticized the use of unilinear models in traditional Marxism. In response to this critique, when I look at transitions between forms of economy I discard the old unilinear succession of forms of economy for an approach based on Markov models. The Markov approach allows you to conceptualize history as having both a statistical trend and at the same time the possibility of “backward” transitions [Cockshott, 2013b].

Readers familiar with the work of Farjoun and Machover will notice that my presentation of price theory is derived from those authors. I have, however, gone beyond them in applying the same forms of argument to analyzing the rise of patriarchy (section 2.4), and to a reformulation of the classical law of wages (section 5.7). I try to show that one can still apply the classical idea of the wage minimum as being set by the lowest wage on which people can still feed themselves. Empirical work since Farjoun and Machover [1983] has shown that, contra Marx, the rate of profit does not equalize between industries. Marxist economists have taken some persuading that this is the case. Mere real-world data does not seem to carry that much weight in economics. In the hope that more formal methods will be found convincing, Appendix B introduces a novel mathematical approach based on random matrices to show why profits do not equilibrate.

In sections 4.4 and 5.4.8 I develop a critique of the Weber-Brenner thesis about the superior rationality of capitalist relations of production. In this view, the need to perform calculations in terms of money, forces capitalists to be more economically rational than previous ruling classes had been. In section 5.4.8 I show that this idea is based on a misunderstanding of the cost structures driving innovation under capitalism, and that in fact capitalist costing systematically biases against innovation. On theoretical grounds, precapitalist social relations are actually more conducive to labor-saving rationalization. In section 4.4 I use the recent work of McDonald to show that this was the case: feudal agriculture was as efficient as, if not more efficient than, capitalism.

Capitalism is inefficient because of the misleading signals that come from monetary calculation. Low wages mean that it constantly underestimates the true cost of labor. This does not just apply to capitalism. It happens wherever costs are estimated in terms of money wages not hours of labor. In section 6.8.1 I show that the system of monetary calculation used in the USSR also generated the wrong signals when it came to a rational use of labor. Only by a transition to a fully communist system of economic calculation could the USSR have escaped its terminal stagnation.

CHAPTER 1

Introduction

Human society has to work to survive.[1] Our food, clothing, and shelter are won by work and, as every parent knows, the next generation is raised by work. Society is, before all else, a collective effort to ensure its own physical continuity.

We are all born into and formed by a society already structured around collective tasks of physical production, of human reproduction, and the reproduction of the social relations that achieve it all.

Societies distribute their members into different social roles, and divide up their waking hours between activities. Some activities, like feeding or dressing oneself, are purely personal. Some, like childcare, family cooking, farming, or industry, benefit others. Different kinds of activity produce their own useful effects: sex—babies, baking—bread, bricklaying—walls. For each effect we need to carry out particular sequences of body movements that interact with the environment, implements, and other people. These are the concrete aspects of activity.

But from the standpoint of society as a whole, each activity has another more abstract aspect, since each is part of the division of labor. The bodies and time of its members are society's fundamental resource. They are both limited. There are only a given number of people alive on any given day, and there are only 24 hours in the day, for some of which our bodies must sleep. The social division of labor has to partition the available time of all these bodies between the tasks required for survival. What is being divided up here are all the millions of person hours that go to make up the social working day. This is the abstract social aspect of activity: activity as part of the social organism.

The division of labor combines a concrete achieved result, particular bodies performing specific actions, with the abstract possibility of a different result. The allocation of bodies to tasks would have to be different. You or I could be doing a different job in six months' time. Had circumstances been other, we could have been doing something different right now.

For a division of labor to exist bodies must be flexible, able to perform more than one task. We can do this. We can switch, we can learn.

We humans are neither the only, nor the first social animals on Earth. Before our towns, there were the castles of the termites, the apartment blocks of the bees, and mazes of the mole rats. Termites are, in terms of sheer biomass and food consumption, the dominant social organism. Our biomass totals some 350 million tons [Walpole et al., 2012], that of termites, 450 million tons [Sanderson, 1996].

These societies too have their division of labor. Termite workers build towers every bit as tall in relation to their bodies as our skyscrapers. They gather wood, they tend underground mushroom gardens and look after young ones. This is a fluctuating division of labor. The proportions of workers performing different tasks vary according to the needs of the colony.

They have a limited repertoire of tasks and their technology changes only over evolutionary time scales, but this is still a division of labor. Individual termite workers do not learn. As species they learn, but any technology they use, and once, millions of years ago, each of their technologies must have been new, was acquired by the slow process of genetic adaptation.

Alongside the workers, their mounds contain others. They are polymorphic species.

There are soldier termites with huge heads and mandibles, huge mothers, and medium-sized fathers. The soldiers cannot work. Their sole task is to defend the home from ants. They block the passages with their huge heads, biting intruders, or squirting noxious glue at them. Aside from this, they are unproductive, unable to gather wood or raise crops, dependent on the workers for their food.

The huge mother or "queen," a sort of yellowish pulsating striped sausage as big as a man's finger, can't work either. She lies in her secure chamber, panting, being fed fungus as she lays eggs. The activities of the mother and the soldiers are always concrete: the mother lays eggs, the soldiers defend. They cannot take up tasks as the need arises the way the workers do.

Faced with insect societies people find it hard not to make analogies to our own. The terms *worker, soldier, queen* are obvious analogies: a projection of the class systems of our society onto a very alien one. People use the term *castes* to describe the different termite body forms, an obvious analogy with the ancient social system of India. But this analogy is limited. The bodies of people in different Indian castes are the same, it is social pressure, not physique, that forces people into the types of work associated with castes. Indian castes, moreover, are hereditary, whereas the members of different “castes” in a termite nest, workers or soldiers all share the same parents.

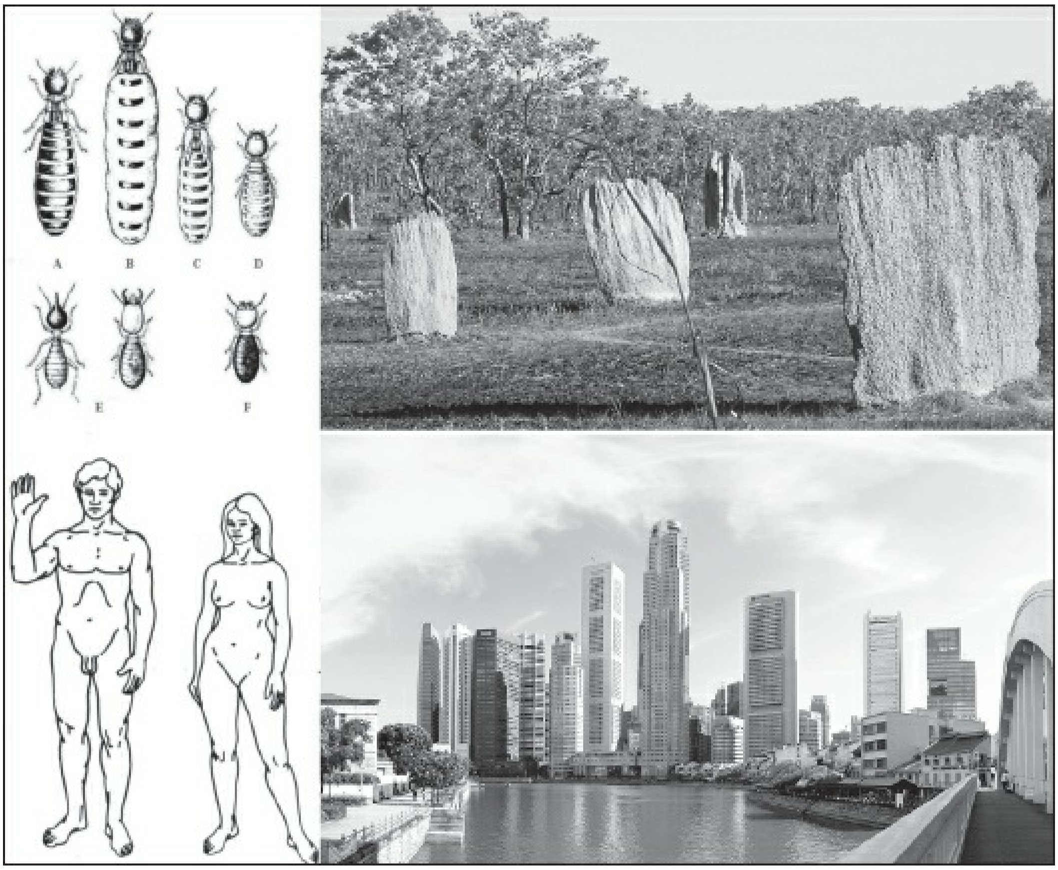


Figure 1.1. Termites are, in biomass, the dominant social organism on Earth. Their workers build towers every bit as tall in relation to their bodies as our skyscrapers. They are polymorphic animals with multiple different body forms within a colony. A: Primary king, B: Primary queen, C: Secondary queen, D: Tertiary queen, E: Soldiers, F: Worker. Because of this polymorphism they do not have a fully developed division of labor. The other main social animal on Earth is dimorphic and can have a more general division of labor. Source: NASA and Wikimedia.

The point that is validly made when talking of termite castes though, is that like the castes of the Hindus; the different body forms of the termites impede a flexible division of labor [Ambedkar, 1982].

Although termite soldiers cannot transfer to building work or vice-versa, there has to be some mechanism regulating the proportions of these two body forms. Too few soldiers in an environment with a lot of hostile ants could be fatal for the colony, but too many means a lot of idle mouths for the workers to feed. In principle the caste ratios could be regulated genetically with different queens laying eggs whose soldier ratio varied. There is some evidence that this is the case [Long et al., 2003]. Here, although a given termite society could not fully regulate its division of labor, natural selection would mean that over a series of generations of colonies, the soldier ratio would adapt to the average needs of these colonies.

Another possibility is that pheromones are used to adjust the development of individuals into different body forms as the need arises [Long et al., 2003]. If this is the mechanism, then even though a mature termite cannot change caste, the caste into which a young one matures is decided quite late in life, so that the colony can adjust the composition of its workforce quite rapidly. This would imply that there was actually more occupational mobility among the termites than in human caste societies.

Why pay attention to these odd little creatures with their grotesquely differentiated bodies?

Because it is easier to recognize features of the familiar when contemplating the strange.

The termites and other social insects seem perfect examples of communism. The individuals act primarily in the interests of the community as a whole rather than themselves. Termite soldiers willingly sacrifice their lives for the sake of their colony. If there is a hole formed in the nest, the soldiers rush out to confront any ants that attempt to break in, while behind them the workers wall up the hole. There is no retreat for them. When the workers finish the wall, the soldiers are marooned outside. Worker bees will fearlessly mob hornets. Many die from the hornet’s sting, but by surrounding the hornet and buzzing they cause it to die of heat exhaustion.

The superiority of this communist lifestyle is testified by the ecologically dominant position that the social insects, particularly the termites and ants, occupy. Anyone who has seen these creatures cannot but be impressed by the complete domination that an army of carnivorous

African driver ants exerts over the territory it marches through, the fearful network of miniature tracks, trunk, and major roads with multilane traffic and the panic of other insects in the locality. and their fruitless attempts to escape before being torn limb from limb by tiny tormentors who form up into teams to pull a beetle or cockroach apart. Their distant relatives, the peaceful termites, exert a hidden, more subtle but even greater domination, venturing out only in their temporary vaulted paths. Secure from predation behind these walls they gather so much dead wood for their mushroom caves that they dominate their ecosystems. No land animal, other than our domestic cattle, has more biomass.

The literally fraternal solidarity of social insects arises because they are all members of the same family with the same parents. When a soldier termite sacrifices itself, it is protecting its direct kin, and indirectly maximizing the survival of its own genes. But look at it another way and we see in these communities the very image of monarchical despotism and exploitation, with workers perpetually on the verge of rebellion.

Think of the poor worker bees. Genetically female but deprived of the power to bear their own offspring, they toil all their lives for a queen who alone is allowed to lay eggs. They are kept in this subordination by the pheromones released by the queen. Take these pheromones away and they rebel. Nieh [2012] writes that:

> After their queen has left with a swarm, orphaned larvae exhibiting rebel traits emerge in honeybee colonies. As adults, these orphans have reduced food glands to feed the colony's larvae and more developed ovaries to selfishly reproduce their own offspring.

Until exo-planets were discovered we had imagined that all planetary systems would be like ours. Now, with a knowledge of their vast diversity, the masked peculiarity of the solar system becomes apparent, and hence a problem for science.

Contemporary academic economics eternalizes the institutions not just of human society, but of contemporary Western capitalism.[2] Anthropologists, archaeologists, and biologists studying social organisms all bring home to us the variety of forms that the production and reproduction of social life can have. They help us to question features that economics takes for granted.

Termite polymorphism (fig. 1.1) might seem irrelevant unless it reminds that we are no more monomorphic than them. We are dimorphic, with male and female body forms. Externally the differences between human females and males do not strike us as grotesque, the way those between termite queens and termite workers do. But in reality we are acutely aware of these slighter differences that impinge profoundly on our social division of labor.[3]

All termite castes are to some degree disabled: only soldiers can defend themselves, only alates[4] can fly, only queens lay eggs, only workers build. Their forms mean that among them the abstract potential of the division of labor is only realized between generations. But this is not true of humans: half have bodies that allow full participation in all social tasks. Women have a flexibility no termite has. They can do any human work.[5] But unlike insects we each learn our tasks within one lifetime. The great development of human technology owes itself both to this ability to learn and to the ability to transmit learned skills between generations.

There is technological evolution by other animals. Spider webs are a technology that has developed from orb webs, which seem to be the primitive form, to sheet webs or cobwebs (fig. 1.2). The oldest orb webs known from fossils date from the Cretaceous, but we have fossils of the orb web spiders themselves dating from the Jurassic. There appear to have been several subsequent independent inventions of the sheet web since then [Blackledge et al., 2009]. Dimitrov et al. [2012] argue that sheet webs do not have to obey the same strict architectural constraints that govern orb webs. This allows spiders to use spaces where orbs cannot be constructed or are very inefficient in catching prey. This is an example of technological development, but one that took tens of millions of years to achieve. Knowledge of how to build a new type of web can only be passed on from a mother spider to her offspring if it is encoded in her genes, and it has been acquired by natural selection.[6] But when women started to develop weaving and textile technology—perhaps around 7000 BC [Barber, 1991] they were able to pass on improvements to their daughters by word and example leading to a rapid development of forms and types of cloth: linen, woolen, different weaves and knits.

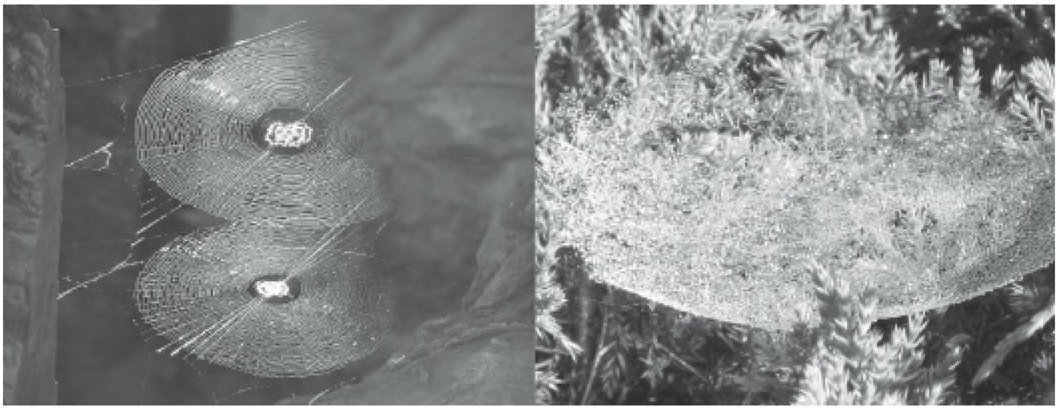


Figure 1.2. Technological development by animals. The primitive orb web (left) was developed into the sheet web (right) which can be placed in positions that are unusable by orb webs. Source: Wikimedia.

This kind of transmission of cultural information is not unique to us. It has been known since Darwin's day that other primates can use tools.[7] Since Goodall's studies at Gombe we have known that tool use can be a local culture [Whiten et al., 1999] rather than a universal trait. The ability to form distinct technical cultures is a primitive primate trait, just more developed among humans. Our greater ability in this stems from our being able to use language rather than mere example to educate our infants.

Our dynamic development of technology has allowed our species to completely transform the way it lives. This is not just a matter of changes in the way we obtain our food: going from hunting to herding, from gathering wild plants to raising crops. It is also a matter of changing divisions of labor, changing the social relations that organize labor, and the growth of ever more complex relations of domination, subordination, and rebellion.

We will be looking at the way technologies have structured the allocation of human time, the social relations under which this has been regulated, and the forms of exploitation and struggles for freedom that this has given rise to. We will deal relatively briefly with the period before the Industrial Revolution, but look at social relations in increasing detail as we explain the dominant structures of today's world economy.

The precondition of any society is the reproduction of people. This is the most basic, in the sense of fundamental, branch of the division of labor. But it is something that in contemporary society appears as not part of the economy. Instead it appears as just "family life," something that is private rather than social. Capitalist market society does not think of an activity as economic unless it involves money. But activities done for payment have been only a very small part of economic life until recently. Even now, they constitute barely half of economic life. If we cast aside the historically narrow perspective that only paid work is work, it becomes clear that sex and the bearing, feeding, and socialization of children are the foundation of economic life.

It is trivially true that without people there would be no economy, but in asserting that human reproduction is the foundation of the economy we are saying more than this.

- The production of the next generation takes time and bodily effort, and the availability of time and energy are the fundamental constraints that any economy has to obey.
- Reproduction determines population. Population changes can drive economic change and changes in power relations. This applies as much today as it ever did.
- The perspective that orthodox economics has is individualist. It defines the "economic problem" in terms of individuals maximizsing their satisfaction. When we take reproduction as our starting point we focus instead on society as an organism. This organism has to reproduce its own conditions of existence: the people, the resources they use, and the social relations they live in. The matter making up a living organism constantly changes, cells die, new ones are generated, but the structure remains. The same applies to a society. Its cells, individuals, change. Its matter, the buildings and tools, change. They both change by being reproduced and replaced.

To produce and wean a baby a mother must consume enough energy for two. The amount of food available determines the extent to which this is possible. If food is in permanently short supply, she may not have enough energy to supply milk to twins, or to feed both a new infant and an unweaned two-year-old. So under these circumstances mothers must regulate their fertility and at times practice infanticide [Diamond, 2012, chap. 5]. The carrying of children also consumes energy, and until very recently babies always had to be carried. Unless cloth has been invented, allowing the baby to be strapped to her back, the baby must be carried on one arm. This means that a mother loses half her ability to produce food while carrying the child. The survival of the child is then likely to depend on the mother's ability to call on the assistance of others: grandmothers, older siblings, male relatives or partners to provide food or care for the infant [Hawkes et al., 1997]. Here, in reproduction, we have the basis for social cooperation and a division of labor.

Once weaned, children have to eat solid food. Where is this to come from?

The age at which the child can be weaned depends on the technological level of society and how it produces food. In an agricultural society the milk of animals and gruels made from grains can be fed to infants before their teeth have developed. In a pre-agricultural society this is not possible, so breastfeeding has to go on for longer. In modern society the availability of formula milk and bottles means that breastfeeding can be eliminated entirely: the modern labor market is unforgiving toward mothers who want to breastfeed or carry their baby around during paid work.

Children, once they can run around, immediately start to be able to gather some food for themselves. In most societies children make up a significant part of the labor force [Minge-Klevana et al., 1980], but it is not until they are teenagers that the food they produce is sufficient to feed themselves. They remain a net energy drain on their adult relatives until then. The removal of children from productive work, which has happened progressively since the nineteenth century, has a huge impact on the allocation of time in society as a whole and on the labor of other family members.

Fertility is the first constraint on the reproduction of the population. The next is mortality, particularly infant mortality. To reproduce a society needs a level of female fertility sufficient to ensure that on average at least one daughter survives until child-bearing age. The number of surviving male children is less of a constraint. In humans about 21 boys are born for every 20 girls. It might at first sight appear that the reproductive potential of the population might be best served by mothers selectively killing off a portion of their male offspring, but this never seems to happen. There are recent instances of societies in which baby girls are killed off [Hughes, 1981; George et al., 1992]. There are also cases where babies of both sexes are killed off [Eng and Smith, 1976]. But selectively killing off female children is only possible in a society with a relatively long life expectancy. Engels [1980] showed that in a society with a life expectancy at birth of between twenty and thirty, which was typical of the world until recent times, any significant level of female infanticide will result in population decline since there will not be enough women surviving to become mothers. Others argue that Engels made unrealistic assumptions about other causes of death, and that the very stability of population in the ancient world should be explained by female infanticide [Harris, 1982]. Although more boys are born than girls, this can be offset by a higher rate of mortality. The type of work they do is more likely to result in fatal accidents, and they are more likely to die in wars.

TABLE 1.1 : Division of Workforce by Age and Gender

Demographic	Part of the Workforce?
Grandmothers	Yes
Mothers	Yes
Men	Yes
Children	Partially
Infants	No

Leaving aside deliberate killing of babies or dying in conflict, the main constraints on people surviving until they can have children of their own have been hunger and disease. Disease itself is a social phenomenon. Diseases have to pass from person to person, so their existence depends on a certain density of population and the degree of connectedness of the population. Isolated small populations do not allow disease germs to survive [McNeill, 2010; Diamond and Ordunio, 1997]. As population density rises and as trade and travel grows, epidemic plagues become a huge danger. They have to spread initially from some sort of animal in which the germ or virus lives naturally. For example, the germ causing the Black Death spread to humans from marmots on the Mongolian Plains and variants of influenza spread to us from domesticated pigs and ducks. So for this to be a danger society needs to have advanced to the stage of domesticating animals and have a sufficiently dense population for the disease to spread. The animal hosts able to spread diseases to us seem to have been concentrated in Africa and Eurasia. In previously isolated populations in the Americas that had never been exposed to Old World germs, the effect of contact with Europeans carrying viruses for colds and smallpox were catastrophic [Diamond and Ordunio, 1997]. Whole populations collapsed in the face of the new disease pressure.

But collapses due to plagues are episodic catastrophes. The more pressing and permanent barrier to population growth is food. The human ability to expand its population in the absence of food constraints is huge. Dickeman examined different estimates of this from populations that settled on previously uninhabited islands and came up with the figure that population numbers could triple every thirty years [Dickeman, 1975]. These were agricultural subsistence populations settling on islands with already developed agricultural techniques and crop varieties, but they indicate just how fast population growth can be. If populations generally do not grow at that rate it is often because they have in some way reached the carrying capacity of the environment, given the technology they have at the time. Lower food availability increases mortality and induces people to take steps to limit their population. So the production of food is the most urgent, and thus in the short term the most important production process.

(In the following chapter we will be looking at the main historical developments in food production and the implications this has had for the general economic structure of society.)

After food our primary need is clothing. We are a tropical species that has migrated across all the climatic zones on the planet. Lacking normal mammalian fur, our penetration of these zones has been dependent on an ability to manufacture a substitute in the form of clothes. The importance of keeping warm is so great that humans have been willing to devote huge effort to it. The manufacture of thread and cloth were, for millennia, the single most labor-intensive activity carried out by human economies [Barber, 1991]. Transformations in cloth-making technique—the invention of power spinning and weaving—were fundamental to the establishment of modern capitalist society.

There is no activity, no transformation of nature without an energy source. Muscles provided our first motors, and food our first energy supply. But next came fire. The use of tools is not specifically human, nor even the learned use of tools. Other primates and even birds can do this. But the manipulation and use of fire is unique to our species. For warmth, for cooking, for light and for defense it has been with us for at least 400,000 years [James et al., 1989; Roebroeks and Villa, 2011], with some suggestions that it could be even earlier than that. Whatever the date of its earliest use, fire allows access to food resources that would otherwise be indigestible. It allows people to live in climates that are below freezing for part of the year. It allows materials to be processed: initially just hardening of wooden tools, but later ceramics, metals, glass, and other chemical processes driven by heat.

Thus the acquisition of fuel has, for hundreds of thousands of years, been a significant absorber of human effort. Firewood or animal dung had to be collected at first. Later it became possible to mine fossil fuel resources. This continues to be a major part of our own economic activity.

After fire came the harnessing of energy in general: the muscles of draft animals, wind in sails and then windmills, the power of falling water, and now energy from atoms or the sun. The quantity of energy under human control determines the scale of our transformation of nature and the productivity of our daily efforts. By monopolizing energy sources individuals, companies, and states have been able to dominate others.

We have kept warm using fire and clothing, but to stay dry and shaded we needed shelter. This involved construction and maintenance of houses and the hard work which goes along with that. Once people have permanent houses, housework in the sense of day-to-day cleaning and maintenance follows. If you live on the move this is not necessary, but settled accommodation forces you to tidy things, remove and dispose of waste, and transport fuel and water into the house. Houses can take several person years of work to build. If these are built up over one or more generations, then the existence of houses must be supported by appropriate social relations. These can involve communal effort like the longhouses of the Iroquois or the Iban of Borneo, which implies a social system based on clans [Loeb and Broek, 1947]. If houses are smaller and settlements are organized on a territorial rather than a lineage basis, every family has its own house, which it maintains. Once cities arise, the time cost of building houses, which are often multistory, means that ownership passes out of the hands of families. Instead a landlord class or later the banks or the state effectively own the dwellings. The mass of the population is then subjected to the need to pay rent to the ultimate owners of their houses.

Housing is one way of modifying the environment: locally. But as human society has advanced it has changed much more of the environment. It has restructured the ecosystems within which people live, replacing wild animals with domestic ones, forests with fields, redirecting water flows, and changing the composition of the atmosphere. These changes in their turn have an impact on the social system we live in.

Any economy depends on information. Information is required for physical production and for the coordination of the economy. At the level of production, information is required about how to make things. Once a new skill or invention is known, the information can pass rapidly, changing the whole way people do things. This is information that is passed between people by example, word of mouth, and later in written texts. Information is also required to *in-form*, that is, give form to things.

The information for a building can preexist as an architect’s diagram. The information for a book can preexist as an original manuscript. The information for a car can preexist in the shapes of the dies, and the tapes of the machine tools on the production line. To such different stages of the embodiment of information there correspond different stages in the division and subordination of labor. At the economy-wide level, information is required to coordinate production: quipu records of the Inca, tax records written on clay, commercial correspondence on paper, information encoded in prices and in purses. All these will feature in our analysis of different social forms of production.

The problem of how processes come to take on a stable recurrent form is widespread in science. It has been of particular concern to biologists and biochemists working on the origins of life. They have to explain how, contra the apparent preference of thermodynamic laws for maximal disorder, we see highly ordered structures, including ourselves. Both Dawkins [2004] and Kauffman [1993] have made useful contributions to how we can conceptualize the stability of orderly processes. The basic argument they develop is that features stabilize if their existence at one time increases their probability of existence at a future moment. But this probability is a conditional probability, conditional on the features being situated in what Kauffman calls “autocatalytic networks.” These are networks initially conceptualized in terms of polymer synthesis [Farmer et al., 1986], each of whose components, when present, increases the probability of the whole network persisting. A flame or a cell is such an autocatalytic network. A cell is a polymer collection: enzymes, lipids, and nucleic acids which, in the presence of an external energy source, will maintain itself and perhaps grow. The different enzymes work together to synthesize one another. Current cells depend on DNA, but at a much earlier epoch more primitive self-sustaining networks must have existed from which cells evolved. These networks, in the absence of the directing influence of DNA, would have relied purely on enzymatic feedback.

These concepts are applicable to modes of production and in particular to those, like capitalism, that develop without a definite directing influence. We will use these concepts either implicitly or explicitly in our analysis of the different historical modes of production and the social forms to which these give rise.

CHAPTER 2

Pre-Class Economy

The founder of Enlightenment political economy, Adam Smith, said that human social development went through the states of Nations of Hunters, Nations of Herdsmen, and Nations of Farmers [Meek et al., 1978]. This last category represents the civilized world of the eighteenth century when all civilized nations were still, in the majority of their population, farmers.

Although presented as an ascending sequence, and thus a series of stages, these social forms could, and indeed did, coexist in different areas of the world. The key thing about this materialist method in history was to seek the explanation for social institutions in the methods by which societies produced their needs.

This view of economic history was given an initial short summary by Marx[8] and was refined by him and Engels [Marx and Engels, 1976; Marx and Engels, 1977; Engels and Hunt, 2010] into a more elaborate set of forms of society: savagery (Smith's Nations of Hunters), barbarism, slave society, feudalism, simple commodity production, and capitalism, which were presented as a historical sequence.

The approach we take here broadly follows those of Smith and Engels updated in the light of historical experience and historical work published since their days.

It is important to note that though these forms of society have an order in terms of their earliest historical appearance, at any given time there can be several of these different forms coexisting. These forms will be interacting on a world scale, and at times even within one country. For example, the United States in the 1850s combined slavery, small-scale commodity production, and capitalist industry within a single country, something that turned out to be a highly explosive combination.

We will in this and the next few chapters give a short run-through of the characteristic combinations of technology and social relations of production in the main hitherto existing types of society: hunting-gathering bands, nomad tribes, early agricultural communities, slave economies, landlord economies, capitalist economies, and industrial socialist economies. We will look in much more detail at the economic structure of capitalist and socialist economies as these are most relevant to the twenty-first century. The earlier forms provide a degree of historical perspective on the more recent ones.

2.1 AGRICULTURE

The biggest revolutionary step in human development is the one that separates hunting and gathering from all subsequent forms, since the development of agriculture and animal husbandry involves humanity descending to a lower trophic level. For any ecosystem on the surface of the world, the primary energy source is sunlight. Primary producers—plants and algae—capture sunlight and use it to fix CO_2 to produce sugars and other carbohydrates. Living organisms also require fixed nitrogen to manufacture the proteins from which all enzymes and most animal tissues are made. This fixed nitrogen comes, in natural environments, primarily from specialized bacteria, some of which are symbiotic with plants. Carbohydrates and proteins made by plants constitute the base of the ecosystem, the lowest trophic level. It is at this base level that the greatest flow of organic material takes place. The organisms at this level are termed autotrophs or self-feeding.

Above this level come the heterotrophs, organisms that feed on others. Animals, fungi, and decomposition bacteria are heterotrophs. Feeding is an inefficient process. Only about a tenth of the chemical energy in food is converted into building up an animal’s own body. So if plants are trophic level 1, herbivorous animals are trophic level 2, and carnivores that eat these herbivores are trophic level 3. In marine environments there may be several more trophic levels: zooplankton eating phytoplankton, being eaten by fish, being eaten by seals, which in turn are eaten by bears and people.

A hunting-gathering population lives in upper trophic levels: 3 or above. They may gather some plant food where climate permits, but the human digestive system restricts what plants they can eat. In a natural ecosystem only a small part of the plant biomass can be eaten: primarily fruit and tubers. Many tubers are indigestible unless cooked, so the harnessing of fire must have been a key technological step in expanding food resources. A population of hunters also has to compete with other apex predators like wolves and bears for the available game, so only a portion of the biological resources at the apex is captured by humans.

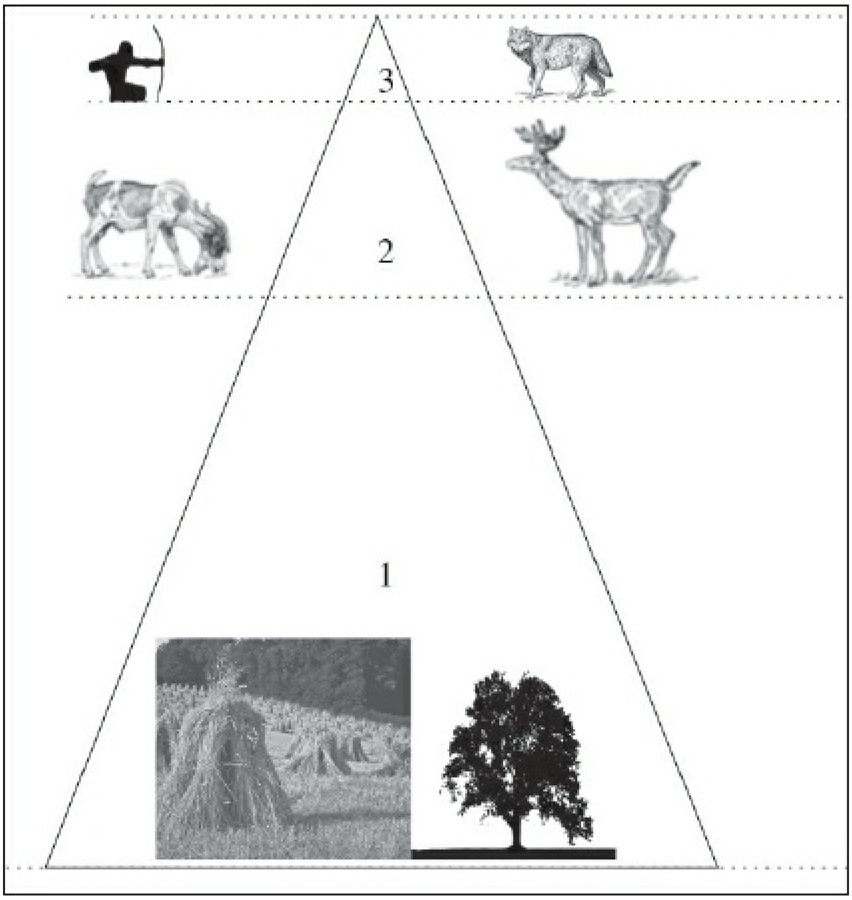


Figure 2.1. Trophic levels 1, 2, 3 as a triangle; the area of each layer of the triangle is proportional to the biomass that trophic level can support.

The penalty for living at a high trophic level is that only a low population density can be supported. This in turn constrains the size and complexity of social groups. Hunting populations can settle down and build small settlements if they happen to live somewhere abundant in fishing resources or at the edge of lakes to which game must come to drink. But the settlement sizes cannot be as big as can be supported by agricultural societies.

We are not in a position to say much about the social relations of Stone Age hunting societies but more recent hunting and gathering societies in Africa have been studied in detail by anthropologists. Woodburn [1982] argues that while hunting and gathering societies are not all egalitarian, all egalitarian societies studied have been hunting and gathering ones.

For a hunting and gathering society to be egalitarian, he argues, nomadism is essential. They must be what he calls “immediate return societies" in which people go out hunting and gathering and eat the food they produce the same day. There is an absence of non-portable products of labor that produce a return only after a significant delay, such as boats, weirs, stockades, pit-traps. There is an absence of stores of food in buildings. There is no dependence on edible wild plants that have been tended by selectively removing competitors. There are are no assets in the form of women held by men and exchanged by marriage systems. In egalitarian hunting and gathering societies people can and do move between different nomadic groups at will, undermining the establishment of authority structures. But this happens more for men than women. In general, the principle of matrilocality holds for women. They stay with their mothers. Genetic study of hunting-gathering societies bear this out showing that the Y chromosome linked variations are much more geographically dispersed than mitochondrial ones [Destro-Bisol et al., 2004]. Since the former are inherited in the male line and the latter in the female line, this indicates a long prehistory of matrilocality. The evolutionary advantages of the matrilocal family are clear—the mother is likely to have the help of a grandmother in bringing up children [O'Connell et al., 1999]. Given the very long time it takes humans to grow up, this is likely to have been a decisive advantage.

Hunting societies also have a universal access to means of violence. Weapons for hunting animals can easily kill people. Any man attempting to dominate another can reasonably fear secret ambush and murder in return.

There is also a universal access to food—up to the effects of a sexual division of labor. Any man can go off and hunt by themself and feed himself if he wishes. Of course in practice people share food, but they are not constrained to do so. A man will expect to be able to feed himself off berries and game when out hunting. A woman will eat most of what she gathers on the spot, only food surplus to personal need is exchanged between the sexes. This personal independence prevents the buildup of authority—including inter-generational authority. As soon as they are physically able, young persons can hunt or gather by themselves. Fathers have no control over stored food, cattle, etc., with which to exert authority over their children.

Sharing is widespread. When an animal too big for one person to eat is killed, it is divided among the band. There may be protocols in which somebody other than the hunter dismembers the carcass and distributes the pieces. These protocols mean that a particularly good hunter will end up contributing more meat than he himself gets from others. Further distribution of goods occurs via gambling. Woodburn notes that among the Hadza he studied men spent far more time gambling than they did hunting. Certain basic goods were excluded from gambling, such as bows and wooden arrows. These are enough for a person to survive. But slightly rarer tools like poison arrows were gambled in games of chance. This prevents any substantial and lasting buildup of possessions.

Combined, these characteristics prevent the formation of relationships of private property as a means of exerting social domination.

Modern authorities are of the opinion that the number of hours a day that hunters and gatherers had to work was less than in the agricultural society that followed.

TABLE 2.1: Time Allocation among Hadza Hunters and Gatherers (hours per week)

	Food Aquisition ex-Domus	Food Processing Domestic	Domestic Maintenance	Domestic Mfg. and Repair	Total
Female (weaned–5)	3.01	12.01	2.35	0.87	18.24
Female (6–13)	18.26	10.46	5.80	1.97	36.49
Female (14–marriageable)	27.76	6.96	7.17	4.05	42.49
Childbearing aged Women	27.58	8.16	2.91	6.23	44.88
Post-menopausal Women	36.80	6.91	2.47	3.53	49.71
Male (weaned–5)	9.05	10.17	2.94	1.44	23.60
Male (6–13)	29.91	8.37	2.60	2.09	42.97
Male (14–marriageable)	44.41	4.05	2.86	2.33	53.65
Adult Men	28.94	4.19	3.22	7.99	44.34

Source: Hawkes et al., 1997..

TABLE 2.2: Time Spent by Nepalese Women (hours per day)

	Conventional Economic Activity	Subsistance Domestic Tasks	Other Domestic	Child Care	Total
Bargsonle	3.64	1.38	3.22	0.56	8.80
Lohuorung Rei	4.99	3.20	4.05	0.14	12.38
Xham Magar	4.93	1.73	1.59	0.78	9.03
Tamang	5.80	1.17	1.46	0.03	8.46
Parbatiya	5.51	1.71	4.37	0.91	12.50
Wewar	2.42	2.50	3.14	1.27	9.33
Tharu	3.39	2.51	2.83	1.88	10.61
Maithili	2.39	2.02	4.35	1.25	9.98
Average	4.13	2.0275	3.12	0.8525	10.13

If comparing with table 2.1, note that these figures need to be multiplied by 7. Source: Levine, 1988.

> A good case can be made that hunters and gatherers work less than we do; and, rather than continuous travail, the food quest is intermittent, leisure abundant, and there is a greater amount of sleep in the daytime per capita per year. The average length of time per person per day put into the appropriation and preparation of food was four or five hours. Moreover, they do not work continuously. The subsistence quest was highly intermittent. It would stop for the time being when the people had procured enough food, which left them plenty of time to spare. [Sahlins, 1998]

Among the Dobe bushmen Sahlins reports that the average working day was even shorter: between two and three hours obtaining food. A woman would gather enough food for three days with one day of foraging. On non-foraging days, food preparation routines took between one and three hours. So given that people in hunting and gathering society could easily survive on a short working day, the problem is to explain why agriculture was ever adopted.

> Considering that cultivation techniques are time-costly, meaning that hunters and gatherers, contrary to common belief, worked less than early farmers, and that the transition to agriculture involved little or no increase in standards of living, the reluctance to take up farming is hardly surprising. [Weisdorf, 2003]

The figures given by Hawkes et al. for the Hadza are rather more than Sahlins estimates for the Dobe. These would imply a maximum of 42 hours work a week, with the implication that the average was substantially less. Table 2.1 shows that the minimum spent by any over-14 group was 42 hours a week, and that for young men and grandmothers the total was around 50. Nonetheless this is still less than women in some agricultural societies expend (table 2.2). Reviewing a wide range of sources Cohen [1977] concludes that in terms of calorie output per labor hour expended, hunting and agriculture are broadly comparable.

The last hunting and gathering period in Eurasia is referred to as the Mesolithic or Middle Stone Age. The process of transition to agricultural society has been referred to as the Neolithic Revolution.

PERIOD	ECONOMY	WHEN
Paleolithic	Nomadic hunting	*from* 2.5 million BC
Mesolithic	Sedentary hunting, fishing	*from* 12,000 BC
Neolithic	Agriculture and herding	*from* 8,000 BC

The technology complex available to Mesolithic people can be characterized by:

- Wood, bone, stone tools
- Fire
- Cords, nets
- Needles, leather implements and garments
- Building of small temporary and permanent shelters of wood, skin, or wattle and daub
- Log and other boats

This technology complex induced the division of labor shown in table 2.3. The Mesolithic appears to have been a transition stage between a nomadic hunting and gathering society and a settled agricultural one, During the Mesolithic fixed communities established themselves in areas particularly rich in game or fish. Long-lived means of production like boats came to be built. According to Woodburn this type of hunting and gathering society is no longer as egalitarian as the purely nomadic type. We do not yet get the formation of social classes but we do get inequalities between men and women and between parents and offspring. The habit of living in settled communities may well have aided the process of transition to agriculture. People living in one place could repeatedly harvest the same wild grains and learn to improve their yield by selectively removing competing plants. Dried grain will keep, so the habit of keeping seeds instead of eating them immediately would prepare people for the discipline that farmers need in order to refrain from eating their seed grain.

TABLE 2.3: Division of Labor in Mesolithic Levant and Anatolia

Reproductive Work	Bearing babies, feeding infants, feeding post weaning, language instruction, etc.
Production of Tools	Bone working, cord making, net making, flint, obsidian work, wood working.
Shelter	Building wood-and-daub or wood-and-skin shelters, leather working for clothes.
Transport	Carrying flint/obsidian, water carrying in skins, transporting gathered vegetable foods and meat, gathering fuel, by hand or in leather bags or nets.
Obtaining Food	Hunting, fishing, collecting nuts, tubers, wild grains, wild olives.
Food Preparation	Grinding seeds and tubers, roasting.

Source: Düring, 2010.

For grain to be harvestable it must have ears that remain intact after the seeds have ripened. Wild grasses tend to drop their seeds as soon as they mature. If this happens they will fall to the ground when one tries to cut them, making gathering appreciably more difficult. Once people sow seeds deliberately, keeping seeds on the ear actually becomes a survival trait in grain. Humans would selectively harvest the whole ears and keep seeds safe until they were re-sown. What had once been a harmful mutation was now favored.

But since the work of an agricultural population seems harder than that of hunters, we have to ask, why did people go to the trouble?

It is not a matter of discovery. Cohen argues that the principles of domestication were well understood.[9] All hunter-gatherer people seem to know that plants come from seeds. The problem is providing a motivation to bother with seeds.

One theory is that of Weisdorf [2003], who argued that it was the rise of non–food-producing specialists that made it worth shifting to agriculture. His argument was that it takes time to learn new skills. It might not be worth working longer to get food when food may be more easily had by hunting, but it may be worth working longer to get clothes, shoes, or tools made by skilled workers. This, he argued, provided the incentive to shift to an agricultural economy in which a farming majority could support a minority of skilled craftspeople. But this sort of argument is in danger of of assuming what it wants to prove. The population of specialized workers depended on an agricultural surplus to support them. But if these did not already exist, then how would people gain a taste for the things that workers were to make?

It also assumes that hunting and gathering people would see having more durable goods as more important than the loss of freedom associated with settling down, but observation of such peoples does not seem to bear this out.

If these specialists already existed in the Mesolithic, that would allow a taste for their goods to be acquired, but it would imply that it had been possible for a hunting and gathering population to support them. If hunting and gathering enabled food to be obtained at less effort, then it would actually have been easier to support the specialists by sticking to hunting rather than swapping to agriculture. If hunting and gathering had worked for a million years, why suddenly change to an entirely different mode of life?

Until 10,000 years ago everyone lived off wild foods. By 2,000 years ago the majority of the world population lived off agriculture. In 8,000 years, on four continental landmasses, people switched to crops. Only in Australia, which arguably lacked appropriate wild precursors of grains,[10] did agriculture not develop.

The remarkable thing is not only that agriculture developed so quickly, but that it developed independently, with different crop plants in so many different places. The transition started a short time, in geological terms at least, after the end of the last Ice Age. That naturally leads people to suspect that climate change may have had something to do with it. But there have been several Ice Ages and interglacials since humans evolved. Why did this last one trigger agriculture around the world, whereas previous ones did not?

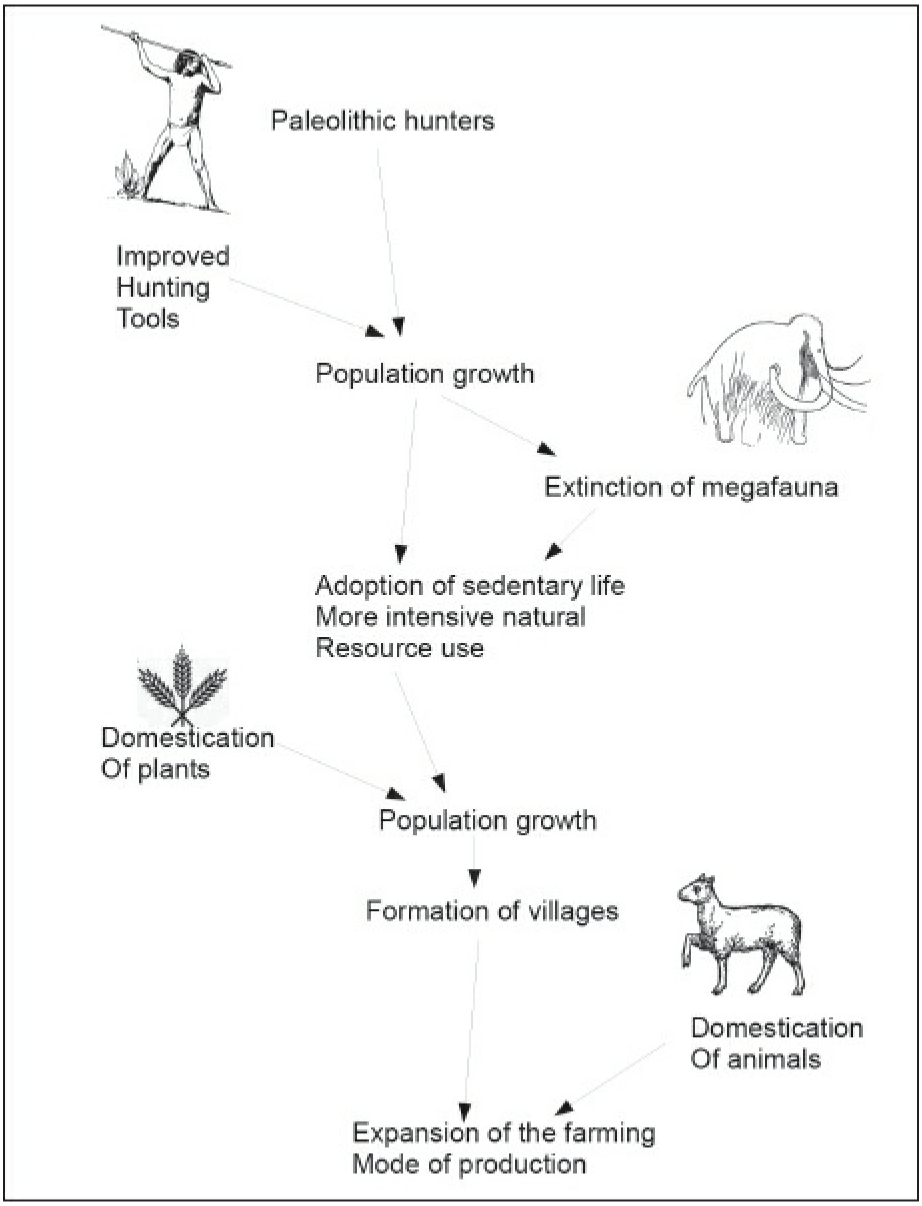


Figure 2.2. Transition from hunting economy to farming economy.

An alternative theory puts the change down to population pressure [Cohen, 1977]. The argument is that the key thing about agriculture is that it allows more people to be supported per square kilometer, a consequence of moving down a trophic level, and also a consequence of ensuring that the food crops dominate all other plant life in the cultivated area. The argument is that due to improvements in hunting technology the population had grown to the point where it was beyond the carrying capacity of the ecosystem in terms of game available. The resulting food shortages gave people the incentive to take advantage of the opportunity to deliberately grow previously wild plants. In the process they set themselves on the path to a mode of production that was on the one hand more labor intensive than hunting, but on the other more productive in terms of output per square kilometer. This step to agriculture allowed further population growth that blocked forever the possibility of a generalized reversion to a hunting mode of life. There is considerable evidence that hunting and gathering populations were responsible for the extinction of large prey animals in many parts of the world, especially where hunters entered new areas that until then had been unpopulated by humans [Mosimann and Martin, 1975; Burney and Flannery, 2005]. This seems to have occurred first in Australia about 45,000 years ago and then in the Americas 12,000 years ago. After the Clovis people arrived in North America from Siberia with their advanced stone spears, they seem to have swept through the Americas like a blitzkrieg wiping out the large prey animals as they went [Harris, 1991]. Northern Eurasian extinction of megafauna took longer but ended about the same time as in the Americas. The extinction of these, outside of Australia, may have prompted the move to a more sedentary Mesolithic mode of life based on a more intensive harvesting of the remaining wild resources. The removal of the possibility to relieve population pressure by migrating into as yet unoccupied territory could further intensify the incentive to develop new food sources. In this view it is the overexploitation of existing resources relative to the size of population that drove change in the mode of production.

Once the transition to raising crops and later to domesticating animals had taken place the population density rose enough to allow the formation of large villages or small towns, though the design of such early settlements as Askl Hðyuk (8500 BC) or Çatalhðyuk(7500 BC–6000 BC) in what is now Turkey was very unlike towns and villages we are now familiar with. Neighborhoods consisted of buildings packed so close together that there were no passageways or roads between them and the houses had no doors, access to them apparently being via flat roofs with ladders down into the rooms [Düring, 2010], as shown in figure 2.3. The settlements appear to have been egalitarian with no obvious distinction between sizes of dwellings and no evidence of temples. The settlements were also unfortified.

The people still used stone tools, and at the earlier stages lacked pottery, though this was acquired in the later Neolithic Period. Subsistence was based on a mixture of domesticated and collected wild plants. Wild sheep were initially herded but by the time of Çatalhðyuk they appear to be domesticated. In addition, cattle and horses were eaten, though these still seem to be wild varieties. Although fewer cattle than sheep were eaten, each cow provides as much meat as thirty sheep, so cattle probably provided more of the meat.

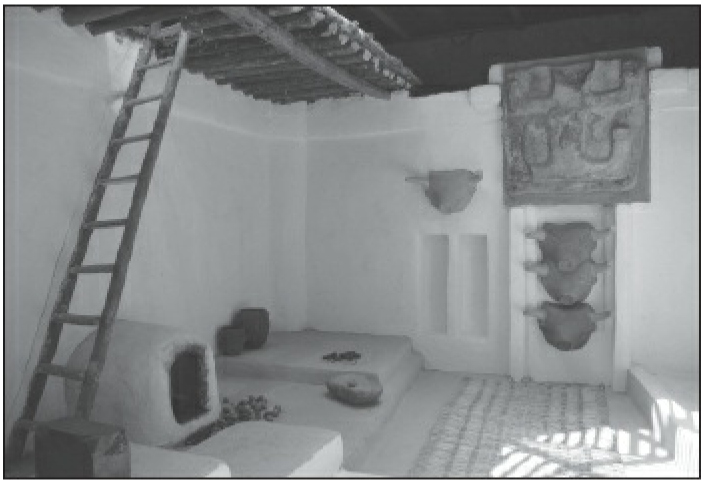


Figure 2.3. Reconstruction of the interior of a house at Çatalhðyuk.

The primitive division of labor is a sexual one, with women gathering plants and preparing vegetable foods, which probably provided the majority of the calories [Mies, 1981] and men catching animals. Artistic evidence indicates that Çatalhðyuk had a similar division of labor.

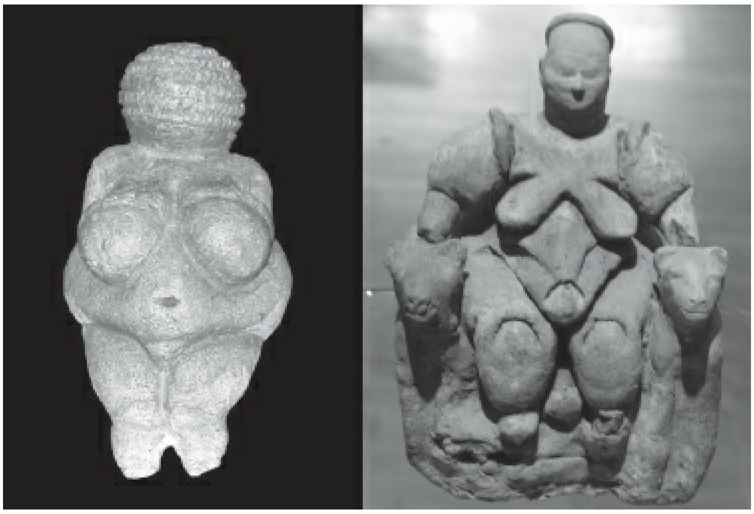


Figure 2.4. Paleolithic (left) and Neolithic (right) female figures The example on the right was excavated at ÇatalhSyuk.

It is not clear whether in the transition to agriculture Neolithic communities became matriarchies, though they may well have been. This idea was lent credence by some of the artwork excavated at Çatalhðyuk (figure 2.4). These, and the Paleolithic predecessors, are normally referred to as goddess figures, but one should be careful about interpreting them in a language drawn from a much later date. The excavations at Çatalhðyuk have also yielded a plethora of phallic sculptures, so representations of both sexes are present. It is a moot point whether to call archaeological finds like these religious images, erotic images, or sex toys. It is even more risky to come to conclusions about the dominance of one sex or the other on the basis of them. More recent excavations have been interpreted as showing that in Çatalhðyuk there was rough equality between the sexes—equal prominence to both sexes in ceremonial burials, similar diet,[11] and patterns of bone wear and tear are cited as evidence for this. Deposits of soot, inhaled during life, are found equally in male and female skeletons implying that both sexes did similar amounts of work in house and outside. In light of the data overall, Hodder [2004] concludes that there is no evidence for either patriarchy or matriarchy. However, as Ryan and Jethá [2010] point out, anthropologists and archaeologists are not necessarily that good at recognizing matriarchies, being wont to see them as simple inversions of patriarchies. There also seems to have been no judicial system. The burials show no evidence of anyone having died from violence, and there are no depictions of tribunals, executions, or punishments in the art of the town.

The Neolithic Revolution led to a long period of comparatively egalitarian social development. If we date the start of agriculture to about 11,000 years ago, then around half the time since then was taken up by the expansion of classless agrarian societies. According to the influential archaeologist Lord Renfrew, the invention of agriculture in Anatolia had a profound effect on languages now spoken across Europe, Australasia, and the Americas [Renfrew, 1989]. The main European, Iranian, and North Indian languages have long been known to have a common ancestor—referred to as Proto Indo-European. This was established by studies of the similarities in vocabularies between current and historical versions of the languages spoken in these areas (figure 2.5).

Renfrew realized that this pattern of languages was consistent with a spread of population out of Anatolia following the invention of farming. Farming can support a larger population per unit area than hunting can, so a farming people will tend to expand at the expense of their hunting neighbors. Not only do they have more food, but having settled down their birth rate rises. A nomadic woman who has to carry her children will not have another until the last one can walk and keep up. A settled life removes this problem while making available animal milk and gruels as baby food, shortening lactation and the return of fertility.

As farming populations grew and spread beyond their original homeland they took their languages with them. The current distribution of languages is the result of thousands of years of migrations that have partially erased the original Neolithic focus of the language spread. Anatolia, within recent history, was settled by Turkic speakers who displaced the original population. But detailed study of how the various languages have changed over time indicates that they started to diverge 8,700 years ago, which is consistent with the idea that the spread of the languages coincided with the Neolithic Revolution in Anatolia [Gray and Atkinson, 2003; Bouckaert et al., 2012].

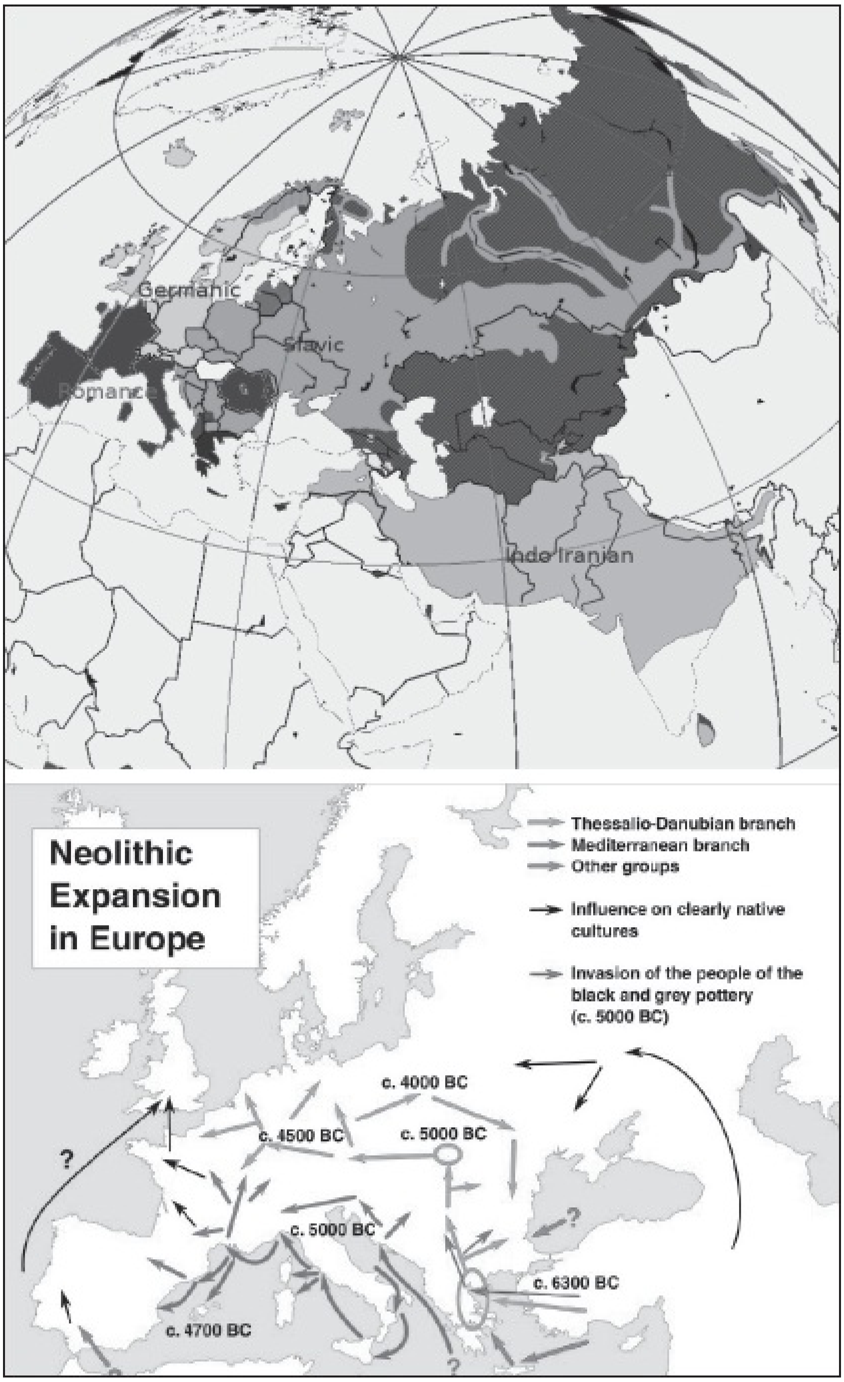


Figure 2.5. Areas in Eurasia where Indo-European languages are spoken (top); suggested population expansion from Anatolia (bottom).

According to Renfrew, this was not an isolated occurrence. Similar population expansion and associated language spreads happened at other places where agriculture was invented [Renfrew, 1994]: in China and with the spread of the Bantu languages from a locus of plant domestication in West Africa.

2.2 REPRODUCTION

A classless agricultural society can be divided into three groups: adults who are direct producers, children who in due course will replace them, and the elders and infirm unable to do the hard work of growing food. In this section we shall derive a simple economic model of production and reproduction in such a society.[12]

We will use the symbol A to stand for the fraction of the population in their years of adult working life, C the fraction of years spent as a dependent child, and E the fraction of years a person spends as an elder. Suppose a person is able to do heavy agricultural work from 18 and at 60 is too old to continue, and that if they reach 60 they are likely to die at 65. This would imply C = [18/65] = 27.7%, A = [42/65] = 64.6%, E= [5/65] =7.7%.

This is shown as the first estimate in table 2.4, but that ignores the effect of infant mortality. A large part of those born never reached adulthood. Suppose half the babies born die in childhood at an average age of 5, but afterward childhood death rates are low. The effect of this is that at birth a child has the prospect of only 11.5 years of childhood, 21 years of adult life, and 2.5 years as an elder, to give a life expectancy of 35 years (figure 2.4). The net effect of high infant mortality is that the fraction of the whole population who are productive is lower than would otherwise be the case.[13]

Suppose that in a year an adult consumes a calories and a child consumes ß, then the annual food consumption F by a community of n people will be: F = n((A+E)a+ Cß).

Now let us assume that an adult worker can produce *p* calories per year in the form of crops. So the community food output will be nAp. Clearly, in order for the community to survive the amount of food grown must on average exceed what is eaten. It must exceed it since they will have to set aside stores to make allowance for bad harvests. A community that ate its entire harvest each year will run short and experience high mortality with the first bad harvest that arrives. But storage of grain is unreliable. Pests eat part of what is stored, so the granaries have to be constantly replenished. If we assume that the community keeps 1/f a year of grain in reserve and that a fraction of this *w* is wasted each year the food requirement will be F((1+[w/f]).

The base productivity condition that has to be met for a community to simply survive is pb ≥ ((A+E)a+ Cß)(1+w/f)/A.

Let us take some figures for this. As a basis we take UN figures

[Tontisirin and de Haen, 2004] for food requirements of people doing moderately strenuous work. These are given separately for men and women and depend on their weights. If we take average weights of men as 68kg and women as 60kg [Igiri et al., 2009], we get an average a = 922,000kcal per year for adults, and for children an average of ß = 600,000kcal per year.

TABLE 2.4: Effect of High Infant Mortality on Average Productive Life

Category	Children (C)	Working Adults (A)	Elders (E)	Life
Start Year	0	18	60	-
Finish Year	18	60	65	-
First Estimate Years	18	42	5	65
Births	100%	-	-	-
Child Death Rate	50%	-	-	-
Average Child Death Rate	5.0	-	-	-
Survivors	50%	50%	50%	-
Average Years in Category	11.5	21	2.5	35
Population Fraction	32.9%	60%	7.1%	-

Using the values of A, C, E from table 2.4, and the assumption that the famine reserve is half a year's harvest, a quarter of which spoils each year, implies that an adult peasant in subsistence farming had to have a calorie production of around 1.5 million kcals per year.[14]

In addition to having a minimum food production rate per adult worker, simple social reproduction required a minimum effective fertility rate. The example so far has assumed a replacement level fertility rate of 4 children per woman and a 50 percent rate of child mortality. If the level of child mortality was higher, say 55 percent, then a fertility level of 4.4 would be needed. The rule is that the replacement fertility FR is defined by FR=2 /(1-DC) where DC is the child death rate.

For the population to expand the actual level of fertility must be above the replacement rate. This can come about either by the number of births per woman rising or by child mortality declining. Deaths in childhood are very sensitive to the supply of food, so an improvement in agricultural productivity can allow better-fed, healthier children more likely to survive to adulthood. But from the standpoint of simple survival, any increase in production beyond the basic reproduction threshold constitutes a surplus. The obverse of this is that any system of class exploitation that confiscates this surplus tends to raise infant mortality and prevent population growth.

Agriculture introduces, for the first time, a dependence of present labor on past labor. Hunters cannot long preserve their catch, so production is directed at immediate needs. Agriculture is, in most places, tied to an annual cycle. Over and above the need to maintain a buffer stock of grain to cover a bad harvest, even normal production depends on storage. Autumn grain must be stored for next year's seed and to feed next year's workers. Those working on planting in the spring are fed by grain harvested the previous year. This creates a dependence of those now working on those who worked before. This temporal dependence first appears as a dependence on the elders, those who came before and harvested before. It later becomes the basis for exploitation by employers or lenders. The elders control the grain that feeds the young and in turn take possession of this year's harvest.

Social relations of production overlap with, and are perceived as, relations of descent and later of patronage. In terms of ritual we can observe, with Neolithic agriculture, the rise of ancestor cults. Elaborate burial mounds are constructed and become lasting memorials. The dependence of the present generation on the past one, a real relation of production, gets projected into the world of myth. The annual real honoring of the father and mother, the handing over the harvest, becomes the basis for sacrificial offerings, first to the ancestors, and later to more abstract divine parents. Relations of filiation become the organizing principle of clan society, of nested circles of relationship out of which hierarchies of clan leadership and ultimately of kingship can grow.

2.3 CLASS FORMATION

Termite society, like all insect societies of which we are aware, is classless. On an evolutionary timescale class society does seem to be selected against. But on the shorter timescale of human civilization it is prevalent. As far as we can make out, the early Neolithic towns like Çatalhðyuk were also egalitarian. There seems to have been a delay of thousands of years between the development of farming 11,000 years ago and the rise of class-based states about 5,000 years ago. This period saw the expansion of agricultural populations from the original centers of domestication across Europe, India, China, et al. By our previous argument that expansion would have been dependent on an appreciable food surplus devoted to extra children. The consumption of a food surplus by an exploiting class would have inhibited the population spread.

Though a precondition for class is a food surplus, this is not enough. A food surplus could go to simply extend the division of labor, allowing some people to specialize in non-agricultural work: potters or smiths. A society with farmers, smiths, and potters is not, as such, a class society, even if the trades become hereditary, since the relationship among the trades is one of equals. There would be no exploitation involved.

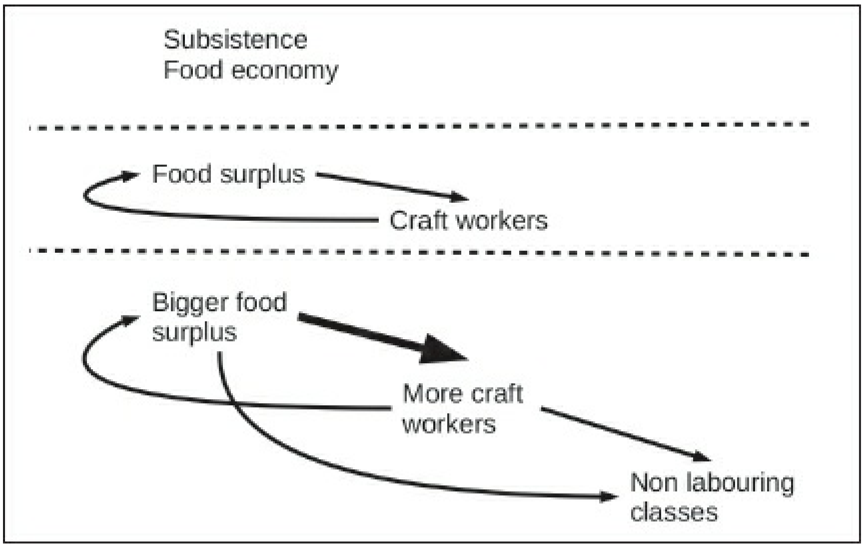


Figure 2.6. Precondition stages for the formation of classes.

Class formation requires that at least part of the food surplus goes to support a group of people that no longer engages in physical production. And this non-productive status has to extend over generations. In any society, infants are non-productive, but that does not make babies a class. For a nonproductive class to exist there must be people who spend the greater part of their life as non-producers, and their children in turn must be likely to have the same status.

But of course the upper class in society tends to consume more than food. They typically have a disproportionate share of other goods, clothes, jewelry, utensils, ornaments, etc. So the surplus they depend on cannot simply be a food surplus. A food surplus is the precondition. Without it there would be no food for the craftspeople producing the items of display and ostentation. An upper class implies a more general surplus. If only enough cloth is produced to clothe the working population rulers go naked. Emperors with clothes imply a cloth surplus, and shodden kings a leather surplus.

A surplus of food is initially required for population growth, next for a specialized division of labor. If smiths are to spend most of their time making bronze tools, they have little time left for growing their own food. But this surplus need not come about by an actual increase in food production. If in a community of 50 one person becomes a smith and another his assistant, no more food is required than if all 50 were engaged in farming. But it does require the 48 who remain farming to either work a bit harder or to become more productive. In the case of bronze or later iron smithing, the products include agricultural tools, initially axes and later digging tools, so a smaller group of agricultural workers equipped with metal tools would have been able to produce as much as a larger group with stone tools. Gilman et al. [1981] argued that relatively few bronze agricultural tools have been found in European bronze age sites. But Wells [ibid.] argues that this is due to differential preservation, that bronze tools, unlike ornaments, are too useful to be buried in the grave sites that are the focus of excavations, and would have been melted back down if damaged. So there is some dispute among archaeologists as to whether the production of bronze agricultural tools actually contributed much to production.

Why is this relevant?

Because social stratification first becomes evident in the European archaeological record during the Bronze Age. Neolithic Europe, like Neolithic Anatolia, seems to have been relatively egalitarian. Relatively communal dwelling is indicated by longhouses, such as those excavated at Balbridie, similar to those used within recent history by communities known to be classless. In addition, during the Neolithic the custom was to have communal burials in barrows [Barclay, 1998]. Bodies were probably exposed to birds of prey [Hedges, 1984] in order to have the flesh removed before bones were transferred to the barrow. In the Bronze Age this shifts to individual burials with some large burial mounds having only one body. Associated with the bodies we now find ornaments, pottery, and weapons. Over the same period ceremonial sites of increasing complexity, including the famous stone rings, start to be built.

However, we have a problem with explaining the rise of class stratification as a direct result of rising productivity—whether bronze tools contributed or not. If bronze tools made it easier, why should the farmers have not simply worked less, or perhaps supported bronze smiths to make them bronze cooking pots, etc.?

Figure 2.7. Hoe agriculture today (left); Bronze Age hoe heads (right). Source: Creative Commons, Cristian Chirita

The topic is more general than one specifically relating to the Bronze Age, since we know that outside of Europe societies without bronze or iron became class societies. Why should a surplus have led to a class structure?

A class society requires a surplus, but the converse does not hold. A food surplus does not necessitate an exploiting class. Establishing that seems to have required other misfortunes: war, patriarchy, and religion.

2.4 WAR, PATRIARCHY, RELIGION, AND THE LAWS OF STATISTICS

For warfare to exist you need something to fight over. Whereas warfare in pure hunter-gatherer societies seems rare [Fry, 2007; Ryan and Jethá, 2012] it has been common in societies with either herding or at least some form of agriculture. It is clear that once cattle or other beasts are herded they can be stolen, and can be the object of a war party. But fighting is not limited to what Smith called Nations of Shepherds, formidable as these have been.[15] Nations and tribes that combine some hoe horticulture with hunting have been warlike. Why?

According to Meillassoux [1981] the motive for the conflict was the capture not of cattle but young women. Pure hunter-gatherer societies are nomadic, with no fixed villages, and mobility of people between wandering small bands. Agriculture ties people down. He argues that the initial form of family in the transition to agriculture is the matrilocal, which means a society in which adult women stay in their mother's home or community. Insofar as there is mobility between communities, it is the men who move, seeking wives in other communities.

In principle either sex can move. You can have a matrilocal system where women stay in their birthplace and the men move, or patrilocal communities where the reverse happens. Although these seem logically to be no more than mirror images, their economic effects are actually very different. The reproductive potential of a community is set by how many young women, rather than young men, it has. This has serious implications for relatively small communities, ones that are not yet able to fully support themselves through the whole year by agriculture. Such communities have to be small relative to their hinterland to prevent the exhaustion of the available game.[16] Within such small groups the laws of chance mean that the numbers of each sex coming of age will fluctuate.

Suppose that we have a small community in which each generation coming of age has on average 40 people. We would expect about half of these to be young women, but as figure 2.8 shows, the number of women could vary between 0 and 40. There is about a 30 percent percent chance that in a given generation there would be fewer than 18 women, a shortfall of 4 women relative to men in their age group. This would presage a 10 percent fall in the population over the next generation. In smaller communities the effect is more marked. A community of 8 families would end up with fewer than 6 young women about 22 percent of the time. But a shortfall of 4 women in this small community implies a shrinkage of the population by a quarter, which would threaten the future survival of the community, bearing in mind that not all of these may be fertile, some may die young, etc.

In principle some of the young men could leave and try to join another community with a surplus of women, but what often seems to have happened, according to Meillassoux, is that the men raid neighboring communities and abduct young women. Given that the community still depends partly on hunting, the men are skilled in the use of bows and arrows, and these skills transfer readily from hunting to raiding.

This leads to endemic hostility and suspicion between communities. Men acquire the social role of warrior both to abduct women from other groups and to protect their own women. Such societies may remain matrilineal, with children being brought up in a relatively communal household with their uncles playing what we would regard as a paternal role. There may be no system of strict monogamy. But the beginnings of the collective dominance of men over women exist. Men as hunters and warriors develop ideologies that represent them as protectors and heroes and which justify relegating women to what are presented as menial horticultural tasks. In particular the abducted women, cut off from their own community, are likely to be in a very subordinate position.

The combination of hunting with horticulture limits the size of settled communities. Meillassoux claims that the precariousness of reproduction leads to abductions and raiding. Hunters develop warrior attributes and male dominance begins to develop. But this is collective rather than individual. There is not yet the figure of the patriarch, exercising exclusive control over the sexuality of "his" women. The society may still approve of considerable sexual license, with various orgiastic rituals and very blurred ideas of paternity [Beckerman and Valentine, 2002; Ryan and Jethá, 2010].

The basic contradiction associated with small matrilineal communities could be solved

- by becoming more exclusively agricultural and piscatorial. While growing in size it is possible to form big matrilineal or even matriarchal communities that do not suffer from frequent random shortages of women of childbearing age.
- by moving toward a patrilineal and subsequently patriarchal form of family and clan.

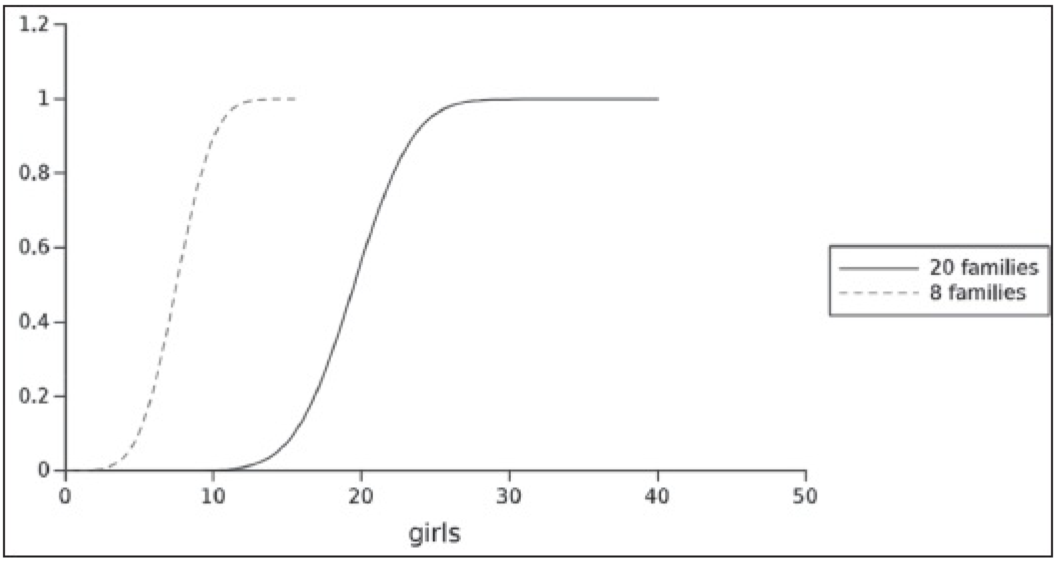


Figure 2.8. Expected number of women in the next generation of small communities where there are 8 or 20 families and each woman has two

children surviving to adulthood. The form is a cumulative binomial distribution: $\Sigma_{k=0}^{n}$ [n!/(k!(n-k)!)].

The probability that a community with several hundred people will suffer serious random swings in its sex ratio is very low. Communities like the Neolithic towns of Anatolia would have been big enough, and sufficiently dependent on agriculture, to avoid the raiding and warrior culture that Meillassoux observed in the more recent tribes that combined hoe agriculture with hunting. Such societies would still have had potential problems within individual matrilineal households if there were no daughters. But this is not such a problem for a peaceful community. It could be dealt with by adoption of daughters from other families, as occurs among the modern matriarchal Mosuo [Stacey, 2009]. While we can only speculate as to whether this took place in Anatolia, it could account for what seems to have been a long period of peaceful development of these communities, without evidence of either stratification or gender inequality in the archaeological record.

What we do know is that later historical cultures with grain agriculture seem to have been predominantly patrilineal and patriarchal. Meillassoux gives a theoretical account of why this happens: The higher output of settled grain agriculture allows a denser population and at the same time makes the diversion of effort from growing things into fighting less attractive. Peaceful relations between adjacent small domestic communities allow the nonviolent exchange of young women to make up the deficits that would always occur by chance. Women moving to another community, where they lack maternal support, are likely to be assimilated to the status that was formerly held by female captives: subordinate to their mother-in-law and husband. Once such transfers become more common, an increasing number of women are in a subordinate status which then generalizes to all brides being subject to the authority of the existing matriarch and the new husband. In the process the general authority of men over women rises.

> It is the procreative powers of a woman that are the subject of negotiation when she is taken into another group for a period generally held a priori to last as long as her fertility. An agreement is reached which decides the devolution of the woman’s offspring since, due to the circumstances cited above, a woman does not procreate for her community of origin (the identity of the family

> which will benefit from her procreation must be made public while the claims of the other community are restricted) and also because, since the woman does not procreate for her own benefit, jurally constituted patrilineal filiation must replace self-evident maternal filiation. [Meillassoux, 1981, 43]

The exchanges between communities can become quite complex, involving debts over time: if 2 women go from community A to community B this year, then it is agreed that at some time in the future 2 other brides will come back in return. This makes daughters valuable in an exchange process that has some similarities with trade. The head of the family, perhaps initially a woman, more probably a man, views them as a resource that gives them power and influence. As such, the default assumption becomes that all daughters will take partners outside the community, and exogamy becomes general.

> Since marriage and social reproduction are the main reason for these external relations, marriage, in order to maintain the elder’s authority, must be prohibited within the group so that nubile girls remain available as subjects of these transactions. Paradoxically, this restriction on marriage becomes increasingly necessary and rigorous in that the group, by expanding, could grow through endogamous intermarriage. When reproduction becomes statistically possible through the mating of members of the community, the power of the elders, rebuilt on matrimonial management, is threatened by the very effects of this management which makes expansion of the community possible. Thus political authority depends on a circumstance which it tends to abolish when it reinforces itself.
>
> The authority must, to be preserved, devise and develop a coercive and authoritarian ideology. Religion, magic ritual, and a terrorism based on superstition is inflicted upon dependants, young people and above all on pubescent women; sexual prohibitions become absolute and punishments for transgression increase. Endogamy becomes incest, and sexual prohibition a taboo. [Meillassoux, 1981, 45]

Religion, magic, ritual, and terrorism based on superstition justified both patriarchy and class hierarchy. Watts et al. [2016] present convincing evidence that religion, specifically in the form of human sacrifice, was deeply implicated in the formation of stratified societies. The Watts study used as their data a large sample of 93 different Austronesian societies, which being island cultures were comparatively isolated.

Evidence of human sacrifice was observed in 40 of the 93 cultures sampled (43 percent). Human sacrifice was practiced in 5 of the 20 egalitarian societies (25 percent), 17 of the 46 moderately stratified societies (37 percent), and 18 of the 27 highly stratified societies (67 percent) sampled.

They then performed a Markov model simulation of the evolution of high stratification and human sacrifice superimposed on the phylogentic tree of the language evolution of the cultures, tracing the origins of stratification and the origins of human sacrifice. They concluded that human sacrifice enhances the probability of transition to a highly stratified state, and stabilizes such a state once it exists.

They conclude:

> Human sacrifice legitimizes class-based power distinctions by combining displays of ultimate authority—the taking of a life—with supernatural justifications that sanctify authority as divinely ordained….
>
> Our results provide strong evidence for the claim that human sacrifice played a powerful role in the construction and maintenance of stratified societies. Though human sacrifice was practiced in the majority of highly stratified societies in our sample, it was scarce in egalitarian societies, and we find that its effect depended on the level of stratification. Specifically, human sacrifice substantially increased the chances of high social stratification arising and prevented the loss of social stratification once it had arisen, yet was not found to increase social stratification in egalitarian societies. This is consistent with historical accounts that speculate that in order for human sacrifice to be exploited by social elites, there must first be social elites to exploit it.

Ingham [1984] makes a similar argument using data from Aztec society. With war, patriarchy, religion and hierarchy in place, the scene was set for the emergence of slavery.

CHAPTER 3

Slave Economy

Among hunting and fishing societies slavery is little developed. Nieboer [1971] listed 88 examples of tribes of hunters and found that only 18 of these had slaves.[17] Slavery arises in clan society through war. Captives can be killed, ransomed, or put to work. But in clan societies without developed commodity production, the potential scale of the institution is limited by the consumption needs of the household holding the slave. This kind of tribal domestic slavery existed until recently in parts of Africa [Evans-Pritchard, 1940] and was in the past widespread. For slaves to be used on a large scale, for it to become the determining element of an economic system, the crops they produce must be sold and that in turn depends on several other things:

1. There must be a market of consumers[18] who are not able to grow their own food. Typically this implies an urban population.
2. There must be the means of transport to move the product from the farms to distant consumers.
3. There must be a market for slaves themselves.

Thus the establishment of a slave economy depends on a certain density of population, without which there are no towns; and a certain level of technology, particularly the technology of transport, without which there are no commodity markets.

3.1 TECHNOLOGY COMPLEX

Unaided human labor cannot transport large loads economically for long distances. For that you need non-human sources of power. Modern globalized capitalism rests on the power of the marine diesel and the high bandpass turbine [Smil, 2010]. Classical slavery depended on the

Mediterranean square rig [Whitewright, 2007] and the ox cart.

The precondition of this distinctive feature of classical civilization was its coastal character. Graeco-Roman antiquity was quintessentially Mediterranean in its innermost structure [Anderson, 1996, 20].

Long-distance transport always depends on the sea. Overland, now as in the past, costs far more in energy to move heavy cargoes than water transport. Land transport by pack animals was limited to high-value products: salt, cloth, etc. Wheeled transport depends in turn on roads and is heavily constrained by the efficiency of the harnesses available. Ancient horse harnesses only allowed limited weights to be pulled without exerting a choking pressure on the horse's neck [Singer and Holmyard, 1956], so the yoked ox cart was the preferred goods vehicle in the classical Mediterranean civilizations. A person can only sustain a power output of between 50W and 90W when working, where a pair of oxen drawing a cart can deliver around 1000W [Smil, 2004].

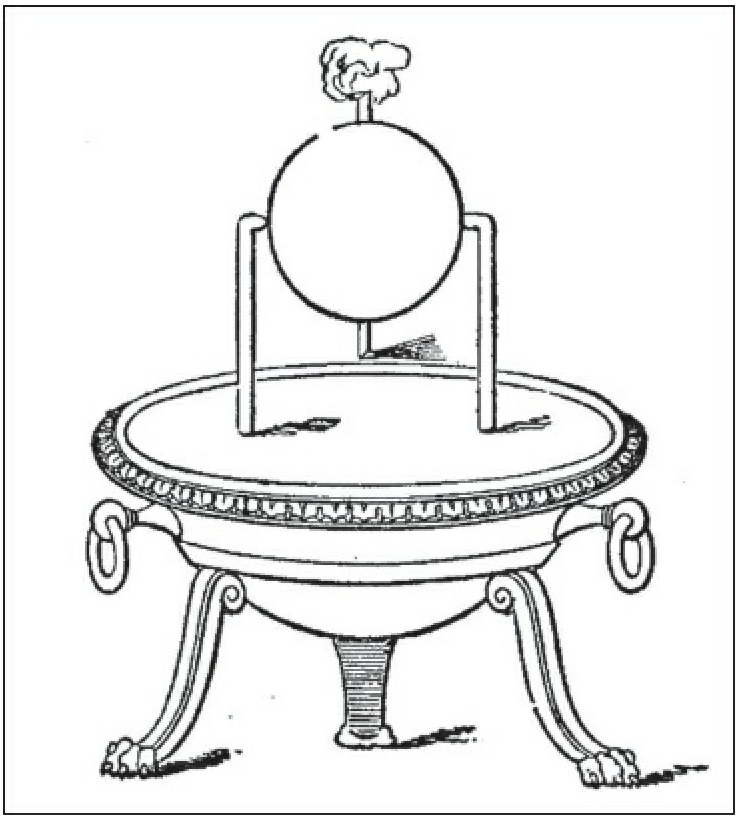


Figure 3.1. Hero's turbine, or *aeolipile*. Source: Jude, 1910.

High slave civilization had the wheel for transport; it also harnessed rotation for other purposes: the potter's wheel, the lathe, mechanical computers,[19] the screw press for olive oil production and, with the water wheel harnessed for the first time, an artificial source of rotary mechanical motion [Singer and Holmyard, 1956]. It knew the crank, contra claims by White [1964], and could build reciprocating machinery of a sophistication not achieved again until the nineteenth century. Although the Romans knew of a steam turbine or *aeolipile* and could make reciprocating pistons that were almost homomorphic to those in steam engines,[20] they had no powered land transport. Even on good roads the cart was only economically effective for shorter journeys. Longer heavier transport relied on water. Carts can transfer from farm to shore, but the overall viability of slave-based export industries, whether in the ancient economy or during the early modern renaissance of slave civilization around the Atlantic, depended on sea and sail.

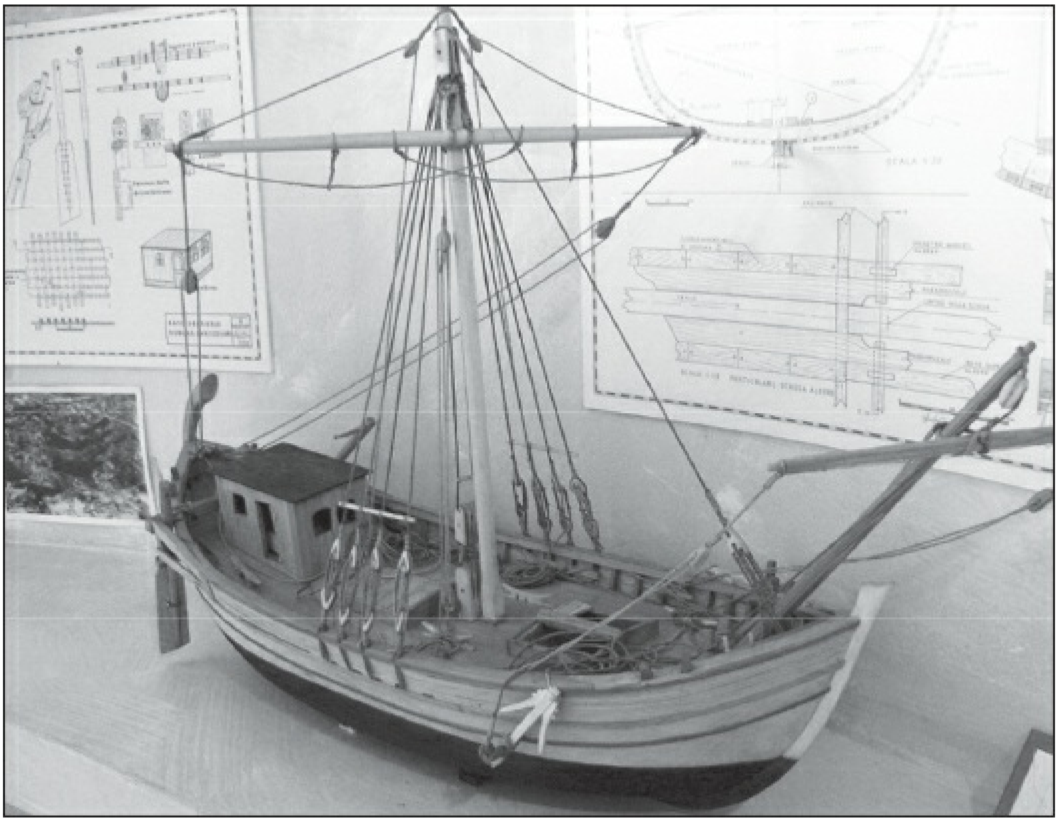


Figure 3.2. Model of a Roman merchant vessel. The square rig may have been capable of adopting a lateen-style configuration by selective reefing. Photo:Wolfgang Sauber, Creative Commons.

Human energy, via oars, can propel a small ship at a cruising speed of 2 to 3 knots. But to achieve this the ship must be narrow and thus ill suited to carrying heavy cargo. A beamy, seaworthy cargo ship needs sail or engine power.

Sails were the first technology that could be used to harness inanimate power. The classical Mediterranean sailing vessels had single masts and were square-rigged. It was believed until recently that this would have limited them to sailing more or less directly before the wind. More recently it has been concluded that sailing to the windward was possible using the rig then available.[21] But the speeds attained beating to windward would be much slower. Casson [1951] provides tables of probable sailing times based on a combination of ancient textual accounts and modern data on prevailing winds. He suggests that while a voyage from Rome to Alexandria, with favorable westerlies, could be made in about 12 days, the return voyage, going against the wind, would have taken between 50 and 70 days.

By modern standards the ships would have been small. While ships of over 350 tons certainly existed, the great bulk would have been under 100 tons. Overall the size range would not have been dissimilar to those used in early modern Europe [Houston, 1988]. Sail continued to be the prime mover during the period of transatlantic slavery, though the ships used in the transatlantic trade up to the late 1700s tended to be twice as large as Houston estimates classical vessels to have been [Garland and Klein, 1985; North, 1968].

The slave economy of the Indian Ocean littoral between 1000 and 1900 also used sea transport, with fore-aft rigging. In this case, the seasonal shifts in the prevailing winds of the monsoon made sailing to windward less essential than in the Mediterranean [Heuman and Burnard, 2010]. The principal technical advances in shipping between the Mediterranean and Atlantic slave economies were:

- Improved navigational instruments, compass, astrolabe and later the sextant.
- Adoption of stouter keel and frame internal construction.
- Internal decks—particularly important for slave transport.
- Better rig, multiple masts, and more fore and aft sails, improved sailing to windward.

The slave economy of Arabia and the Indian Ocean is thought by some to have pioneered the fore and aft rig with what was called the lateen rig. The English term “mizzen,” as in mizzenmast, arguably derives from the Arabic *mizan* meaning a balance. A lateen sail is triangular but hangs from a yard that looks like a balance, low at one end [Hourani and Carswell, 1995]. But Casson [1956] and Whitewright [2009] argue that there is evidence that the lateen sail was in use during the late Roman period. If that is the case, then a key technical step facilitating the long- distance trade required for the slave form of economy may, via the fifteenth-century Portuguese, have been transmitted from the classical to the early modern slave economies.

These advances were a precondition for the establishment of a slave economy of oceanic rather than Mediterranean scale.

Figure 3.3. The lateen rig. Source: Pearson Scott Foresman archive, released to public domain.

The operation of sailing ships necessarily tended to take a capitalist form. Not only were the ships expensive, necessitating partnership forms that presaged the joint stock company [Banaji, 2016], shipping was, in the precapitalist economies, the main instance of production by means of powered machines. The sailing ship used wind power to replace what would otherwise have required a large number of galley slaves. In this it shared one of the archetypal traits of capitalist industry—the replacement of human labor with powered devices. The anomaly of merchant capital existing in antiquity and the Middle Ages should be understood as arising from shipping being the first field to which such machines were applied. The profit of merchant capital should then be understood as a special early and precocious case of the production of relative surplus value (see section

5.4.9).

By using sail-power shippers in, say, first-century Italy could convert grapes for wine into Egyptian corn for sale in Italy such that the labor that would go into growing the grapes, plus the labor of shipping, was less than the labor that would be required to grow the same amount of corn in Italy. To the extent that the corn imported from Alexandria entered into the subsistence of slaves exploited in Italy, the cheapening of corn would have decreased the fraction of time that slaves had to work to produce their subsistence, increasing the number of hours a week that yielded an income for the slave owners. A portion of this increased surplus was then appropriated by the sea captains and shippers as monetary profit.

3.2 SCHEME OF REPRODUCTION

Slavery can dominate an economy even if slaves make up only a minority of the population. According to Finley [1980] slaves made up around a third of the population in the U.S. South, and similar proportions in Brazil, ancient Rome, and ancient Athens.[22] These were slave societies because slavery was the main source of exploitation and hence the main source of the economic surplus upon which the prosperity and political power of the ruling classes depended. Each great economic system is characterized by a distinct mechanism by which an economic surplus is extracted. This mechanism then structures the whole system of social reproduction. From it arise characteristic political struggles and forms of state.[23] From this standpoint, the crucial feature of slavery is that the slave is a person who is bought and sold and who is forced to perform labor for another.

This element of being bought on the market means that slave economies have, like capitalist ones, a relatively well-developed set of markets. Figure 3.4 outlines the essential market flows associated with the basic unit of slave production: the agricultural estate. The estate owner must lay out money for the purchase of slaves. Once bought the slaves are set to work. Some of the crops they raise are retained on the estate to feed the workforce. This portion of the crop does not enter the market. The surplus product of the estate does. Hence the viability of a slave estate depends on the surplus product being worth significantly more than the slaves bought to produce it. The existence of slaves on a market, whose value can be compared to the value of the crop they can be forced to grow, means that it is at times rational for the slave owner to work them to death.

While countries depended for the supply of servile labor on the natural increase of their own slave population, there existed an obvious limit to the range of the system and the hardships it was capable of inflicting. Where the character of the climate, or the nature of the work to be done, was such as to be seriously prejudicial to human life, slavery, if recruited from within, could only exist through giving attention to the physical requirement of slaves. Without this slavery would become extinct by the destruction of its victims. But, once a commerce in slaves is established, restraints upon the fullest development of slavery are effectually removed [Cairnes and Smith, 2003, IV.iii].

Unlike a modern capitalist system, slaves do not constitute a large market for commodities. They themselves are commodities, and are not[24] buyers of commodities. The agricultural slaves subsist largely on the food they grow on the estate. Such clothes as they are provided can be produced by other slaves on the estate. So though a slave society does develop a market, its extent is much more limited than in a modern economy. The surplus product of the slaves is marketable, but not the product necessary for their subsistence, nor the product of what is often a very large subsistence agriculture sector alongside and between the slave estates.

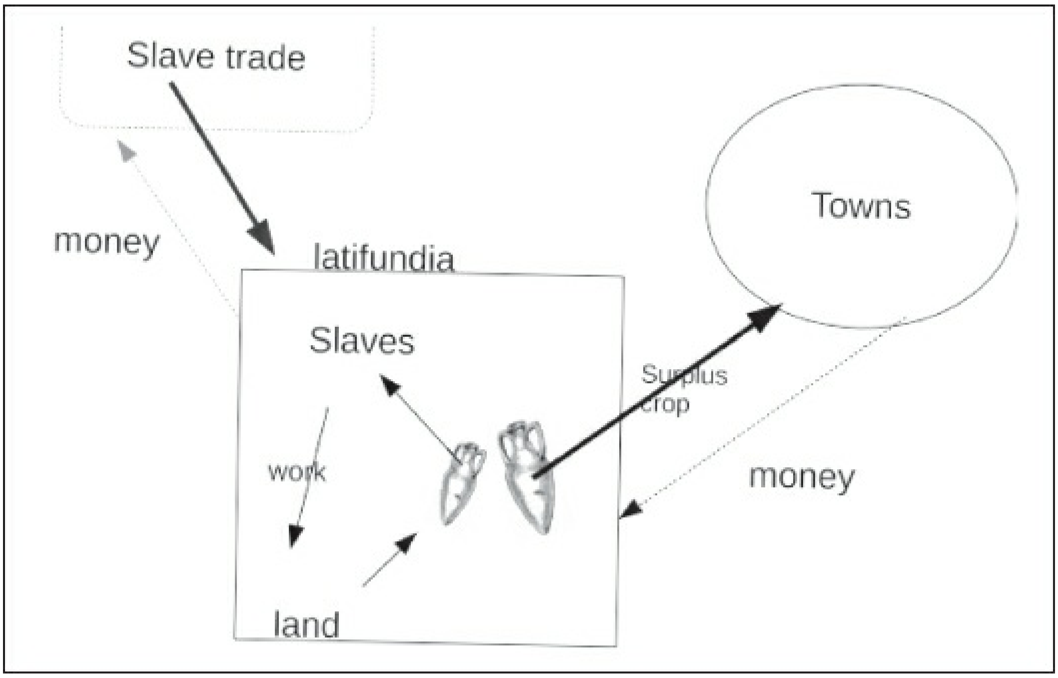


Figure 3.4. Main pattern of purchases and sales by slave estates.

The surplus product of the countryside, predominantly from slave agriculture, had to be sold to urban markets. This presupposed technical means of transport, as I have discussed, are roads, carts, ships, and harbors.

But it also implied that the urban population had to have the money to buy the crops.

The basic balance of the political economy has to be:

1. Sales by latifundia – purchases of slaves = Owners' profits
2. Food purchases by urban economy = Owners' profits + sales to slave importers

The urban sector gets the money to buy the products of the latifundia because the slave-owning aristocracy live in town and spend their profits there. They maintain their *familia urbana* there. This is made up not only of the *paterfamilias*, his wife, and children, but also a retinue of domestic slaves. Food and supplies for these families are bought on the urban market and indirectly support a whole middle class of professionals and traders, many of whom would themselves own one or two slaves. This entire mass is directly or indirectly supported by the revenues of the slaveowners.

There remains the cost of the slaves purchased by the latifundia. The money for these goes from the latifundia to slave merchants. How does that money circulate back to the towns to enable them to purchase food?

Without it, the towns would not have sufficient cash to buy the entire surplus product of the latifundia. Although one possibility would be for the slave merchants to purchase export goods from the towns which they then exchange for slaves on the barbarian frontier. This is an oversimplification for classical slavery but a fair model of the relation between the metropolitan British economy and its slave plantations in the West Indies. So the closing and balancing equation of the slave political economy is:

Sales of slaves = Purchases by slave merchants

3.3 CONTRADICTIONS AND DEVELOPMENT

In reality the reproduction scheme outlined so far is a considerable oversimplification. There would be some sales to the towns by free peasant farmers, and some exports of manufactures to these peasants. But we can think of this exchange as being independent of the monetary circuit generated by the slave economy. Remove the slave sector, and the volume of commodity exchange between town and country would be much lower. Conversely, should the market shrink, so would the viability of large-scale slave agriculture. Indeed, with the collapse of the classical slave economy in the West by the sixth century there was a huge relapse in the level of commodity circulation and shrinkage of the monetary economy.

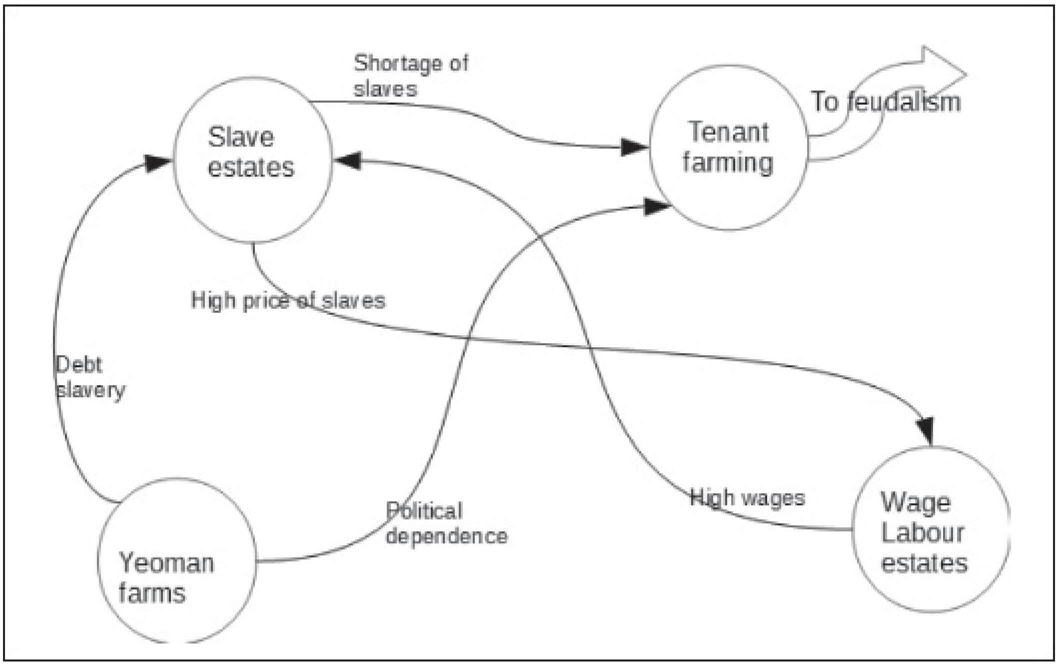


Figure 3.5 Transitions between agriculture subsystems in a slave economy.

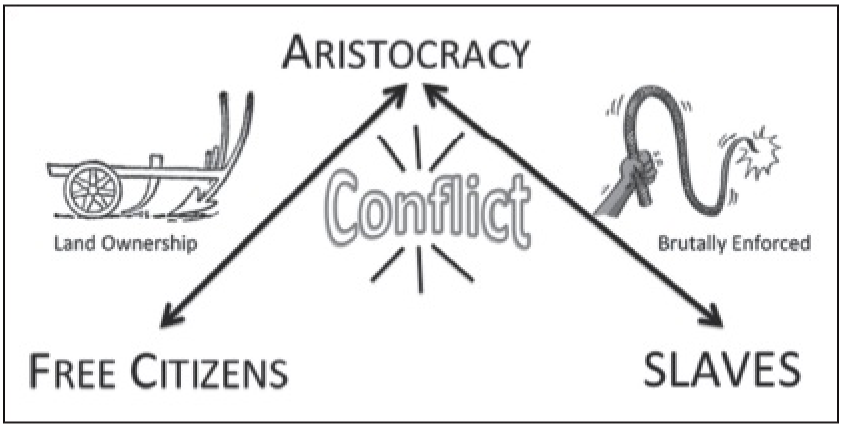


Figure 3.6. Class antagonisms in slave society. Drawing: Karen Renaud.

Rostovtzeff [1927] attributed this to the progressive spread of classical civilization undermining the market conditions necessary for its own existence.

> The time was past when Greece and then Italy supplied the whole world with wine and oil. Under the Roman Empire nearly all the provinces grew enough of both commodities to satisfy their own

> requirements and even export the excess. This was a serious blow to the agricultural prosperity of Greece and Italy. Having nothing to export in return for the imported grain they were forced to revert to a more primitive form of agriculture and once more to grow corn for their own needs [Rostovtzeff, 1927, 258]

In addition there was, at various times, exports of specialized manufactures: cloth, pottery, metal, and glasswares, etc., from one area to another. Much of this too was made by slaves. According to Rostovtzeff the spread of the technology of mass production of pottery from Greece to Italy, to Southern and then Northern Gaul, had the effect of suppressing the original industrial prosperity of Italy.

At the same time a shift to an increasing employment of wage labor and sharecropping took place on the land. This was a rational response to the increasing difficulty in obtaining slaves. Finley [1980], Harper [2011], and Rostovtzeff all argue that the choice by the estate owners between employing slaves and other forms of exploitation—wage labor, sharecropping, tenant farming—was rational and dependent on the relative availability of these types of workers (Figure 3.5). The free yeomanry, from the period of the Republic on, were subjected to the pressure of competition from the slave estates and were constantly threatened with being forced into debt slavery themselves or into the statuses of tenants or urban proletarians.

A slave economy is unstable unless it has a political superstructure that uses a substantial free population as a counterpoise to the slaves.[25]

> The slave lives in a society that regards him as a slave; slavery cannot exist where there is not a society of freemen. Therefore the despot, however great his power, is not, as such, a master of slaves. The slave owner has the community on his side. [Nieboer, 1971, 32]

We know from the United States that in the traditional slaveholding territories the armed free citizenry formed a solid block against the slaves, with their militias being readily available to suppress slave rebellions.[26] The same principle held in the ancient slave republics, which also rested on an armed free citizenry. But while the distinction between slaves and freemen and the pride of the latter prevented any solidarity between free peasant and slave, it was not enough to suppress class conflict within the free. As described by Parenti [2004] and Rostovtzeff [1927], the resulting class conflicts between the free peasants and proletarians on the one hand and the slave-owning aristocracy dominated the late Roman Republic. Similar conflict in Athens had led to a revolution (508 BC) which inaugurated the Athenian democracy (figure 3.7). This was recognized by contemporaries to be the rule of the poor as opposed to the "rich," which we can interpret to mean the political dominance among the free of the peasants and artisans as opposed to wealthier slave owners.[27] In the Roman constitution political power was pretty securely in the hands of the slave-owning aristocracy, a factor that doubtless encouraged the American slaveholding aristocracy to adopt it as a model.

The existence of a large slave sector in both agriculture and manufacturing made it impossible for the Roman proletariat to combine in unions to achieve better conditions. Slavery degraded the condition of all labor. Real wages for free laborers in the late Roman Empire (300 AD) were about a third of those in London or Amsterdam during the early period of capitalism. They were even below wages in India during the seventeenth century, though they probably compared well with wages in India during the nineteenth century [Allen, 2009] after the native Indian handicraft industry had been ruined by British industrial competition. Very little of the great material wealth of the slave society, evident in its monuments and archaeological remains, filtered down to those working at the base. Competition with slaves means that wages of the free cannot rise much above the level of the slaves themselves. This is true wherever and whenever slavery exists and recognition of this was behind the solidarity shown by the British workers movement to the Union cause in the U.S. Civil War. The depression of wages produced by the institution of slavery meant that there could be only a restricted market supplying wage earners either in the town or the country.

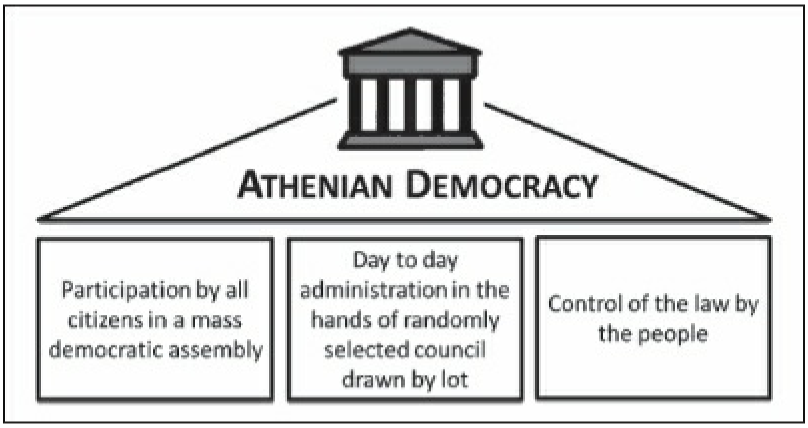


Figure 3.7. The Athenian constitution represented the most extreme form of the political influence of the free peasants and artisans. Drawing: Karen Renaud.

3.4 HUMAN REPRODUCTION

Unlike the feudal economy that succeeded it, the slave mode of production of antiquity possessed no natural, internal mechanism of self-reproduction, because its labor force could never be homeostatically stabilized within the system [Anderson, 1996, 76].

The preservation of the slave system depended on a steady stream of new chained captives. In the view of Weber [2013], slave economy creates a permanent deficit of slaves that can only be made up from outside sources. Initially, during the centuries in which first the Republic and then the Empire spread over Italy, North Africa, Greece, and then Asia Minor and much of Europe, this source of slaves were as war captives. This process supplied slaves to man the latifundia and at the same time, by war taxes, impoverished the free peasantry, enabling slavery to become the dominating economic form.

As captives, slaves suffered high levels of mortality through overwork and had few opportunities to form families. Weber argued that the Roman slaves tended to be sexually segregated with men kept in barracks on farms, and women kept as domestic servants. Coupled with a high rate of mortality through overwork and ill treatment this meant that there would be a perpetual deficit, which in turn motivated the ruling class in its centuries-long spree of war and conquest. Caesar was reputed to have sold off literally hundreds of thousands of captives from his conquests [Finley, 1980, 71]. With the end of conquests, Dacia (modern Romania) in the second century being the last sizeable one, the supply dried up. In consequence the ruling class found it economic to shift to a system of landlord-based exploitation—either sharecropping or a form of proto-feudalism called the *colonate*. Tenants were still tied to their patron, and their families could be relied on as a source of labor from generation to generation.

TABLE 3.1: Excess Mortality among Slaves in Ante-Bellum U.S. (figures per 1,000)

Age	Slaves	Entire United States
0	350	179

1–4	201	93
5–9	54	28
10–14	37	19
15–19	35	28
20–24	40	39

Source: Steckel, 1986.

Slavery was associated with a patriarchal family structure in the ruling class. Strict control was exercised over the sexual activity of free women. In Roman law any sex with a free woman outside of marriage was a criminal offense: criminal adultery in the case of a married woman; *stuporum*, or violation, in the case of an unmarried one. Because the Roman state had no standing police, such crimes would only be prosecuted if the family or husband of the woman brought criminal charges. The sexual powers of a woman were regarded as the property of her family or husband, who were, consequently, the ones who had to seek redress.

Although formally the system was one of monogamy, for the slave-owning men it was one of polygyny. Only children of a man's free-born wife could count as family heirs, but over and above that there were socially sanctioned forms of extramarital sex:

1. *Concubinage* relationships were openly acknowledged with women of inferior social class, either slaves or at best freed slaves. The aim of these non-marital relationships was sex without offspring.
2. *Prostitution* as an institution arose with the slave system. The necessary conditions for its existence were, and remain:
   a. Patriarchal dominance of men over women.
   b. A trade in enslaved or impoverished women to fill the brothels. Heuman and Burnard [2010] report that, even today, the flow of sexually trafficked women in South Asia is on the order of 300,000 a year.
   c. A class of relatively wealthy men.
   d. A well-developed system of monetary economy, in order that sex could be converted into a paying business.
3. *Sexual exploitation* of domestic slaves.

In all class societies employing servants,[28] domestic servants have fallen victims to the lusts of their masters. While this was deplored by the *mater familia* the servants were at once powerless in the face of their masters and liable to whipping by their mistresses if their having yielded was discovered. The *dominus* on the other hand obtained not only sexual gratification but saleable slave children.

The prostitutes were, in the main, slaves, and the slave-owning class felt no particular shame in exploiting them. The hypocritical double standards of Roman sexual policy were summarized by the Christian moralist Salvian in his aphorism *adulteria vetantes, lupanaria aedificantes*, "prohibition of adultery, building of brothels."

It is worth noting here that sexual and economic exploitation are distinct. Economic exploitation involves the appropriation of the physical product of a laboring class by an exploiting class. Sexual exploitation is any practice in which persons achieve sexual gratification or offspring through the abuse of another person's sexuality [Defeis, 2000]. This remains an issue in post-slave societies.[29]

Weber's analysis has been criticized more recently by Harper [2011], who says that Weber underestimates the significance of natural reproduction among the slaves. Even if female and male slaves were kept apart, slave women were objects of sexual exploitation by their masters, and any resulting children could be sold off at a profit at the slave market. Harper argues that it is unsafe to generalize from the generally high slave mortality of the United States to older slave economies. Mortality in early slavery may have been somewhat lower, though in the absence of reliable data there is an inevitable uncertainty about estimates of mortality so long ago. We do, however, know that slavery survived in the United States for some time after the termination of the slave trade, and it certainly survived, though not necessarily on the same scale, in the Roman Empire after conquests ceased. This indicates that a substantial proportion of the labor force in the latter period of both slave systems may have been born slaves.

On the other hand Harper himself documents the extent of the longdistance slave trade, importing slaves from sub-Saharan Africa, from the Gothic frontier, and as far away as the Caucasus. Such large-scale imports indicate that natural reproduction was insufficient to maintain the slave economy, and that it remained to a significant extent parasitic on the population surplus of the surrounding tribal and clan societies. It is therefore possible that Weber was right, that as the external supply of slaves slackened, whether from conquest or trade, their price rose and motivated a shift to the colonate. This in turn would have changed the basic relation of exploitation from one that presupposed commodity production to one in which commodity production was ancillary. This change in production relations would then produce as an effect the general collapse of markets observed alongside the collapse of the Western Empire.

The Weber account, in which slavery collapses into a system of landlord dominance over sharecroppers and tied peasants, also fits in with what happened in the United States and Brazil after slavery. If the possibility of slave exploitation is shut off, but land is still held by the old slave owners, this is probably the inevitable consequence.

Why, then, did importing slaves over the frontiers not continue indefinitely?

Technological development of weapons is one possible answer. The greater availability of iron enabled the development of the cataphract, or armored knight. With the invention of the stirrup (fifth century) an armored horseman could use a lance without being thrown from his horse by impact. These technical changes produced a decisive shift in the balance of military power from infantry to the shock power of cavalry [Wintringham and Blashford-Snell, 1943; Ferrill, 1986; White, 1964]. The slave state had relied on the superior fighting ability of its professional infantry to maintain strategic dominance over the barbarian societies around it. Whether this military technology was a factor in the collapse of empire, it does explain why, feudalism having been established, citizen infantry were unable to challenge the dominance of the horse-riding aristocracy until the late Middle Ages. The undermining of heavy cavalry, and thus the military aristocracy, had to await musketry.

The progressive social transformation of barbarian society into class society [Heather, 2009] also removed the organizational superiority that the Roman state had over its neighbors and may have undermined its ability to exploit them in slave raids.

The precise historical contingencies by which the Roman slave state fell are not, however, central to a theory of the overall dynamics of the slave form of economy, since that is just one slave society. Slavery continued to exist, even if as a minor component of the system of exploitation well into the Middle Ages. Perhaps 10 percent of the English population were slaves in 1066, and in the Byzantine, Arab, and Ottoman empires that succeeded Rome slavery also continued [Heuman and Burnard, 2010]. Slaves never stopped being captured in sub-Saharan Africa and traded across the desert to the North. The slave mode of production became firmly established in the Sahel empires like Bornu and Sokoto. Heuman and Burnard report that by the mid-nineteenth century there were as many slaves in Sokoto as in the United States. From the 1500s on the slave trade, which had previously been directed North and East, was diverted to the South, to the Bight of Benin and the transatlantic trade. Between 1500 and 1900, about 12 million slaves were shipped from the coasts of Africa to the plantations of Brazil, the Caribbean, and North America. Over the same period about 5 million African slaves were sold to the Islamic world. The total number of slaves traded in the Indian Ocean area over this period was much larger, but most were traded from other areas: within India, from Central Asia and China (ibid., chap. 3).

The effect of two thousand years of slave trade on Africa was a chronic demographic drain, slowing down social and economic development. This is the essential parasitism of the slave system. Slave labor is profitable because the reproduction costs of the slaves are met by the societies from which they are taken. Overall they transfer the work of human reproduction from one territory to another. And by reducing the price of slave labor below the level that would allow their reproduction, it encourages the most reckless overworking of the wretched captives.

The important things to take away about the slave economy are:

- It is a system of production that generates a well-developed commodity exchange. This is something it has in common with capitalism.
- Its dominance over other forms of exploitation rests on an ability to draw on external sources of slave labor. This dependence on external supplies of labor is something we will meet in capitalist economy.

3.5 COMMODITIES AND PRICES

In the preceding discussion of slavery I said that one of the distinguishing features of slave economies is that they have well-developed markets. But so far I have treated the idea of markets and commodities in an informal, commonsense fashion. We need to go into the issue more deeply and present a theory of commodities. In this book I will use the classical theory of commodity circulation and price.

By the classical theory, I mean the theory that labor is the source of value. This was generally accepted from the time of Ibn Kaldun[30] through Petty[31] and Adam Smith down to that of Karl Marx.[32], [33]

3.5.1 Neoclassical Prices

If you had an economics course at school or college, classical theory is unlikely to be the theory you were taught. Instead you would have been taught the neoclassical theory that was developed in the late nineteenth century by writers like Jevons or Marshall. It is arguable that neoclassical theory gained its popularity because the classical theory, having by then been adopted by socialist writers, had a rather disreputable image in polite society. The neoclassical theory appeared considerably more sophisticated. It was more mathematical and had a scientific feel.[34] Its plausibility for young students is enhanced by a beguiling use of diagrams. For those of you who did not take an economics course, figure 3.8 is what millions of students have been given as the theory of price.

There are two lines, sometimes drawn slightly curved: one is called the supply function, the other the demand function. The demand function rests on the commonsense notion that if something is cheap, people will buy more of it, so it slopes down. Teachers have little difficulty getting this idea accross to their class.

The other line, the supply function, is shown sloping the other way. What it purports to show is that as more is supplied, the cost of each item goes up. Teachers have more difficulty with this, as common knowledge and experience will have taught students that the reverse is the case: as industries ramp up production they find they can produce more efficiently and supply the output at a lower cost. Such objections provoke some hand waving at the blackboard as well as excuses.[35]

The great thing about a classic diagram is that it is both memorable and intuitively understandable. If you can present math this way you leverage the processing ability of our visual cortex to understand it. That is why Venn diagrams are so much easier for students to grasp than axiomatic set theory [Lakoff and Nunez, 2001]. Our brains tell us that if it looks right, it not only is right, but it is real. So having seen the diagrams, students come out thinking that supply and demand functions are real things—after all, they have seen them. Not only that, one can see that the intersection of these functions exactly predicts both the quantity of the commodity sold q, and its price p.

Had the theory been presented entirely in algebraic form it would be more confusing, less appealing, and more subject to critical analysis. I will demonstrate that once you convert it to algebraic notation it is evident that the theory violates two cardinal principles of the scientific method. Its science feel is faked.

"Occam's razor" is the principle widely credited to the monk William of Ockham in the Middle Ages. He is supposed to have said that in an explanation "*frustra fit per plura quod potest fieri per pauciora*" [Adams, 1987], "it is futile to explain with many things what can be done with fewer." His dictum has been widely adopted by scientists who interpret it to mean that when constructing a hypothesis you should keep it simple.[36]

Why is this a good principle for science?

Beyond philosophical beliefs that the laws of nature are simple and elegant, there are pragmatic reasons why sticking to Occam's razor is good scientific practice. The main one is that if you make your theory complicated enough you can make it fit any particular set of observations, but this is at a cost of loss of generality of predictive ability. A famous example is the way that the Greek geocentric theory of astronomy was extended by adding epicycles to account for the retrograde apparent movement of Mars.[37] Ptolemy was able to get good predictions, something that classical economists signally fail to do, but he got them at the cost of a theory with little inner logic, and one that we now know was totally inside out.

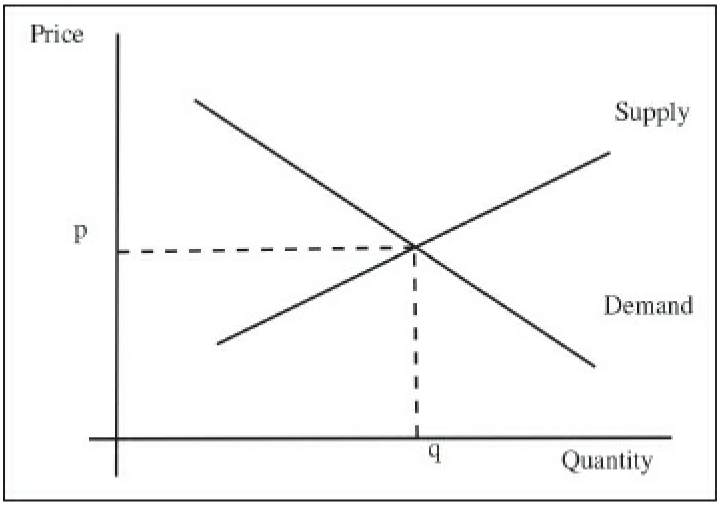


Figure 3.8. The theory of price taught to millions of students.

The neoclassical supply and demand theory does multiply entities without cause. Each of the functions has at least two parameters specifying its slope and position.[38] But the real observed data only has two parameters: a price and quantity on a particular day. So the theory attempts to explain two numbers and in the process introduces four new numbers—entities lacking necessity.

For Ptolemy the epicyclic complexity brought precision in predicting planetary motion, and in the sense that there were no more epicycles than was necessary to achieve that precision, Ptolemy's theory obeyed Occam's razor. But the profligacy with which the economists strew free variables around, brings the opposite effect. Their price theory is underdetermined and makes no testable predictions at all.

Testability is another cornerstone of the scientific method. A causal theory should be testable to see if it is true. For that to work, the entities you use have to be measurable. But what testable predictions does the neoclassical theory make about the structure of industrial prices in, for example, the U.S. economy?

It can make none, since the supply and demand functions for the various commodities are not only contingently unknown, but are in principle unknowable. The theory says that the two functions uniquely define the price and quantity that will be sold on a particular day, but there are infinitely many pairs of lines that could be drawn so as to intersect at the point (q, p) in figure 3.8. It is no good trying to look at how the prices and quantities sold vary from day to day, since the theory itself holds than any changes in price or quantity must be brought about by "shifts" in the functions. What this means is that the economics teacher goes to the board with a ruler and draws two more lines intersecting at the new price and quantity. This, the teacher tells the class, is what happens in a real market: prices change because the supply and demand functions move about.

But splatter any arbitrary set of points on the price-quantity graph, and you can draw intersecting lines through each and every one of them. Let these points be prices on successive days, there could never be a sequence of these price value measurements that could not be explained by suitably shifting a ruler about and drawing pairs of intersecting lines. So the theory is unfalsifiable. It makes no specific operational predictions about prices and quantities. It is true by definition and vacuous by definition. It is not even wrong [Woit, 2002].

3.5.2 The Classical Theory of Prices

The classical theory of prices, was simple, testable, has been tested, and has been shown to be correct. It said that the prices at which commodities sell tend to be in proportion to the labor required to make them. Things are valuable if they are hard to make, they are cheap if they are easy to make. A pithy summary of the theory was Marx's statement:

> The value of one commodity is to the value of another commodity as the quantity of labor fixed in the one is to the quantity of labor fixed in the other. [Marx, 1910, sec. 6]

The classical economists hedged this position with various qualifications but these do not prevent the theory from giving rise to meaningful, testable predictions. The qualifications are mostly of the form that such and such will cause some degree of random fluctuation between relative prices and relative labor ratios.[39] For example, if one woman is an unusually fast worker an hour of her work will create more value than average. If one factory uses an unusually efficient system of production that enables it to use less labor than usual, then one hour of its workers' time will create more value than average. In addition classical economists expected relative market prices to fluctuate slightly above and below the ratios of labor the goods contained. The theorists were working prior to the development of statistics as a modern discipline, but it is easy to translate what they were saying into modern terms.

Two mathematicians in the 1980s, Farjoun and Machover [1983], formulated the classical claims roughly as follows: price ratios between pairs of commodities are random variables whose expected value is the ratio of the labor contents of the two commodities.

So if we take two commodities: a particular model of size 8 men's boots, and a particular model of a Volkswagen Golf car, and we knew the ratio of how much work went into each of them, then we would have a reasonable prediction of what their relative prices would be. More precisely, the price ratio will be normally distributed (figure 5.21) around the labor content ratio with a relatively small standard deviation.

3.5.3 Evidence for the Theory

In this form the prediction of classical price theory is eminently testable, provided that we make some stipulation about how small this standard deviation will be. It has been argued that at least one of the classical economists, Ricardo, estimated that 93 percent of the differences in relative prices would be explicable by differences in labor content [Petrovic, 1987]. Farjoun and Machover argue on very general statistical grounds that the standard deviation of the price/labor ratio would be about 1/6 of the mean of the distribution. Thus if the average ratio of money to time was $18 per hour, the spread of this ratio for different goods would be about $3.

Since the 1980s it has been possible to use computer calculations to obtain estimates of just how closely the selling prices of industrial outputs correlate with the direct and indirect labor used by these industries. There have been a large number of studies done[40] that tend to confirm these hypotheses. In general the studies find the correlation between industrial output prices and labor contents to be greater than the 93 percent anticipated by Ricardo. Generally the correlations are in the range of 95 to 97 percent. Cockshott and Cottrell [1997a] tested the standard deviation of the price to value distribution and found that the standard error was actually smaller than that predicted in Farjoun and Machover [1983], closer to 1/10 than 1/6.

The classical theory of price has been tested and found to be correct. The neoclassical theory is untestable, and will be ignored in what follows.

3.6 LABOR AND PRICE UNDER SLAVERY

But this evidence that labor content determines price all comes from the modern economy. The first historical writing linking labor time to value is in the work of Ibn Kaldun in the fourteenth century. If he at that date was stating as a fact that value originated in labor, we can safely assume that he observed this relationship in practice. Of course, it would be a rough and ready empirical observation, not a precise econometric study, but it does indicate that this relationship was apparent in the fourteenth century.

We do not have any written sources making a similar causal observation from the time of classical slave society. North Africa in the fourteenth century did have a fairly extensive use of slaves, but they were predominantly in domestic contexts and in small-scale agriculture. A series of slave revolts between the seventh and ninth centuries had led to a reduction in large-scale plantation slavery [Heuman and Burnard, 2010]. Large groups of slaves were more likely to rebel. So Kaldun's observations cannot have been based on observing prices in a full slave economy.

We do not know that prices were governed by labor content in these periods, but the idea is plausible because slave plantations appear to have made rational use of the labor available to them. Consider the following discussion of how to organize slave labor by Cato.

When the master arrives at the farmstead, after paying his respects to the god of the household, let him go over the whole farm, if possible, on the same day; if not, at least on the next. When he has learned the condition of the farm, what work has been accomplished and what remains to be done, let him call in his overseer the next day and inquire of him what part of the work has been completed, what has been left undone; whether what has been finished was done betimes, and whether it is possible to complete the rest; and what was the yield of wine, grain, and all other products. Having gone into this, he should make a calculation of the laborers and the time consumed. If the amount of work does not seem satisfactory, the overseer claims that he has done his best, but that the slaves have not been well, the weather has been bad, slaves have run away, he has had public work to do; when he has given these and many other excuses, call the overseer back to your estimate of the work done and the hands employed. If it has been a rainy season, remind him of the work that could have been done on rainy days: scrubbing and pitching wine vats, cleaning the farmstead, shifting grain, hauling out manure, making a manure pit, cleaning seed, mending old harness and making new; and that the hands ought to have mended their smocks and hoods. Remind him, also, that on feast days old ditches might have been cleaned, road work done, brambles cut, the garden spaded, a meadow cleared, faggots bundled, thorns rooted out, spelt ground, and general cleaning done. When the slaves were sick, such large rations should not have been issued. After this has been gone into calmly, give orders for the completion of what work remains; run over the cash accounts, grain accounts, and purchases of fodder; run over the wine accounts, the oil accounts—what has been sold, what collected, balance due, and what is left that is saleable; where security for an account should be taken, let it be taken; and let the supplies on hand be checked over. Give orders that whatever may be lacking for the current year be supplied; that what is superfluous be sold; that whatever work should be let out be let. Give directions as to what work you want done on the place, and what you want let out, and leave the directions in writing. Look over the livestock and hold a sale. Sell your oil, if the price is satisfactory, and sell the surplus of your wine and grain. [Hooper and Ash, 1935, 9]

Note the reference to the need to calculate the amount of labor time expended to produce particular yields of wine, grain etc. It is assumed that there are “cash accounts, grain accounts, wine accounts, oil accounts,” everything that is required for a rational computation of the labor devoted to each branch of agricultural production and the yields it produces. The instructions end up with the instruction to sell if the price is satisfactory. We have here all that is necessary for labor time to regulate prices in a slave economy.

The *dominus* knows what each product has cost in terms of labor, knows the prevailing market price and will only sell if the price is “satisfactory.” But what can this mean? The standard of what is satisfactory is provided by the “calculation of the laborers and the time consumed” along with the oil, grain, and wine accounts. He knows the relative costs in terms of slave labor of the different products, and can thus judge when the relative prices are satisfactory enough to justify selling. If the price falls below a satisfactory level, the estates will withdraw from selling that product until the price rises.

It is not necessary to do what Smith did, and project back the regulation of price by labor to an imagined past when individualized hunters exchanged beavers for deer. A past that could only be imagined, since the individualization required for regular trade does not exist in hunter-gatherer society. Smith imagines specialized deer and beaver hunters prior to the private property and general commodity exchange in order to give a mythical account for something that he observed to be actually occurring in the combined slavery and capitalist systems of the eighteenth-century Atlantic economy. But if we read the classical writers on agriculture we can grasp the process better. The latifundia produced multiple commodities, their relative labor costs were known to the owners and this provided the basis for labor to regulate price.

The slave-owning class did not only own farms, they also ran other forms of business. If slave labor yielded a higher return in cash terms in some other branch of activity, they would either set up rural production on their estates, or invest in urban slave workshops. We do not know that prices were actually regulated by labor in Rome, but it is a reasonable hypothesis. It is also one that could be tested.

In principle, research could be done to see if prices in slave economies followed a law of labor value. The relative prices given for example in the edict of Diocletian [Bolin, 1958] in 301 A.D. could be compared with estimates of the time taken to make things under the technical conditions of that era. For agricultural products, techniques of production remained similar until recent history, so data on labor use from more recent periods could be exploited. For the slave economies of the Americas there is of course much more extensive data available. This would make a similar investigation much easier.

3.7 MONEY

Money in the form of coinage arises in societies with markets, and indeed it is arguable that it is a major factor forcing such markets into existence. Developed slave economy presupposes money and monetary exchanges. In this section I will look at the general properties of money that first arose under slavery. These are properties that persist right down to the present.

Purchases with money allow the establishment of a set of consistent market values. Suppose, as in Diocletian's price edict, an egg sold for 1 denarius, and a measure of wine for 8 denarii, and a measure of olive oil for 40. We can set this out as a table A (page 73).

Then we can easily see that a measure of wine has the value of 8 eggs.

This is obvious with two commodities and with money, but if you consider a hypothetical barter economy without money then the whole business is much more complicated. You now have a matrix of pairwise swap ratios as in table B (page 73).

Read this as saying, for example, that a measure of olive oil will swap for 40 eggs or for 5 measures of wine.

But consider the complexity that can arise with these three commodities without money prices. Instead of 3 prices, we have 9 exchange ratios. If we had 4 commodities we would have a 4×4 table with 16 ratios. In general the size of your exchange rate table grows as the square of the number of commodities being bartered. Diocletian set the prices of around 1,000 of them. If, instead of specifying money prices he had fixed a collection of barter rates, the table would have had a million numbers. Given that the Romans had to do all their calculations using the abacus it would have been quite impossible to do the calculations for such a table, let alone distribute copies of it.

Commodity	Denarius Price	
Eggs	1	
Measure of Wine	8	(A)
Measure of Oil	40	

Commodity	Eggs	Measure of Wine	Measure of Oil	
Eggs	1	1/8	1/40	
Measure of Wine	8	1	1/5	(B)
Measure of Oil	40	5	1	

Commodity	Eggs	Measure of Wine	Measure of Oil	
Eggs	1	1/8	**1/20**	
Measure of Wine	8	1	1/5	(C)
Measure of Oil	**20**	5	1	

One effect of money is therefore data compression.

Instead of specifying a million ratios it was enough to give a thousand prices in denarii.

But this compression only works for what I have called consistent swap tables. In a sense this definition is circular, since the consistent swap rate tables are the ones you can create from a single set of money prices. But the logic of private agents engaging in exchanges means that any other sort of swap table is unstable. Suppose we took table B and changed just one number, the swap ratio between olive oil and eggs to give table C (above) with the changed entries is shown bold.

Suppose I start out with 20 eggs. By the exchange ratio in table C I can get 1 measure of oil. Then, by the last row, I swap that for 5 measures of wine. Then by the middle row, I can swap each of these for 8 eggs each, giving me 5 × 8 = 40 eggs, twice as many as I started with.

A consistent swap table does not let you do this. It is consistent because any circular sequence of barters takes you back to what you initially had. It does not allow trading for profit. In reality, you never get elaborate systems of barter, the number of exchange ratios that would be needed are simply intractable to manage. But even supposing you could have such a barter economy, inconsistent swap tables would be unstable. Consider table C again. Nobody who had olive oil would be willing to swap it directly for only 20 eggs, since they would know that by swapping first for wine and then for eggs they could get 40 eggs. So, subject to a certain amount of random noise, you would only get consistent sets of swap ratios.

Pairwise barter gives an intractable number of ratios: a thousand goods imply a million swap ratios. They also involve hard calculations, and lots of divisions, which were hard to do in the past.[41]

Consistent swap ratios are reducible, in information terms, to a single column of numbers as in table A.[42] Such a column gives us the relative values of the goods. Any society in which exchange occurs is thus enabled by the logic of exchange, and forced by reasons of computational complexity to use something equivalent to a column of prices. The information content in this column, associating a number with each type and unit of a good, is a value system. The units used to express the values are the standard of value. It does not matter if we use one of the goods on the market as the standard of value: cattle, silver, volumes of barley, or instead use a state-issued unit like the denarius. Any of these are capable of acting as the standard of value. We are dealing with an abstract computational imperative that is indifferent to the material used.

You do not need physical coins to have a standard of value. Polanyi et al. [1957] argued that in ancient Mesopotamia there was a standard of value, the shekel, which was either a measure of barley or the amount of silver that weighed the same as a barley corn. The existence of this standard did not imply that transactions were actually carried out by handing over measures of barley to buy things. Instead accounts were kept by scribes on clay tablets, recording physical movements of goods and their equivalent value in shekels. But for this kind of transaction to work you depend on written records and a class of numerate scribes. The Mesopotamian system, which relied on scribes, did not allow illiterate people to engage in distributed transactions as easily as coinage does.[43]

Standards of value have not just been used for buying and selling. They were also used in the Sumerian civilization to measure tax liabilities. By expressing these in measures of barley, but allowing tax debts to be settled in different goods: oil, salt, dates etc., barley as the standard of value allowed the state to accept different goods in kind without having to specify exactly which goods each farmer would supply. Law codes therefore specified the barley equivalent of a wide range of goods [Postgate, 1992]. As I said, the idea of a system-generalized barter is a fantasy for computational reasons, but one could still hypothesize that the logic of consistent exchange along with computational simplicity drove commodity producers to adopt a universal equivalent like the Sumerian *gur* of barley. But it is not even clear that this arose out of commodity exchange rather than the demands of tax collection.[44]

What distinguishes circulating money from an abstract measure of value or unit of account is that money is made up of distinct physical objects that can be carried about, counted, and passed from hand to hand. These take two distinct forms:

1. Relatively rare privately produced objects like the cowrie shell, widely used in the urbanized semi-slave economy of West Africa, or the bronze bracelet manillas they used for higher denominations.[45] This is referred to as "primitive money."
2. State-issued coins that originated in China and later in the slave economies of the Mediterranean.

The physical properties of the money are important. The money has to be made up of durable discrete units rather than being a continuous quantity. Cowries could serve as money but palm wine cannot. There is a link between discreteness and calculation. The term "calculation" derives from the Latin for pebble, because calculations were done with pebbles or counters. Coins are a self-recording and self-calculating system. If you have a collection of coins in your purse, they, by their physical presence, act as a record of your claim upon social labor. You do not have to make a separate symbolic record of it in a ledger or on a computer.

Banking systems of recorded credits have existed since Babylon [Davies, 2010] at least. They were widespread in the Roman period [Banaji, 2016] and have reached full fruition now. Systems of giro transfer were already well developed in Hellenistic Egypt, with the unit of account in this case being grain rather than coin. But banking requires the permanent recording of transactions and balances. This demands time, resources, and a class of literate and numerate laborers that was, until the modern age, in short supply. These costs meant that while merchants and the wealthy could resort to banks to facilitate transactions, the vast bulk of the population stood outside the banking system until the invention of computerized records,. They might have local debit accounts with individual traders, buying on the slate, but that was all. Credit accounts, or debit accounts of the sort run by Visa, could not extend to the whole population until electronic record keeping became general in the late twentieth century.

In contrast, coins or cowries provide a distributed system of record that requires no more than a simple ability to count. You do not even need to know how to add or subtract. Take the coins out of your purse and hand them over and the relevant sum is automatically deducted from your account. Similarly, the sellers' accounts are credited as soon as they pocket the coins without them needing to know how to do long addition.

In addition to these practical advantages, money has to be logically distinguished from banking. This is no longer obvious to us today since so much of modern commodity exchange uses banking operations rather than money. This leads people to identify bank accounts with money. But there is a big logical difference. Money only comes in positive quantities. Bank accounts may hold positive or negative values, credits or debits. Money therefore is a model for the positive whole numbers whereas bank accounts are a model for the signed whole numbers [Badiou et al., 2007]. This difference is obscured in modern discourse about the "money supply" and public finance. Arguments that are logically valid when applied to money are no longer valid when applied to bank credit.

Records that embody social power need to be proof against forgery. Today we use elaborate electronic ciphers for the most mundane purchase, ciphers that were beyond the ken of the most sophisticated intelligence services in the mid-twentieth century. Other ages have relied on signatures and seals on records or on the matching ends of broken tally sticks [Wray, 2004]. Whatever the technique, money relies on its units being hard to forge. Cowrie shells were used as currency far from where the mollusks were found, and as natural products could not be handmade.

Coins have relied on two techniques. The exact replication of the dies from which they are stamped is hard, so counterfeit coins were visibly different from originals when closely examined. Second, for high-denomination coins, the material from which they are made may itself be expensive: either a pure precious metal or an alloy that has expensive components. Many European coinage systems for the past 2,600 years worked this way.

In contrast, Chinese money was exclusively base metal for three thousand years until they issued silver coin in 1890. Initially the coins were shaped like cowries or agricultural implements: hoes, knives, etc. [Davies, 2010]. By the third century BC the standard form of round coin with a central hole had been arrived at.[46] Western economists, ignoring this long history of base metal money in China, tended to assume that the precious metal content of a currency was essential. The Chinese had to rely on the power of the state rather than the composition of the coins to suppress forgery. Incentives to forge were also diminished by the low value of the individual coins. For larger transactions paper money has been in use in China for over a thousand years. Paper notes obviously have the same discrete self-recording character that cowries and coins had.

Why are coins and, leaping ahead, paper notes able to measure value and record claims on social labor?

The answers given by the classical economists differed somewhat. According to Marx, money had value because the coins were made of gold or silver and the value of a gold coin was simply the value of the gold it contained.[47] Gold required a lot of labor to mine, so a small weight would exchange against many hours spent on other activities. In this view, coins were just state-standardized weights of gold. The state simply steps in to provide convenient portable chunks of the metal. The royal stamp on them was a certificate to say that the gold was pure and the weight accurate.

Ricardo started out from a similar assumption, but then said that the actual prices of goods would be affected not just by the labor required to mine gold, but by the quantity of money circulating in a country [Ricardo, 1811]. If there was an outflow of gold to pay for imports, the stock of gold circulating as coin would be curtailed. With less money being available to purchase commodities, there would be a general fall in prices. Lower prices of that nation’s goods would then promote exports, while at the same time the shortage of bullion would hamper imports. In the end the imbalance in trade would be compensated for by price shifts brought about by the change in the quantity of money. This was the initial form of the famous quantity theory of monetary value.

Marx disputed this mechanism. He held that only a small portion of the bullion in a country was at any time actually in circulation. A larger part was held as hoards so that these would buffer the effect of changes in quantity. An increase in the gold stock in a nation would simply cause more bullion to be hoarded as reserves in private strongboxes or banks.

These views reflect the range of debate taking place in early nineteenth-century Europe, and are posed in the context of a specifically European history of gold and silver coinage. But the perspective fails to generalie to the long history of money in China or to the monetary systems that exist in the contemporary world, neither of which rely on gold or silver. Ricardo's concern with bullion outflows actually related to a persistent feature of the trade between Europe and China. While Europe had, since the opening up of sea routes to the East, craved high-quality Chinese manufactures, it had little of equivalent quality that it was able to export in return. The West had to resort to exporting bullion to purchase its imports from China. A large part of the silver from European colonies in the New World went across the Pacific to pay for imports of tea, ceramics, silks, and the like from China. Ricardo's purported equilibrating mechanism was ineffective given the poor quality, as seen from the Chinese perspective, of European exports. A fall in the price of substandard European potteries would not induce the Chinese to buy from these rather than their own fine porcelain manufacturers. The recourse of the East India Company was instead to go into the drug trade and export addictive opium to China via their Hong Kong trading post. Once in China, of course, the bullion did not have the inflationary effect predicted by Ricardo because the currency was not bullion based; it vanished into hoards as predicted by Marx's monetary theory.

However, neither Ricardo's nor Marx's theory adequately explained the Chinese situation. Since China's money was either paper or copper why did it have any value at all?

If we look at the historical origin of coinage in the West, the earliest coins were issued by Lydia, home of the legendary King Midas, at the start of the seventh century BC [Bolin, 1958]. These certainly seemed to fit in with the idea that they were state-standardized weights of precious metal. They were shaped like coffee beans and had an emblem of a lion on one side. They were made to an accurate standard weight. Within a short period of less than a century these evolved into round coins.

The classical account of the origin of coins falls down on one crucial detail. The Lydian coins were not made of gold but of electrum, a gold-silver alloy that naturally occurs in the area. This means that people accepting the coins as a standard weight in gold would have been deceived. Not only that, but the gold content of these coins was lower than in naturally occurring electrum, indicating that the kingdom of Lydia was adding silver to the mix before stamping the coins [Cowell and Hyne, 2000]. Bolin [1958] points out that from the earliest days the issue of coins could be a profitable activity. He recounts that during the Roman Empire there was a process of reducing the precious metal content of the currency, with the denarius moving from a silver coin to a predominantly copper coin with a thin silver coat for appearance's sake. The process is mirrored in more recent monetary history with the English penny moving from a silver coin, up to the eighteenth century, and then switching to copper, then to bronze, and shrinking as it did so. The contemporary penny is not even solid copper; it has an iron core coated with copper.[48] This reinforces the Chinese experience that commercial activity can be carried out for prolonged periods with token currencies—much of the third century in the Roman case, since 1947 in the British case.

Coins found in hoards are one of the most common relics of past ages, and there has been a temptation on the part of some[49] to equate periods of fine silver and gold coins with particularly well-developed commodity production. Were this a safe assumption, then London must have been more prosperous and commercial under George I than under George VI in whose reign the coinage became entirely base metal.[50]

An alternative theory of money, whose recent exponents include Wray [2004] and Ingham [2004], attributes its value to the ability of the state to impose obligations like taxes and fines on its subjects. The state lays claim to part of the social surplus product. If the state specifies that the tax obligation is to be met in labor or grain, then money does not arise. But if it is willing to accept coins of its own issue, then these acquire value. They do this not because of labor that went into the coin, but because the coins stand in for the labor that would otherwise have been directly performed. So long as there is within an area a unified state with effective tax or tribute-raising powers, and it is willing to accept its own coin in settlement of tax debts, then these coins will have an effective circulation. This theory explains:

1. Why there is usually a distinct monetary or coinage system for each state.
2. Why societies have been able to operate for long periods with purely token monies.
3. Why the issue of money is not only a source of revenue for the state but has been protected by ferocious penalties.
4. Why and how states can change the monetary system. For example, British colonial authorities demonetized the cowrie by specifying that tax debts now had to be met in British-issued coin [Forstater, 2003].

Prior to the invention of coins or paper money the state's appropriation of surplus labor was in the form of labor obligations or it was specified in the physical form of grain or crops. We call this the real appropriation of the surplus product. Monetary taxes are, in contrast, a merely formal or symbolic appropriation of wealth.

But the state needs to appropriate a real surplus. It needs actual labor to build roads, actual food for its soldiers, real iron for its weapons. Such real wealth is purchaseds with coin.

Coin divorces real from formal appropriation. The two become separate in time, space, and person. They can be separate in time because the state can purchase resources, appropriating the real surplus, prior to money taxes being paid. Indeed, unless the state has issued the coins by buying things, there is no money available to pay taxes. It is separated in space since taxes raised in one part of the state can be used to purchase labor and resources in another part. This frees a regional state administration in an empire from a dependence on purely local resources. Finally, the invention of coinage allowed the separation of the taxpayer from the physical surplus provider. Taxes levied on peasants can pay the wages of a professional standing army without the peasants themselves having to serve. Without the ability to pay a mercenary professional army, the conquests of an Alexander or Trajan would have been impossible [Davies, 2010].

For all this to happen, society had to reorganize itself on mercantile lines. The peasants, to pay their taxes in money, must produce cash crops. Merchants, sea captains and crew must link the provinces where taxes are raised to the metropolis where they were spent, and whose population partly depended on the imperial expenditure.

Whether in the Macedonian, Roman, or British empires, imperial coins and imperial taxes transformed self-sufficient communities into commodity producers [Forstater, 2003]. Monetization transformed limited domestic slavery into the ruthless exploitation of the latifundia, boosting the surplus that supported an urban ruling class. Cash linked state and aristocracy, via a chain of commodity production and handling to free or enslaved primary producers. From the moment the state issued money and compelled its return in tax, people saw the world in its silver mirror, and in a mirror everything is reversed. Forced to give unto Caesar that which was Caesar’s, the very instrument of their subjection, coin, came to appear as the truest of true wealth. Their actually useful crops and artifacts now appeared as mere instruments to acquire money, which alone now counted as real value. In the epoch of the transition to what Aristotle called chrematistics, or the striving for money, its absurdity could still be seen by poets or philosophers. The parable of Midas, king from the land where coins were invented, demystified the image in money's mirror, but heedless of fable or moralist, humanity were yet forced to live the illusion.[51]

Figure 3.9. Image from Trajan's Column. Without coins to pay a mercenary professional army, the conquests of Trajan would have been impossible. Source: Cichorius, 1900.

CHAPTER 4

Peasant Economy

> The power of enclosing land and owning property was brought into the creation by your ancestors by the sword; which first did murder their fellow creatures, men, and after plunder or steal away their land, and left this land successively to you, their children. And therefore, though you did not kill or thieve, yet you hold that cursed thing in your hand by the power of the sword; and so you justify the wicked deeds of your fathers, and that sin of your fathers shall be visited upon the head of you and your children to the third and fourth generation, and longer too, till your bloody and thieving power be rooted out of the land.
>
> —GERRARD WINSTANLEY

The pre-class economy discussed in chapter 2 was a world system, or to put it another way, a universal state in social development. The capitalist economy that I examine in chapter 5 likewise has become a world system, a near universal state of economic development. The slave economy of Chapter 3 contrasts with these in that it became dominant only in certain portions of the world, at widely spread intervals. The worlds of slavery were seas and their littorals. In this chapter I return to a near global form of economy, peasant economy, with its accompanying forms of exploitation. Some parts of the world did skip peasant economy or, at least, never experienced it from autochthonous development: boreal regions, steppes, and semi-deserts. But it has been, for most of settled humanity, the most widespread and longest-lasting sort of economy. In the traditional Marxist schema peasant economy was subsumed variously under feudalism or Asiatic production, with the latter being a dangling branch from the otherwise nice historical sequence in Figure 4.1.

In contrast, I will present a model in which there is a peasant mode of production in the context of which more than one type of class structure is possible. For now just consider all peasant economies as a group and replace the sequential model in figure 4.1 with something more like figure 4.2. This kind of picture (see also figure 3.5) is what would now be called a Markov process or state transition diagram. Markov processes[52] are a way of conceptualizing the time evolution of systems with a finite number of distinguishable states. The ellipses in the diagram are states and the labeled arrows, often called arcs, between them represent possible transitions. For a proper Markov model the labeled arcs would each have a probability associated with them, giving the likelihood that a transition would occur along one of those arcs in a given period of time. For historical processes one would probably want to have transition probabilities per century. In principle, given enough historical data, one could assign rough values to the transitions I have labeled *a* to *i* in the diagram.[53]

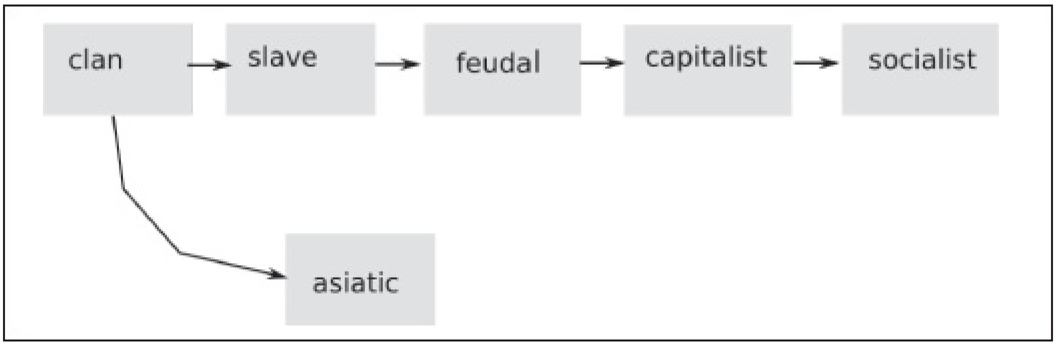


Figure 4.1. Marxist model of sequence of modes of production.

The labeled arcs in figure 4.2 are those for which clear instances are easy to find. Looking at either of the two diagrams the impression is given of entirely self-sufficient development in which an individual society either goes through a sequence of stages or jumps between states. That indeed is what simple Markov models describe. But real societies interact with one another in different places: trade and invasions; and the diffusion of information allows one society to affect others, so a simple Markov process is inadequate as a representation. Some of the transitions, (b) for example, the transition to feudalism in Germany, came about as a long-term consequence of the confrontation between German clan society and the adjacent slave empire of Rome [Anderson, 1996].[54]

The overall picture is one of a directed graph of historical states. There may be loops in the system, but despite this there is an overall directionality. The directionality arises from the absence of certain transitions—no back transition to peasant economy from capitalism, for example—and from differences in the probabilities of transitions. In the graph given, it is an open question what mix of socialist and capitalist economies will prevail in the long run, depending as it does on the relative transition probabilities (i) and (f).

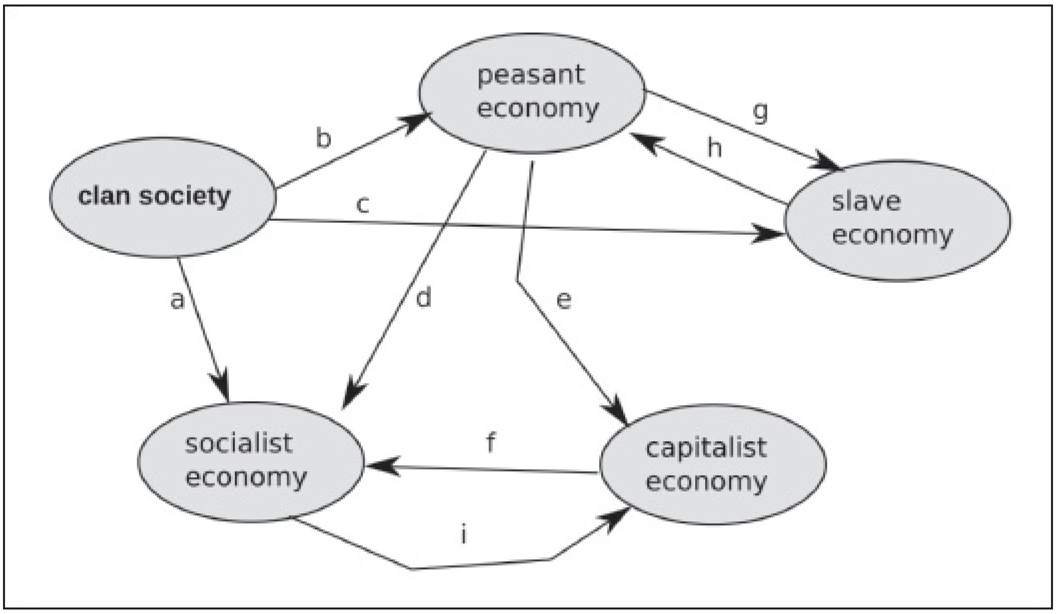


Figure 4.2. Markov model representation of transitions between forms of economy. Examples of the labeled transitions: (a) Mongolia; (b) Germany transition to feudalism; (c) slave economy West Africa; (d) Chinese Revolution; (e) Britain; (f) East Germany; (g) Roman Republic; (h) Late West Roman Empire; (i) Russia.

The nodes in Figure 4.2 should be understood as macroscopic descriptions of the states of societies. Within the macro description “peasant economy” there would be a variety of different possible property relations and class relations, just as the node labeled “slave economy” contains a nested Markov model (figure 3.5) that describes its internal dynamics.

4.1 NATURAL AND TECHNICAL CONDITIONS

Peasant economies, as the name implies, are primarily agricultural. The greater part of the population live in families whose main activity is the growing of crops. Secondary activities of the families are food preparation, textile preparation or production, building, and some ancillary crafts.

The only available mechanical energy source for agriculture is muscle power, though wind and water may be used for milling. The only available thermal energy sources are biological waste such as wood, dung, or straw.

What general implications do these conditions of existence have for peasant economies?

What restrictions do they pose on life and the social relations operating in these economies?

The technological restrictions are pretty broad, since peasant economies have existed in so many climatic zones, with such a broad range of crops. One has to ask what the common properties of this mode of production are that reach across all the incidental differences in types of farming. North Indian peasant economy of the Middle Ages depended on advances in the lifting of water: the Persian wheel, lined wells and tanks. But from the standpoint of European feudalism other technologies: moldboard ploughs, three-field rotation have been seen as crucial [White, 1964]. The varieties of technology and the existence of rather different forms of surplus extraction have been used to argue [Mukhia, 1981] that it is pointless to use the single concept of feudal to designate such different systems. Others have argued that the existence either of *extra-economic* coercion [Hirst and Hindess, 1975], or very detailed features such as serfdom, manorial economy, restriction of commodity circulation were quite general [Sharma, 1985; Sharma, 1958] and allow us to use the same basic concept right across continents. The applicability of the term *feudal* is a controversial question.[55] Instead I will look at general constraints of peasant economy and how these shape the variations in the types of exploitation they have supported.

The first point is that peasant economy is distinct from nomadism: recall Smith's distinction between nations of farmers, shepherds, and hunters. A stationary population is the precondition for the establishment of exploitation. Nomads can simply remove themselves.

What fixes a peasantry in place?

One may say that they were serfs tied to the land, but that kind of legal binding to the land only becomes necessary if there is some alternative, if the peasants have the option of moving. This either involves them moving to unclaimed land or emigrating to towns.

If there is plentiful unclaimed land this certainly acts as a potential constraint on feudal exploitation. Any servile workforce given the opportunity will try to escape, and the prevention of such escape depends on multiple factors. One is that there must be an effective state structure that can be relied on to return escapees. Another is that the distance to the virgin soil must not be too far. Finally, the type of natural vegetation plays a role. Clearing hardwood forests for fields is much harder work than plowing steppe-land, and this work acts as a practical disincentive to migration. So the strategic position of a peasant population in an area with a weak state on the edge of steppe is rather different from a peasant in the middle of a densely settled and long cleared river valley. In the first circumstance, whatever the law says, there will tend to be a drift to free settlements, in the latter the legal proscription on movement only takes effect as a way of restricting migration to cities, and that is only effective where the same state power prevails in town and country. Where you have free towns, as in Europe during the feudal period, once in the town the serfs were safe. Where state power operates as effectively in town as in country, for instance in the Ottoman Empire or the antebellum U.S. South, servile flight was much harder.

Frontier territory between agriculturalists and hunter gatherers, as in the original Neolithic expansion or European colonies, is not conducive to feudalism, whereas the edge of steppes inhabited by nomads, as in sixteenth-century Russia, allows a feudal military caste to justify its existence. Domar [1970] argued that in a peasant economy there are three elements that can never coexist: a class of exploiting landlords, free unoccupied land, and free peasants. Two of the three can exist but not all three. If there is unoccupied land free peasants will migrate to it rather than submit to paying rents, so a landlord class cannot stabilize. If there is no free land, then a free peasantry can be forced to pay rent to gain access to privately held land. But if an exploiting landlord class exists, and there yet remain untilled forests or steppes, then the peasants must be reduced to serfdom to prevent their movement.

> Assume that labor and land are the only factors of production (no capital or management), and that land of uniform quality and location is ubiquitous. No diminishing returns in the application of labor to land appear; both the average and the marginal productivities of labor are constant and equal, and if competition among employers raises wages to that level (as would be expected), no rent from land can arise, as Ricardo demonstrated some time past. In the absence of specific governmental action to

> the contrary … the country will consist of family-size farms because hired labor, in any form, will be either unavailable or unprofitable: the wage of a hired man or the income of a tenant will have to be at least equal to what he can make on his own farm; if he receives that much, no surplus (rent) will be left for his employer. A non-working class of servitors or others could be supported by the government out of taxes levied (directly or indirectly) on the peasants, but it could not support itself from land rents. [Domar, 1970]

The Domar/Neiboer theory of the fundamental economic origins of serfdom predicts the dynamical transition system shown in figure 4.3. It is not difficult to find historical examples of these transitions.

4.2 FORMS OF SURPLUS

One should avoid the anachronism of projecting back the trinity of land, labor, and capital of modern political economy onto precapitalist society. There is a temptation to see slavery as being based on property in persons, feudalism on property in land, and capitalism on property in capital goods. This may be formulated as a landed aristocracy having either a class monopoly over land or individual private ownership of land. The surplus they live off is then seen as the consequence of that ownership or monopoly. While this concept makes sense in the modern period and in countries where there is a well-developed market in the rent of land and a multiplicity of farmers wanting to rent it, projecting this back onto earlier peasant economies is questionable. The very existence of serfdom, or the restrictions that Indian feudal law placed on village communities moving [Sharma, 1985], shows that it was not the land that was key, but the workers on the land. Only when labor productivity and the population rises to the point where all the land can be productively worked using only part of the population, can ownership of the land itself act as a monopoly source of revenue [Domar, 1970]. Otherwise, feudal exploitation, like slavery, was about the direct or indirect control over the labor of the working population.

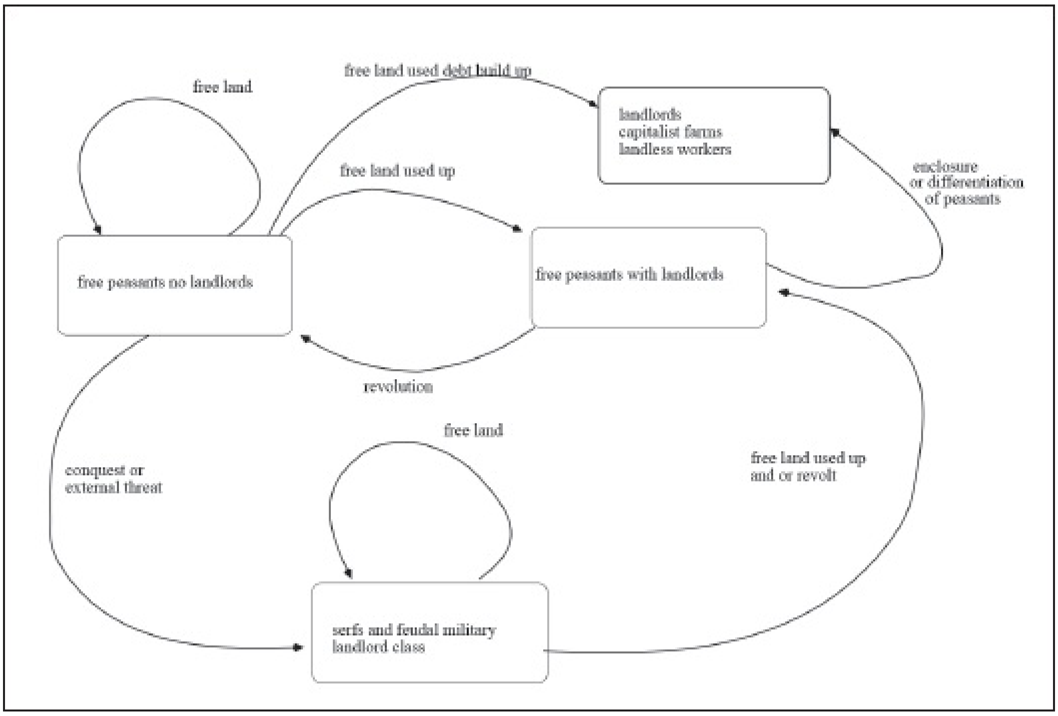


Figure 4.3. Transitions between property relations in peasant agriculture.

Titles to ownership, which passed mainly by royal assignment, inheritance, or marriage rather than purchase, were titles against other members of the feudal class. They were not property titles against serfs, but over them. They entitled one family and their descendants to the revenues accruing from the population of a territory, to the exclusion of other families from the same class. Whether these revenues are called by historians rents or taxes is not terribly significant to us now, nor was it important to the peasants. The distinction between these relates at most to which part of the military feudal class it went to. In all cases the revenues are local and arise from the labor of a peasant population that directly or indirectly gives up part of its working year to generate the revenues. This giving up of work time can come in three basic forms:

1. Direct labor service on manorial estates.
2. Giving up part of the crop they had grown on the plot they were allotted for their own cultivation.
3. Paying a rent in money.

Which of these dominate at a particular time and place will be history sensitive. The first form is only going to occur if the land is divided between peasant plots and manorial estates, which in turn may be dependent on the prior history of a country. In Western European lands where feudalism succeeded the prior Roman system of slave labor on villas, manorial lands were more likely than in places where feudal subjugation occurred by the conquest of a free peasantry. The standard Marxian account of this is to treat all of these as varying forms of extra-economic coercion, contrasted with the purely economic labor contract under capitalism. This extra-economic coercion is then used to explain why the state form under feudalism devolves judicial powers to the local aristocracy, who as a military caste have the means to directly coerce their subordinates. Relations thus appear as those of personal dependence and subjugation, unlike the apparently impartial anonymity of capitalist law.

Figure 4.4. The castle of the contemporary Duke of Buccleuch in Scotland. Feudal concentration of land ownership and land revenue continued well into the modern era.

One may wonder whether this notion of extra-economic coercion really gets to the heart of things.

Consider the position of a farmer in contemporary Scotland, where the feudal concentration of land holding has scarcely changed. Half of the country is owned by 432 aristocratic families [Hunter et al., 2013]. Suppose the farmer, renting from, say, the Duke of Buccleuch, fails to pay his rent. The Duke can apply to the Dumfries Sheriff's court for an eviction order and, if the tenant does not comply, the sheriff officers, or Queen's Messengers at Arms, will be dispatched to enforce the eviction order. The Duke is no longer, since the abolition of feudal tenure in 2000 [Parliament, 2000], the personal feudal superior of the farmer, but he can still apply for coercion to be used. He no longer sends his own men-at-arms to enforce his will, but the authority royal still enforces it.

In Scotland, one may say that this is just a residual trait of feudalism and monarchy. But consider a farmer in Oklahoma who, having got into debt to a bank, having the loan foreclosed, has the Oklahoma County Sheriff conduct a forced sale of the farm. Here we have the State of Oklahoma, which has never known feudalism or monarchy, applying the same extra-economic coercion to a farmer, not to enforce subservience to a lord, but to a bank. The same coercion applies to any homeowner who defaults on their mortgage. Is this coercion economic or extra-economic?

The payment of interest and rent in today's society is presented, by law and economic theory, as something reciprocal. You pay a price for capital you borrow or land you rent. As such it is a market exchange, something purely economic, a voluntary transaction with a fair price. But this is no more than a convenient fiction. The Duke provides nothing to the farmer. He is just entitled, no longer by the title *duke*, but still as a landowner, to collect a rent to which he has not contributed. Behind right still stands coercion.

Equivalence and reciprocity likewise masked relations of feudal dependence. The superior offered armed protection to the subordinate, and, perhaps, aid in time of want:

> To that magnificent lord so and so, I, so and so. Since it is known familiarly to all how little I have whence to feed and clothe myself, I have therefore petitioned your piety, and your good-will has decreed to me that I should hand myself over or commend myself to your guardianship, which I have thereupon done; that is to say in this way, that you should aid and succour me as well with food as with clothing, according as I shall be able to serve you and deserve it.
>
> And so long as I shall live I ought to provide service and honour to you, suitably to my free condition; and I shall not during the time of my life have the ability to withdraw from your power or guardianship; but must remain during the days of my life under your power or defence. Wherefore it is proper that if either of us shall wish to withdraw himself from these agreements, he shall pay so many shillings to the other party (pari suo), and this agreement shall remain unbroken. [A Frankish Formula of Commendation, Whitcomb, 1899]

To label contemporary interest payments by a farmer to a bank economic but corvée, extra-economic, is to remain within the viewpoint of modern law. From the standpoint of feudal law, a modern mortgage agreement might seem impersonal, naked, and un-Christian exploitation. Class societies have their own specific ways of justifying exploitation. There is, however, something that is being pointed out when historians talk of extra-economic coercion. The term is mystification, but it hints at a real contrast between two modes of production: small-scale agriculture—the mode of production of feudalism versus machine industry—and the mode of production of capitalism.

As Table 4.1 brings out, the basic unit of production under feudalism was small.[56] The median workforce on an estate listed in the Domesday Book was only five. Since the peasants' wives and children may have worked part of the year this is a bit of an underestimate, but this is still a pretty small enterprise, with the median estate having access to only 3 plows. If these are 2 ox teams then the medieval land measurement system would imply that they could plow 2 oxgangs of 15 acres for a total of 30 acres. If the teams were of 4 oxen then the amount would be twice as much, if 8 ox teams 4 times as much. If we assume that the demesne teams exclusively plowed the manorial land, and were 8 ox teams the maximum estimate of median demesne would have been around 240 acres. Alongside this there may be another 120 acres of land directly farmed by the peasants for their own benefit. When cultivating their own plots the peasants were in control of the production of the crop and took direct possession of the crop they harvested. In parallel with this, the same kind work process goes on each year to cultivate the lord's land.[57]

Table 4.1: Average Properties of Essex Estates in the Domesday Book

Variable	Mean	Median
Annual Value	£108	£65
EQUIPMENT:	1.9	2.0
Demesne Plow Teams		
Peasant Plow Teams	2.3	1.0
Livestock	542	388
LABOR:	0.6	0
Freemen		
Serfs	12.1	4.0
Slaves	2.2	1.0
LAND :	504	360

Plow Land Acres		
Woods Pigs	105	30
Meadow Acres	12	6
Pasture Sheep	28	0

Because the production is small-scale, with only a limited division of labor, the peasants see the whole process through from sowing to harvest, and literally see the results going to their granary or the lord's granary. The end result is something with which they could potentially feed their own family. The diversion is clear and unmasked. If we contrast this to a capitalist firm there are at least the following differences:

1. The employees are not replicating what they do at home; they are making something quite different.
2. The scale of production is much larger; each employee is a small fragmented part of a complex workforce.
3. The final product may well never be seen by many employees, given the fragmented character of the process. No one person sees the whole process through.
4. In only exceptional cases, such as bakeries, breweries, etc., is the end product something that the workers could potentially live off directly. Instead it is destined to be invisibly sold for prices that are obscure.
5. The worker appears to be directly paid for the work put in—it is not free labor like a corvée obligation.

The technical structure of capitalist production means that there is no real possibility of the product being individually appropriated by the employees of the firm. Even the value of the product is obscure, immensely so nowadays when the sale of the product may go through so many shell companies that even highly trained government tax inspectors have difficulty finding out what is really happening. The only alternative to the appropriation of the product's value by the firm would be some form of takeover by the state or workers' cooperatives. An attempt to do this would be directly political, the equivalent of a peasant revolt. Workers who unofficially take over factories are stymied by legal proceedings that block supplies, confiscate products, etc. They meet extra-economic legal coercion.

The product in a peasant economy can, in contrast, be directly appropriated. An individual peasant family gathers its harvest and would retain all of it did they not have to pay rent. It is not only feudal exploitation that is backed by coercion. That is a property of all exploitation. It is that the exploitation is more transparent and the state power that backs it takes on the character of personal authority.

This personal character of state authority in feudal economies is a necessary outgrowth of circumstances in which it is difficult for the state to maintain a salaried bureaucracy and a salaried standing army. If the state lacks a regular monetary income it is forced to allocate land for the maintenance of its officials and troops. The exact legal form in which this occurs, whether it is the delegated right to raise local taxes from the peasantry or an explicit grant of estates in return for raising troops, is a secondary issue. It is the absence of a well-developed monetary revenue that is the underlying cause. That absence may have immediate reasons associated with the inability to establish a reliable tax base, but the overriding long term cause will be a poorly developed commodity circulation. A poor commodity circulation is itself the result of either or both of two economic causes: a small surplus product or an undeveloped transport technology that impedes the consumption of commodities far from where they were produced. From thence comes the contrast between slave economies with developed commodity circulation, good road and sea transport, and early feudal economies with neither. With the redevelopment of transport and monetary economy, more impersonal forms of state authority again became possible.

4.3 REPRODUCTION STRUCTURE

Figure 4.5 illustrates the flow of labor and goods under a manorial system such as existed in classic European feudalism. Contrast this with the flows under the villa/latifundia economy of the high Roman Empire, illustrated in Figure 3.4.

In both cases the direct producers get only a portion of the food they produce. Another portion is appropriated by the *dominus* or lord. Only a portion of the product enters into trade. But whereas the villa system was obliged to run at least a partial monetary surplus on current account to pay for replacement slaves, a manor can survive with a much lower portion of the product being traded. At its minimum, trade can be limited to luxuries and weapons purchased by the lord. Early feudal economies therefore supported a smaller urban sector than slave economy had. In Essex in 1086 less than 5 percent of the population was urban (Table 4.2). One can use population breakdowns like this to set some broad limits on the rate of exploitation in the economy. To get an upper limit, assume that all of the urban sector was supported by the expenditures of the lords, that the slaves were all domestic servants, and that the others—who are variously described as "men" and priests—were all unproductive. We then get the calculation shown in Table 4.3.

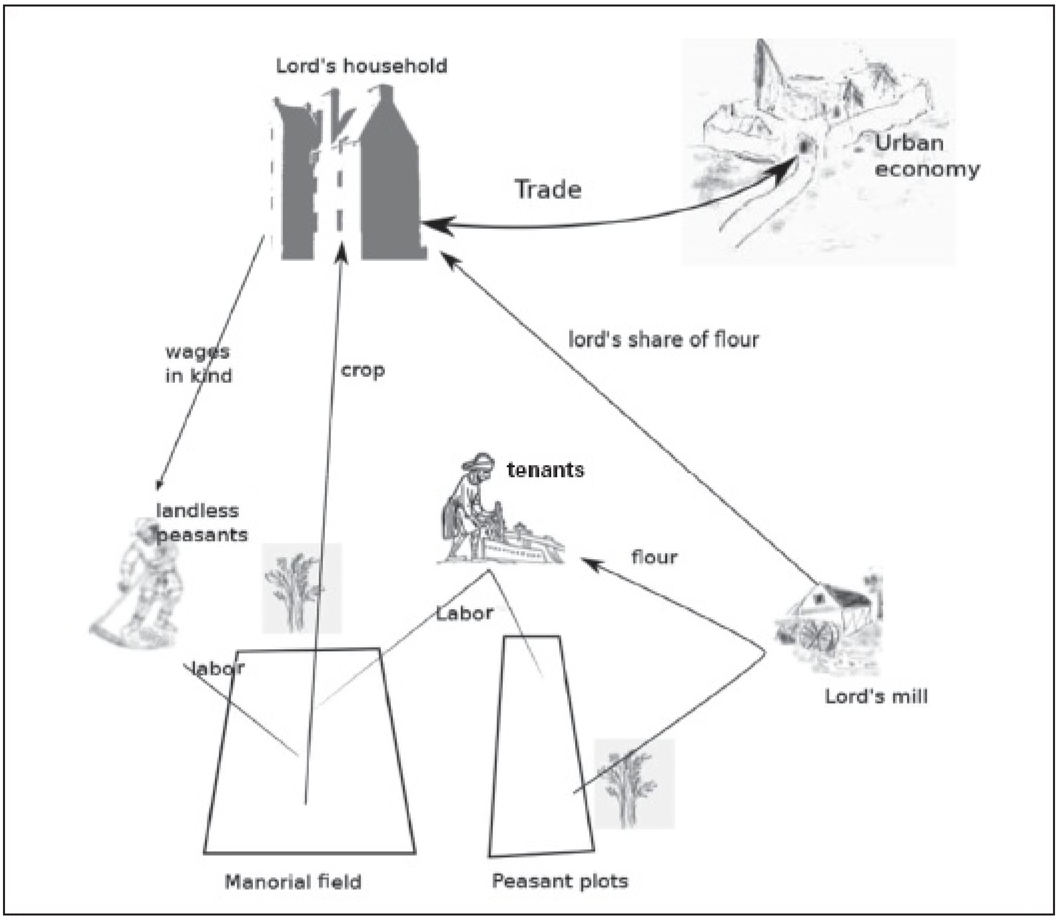


Figure 4.5. Product and labor flows in manorial system.

To get a lower bound on the rate of exploitation assume that none of the slaves were domestic servants, all being field laborers, and that half of the output of the towns was sold to peasants in return for part of their crop. If we apply the same method as above, that gives an exploitation rate of only 3 percent, which seems implausibly low, so the assumption has to be that a significant proportion of those listed as *servi* were actually servants in the modern sense. But note that even the upper bound for the rate of exploitation is very low by modern standards.

The next important distinction between slave and feudal economies is that on the manorial estate; the majority of the direct producers formed family households which either fed themselves on their own plots or were fed by wages. In either case the laboring population reproduced itself without recourse to imported forced labor.

TABLE 4.2: Breakdown of Population of Essex, 1086

Category	Percent of Population
Rural	95.5%
Urban	4.5%
Bordars	47.9%
Villains	27.6%
Slaves	12.3%
Freemen	7.1%
Others	0.7%

Source: McDonald, 2002.

TABLE 4.3: Calculation of a Feudal Rate of Exploitation

Urban	4.5%	-
Slaves	12.3%	+
Others	0.7%	+
Maintained out of Surplus	17.5%	(s)
Productive Population	82.5%	(p)
Rural Exploitation Rate	21.2%	(s/p)

Feudal estates in China and Europe made extensive use of artificial power—primarily water, but also in places wind power. There are over 6,000 mills listed in the Domesday Book, about one mill for every three manors, and this is for the eleventh century. The mills provided an additional means by which the lords could exploit their tenants, since the estate would take a share of all grain milled. In a sense this was analogous to a form of capitalist exploitation, since it gave the lords a revenue by virtue of owning machinery rather than land. But it differed from later capitalism in that the people being exploited did not operate the machinery. There was obviously a limit to the cut that the lords could take, since in the last resort the peasants could go back to grinding the corn the old way, using querns at home. But the lords could appropriate part of the productivity gain that came from water power.

The most critical feature that differentiates peasant agriculture from commercial slave economies and capitalist agriculture is that a large part of the working population has access to land on which they can feed themselves. This access may be in the form of secure ownership of plots, communal access rights, or rented plots. The crucial thing is that they are able at least to survive, and that there is often a sufficient reproductive surplus to allow gradual population growth. The Domar theory predicts that population growth in a serf economy should lead to a transition out of serfdom once the unoccupied, unappropriated land no longer exists. But this is at most a necessary condition. It is not sufficient since the landowners are likely to try to hold onto serfdom for some time. An actual shift from free tenants paying money/rent to one where farming is carried out mainly by capitalist tenant farmers, as occurred in Britain, requires that a significant part of the rural population be deprived both of security of tenure and of access to communal lands. The persistence of communal lands was a key feature of much traditional peasant economy.

4.4 COMPARISON WITH CAPITALISM

We should neither accept the view that suggests that traditional agriculture with substantial resources held in common is inefficient, nor concede that feudal agriculture, a sub-species of traditional peasant farming, is economically irrational. The Hardin [1968] thesis that communal lands will inevitably be degraded by overuse has been systematically refuted by Ostrom et al. [1999]. We know that communities tended to have elaborate procedures and rules to prevent the overuse of common land and to regulate fair access.

There is a certain retrospective complacency that holds that capitalist ways of organizing are uniquely rational, and that only monetary economy, with universal private property in land and wage labor, can be efficient. That this view is prevalent in Anglo-Saxon liberal economics is not surprising, given that in Britain the old landowning classes remain secure not only in their traditional estates, but also in their position within the social hierarchy. Similarly, the Austrian school of economics, formed under an aristocratic Habsburg monarchy, has long emphasized the impossibility of rational economic organization without private ownership and money [von Mises, 1935; von Mises, 1951; Hayek, 1935]. But this arguably Weberian notion of unique capitalist rationalism is influential even among Marxist economists Heinrich and Locascio [2012]. In this conception, unless you have wage labor there can be no rational calculation of comparative costs. The argument goes that rational calculation requires the value form, and that this form only comes into dominance once labor becomes abstract labor, which is treated as being equivalent to waged labor. In section 3.6 I argued that not only were prices well developed in slave economy, but that there was, at least in the manuals of agriculture of the day, a clear attempt to make rational use of the slave labor available. The weakness of my earlier argument is that it lacked statistical support, relying as it did on literary sources. For feudal economy much better statistical sources have survived, and it is possible to make a strong case for the economic rationality of the system.

Contra the claims of the Austrian school, techniques have been known since the 1930s [Kantorovich, 1960; Panne and Rahnama, 1985] that allow efficiency calculations independent of prices. The branch of math used, linear optimization, was pioneered in the USSR as a means of maximizing industrial output in the planned economy. If a factory had a particular set of machinery—say three types of lathes—and was tasked with maximizing output of two goods in fixed proportions, what was the best way to schedule the use of the machines?

Linear optimization provided an answer.[58]

The key idea here is that a unit of production, whether it is a feudal manor, a Soviet factory, or an American open-cast coal mine, will have several types of resources that have to be combined to produce outputs. The nature of the productive resources along with contemporary knowledge will determine what are called "techniques" which combine inputs in fixed proportions. For example, when plowing in the Middle Ages, plowmen, plows, and oxen could be combined as two, four, or eight ox teams. Each of these would comprise a technique. If one has enough data on inputs and outputs from enough farms one can use linear optimization algorithms to deduce what the best underlying techniques are.

McDonald [2002] applied linear optimization analysis to large databases of estates in Essex and Wiltshire [McDonald, 2010] described in the Domesday record. For each of over 500 individual estates he had the data summarized (see Table 4.1), along with information on the output of each estate. From this it was possible to rate the efficiency of each of the estates against what was contemporary best practice. For each estate he calculated the maximum it could have produced given its acreage, labor force, plow teams, mills, etc. He compared this with what it actually produced. The ratio gives the efficiency of that particular estate. He found that on average the feudal estates ran at 64 percent efficiency.

Was 64 percent good or bad as an efficiency rating? One can only make a judgment if one has efficiency ratings for large groups of production units from other historical periods. These ratings, to be comparable, must have been computed by the same linear optimization technique used for the Domesday sample. McDonald compared Domesday estates with other examples in the linear programming literature where similar methods had been used. His results are summarized in Table 4.4.

It has to be admitted that, from this data, Saxon feudal economy looks pretty good. It was a lot more efficient than nineteenth- or twentieth-century U.S. farms and comparable to the efficiency of mechanized U.S. open-cast coal mines. Only in the highly engineered technology of steam power stations did a population of units of production show better efficiency.

Remember, what is being measured is not the absolute labor productivities of farms or mines. This would be impossible since the crops produced in England in 1086—wheat, barley, wool—are not the same as the cotton, corn, and beans grown in the U.S. South, or the Mediterranean-style crops of California. Nor can we conclude that wheat production per worker year in Essex was as big as it was on the same Essex land in the nineteenth or twentieth centuries. No, what is being compared is how efficiently the enterprises were being run given the technology available at the time. Table 4.4 shows that even in the absence of competitive-factor markets, at a time when manors never needed fear bankruptcy, with the labor of serfs and slaves, feudal demesnes were at least as efficient as their modern equivalent. McDonald's work has to be counted as strong evidence against claims of superior capitalist rationality.

TABLE 4.4: Comparing the Efficiency of Feudal Production with Modern Production

Historical Sample	Dates	Mean of Efficiency
Domesday Manors	1086	64.3%
U.S. Southern Farms	1880	12.0%
U.S. California Farms	1977	28.0%
U.S. Midwest Mines	1975	60.8%
U.S. West Mines	1975	61.1%
U.S. Steam Power Stations	1947–63	80.0%

Source: McDonald, 2002, chapter 6.

The productivity of modern farms owes, I think, more to tractors and to Haber[59] than to any inherent capitalist efficiency.

4.5 THE SMITHIAN CRITIQUE OF FEUDALISM

An economy can be partitioned into two aggregate sectors: the productive or basic sector [Sraffa, 1960], the output of which enters directly or indirectly into the consumption of the working people and their dependants, and the "unproductive sector" that comprises the remaining economic activities.[60] I used this distinction in section 4.3 to get ballpark figures for the rate of exploitation in mid-feudal England.

The conceptual distinction between these two types of labor goes all the way back to Adam Smith. He criticized the extent to which the landlord classes and "great merchants" wasted resources in employing unproductive personal servants:

> The rent of land and the profits of stock are everywhere; therefore, the principal sources from which unproductive hands derive their subsistence. These are the two sorts of revenue of which the owners have generally most to spare. They might both maintain indifferently either productive or unproductive hands. They seem, however, to have some predilection for the latter. The expense of a great lord feeds generally more idle than industrious people. The rich merchant, though with his capital he maintains industrious people only, yet by his expence, that is, by the employment of his revenue, he feeds commonly the very same sort as the great lord. [Smith, 1974, II.3.7]

He goes on to argue that with the transition out of feudalism the proportion of the national revenue that goes to the support of productive workers rises.

> Thus, at present, in the opulent countries of Europe, a very large, frequently the largest portion of the produce of the land is destined for replacing the capital of the rich and independent farmer; the other for paying his profits and the rent of the landlord. But anciently, during the prevalency of the feudal government, a very small portion of the produce was sufficient to replace the capital employed in cultivation. It consisted commonly in a few wretched cattle, maintained altogether by the spontaneous produce of uncultivated land, and which might, therefore, be considered as a part of that spontaneous produce. It generally, too, belonged to the

landlord, and was by him advanced to the occupiers of the land. All the rest of the produce properly belonged to him too, either as rent for his land, or as profit upon this paltry capital. The occupiers of land were generally bondmen, whose persons and effects were equally his property. [Smith, 1974, II.3.9]

Smith alternates in his argument between an individualistic and a social approach to the question. From the standpoint of the individual rich man he says that spending on servants depletes his capital whereas spending on productive workers returns the capital with a profit. He also looks at the effect that this has on the overall division of labor.[61] In progressive bourgeois states like England and Holland the cities were manufacturing centers, whereas under the ancien regime at Rome or Versailles they were full of idle, dissolute, and poor servants of the court. So his basic argument was that under feudalism the surplus product was overwhelmingly spent unproductively, whereas in the modern (eighteenth-century) countries, the greater part of funds were spent employing productive laborers creating a more industrious, prosperous, and sober society.

To see the implications of Smith's argument look first at the physical and monetary accounts of a feudal style economy about the size of sixteenth-century Scotland's economy in Table 4.5. The population division is designed to resemble that shown in Table 4.1 as part of the earlier discussion of feudalism. We neglect the food consumption of the lords themselves and of the urban masters. The peasants are assumed to deliver rent in kind of 1,752,000 qts corn to the lords who use 1,314,000 qts to feed their servants and themselves and the remainder, 438,000 qts, is sold on the town markets for £657,000. With the money they get from selling the corn, the lords buy an equivalent £657,000 of urban goods. We can assume that these will be a mix of agricultural implements, arms, and luxuries. On the assumption that in both town and country the rate of exploitation is 25 percent, the masters in the towns must make a profit of £164,000 that they are assumed to spend on urban goods.

TABLE 4.5: Feudal Economic Consumption

	People (in thousands)	Corn Consumed (1,000 qt.)	Corn Produced (1,000 qt.)	Rent & Profit	Urban Goods
Peasants	400	7,008	8,759	£2,628,000	-
Servants	75	1,314	0	-	-
Townsfolk	25	438	0	£164,000	£657,000
Total	500	8,759	8,759	-	-
Value	-	£13,139,000	£13,139,000	£2,792,000	-

Feudal economy of the type criticized by Adam Smith as being unproductive, prices taken to be in ballpark for 1500 at 30/- per quarter. Consumption of food is estimated on the basis of 2,200 calories per person per day, which is then converted to corn on the basis that 1lb of corn provides 1,637 calories. Source: Compiled by the author.

Although the table shows the value of corn produced and consumed in money terms, this is just an attributed value, since in a feudal economy most of the crop is never marketed. The total sum of "vendible" commodities, to use Smith's terminology, can be calculated as follows:

Sales of urban goods to lords	£657,000
Sales of urban goods within towns	£164,000
Sales of corn to towns	£657,000
Total	£1,478,000

Now suppose that there is a social transformation and the servant class is transformed into wage workers in urban manufactories as Smith advocated. The output of the urban sector would grow by 300 percent as there would now be four times as many urban workers. Similarly, grain sales to the urban sector would grow, since while servants were fed in their master's hall, wage workers had to buy bread on the market. The overall effect would be to grow the market economy to £5,192,000. Is this just an illusion, though, brought about by commodifying what was previously an element of natural economy?

No, not entirely, since the real output in kind of the urban economy would be three times what it was before the erstwhile retainers were proletarianized, though the increased sale of grain to the towns does not involve any more actually being grown than before. The growth of commodity circulation exaggerates the real increase in production; but there is a real increase all the same.

But this does not get to the heart of Smith's distinction between the unproductive economy generated by feudalism and the productive one generated by the manufacturing bourgeoisie. For in the example I have given almost the entire market for the urban product is still provided by the rural aristocracy. Their marketization of the grain they collect as rent gives them the revenue to consume the greater part of the augmented urban production. Smith contrasts the situation of Edinburgh in the seventeenth century and earlier with its position after 1707 as follows:

> There was little trade or industry in Edinburgh before the union. When the Scotch Parliament was no longer to be assembled in it, when it ceased to be the necessary residence of the principal nobility and gentry of Scotland, it became a city of some trade and industry. It still continues, however, to be the residence of the principal courts of justice in Scotland, of the Boards of Customs and Excise, etc. A considerable revenue, therefore, still continues to be spent in it. In trade and industry it is much inferior to Glasgow, of which the inhabitants are chiefly maintained by the employment of capital. The inhabitants of a large village, it has sometimes been observed, after having made considerable progress in manufactures, have become idle and poor in consequence of a great lord having taken up his residence in their neighbourhood. [Smith, 1974, II.3.12]

The observations that Smith makes about the two cities remained valid at least until the late twentieth century. He considered cities like Glasgow "as trading cities … as cities which trade not only for their own consumption, but for that of other cities and countries." In contrast to cities like Paris or Rome or seventeenth-century Edinburgh that traded only for the consumption of the royal courts and nobility in residence. One could make similar observations today, contrasting Washington to New York, Brasilia to Rio, Canberra to Sydney. The key issue is the ratio between capital and revenue, and thus between productive and unproductive employment.

> The proportion between capital and revenue, therefore, seems everywhere to regulate the proportion between industry and idleness. Wherever capital predominates, industry prevails: wherever revenue, idleness. Every increase or diminution of capital, therefore, naturally tends to increase or diminish the real quantity of industry, the number of productive hands, and consequently the exchangeable value of the annual produce of the

> land and labor of the country, the real wealth and revenue of all its inhabitants. [Smith, 1974, II.3.13]

The issue is not just the sort of static comparison I calculated above, a one-time transfer of retainers to wage laborers, but the process of continuously accumulating capital, continuously converting revenue into capital, which increases physical productivity. Smith's fundamental objection to unproductive expenditure is that it impedes the accumulation of capital. It is only by converting revenue into capital that the productive capacity of society in real terms can increase:

> As the capital of an individual can be increased only by what he saves from his annual revenue or his annual gains, so the capital of a society, which is the same with that of all the individuals who compose it, can be increased only in the same manner. [Smith, 1974, II.3.15]

He realizes that with the accumulation of capital an increased part of the workforce is engaged in simply replacing and maintaining the capital, and that in consequence the rate of return on capital will fall as the proportion between capital and revenue rises.[62] This, he believed, was a necessary accompaniment to economic progress. We will examine this in more detail in the next chapter.

His concern with the accumulation of capital is why he makes a sharp distinction between productive activities, which actually produce a persisting physical product, and unproductive services that "perish in the very instant of their performance." The objection to feudalism as a social order was not inefficiency, but profligacy and waste. It was the way that the nobility wasted labor in prodigal displays of luxury that held back progress. We will see in a subsequent chapter that this same objection comes to apply to the rentier classes of modern capitalism.[63]

CHAPTER 5

Capitalist Economy

The hand mill gives you society with the feudal lord; the steam mill, society with the industrial capitalist.

— KARL MARX, 1847

The capitalist mode of production *is* machine production. Capitalist societies feature:

- Energy mainly from artificial not human sources
- High-yield agriculture supporting large urban populations.
- Widespread use of machinery and applied science.
- Lots of waged workers making commodities in private enterprises.
- The surplus product appearing as monetary profit.

The components listed above constitute an auto-catalytic system [Kauffman, 1993]. Given external sources of energy, the composed system reproduces itself and grows. Obviously these components do not spring full-formed. There were earlier auto-catalytic social systems. Some of the elements that make up capitalism must be generated by these prior systems before capitalist dominance.[64] As Althusser et al. [2006] argue,[65] partial combinations of capitalist elements have come together before without leading to full capitalism. If Russo [2013] is to be believed almost all the elements came together in Ptolemaic Egypt. Althusser cites Renaissance Italy as another capitalism that might have been. The eventual formation of a new system was a stochastic sputtering process before it finally caught fire.

Each historical type of economy involves a characteristic technical way of making things—Marx's mode of production—which is combined with social forms or relations of production. The most critical of the latter is the form of extraction of the surplus product. In later sections of this chapter I will examine how this surplus is produced and how that interacts with the typical technology complex of capitalism: high-yield agriculture, machinery, applied science, and artificial power. Since all of these are tied together by production for the market, that is what I look at first.

5.1 THE CAPITALIST PRICE MECHANISM

In section 3.6 I discussed how the regulation of prices by expended labor worked in slave economies. And in section 3.5.3 I referred to the extensive empirical literature showing that labor time regulates contemporary prices. But in modern capitalist economies the mechanisms by which this happens are not as self-evident as they were under slavery. A similar process to that I described for latifundia would work for companies that also made several product lines. They can compare the labor required by different lines of products—different models of cars, for example—and set their selling prices to be roughly proportional to the labor used. The situation of a car company, though, is different in two important respects from a slave estate:

1. A car firm has to buy many of the components that make up the final car. The cost of these components can be a significant part of the final selling price, whereas the latifundia was much more self-sufficient. They may have brought in some supplies, but not many.[66]
2. A *dominus*, or feudal lord, already claims the laboring capacity of his slaves and serfs. He can therefore directly calculate labor time expended on different crops without resorting to calculations in money terms. Thus precapitalist economy should be more directly rational in terms of social labor. A firm has to buy the labor force by the week or month, and so is faced with a more immediate monetary cost, not just a cost in terms of labor. The wage cost is then homogeneous with component costs. Both are in terms of money.

The first point, that firms buy in components, is not a serious problem. If the firms simply pass on the component costs in the final product, and make their markup on components proportional to the labor they employ, and if all firms follow this practice, all prices including those of the components will, by recursion, end up being determined by the ultimate labor used.

Although firms do have to hire labor power, and are thus presented with it as a monetary cost, this does not prevent them from doing internal estimates of what a project will cost in terms of person months. Indeed they are obliged to do this first, otherwise they do not know many workers they must hire. Even in a capitalist monetary economy direct calculations of labor time are logically prior to calculations in cash.

But by itself this is not a watertight argument. Why should different firms in different industries use the same markup for labor?

Why indeed should it be labor that they base their markup on, rather than other costs?

In my argument I will repeatedly rely on what is called either the law of averages or the law of large numbers. An example of the law of averages is: individual women vary in heights, but it you take 100 women at random and work out the average height of these 100, it will be very close to the average height of all women. The tall women in the sample will cancel out the short women. I will use this kind of argument repeatedly.

Returning to firms: we do not have to assume that all firms have the same markup We only have to demonstrate that there must in practice be a narrow range of markups used. If most markups are pretty close to the average, then labor ends up determining the price structure.

First, consider that the labor content of any product is made up of two parts:

$$\begin{array}{l} \quad\text{Labor content of components} \\ \underline{+\ \text{Direct labor used to make it}} \\ =\text{Labor content of the product} \end{array}$$

The term “components” here should be understood to include not only things that physically pass into the product like tires on a car, but also the things like the electricity used and the fractional wear-and-tear on the productionline machinery.

Now consider the ratio of selling price to labor content. We can expect this to vary randomly among products, but the scale of this random variation will be small. The price will also have two components:

$$\begin{array}{l} \quad\text{Money cost of components} \\ \underline{+\ \ \text{Wages} \times \text{Markup}\qquad\qquad} \\ =\ \ \text{Total price of the product} \end{array}$$

Since many different components will be used in any given product, and since the price-to-labor ratios of these will vary in different directions, some above the average, some below the average, these variations will tend to cancel out. The total price-to-labor ratio of any large bundle of components will, by the law of large numbers, be very close to the average ratio prevailing in the economy. So to a good approximation, we have:

$$\text{Components' labor content} \approx \frac{\text{Money cost of components}}{\text{Average markup} \times \text{Average wage}}$$

The expression *Average markup* × *Average wage* gives the Average Value Added by Labor (AVAL). It measures how many £, $, or € are added to the output by an hour's work. What do we know about the *markup* in individual firms?

Well we know that the *average mark-up* must be greater than 100 percent. Were it not, there would be no profits and the economy would not be capitalist. If the markup was 150 percent it would mean that firms made a gross surplus of 50p on every £1 they paid in wages. How this gross surplus is divided up into profit, rent, interest, and tax does not concern us here. What is important is that it exists.

We also know that very few firms will be operating at a loss. Some firms may be loss making for a short while, but the process is self-limiting. They either return to profit or close. So very few individual firms will have a markup that is below 100 percent. Let us say that at most 1 percent of firms have a markup that means they make a loss. If the average markup is 150 percent we can use a table of the normal distribution to work out what the standard error of the markup must be to ensure that only 1 percent of firms make a loss. It has to be 21.5 percent. This means that 95 percent of firms would end up with a markup of between 107 percent and 193 percent.

One measures the spread of data by its coefficient of variation given by the rule

$$\text{Coefficient of variation} \approx \frac{\text{Standard error}}{\text{Average}}$$

In the example we have so far the coefficient of variation (CV) in the markup would be 21.5/150 = 14 percent. The laws governing the markup's variance are:

- The smaller the fraction of firms that are loss making, the smaller the spread of the markup

- The higher the average markup, the higher the spread of the markup. A normal distribution is symmetrical so if the average markup is 200 percent then the spread of markups would be between 114 percent and 286 percent, which is twice what you get with a 150 percent markup.

The average markup for the whole economy is given by:

$$\text{Average markup} = \frac{\text{Total wages} + \text{Total surplus}}{\text{Total wages}}$$

The data needed can easily be obtained from published National Income statistics allowing us to estimate the spread of markups used by firms. It is obvious that the variation of the £/hour ratio of the final output is bound to be smaller than the spread of markups. Selling prices are determined by firm markups plus the passed on cost of components. By the law of averages, the spread in the £/hour ratio in a bundle of components is smaller than the spread for individual commodities. So passing on the component cost will dampen the £/hour spread of final selling prices.

If the component costs were to make up, say, 1/3 of the selling price then this would reduce a CV of 14 percent in mark-ups to something more like a CV of 10 percent for selling prices [Cockshott and Cottrell, 1998b].[67]

In conclusion, I have shown[68] why the classical economists were right in assuming that prices are determined by labor. The classical theory has the simplicity prescribed by William of Ockham, is testable as the scientific method demands, and its operation is enforced by simple statistics. So we see in table 5.1 that the correlation between the monetary value of output in different U.S. industries stands at the 97 percent level with the direct and indirect labor required to produce these outputs. Note that the variation in industry monetary outputs is almost completely due to the differences in direct and indirect labor used to produce their outputs [Cockshott and Cottrell, 1997d].

Another testable consequence of this classical theory of prices is that profit rates will be higher where the labor-to-capital ratio is higher and vice versa. We will see later that this is an important historical effect shaping the long-term future of capitalism, but it also operates in real time to cause those industries with a high capital-to-labor ratio to have a lower rate of profit.

TABLE 5.1: Correlation of Matrix of Logs of Estimates of Total Industry Output for 47 Sectors of U.S. Industry as Predicted by Sraffian (Sraffa, 1960) Prices

	P	E_1	E_2
P	1	-	-
E_1	0.971	1	-
E_3	0.968	0.998	1

P = observed monetary value of output; E1 = labor content;
E2 = monetary value of output. Source: Cockshott and Cottrell, 1997d.

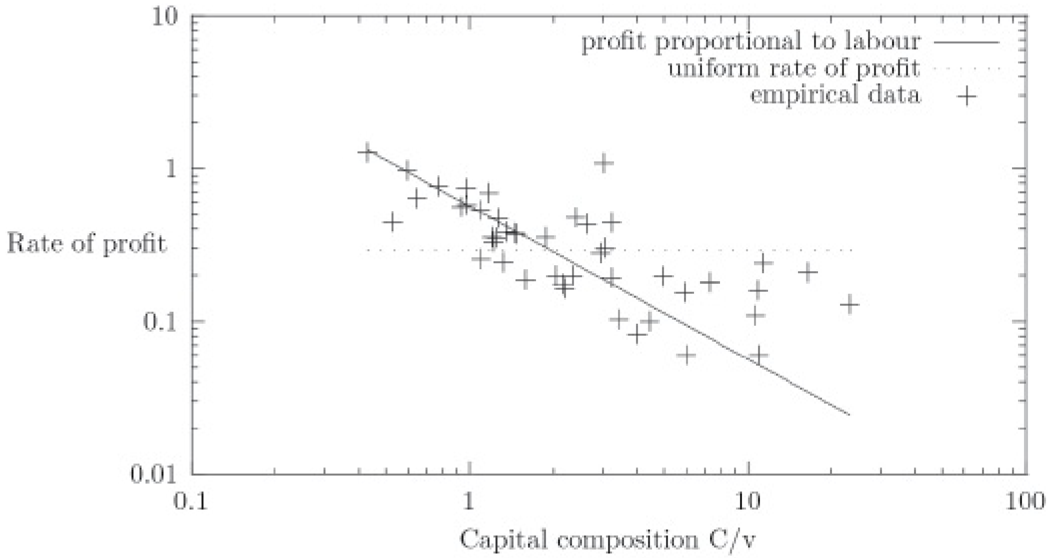


Figure 5.1. Relationship between profit rates and capital composition for U.S. industries, Bureau of Economic Affairs fixed capital plus one month's circulatingconstant capital as estimate of capital stock (log scales). Source: Cockshott and Cottrell, 1997d.

This is shown in Figure 5.1 and Table 5.2. The table displays the correlation coefficient between the rate of profit and organic composition, and also between the profit rate and the inverse of organic composition, across 47 U.S. industries. The former coefficient—at .454—is statistically significant at the 1 percent level.[69] Figure 5.1 shows very clearly that those U.S. industries with high capital-to-labor ratios have low rates of profit.

5.2 RECURRENCE RELATIONS

The arguments for why labor regulates prices have so far been pragmatic and detailed. They rely on firms not going bankrupt, and on contingent information about the distribution of national value added between labor and capital. These factors are real and immediate, but they are themselves consequences of deeper structures.

Any economic system is a process, one that undergoes constant change at the fine level, but shows relative stability at the coarse level. There is change at the level of all the individual products that are being transformed by labor and are then consumed or emplaced. The population is made up of mortal members, so its membership constantly turns over. But there are certain stabilities. From year to year the number of people changes only slightly. Towns grow and shrink, but they can endure with the same basic street plan for centuries. Industries and family lines grow and die over periods from decades to centuries. Firms and households do the same over shorter periods.

But what are these things that grow, persist, and die?

TABLE 5.2: Profit Rates, Markup, and Capital Composition, Bureau Economic Affairs Fixed Capital Plus One Month's Circulating Constant Capital as Estimate of Capital Stock for 47 U.S. Industries

	s/C	C/v	s/v
Mean	0.29	1.95	0.57
Standard Deviation	0.22	3.04	0.50
Coefficient of Variation	0.76	1.56	0.88
	s/C and C/v (weighted by C)	s/C and v/C (weighted by C)	
Correlation Coefficient	–0.45	0.78	

Profits = s, wages = v, capital stock = C. Source: Cockshott and Cottrell, 1997d.

They are all processes, and their apparent "thingness" rests on repetition, which enmeshes a homeostasis that preserves a certain basic structure. Production is often directly recurrent, as in the annual agricultural cycle, or the three-minute repetition cycle of the original Ford production line. In other industries, like shipbuilding, the repetition is more approximate. The individual ships differ in size, shape, and construction time, but still retain a structural cycle, from laying the keel, through assembly, to launch and fitting out.

The fleeting stability of units of production rests on their slowly changing workforces and long-lasting production facilities. For the domestic economy, the slowly changing workforce was one or more generations of family members, who gradually replace one another. The long-lasting facilities were the buildings, granaries, and farmland which, having been originally cleared from forest, had by generations of effort been developed. For a car firm you have employees who, as a collectivity, have the knowledge and skill to cooperate in making cars. The long-lasting facilities are the buildings and equipment, which, like the farm, gradually develop over time.

These stable components combine, at any one instant, with material in flux. There is material waiting to be transformed: seed, car parts. There is material undergoing transformation: growing oats, partially assembled cars on the line. At times, there are transformed products: a full granary, finished cars in the lot. The whole process is impelled by external sources of energy.

Traditional farms are solely solar. Industry has two energy sources. First is the primary motive power, electricity today, but once coal or flowing water. Second is human labor power, energized by food. The domestic farm generated human energy internally, but for a factory it comes from outside. Workers walk in fed, energized for the day's work. Whereas the farm regenerated its own inputs, its seed corn, the factory's components and raw inputs come in the gate. The transport and sale of commodities fits within these (almost) repetitive cycles.

The fact that the factory exists and produces things constrains the rest of society to be so organized that each day a cohort of workers are ready to cross its threshold; that there is a flow of its primary energy source; that there is a stream of components and raw materials being delivered regularly; and that there is a regular uplift and transport away of the products it makes.

When I say that the factory constrains the rest of the society to have certain features I mean:

1. That a particular combination of embodied technologies and social forms together form an auto-catalytic net that tends to persist.
2. That the actual existence of factories implies that there must exist one of the possible auto-catalysis systems that boost the probability of factories.
3. In this sense the factory, which we know to exist, constrains the rest of society.

In all, the factory implies a much more stringent set of constraints on the rest of society than is implied in the existence of a subsistence farm.

The interface between the factory and society is complex. It implies that the society in which it is embedded must be able to generate and sustain the workers who come in each day. It is not enough that the people exist and have the relevant skills. They must be generated as factory workers, not as some other kind of person. They must be free to work in the factory rather than tilling their own farms or being tied up in some different activity.

The delivery of primary energy implies a whole organized supply network. At one time this might be something local, an enchanneling of a river by weirs and millraces. Later it is more encompassing: canals to deliver coal, mines to extract it. Now it implies electricity grids, with networks of generators synched to a 50Hz cycle.

The supply of raw materials and components implies a transport network and a supply chain. It implies other factories. The complexity of the supply network grows, literally exponentially with the the number of inputs to the factory.[70] This complex of recurrence constraints is the determining role of the productive forces. Recurrence relations select out only certain sets of social forms and relations as compatible.

There is not just a single set of reproductively competent social relations for industrial production. Theory and history teach us that there are at least two, possibly more, characteristic social forms of industrial society. Which set of social relations the factory is embedded within depends on real history. In modern terminology it is path-sensitive, dependent on whether the society has undergone capitalist or socialist industrialization.

We are in this chapter only concerned with the former. So we have to assume that there is no overarching social planning mechanism that will deliver the components that the factory needs, no system of general labor allocation that will ensure that fed and clothed workers turn up each day. Instead, all of these preconditions must be arrived at by the exercise of private contract. Nothing arrives without a prior promise to pay a monetary equivalent.

In the absence of a public direction of labor and resources, the social power of the state symbolized in money is co-opted by private firms to command[71] both the living and embodied labor their survival demands. They can demand labor and components, so long as they have the cash. Behind these transactions, admittedly, stands the state power, ready to enforce the law of contract, ready to enforce debts in its currency, but the contracts themselves are private. Hence the arguments I used earlier to explain the enforcement of another law, what Marxist economists called the "law of value,"[72] express the real dependence of firms' reproduction on the laws of contract. These are constructed so as to be neutral with respect to the distribution of the social power of money. The state treats both firms in a contract equally and is concerned only that stipulated monetary equivalents are paid for goods delivered. The law of contracts is neutral with respect to the distribution of money between legal personalities.[73] The survival of the firm as a technical and labor cooperative unit then depends on its survival as a contractual unit, as a legal person, an owner of property.

In order to reproduce themselves in the absence of a social plan, factories have to be able to command the delivery of labor and components. The latter implies that they must, albeit indirectly, be able order the allocation of social labor into the making of those components. The statistical laws regulating price, which I explained in section 5.1, act to make sure that command over money becomes, on average, command over an equivalent amount of labor, thus allowing a decentralized planning of the economy to take place.

Finley [1980] argues that whereas ancient authors were quite open about the exploitative nature of their society, modern ideology strives to suppress talking about it. The power of command, domination of the slave lord or *dominus* was open, unashamed and enforced with whips and branding irons. That of the capitalist is presented in the guise of equality on the market and fraternity as citizen. The worker and Ford, the farmer and chain supermarket Walmart, meet and contract as legal equals. The fact is, of course, that behind the legal facade, they are far from equal. Ford or Walmart have financial resources that are perhaps a million times as great as an individual worker or farmer. The £-millions in the accounts of the firms put them in a position of vastly greater bargaining strength than a worker who would be hard put to survive a month without pay, or a farmer who, by harvest time, has run down his assets to almost nothing.

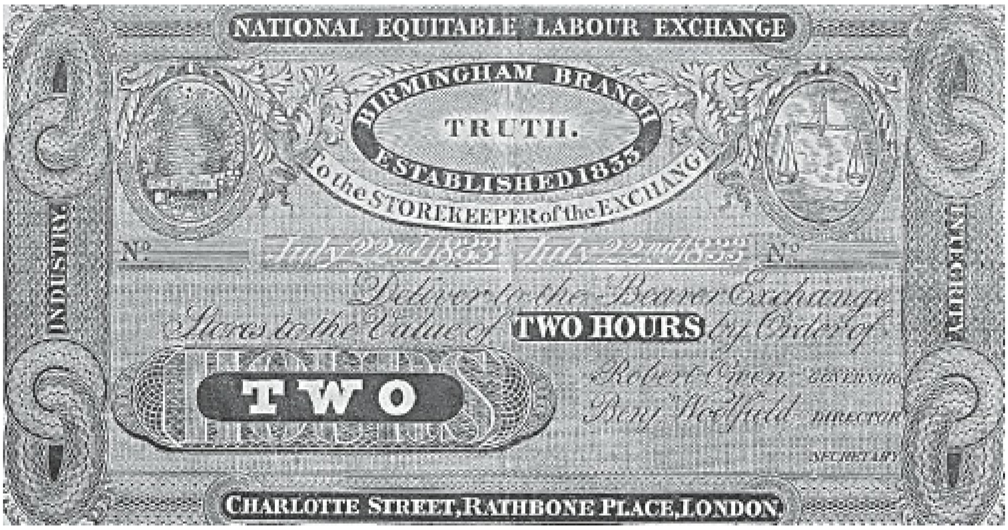


Figure 5.2. The labor certificates issued by the labor exchanges of the socialist pioneer Robert Owen.

The classical economists had unmasked what was happening in this process. They wrote in a still aristocratic Britain, in which the common people could neither vote nor, in the main, read. You find in Smith an openness about class and command that came to those with a classical education. He saw that money was the power to command the labor of the lower classes. In his day the coinage was still gold; open fiat money in Europe was yet to come, though the Chinese had long known it. But by the early nineteenth century, having experienced the suspension of banknote redemption during the French wars, socialist writers started to propose that instead of gold, money should be openly denominated in terms of labor. Instead of having the motto “I promise to pay the bearer on demand the sum of One Pound” they would promise goods to the value of one hour (Figure 5.2).

There are two reasons why this idea has never been implemented. One of these is minor. Although prices are regulated by labor, it is approximate, so there is around a 10 percent margin of error above and below, thus there would never be an exact equality between the labor performed and the price obtained. But that pales to insignificance compared to the much bigger political obstacle. Were such notes to be introduced they would highlight that behind the apparent equality of employer and employee there is in reality a deeply unequal relationship. Such notes would be little short of revolutionary pamphlets. They only made sense, in the context of socialist pioneer Robert Owen’s exchanges, if they were to be part of a process of moving the whole economy over to communist operation.

5.3 CAPITALIST SURPLUS

Under slavery, the profits of the slave owners were no mystery. The slaves worked for free, and everything they produced belonged to their master. He had to give them part of the crop as food, but anything that remained he sold as a profit. In modern society it appears, according to orthodox economics, that workers are not only paid, they are paid the full marginal product resulting from their efforts. The slave was nakedly exploited, whipped to work, with no standing before the law. An employee enters into a voluntary contract that, in law at least, is one between equal parties, and if economic theory is to be believed, the wage he/she gets actually expresses a relationship of equal exchange. She gets paid the value of her labor, and that value is defined by the marginal or extra product that the company gets by taking her on as an employee. The argument goes that were she paid less, then it would be worth the company taking on more workers until the point was reached at which the last worker taken on yielded no additional profit.

The theory on which this account of remuneration rests is the one that gave us the supply and demand functions shown in Figure 3.8. We explained in section 3.5 just how vacuous this theory was from a scientific viewpoint, but even if we accept the counterfactual assumption of diminishing returns to scale, then all workers but the last one taken on must be exploited. All others are paid less than the value of the product that their labor produces. Clearly if Owenite principles applied and each worker was paid the average value added by labor there would be no profit; the entire value product would go to labor. That would imply a cooperative rather than a capitalist economy. If the ownership structure remained capitalist, and if in each industry the average wage was equal to the average value added by labor in that industry, then clearly around half the firms, those with below average labor usage, would make a profit, and half, those with above-average labor usage, would make a loss. This would be an unsustainable situation. Half of the firms would soon be bankrupt. So we have to assume that in a capitalist economy there will be a markup on wages. Clearly, if real wages can be reduced, or people can be made to work longer and harder, the markup will be bigger. We will look at what governs this markup in more detail in sections 5.4 and 5.7 but a typical example of what average markup prevails in a capitalist economy is given in Table 5.3 (page 116).

One could envisage that an economic reform, say analogous to the abolition of slavery in the nineteenth century, could similarly abolish wage labor and capitalist profit. Legislation specifying that the employees of a company are the owners of residual value added would abolish the need for a markup over wage income. In a cooperative economy like that which used to operate in Yugoslavia, with workers the final owners of residual value added, markup is unnecessary because there will be differences in take-home pay between more and less productive cooperatives. Workers in this case bear both the risks of market variations and pocket its benefits.[74]

TABLE 5.3: Calculating the Markup on Wages in the UK

	£M
Total Consumption of Intermediates	£1,526,425
Taxes Less Subsidies on Production	£23,303
Compensation of Employees	£873,202
Operating Surplus	£650,409
Value Added	£1,546,914
Output	£3,073,339
Markup on Wages	£1.77
Rate of surplus value	£0.77

Data from *2013 Summary Supply and Use Tables* for the United Kingdom, Office of National Statistics.

In terms of its current reproduction, the capitalist form of economy stands directly on property relations and property law. It is sustained by an edifice of company law that defines shareholders not employees as the appropriators of value. Its replacement, like the replacement of the slave system in the Americas, will ultimately be the result of political and legal changes. But that does not explain how, within the system of private commodity exchange, the specifically capitalist mode of making things, with its accompanying social relations, became dominant. To understand this we have to examine in more detail why the technological complex specific to capitalism reinforces capitalist social forms.

5.4 TECHNOLOGY AND SURPLUS

We said earlier that capitalist societies have high-yield agriculture able to support a large urban population; a significant part of social labor time devoted to the production of commodities by private producers; widespread use of machinery and science; artificial sources of energy; and a significant part of their surplus product represented as private profit obtained from wage slavery. It should be clear that taken individually, several of these features have existed in precapitalist societies. Any urban civilization needs an agriculture that delivers a surplus product. The slave economies had many private producers of commodities, and a significant part of their surplus, since it was sold, was represented as money profits. Both antiquity and the Middle Ages knew of wage labor. Where slave and feudal economies differed significantly from capitalism is in a much more limited use of artificial energy and their failure to carry out ongoing scientific research that could be applied to improving the economy.

5.4.1 Vital Energy

The Neolithic Revolution had such a big impact because it enabled humanity to access much more energy by moving down a trophic level. But between the Neolithic Revolution and the development of capitalist economy, societies remained in a sense natural economies. They were natural in that their energy source was still biological, and as such was limited by the inherent losses that are incurred as solar energy goes through photosynthesis, metabolic loss in plants, and then metabolic inefficiencies in human and animal bodies before being converted into mechanical energy in muscles. There were two exceptions to this, first and most important the harnessing of zephyrs for navigation, and second, enslaving naiads to turn wheels.[75] Though the key inventions required for water power, undershoot and overshoot mills, were there, industrial use seems to have been relatively limited. We know of only one industrial scale application of water power in the ancient world, the 16-wheel mill at Barbegal [Leveau, 1996], though smaller mills were apparently widespread. The famous Barbegal mill, even at 100 percent mechanical efficiency would have had a maximum output of only 0.044MW from the estimated flow of 250L/s over an 18M drop [Lorenz et al., 2012]. A more realistic estimate at a typical 60 percent efficiency would be 0.026MW.

As table 5.5 shows, even at the earliest stage of capitalist industrialization Britain had a thousand times as much installed water power as that behemoth of antiquity, the Barbegal mill. At the same time we should avoid a tendency to prettify capitalism in comparison to prior forms of social relations, and claim that prior forms of economy had little incentive to minimize labor input. If you read the passage I quoted from Cato on the management of latifundia he is anything but sloppy about the use of labor. Labor time is an expensive resource to the slave owner as well as for the capitalist; slaves were only intermittently cheap. It makes sense to minimize the number of slaves you set to do a task.

Any set of social relations has some incentive to reduce expended labor. Every free peasant or artisan wants to reduce their effort, and will use any technique available to them to do so. Feudal lords or slave owners likewise wish to maximize the output their slaves or serfs produce. If anything, Marx argues that capitalism, because of the wage labor relation that involves paying for labor at a fraction of its true value, is irrational in its tendency to undervalue living labor relative to dead labor. We should therefore expect capitalism’s progressiveness in terms of implementing labor-saving machinery to be inversely proportional to the level of real wages. The more that workers are impoverished and have their wages driven down by the flood of dispossessed peasantry, the slower capitalism will mechanize. In contrast, where proletarians had the opportunity to emigrate to virgin lands, as to the America of the nineteenth century, the greater was the incentive to use machinery.

There are about sixty known Romano British water wheels, but we must assume that only a small proportion of sites have been discovered. It is also unclear how many of the 6,000 or more English mills in 1086 had been in use continuously since Roman times. The presence of many horizontal Saxon or Norse mills probably indicates most had been built in the subsequent 600 years. What we do not know is the total installed power, but allowing say 1.5kw to 2kw per mill, which seems reasonable for small undershoot or Saxon horizontal ones, we get a total installed power in mid-feudal England of about 12MW, or 460 times what the largest known Roman industrial establishment used. Lynne White [1964] argued that the diffusion of watermills was a characteristic superiority of the feudal as opposed to the slave economy.

Peak usage of water mills in the feudal period in England in the 1300s would have been about twice that. Given that in the period from 1086 to the mid-fourteenth century the population more than doubled, it would indicate that there was a stable ratio of artificial to human energy available during the period. We have a ratio of only around 7 watts of water power per head of population. By this point almost all villages would have had a mill or been within easy reach of one. Langdon [1991] indicates that up to 90 percent of feudal manors in England had mills, in which case control over these vital means of production would have been a critical factor in the dominance of the upper class.

None of this indicates that the feudal ruling class was slack in its adoption of such labor-saving machinery as was known at the time. If we assume that the sustained output of an adult manual worker in peasant agriculture is no more than 75 watts and that in 1086 the peak output of human labor would have been around 70MW, then in mid-feudalism artificial energy supplied about 17 percent of the peak human energy. If we look at the mid-1700s we have an installed base of artificial power of about 63MW, mostly water, but some wind and steam. A population of around six and a half million gives a human labor output of at most 285MW, so that by this phase artificial power was providing around 22 percent of the human effort. A bit better than feudalism, but not much.

By 1870 we have a British population of 21 million, which doing heavy manual work could have delivered about 945 MW, but had an installed capacity of artificial power of 1700 MW or almost twice the manual output of physical power. This is a phase change in the mode of production brought about by steam power and reinforces Marx’s argument that it is the steam mill that gives rise to the industrial capitalist.

5.4.2 Hero’s Turbine Not Enough

The ancient Romans already had a working steam turbine in Hero’s aeolipile. Why were they not able to turn this to use in industry, pumping water or turning millstones?

Why no Industrial Revolution in antiquity?

There are well-known arguments about the social relations of slavery impeding the development of labor-saving technology, but is this enough of an explanation?

We know that the ancients harnessed the power of water for grinding corn and other industrial uses, so they were not completely indifferent to artificial sources of power.

Could they not have used steam turbines instead of water wheels to grind corn?

After all, steam turbines are used in current nuclear and coal power plants, surely they would have been ideal?

I think not. There are inherent limitations to the usefulness of Hero’s device, basically its low torque and inefficiency. Steam turbines are now the preferred prime mover, but their superiority has depended on the ability to produce high-pressure steam and high-rotational velocity. The actual technology that started the Industrial Revolution—the Watt steam engine—had the virtue that it could develop very high torques at low velocity using very low steam pressures.

In order to get a functioning fossil fuel economy you had to have a prime mover and a way of providing fuel for it. The main fuel available was coal, which was obtained from mines, which were prone to flooding. It is almost a chicken and egg situation. You need coal for steam engines, but to drain coal mines you needed steam power. The Watt engine was originally developed for pumping out mines, an application that required a lot of force but tolerated a relatively slow engine. The torque T supplied by a Hero-style turbine is given by the rule: $T = p \times 2a \times r$, where wheel *p* is the steam pressure, *a* the area of each exhaust nozzle, and *r* the radius of the turbine.

The torque provided by a Watt beam engine was given by a similar rule: $T = p \times a \times l$.

Here *p* is now the pressure difference between the boiler and the condenser, *a* the area of the cylinder and *l* is the beam length.

The early Watt engines were huge, with beam lengths of over 3 meters compared to the few centimeters for the length of hero turbines. This is a factor of 100 difference. In terms of diameter of bore a practical Hero turbine would not have exceeded 1 cm against half a meter for a Watt engine. This is a factor of about 2,500 greater area for the Watt machine. Let us assume both operate at the same steam pressure, since the technology of boiler construction was initially the limiting factor. That means that the torque of an early Watt engine was about a *quarter of a million* times greater than an aeolipile.

Could you build an aeolipile that generated comparable torque?

Well yes, if you had arms a couple of meters long on the turbine and nozzles a half a meter in diameter, then the torque would be comparable. But the nozzles of the aeolipile are open to the air, so a nozzle half a meter across would use up an entirely impractical quantity of steam.

5.4.3 Practical Turbines

An aeolipile is only practical as a power-generating device if the revolutions per second are very high. A small torque multiplied by a very high number of revs per second can generate a useful amount of power.

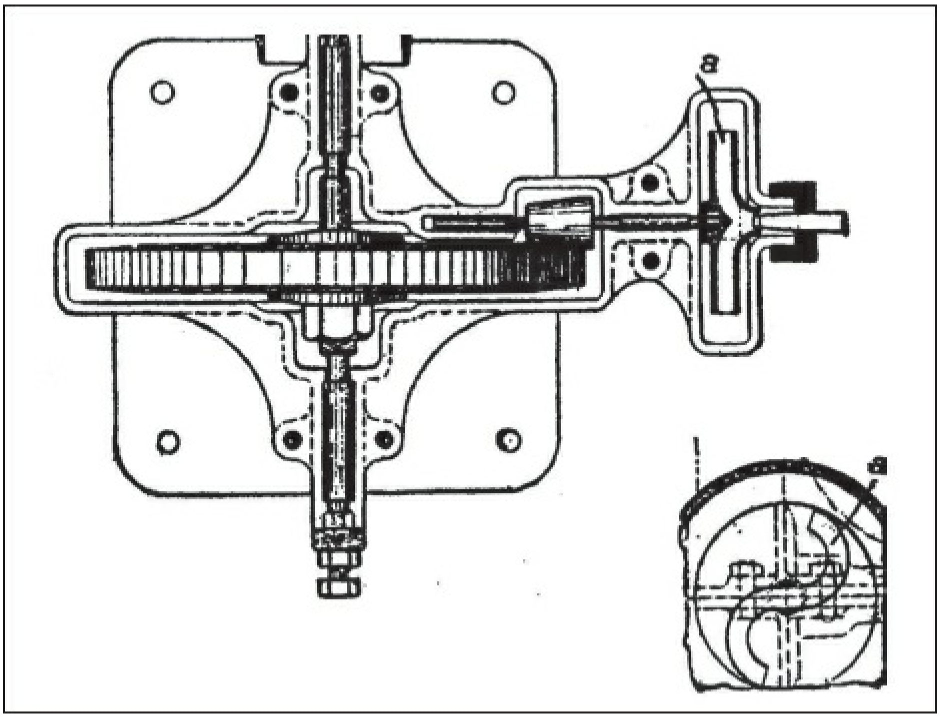


Figure 5.3. Laval's first turbine used to power a cream centrifuge in 1884. It used a simple modification of Hero's turbine in concept, but relied on precision engineering and high-pressure steam. The part marked *a* is the modified aeolipile. Steam enters from the right. Source: Jude, 1910.

The aeolipile had to go through a series of steps before it could be converted, in the 1880s into practical turbines by Laval and Parson. The first practical use of a reaction turbine was for Laval's cream separator. This required very rapid rotation, around 1000rpm, to centrifugally separate cream from milk, so a high-speed device was desirable. Laval's first prototype was based on the aeolipile but heavily geared down, using friction gear to get it to 1000rpm. His second prototype switched to the impulse principle—directing a jet of high-pressure steam against a rotating set of turbine blades.

TABLE 5.4: Performance of Production of Laval Turbines

Horsepower	Radius	Revs per minute of turbine	Revs per minute of geared output
5	5cm	30,000	3,000
30	11cm	20,000	2,000
300	35cm	10,000	750

Source: Data from Jude, 1910.

Rotation speeds were very high. The 300hp turbine in table 5.4 had a peripheral velocity of 366M/s or 1317Kmph—supersonic velocity. Such huge velocities needed high-tensile steel.

Between the start of steam power and the first practical use of a reaction turbine over a hundred years elapsed, during which many engineers came up with suggestions for turbines. But it was not until the 1880s that Parson and Laval designs actually got into use. They depended on having high-pressure steam, precision engineering, and high-strength steels to work. None of these were available to the Romans. They had neither the blast furnaces and forges to make the wrought-iron boilers, nor Bessemer converters to produce turbine steel. Steam turbines only became practical as a source of power once industrial society was in full swing.

Well, even if turbines were not practical, what stopped the Romans building something like one of Watt's engines?

Basically a lack of scientific knowledge. The Watt engine depended for its power stroke on atmospheric pressure. Steam was supplied at near atmospheric pressure, and then condensed to create a vacuum. That depended in turn on key prior concepts—the discovery of atmospheric pressure by Torricelli, the demonstration of Guericke, and the concept of heat as a quantity to be conserved developed by Watt's supervisor at Glasgow, Professor Black.

Technologies have an order of dependence to them that cannot be arbitrarily skipped over. Without the knowledge and skills associated with a particular stage of technology, you cannot simply go on to develop the next.

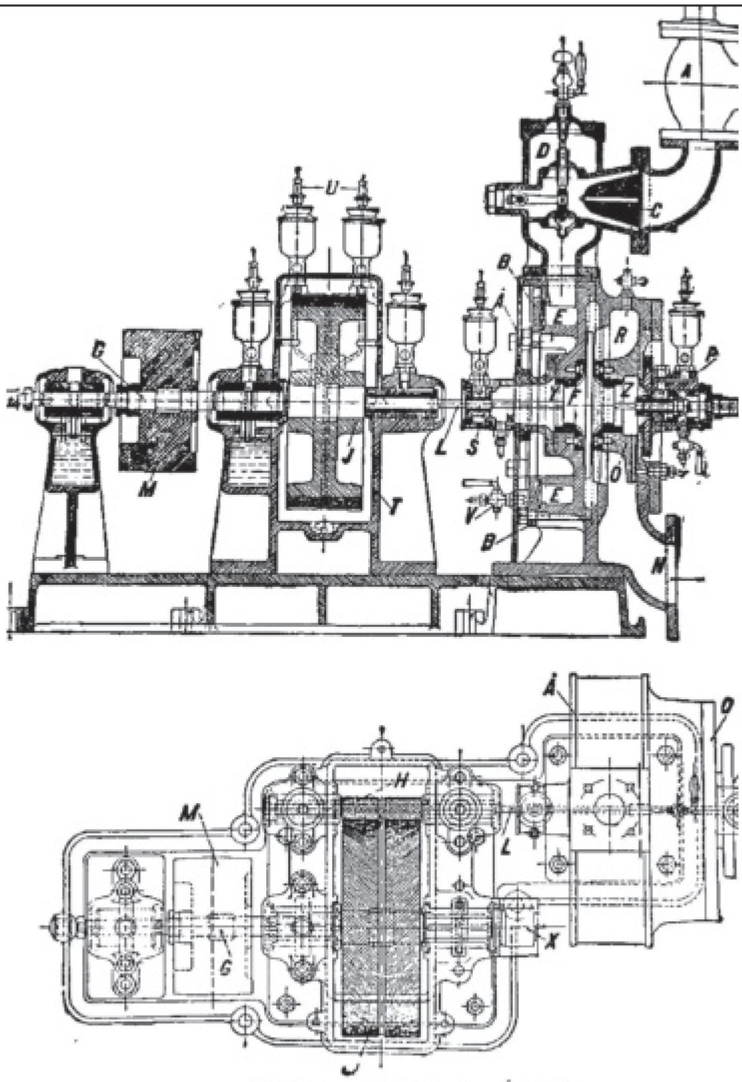


FIG. 67.—20 H.P. De Laval Turbine.

A. Steam stop valve.
B. Steam chest cover.
C. Steam sieve.
D. Governor valve or throttle valve.
E. Steam chest.
F. Turbine wheel.
G. Shaft for belt pulley.
H. Pinion.
J. Gearing wheel.
L. Flexible shaft.
M. Belt pulley.
N. Exhaust outlet.
O. Cover for exhaust chamber.
P. Ball bearing.
R. Exhaust chamber.
S. Tightening bearing.
T. Gear case.
U. Sight-feed lubricators.
V. Drain cock for steam chest.
X. Centrifugal governor.
Y, *Z*. Safety bearings.
A. Isolating plate.

Figure 5.4. Laval's second turbine switched to the impulse principle and went into production. With this the principle of the turbine was turned into a practical device. The electricity you use today is produced by a machine derived from the turbines of Laval and Parson. Source: Jude, 1910.

5.4.4 Why Power Was Essential

Why was energy so vital to the development of capitalism?

Fundamentally it is because by substituting inanimate energy for human muscle, the amount of human time and effort required to make things was reduced. A powered machine replaced the work of human hands and arms. This produced gains in speed, mass, and parallelism.

The natural resonant frequency of human limbs sets a maximum number of strokes per minute with which a hammer, saw, or needle can be moved. A powered reciprocating mechanism can operate considerably faster. Contrast the number of stitches per second on an electric sewing machine with what can be done with a hand-held needle. When the completely rotary motion of a circular saw replaces the back and forth of a handsaw the acceleration is even more marked.

The weight that can be moved with each stroke or motion can be hugely increased by applying power. Trip hammers turned by water wheels were vastly heavier than any blacksmith could wield, steam hammers and hydraulic presses increased the mass of the hammer by further orders of magnitude. The same magnification applies in a comparison between spades and steam excavators.

Alongside gigantism went parallelism. Instead of one woman turning one spindle, a water wheel or steam engine could turn 100 spindles for each horsepower it produced. A megawatt is 1341 horsepower, so the 90 megawatts or so of installed British water power in 1800 could have turned about 12 million spindles. Of course some of these were powering other machines, but this gives some indication of the equivalent number of workers who would have been needed to produce the same result. But it underestimates the gain in productivity from external power, since the speed of the power spindles is so much faster.

In table 5.6 note the phase change brought about by steam power between 1760 and 1871. Assume that the sustained energy output of a worker doing manual work averages 75 watts, and that 58 percent of the population was able to do manual work. We assume that mills in the Middle Ages had an output of the order of 2Kw.

A hand spinner could attain a productivity of between 2.5lb and 6lb of yarn per week [Humphries et al., 2016]. A water-powered spinning mule, the standard device used in the British textile industry, would have hundreds of spindles per worker and each of these spindles could produce between 25lb and 120lb of yarn per week [Leunig, 2003].[76] In consequence, each water-powered spindle was of the order of 10 or 20 times faster than the human-powered one. This means that 90 megawatts of water power devoted to spinning would produce more like the output of 200 million hand spinners. By comparision, prior to the application of powered spinning female labor working on spinning had grown exponentially (see Figure 5.5). By 1770 it had required about three-quarters of a million women, or 62 percent of English women in the 25–59 age group. Only a few decades later machine power equivalent to over a hundred million workers had been installed, which gives some impression of the leap in productivity involved.

TABLE 5.5: Installed Artificial Power in Britain, in MegaWatts

	1760	1800	1830	1870	1907
Steam	3.75	26	123	1,535	7,181
Water	52	89.4	123	186	132
Wind	7	11.2	14.9	7.4	3.7
Total	63	126	260	1,713	7,332

Source: Figures computed from Crafts, 2004.

TABLE 5.6: Comparison of Human and Artificial Energy Output in England

Year	Mills (in thousands)	Megawatts (artificial)	People (in millions)	Megawatts (human)	Artificial as a % of human
1086	6	12	1.6	70	17
1348	13	26	4.5	198	13
1750	-	63	6.45	285	22
1870	-	1,713	21.4	942	181

Source: Population for 1086 and 1348 from Broadberry et al., 2010, tables 1 and 2. Population for 1750 and 1870 from Chandler, 2014. Mill numbers from Langdon, 1991.

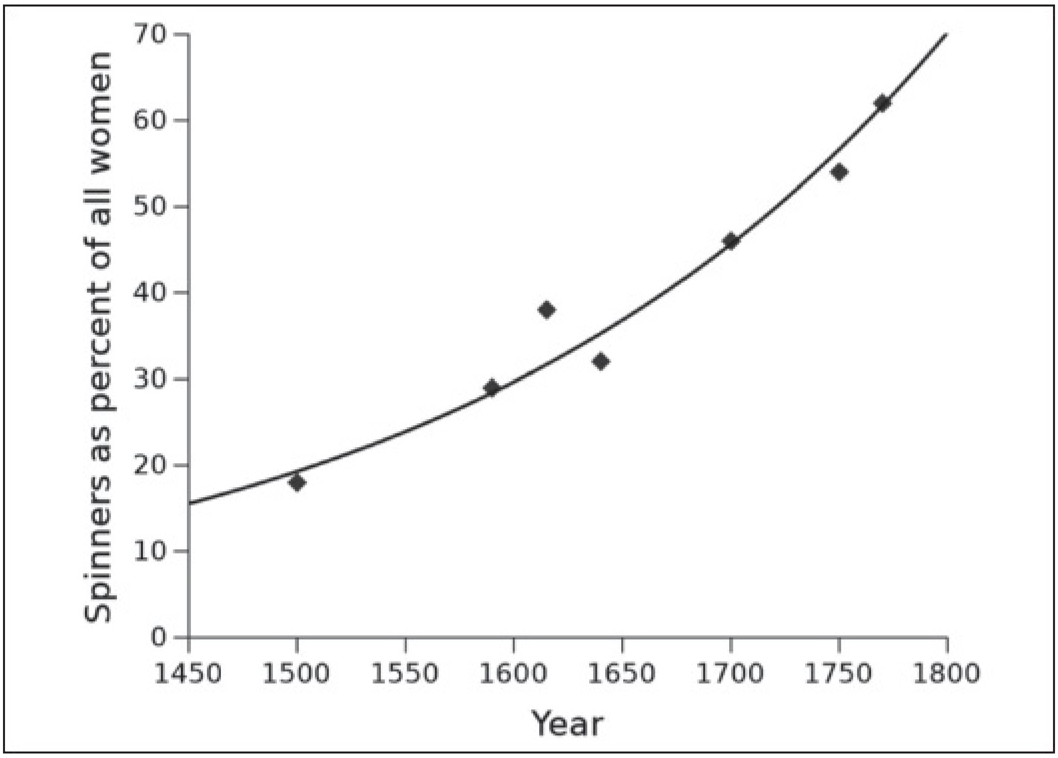


Figure 5.5. The proportion of the female population required to work as spinners to support the textile industry grew exponentially in the leadup to industrial capitalism in England. Prior to the adoption of the mules shown in figure 5.6 the number of spinners was already near its practical limit. Source: Graph drawn from data in Allen, 2015.

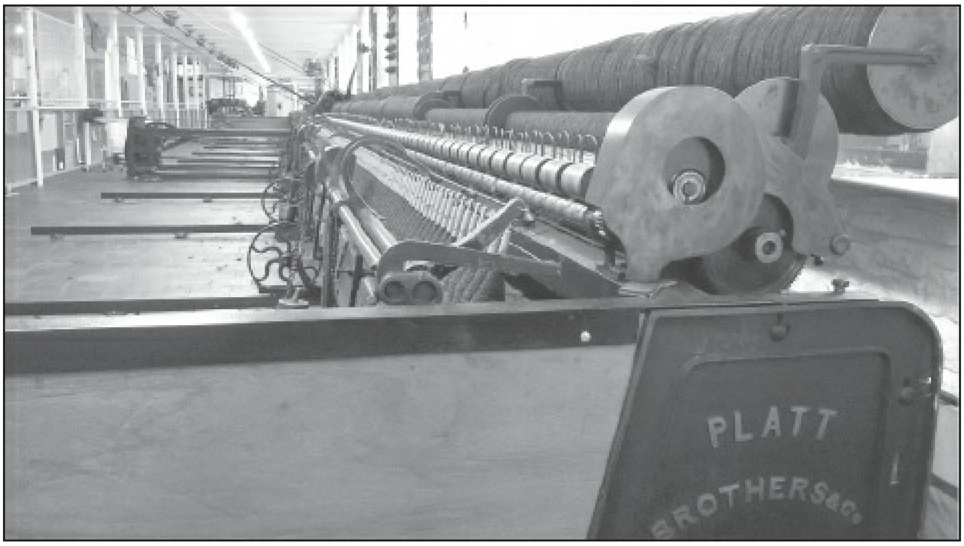


Figure 5.6. Water-powered mules such as this one at Robert Owen's old mill at New Lanark applied artificial energy to a huge number of spindles while an automatic sequencing mechanism replicated on a much larger scale the motions of a human spinner's arms.

Capitalist production first took root using the water power technologies available from antiquity; its novelty in this respect was not the power source but the scale on which it was used and its application to highly parallel machinery. The real novelty, steam power, was at first relatively specialized in its application—used exclusively for pumping water, particularly from mines. It was not until the 1830s that steam power overtook water in installed capacity in Britain, even later in the United States. It has been suggested [Malm, 2013] that the reason steam eventually replaced water in the cotton industry was more a matter of class conflict than technical rationality. Water mills were in isolated rural spots where it was easier for the mill workers to organize strikes than in big cities with their abundant potential scabs among the unemployed. Steam power enabled masters to move from where labor was scarce and strong to where it was abundant and weak.

Could capitalism have developed differently, in a way that did not rely on fossil fuel?

Was it just a contingent accident that Faraday's dynamo and electric motor were invented decades after Watt's engine?

Had electro-magnetism been investigated earlier, power could have been transmitted from fast-flowing rivers to power factories in cities, thus giving the masters the edge over their workers that steam provided. This transformation, though, had to await Edison, Tesla, and Kelvin in the late nineteenth century. But even then water power would not have been sufficient to rival steam. In the year 2000 the installed hydropower of the UK was 1400 MW, which is less than the installed steam power was in 1870, and only about a quarter of the total installed power of all types by the end of the nineteenth century.

TABLE 5.7: Average Output of Thermal Energy Equivalent in UK Coal Mines (25GJ per ton)

Years	MW Thermal
1760-1765	4,122
1800-1805	11,019
1830-1835	25,367
1853-1862	56,690
1873-1882	111,219
1883-1892	136,860
1893-1902	163,762
1903-1912	204,565

Source: Figures from Pollard, 1980; and from 1873 in *Historical Coal Data: Coal Production, 1853-2014*, UK Dept of Energy and Climate Change.

I speculated above about a counterfactual situation in which Faraday's generator had been invented before Watt's engine. There might be conceivable circumstances in which electromagnetism was developed before steam power, but there are real logical dependencies existing between scientific and technological advances. Heilbroner [1967] argues that it is just this set of dependencies that lie behind Marx's insistence on the primacy of the productive forces in giving direction to economic and historical development. Knowledge is cumulative. You need prior knowledge of one technology before you can think of improving it. Without the Newcomen engine as a starting point Watt would not have hit on his separate condenser. The possibility of him thinking that it would be worth using a separate condenser, however, depended on his having a prior concept that heat was a quantifiable "substance" that could be saved by not repeatedly cooling the cylinder the way Newcomen did. That in turn was only possible because of Watt's scientific training in Black's laboratory in Glasgow University [Cardwell, 1971], then the leading center for thermodynamic research.

Newcomen and Savery's pioneering engines in turn depended on the prior dissemination of Torricelli's work on atmospheric pressure, since these devices were, in the language of the day, "atmospheric engines." The power stroke of the engine was driven by atmospheric pressure. The fact that improvements to machines often came not from professional scientists but from technicians like Watt and Cugnot should not be taken to indicate either that the technicians were ignorant of the underlying scientific principles of the machines or that the discoveries were not dependent on these principles. For example, the conversion of rectilinear motion into rotary motion was a considerable engineering problem.[77] This was solved by cranks or planetary gears, but that left another problem. With a beam engine you had to combine vertical motion of the piston rod with rocking motion of the beam that would tend to bend and unseat the piston rod. Watt solved this with his parallelogram linkage [Koetsier, 1983; Ferguson, 1962]. The ability to come up with this requires at least a deep grasp of classical geometry and probably also of Cartesian techniques [Dennis, 1997] in order to prove its validity.[78] Something which, when we see it in a museum now, looks literally clunky and crude, actually involved math that would severely tax most contemporary students.

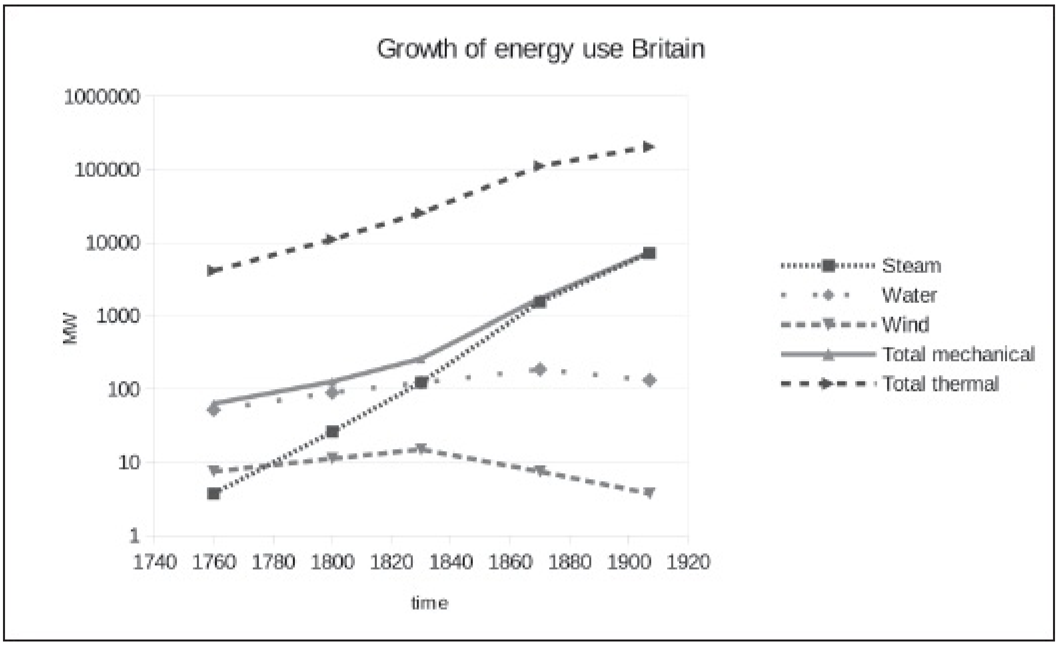


Figure 5.7. Growth of different forms of energy use during the development of British capitalism. Given the log scale of the Y axis, a straight line represents an exponential growth rate. Source: From Tables 5.5 and, 5.7.

A condition therefore of capitalist civilization, and the technical advances on which it depends, has been the continuing development of science and the educational and research base on which science relies. These are not something generated internally by capitalist enterprise. They depended initially on royal and later republican state patronage which well preceded the growth of actual capitalist machine industry. Russo [2013] shows to what extent the science of the seventeenth and eighteenth centuries still rested on royally funded research of the Hellenistic period in Syracuse or Alexandria. From the seventeenth century royal patronage of research resumed and the universities in Europe became centers of science rather than just religion.

Scientific knowledge, once published, is not property. There is no profit to be made from it, so it has in the main to be produced by social rather than private research. However great the incentive for capitalists to innovate may have been, the mere existence of commodity relations and wage labor would not have been sufficient to generate the capitalist mode of production. Innovations driven just by trial and error, without theory, are slow and limited. They only become rapid when coupled with socially produced and accumulated, non-commodified, theory. Patents and intellectual property rights allow certain innovations to be made profitable to firms by giving them a temporary monopoly—usually around twenty-five years. But scientific advances usually bring their benefit well into the future so that were basic research to be done for a profit it would be necessary to make scientific knowledge itself patentable, and also make these patents last for much longer—of the order of a century or more.

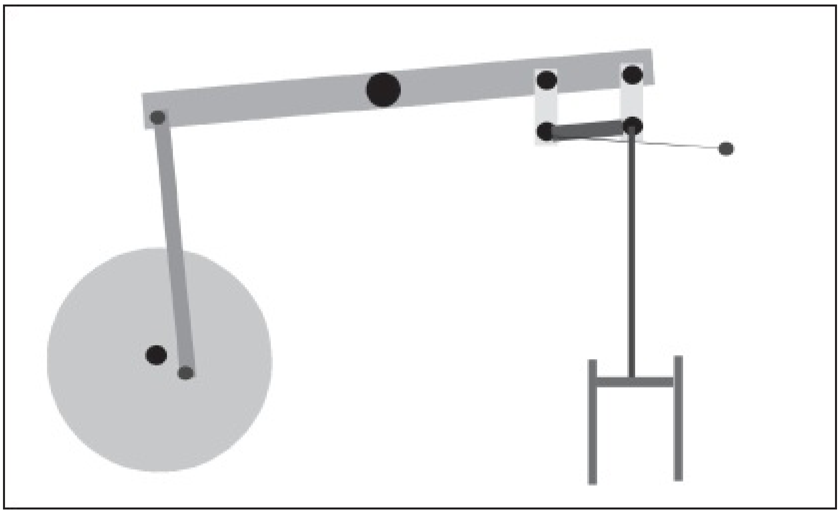


Figure 5.8. The conversion of the straight-line motion of the piston rod into the rocking motion of the beam was a difficult geometry problem solved by Watt's parallelogram linkage. Solving the problem requires a good level of geometrical education.

But a rational capitalist firm will discount future returns from patents by a guess at what the long -term rate of interest will be. Let us make the conservative estimate that they would use a 5 percent discount rate. This means that the present value of future revenue from the long-term patents you would need to take out on scientific theories becomes negligible (see page 129).

So capitalist profit seeking will itself never generate the science needed for substantial technical change. This basic property of capitalist accounting further undermines the Brenner [2001] thesis about the existence of commodity–wage labor relations themselves being a sufficient explanatory factor for the rise of the capitalist mode of production. McDonald's data on the economic efficiency of classic feudalism casts additional doubt on the Brenner thesis.

5.4.5 An Iron Subjugation

If we take into account that motive power was only one use of fossil energy, and for a long time only a subsidiary use, it becomes even clearer how much capitalist industry had to depend on fossil fuel. Coal was obviously used domestically for cooking and heating, but that is not a capitalist use of energy. But the iron industry, the brick industry, cement production, pottery, baking, brewing, etc., were all huge consumers of coal. This was either to provide heat or to provide direct chemical energy. You cannot convert iron oxide to metallic iron without the chemical energy of carbon as a reducing agent. The rapid expansion of all of these industries in the nineteenth century was only possible because coal mining provided far more carbon than coppicing and charcoal burning did.

Life of Patent	Present Value of Revenue Stream for Last Year of Patent
1	95%
10	60%
25	28%
50	8%
100	1%
200	0.01%

With the transition from biological to fossil fuel in iron production we definitely have a resource depletion-driven transition, analogous to the megafauna extinction hypothesis, which was discussed in an earlier chapter. From the start of the iron age until the eighteenth century, iron production had relied on charcoal for fuel and to provide chemical energy. For the greater part of that period the consumption of wood was limited by the small size of the hearths and the fact that their airflow came from manually operated bellows.[79]

The first furnaces were of the “bloomery” type. They produced a solid bloom containing a mix of iron and slag. This then had to be hammered to expel the slag and form wrought iron. The early small furnaces, operating by manual bellows, did not produce high enough temperatures to actually melt the iron. Now, consider that the heat loss of a furnace is proportionate to its surface area, whereas the heat-generating capacity is proportionate to the volume of burning fuel. Heat loss is consequently proportional to the square of the linear dimension of the furnace, and heat produced to the cube of its dimension. So if you build a larger furnace the temperature it can attain will rise.

But a larger furnace requires more air to be driven through it, more than a man can drive. Water-powered bellows allowed these larger furnaces. Initially the aim was to provide larger blooms, from which bigger objects could be forged. But a side effect was that, with sufficient blowing, it became possible to heat them to the point at which they obtained liquid iron that could then be cooled as cast iron.

When operated as bloomery furnaces, the blooms were too big to be hand forged, requiring instead the trip hammers shown in figure 5.9. This stage had been reached by the end of the fifteenth century in Italy and by the sixteenth century in central Europe [Williams, 2003].[80]

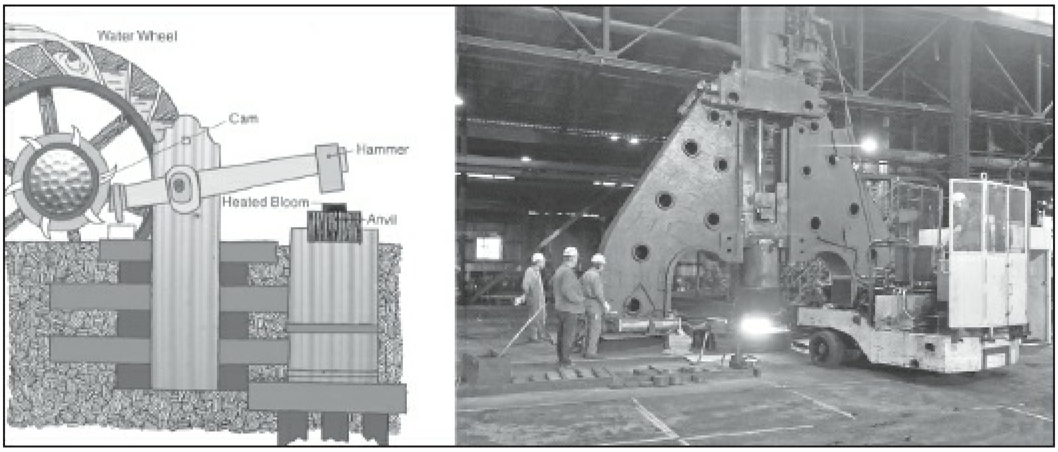


Figure 5.9. Water-powered trip hammers could strike much heavier blows than a person. Modern hydraulic ones (right) are even more powerful. Source: Wikimedia, license Creative Commons, attribution Rainer Halama.

The larger scale of production, made possible by water power, meant that iron works moved over to a specifically capitalist mode of production at this quite early date. The scale of production was beyond what the individual smith working on his own could achieve, needing both substantial fixed capital and a larger employed workforce. As the physical mode of production developed, its social form had to change, but it still remained embedded in the natural feudal economy. The iron works used three energy sources in descending order: the chemical energy of charcoal, gravitational energy of flowing water, and metabolic energy of its workers. But the chemical energy was still provided from an organic source: wood that was burned in low-oxygen conditions to produce charcoal. As such, the iron works had to be situated where there were both woodlands and flowing water and thus have a semi-agricultural dependence on woodlands owned by the aristocracy. This process was integrated into feudalism in a second sense in that a major product of the iron industry in the fifteenth and sixteenth centuries was the armor worn in battle by the upper class. In addition, although water power was used to drive bellows and trip hammers, forging of much of the final product—swords, mail, helmets, etc.—was still done manually by smiths. In the early stages of powered iron works they were often owned by the aristocracy or by church institutions—the superstructure of feudalism. Later they were rented out to capitalist masters, with rent being due on the woodlands used for fuel, etc. In formal terms the iron masters and their workers might have to acknowledge the lord who owned the land as their feudal superior—swearing the appropriate fealty oaths, but in practice the relationship was one of renting.

It has been a point of controversy as to whether blast furnaces and foundries of the Middle Ages should be considered industry or manufacture [Myska, 1979]. Nowadays we do not tend to conceptually differentiate between the two, but Marx claimed that there was an important historical distinction. What he termed manufacture was a process in which manual labor with hand-operated tools predominated.[81] In his conception, industry required the use of powered machinery instead. Manufacture might group together many workers in a single site, and they might be wage laborers, but they were still working by hand. As such their subordination to the capitalists was “formal,” that is to say, only existing in the social *form* of wage labor. Manufacturing in this sense also existed in classical antiquity using slaves. What Marx considered the capitalist mode of production proper, where workers were subjected to a “real” subordination to the capitalists, came with modern powered industry. Prior to that the workers could in principle have set themselves up as independent producers—the tools they used still being cheap and simple. Indeed, one typically had a coexistence of self-employed workers and manufacturing, since the technical advantages of manufacturing were not yet sufficient to force the independent worker out of production.

On this account, the iron foundries of the Middle Ages involved real subordination of laborers to their employers. They were free wage laborers rather than serfs, but they had no real possibility to compete with the iron masters unless they could acquire sufficient capital to buy a blow-furnace, water wheel, dam, mill-race, etc. These means of production were inherently too big to be operated by one smith and his family. Local blacksmiths were, as a result, displaced from the initial production of iron, instead working up small ingots or chunks originally produced by large blow furnaces into final products. It is thus better to see both water-powered ironworks and sailing ships as pockets of capitalist industry within a predominantly feudal agricultural economy. Capitalist shipping merchants and capitalist iron masters both depended on the harnessing of an artificial source of power: wind or water. In both cases the scale of the investment, and the rise in productivity it allowed, secured their real class position.

The sequential development, first of water-blown bloomery furnaces and then of the actual blast furnaces producing liquid iron, caused a reduction in the labor input needed. A bloomery furnace had an intermittent operation. It was loaded, blown, the bloom extracted, and then a new load and batch had to be started. Blast furnaces worked nonstop, being periodically tapped. This reduced the labor required to produce 100kg of iron from 4 working days in the fifteenth century to 2.7 working days in the eighteenth. In addition the availability of liquid iron meant that objects could be cast from it. Casting is much less labor-intensive than forging, and allows the easy production of more elaborate standardized products: cooking pots, stoves, railings, and later machine parts. It had long been possible to make such objects out of cast bronze, but iron is much cheaper. This widening of the market and cheapening of the product meant a greater demand for fuel. So long as furnaces were hand-blown and used hand-forging, one could have an equilibrium between two bio-energetic processes. The human energy to operate the forges depended on photosynthesis in cornfields, whereas the chemical energy to provide heat depended on photosynthesis in forests. The limited human energy to drive bellows constrained the oxygen supply to the furnaces which in turn constrained the demand for charcoal. Water power, however, could supply so much more oxygen that the forests could no longer keep up with the demand for charcoal. Deforestation threatened the iron industry’s continued operation unless an alternative source of carbon was found. The answer of course was coke, independently invented in China and England. Pyrolysis of coal produced almost pure carbon, suitable for furnace operation.

Freed from the bounds set by biological carbon production and, by using steam blowing, freed from the vagaries of erratic river flows, the capitalist iron and steel industry was able to embark on exponential growth.

I have given iron production as an example of capitalist development for several reasons. It was a pioneer capitalist industry, one of the first to apply artificial energy and one of the first to rely on fossil fuel. It illustrates the process by which employees came to be, in a real and inescapable sense, under the subordination of capitalists. It shows how technical advances improved the productivity of labor: expanding scale, improving thermal and labor efficiency, and, via casting, allowed new and less labor-intensive production processes. It was also a strategic industry, one on which a whole mass of others came to depend, since almost all of them came to depend on iron machines and fitments. But all of these features could, in varying degrees, be replicated in examinations of other industries: transport, power, food processing. In all of them the application of powered machines and fossil fuels allowed rising labor productivity that closed off whole branches of production from the self-employed artisan.

5.4.6 Automation or Self-Action

The sailing ship or the water mill harness a non-biological power to produce continuous motion. As animals we can only do the same by performing a repeated sequence of movements by our limbs. Before the invention of the water mill, grain was processed by rubbing a grinding stone backwards and forwards in a kneeling position, an action that produced premature degeneration of the knee [Hedges, 1984]. The next advance was the hand-operated rotary quern, two circular stones with flat surfaces and a central axis, one on top of the other. The upper stone is turned by a cranking motion of one hand using a stick poked into a hole in the upper stone. This greatly reduced the effort needed and allowed work to be done from a sitting position. The water-powered mill was a direct development of this sort of hand-operated small grinding device. But the hand miller had to repeatedly carry out the same rhythmic motions of his arm to achieve the continuous rotation. Similarly, with spinning, continuous motion of the wheel comes from reciprocation of the limbs, onto which is superimposed the arm motions necessary to first draw out, twist, and then wind on the yarn.

So much, so obvious. But this ability to perform a sequence of actions, even if it is repetitious, is something that was initially unique to humans and other animals. The sails of a ship simply transmit a continuous force, there is no sequencing required. A model sailing boat, with its sails appropriately set, will glide autonomously across a pond.

A labor process, in contrast, is not simply an expenditure of energy, it is a structured sequential pattern of, typically repetitive, motion. The key invention enabling the mechanization of repetitive motion is the pinned cylinder, such as that shown in figure 5.10.

The earliest known representation of this device dates from 1201 in a musical automaton, described by Al Jazari Meneghetti and Maggiore [2011]. It came to be extensively used in musical automata, barrel organs, musical boxes, etc., during the early modern period, and from the eighteenth century started to be applied to industrial automata. The automation of the spinning industry with the mule, as much as Charles Babbage's early computer called the "difference engine" depended on variants of this device. Another device following the same principle would be the Jacquard loom. These devices allow the automation of any labor process that, in modern computing terms, is a "do forever" loop made up of multiple *parallel* steps. What these cannot do is make decisions; they have nothing equivalent to the "if … then … else …" construct in modern programming languages. Because of this they could only be used by capital to replace routinized labor, work that involved repetitively performing exactly the same actions all day long. Any kind of work that requires sensory interaction and decisions on this basis remained outside its scope. That obviously included the great mass of clerical work, accounting work, or activities like those of Hayek's famous shipping agents. But many other tasks, which in social terms are still seen as menial or low status: fruit picking, sorting potatoes, cleaning, etc., also require the workers to make continual decisions and judgments.

The pinned cylinder model of automation is the one satirized by Kurt Vonnegut [1952] in his dystopian *Player Piano* dating from the early 1950s. He portrayed an image of a late twentieth-century American capitalism in which skilled workers have their every action copied to magnetic wire and replicated on automatic machines like the piano of the title. The late date of this novel indicates just how long capitalism had relied on this type of automation—170 years after the invention of the spinning mule.

The principle of a machine able to make decisions, and thus able to replace a large part of clerical, computational, and accounting work, had already been arrived at by the first third of the nineteenth century [Lardner, 1834], but its practical application was delayed until the availability of electronic switching devices [Turing, 2004] and appropriate electronic memory technology [Williams, 1948]. Vonnegut's owl of Minerva flew just before the dawn of computer capitalism.

Decision making in a much more primitive form had been available in the form of Watt's governor, a device based on centrifugal force that regulated the speed of stationary steam engines used in mills. But until the development of the electronic computer it was not possible to build machines that could deploy complex and varying behaviors in response to external conditions. This meant that the first wave of capitalist automation was restricted to the replacement of tasks that were either of inherent simplicity or those upon which the division of labor had already enforced a simplicity. The electronic computer, however, had the potential to replace any decision-making or guidance task that had previously been performed by humans [Turing, 1950]. Initially the effect was in clerical occupations, insurance, banking, etc. But the productivity gains from automation in these areas were slow, not enough to stop these sectors using up a growing part of social labor.

A key point about the electronic computer is that it is a universal machine, a very general-purpose technology. The standard design of a PC can be applied to a whole range of computational or industrial control tasks. The first-generation sequencing technologies tended to be machine specific. You could not take a barrel organ mechanism and incorporate it, unmodified, into a weaving machine. The generality of the computer means that it begins to approximate to the generality of human work. Standard, mass-produced IBM 360 computers were able to replace a wide range of different clerical and accounting tasks during the 1960s and '70s, and various generations of derivatives of IBM 5150 type machines continued the process from the 1980s. This process of using general-purpose computing machines was the second wave of capitalist automation —roughly covering the second half of the twentieth century. A third phase opens up with the development of multipurpose robots. Typically these had one arm, though two-arm versions are also available. They differed from first-generation automation in being multipurpose, and from second-generation automation in being applied to physical production rather than information processing. They are, however, still not the universal workers of fiction, since they are in the main screwed to the floor. Those that can move around have so far very limited mobility, endurance, and situational awareness. They are, as yet, quite unable to act as a general purpose replacement for human workers.

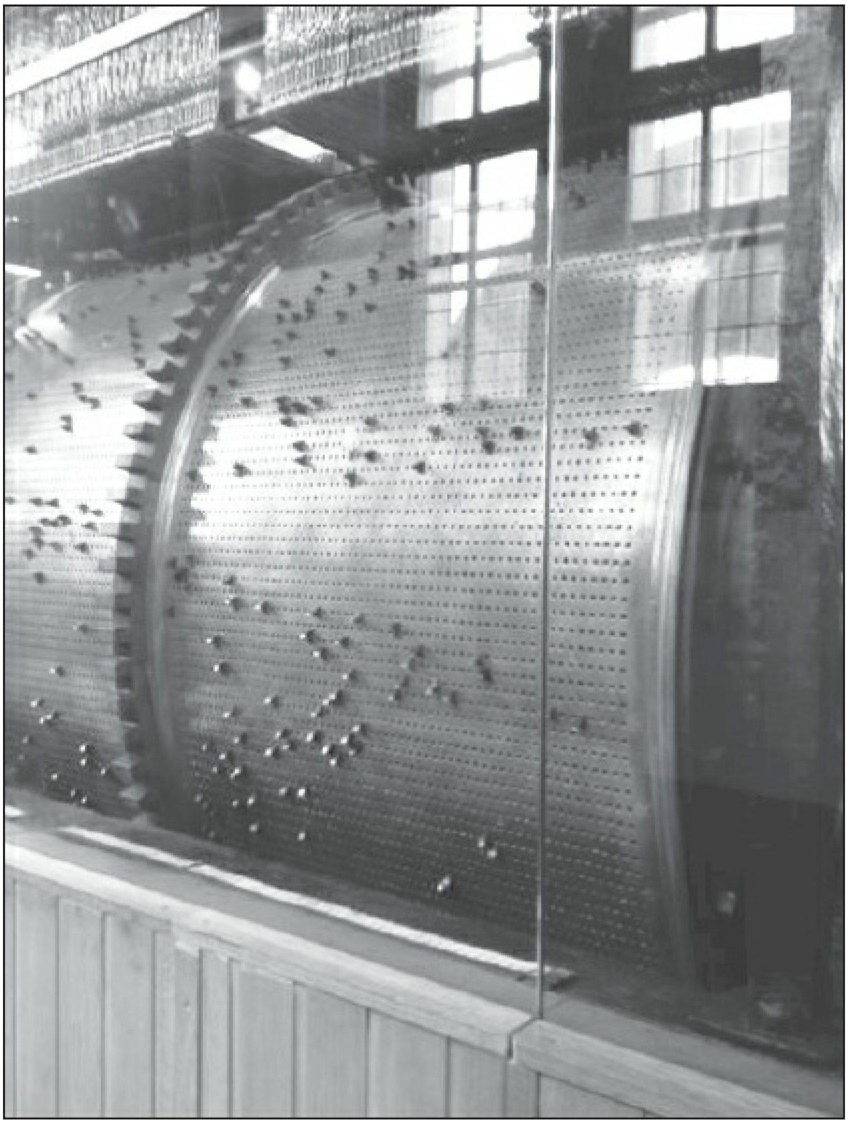


Figure 5.10. Pinned cylinder mechanism used in the ancient clock tower in Bruges. This basic sequencer device was the key to the first generation of capitalist automation. Photograph: Beverley Armstrong.

This is not to imply that such universal robots will be impossible to build some time in the future.

5.4.7 Profit of First Use

Technology boosts profits in two distinct ways. The first affects the individual business introducing the innovation, the second affects all capitalist businesses collectively.

The first mechanism is easy to understand. Recall that commodity prices are closely correlated with the labor required to make things. It is evident therefore that the adoption of labor-saving technology in a branch of business will tend to reduce the relative price of its product.

But technology adoption is typically not even. One or two businesses will be early adopters. The first adopter is able to slightly drop their price and increase market share. This is illustrated in table 5.8. The initial situation is that the product requires a total of 10 hours' labor, which, with the average value of an hour's labor being £20 means a selling price of £200. After the innovation the labor content falls by half. Before the innovation the per-unit profit was £50, after the new technique becomes general it falls to £20.

We assume that a firm selling 1,000 units originally may now be able to sell 1,200, so their total profit does not fall as much as the per unit profit.

However, during the actual period of innovation, the first user of the technology has a big competitive advantage. Suppose that while everyone else is selling a £200 unit, they sell at £150 per unit on a cost base of £80. They increase their profit per unit, while undercutting their competitors. We assume that they double their sales during this transition period to 2,000 per year. So their profit goes up on two accounts, the margin rises, and the throughput rises. Unless the first adopter can prevent access to the new technology it will become general and the advantage will be short term. Both the adopter and other firms will end up in a position similar to that in the second column of the table.

The existence of patent laws may allow the first user a relatively extended period of advantage, promoting concentration and monopolization of the industry. But there are often multiple ways of improving a production process. Patenting one of them increases the incentive for other firms to devise alternatives not yet patented. In the absence of patent protection, the incentive for competitors to adopt the new technique will be even stronger.

5.4.8 Wage Levels and Innovation

A capitalist economy thus has a mechanism that stimulates the adoption of labor-saving technology that was not present in previous systems. Dependent as they are on the sale of commodities for existence, the very survival of the productive units comes to depend on keeping up with the prevailing rate of technical improvement. This mechanism is argued by Brenner [2001] to have been a key factor in generating the improvements in agricultural activity that provided the surplus labor supply for the subsequent growth of capitalist industry.

But one should be cautious not to overstress capitalism's ability to innovate. For one thing, agriculture of the early modern period was relatively small-scale, competitive, and did not make extensive use of machinery. For another, pressure to innovate does not work reliably, it can be stifled either by very low wage rates or by monopoly.

Robert Allen [2011, 2015] has convincingly argued that the initial conditions for the profitability of powered industrial machinery first occurred in Britain in the late eighteenth century. In other countries, the level of wages was so low that it just did not pay to use such machines. Figure 5.11 provides selected information from the databases Allen has compiled of real wages over time in different countries.

While for England, France, and Italy the real wage rose sharply after the labor shortages of the Black Death, it can be seen that it was only in England that it stayed high. Thus when the scientific knowledge and arts necessary for powered industry had been developed in the Renaissance, only in England did it pay to use them.

In table 5.8 the improved technology involved a reduction in both direct and indirect labor. Suppose instead that we consider an innovation that reduces direct labor at the cost of using more indirect labor in the form of machines, as occurred during the early Industrial Revolution.

Table 5.9 gives an example of a technical change that, unlike the previous example, saves direct labor by using some additional indirect labor in the form of machines. The innovation saves 10 percent of the total labor, but there is no profit to be gained from its use. The capitalist must pay in full for the indirect labor that they buy in from other capitalists, but he only has to pay for half of the labor that he gets from his employees. Thus there is no additional profit to be had from making the switch to the new technique.

But if wages rose from £10 an hour to £15 an hour, as shown in the High Wages columns of the table, then the relative profitability changes. The innovation now becomes profitable.

It should be noted that this implies that free peasants, with access to enough land, should have a greater incentive to use labor-saving machinery than capitalist farmers. The free farmer will value his own labor at full value since all the marginal produce returns to him, so any machinery that brings an overall improvement in labor productivity is worth adopting. Capitalist farmers in contrast have the perverse incentives shown in Table 5.9. This may have relevance to the idea that it was the spread of wage labor that encouraged innovation in what is, in retrospect, seen as the runup to capitalism in Britain.

TABLE 5.8: Profit of First Use

Value added per hour: £20
Wage per hour: £10

	Old Technology as Standard	New Technology as Standard	First User
Indirect Labor Content	5	3	3
Direct Labor	5	2	2
Total Labor	10	5	5
Components Price	£100	£60	£60
Wages	£50	£20	£20
Profit	£50	£20	£70
Unit Price	£200	£100	£150
Volume Sold by Firm	1000	1,200	2,000
Total Profit	£50,000	£24,000	£140,000

TABLE 5.9: How the Motivation of Capitalists To Use Labor Saving Inventions Depends on the Level of Wages

	LOW WAGES		HIGH WAGES	
	Old Tech	New Tech	Old Tech	New Tech
Indirect Labor	5	6	5	6
Direct Labor	5	3	5	3
Total Labor	10	9	10	9
Wage	£10		£15	
Indirect Cost	£100	£120	£100	£120
Wage Cost	£50	£30	£75	£45
Total Cost	£150	£150	£175	£165
Unit Price	£200			
Profit	£50	£50	£25	£35
Adopt?	No		Yes	

Whether this is plausible depends on what one's standard of comparison is. Are we comparing the incentives to use machinery or the incentives to invest in agricultural fixed investment?

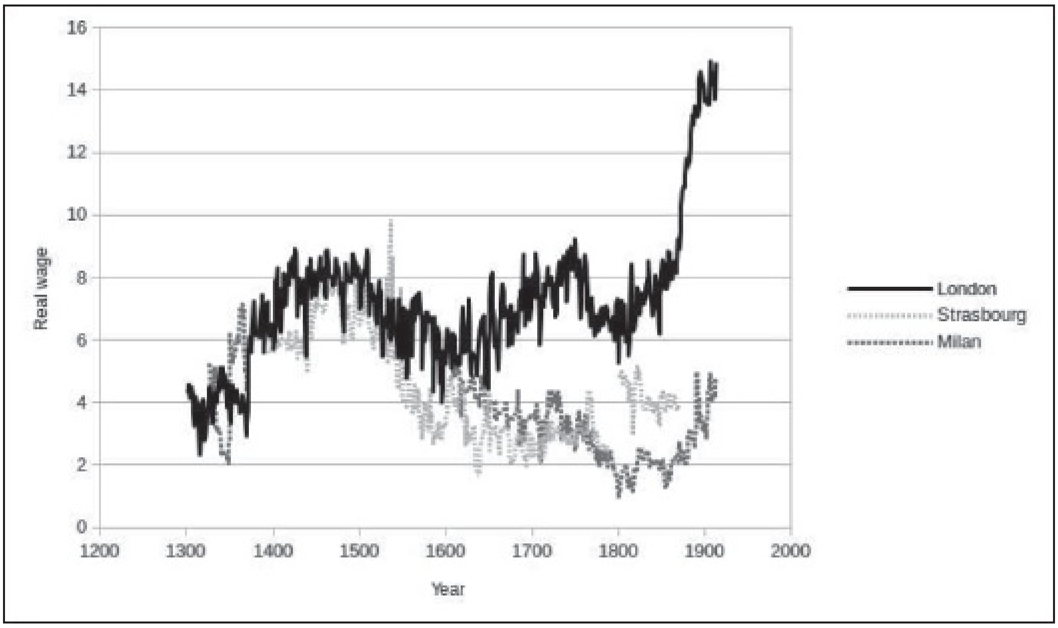


Figure 5.11. The higher rate of pay in England compared to other European countries in the 1700s provided the incentive for industrialization. Source: R. C. Allen database.

Are we comparing capitalist farmers to free peasants, to a manorial economy with serfs, or to slave latifundia?

Vis-à-vis yeoman farmers, the argument from Table 5.9 implies that a transition to wage labor would delay the use of machinery.

If we examine other forms of "capital investment" in farming—clearing, draining, manuring, planting windbreaks, building dykes, etc.—the situation is quite different. A feudal lord or slave owner has the same relative incentive to make these improvements as a free farmer since these are not really capital investments. They are not bought in as commodities. Instead the lord sets his already enserfed or enslaved workforce to the task. The calculation is again one in which labor is compared with labor, and the investment that maximizes increased output will be chosen. So the slave owners of the U.S. South were quite willing to set their slaves tasks of clearing forest and bringing land into cultivation. A large capitalist farmer in early nineteenth-century England would have the same rationale with respect to land improvements. Again the "fixed capital" is valued the same way as current labor; both are paid the same weekly wage. Indeed, it is arguable that the incentive for a slave owner to engage in fixed investment may be greater than that of a capitalist. If the capitalist employs labor by the week, each additional week costs him. Hiring labor to clear forest or put in drains is expensive.

For the *dominus*, his slaves are a sunk cost. He also has to feed them all year-round. The number of slaves he must own is set by the labor requirements at the busiest times of the year—plowing and harvesting. During the slack periods, there is surplus labor available, which effectively costs nothing if it is set to improving the land. This would imply that, if anything, the advent of wage labor would slow down the rate of fixed agricultural improvement.

The superiority of capitalist production in terms of fixed agricultural improvements should not be assumed. In this domain both capitalist agriculture and servile agriculture are on at least the same footing with respect to the comparative costs of immediate versus longer-term use of the labor they control. The superiority of capitalism over servile relations could only exist in the context of bought-in means of production: machinery or chemical fertilizers. We can illustrate this with a concrete historical example. Suppose a nineteenth-century slave owner had to choose between two ways of maintaining output:

1. Buying in Chile saltpeter to maintain fertility.
2. Allowing the soil to become exhausted, but using his slaves to clear virgin forest to replace it.

Option 2 would be the rational course to follow. Saltpeter costs money; the spare labor time of the slaves was free. This had consequences. The slave plantations had an incentive to constantly expand onto virgin soil as Cairnes and Smith [2003, pp. 52–54] recounted. This process brought them into fatal conflict with a free peasantry also migrating to the same territories.

The superiority of wage labor over servile labor exists only with respect to bought-in capital goods. Before powered machinery and agricultural chemicals had been invented, the mere institution of wage labor would not tend to bring a big boost in efficiency. Indeed, allowing for the technology then available, McDonald [2010] showed that feudal economy could be very efficient.

Returning to machinery and extending this argument to cooperatives, these again have a higher motivation to use modern machinery than capitalist firms. In general the higher the level of wages and the lower the degree of exploitation, the greater will be the incentive for the employers to introduce labor-saving inventions. Conversely, low wages and servile conditions act as a huge deterrent to the use of modern machinery.

This is brought out by contrasting two parts of the former British Empire, India and the United States. Modes of production, ways of making things, do not exist in isolation. Slaveholding and landlordism were discussed in chapters 3 and 4 but historically capitalist production has coexisted with both of these, and in some parts of the world like India, still does.[82] It is easy to think of the United States as always having been a capitalist society, and to consider the American Revolution as an archetypal bourgeois one. That is not the standpoint I argue here. I have presented the antebellum U.S. South as a classic slave mode of production.

The class structure after independence was unlike anything in early capitalist Europe. You had to go back more than 2,000 years to find something similar: the slave republic Rome on which the Americans consciously and deliberately modeled themselves. At the top was the slave-owning aristocracy that did no direct productive work, but lived off the labor of the slaves. Below the aristocracy was a class of free citizens who worked for a living. These would be small farmers or artisans. At the bottom were slaves with no political or civil rights, the private property of aristocrats. The main class conflicts were between the slave owners and the slaves on the one hand, and between the slave owners and the free citizens on the other. Since the slaves had no political rights either in Rome or the United States the conflict between them and the slave owners was brutally physical, with the owners' dominance enforced by whips and chains. Free citizens on the other hand had civil rights, and the fact that they outnumbered the richer slave owners meant that the political power of the slave owners was potentially threatened by the free peasants and artisans. The main conflict between the slave owners and free peasants was typically over land ownership. The progress of slavery meant that more and more land tended to fall under the control of the big slave estates, threatening to proletarianize the free citizens. In both Rome and the United States, the free-citizen farmers and artisans were allies of the slave owners. As with expansionist Rome, the external contradiction was between the propertied classes of the Republic and the surrounding free peoples. The expansionary imperialism of both states was driven by both the desire of the senatorial classes to acquire further estates and, more significantly, to promote colonies in which a potentially threatening proletariat could be settled as independent farmers. As Weber [2013] argued, the parallels between Roman and American peasantry were exact right down to the geometry of landholding. In both cases the land was divided up on a square grid of farm plots with long straight roads—something that only a conquering empire could achieve.

The ending of slavery did not mean a direct transition of the U.S. economy to capitalist production. The mode of material production across much of the economy remained firmly pre-capitalist, reliant on manual work without powered machinery. Social relations were characterized by a mix of semi-feudal and semi-servile relations in the South, free peasants in the West, and capitalist industry in the Northeast. The twentieth century saw the United States undergo a transition from a predominantly rural economy of semi-feudal black peasants and independent white ones to a predominantly urban waged population. The agricultural depression from the 1930s allowed banks to foreclose on farms driving farmers into cities. In the South, the landlords made use of mechanization to dispense with and evict their black sharecroppers who also moved into the cities.

By the end of the nineteenth century in India mechanization had made little inroads into agriculture, and even in textile production, which is normally the first industry to be automated, the transition from manufacturing to machine industry was far from complete (see Table 5.10).[83]

Why was this?

Important factors seem to have been a combination of very low wages with the persistence of semi-servile relations of production in India. Although slavery had been formally abolished in India in 1843, in practice it continued in 1900 and still exists, with estimates that there are around 40 million bonded laborers in modern India [Narula, 1999]. Scheduled caste tribes made up 24 percent of the Indian population in 1991. But the government itself accepts that more than 86 percent of bonded laborers are from these groups. This occurs despite the prohibition of all forms of forced labor under article 23 of the Constitution and the 1976 Bonded Labor System Abolition Act.

Bonded labor by members of the lower castes is rife in agriculture, even in more developed regions like the Punjab [Srivastava, 2005]. In the brick kiln industry some three million workers are employed in conditions amounting to bonded labor. Brick kilns are heavily guarded and severe restrictions placed on workers' movements. Workers are typically in debt to their employers and the debt relation persists from season to season [Gupta, 2003].[84]

Similar conditions of near slavery exist in other sectors where heavy manual labor is done in quarries, mines, hand loom weaving, salt pan work. and construction. In Tamil Nadu of 750,000 workers in the quarries two-thirds are bonded laborers, with, in many cases, whole families being enslaved.

Given the close link that exists between slavery and caste oppression it is worth considering the United States. Slavery had remained legal there even after it was formally prohibited in India. Dilip Menon [2006] recounts how in the nineteenth century, novelists of the Indian lower castes saw the similarity between their own condition and that of the Negro in America. Even after the Civil War and Lincoln's abolition of slavery, a social upheaval far greater than anything India went through in its path to independence, the Negroes in America remained a caste apart. Deprived of civil rights until the 1960s, segregated from the white population, denied entry into many jobs and professions—prohibited even from fighting for their country.

TABLE 5.10: Cloth Production in India by Sector

Year	Mill Production	Decentralized Powerloom Production	Decentralized Handloom Production
1900–03	483	0	793
1936–39	3,630	0	1,420
1980–81	4,533	4,802	3,109
1997–98	1,948	20,951	7,603

Sources: Clark and Wolcott, 2003, 7; Mazumdar, 1984, 36.

Ex-slaves or descendants of ex-slaves faced many of the same prejudices as untouchable slaves and ex-slaves. What was it but a fear of pollution that forced them to use separate water supplies—Dalits being prohibited from using the tanks supplying Hindus and Negroes having to use separate drinking water fountains?

The whole edifice of segregation was a series of pollution taboos meant to enforce a subhuman status.

One system was called *caste* and the other *race*, but what is a name?

Both are imaginary justifications for real exploitation. Given the fundamental mixing of the human gene pool, and the fact that we are all of African descent, race was as much an imaginary social construct as caste. Its functional meaning was the same, to demarcate a servile section of the population. Both categories drew on religion for their support—with Negroes being labeled as children of Cain by white Christian sects.

The notion of caste and the notion of race are part of what Althusser [1971] termed the ideological state apparatus of exploitative society. By this he means the set of ideas and institutions by which human agents are socialized, whose function is to ensure the continued reproduction of the existing relations of domination and servitude.

In the context of what I have said about the role of economic backwardness in sustaining caste in India, the economic background to the struggles of the Negroes in mid-twentieth century United States are relevant. There was nearly a century of delay between the abolition of slavery and the winning of civil rights by the Negroes in the 1960s. Why did it happen then and not in the 1890s, for example?

A theory put forward by Marxists among the black proletariat of the United States who lived through this change is that during the 1950s and ’60s a crucial economic change had occurred. When the slaves were freed, they had remained a semi-servile class of sharecroppers. They continued to carry out the same agricultural labor as their erstwhile masters transformed into landlords. The former slave owners continued to profit from the labor of the freed slaves, but now it was done with a semi-feudal relation. The crucial fact was that the mode of material production had not changed. Cotton production still depended on manual labor to tend the fields and harvest the crop. The Negroes were formally free, but they were still doing the same sort of physical labor as the slaves had done. It was not until the 1940s that the federal government stepped in to enforce legislation against bonded labor.[85] Alongside semi-feudal sharecropping and peonage, slave production continued on a large scale in the United States using prison labor. By the 1870s it had already started to be the case for Southern states to pass vagrancy laws whose main purpose was to allow poor, predominantly black, men to be rounded up and hired out as slave labor [Blackmon, 2009].

With the enforcement of legislation against debt slavery, and with the migration of sharecroppers to the industrial North there arose for the first time an incentive to mechanize Southern agriculture. In the 1950s machines were introduced that could harvest cotton, weeding came to be done by spraying chemical weed killers, and the whole process of agricultural production shifted from manufacture to machineofacture. The mode of material production became specifically capitalist. Consequent upon a change in the mode of material production, the social relations of production had to change too. The semi-feudal sharecropping system gave way to capital-intensive agriculture. The class of sharecroppers was freed from the land to become a proletariat who migrated to the great urban manufacturing centers. The physical movement away from the rural South, and the social movement from the personal dependence of sharecropping, laid the grounds for a political struggle for equal civil rights. Blacks were now participants in the labor market, working side by side with white workers on the assembly lines of Detroit. Under these circumstances the clash between their caste status and the formal equality of labor presupposed by the capitalist market became intolerable. But the process of gaining civil liberty was not automatic. It was only through a prolonged and bitter struggle that legal rights could be enforced. Like any state apparatus the ideological apparatus of race could only be broken by struggle. This struggle in the United States is clearly not complete:

- blacks are disproportionately found in the less skilled and worse paid sections of the proletariat
- and as proletarians they are still very much exploited, now by capitalists, where previous generations were exploited by landowners and slaveholders.

But their struggle has progressed further than that against untouchability in India.

In this process there have been feedbacks between social relations and technology. The class of white farmers and landowners introduced machinery to their farms in the mid-twentieth century not with the view to its social effects but in order to make more profit. The social consequences that followed the black struggle for equal political rights were unforeseen. A new form of technology changed economic relations; this in turn brought political conflict which changed society. But one should not assume from this that technological change was inevitable. If slavery had persisted in the Southern states, had, for example, the Confederates won the Civil War, it is doubtful that there would have been the motive to mechanize.

The points of similarity between the United States and India during the twentieth century are:

1. The existence of a depressed caste subjected to at first openly servile and later semi-servile relations;
2. The predominance of manual labor in the semi-servile sector;

3. The use of violence and terror to maintain the depressed caste in its place;
4. Severe social segregation.

The significant differences are:

1. The somewhat more advanced level of capitalist industrialization in the United States during the 1960s relative to India now (see Figure 5.12, p. 142);
2. Historically the United States suffered from chronic shortages of labor relative to capital.

Eventually, Indian agriculture will mechanize, and the peasantry disperse. The mines, quarries, brickworks, etc., within which Dalits are enslaved will use Leibherr and Komatsu mass excavators rather than human labor.

This is what one can expect from capitalism, but how long will it take?

One of the basic points I made earlier is that the rate of technological advance in a society tends to be inversely proportional to the rate of exploitation. Where labor is cheap, it will be wasted. Marx and Cairnes Smith [2003] made this point with respect to slavery, that it was inimical to mechanical progress. Marx emphasizes that under capitalism, where wages are low, the most backward techniques of production will be used. From this standpoint, the very intensive exploitation of Dalit labor must be a major cause of technical backwardness in the Indian rural economy. Why else should the full mechanization of some industries have been so long delayed?

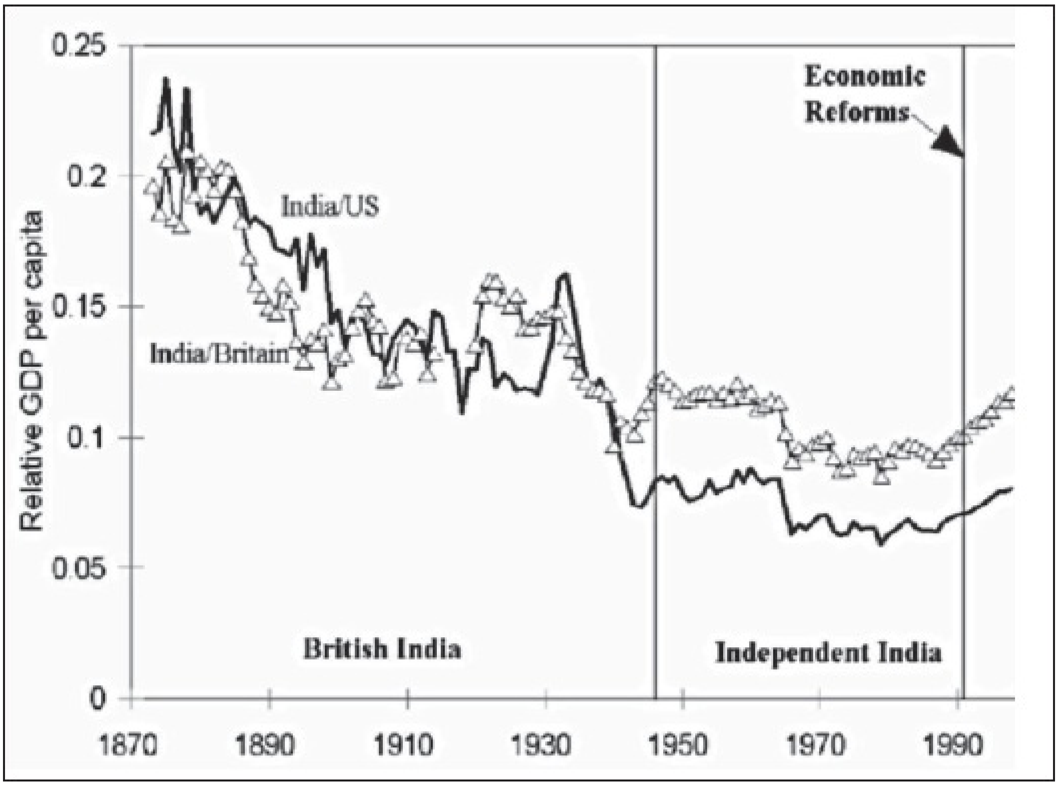


Figure 5.12. Indian GDP per capita relative to the United States 1873 to 1998. Source: Clark, 2003.

Until labor becomes expensive there is little incentive to replace it with machinery. This is a crucial difference between India and the United States, which, from its founding, had a relative shortage of labor, both compared to available agricultural land and, later, compared to capital stocks. The shortage of labor had both been the drive behind the initial capture and transportation of slaves from Africa and the nineteenth-century flow of European immigrants. When this was cut off by the 1921 Quota Act, the demand for industrial workers in the North allowed the rapid absorption of former sharecroppers into the industrial working class. The labor shortage was a necessary consequence of colonial economy. Land from which the natives had been dispersed became available for settlement, acting as a constant drawdown on the pool of employable workers in urban areas. Capitalism demands a working class deprived of the means of production—but if land was to be had for free from the federal authorities, that condition was not met. Retaining workers depended on U.S. wages being substantially higher than in contemporary Europe, where land had long been monopolized by the aristocracy. This in turn led to intensive use of machinery and high productivity of labor in the United States. As Figure 5.12 shows, the result was a long-term tendency for India's productivity to fall further and further behind that of the United States.

5.4.9 Relative exploitation

Marx distinguished two forms of exploitation: absolute and relative. In absolute exploitation, which he called absolute surplus value, the workers are forced to work longer hours. He described working 12 or 14 hours a day in British factories in the early nineteenth century.[86] In relative exploitation, although the working day stays the same, the proportion of it going to the employer rises because of technical advances.

The mechanism here is not the same as the profit of first use described earlier. That is a transitory phenomenon and involved a redistribution of profit between competing firms. A general increase in exploitation requires that the proportion of total social labor making goods consumed by workers falls while the proportion making goods that go to the employing class rises. Clearly, if the average labor cost markup, in the sense of Section 5.1, is 200 percent, and if there is a general proportionality between prices and labor content, then half of social labor would be devoted to supplying the needs of the workforce and would be surplus.

This change in proportion could come about by simply reducing the living standards of employees so that their total consumption fell, or it could happen because the labor required to produce wage goods had fallen. So labor productivity must rise in the industries producing articles of mass consumption. Not all rises in productivity increase relative exploitation. Higher productivity in factories making Rolls-Royce cars would not contribute to an overall increase in exploitation. It would not reduce the proportion of the labor force necessary to support the working classes. The rate of exploitation would remain the same, even if it meant the rich could now buy more—slightly cheaper—luxury cars.

In contrast, higher productivity in agriculture or oil extraction tends to increase relative exploitation. If food and heating can be had with less labor, fewer millions will be working to grow food for the laboring population. Some of those redeployed from farming may end up making mass-produced consumer goods, but some of them will end up producing luxuries or being employed as personal servants of the rich. The net effect is a shift from labor that supported the direct producers to labor that supports the propertied classes. This was very evident in the big rise in the number of personal servants during the nineteenth century in England.

Something like oil enters directly into working-class consumption, but also, as a source of energy, enters into almost every item of mass consumption. Thus shifts to cheap energy sources have been, along with improvements in agriculture, one of the main sources for the growth of relative surplus value.

It is important to recognize that the relative exploitation mechanism does not depend on the mechanical advances occurring within a capital-labor relation. The big improvement in productivity in French peasant agriculture from the 1950s to the 1970s contributed to relative exploitation there even though the improvements took place on non-capitalist family farms. Any technical advance reducing the labor that goes to sustain the working population counts.

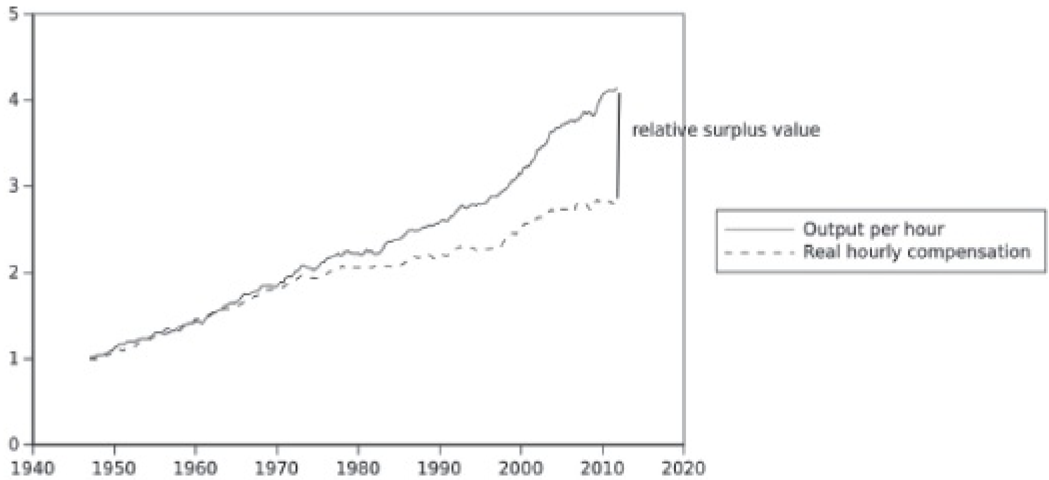


Figure 5.13. Production of relative surplus value in the United States using 1947 as index year. Source: Dataset from Fleck et al., 2011.

Clearly for this mechanism to work, the rate of growth of the real wage must be slower than the rate of technical innovation in the industries producing the real wage. But this consideration lies beyond the development of technology or productive forces. It depends on the relative rates of growth of capital and labor, on demographics and accumulation. However, if we look at Figure 5.13 the conditions in the United States from the late 1960s allowed lots of relative surplus value to be produced. Although productivity rose, very little of that gain went into wages. More and more of the value produced ended up in the hands of the top 1 percent of the population and less in the hands of the lower classes. Indeed if we look at the pretax incomes of the bottom 50 percent of the population of the United States, the bulk of the working classes, we can see that they have remained almost static for half a century (Figure 5.14).

Innovation in the production of consumption goods will thus tend to increase relative exploitation and as a result the total profit per worker will increase. Whether or not the annual rate of profit per £1 of capital advanced will rise is a more complex question that, again, can only be properly understood in the context of the dynamic analysis of accumulation in Section 5.9, which will show that developments in labor productivity do tend to raise the rate of profit.

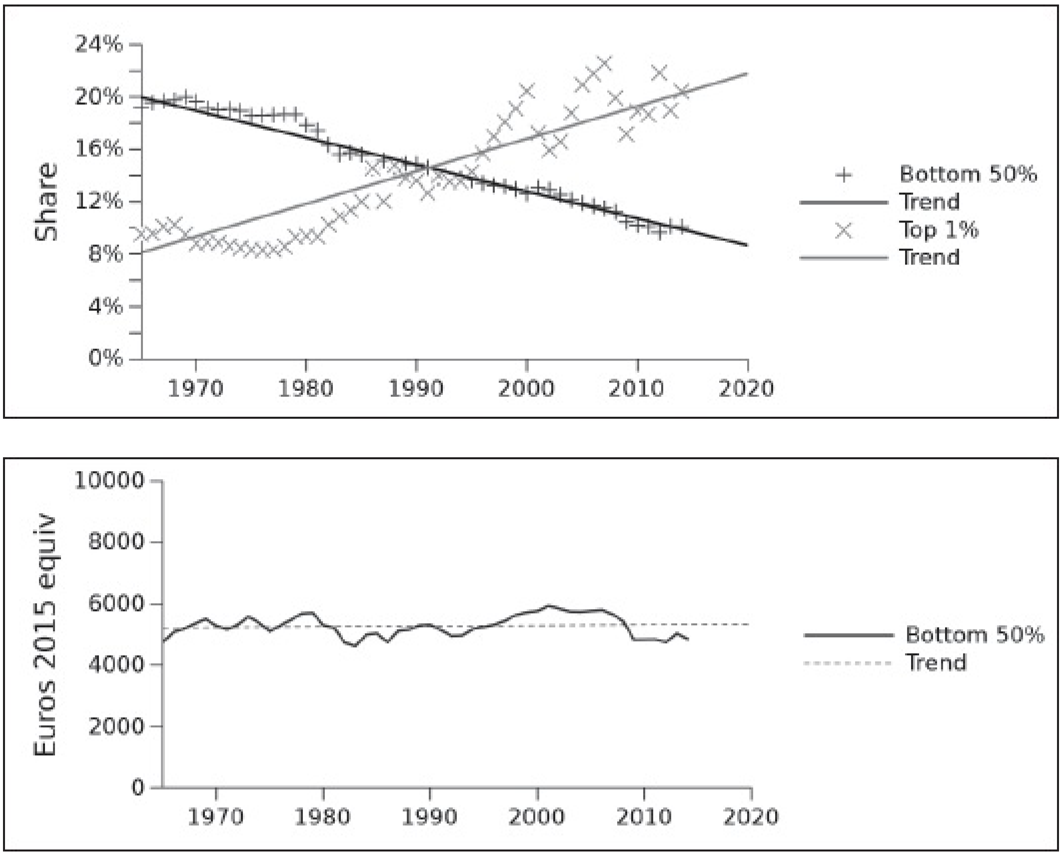


Figure 5.14. Income share and real per capita of the bottom 50 percent of U.S. adults. Source: http://wid.world/data/.

5.4.10 Summary

The argument in Section 5.4 is that powered machinery is essential to capitalism.

- The higher productivity of capitalist machine industry drove independent producers to ruin, and subjected them to the domination of capital.
- This has historically depended on the harnessing of artificial power

along with automatic control mechanisms.

- Competition and the potential profits from innovation encourage technical change.
- But the drive for innovation varies inversely with the existing level of exploitation. The stronger the position of the working classes, the more capital seeks machinery to replace them.

5.5 CAPITALISM AND POPULATION

The first phases of capitalist development are characterized, except in colonies like the United States or Australia, by an abundance of labor relative to capital. If the capitalist system is to fully take hold in the form of machine industry, the growth of capital stock must outrun the growth of the labor supply. It was for this reason that Adam Smith was so keen to emphasize the distinction between productive and unproductive labor. If a man employed a multitude of menial servants, Smith said, he dissipated his capital. If on the other hand he employed workers in manufacture, his capital returned with a profit. Smith emphasized the importance of accumulating and not wasting what Marx would later call surplus value. Smith's polemic was directed at waste occasioned by an idle and profligate aristocracy. Though society was, by modern standards, poor, with relatively primitive technology and a more limited social surplus, productive accumulation and thrift were essential.

This, too, emphasizes the importance of thoroughgoing agrarian revolutions of the French, Russian, or Chinese types. The forcible suppression of unproductive classes of landowners and priests freed resources for industrialization. China in 2006 was reinvesting 50 percent of its total national product in new capital goods. It could never have reached this level of accumulation were it not for an agrarian revolution in the 1940s that stopped the landlords from unproductively consuming the peasants' surplus.

5.5.1 Population, food, and empire

Capitalism is a hyper-urban civilization. The urbanization implies a rise in the labor productivity in agriculture to support the urban population. The historical problem of achieving this was made harder by the fact that in its early phase capitalist societies show a rapid exponential growth in total population. Indeed I will show in Section 5.9 that rapid exponential growth of population is a precondition for the very profitability of capitalism. Simple urbanization, the move of a given population from country to town, only requires a growth in labor productivity on the land, so that each peasant can support several townsfolk. When urbanization is combined with rapid population growth, there must also be an increase in absolute farm production alongside an increase in production per farmer.

How can this increase in total production come about?

Obviously there either has to be an extension of the area of cultivated land or the output per square meter of ground has to go up. With pre-industrial agriculture, that is, agriculture that does not depend extensively on industrial inputs, increases in production from a fixed area of land are dependent on biological processes. Fertility can be raised by more sophisticated crop rotation regimes, and the recycling of human and animal waste. The first process, however, requires that part of the land be set aside for clover, beans, etc., to restore soil nitrogen. The nitrogen fixation is ultimately dependent on a rather indirect energy path: photosynthesis in legume leaves, transport of surplus glucose to the roots where some of it is made available to nitrogen-fixing bacteria, which then use a portion of that energy for their own reproduction and another portion for fixing nitrogen. As such the process of nitrogen fixation requires on the order of one-quarter of the total solar energy being captured on the arable land. Some of this may be recaptured as subsidiary protein foods: pulses or milk from cattle grazed on clover. White [1964] argues that the improved availability of proteins from these sources under feudalism contributed to a healthier and denser population than that achieved under classical agriculture. However, the point remains that natural nitrogen fixation competed for land with grain production.

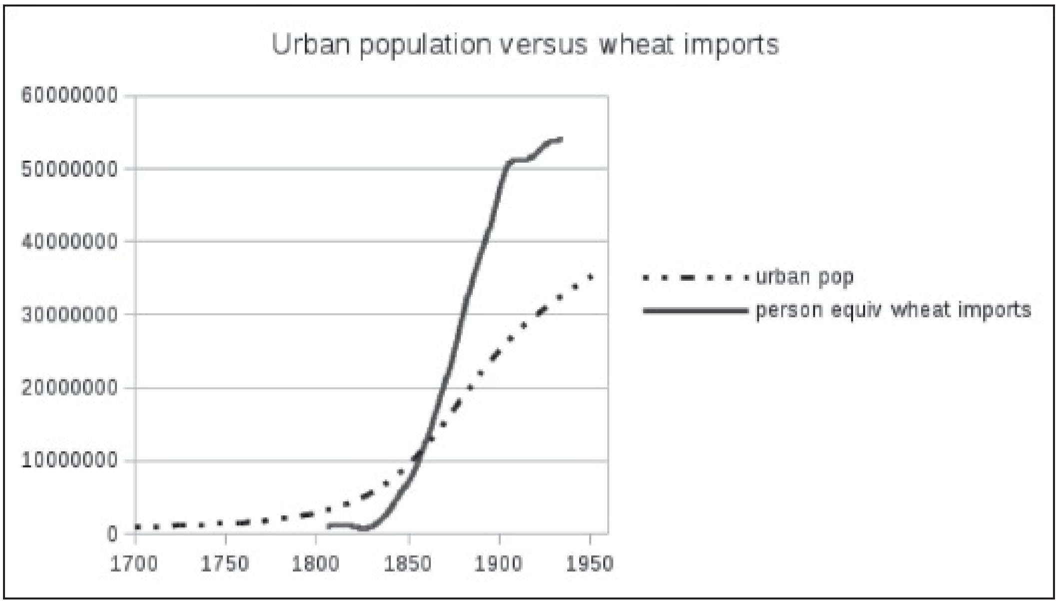


Figure 5.15. British wheat imports, expressed as the number of people they could feed, compared with English urban population. Assumption is that wheat consumption per head would be 100kg per year. Source: Mathias, 2013; and Thompson, 1993, chapter 1.

Chinese pre-capitalist agriculture achieved significantly higher outputs per acre than contemporary European systems, thanks to intensive reuse of human and animal fertilizers, but as Braudel [1992] points out this was achieved at the cost of a great deal of labor; and as a consequence of the high population density, the availability of meat protein was much poorer than in Europe. The lower population density in pre-capitalist Europe allowed more land to be set aside for grazing. This meant both more meat as food, and more animal muscle power to supplement human labor in the fields.

Prior to the tractor, raising labor productivity on the land depended on harnessing horses and oxen. Nineteenth-century agricultural machinery was designed to be horse-drawn, but horses compete for land. They need grazing and, when working intensively, require forage grains like oats. So pre-industrial agriculture depended on using part of the photosynthetic energy for nitrogen fixation, and part to provide animal motive power. The greater the labor efficiency of the system, the greater the proportion of the captured solar energy that was diverted from human food. The combination of an exponential population growth and a mode of production in agriculture that combined high labor productivity with animal power could only be achieved by:

- Territorial expansion into previously uncultivated lands.
- The development of improved means of transport to bring grain from these marches to the great cities.

Thus the nascent capitalist mode of production was inevitably imperialist. It evaded the Malthusian dilemma by extirpating the native inhabitants of the North American prairies and the Argentine pampas to feed the burgeoning cities of England and New England. As Figure 5.15 shows, by the 1850s Britain was already importing sufficient wheat to feed the entire urban population of England. In the next 75 years the urban population grew threefold, but wheat imports outstripped this. Canals, railways, and clipper ships became vital means of food production. By 1900 other growing capitalist powers were justifiably convinced that industrial development depended on the acquisition of colonies [Fischer, 1967; Fischer and Fletcher, 1986]. The future seemed to lie with those great empires that dominated temperate agricultural plains: Britain, the United States, and Russia. Without empires of their own to supply food imports and, by colonial emigration, to relieve the population pressures of early capitalism, industrial developments in Germany and Japan were, it seemed, bound to falter. So began a period of inter-imperialist rivalry that tore the world for half a century and gave birth to a German project to replicate on the steppes the extirpation and colonization already achieved on the prairies.

It is a mistake to see this colonial rivalry as just arising from the relations of production, from the need to export capital, as presented in the classical Marxian critique of imperialism [Lenin, 1999; Bukharin, 1976]. This played a part, but colonialism had deeper roots. Its roots extended down to the actual mode of material production out in the fields; roots in bio-energetics; and in the specific demography of capitalist industrialization.

After 1945 the drive for agricultural colonies died out. Capitalism in Germany and Japan could now, apparently, prosper without them. Why this change?

Three things are the answer: birth control, the Haber process for ammonia production, and tractors. The first slowed population growth. Artificial nitrogen fertilizer freed agriculture from the constraints of crop rotations. Tractors meant that labor productivity on the land no longer depended on setting aside land to feed horses. Agricultural productivity in

Europe rose to levels at which grain colonies became redundant. By the late twentieth century even England grew enough wheat to feed itself. A major change in geopolitics was driven by changes in the underlying mode of production and population dynamics.

5.5.2 Family and population

In all countries capitalism coexists with, or better articulates with, the domestic or household economy. Sahlins [1972] developed the concept of the domestic mode of production to describe early economies, and Delphy [1980; Delphy and Leonard, 1984] develops the concept of the coexistence of the domestic way of making things with capitalism in her studies of French patriarchal families, particularly peasant families. The idea of the domestic mode of production or domestic economy is examined in greater depth by the Marxist anthropologist Claude Meillassoux [1981] who says:

> Neither feudalism, nor slavery, even less capitalism, know such regulating and correcting built-in mechanisms governing the process of reproduction. On the contrary, in the last analysis, we find that all modern modes of production, all classes of societies depend, for the supply of labor-power, on the domestic community. As for capitalism, it depends both on the domestic communities of the colonized countries and on its modem transformation, the family, which still maintains its reproductive functions although deprived of its productive ones. From this point of view, the domestic relations of production can be considered as the organic basis of feudalism, slavery as well as capitalism or bureaucratic socialism. None of these forms of social organization can be said to represent an integrated mode of production to the extent that they are not based on homogeneous relations of production and of reproduction. (xiii)

Domestic production in the feudal period was the real base of the economy. Peasant households grew food, milled grain, cooked it, spun wool, wove it, and out of this fed themselves, clothed themselves, and raised the next generation. Since this could typically be done in, say, three days' labor a week, that left three other days during which they could work, unpaid, in the manorial economy. With the liberation of the peasantry in France from feudal dues, the surplus time could be devoted to producing cash crops to sell on the market.

Inside the domestic economy there is, Delphy argues, a class antagonism between patriarchs on the one side and on the other side wives and to an extent older children. The patriarchs exploit their wives and children. The wives and children provide labor that yields goods that are partly consumed on the farms, and partly sold on the market. The property relations ensure that the product from the sales of these commodities belong to the male head of household. In addition, the patriarchs typically did fewer hours' work a week than their wives. This is not from a historical materialist standpoint of *women's oppression*, which is too liberal and vague. It is an exploitative class relationship built into the production and property relations.

In the stage of patriarchal commodity production, the patriarchs have a direct interest in their wives bearing children. Children, in a period before compulsory schooling, are an additional labor force to be exploited on the farm from an early age. The pro-natalist ideology of Catholicism, with its accompanying emphasis on premarital chastity for girls, is a pretty direct ideological expression of these production relations.

As capitalist industry developed the number of use values produced within the domestic economy started to decline. First to go was milling as water and windmills replaced querns. This was well underway in the late feudal period. Next, spinning and weaving as factory production of cloth took over by the mid-nineteenth century. Home manufacture of clothes, extended by home sewing machines, lasted until the mid-twentieth century. But production of people continued unabated. So much so that the domestic economy characteristically produced a surplus population that migrated to towns to become wage workers. This stage constituted Lenin's second economic form: petty commodity–producing peasant farms. It was also the dominant economic form over much of the U.S. countryside at the same period.

Expanding capitalist industry required an ever greater labor force, and got it cheap. The wage rate paid did not have to be sufficient to fully recompense the cost of reproducing the next generation, since the patriarchal domestic economy was the main source of supply of labor. This is still the case in India, for example.

Marx termed the supply of workers from the countryside the latent reserve army of labor. Latent, because the reserve population was hidden but present, to be called to the colors when the industrial cycle goes through an expansionary phase. But this latent reserve army eventually dries up. Once the latent reserve starts to be exhausted real wages have to rise to fully cover the cost of reproducing labor power. Kuczynski [1946] argued that it was not until almost a century after the start of the Industrial Revolution in Britain that this stage was reached in the 1870s.

5.6 DOMESTIC AND CAPITALIST ECONOMY

Working-class families are a partial transformation of the old domestic economy. They still produce people, but they no longer produce any other commodities, and the children they produce have a quite different economic significance to the family. In the rural patriarchal family the children were, within a few years, useful workers who contributed to the family income. In the first phase of industrialization, families would hire out their children as young factory workers. But soon capitalist industry required an educated workforce. Compulsory schooling followed. Children now became a cost not an asset. The work of child-rearing lasts longer, without the income in kind or cash that kids once brought.

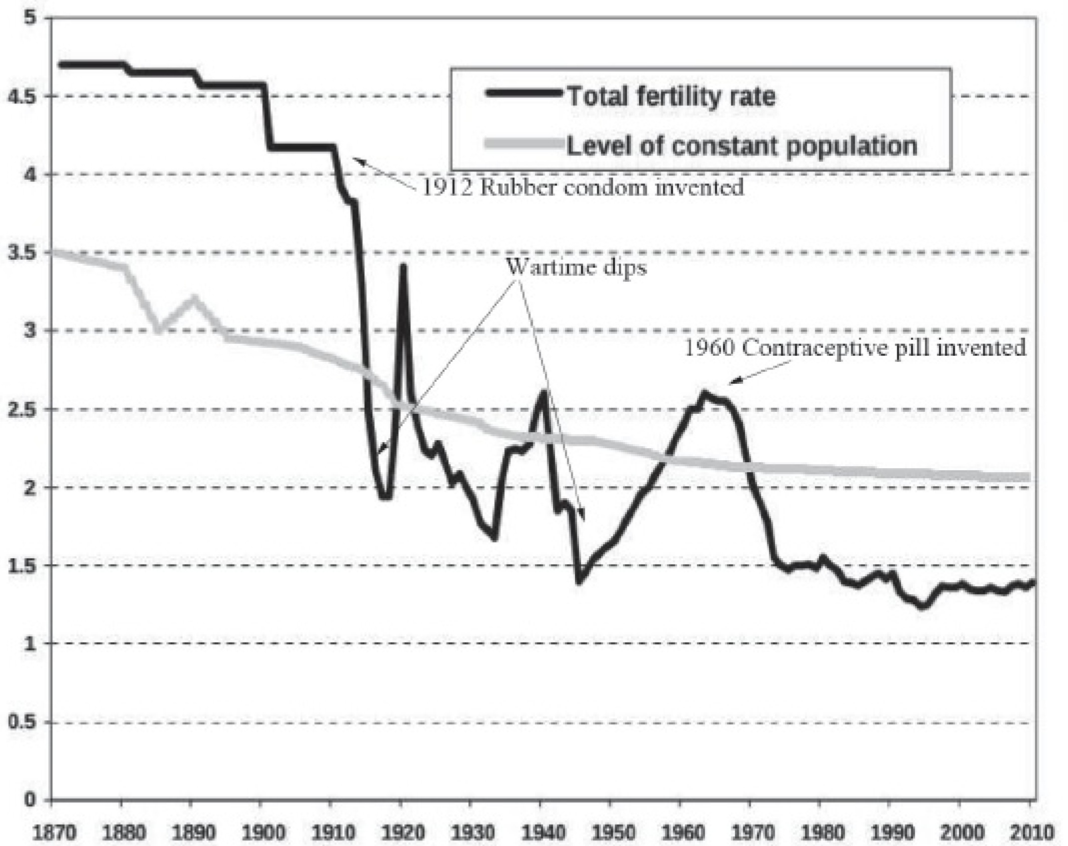


Figure 5.16. Characteristic capitalist law of population. Developed

capitalism suppresses fertility below reproduction requirements as shown in this historical trend of German birth rate. Source: Michael J. Kendzia, 2012.

Children remain necessary to society, and as a future source of labor power they are an obvious necessity for employers, but the family now raises them in what amounts more to a social duty conditioned by ideological expectations rather than an internal economic necessity. The inevitable consequence of this has been a decline in family size, a falling birth rate. As Figure 5.16, shows, the tendency is for birth rate to fall below reproduction levels. Similar trends exist for other developed countries. Capitalist countries like the United States, with substantial immigration from predominantly agricultural countries, show higher fertility due to the delayed transformation of family forms.

In patriarchal domestic economy the labor of wives and children are directly exploited by the husband. Their labor contributed directly to his property. The development of capitalist society gives women equal rights to property and eliminates most of the productive activity in the household. Both sexes are now forced to sell their labor power, something that neither did in the old patriarchal family. For both sexes the working day is divided into working hours they sell to an employer, and hours they continue to work in the domestic economy. If we take Canada as an example—it publishes excellent statistics on time use—we can see in Table 5.11 that while total working hours for men and women are almost exactly the same, the way these hours divide between work in the domestic and market economies are in reciprocal proportions for men and women. For men it divides 3:2 in favor of the market economy, whereas for women the ratio market/ domestic is only 2:3. The important thing to note, however, is that while we would conventionally say that Canada is a capitalist economy, the time-use statistics show that it is only at most 50 percent capitalist. Half the work done each day is still done in the home, and a significant part of the paid work, particularly that done by women [Morissette et al., 2013], is done for the state not for private firms, and as such generates no profit.

5.6.1 Gender pay inequality

Now let us look at how the interaction of the domestic and capitalist modes of production affects the position of women in paid employment.

In 2005, the year that Table 5.11 covers, average male hourly pay was $23.41 and average female pay was $19.96 [Morissette et al., 2013]. Taking into account the difference in hours worked that means that on average a Canadian woman earned only a little over half as much money per day as men (Table 5.12).

It is obvious that the biggest factor affecting daily earnings of women was the shorter number of hours for which they sold their labor power. But that left a gap in pay rates to explain. Let us take what a prominent organization speaking for women says. The Canadian Womens' Association[87] gave the following reasons for the gap:

1. First, traditional "women's work" pays less than traditional "men's work." As one researcher notes: "Female-dominated job classes are often seen as not being skilled because the tasks are related to domestic jobs that women were expected to carry out for free in the home." 2. Second, most women workers are employed in lower-wage occupations and lower-paid industries. Women work in a narrower range of occupations than men and have high representation in the 20 lowest-paid occupations. About two-thirds of the female workforce are concentrated in teaching, nursing, and health care, office and administrative work, and sales and service industries. Women aged 25 to 54 accounted for 22 percent of Canada's minimum-wage workers in 2009, more than double the proportion of men in the same age group.

TABLE 5.11: Time Use of Canadians, Calculated by Sex

	Males hours per day	Females hours per day
Total	24	24
Total Work	7.8	7.9
Paid Work and Related Activities	4.7	3.1
Paid Work for Employer	4.2	2.8
Commuting	0.4	0.3
Unpaid Work in Domestic Economy	2.7	4.2
Household and Related Activities	2.3	3.8
Childcare	0.3	0.5
Civic and Voluntary Activities	0.3	0.4
Education and Related Activities	0.5	0.6
Personal Care	10.4	10.8
Night Sleep	8.2	8.4
Meals (excl. Restaurant Meals)	1	1

Other Personal Activities	1.2	1.4
Free Time	5.7	5.3

Figures averaged over a seven day week, for population age 15 and older. Source: Statistics Canada, *General Social Survey, 2005,* Catalogue no. 12F0080XWE. Last modified: 9/8/2009.

TABLE 5.12: Median Wages in Canada, 2005

	Paid Hours per Day	Pay Rate	Daily Earning
Female	2.8	19.96	55.89
Male	4.2	23.41	98.32

3. Another reason for the wage gap is that more women than men work part-time. About 70 percent of part-time workers in 2013 were women, a proportion that has remained steady for three decades. Women working part-time or temporary jobs are much less likely to receive promotions and training than those in full-time jobs. Women work part-time for several reasons, including lack of affordable child care and family leave policies, along with social pressure to carry the bulk of domestic responsibilities. These factors make it more likely for women to have interruptions in employment, which has a negative effect on income.
4. A large portion of the wage gap remains unexplained and is partly due to discrimination. An estimated 10–15 percent of the wage gap is attributed to gender-based wage discrimination.

This appears as a good surface account of the difference but it begs some questions. Why does traditional women's work pay less? Surely that is just using the gender wage gap to explain the gender wage gap?

The same circular reasoning is present in point 2. If there is a gender wage gap, it follows that any industry with a high proportion of women will have relatively low wages compared to an industry with a high proportion of men. So this is again circular and cannot get to the cause of the gap.

Point 3 is the only real causal explanation, related to the role of women in the domestic economy and a reason why they have difficulty getting out of that economy. Point 4 is merely saying that there is some unexplained difference and that by this definition must be discrimination. But what causes this discrimination? Employers would like to reduce the wages of all employees. The question is why they are more successful in holding down women's wages.

In Figure 5.17 it is clear that the historical trend has been for the wage gap to decline. There was a 20-year period from the mid-1980s during which men's wages were static and during which women's wages rose. We need to explain first why a gap exists at all, and then why the gap has changed with time.

Morissette et al. [2013] examine the change in the gap by doing multi-factorial analysis against union membership, marital status, tenure of job, education, and occupation. Taking all factors into account they could explain about 38 percent of the decline in the wage gap. The three most significant explanatory variables were union membership, educational status, and occupation. Changes in union membership by men and women accounted for 11 percent of the decline in the wage gap (see Table 5.14).

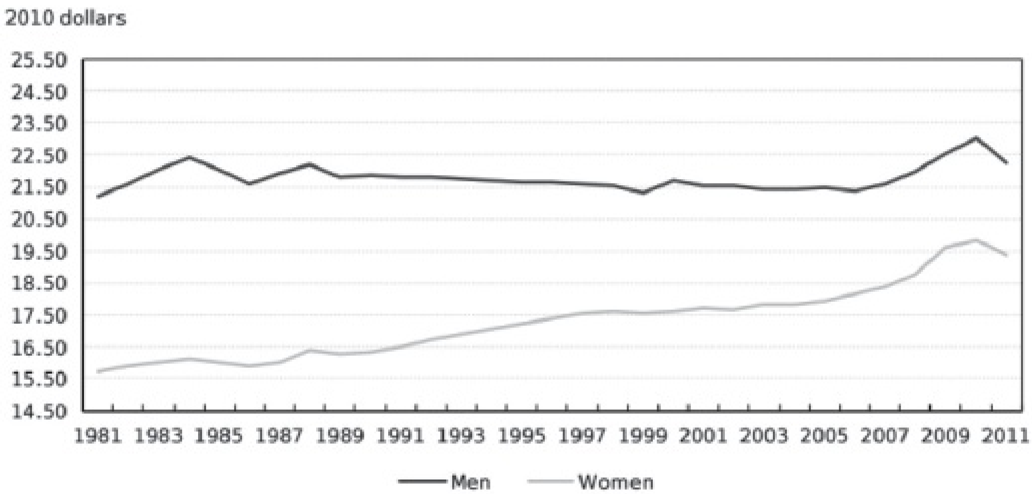


Figure 5.17. Canadian real wages for men and women. Source: Morissette et al., 2013.

Women in Canada are now more unionized and better educated than men, reversing the previous situation. Women typically have been in their job slightly longer than men, again reversing the situation that used to hold. Both men and women are more likely to be employed in health or government services, which have been growth sectors of the economy (Table 5.13).

Morissette et al. [2013] have as summary conclusion:

> Although women today still earn relatively less than men on average, the gender hourly wage gap decreased significantly over the last three decades. Relative to men, women increased their

productivity-enhancing characteristics at a faster pace than men did.

This account depends on the idea that wages are determined by productivity. That is to say it follows the textbook neoclassical idea that wages are set by the marginal product of labor and that the wage contract is an equal non-exploitative one. But even if we accept this, which obviously Marxian economists do not, they are only able to account for 38 percent of the change. They are left with 62 percent unexplained.

TABLE 5.13: Change in Statuses for Men and Women in Canada

Workers Aged 17–64	Men 1998	2011	Change	Women 1998	2011	Change
Average Tenure (mos.)	102.2	99.9	–2.3	94.2	101.3	7.1
% with Univ. Degree	19.4	24.6	5.5	20.4	29.9	9.5
% Unionized	33	29.7	–3.3	31.3	33.1	1.8
% in Health Occupations	1.5	1.9	0.3	8.9	11.7	2.8
% in Occupations in Social Science, Education and Gov't Service	5.2	5.3	0.1	11.2	14.5	3.3

Source: Morissette et al., 2013, table 3.

TABLE 5.14: Explanation of Change in Wage Gap

	Change	Percent of Gap Explained
Age	0.002	-2.8
Education	-0.006	10.5
Province	0.003	-4.6
Union Status	-0.006	11.4
Marital Status	-0.001	1.3
Tenure	-0.004	7.3
Occupation	-0.010	18
Industry	0.002	-2.8
Total Portion Explained	-0.021	38.4
Portion Unexplained	-0.035	61.6

Source: Morissette et al., 2013.

The statistical analysis in Table 5.14 focuses on things where there are only minor differences between men and women and leaves out the one big thing that differentiates them: women's greater participation in the domestic economy.

Now look at Figure 5.18 and compare it with Figure 5.17, and you can see that they look pretty similar. As the women's share of the workforce rises their wage rate as a percentage of men's wages rises. In fact, the correlation between the two series is 90.9 percent. That means that only 9.1 percent of the change in the wage gap needs to be explained by other factors: for instance union membership.

This strongly suggests that should men and women end up working an equal number of hours in Canada the wage gap will either be eliminated or slightly reversed; taking into account women's higher unionization and better education.

5.6.2 Narrowing the wage gap

But what are the obstacles to a higher rate of women participating in the workforce?

The key point is that a set of activities are still performed within the domestic economy, and of these women do more than men (Table 5.11). The domestic economy still organizes a part of the work necessary for social reproduction. This work still needs to get done. Basically there are three ways that women's workload in the home can be reduced: (1) a larger share of housework has to be done by men; (2) the productivity of labor in these tasks has to rise; (3) the same tasks have to move out of the domestic economy.

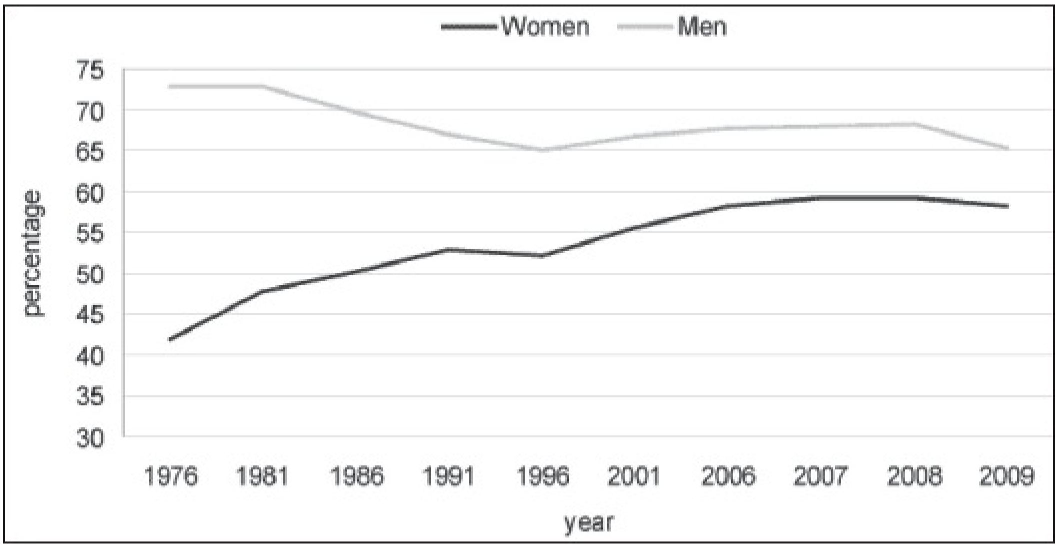


Figure 5.18. Canadian employment rates of women and men, 1976 to 2009. Source: Statistics Canada, Labor Force Survey.

5.6.3 Division of domestic labor

We have been using Canada as an example. Canada and the United States have almost identical figures for the share of housework done by women and both countries are near the top of the world ranking for having the comparatively equal divisions of domestic work between the sexes (Table 5.16). Bianchi et al. [2000] use data from the United States to show that there was a significant fall both in women's share of housework and their absolute hours from 1965 to 1995. Starting at 30 hours a week, unpaid housework by women fell to 17.5 hours, while that of men rose from 4.9 hours to 10 hours. However, it is unclear if this shift is continuing. There was a previous edition of *Time Use of Canadians* in 1998. By comparing it with the 2008 edition we can see if, over a decade, there was a change in the housework done by men and women. As Table 5.15 shows the share of housework done by men did rise modestly over the ten years, but this did not reduce women's housework, since both men and women did more of it.

If women were actually doing more housework in 2008 than in 1998, how did their participation in paid work rise?

Because they worked longer paid hours too! In general, as Figure 5.19 shows, the higher the total amount of unpaid domestic labor shared between the two sexes the more equal the male share of it is likely to be.

TABLE 5.15: Comparison of Hours of Housework in Canada, 1998 and 2008

Year	Men's hours Housework Per Day	Women's Hours Housework Panama	Ratio m/f
	m/f	-	-
1998	2.4	4.1	0.58
2008	2.7	4.2	0.64

So men doing more housework only frees women of it if the total amount of housework remains constant.

5.6.4 Reducing overall housework

Figure 5.19. There is a positive relationship between the average number of hours spent by both sexes in the domestic economy, and the share of unpaid labor done by men. Source: UN Gender Statistics, Time Use database, showing 188 country/year combinations.

At first sight it might seem that an answer to reducing domestic work would be more machinery in the home: washing machines, dishwashers, vacuum cleaners, mowers etc. However, it *is* questionable that these are effective in reducing overall hours spent in housework. Vanek [1974], using U.S. data, reported that over the period during which these sorts of machines became available there was no significant decline in the housework done by women. Subsequent detailed time use study of Australian households has backed this conclusion. The Australian time use surveys collected data not only on time spent on tasks but also what appliances were available in each household. In a multiple regression study drawing on this data Bittman et al. [2004] conclude:

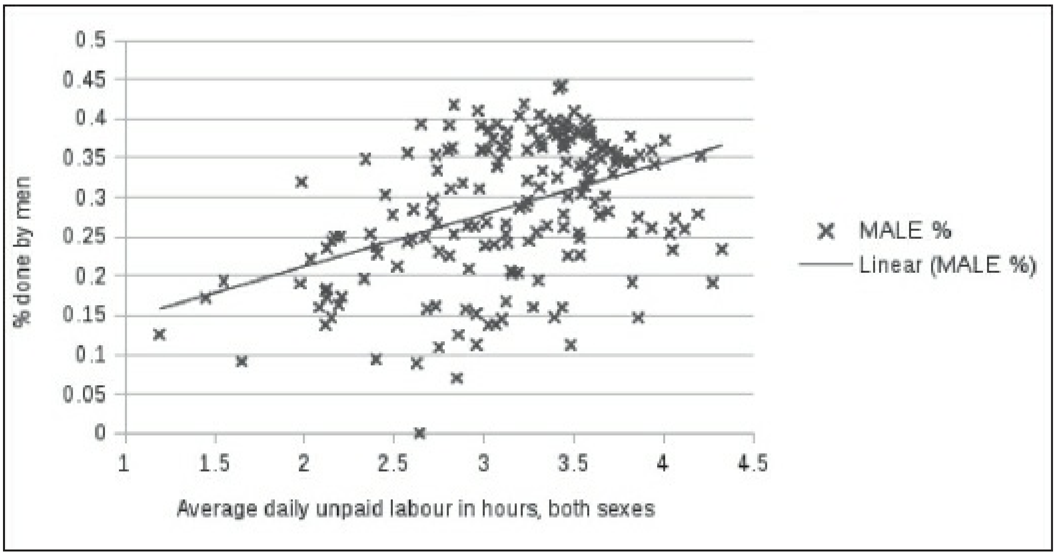


Figure 5.19. There is a positive relationship between the average number of hours spent by both sexes in the domestic economy, and the share of unpaid labor done by men. Source: UN Gender Statistics, Time Use database, showing 188 country/year combinations.

TABLE 5.16: Share of Unpaid Domestic Work Done by Men in Some Countries

	Male Percent of Unpaid Work
HIGHER	
Sweden	44.17%
Canada	39.81%
Estonia	39.30%
Bulgaria	34.28%
MEDIUM	
Lesotho	28.43%
China	28.00%

Peru	27.43%
Israel	26.80%
LOWER	
Tunisia	11.27%
India	9.38%
Cambodia	9.09%
Pakistan	8.89%
Mali	7.02%

Despite its capacity to cook food in a fraction of the time needed by conventional stoves, owning a microwave has no significant effect on the time use patterns of women, even when the number of meals out is held constant. Nor does the deep freezer's ability to harvest the economies of scale in meal production significantly reduce the average time that women devote to meal preparation or to housework overall. While the data does not separate the process of food and drink preparation and the associated meal cleanup, it would seem reasonable to expect that a dishwasher, by reducing the time required for meal cleanup, might lower the overall time spent in the kitchen. Contrary to expectations, however, dishwashers appear to have no significant effect on the time Australian women spend in food or drink preparation and cleanup or in the daily hours devoted to housework.

TABLE 5.17: Relative Rates of Exploitation of Men and Women in Canada, 2011

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Wages	Surplus	(2)/(1) s/v	Av. Wage Male	Av. Wage Female	Av. Both	Av. Value Created
	$766B	$497B	0.65	25.03	$21.85	$23.48	$38.72
s/v				0.55	0.77	0.65	

Note: s/v indicates rate of surplus value. Source: Statistics Canada, income and expenditure tables; Statistics Canada, *Labour Force Survey;* and figure 5.17.

Possible explanations are that the growing availability of machine washing coincided with people owning more clothes, and perhaps greater social pressures toward keeping them spotless. Time saving need not be the motive for buying machines. Dishwashers may be more pleasant than sink washing even if they give little speed-up. The overall conclusion would seem to be that short of general-purpose domestic robots becoming available, domestic machinery will have little further impact on women's labor in the home.

5.6.5 Moving tasks out of the domestic economy

Improvements in labor productivity in industry have in the past depended not only on the use of machinery but also on economies of scale. Greater scale allows greater division of labor and rationalized economical steps. Less labor is used to prepare a burger and fries at McDonald's than if it is made at home, not just because McDonald's has bigger fries fryers and racks to hold burgers, but because the higher throughput allows the intensive use of the equipment. It is the small scale of domestic production that ultimately limits its productivity.

But of course in a market economy people can buy services. They can go out to fast-food joints instead of eating at home. They can send their infants to preschool instead of looking after them all day themselves. If they are rich enough in the UK, they send older children off to boarding schools as soon as the kids turn seven. The rich hire housekeepers to clean, send clothes out to laundry, etc.

These services are available as commodities but who can afford them?

For a task to move out of the domestic economy, the hourly wage earned by the lowest-paid family member must be enough to purchase goods or services that could otherwise have been done within the household in one hour. Thus if a family has one child under school age, they can only afford to buy childcare if one hour of childcare costs less than the lowest-paid person in the house, usually a woman, earns in an hour.

But the childcare, if provided by a profit-making business, will sell at the full value of the service. That is, the childcare fee will include wages, profits, rent on the building, heating, etc. Suppose that the salary of the childcare worker is \$16 an hour, that a further \$12 goes in profit and rent, and \$4 in other overheads. Then if each childcare worker can look after three children the overall cost per hour will be on the order of \$11. At this level it would not be worthwhile for a worker who was herself on \$16 an hour to put a child into care since, allowing for tax deductions, travel costs, she would have almost nothing left over. If two children had to be put into care, it would be impossible.

It is no surprise then that private childcare has initially been only affordable by households on higher wage rates. But this is clearly irrational from the standpoint of economizing on social labor. A single child at home ties up one adult. A single child in a kindergarten ties up only one-third of an adult. But since workers only get part of the value they create back in wages, something that would be socially efficient becomes privately unaffordable.

There is a feedback mechanism here. So long as women are disproportionately tied to home childcare, their participation in the labor force is lower, and we have seen that this results in lower average wages for women. But this lower pay rate makes childcare unaffordable and ensures that it is women, not men, who are likely to stay at home. The elimination of a gender pay gap thus depends, at a minimum, on the socialization of childcare. The socialization of infant care, its move out of the household, is thus dependent on the provision of either free state nurseries or highly subsidized private ones.

We will return to this topic in chapter 7.

5.7 DISTRIBUTION OF WAGE RATES

But behind the question of gender differences in wages is a bigger question. What determines the distribution of wages in general? For there is not just a single male and female wage. For men and women there are spreads of pay rates. Figure 5.17 shows a line for men’s wages and a line for women’s. But these are the median lines, as many men’s wages fall below the male median line as lie above it.

In Figure 5.20 there are two lines, one for male and one for female wages, but these represent cumulative distribution. The horizontal axis is wage levels and the vertical axis measures the fraction of people earning less than a given wage. The horizontal lines represent 10 percent, 25 percent, and 50 percent of the respective gender. The circles and triangles represent raw data from the U.S. Bureau of Labor Statistics for the first quarter of 2016.

The shape of the curve fitted to the data is what is called a log normal cumulative distribution. What does this mean? Well, readers will be familiar with the bell curve–shaped normal distribution. A normal distribution is one of the most commonly occurring in statistics. You get it where a measurement is the result of a collection of randomly operating causes that add together.

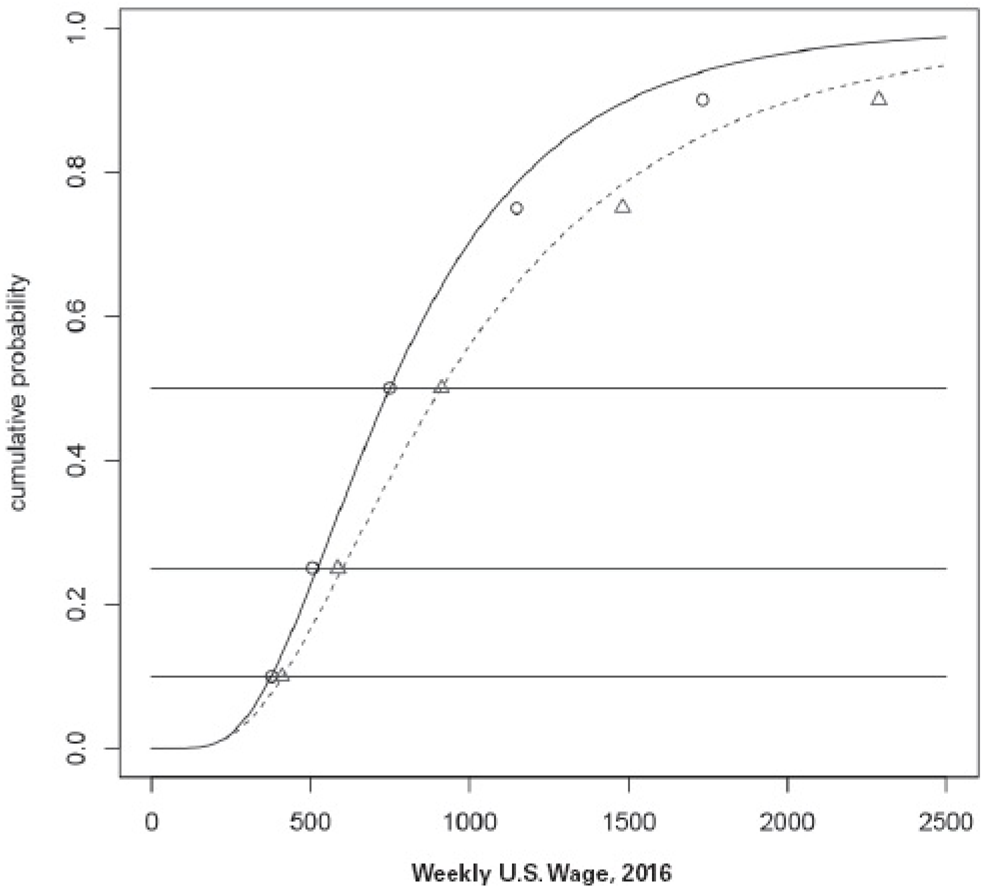


Figure 5.20. Distribution of weekly wage rates for the United States, 2016, fits for the bottom half of the distribution a log-normal curve. The solid line is a log-normal distribution fitted to the median and lowest decile of female wages, the dotted line is a log-normal curve fitted to the median and lowest decile of male wages. Note that for the third quartile and ninth decile the empirical distribution is shifted to the right compared to a log-normal form. Source: Bureau of Labor Statistics, Usual Weekly Earnings of Wage and Salary Earners, April 19, 2016.

If we consider the wages of every person in the United States during a particular week, these wages will be affected by all sorts of factors, which, if we select someone at random that person will seem random. The gender, the job they do, how long they have done it, their age, the region of the country they live in, whether they had days sick that week—the list of factors is vast. Should we therefore expect wage rates to be normally distributed?

A little thought tells us that wage rates cannot be distributed this way. The normal distribution is symmetrical about the average. The average value occurs in the middle as the most frequently occurring value. It then spreads out on either side. Suppose the average weekly wage is $900. We know that there are plenty of people who earn more than twice the average wage, more than $1,800 in this case. Suppose 10 percent of people earn more than $1,800, or $900 above the average. If wages were normally distributed, the same number of people would have to earn less than $900 below the average, that is to say less than 0 dollars. There would have to be significant fraction of people earning *negative* wages. But we know this does not happen.

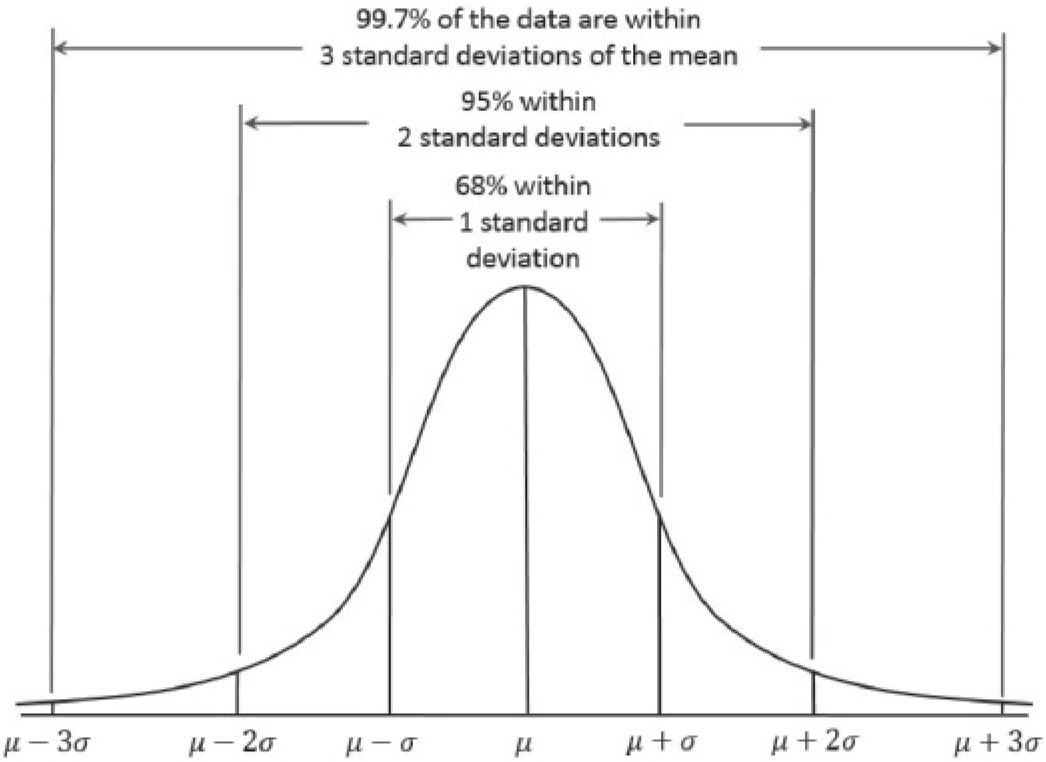


Figure 5.21. Classical normal distribution in which μ is the mean of the distribution. Source: Dan Kernler.

It is not logically impossible for wages to have a normal distribution. If the distribution of wage rates was very narrow, so that with a mean of $900 the standard deviation was, say, only $100, then the probability of anyone earning either twice the mean wage, or less than nothing, would be vanishingly small. It is an empirical fact that wage dispersions are much bigger than this in the upward direction, which precludes the distribution being normal.

While a normal distribution is generated by random processes that are additive, processes in which random factors are multiplied together have a log normal distribution. That is, if you plot the factor you are measuring on a logarithmic scale, the frequency curve you get is the familiar bell shape.

The point is that multiplication on normal numbers becomes addition of their logarithms and so gives a bell curve when we plot it on a log scale. Suppose that some of the factors I described as working on wages actually work in a multiplicative way. If mean wages are multiplied by 0.8 if you are a woman and by a further 0.85 if you are black, 1.2 if you have a degree etc., etc., then you would expect the distribution to be log normal.

Mandelbrot [1962], whose research into fractals later won him fame, observed that the lower part of income distributions is well described by a log normal function while the upper part has what is termed a power law distribution, that is, there are more people on higher incomes than a log normal distribution would predict. We will not discuss the problems of the upper income distribution, which includes property and managerial income here, but it is examined in some detail in Cottrell et al. [2009].[88] Figure 5.20 bears out Mandelbrot's observation. All of the first decile, first quartile, and the median for male and female wages fall nicely on log normal curves, but the third quartile and the ninth decile indicate that the right tail of the distribution is flatter than log normal.

The key things we need to determine for wages are:

- What is the mean wage
- What is the median wage
- What is the spread or standard deviation of the distribution
- Can these arguments be used to account for the difference in male and female workers' wages

Given the standard deviation of the distribution and its mean, the median will be determined, so in essence we have to understand what drives these two parameters. For a log normal distribution the mean wage should be somewhat above the median wage, which is what we always observe.

In a fundamentally chaotic system like a market economy we should expect random processes to spread out the wage distribution until some constraint sets a bound on its spread. It has long been known that there is a lower limit to the wage distribution: a subsistence minimum.[89] That this is not some outdated nineteenth-century concept is borne out by the statistics that show that at the tail end of the income distribution even in a rich country like the United States many families go hungry. Coleman-Jensen et al. [2015] state that 8.4 percent of American households have low food security and 5.6 percent very low food security. Overall 48 million people in the United States were food insecure in 2014. People on wages that put them in the low food security category have a wage that is not enough to survive on without federal or charitable food aid.

Households classified as having low food security have reported multiple indications of food acquisition problems and reduced diet quality, but typically have reported few, if any, indications of reduced food intake. Those classified as having very low food security have reported multiple indications of reduced food intake and disrupted eating patterns due to inadequate resources for food. In most, but not all, households with very low food security, the survey respondent reported that he or she was hungry at some time during the year but did not eat because there was not enough money for food.

- 96 percent reported that they had eaten less than they felt they should because there was not enough money for food.
- 69 percent reported that they had been hungry but did not eat because they could not afford enough food.
- 45 percent reported having lost weight because they did not have enough money for food.
- 30 percent reported that an adult did not eat for a whole day because there was not enough money for food. [Ibid.]

The category that is now called very low food security used to be simply described in the statistics as "hunger," but the U.S. government now uses a euphemism for the same thing. But as Table 5.18 shows, hunger, far from declining as the United States gets richer, has been increasing.

Bear in mind that the wage in dollars necessary to feed oneself will vary between countries and in terms of mode of life. If a person is still in a position to grow some food of his own, that obviously makes a difference. If a person can collect firewood or other fuel, he needs less cash to live on than a city dweller who can only cook with electricity. In addition, part of the wage goes to housing costs, which vary enormously between high-rent cities and poor rural areas. A wage that allows people to feed themselves in the countryside can leave them hungry in a city. The subsistence minimum sets the lowest wage, but what then sets the average wage?

Any chaotic system will tend to increase in entropy until it hits some constraint. For distributions like the normal or log normal ones, an increase in entropy involves a rise in the variance, a spreading out of the curve. But if the left-hand lower limit of the curve is fixed by the minimum subsistence wage, a spreading out necessarily increases the average wage. What stops this entropic pressure?

TABLE 5.18: Trends in Prevalence Rates of Food Insecurity and Very Low Food Security (Hunger) in U.S. Households, 1995–2014

	Food Insecurity % of Households	Very Low Food Security % of Households
1995	11.94	4.14
2000	10.47	3.13
2005	11.00	3.87
2010	14.51	5.35
2011	14.94	5.72
2012	14.51	5.72
2013	14.28	5.58
2014	14.05	5.59

Source: Coleman-Jensen, et al., 2015.

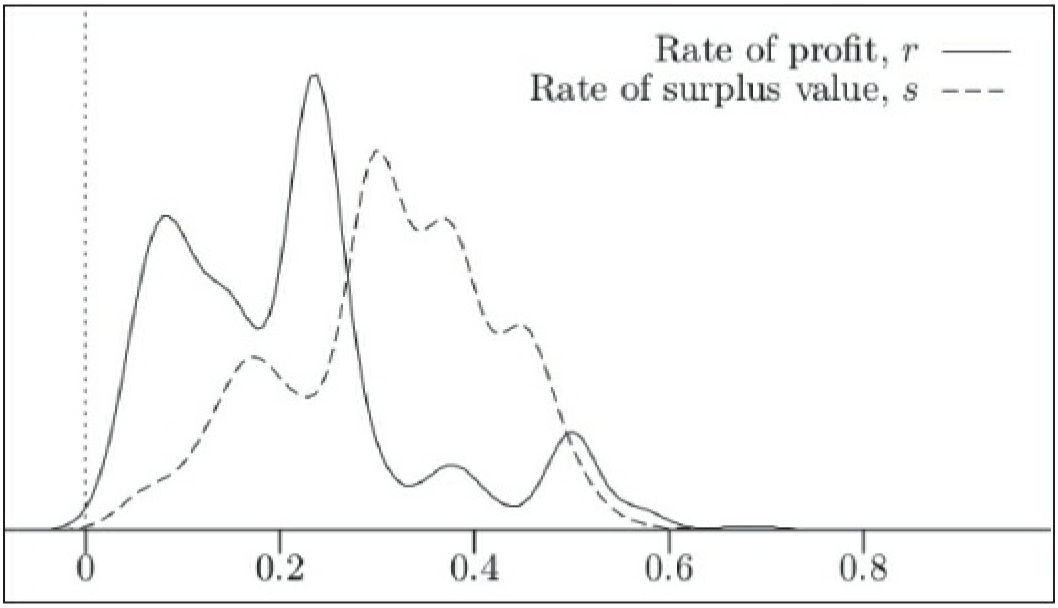


Figure 5.22. Probability density functions for the rates of profit and surplus value in Britain, 1984. Source: Cockshott and Cottrell, 1998a.

Clearly the process must ultimately be bound by the added value produced by labor. The mean wage cannot be higher than the mean value added by labor; indeed, so long as capitalism persists it must fall some way short of that. We know that across the economy as a whole labor adds surplus value that feeds into property incomes. The question we should ask is what stops the average wage from rising so high that surplus value is reduced to a minimal level? Why does surplus value typically make up something between a third and a half of national revenue, rather than only 2 or 3 percent of revenue?

To answer this you have to realize that there is not just a single rate of surplus value in an economy. Like all economic variables it has a distribution. There are different rates of surplus value from firm to firm and from industry to industry. As an example, Figure 5.22 gives the dispersion of rates of surplus value between British industries in 1984. Some producers within an industry are less efficient and use more labor than average. Wages paid also vary by industry and by firm, but the effect of a general upward shift of the wage rate distribution will particularly affect industries and firms with low rates of surplus value.

If you look at the distribution in Figure 5.22 you can see that its lower edge just touches a zero rate of surplus value. A rise in wages will tend to tip the lower tail of firms into the red. We know that only a small portion of firms can be in the red at any one time. Firms making a loss either shut down or lay off staff to end the losses. A shift in the wage distribution of the type shown in Figure 5.20 to the right shifts a surplus value distribution like that in Figure 5.22 to the left.

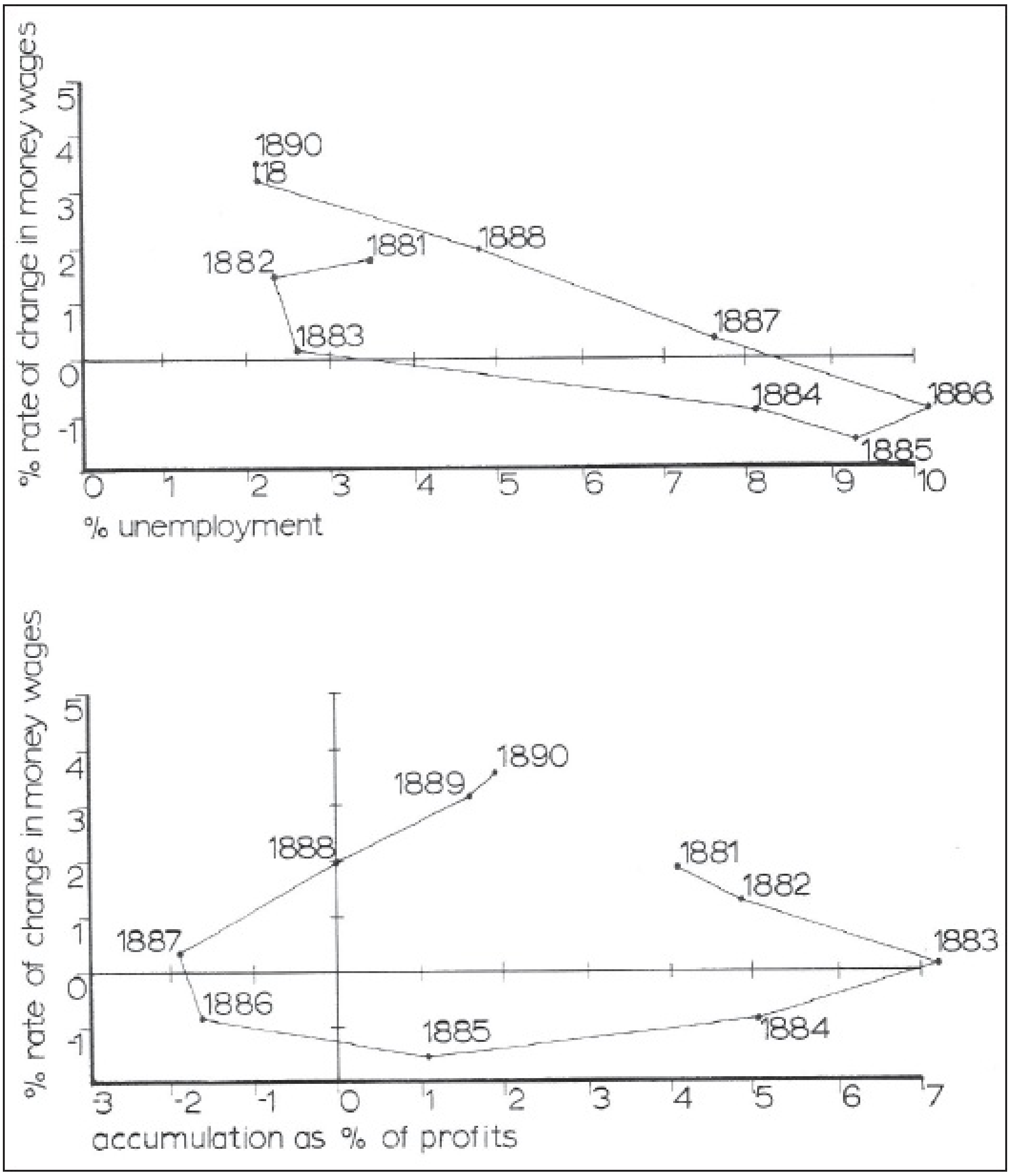


Figure 5.23. The British busiensss cycle, 1881–1890. The above figures show the process for a classical nineteenth-century business cycle, one in a period when the basic mechanism was not obscured by government counter-cyclical policies. These basic cycles took on the order of 7 to 10 years.

If we look at a snapshot picture, it seems that any tendency of the wage distribution to spread out is being prevented by the dispersion of the rate of surplus value. An increase in the variance of the wage rate pushes firms on the lower edge of the surplus value rate distribution into crisis. They lay off workers and the resulting unemployment and competition for jobs forces down wages again.

Snapshot pictures suggest a nice stochastic equilibrium with the dispersion pressure of the rate of surplus value distribution acting to limit the entropic spread of the wage distribution. But that is misleading. The feedback relations are not instantaneous. There is no equilibrium; instead what happens is a cyclical process. Figure 5.23 shows the process for a classical nineteenth-century business cycle, one in a period when the basic mechanism was not obscured by government counter-cyclical policies. These basic cycles took on the order of 7 to 10 years.

Rising wages lead to layoffs, which lead to unemployment, and wages start to fall. Later firms take workers on again at lower wage rates and unemployment falls. With falling unemployment firms have to bid up the price of newly hired labor allowing the wage dispersion to rise. Then the cycle repeats.

There is, however, no reason to suppose that it repeats exactly, so over time the rate of surplus value may wander. Capitalism is an anarchic, disorderly system. State regulation may reduce disorder, but in the absence of such intervention we should assume that the system will show maximal disorder. Is there a rate of surplus value in the economy that corresponds to maximal disorder?

Surprising as it may seem, the most disorderly state of the economy occurs when there is no surplus value. Disorder is measured using the concept of entropy [Shannon, 1948]. The higher the disorder of something the higher its entropy. The idea originated in the study of heat, thermodynamics, but has subsequently been extended to information theory, statistics, and many other areas of science. There is an entropy or disorder involved with statistical distributions like the normal or the log normal

As median wages rise, the entropy of the wage distribution rises. But wage rises reduce the rate of surplus value. For the economy to remain viable, with only a tiny fraction of firms being in the condition of having a negative rate of surplus value, a smaller mean s/v requires the surplus value distribution to become more compressed—to have a smaller variance. A compression of the surplus value distribution makes the conditions of firms more orderly. The firms become more alike in their ratio of wages to profits. Firms in a given industry come to use a more standardized technology. If firms become more alike their entropy must fall. A spread of the wage distribution means that wage disorder rises. Does the disorder of the wages rise faster than the consequential fall in firm disorder?

The answer is yes. Table 5.19 shows that as the mean wage rises, the disorder of the whole system is maximized. So even if we assume that capitalism is in the long run governed by a principle of maximal disorder this would not preclude a long-term rise in the proportion of income going as wages. One could have a sequence of business cycles, each of which resulted in the least competitive firms being forced out of business. When expansion took place again the dispersion of rates of surplus value could be lower allowing a lower overall rate of surplus value. But for this optimistic process to occur it would have to be the case

- That the fall in wages during the downswing was less than the rise in the upswing.
- That no other factors, such as increasing reserve army of labor, forced down wages in the long term.
- That the internal disorder of the firms was not so increased by technical advances as to offset the culling of less productive firms in the crisis.

Since technical change occurs all the time, and occurs unevenly in a competitive capitalist economy, this will set a lower limit on the dispersion of rates of surplus value, and thus on the wage share. The theoretical possibility of wages rising until they consume the entire social product could only happen if there was no disorder among firms—in effect, it demands a comprehensively planned economy not a capitalist one.

In Table 5.19 the minimum, mean, and median wages are given as labor-value fractions of the working day. H(w) is the entropy of the wage distribution, H(s) the entropy of the surplus value distribution. Rising median wages correspond to rising disorder in the whole system, and thus are not prohibited on thermodynamic grounds. Wage distribution assumed to be log normal and surplus value distribution to be normal.

5.8 THE NEXT GENERATION

Let us now return to the issue of the differences in male and female wage distributions. A working hypothesis for what causes this is as follows:

- Male and female wage distributions are both constrained to be log normal.
- Lower bounds of each distribution are almost the same and are set by the survival wage of a single person.

- Slightly higher up is the subsistence minimum wage for a family.
- Since a larger number of men than women are the sole earners in a household, a smaller number of men can be employed at levels below the family subsistence level.

TABLE 5.19: As the Median Wage Rises, the Mean Wage Rises More Rapidly

Minimum Wage	Median Wage	Mean Wage	H(w)	H(s)	H(w)+H(s)
0.1	0.43	0.50	1.63	1.05	2.68
0.1	0.44	0.54	1.77	0.97	2.74
0.1	0.45	0.58	1.91	0.88	2.79
0.1	0.46	0.63	2.06	0.78	2.85
0.1	0.47	0.68	2.23	0.68	2.91
0.1	0.48	0.73	2.39	0.58	2.97
0.1	0.49	0.78	2.57	0.46	3.04
0.1	0.50	0.84	2.76	0.35	3.10
0.1	0.51	0.90	2.95	0.22	3.18
0.1	0.52	0.96	3.16	0.09	3.25

In the table, the minimum, mean, and median wages are given as labor value fractions of the working day. H(w) is the entropy of the wage distribution; H(s) is the entropy of the surplus value distribution. Rising median wages correspond to rising disorder in the whole system and thus are not prohibited on thermodynamic grounds. Wage distribution assumed to be log-normal and surplus value distribution to be normal.

- Thus the standard deviation of the male wage distribution function must be greater.
- Thus the median of the male wage distribution must also be greater.

This is explained slightly more formally in a note.[90] It follows that the male-female wage gap will persist until it is equally probable that either sex is the sole earner of a family. This is compatible with the observation that the wage gap declines in proportion to the decline in the male-female participation rate gap. (See Figures 5.17, 5.18.)

In the past this basic mechanism has been cast in terms of the need of the male wage to be enough to ensure the reproduction of the next generation of workers.[91] But this is a rather teleological argument. The next generation is twenty years in the future, so how is their existence or nonexistence supposed to affect wages today?

The Ricardian law of wages provided a feedback mechanism. It is when it:

> exceeds its natural price that the condition of the laborer is flourishing and happy, that he has it in his power to command a greater proportion of the necessaries and enjoyments of life, and therefore to rear a healthy and numerous family. When, however, by the encouragement that high wages give to the increase of population, the number of laborers is increased, wages again fall to their natural price, and indeed from a reaction sometimes fall below it.
>
> When the market price of labor is below its natural price, the condition of the laborers is most wretched: then poverty deprives them of those comforts which custom renders absolute necessaries. It is only after their privations have reduced their number, or the demand for labor has increased, that the market price of labor will rise to its natural price, and that the laborer will have the moderate comforts which the natural rate of wages will afford. [Ricardo, 1951, chap. 5]

But my formulation, derived from Marx, is not presuming that. I, like Marx, expect the mean wage to be significantly above the subsistence level, and I do not assume that a capitalist society is necessarily able to successfully reproduce its working population. Indeed, the evidence is to the contrary.

All I am assuming is that if the lower limit of wages crosses the narrow boundary between hunger wages and starvation wages, mortality among the workers rises rapidly. Well before wages fall to starvation levels undernutrition results in increased mortality from disease [Harris, 2004]. Capitalist firms and governments have not been stopped by moral scruples from working people to death on starvation wages. In famine relief projects the government of British India worked literally millions to death on public works projects [Davis, 2002], and in the 1940s German firms notoriously did the same with forced foreign labor. It is not morals, but the very rapid death rate of such practices, that makes them unsustainable.

In concluding that this reality forces the lower boundary of the adult male wage up a bit to be above family starvation levels, the only other assumptions necessary are: (a) that families exist, (b) that more men than women are sole breadwinners, and (c) that a great many poor parents will go hungry themselves to put food on their children’s plates.

As a larger portion of the population becomes economically active, that is, employed in the capitalist sector, the share of the surplus product tends to rise. The same population has to be supported, but more workers are there to do it. At the same time, tasks essential to life, like the preparation and cooking of food, move out of the home. Food is semi-prepared before it appears in the supermarkets, clothes are ready-made. As food preparation and clothes preparation moves out of the house, it is done with less labor. The total time necessary for the day-to-day reproduction of the population shrinks while the number of workers grows. In order to get by a mode of life is established that becomes dependent on all adults in the household engaging in waged work. The result is to intensify the perception of child-raising as a burden. Children become seen as a lifestyle choice to be avoided if you cannot afford them. The birth rate falls below reproduction levels, the working population shrinks, and the economy goes into a long-term crisis expressed in declining profitability.

Teleology aside, capitalist economies have relied on coexisting patriarchal and subsistence communities to supply at least part of the next generation of workers. Migrants from the countryside within their boundaries, or colonies without, fed the industrial growth of the great powers. The same process clearly continues. Single migrant labor has the advantage that it can be employed at below a family wage. The cost of bringing up the worker was met by the distant household into which they were born. So capitalism, like slave economy, has long relied on importing labor. In some cases like the coolies imported from China to the Americas in the nineteenth century the social form was only marginally advanced from slavery. But the principle of increasing exploitation by offloading the reproduction costs of labor to surrounding societies remains in force in the metropolitan countries to this day. If this avenue is restricted the form economy goes into structural crisis.

5.9 LONG-TERM TREND OF PROFITABILITY

Capitalism is production for profit. It is run with the aim of monetary gain. This drive may seem far removed from issues of population, but, from the standpoint of political economy, they are closely related. Ultimately, monetary gain is a demographic question. Monetary quantities are determined by labor. They are the abstract symbolic representation of labor relations.[92]

Population growth is the fundamental constraint on profit because population growth constrains labor. Profits are measured in money, but this is only a nominal measure since the value of money changes over time. The real measure of profit, or any other sum of money, is the amount of labor embodied in commodities that it will exchange against. It is of no advantage to a firm if their money profit goes up, but the amount of embodied labor that this commands actually falls.

If we want to ask what, in the long run, and at the level of society as a whole, determines the possibility of making a profit, we concern ourselves with the amount of labor society has, not the amount of money.[93]

We can express the process informally with the following argument. Suppose initially that profits make up 50 percent of net national income and that the capital stock is equal to 200 percent of national income. Now suppose half the profits are reinvested, then the capital stock grows and profit rate will fall, as show in the table on page 173.

This simple process is behind the tendency of the profit rate to fall over time. Understanding the process in more detail requires that we look at how population growth and productivity will affect things. To do this we have to move from an argument in terms of money national income, which is affected by inflation, to one in terms of person years. The total profit in the economy will then be given by

	Year 1	Year 2	Year 3	Year 4
Profit % of National Income	50	50	50	50
Capital Stock as a % of National Income	200	225	250	275
Profit Rate %	25	22	20	18

$$\text{Profit rate} = \frac{\text{Profit}}{\text{Capital stock}}$$

Here the wage share is expressed as the fraction of a full-time equivalent working year required to produce the goods consumed by the average laborer. The dimension of Profit is millions of full-time person years per annum, which is obviously the same as millions of full-time equivalent persons. We can view this as the population that produces those goods purchased out of profits. The reality of profit, behind the screen of money, is the millions of people it commands: the producers of luxury goods, tax advisers, servants plus the people working to produce new capital goods whose wages are paid out of reinvested profit. Capital stock is the accumulation of past labor; it can be accounted for in terms of the working years it took to produce. The rate of profit per annum is then given by the capital stock measured in millions of person years:

$$\text{Profit rate} = \frac{\text{Profit}}{\text{Capital stock}}$$

The dimension of Profit Rate, persons/person-years, is Time^{-1} as we would expect. The profit rate will fall if the rate of growth of capital exceeds the rate of growth of profits, that is to say, if the capital stock grows faster than the population available to produce profit goods.

The main determinant of the rate of growth of the mass of profit will be the growth of the working population. A secondary influence will be any change in the wage share over time. Why is movement of the wage share secondary?

Suppose the working population grows by 5 percent a year. If the wage share remains constant then total profit will also grow by 5 percent. Consider the effect of a reduction in the wage share: if the wage share is initially 0.6 then a 5 percent reduction in the labor content of the real wage will produce a 3 percent increase in the profit rate; but if the initial wage share is merely 40 percent, the same 5 percent reduction in the labor content of the wage will raise the rate of profit by 2 percent. The lower the wage share falls the less significant is the impact a given percent reduction in the wage share.

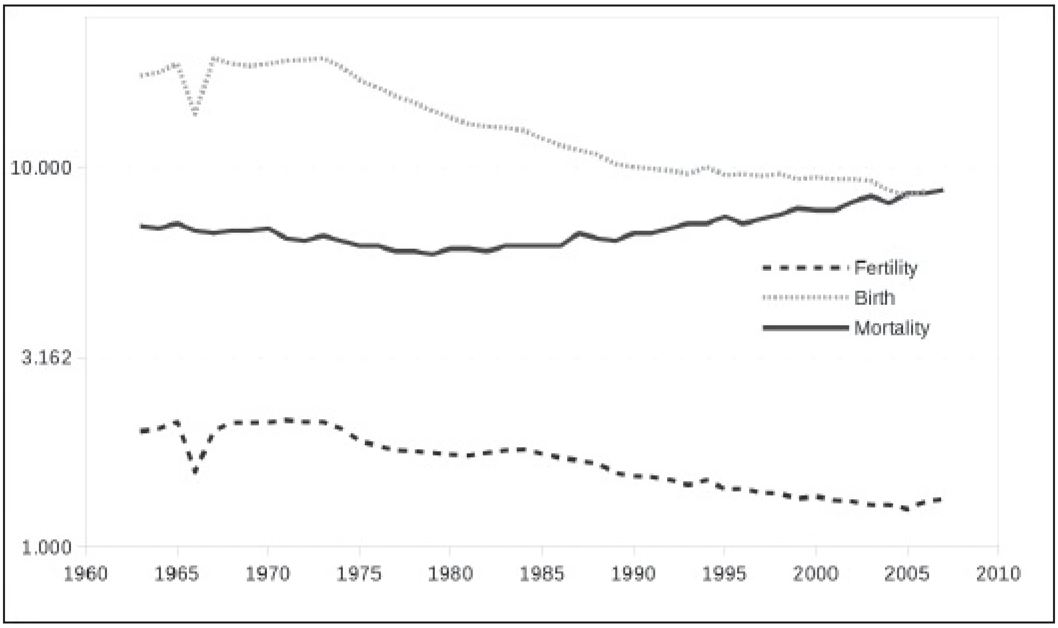


Figure 5.24. Evolution of the birth rate and death rates in Japan. Source: Extended Penn World Tables (EPWT) Marquetti, 2003.

In the long term the rate of change of profit is strongly affected by the rate of growth of the working population:

n = rate of working population growth ≈ rate of profit growth

In the early stages of capitalist development it grows very rapidly. In nineteenth-century Europe this was as a result of improved food supply after the Agricultural Revolution. In the twentieth century the same process was experienced in many third world countries, as a result partly of the Green Revolution, and also as a result of medical advances limiting infant mortality. This phase of rapid population growth is the first demographic transition as societies moved from patriarchal agriculture to capitalist or socialist industrializations.

Later, with the elevation of the social status of women, the abolition of child labor, and with education becoming more costly, family sizes shrink. In highly developed capitalist countries the population stabilizes or even starts to decline, in a second demographic transition. What is the implication of this?

So long as population was expanding there existed the possibility of a positive equilibrium rate of profit so long as capital stock grew no faster than the working population.

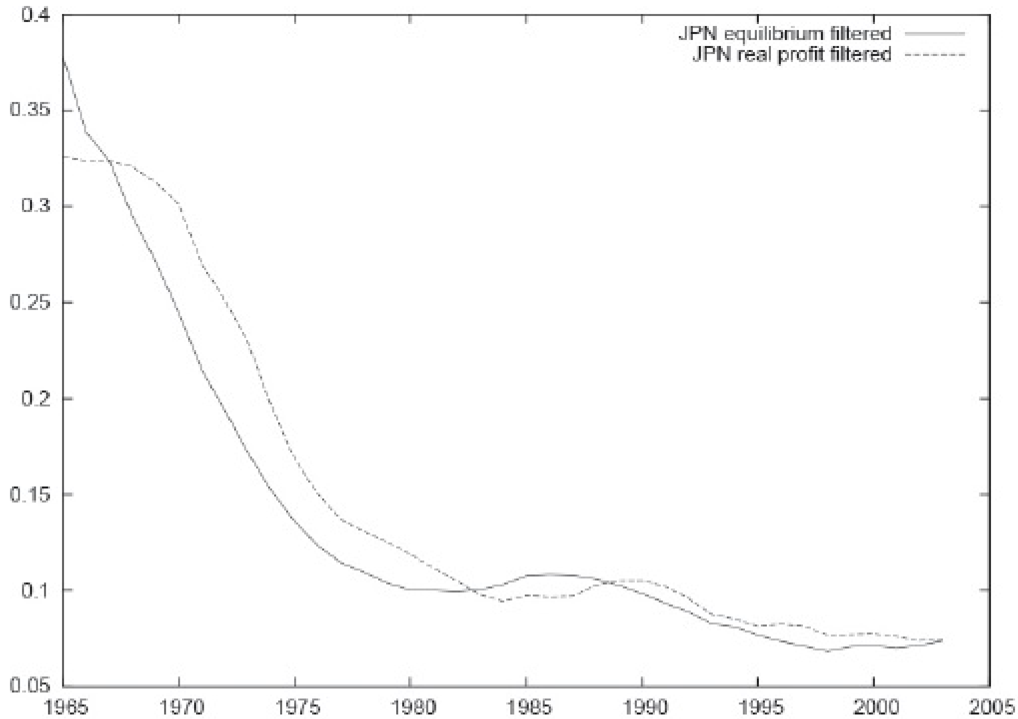


Figure 5.25. Evolution of the actual profit rate and dynamic equilibrium

profit rate in Japan. Source: Image produced by software written by T. Tadjadinov.

The growth rate of capital stock is given by:

$$\begin{array}{r} \text{accumulation share} \times \text{profit rate} \\ \text{growth of labor productivity}\ - \\ \text{depreciation rate}\ - \\ \hline \text{growth rate of capital stock} = \end{array}$$

where the accumulation share is share of profit going as accumulation. The growth of labor productivity(g) has a negative effect since it accelerates the obsolescence of existing capital, as does the rate of depreciation (δ). It follows that the dynamic attractor for the rate of profit, the equilibrium rate of profit is:

$$\text{equilibrium rate of profit} = \frac{n+g+\delta}{\text{accumulation share}}$$

The second most important determinant of the rate of profit is the share of profit that is accumulated.

When a large portion of profit is accumulated this will depress the percent rate of profit. Conversely, if most of profit is consumed unproductively, then the effect is, paradoxically, to raise the rate of profit.

If population stabilizes, n = 0 and the rate of profit falls to a level only sufficient to cover depreciation plus a boost term due to improvement in labor productivity. It is not widely recognized in the media, but the general trend is for technical improvements to slow down over the course of the development of a capitalist economy [Eichengreen et al., 2012; Marquetti, 2003; Edgerton, 2011b]. Economies with stable or falling populations like Japan end up with very low rates of profit as shown in Figure 5.24. The equilibrium profit rate in that graph is r* given above. Note how closely the actual rate tracks the rate predicted on first principles from the labor theory of value. The actual rate of profit tracks the dynamic equilibrium rate after a couple of years delay.

Because of the tendency of the rate of profit to fall, capitalist economic growth does not correlate positively with a high rate of return on capital. A country like Japan with a high investment rate can grow fast, but the effect of the high investment rate is a low rate of return on capital as shown in Figure 5.26. Contrary to expectations high rates of capital return do not correlate with fast growth.

A tendency for the rate of profit to move to zero after the second demographic transition lies behind the ever lower rates of interest in Japan. If the rate of population growth falls to zero, the dynamic equilibrium rate of profit is also zero. If population growth is negative, the attractor for the rate of profit is negative.

A key factor in the stagnation of the Japanese working population is that a declining birth rate—common to many capitalist countries—combines with a policy of strict immigration restriction.

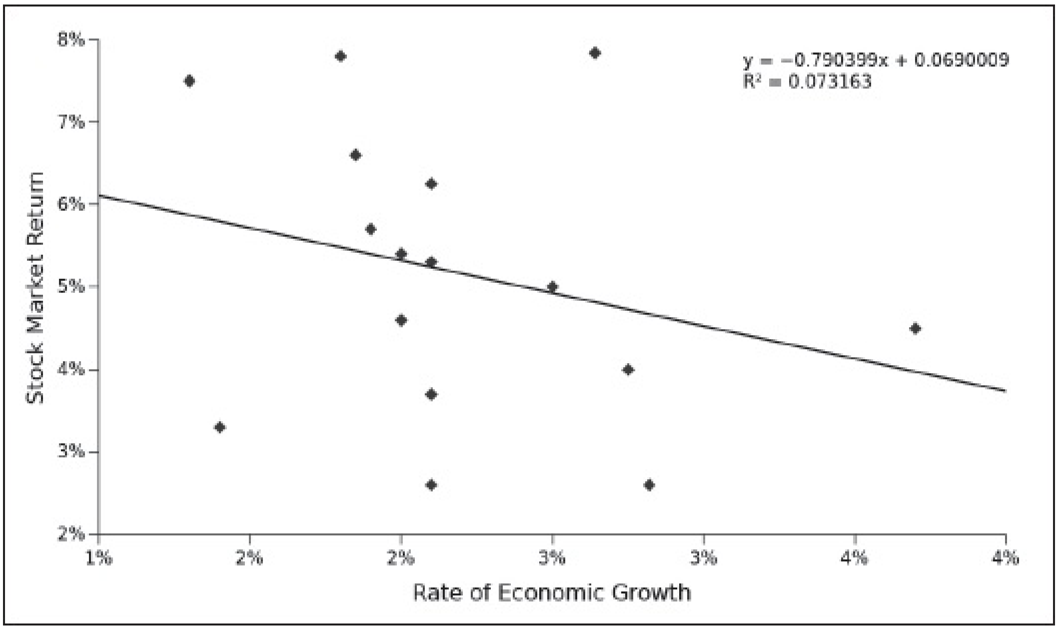


Figure 5.26. Relationship between return on stocks and economic growth for 16 developed nations between 1900 and 2006. Source: Siegel, 2002.

Countries that allow immigration can offset the tendency of the rate of profit to fall to zero. Immigration boosts the working population in three ways:

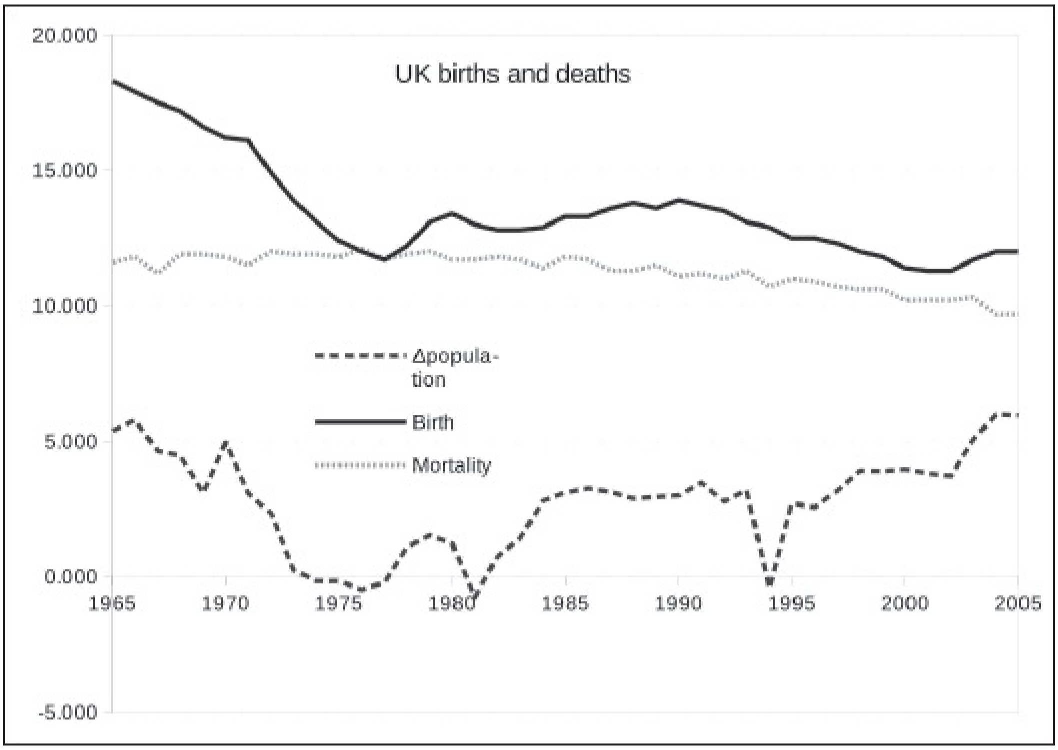
1. It directly and immediately compensates for a low birth rate.
2. The activity rate of immigrants is high because they are disproportionately of working age.
3. Immigrants' families tend to have higher birth rates than the settled population of developed capitalist countries, so that they indirectly compensate for the low birth rate of the former.

The net result of rapid immigration is to raise the rate of exploitation

(Figure 5.28). For the UK between 1970 and 2008 there was a 75 percent correlation between the rate of exploitation and the level of inward migration. Statistically this means that 75 percent of changes in exploitation can be explained by changes in immigration. A high rate of immigration tends to produce a higher rate of exploitation. When we say that 75 percent of changes in exploitation can be explained by changes in immigration, this is in a statistical sense if you correlate one against the other. In practice there are temporal trends in both immigration and exploitation. Both rose from a low in the 1970s. This corresponded to a move toward a general neoliberal policy of freer movement of both labor and capital and restrictions on the rights of trade unions. Figure 5.27, upper panel, shows the growth in immigration from 1976 with a short dip in the early 1980s. The lower panel shows that the equilibrium rate of profit r* starts to rise steadily from 1976 onward, with no interruption. Since changes in the equilibrium profit rate r* are driven mainly by changes in the growth of the workforce and by the accumulation share, we can conclude that the rapid rise in r* from 1978 was due to a slower rate of accumulation combined with the more rapid growth of the labor pool.

The actual rate of profit generally lags the equilibrium rate for the UK as for Japan. It lags because it takes time for the capital stock to adjust in response to changes in accumulation. It also has some independence, in that over the short term changes in the rate of surplus value affect the rate of profit. Changes in the rate of growth of the labor force—the slowdown from 1965 to 1975 and the gradual acceleration from then on, are the single biggest factor explaining the long-term shape of the profit rate curve, with fluctuations in accumulation during the trade cycle explaining the decadal oscillations imposed on that.

Variations in the rate of accumulation affect the equilibrium rate of profit because a fall in accumulation reduces the capital stock over which the rate of profit is calculated. In addition, the real rate of profit can be affected by slower accumulation tending to increase exploitation, as shown in Table 5.20.



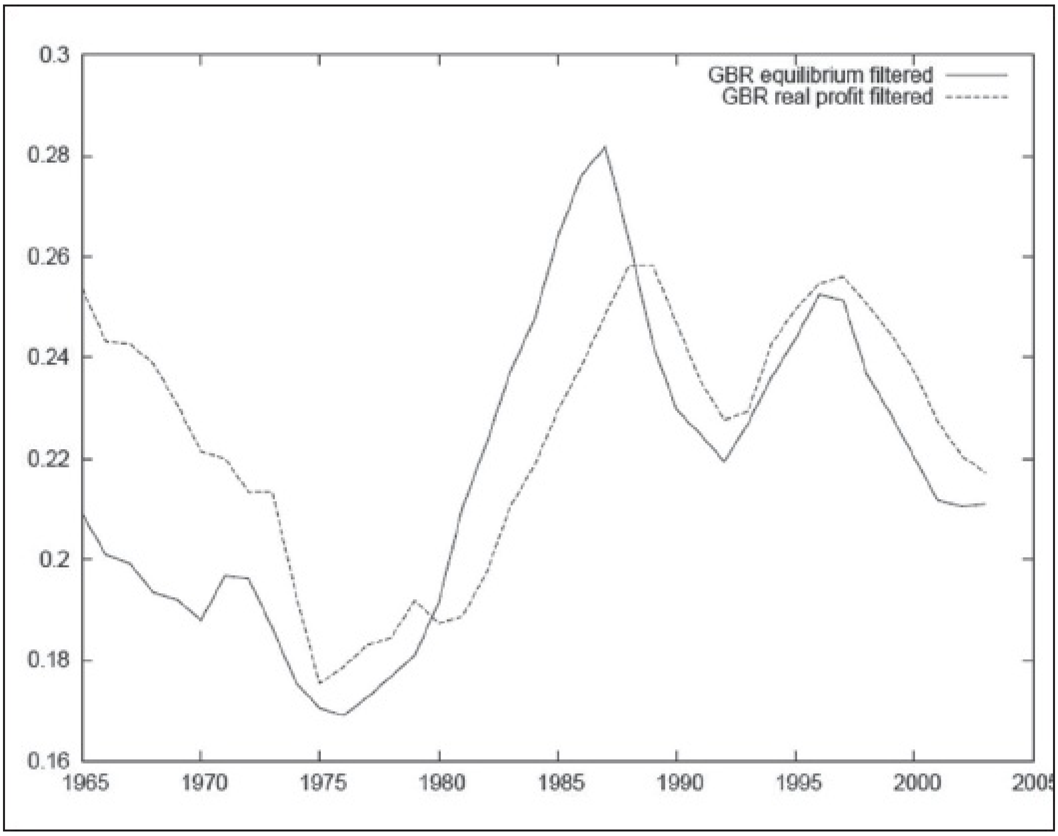


Figure 5.27. Evolution of the population growth (top), actual profit rate and dynamic equilibrium profit rate (bottom) in UK. Source: T. Tadjadinov; Extended Penn World Tables (EPWT), Marquetti and Foley, 2002, ver 4.0.

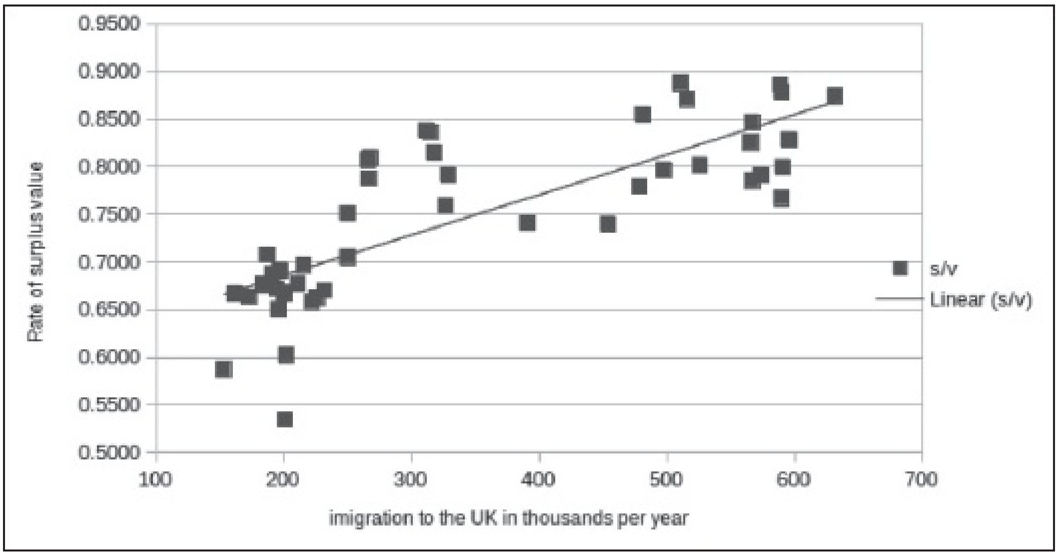


Figure 5.28. UK rate of surplus value as function of immigration levels.

The connection between population growth and real wages was a key component of the classical theory of wages. In this, wages were the sum necessary to reproduce labor. The regulation of wages was seen as occurring via population growth. If wages rose substantially above what was needed to reproduce the existing population, then more children would survive to adulthood and the population would grow. Competition between workers would then work to drive down wages toward the subsistence level.

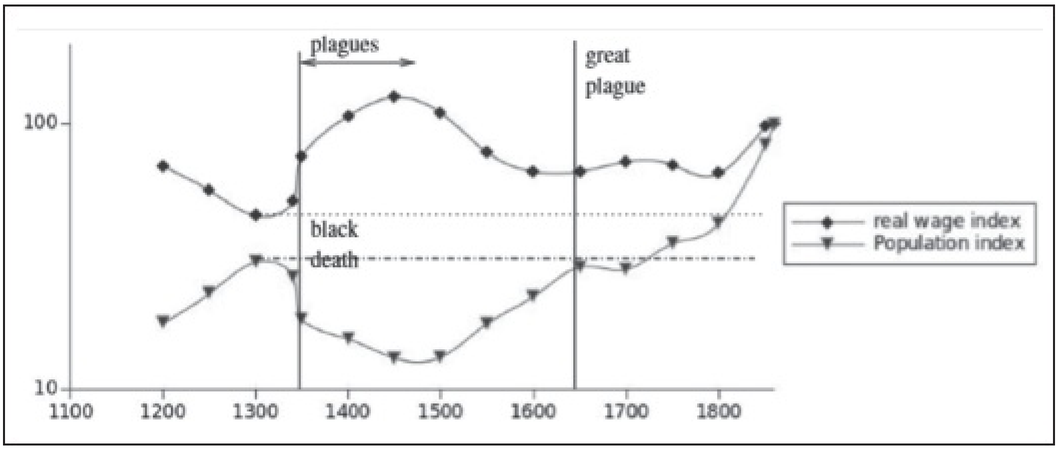


Figure 5.29. The effect of the Black Death on farm wages in England, subsampled at 50-year intervals. Vertical axis shows indices of population and real agricultural wages, with 1860 being the base year. Source: Data from Clark, 2007.

This classical theory does appear to be a good fit to the long-term movement of wages over many centuries in the pre-industrial era. In Figure 5.29 we can see that real wages move in an almost mirror image to the movements of population for the period 1200 to 1750. An extra data point is inserted for 1340, just before the Black Death, to show that the rise in real wages coincides with the fall in population.

The Black Death produced a sharp fall in population and an equally sharp rise in wages. Successive outbreaks of the plague continued to drive population down for one hundred years, with corresponding wage rises.

From 1500 a combination of better wages with some degree of immunity to *Yersinia pestis* allowed population to recover. With the growth in population the levels of wages fell again. They did not, however, fall right back to pre-plague levels (upper horizontal line) even though the pre-plague population was regained by the early eighteenth century. The great plague of the late seventeenth century again reduced population, by as much as 20 percent in some areas of the country. This is associated with a late seventeenth-century rise in wages. Even in the late eighteenth century the time when the classical theory of wages was developed, some inverse relation between population growth and wages still held, though less strongly than before. It was not until the takeoff of the specifically capitalist mode of production in the nineteenth century that the strong inverse relationship partially broke down. The higher rate of relative surplus value made possible by machine industry allowed real wages to rise even while population grew. But if you look at the vertical scale, you can see that even by 1860 real wages had not regained the peak attained during the labor shortage of the late Middle Ages. Farm laborers were better off in 1450 than in 1850.

More rapid population growth boosts the rate of profit by two distinct mechanisms. On the one hand a more rapid expansion of the labor force increases competition for jobs and allows the rate of exploitation to be increased. The rate of surplus value tends to be higher in years when the rate of population growth is higher,[94] Secondly, a growing population absorbs accumulated capital preventing, or at least slowing down, a rise in the capital-to-labor ratio.

Table 5.20 shows that the exploitation rate tends to be high when the birth rate is high and the workforce expands rapidly and tends to be low if the rate of accumulation is high. These reflect the relative competitive positions in the market of labor and capital.

TABLE 5.20: Correlation of the Exploitation Rate

Variables	Correlation
(b, s/v)	35%
(dN, s/v)	13%
a, s/v	-56%

Note: Correlations were performed accross vectors of 1220 individual year samples drawn from 30 countries; “b” is the birthrate, “dN” is the annual percentage change of the employed workforce, Cf is the share of investment in surplus. Source: Extended PennWorldTables.

The effect of a rapidly growing population is most strikingly seen if we contrast an emerging capitalist economy like South Africa with a mature one like Japan. As Figure 5.30 shows, instead of falling the South African profit rate rose rapidly from the 1970s. A similar pattern is seen in other African countries like Egypt [Zachariah, 2008]. Note how the acceleration of employed population growth allows a rising rate of profit. Compared to Figure 5.27 the absolute rate of profit on capital stock in South Africa is about 4 times as high as in the UK.

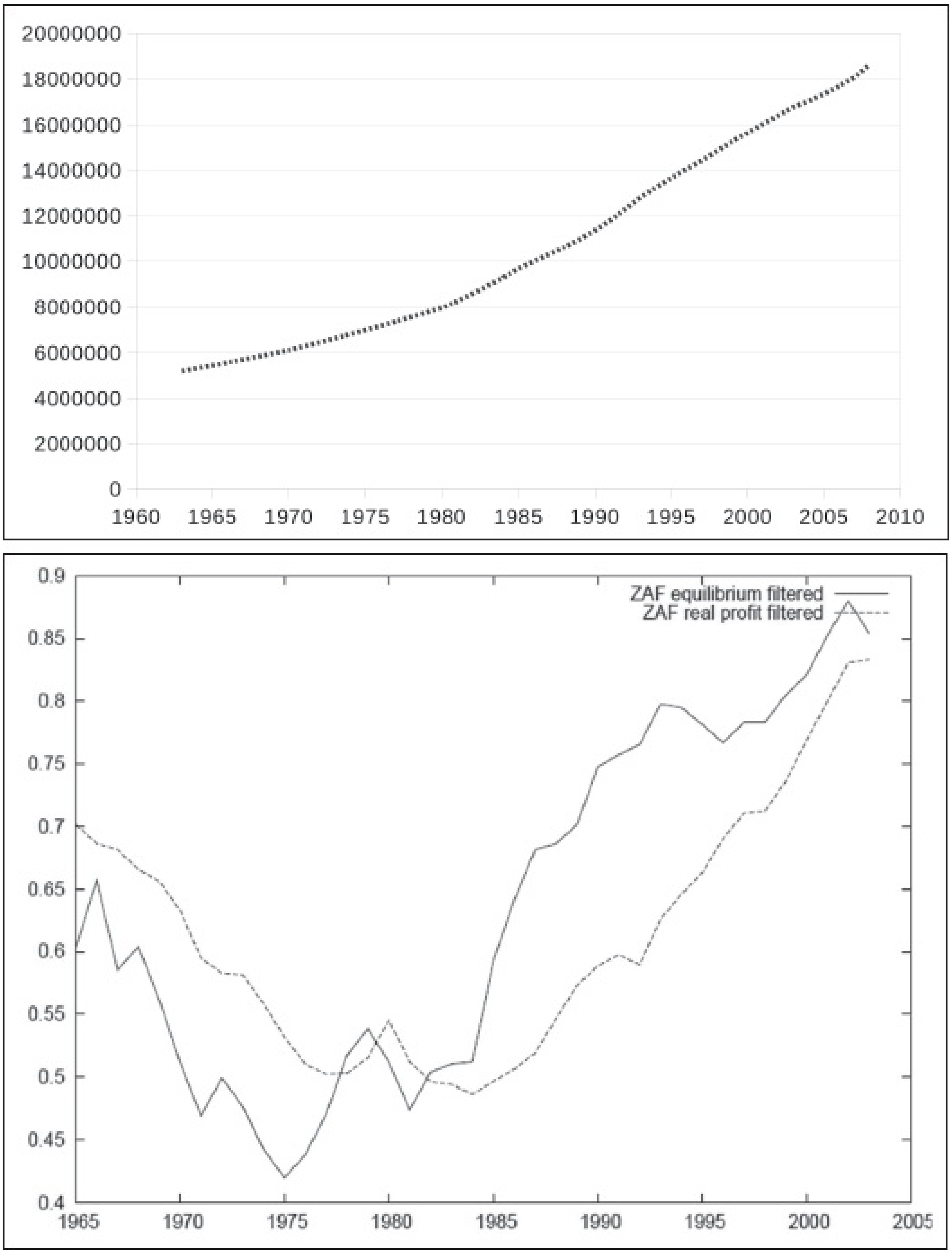


Figure 5.30. South African employed population (top), profit rate (bottom). Source: Extended Penn World Table, Marquetti and Foley, 2002, ver 4.0.

In such nations the capital accumulated each year is insufficient to keep up with the rising population, so the capital-to-labor ratio falls. A lower capital-to-labor ratio then gives rise to a higher rate of profit. Ultimately it is sex that drives capitalism. The soaring profit rate in South African capitalism is driven by the much greater sexual productivity of

South African women. South African fertility was still 2.5 in 2008 against only 1.3 in Japan. But South Africa is already on the path toward capitalist maturity. In 2008 the fertility rate was only half what it was forty years earlier. In other African countries the demographic transition is barely starting. In Nigeria, fertility in 2008 was a huge 5.7 children per woman, in Zambia 5.8, in Tanzania 5.6. Equatorial Africa is, in the early twenty-first century, capitalism's last best hope of profitability. But across most of the world, fertility is falling (Figure 5.31). It is barely at reproduction levels. This poses a long-term threat to capitalism since the essence of the accumulation of capital is the growth of the proletariat.[95]

What are the implications of this for profitability worldwide?

If world population growth halts, the dynamic equilibrium gross rate of profit worldwide will end up just being sufficient to replace depreciation of existing capital stock. Data by Maito et al. [2014], given in Figure 5.32, indicate that the core capitalist countries have leveled out at a profit rate of 10 to 15 percent. Since Marquetti and Foley [2002] give figures in the same range for the depreciation of stock in the core countries it seems probable that capitalism is already reaching a stationary state in these countries. Zachariah [2008] found in his study that in the core countries "gross investments are increasingly going to cover depreciation, i.e. the part of the capital stock used up in production."

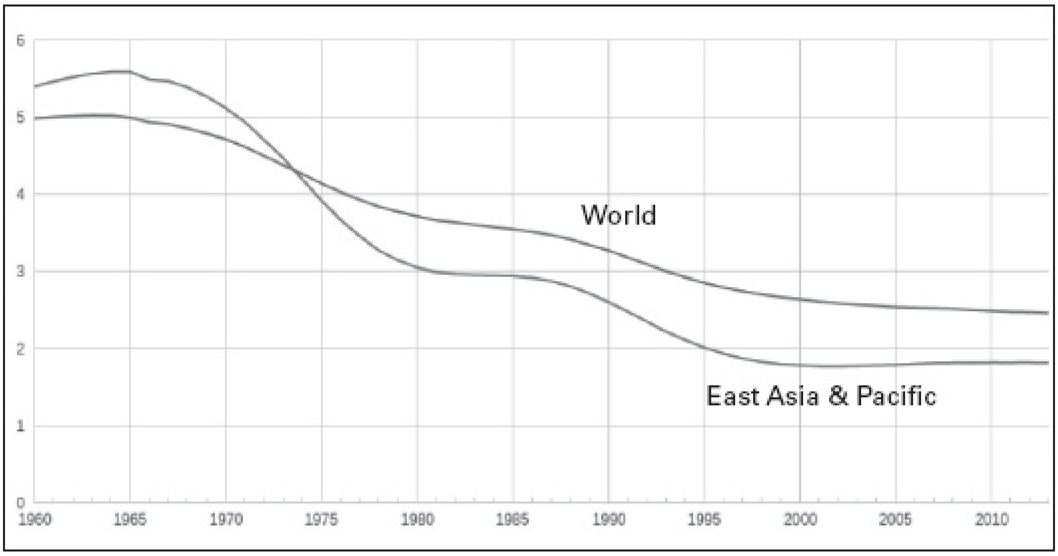


Figure 5.31. The decline in world fertility levels. Source: World Bank., 2014.

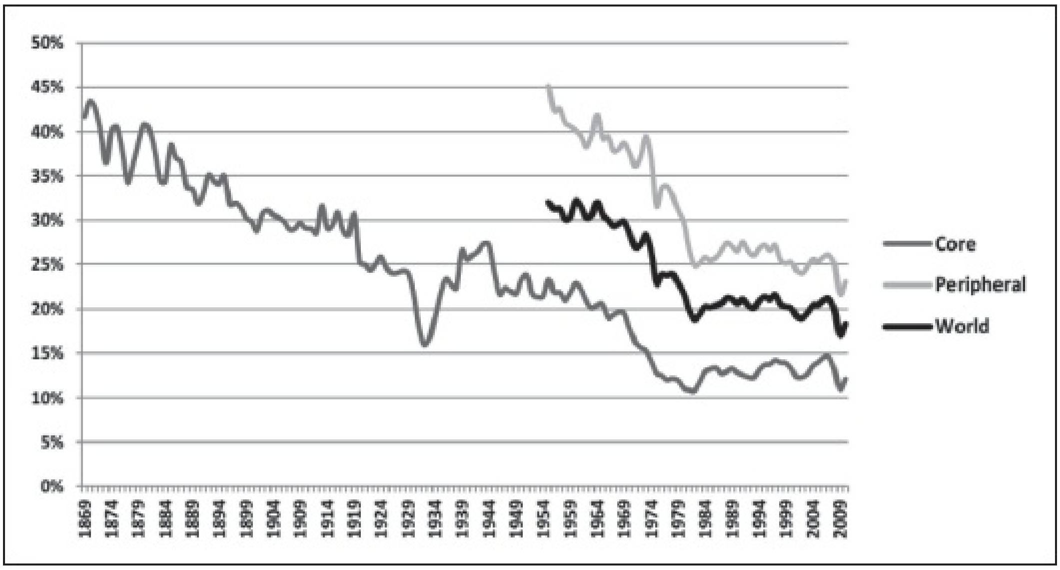


Figure 5.32. World rate of profit and average rate in core and peripheral countries (1869–2010). Source: Maito et al., 2014.

Due to the continuing availability of labor from the countryside, the peripheral countries show a higher rate of return, but if data in Figure 5.31 is taken into account the trend for the world as a whole will be toward what has already happened in the core.

At this point the value of the world capital stock in billions of person years would be stationary. Investment would only be sufficient to compensate for depreciation and the gradual cheapening of the capital stock in value terms due to productivity improvements. But accumulation of value will have ceased. This amounts to an existential crisis for capitalist civilization.

5.10 PRODUCTIVE AND UNPRODUCTIVE ACTIVITIES

In Section 4.5 we recounted Adam Smith's critique of the feudal profligacy. It was a critique that focused on the distinction between productive and unproductive workers. With this distinction Smith was expressing the viewpoint of a social group—the urban manufacturing capitalists—who had scarcely existed in the feudal period. As critic of the great lords' profligate waste he stood on the ramparts of modernity, from whence to glower with disdain on previously *honorable* professions. From such heights, ministers of the church and army officers were down on the same level with Punch and Judy shows and menial servants.

The wheel of history turned and there came a day when the manufacturers themselves aspired to great lordship. They bought titles and ordered mansions to rival the old aristocracy. That of engineering magnate William George Armstrong, Cragside (Figure 5.33), epitomizes this fusion of aristocratic and manufacturing values. Built in a grand Tudor revival style, looking like a castle, it contained the latest inventions of the Victorian era: electric lights, hydraulic lifts, powered washing machines; and it was staffed by dozens of servants. With manufacturers now aping aristocrats, Smith's radicalism passed into a decent obscurity. Only Marx, theoretical spokesman of the International Working Men's Association, still thought Smith's idea worth remembering. Manufacturing workers, it seems, were not blind to the profligacy of their masters.[96]

Recall that Smith proposed two conditions for paid work in order to be considered productive:

1. The workers must be employed out of capital not revenue.
2. The work must result in the physical production of lasting vendible commodities.

In his notes on Smith, Marx [1999] initially weakened the definition so that only the first criterion was needed. Any work that was employed out of capital should, he said, be counted as productive. However, he later seemed to have realized the inadequacy of this simple criterion, when he argued that labor employed by merchants could not count as productive, since buying and selling was not itself a productive activity [Marx 1971, chap. 27). In effect he shifted back to accepting Smith's rule that to count as productive labor had to be both physically productive and employed out of capital. Marx's followers use a broad definition of "unproductive," where all work that is devoted either to the distribution of income (accountancy, banking, advertising, etc.) or to the maintenance of the social order (police, army, church etc.) counts as unproductive, and productive activity is defined similarly to the way Smith did, but with the proviso that transport is also productive [Deepankar, 2015]. That is, productive work must either produce or move a physical and vendible commodity. The opera singers or prostitutes of Smith's time produced no persisting commodity and were unproductive. But if today Placido Domingo is recorded singing, and CDs are pressed and sold of the recording, or if today an actress performs for a sexually explicit film that is then sold as a DVD, the same physical acts become capitalistically productive.[97]

The unproductive sector exists by the support of the surplus product of the productive sectors. The expansion of the former reduces amount of surplus available for reinvestment in the latter, and thus affects long-run capital accumulation. As argued in section 5.4.9, it is only in the productive sector that technical advance reduces the necessary labor of society [Cockshott and Zachariah, 2006]. Any critique of unproductive activity is comparative. It says that if society were organized differently, production would increase. So Smith was saying that once great feudal lords no longer maintained retinues, the retainers could be put to profitable and productive work. Marxians say that if society were communistically organized, then many of those currently working for the banks would be redeployed to making things or providing other social services. Neo-Smithians argue that if those currently employed by the state to provide public services were redeployed to the private sector, production would rise [Bacon and Eltis, 1978].

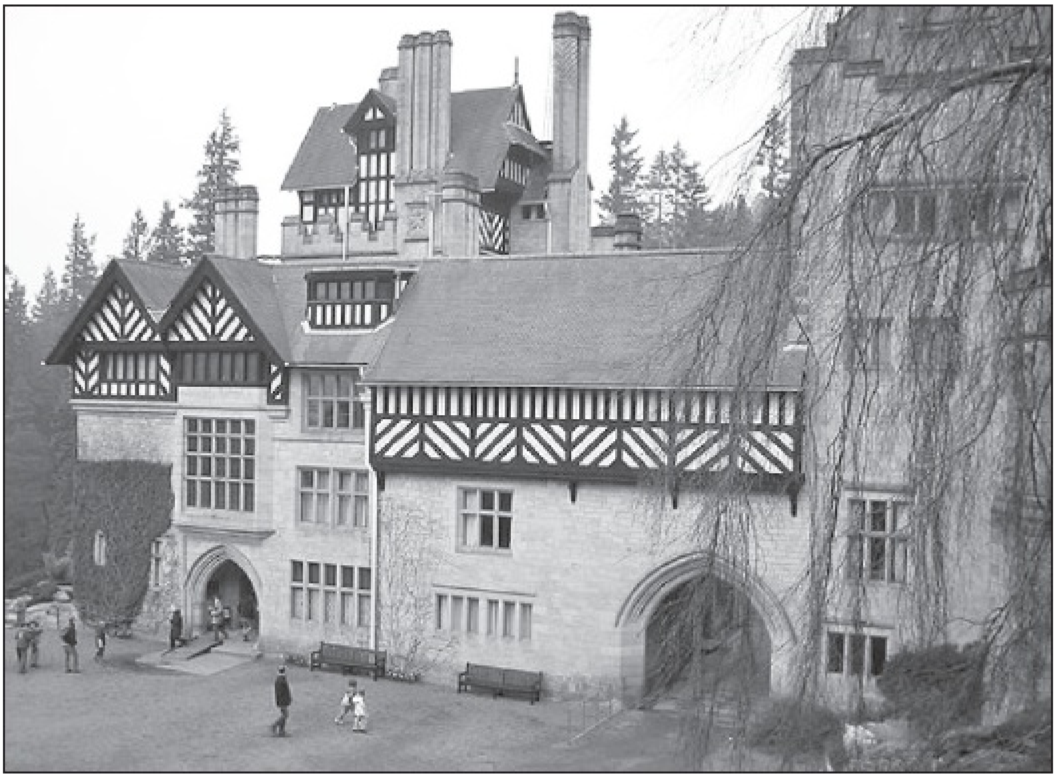


Figure 5.33. Cragside House, constructed for the Newcastle armaments manufacturer William George Armstrong, later Lord Armstrong. Photo: Dave Sumpner, English Wikipedia.

It is worth looking at a number of sectors of the economy to see what is meant by designating them as unproductive. We will soon discover that there can be a marked contrast between how things appear from private and social perspectives.

5.10.1 Violence

First let's return to the Gothic splendor of Cragside and its owner, Lord Armstrong, who employed hundreds of workers in his engineering works in the north of England. These, surely, were the very archetype of the productive laborer. But what were they making?

In the main they were making cannons. Armstrong's greatest invention had been a breech-loading gun that fired explosive shells rather than the old solid cannon balls (Figure 5.34). With these, the Royal Navy equipped a new fleet of "ironclads." But was this productive?[98]

There is no doubt that the guns were physical and vendible commodities, meeting one of Smith's criteria. And the workers who made them were paid out of Lord Armstrong's capital, not his revenue. Indeed, he grew rich enough as a result to retire in baronial style. From his private standpoint the answer was surely yes. He had followed Smith's advice and employed workers in manufacture to great profit. But from the standpoint of society how could this activity count as productive?

The whole point of the original distinction by Smith was to show how labor could be deployed to increase the wealth of nations. The manufacture of instruments of destruction can never do this. Once, in 1914, when the accumulated engines of Armstrong, Schneider, and Krupp were set to work, they wrought a destruction that took decades to recover from. Table 5.21 shows that in the period Smith was writing, wars were frequent. Between 1702 and 1815, Britain was at war almost half the time. The absorption of labor and resources in war, from an as yet largely unmechanized economy, must, by absorbing so much of the surplus product, have significantly slowed the accumulation of capital. With the advent of a full war economy in the twentieth century, with up to 70 percent of output being wasted on weapons, the destructive effect on the economy was huge.

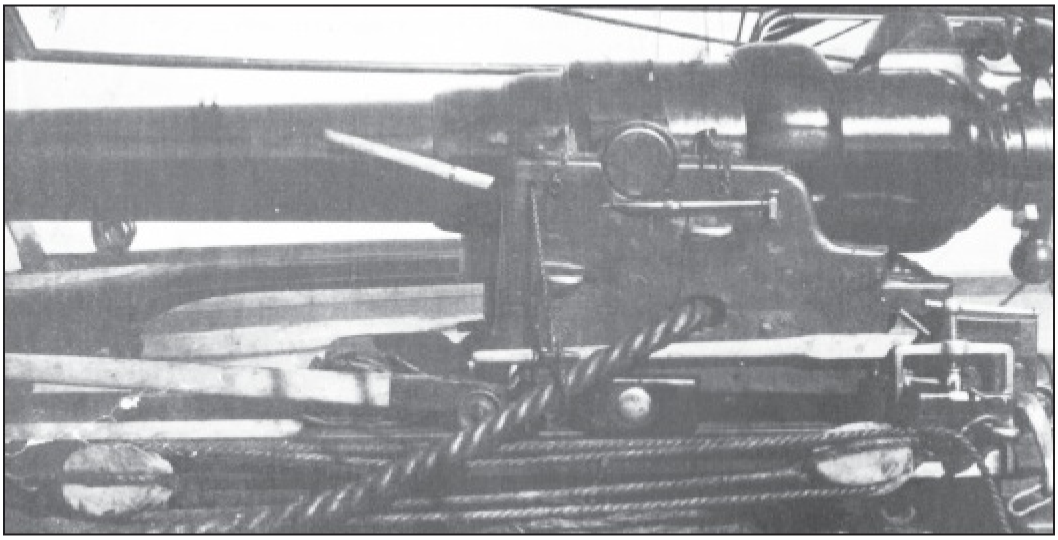


Figure 5.34. A 7-inch-caliber rifled breech-loading gun manufactured in the works of William George Armstrong. Photo: public domain.

From the early days of industrial capitalism until the late twentieth century armaments production in the UK was carried out both in Royal Arsenals and Royal Dockyards, and by private firms like Armstrong's Elswick works. It is clear that if the work was done in a Royal Dockyard, the laborers there could no more count as productive laborers than could the sailors who manned the British navy's ships.

TABLE 5.21: Additional Expenditures in Time of War for Britain 1702-1918

Year	War	Peak Percent of GDP Devoted to Wa r
1702-1713	Spanish Succession	5.1
1740-1748	Austrian Succession	5.7
1756-1763	Seven Years	16.1
1775-1783	American Independence	9.8
1793-1815	French and Napoleonic	9.4
1854-1856	Crimean	0.7
1899-1902	Boer	2.7
1914-1918	First World	49.3

These are expenditures over and above normal state expenditure which averaged 6.7% of GDP over the period. From Barro, 1987.

For a ship built in the Royal Dockyard, the cost to the government would simply be the wages of the workers plus the costs of machinery and steel that the dockyards could not make. For a ship built by a private firm it would include these costs plus a profit margin. If the private yard was to make a profit it could do so in either of two ways:

TABLE 5.22: Percent of GDP of the Great Powers Going to War Expenditure, 1939-1944

	1939	1940	1941	1942	1943	1944
U.S.	1.00	2.00	11.00	31.00	42.00	42.00
UK	15.00	44.00	53.00	52.00	55.00	53.00
Germany	23.00	40.00	52.00	64.00	70.00	-
Italy	8.00	12.00	23.00	22.00	21.00	-
Japan	22.00	22.00	27.00	33.00	43.00	76.00
USSR	-	17.00	28.00	61.00	61.00	53.00

Source: Harrison, 2000.

1. It levied a markup over and above the cost of building the same ship in a Royal Dockyard. But for this to occur we have to assume some degree of collusion by the state, with the government being deliberately willing to subsidize the private company when it could have the work done more cheaply using its own facilities.
2. It sold the ship at about the same price as the cost of construction in a Royal Dockyard but either used better machinery to reduce labor costs or paid lower wage rates, and as a result could still skim a profit. This would only operate if the management or the capital equipment of the private works was substantially better than the government facility.

Clearly the same costing argument applies to any activity that can be provided directly by the state or put out to tender by the state.

Buxton and Johnston [2013] examined the costs of comparable work done in the private and public shipyards. Their work indicates that the costs of ships to the government in terms of pounds sterling per ton were the same for both. The efficiency of the Royal Dockyards was no different from that of the private yards.

The third column of Table 5.23 indicates if a sister ship was ordered from a publicly owned shipyard. The means are given for all ships in the second column and for only those ships with publicly built sisters in the third column. Table 5.23 shows that the average markup on ships where private yards were in direct competition with publicly owned shipyards was very low at only 1.8 percent. Given the spread of markups on ships, with many selling at a loss, it means that private yards had to quote the Navy break-even prices.

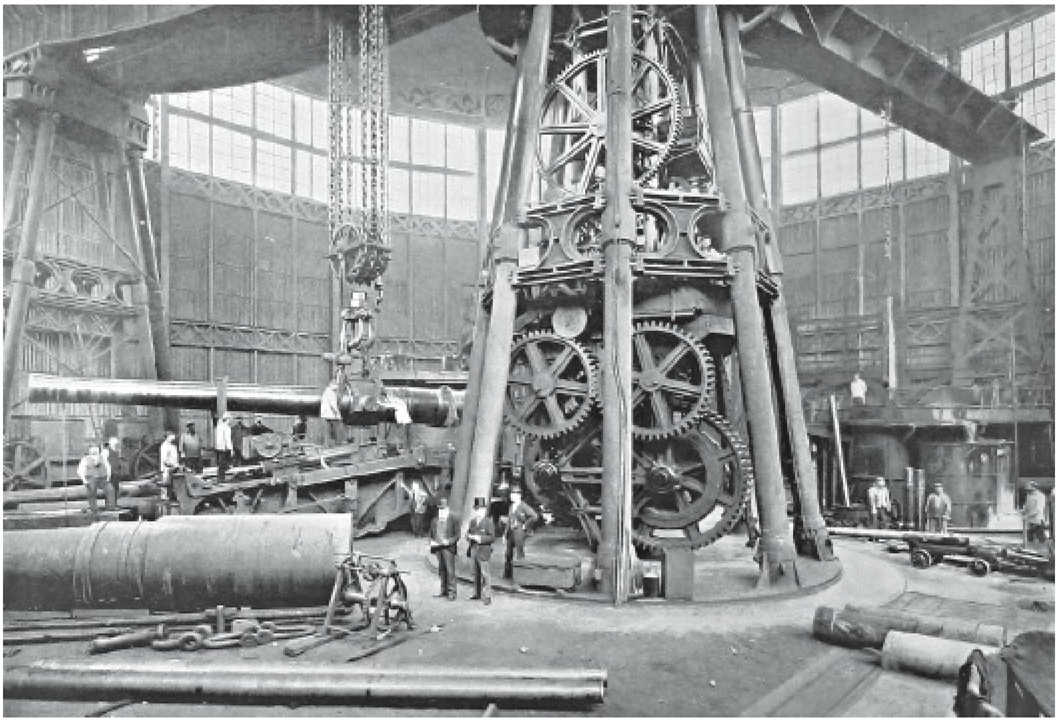


Figure 5.35. Heavy cannons, probably 13.5-inch rifled breech loaders, being constructed at the state-owned Royal Arsenal in the 1880s. Private arms firms like Armstrong and Vickers were in competition with these and similar state works. Photo: public domain.

TABLE 5.23: Markup on Prime Costs on Sample of Privately Built Royal Navy Capital Ships

Ship	Mark-up %	Royal Dockyard Sister Ship
Vengeance	-4.2	Y
Dominion	21	Y
Agamemnon	-6	-
Invincible	2.9	-
Inflexible	11.1	-
Superb	-15.3	Y
Vanguard	4.9	Y
Colossus	4	Y
Australia	2.4	Y
Ajax	5	Y
Audacious	-5.1	Y
Conqueror	5.3	Y

New Zealand	6	Y
Princess Royal	11.2	Y
Benbow	-5.7	Y
Emperor of India	1.4	Y
Tiger	4.8	-
Valiant	-5.6	Y
Mean	2.1	1.8
95% CI for the Mean, FROM	-1.9	-3.3
TO	6.2	6.9

The third column indicates if a sister ship was ordered from a publicly owned shipyard. The means are given for all ships in the second column and for only those ships with publicly built sisters in the third column. Source: Buxton and Johnston, 2013, chapter 11.

Armaments firms like Armstrong and Vickers seem to have made most of their profits from selling to foreign navies who lacked their own shipyards.

The data for naval construction seems to indicate that for an activity where the state directly competed with private contractors, it was very hard for them to make a profit (Figure 5.36). If, however, the state loses its ability to compete directly—as has happened as a result of privatizations in the late twentieth century, the opportunity for private firms to mark up costs at the taxpayer's expense is bound to be much higher.

Armstrong's ships and guns exchanged against tax revenue. Every £ of profit his firm earned had been taken in tax from someone else, whether in England or overseas. The classical economists had argued that taxes had to fall on the surplus revenue of the landowners and capitalists—the workers being too poor to be worth levying an income tax on. So Armstrong's profit was a direct deduction from the profits of other capitalists. The resistance of the manufacturers' party, the Liberals led by Gladstone, to expensive naval budgets stemmed from this fact [Friedman, 2012].[99] So by the argument used by Marx against the productivity of shop workers[100] we must rule the Armstrong cannon works and all they employed as unproductive.

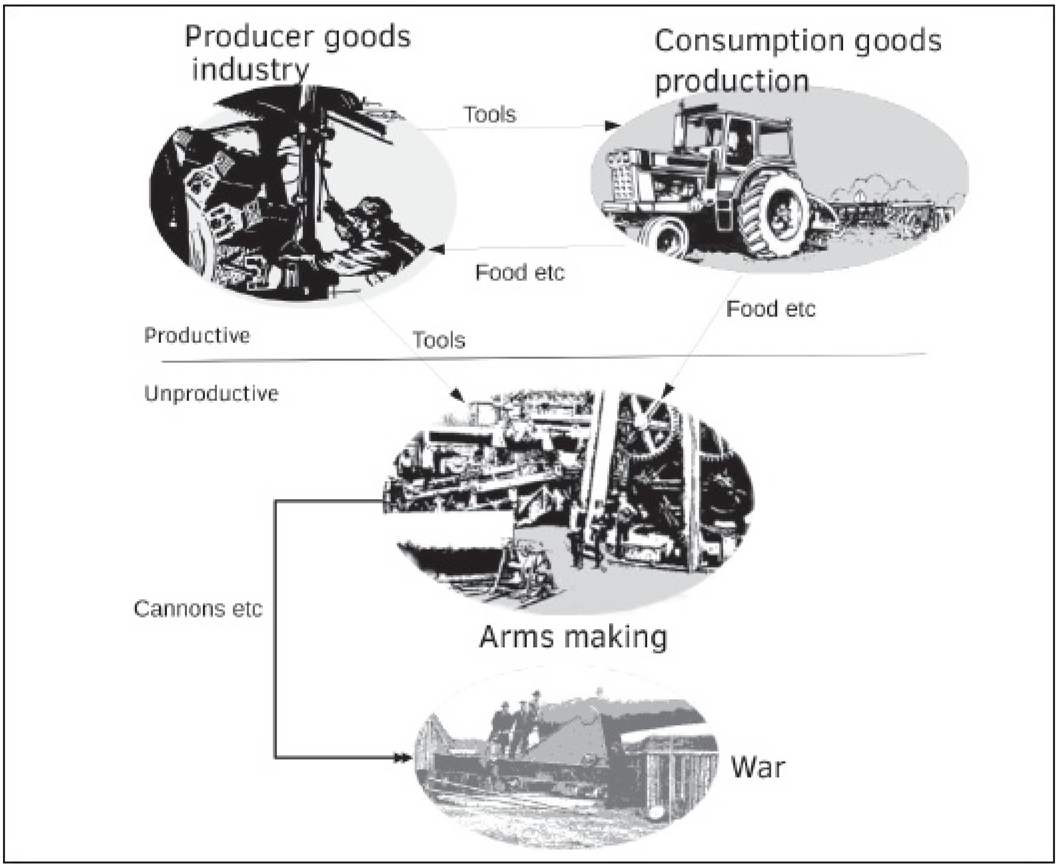


Figure 5.36. Difference between the unproductive war industry and the productive economy when outputs of industries are examined. There is a mutually supportive feedback between the productive sectors, whereas war production acts as resource sink.

More generally, no activity which is itself unproductive becomes productive by a mere change in the social form under which it takes place. Privatization does not make an unproductive activity productive.

5.10.2 Vice

The existence of money and monetary payments gives rise to the illusion that anything that garners money must itself be productive, an illusion actively fostered by those who derive their incomes form activities thus sanctified. A contemporary example is how, since the ideological dominance of neo-liberalism in the 1980s, there has been a move to re-label prostitution as “sex-work” [Jeffreys, 2008] and gambling as an “industry.” Since in capitalist society a major component of work is waged labor, where it appears that labor is being exchanged for money, any transaction in which money changes hands is made to seem like labor. Again, since in commercial societies most industry is run for a profit, then anything run for a profit, including casinos and brothels, looks like an industry. This is what Marx termed commodity fetishism, and Schumpeter called the “veil of money” [Klausinger, 1990]. It blinds us to the actual social relations behind cash transactions. A moment’s thought is enough to see that gambling merely redistributes existing money, and produces nothing new of value. It makes as little sense to talk of a gambling industry as of a pickpocket industry. Indeed, prior to 1960 the law in Britain regarded the one as criminal as the other.

We saw with warship building how an ultimately destructive activity can be presented as a productive industry. If one compares the BAE Systems yard in Govan that is building aircraft carriers, with the Daewoo shipbuilding yard in Korea building container ships there are obvious similarities: the employment of waged workers, the use of similar skills, the production of a physical ship. It is only by looking at what the resulting ships do, that we can see that the first is destructive and the second productive. Brothel-keeping sits at an intermediate level of veiling: not as obviously unproductive as casinos nor so obscurely unproductive as BAE Govan. Brothels are not in business to turn out a physical product, they are one of Smith’s unproductive services vanishing at the moment of their performance, but the sex work advocates ask, Do they not employ waged workers; what is special about the work of prostitutes that makes it different? Should they not be treated like any other job and given the security that comes with a recognized form of employment?

One response is to point out that as an institution, brothels originated in slave society and, internationally, are still to a substantial degree dependent on what was called the “white slave trade” and is now termed human trafficking. Another response is to pull away the money veil and point to what would ultimately be criminal actions. Just as warship building hides a conspiracy to commit piracy and murder, procuring veils conspiracy to rape [Jeffreys, 2008]. Kollontai [1921], speaking well before the cant about sex work had been invented, and in an early socialist, rather than capitalist, economy, understood very clearly why it exists in capitalist countries and why it was unproductive in a socialist economy:

> The trade in women’s flesh is conducted quite openly, which is not surprising when you consider that the whole bourgeois way of life is based on buying and selling. There is an undeniable element of material and economic [sic] considerations even the most legal of

> marriages. Prostitution is the way out for the woman who fails to find herself a permanent breadwinner. Prostitution, under capitalism, provides men with the opportunity of having sexual relationships without having to take upon themselves the responsibility of caring materially for the women until the grave.
>
> And what, after all, is the professional prostitute? She is a person whose energy is not used for the collective; a person who lives off others, by taking from the rations of others. Can this sort of thing be allowed in a workers' republic? No, it cannot. It cannot be allowed, because it reduces the reserves of energy and the number of working hands that are creating the national wealth and the general welfare, [and] from the point of view of the national economy the professional prostitute is a labor deserter. For this reason we must ruthlessly oppose prostitution. In the interests of the economy we must start an immediate fight to reduce the number of prostitutes and eliminate prostitution in all its forms.

There is a commonsense obviousness under the changed social conditions about why prostitution is unproductive. In a society where goods were allocated on ration, a prostitute was seen to be taking the rations of others and not contributing to national wealth and general welfare. When economic relations were no longer disguised by money but seen in physical terms, this was a commonsense practical observation, and if it was obviously true in an unveiled economy, it must already have been true behind the money veil in the previous capitalist economy. Gilded by money, unproductive activities in a commercial economy appear productive, intercourse becomes "sex work."

In one sense of course, sex is work, and productive. Both parties involved expend metabolic energy in the act, and the productive issue causes the mother to expend far more energy in the gestation and birthing. Such labor is, in reality, the foundation of all other production. But this is not what apologists for brothels mean. To them, work is where money changes hands. Never mind that since Roman times the aim of commercial sex has been for men to avoid any responsibility for the children who result. They could expect neither inheritance nor sustenance from the fathers. Exposure, abandonment or the dubious mercy of the foundling hospital was often their fate:

> The figures for this traffic, available for many cities, are truly shocking. In all of France fully 127,507 children were abandoned in the year 1833. Anywhere from 20 to 30 percent of all children born were left to their fate. The figures for Paris suggest that in the years 1817–1820 the “foundlings” comprised fully 36 percent of all births. In some of the Italian hospitals the mortality (under one year of age) ran to 80 or 90 percent. In, Paris, the Maison de la Couche reported that of 4,779 babies admitted in 1818, 2,370 died in the first three months and another 956 within the first year. [Langer, 1963, p. 9]

So notorious was the mortality rate of these institutions that Malthus [1872] remarked:

> Considering the extraordinary mortality which occurs in these institutions, and the habits of licentiousness which they have an evident tendency to create, it may perhaps be truly said that, if a person wished to check population, and were not solicitous about the means, he could not propose a more effective measure than the establishment of a sufficient number of foundling hospitals, unlimited as to their reception of children. [152]

As an institution prostitution was doubly destructive of labor power; not only did it condemn to an early death the prostitutes’ infants but the money that patrons spent in the brothels was taken from the mouths of their legitimate offspring.

5.10.3 Finance

What is now called the finance industry is another big unproductive sector. Apologists for the banks say this Smithian classification is misleading. The real criterion of whether the banks are productive is to be found in their balance sheets. It was, they would say, an archaic Calvinist prejudice on Smith’s part to tie productiveness to physical production. But do banks produce anything of value? Do they produce “financial services,” and if so what are these services?

One instance of a financial service is charging for clearing checks or for making payments into other accounts. However, what one sees when one looks at the UK banking sector is that such charges are insufficient even to meet the wage bills of the banks. For the general public, this is the main use of banks, but it is not their main source of revenue. That comes instead from profits on financial contracts. Over time the banks and other financial institutions have come to make a part of their revenue by trading in financial contracts of ever greater complexity and abstraction.

The orthodox justification for the banks playing a productive role is that they provide the finance that the economy needs.[101] Money, according to Adam Smith, is the ability to command the labor of others.[102] The provision of credit gives a capitalist the authority or permission to commandeer part of the pool of social labor to his project.

The provision of a line of credit by a bank is simply an act of giving permission. What makes it seem different from, for example, a building permit, is that the permit is allocated by a private body. If you want to extend your house you need two permits, one from an office of the city who checks the soundness of the design, and one from the bank who checks the soundness of your credit. The fact that somebody can hand out permissions does not make them productive.

If we look at what actually happens, it is builders, plasterers, and plumbers who actually make houses. The city or bank official who signs a permit no more makes the house than did Hadrian in building the wall that bears his name. Society projects onto the powerful a creative genius that really pertains to those they command. When permits are in demand, those handing them out can take their cut. If a city official does this we call it a bribe, when a bank does it we call it interest. At one time the charging of interest (usury) was regarded as the moral equivalent of an official taking a bribe. With the rise of bankers to political dominance, their very wealth, obtained in this way, comes to be seen as a token of social respectability.[103]

It may seem that a loan, unlike a permit from the town hall, gives access to the real resources to build the house. But this is an illusion. Workers build houses using bricks and timber, the loan gives the homeowner command over these resources. If the building industry was under state control, or even when, as in the 1940s in the UK, bricks were simply rationed by the state, access to the bricks and labor would also depend on an official permit. It is an artifact of the current legal order that private citizens cannot print their own money or issue generally acceptable authorization for work. Banks, on the other hand, are in the special position that they can issue money without legal constraint. Section 3.5 explained how monetary relations arose from the action of states in commuting taxes in kind into money taxes. This forced everyone subject to tax to acquire money and to enter the commodity economy. The power of money to command labor is a delegated power, derived from a prior direct command that the state has over the persons of its citizens. Nowadays, such direct command it limited to military conscription, and usually only young men are subject to it. For the rest, the state accepts money in settlement of citizens' debts.

Debts to the state are the original sins. They exist independent of our volition or actions. The innovation of the modern age is the way that absolution is offered: by check or credit card.

The state accepts private checks for tax payments because the clearing banks have deposit accounts with the state bank. When people sent the exchequer checks drawn on bank X, the account of bank X with the state bank is debited correspondingly. The combination of state banks with private banks gives rise to the specifically capitalist monetary system. The volume of commercial transactions required by the capitalist economy long outgrew the possibility of cash settlements in precious metal coins.[104] The replacement of money by credit has been essential to the growth of capitalism, but it has in the process given immense power to private financial institutions.

Deposits with private clearing banks holding accounts with the Bank of England, European Central Bank, etc., are in general as acceptable as cash, but the banks themselves can create them at will. The banks do not, as is naively supposed, channel capital from savings to investment.[105] Instead, when a bank gives a line of credit to a firm for investment, this in effect authorizes the firm to draw on and mobilize social labor for its private purposes. The creation of credit in the account of the firm is an instantaneous bookkeeping operation and does not depend on any prior saving of real resources. Conversely, the advance of credit need not fund any current social labor. If a bank advances credit to a firm to employ staff that obviously does use labor, but if credit is advanced as mortgages for already existing houses, or the acquisition of speculative financial assets there is no corresponding allocation of labor. The former is productive in a very limited sense—in that it authorizes real production—the latter is unproductive in every sense. It is an illusion to see the banks as acting as intermediaries, lending out the deposits of the rentier classes to industry. It is not a two-step operation: first take deposit; then make loan. Instead the two operations occur simultaneously, and it is at least as realistic to say that the lending creates the deposits as vice versa.

Suppose Deutsche Bank advances an overdraft facility to BMW. BMW then orders steel plate for its plants from ThyssenKrupp AG. A month after delivery BMW pays ThyssenKrupp 5,000,000 euros, drawing on its overdraft facility. What happens next is that in a single *atomic transaction* the Deutsche Bank computers debit the account of BMW and credit that of ThyssenKrupp. The software operation is designed to be indivisible, and its effect is to create a deposit that exactly counterbalances the loan to BMW.

As a consequence of the falling rate of profit described in Section 5.9 opportunities for profitable investment shrink, and the share of financing provided for productive purposes becomes less. The financial sector now directs most of its loans to financing the government debt, real estate, or speculation in paper or electronic assets. These purely symbolic operations, operations on computer records, can still effect an indirect claim on real resources since, in addition to clearing transactions and taking deposits, banks act as fund managers. In the latter role they levy a management fee of perhaps 1 percent of the value of the funds they actively manage. The ongoing extension of credit means that all assets tend to appreciate over time so the total fees become huge. Between 2009 and 2014 the portion of management fees paid out to individual bankers in London amounted to more than £100 billion [Kollewe, 2015].

5.10.4 Modern rents

Even when banks operated as they are theoretically supposed to, extending credit for real productive investment, the work that went into granting the loans remained unproductive—and administrative overhead was analogous to issuing building permits. But at least it enabled productive activity. Finance today, as in the early years of capitalism, operates more as a rent collection agency. Since so little finance goes to increasing real production, these rents can only be sustained by depressing the real living standards of much of the population.

This process is particularly evident in housing. The price of houses breaks down into two components, one being the actual cost of building a house, and the other being the capitalized rent of the underlying ground. As feudal rents gradually converted into money rent, farming land acquired a price that was set by the rule:

$$\text{Price} = \frac{\text{Rent}}{\text{Interest rate}}$$

Suppose that in 1800 an estate in Ireland yielded £1000 a year in rent from the peasantry and the interest rate was 5 percent.[106] The price of the estate would then be £ [1000/0.05]=£20,000 as this is the sum that an investor would have to lend to the government to obtain the same revenue as from the land. From the earliest stage of industrial capitalism there has been a close unity between rent collection, debt, and violence. The great bulk of the interest-bearing securities in the early nineteenth century were ones issued by the state to finance the purchase of ships and cannons. The biggest source of funding for these loans were grand aristocratic families whose incomes came initially from ground rent. The banking system, and the markets in land and government bonds, then allowed this class to balance its revenues between direct exploitation of their tenants and indirect exploitation of the taxpayers.

But what determines the rent that can be obtained?

Ricardo [1951] argued that rent levels depended on the differential fertility between the worst land in use and the land on which the rent was paid.[107] If the worst land yielded no rent, then the landlord could charge almost the entire differential fertility of the better land as rent. Were he to charge more than the difference in fertility the peasants would shift to the worse, rent-free land. Whether this is realistic is questionable, since even on the worst land in a province, the landlords were unlikely to allow peasants to till scot-free.[108], [109] But whatever the zero-point rent on the worst land, Ricardo's principle will still apply. Landlords, free to alter rent, will charge rents that cancel out any gains from differences in soil fertility. The mere threat to withhold land from production is sufficient to allow the landlord class to appropriate part of the surplus produced in capitalist economy [Campbell, 2002], since all economic activities other than shipping take place on land and as such are dependent on access to it.

In agriculture the landlord is able to appropriate not only natural differences in fertility—due to differences in aridity, rockiness, and slope of the soil—but the accumulated result of past improvements carried out over centuries. A constant struggle exists between the landlord and the capitalist farmer over these improvements. The interest of the landlord is to rack up rents as a consequence of any improvement made by the tenant. The tenants as a class, in contrast, have an interest in long leases during which rents are fixed to allow them to benefit from capital invested in improvements. The threat that any investment by the tenant will end up in the landlord's pocket inevitably acts as a disincentive to investment and improvement.

This dependence of rent on past capital investment is even more pronounced with urban rents. These are rents on a built environment that is entirely an effect of past labor. On the surface, the rent that an urban tenant pays appears as a payment for an artifact—the house. As such, it seems to the landlord too that house rent is a return on the capital he invested in buying the property. The actual causal relation, that the property price is capitalized rent, is thereby inverted. The rent that can be obtained for two similar flats, one in the center of a big city and one a 50km commute from that city, will be very different. The city-center flat will rent for more, because the city-center tenant saves the travel cost in money and time of the 50km commute. Private property in land then imposes on all tenants a financial loss equivalent to the travel cost met by the distant commuter. As capitalism concentrates jobs in huge cities, workers are either forced to spend hours traveling, and to buy the cars needed to do this, or to forfeit an equivalent cost in rent to the landlord class. In economically developing cities rents trend up, as the commuting circle expands. The price of a house bought to rent is determined by the capitalized rent, so property prices similarly escalate. Expectations of capital gains on rented houses make such investment doubly profitable—there is the rent return, plus the speculative profit to be had from selling the house at a higher price later.

Rent perYear	Return on Capital	Price Floor of Flat
£5,000	6.0%	£83,333.33
£5,000	4.0%	£125,000.00

The rent-driven appreciation of property prices then becomes coupled with another process: the generally declining rate of profit in productive investment. Suppose the rate of return on productive investment falls from 6 to 4 percent, then, quite apart from any change in general rent levels, the price of a flat returning a rent of £5,000 a year will appreciate as shown above.

Figure 5.37 illustrates how these two processes have operated in the London area. It shows prices for flats in London and in East Anglia, the latter area being effectively on the margin of the London commute distance. London flats are consistently more expensive due to differential rent effects. Landlords in London can charge higher rents than landlords in, say, Norwich, because the cost of working in London and commuting from Norwich is so prohibitive. Flat prices, which are dominated by the buy-to-let market, are in consequence much higher in London. But in both areas the long-run trend, in units of the median annual wage, has been up. It is plausible that this is a consequence of the long-term fall in the rate interest, which itself is an enforced result of the falling rate of profit. As the rate of return on capital generally falls, the central banks of leading countries are motivated to drive interest rates down to try and encourage investment despite the generally low rate of return on industrial capital. The availability of cheap mortgage finance then allows landlords to bid up the price of flats and still turn a profit on the rent they earn. Since private buyers must compete with landlords in the housing market, they too have to pay a higher price.

Home ownership was promoted in Britain in the twentieth century as the path to a property-owning democracy. Even if the mass of the population could no longer hope to be economically self-sufficient, owning their own house would at least make them independent of landlords. This dream was used to justify the selling of publicly owned low-rent housing to sitting tenants. As the original sitting tenants died and their homes were sold, these flats, originally built by the cities to provide cheap housing, fell into the hands of a new landlord class, which had either the ready capital or the access to credit that allowed them to outbid young working-class families for flats coming on the market. Those who are able to buy flats or houses are, in big cities, faced with prices so high that the bank debts they assume leave them little better off than tenants once were. As Figure 5.37 shows, by 2016 a London flat, let us not speak of houses, cost the equivalent of twelve years' wages. Home ownership is more apparent than real, since legally the banks have first call on any proceeds of the sale, and the payments in interest to the bank will be almost as much as a landlord would have charged. The banks become indirect landlords, and their revenues, although taking the form of interest, are, in effect, rent. Ground rent in capitalist society is always a payment for inefficiency. Classical differential rent tended to rise, according to Ricardo, as less efficient land was brought into cultivation. Urban rents rise as cities become more inefficient; unplanned development forces workers to bear either higher transport costs or higher rents. The banks and the landlord classes are then the beneficiaries of such inefficiency.

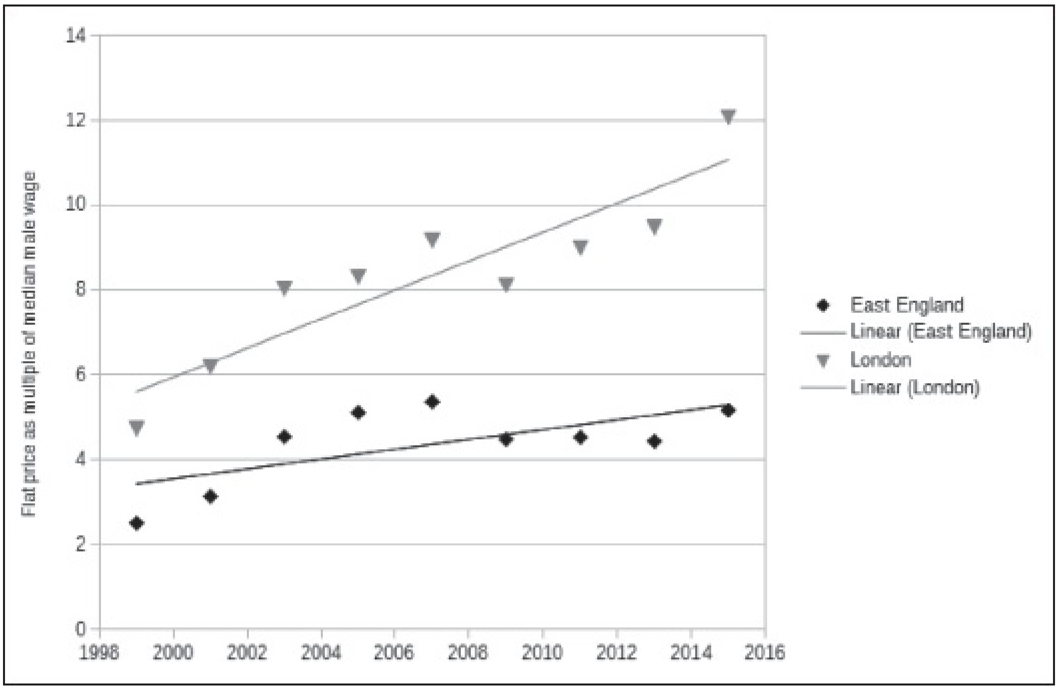


Figure 5.37. Movement in flat prices, measured in terms of years of median salary needed to purchase the flat, for London and an area at the outer limit of the London commute zone.

What governs the relative value of landed property versus productive capital?

The value of landed property is an imputed capitalization of the revenue that flows as rent. If the average rate of return on capital is used for calculating its value, then the share of wealth represented by landed property will stand in the same ratio as the ratio of total rents to total profits on capital. Under conditions of falling profit rates, however, the apparent rate of return on land will be greater than that on capital, since landed property steadily appreciates in market value.

TABLE 5.24: Structure of U.S. Bank Loans Just before the Onset of the Credit Crisis

Financial Instrument	1 October 2008	
Residential Mortgages	$2,103	
Commercial Real Estate	$1,721	
Consumer Loans	$860	
Non-Producer Loans	$4,684	75%
Commercial and Industrial	$1,586	25%

Figures in $billions. Source: U.S. Federal Reserve.

Assume that the working population of a nation is fixed at 20 million and that half the working year goes as surplus. The value of the surplus is then fixed at 10 million person years. Suppose that the initial capital stock is 40 million person years, and the rent revenue is 2 million. This rent has to be deducted from the surplus to give the profit to capital. The rate of return on capital is then [(10-2)/40]=20%, and the market value of the landed property will be 10 million.

Now suppose that of the surplus of 10 million, 5 million goes in investment. Next year the capital stock will be 45 million and the rate of return will have fallen to [(10-2)/45] = 17.8%.

At this new rate of return the capitalized value of 2 million in rent is now 11.25 million. The landlords have thus had a return of 2 million in rent, plus capital gains of 1.25 million, so the market profitability of landed property will be [(2+1.25)/10]=32.5%, which is much better than the return to be had on productive capital. So long as the capital stock grows faster than the population this will go on. Investing at the same rate of 5 million per year the effect after twenty years is that the capital stock has reached 140 million and the rate of return is down to 5.7 percent. Landed property now has a capitalized value of 35 million, and the market profitability of landed property, including appreciation, is 9.6 percent. Landed property will, in late capitalism, seem to be consistently more profitable than productive investment. As a result the funding provided by the banks goes disproportionately to real estate.

Where does this inflow of cash end up?

Some of it goes to build new properties. Higher land prices justify higher buildings, so city centers are continually in the process of being destroyed and reconstructed to pack the maximum square meters of residential and commercial property onto each square meter of land. Another part of the loans simply go to finance purchase of existing properties or to remortgage properties at inflated prices. Since the flow of funds into the sector must balance the flow of funds out, and only part of the inflow goes to meet real new building costs, where does the rest end up?

In the main it gets diverted into consumption expenditure. Upper-middle-class home owners sell houses in the cities, move elsewhere to consume the profits. Commercial real estate firms distribute, in dividends, profits gained by selling properties at higher prices. This too ends up funding the consumption of the rentier classes. A similar phenomenon applies to any property title that promises to bring a stable future income. A declining general rate of profit means that shares in companies that do not expand their capital base appreciate. Holders of these shares, whether individual rentiers or fund managers, can then appropriate a portion of the capital appreciation as revenue. In the process the capitalist class as a whole takes on more and more the aspect of former ruling classes: rent seeking and revenue consuming. Periodic banking crises reveal how the capital base of the system has vanished in an orgy of luxury consumption. Now, all free market objections to state intervention vanish overnight; the taxpayer is called in to make up the loss.

CHAPTER 6

Socialist Economies

6.1 WHAT DOES SOCIALISM MEAN?

Mises [1951] noted that socialists have no uniform idea of what socialism is. Each socialist, or at least each group of socialists, proclaims that only its view of socialism is right and that all others are misleaders, enemies of the people, etc. Each socialist, he claims, implicitly assumes that the future socialist state will be headed by himself. True socialism is what that socialist will decree. All other views are dangerous heresies best dealt with by the firing squad.

This seems to be a fairly accurate caricature of a substantial fraction of the socialist movement. While the communist parties tended to have a fairly clear idea of what they wanted to achieve, based for the most part on an emulation of the USSR, other socialist parties have been loath to give a concrete view of how socialism should be organized. On all sides there has been a reluctance to examine the practical problems of organizing a socialist economy.

Socialism arose first as philosophical movement by thinkers like Owen and Fourier in the early nineteenth century. At that stage socialist thinkers were willing to advance quite detailed utopian plans for the reorganization of society. Later it became a political movement of the working classes seeking a just society. Marx and Engels, the thinkers with the most lasting influence in the workers' movement, applauded the work of the early utopians in establishing the socialist movement. They were in particular full of praise for Owen. But they were severely critical of the utopias of later philosophers like Proudhon and Dühring. They claimed that the later utopians were pale reflections of the earlier pioneers and that their utopias were for the most part internally inconsistent.

Marx took the view that as a scientist he could not put forward detailed theories about socialism, a form of society that did not yet exist. Economic and social research had to base itself upon the data provided by real society. He was ready to identify features of contemporary capitalism that revealed the potential for a future socialized production system but not to construct a detailed theory of socialism in the absence of data. He was willing to say that capitalism had generated a class struggle that would lead ineluctably to the dictatorship of the proletariat and thence to a classless society. As to what this society would be like, he was only willing to give sketchy predictions—that it would be based on planned production rather than the market, that it would not use money, etc.

After the Russian Revolution, and in particular after the mid-1930s, the Communists held that Marx’s views had been amply born out in practice. The dictatorship of the proletariat held sway, the economy was operated under a single plan and classes were being abolished. They had had to invent things as they went along. They had had to improvise and much of what they did could not have been predicted in detail from Marx’s writings. But this was to be expected, socialism was something born out of real life and history not the crystallization of philosophers’ dreams. For the Communists, from the ’30s to the ’60s, if you wanted to know what socialism was you just had to look at Russia.

For other, non-communist socialists the issue was more problematic.[110] Although the great majority of socialists during the period from the ’30s to the ’50s took things at face value and accepted that Russia was socialist, there was always a minority who did not, and in Western Europe during the last fifty years such views have probably come to represent a majority of socialist opinion.

From the early days of the communist revolution in Russia the Social Democratic parties in Europe argued that socialism could not be established by the methods of dictatorship that the Bolsheviks were using. They argued that the workers’ movement had during the previous decades struggled hard to win the franchise, for freedom of association and the press. To establish a one-party dictatorship, impose censorship, and to imprison and execute political opponents went against everything the movement had stood for.

Socialism, they argued, could only be established on the basis of a free press, free political parties, and open parliamentary elections. A socialism that denied this was either not socialism or not worth having. This is a clear and principled argument and the Social Democrats stuck to it for decades. Its weakness was that the communists could simply retort: “Who says you can’t build socialism using a dictatorship? That’s just parliamentary cretinism. We have tried dictatorship and it works. You tried parliament and where is your socialism?”

On economic grounds, the Social Democrats had less to say against communism. Social democracy has a liberal definition of socialism both in the sense of looseness and in the Manchester sense. A mixed economy with social welfare legislation and some elements of industrial planning would certainly qualify, so their economic criticism of Soviet Communism was that *it is not necessary to go so far so fast*. The economic direction was not in question, rather, it was the counsel of moderation. Public ownership of the means of production, planning, welfare rights, and an egalitarian income distribution were accepted as socialist objectives by both Communists and Social Democrats. The latter presented themselves as the democratic socialists without challenging the socialism of the latter, only their totalitarianism.

Although there has been considerable overlap between Trotskyism and social democracy, with all Social Democratic parties worth their salt having Trotskyist fractions, their founder had been a prominent Communist politician, and in consequence their arguments as to why the Soviet Union was not socialist started from different premises. The two key arguments were:

1. Socialism in one country:
   a. It is in principle impossible to build socialism in a single country.
   b. The USSR is one country.
   c. It follows that the USSR could not be socialist.
2. The argument from plenty [Mandel, 1985]:
   a. Socialism is only possible in conditions of abundance when mankind passes from the realm of necessity to freedom.
   b. The USSR was plagued by shortages, which in turn stem from it being an isolated country.
   c. Hence the USSR could not be socialist.

There seems to be not one but several possible questions relating to socialism in one country.

1. Is socialism possible in one country?
2. Is socialism possible in more than one country?

3. In the long term is socialism more stable in:
   a. A single country.
   b. Many countries.

In short, my answers to this would be 1) Yes, 2) Yes, 3) a. This may seem a bit paradoxical but my meaning will become clearer as the argument progresses.

From my perspective questions 1 and 2 are partly empirical. Only partly, because the meaning of the question still relies upon the interpretation one makes of the word *country*. This is commonly used to refer to a nation-state, but nations and states are not coterminous. The USSR was an international organization not a nation-state in the old sense. If by country we mean explicitly a nation then it must be said that we lack empirical evidence to decide if socialism is possible in a single country. If by a country then we mean a single state power, then we have historical experience of the existence of a single socialist state from the early ’30s to the late ’40s. The time period given is determined by the point at which the distinguishing characteristics of a socialist economy came into being.

On either definition of a country, nation or unitary state power, then since the late 1950s it has been clear that a plurality of socialist countries can coexist. I give the late ’50s as the crucial period here, since until then the People’s Democracies of Eastern Europe were only nominally independent state powers. Communist parties there were the effective agents of state power and the parties remained so tightly coordinated that it was doubtful that the states could really be considered as independent. China, where the Communist Party was independent of Moscow, had not established a socialist economy in the early 1950s.

On the question of whether socialism is more stable in one country or several, it appears that it is more stable in one, provided that by “country” one means a unitary state power.

A unitary state power was better placed to present a united front to the hostile capitalist world, and best placed to coordinate the economic development of nations at different levels of development. One only has to consider what the chances of socialism’s survival would have been had the USSR not been formed, and had there existed instead a multiplicity of sovereign nation-states on its historic territory. The great imperial powers of 1919 would likely have subordinated them one by one. In the post–WWII period, splits between socialist states, USSR/Yugoslavia or

USSR/China or China/ Vietnam, were exploited to strategic effect by opponents like the United States and hamstrung by their economic development. In a paradoxical sense, it can be said that the abandonment of the policy of socialism in one country *i*n the sense of a monolithic state by the communist movement in the late ’40s to early ’50s contributed to their collapse in 1990.

The argument from plenty against socialism is convincingly dealt with by Nove [1983b, 15–20], but we can give a brief summary of its problems here. Consider the standards of life of the working classes of Europe when Marx or even Lenin were writing. Now consider what the conception of abundance would have been then: adequate and nutritious food, warm clothing and good dry shoes, houses with good heating and sanitation, access to education, culture, literature, and leisure, an 8-hour workday, free medical treatment. Given the conditions of life of the nineteenth-century British proletariat, or the workers in czarist Russia, this would have seemed abundance. It would still be abundance to most of the world’s population. It is easy to forget, living in Western Europe, that the norm for the world capitalist economy is Mexico City rather than Berlin, Lagos rather than Stockholm. Cars, televisions, home video cameras, computers would not have featured in the agenda of nineteenth-century socialists. By the standards that the workers movement originally had in mind, the workers of East Germany, Czechoslovakia, and to large extent the USSR were already entering into an age of abundance by the ’80s, while for significant sections of the population even a rich free market economy like the United States in the ‘80s failed to provide abundance of such necessities. Despite this, these economies were still clearly in the thrall of scarcity.

This was true whether the measure of scarcity was the presence of queues, the budgetary constraints faced by the government, or the aspirations of the population for oriental luxuries. The advance of technology had given rise to new aspirations that had yet to be met. In any technically advancing world this is bound to be the case. Newly developed technologies open up possibilities that cannot immediately be met in unlimited quantities. It may well be the case that in market economies advertising artificially stimulates these needs (which is a case against advertising), but even in the absence of ads there was no lack of black market demand for Sony products in the USSR. Beyond this, it is an open question as to whether the current consumption pattern of, for example, France could be extended to the whole world population given ultimately limited resources.

It is, moreover, doubtful that the establishment of a socialist world economy would have been helpful in alleviating scarcity in the USSR. Although its national income per head was below that of the leading capitalist countries, it was still well above average by world standards. As such, it would have had to make substantial aid contributions to socialist countries in the Third World. It had to do this for China in the ’50s. The contributions it made to Vietnam, Cuba, Angola, etc., were already a subject of some popular resentment.

Another school of socialist thought was the Communist left. Their most articulate theorist was Amadeo Bordiga, the founder of the Italian Communist Party, who actually remained politically active down to the 1960s. In 1952 Stalin published a short book, *Economic Problems of Socialism,* which set the terms of communist orthodox debate about the Soviet economy. Shortly thereafter a publication by Bordiga appeared under the imprimatur of the International Communist Party, called *Dialogue with Stalin* [1954]. In this Bordiga argued against the idea that the USSR was socialist, holding instead that its economy was a form of state capitalism. Some of his arguments parallel those of the Trotskyists, that socialism was not possible in one country and that it demanded abundance. To this he added the argument that the USSR continued to be a commodity-producing society. The Marxist vision of socialism had always been one in which commodity production was abolished, he argued. But in the USSR workers still worked for money wages and payed rubles for goods in the shops.

At a formal level he was correct—money did exist. But the difficulties involved in establishing a genuine market economy in Eastern Europe after the counterrevolution of 1990 indicate that the social reality behind money and prices in these countries was somewhat different from that in the West. In the consumer goods markets, prices bore only a weak relation to the amount of social labor required to produce them or to demand. In producer goods there was not really a market at all, since money alone was not enough for an enterprise to ensure supply of a good, if this good had not been allocated to it in the plan. Bordiga was right in raising the existence of money and the commodity form as a potential problem, but like most other leftist writers he was none too specific as to what alternative form of economic calculation to use.

During the 1960s the leaders of the Communist Party of China started to argue that the USSR had reverted to capitalism. It was claimed that Khrushchev, and then Kosygin, had taken the road to capitalism and that the USSR had passed from being a socialist state to being a social-imperialist one.

Given that the economic changes introduced by Khrushchev were fairly minimal this argument was hard to sustain. If, however, one views them as allegorical comments on an internal Chinese political debate about the appropriate way forward, then they make a lot more sense. Within China there was a fierce struggle between the Maoists and the followers of Liu Shaoqi and Deng. Liu was stigmatized as China's Khrushchev. Alternatively this can be seen as labeling Khrushchev as Russia's Liu.

If the economic policies followed by Deng after he came to power are indicative of what was being proposed in secret party debates during the '60s then the charges of "capitalist roadism" seem to have had some reality in the Chinese context. But until Gorbachov, those advocating similar measures in Russia were far from the centers of political power.

It is now a century and a half since Marx was writing, and today we have much more historical evidence to go on than he had. We have had extensive opportunities to observe societies that were by common understanding called socialist. We say "by common understanding" being well aware that some people dissent from this, but whether one takes account of the constitutions of these societies, which proclaimed them to be socialist, the common view of their citizens who believed them to be socialist, or the common view of the international press which declared them to be socialist that appears to have been the consensus view.

Many currents of thought in the socialist movement have dissented from this consensus, on the grounds that the conditions in countries of "hitherto existing" socialism violated numerous socialist ideals.

This may well be true, but as social scientists we cannot judge the real world by the standards of an ideal one. It is not the job of reality to materialize our ideals. Reality just *is* in all its glories, horrors, and contradictions. When judging the reality of socialism in comparison with ideals advanced by its early advocates, we adopt an unusual criterion. We do not judge feudalism or capitalism by the standards of an ideal, and were we to do that we would soon find that no real capitalist society corresponded in whole to this ideal. One may note that it was a common argument by opponents of socialism to say that since welfare-state Britain differed in many respects from the ideal type of nineteenth-century capitalism, it was no longer really capitalist.

If a thinker advances a theory about a kind of society before it ever comes into existence, the scientific status of the theory is weak. If the predictions of the theory come to conflict with later observation one can either decide that the theory needs modification or that reality has been misbehaving. If one adopts the latter policy and says that socialism has never existed anywhere in the world, one may hope (perhaps vainly) to escape some current political unpopularity, but one has hardly advanced one's ability to deal practically with the problems that led to this unpopularity. An ideal can be kept pristine but its very distance from reality vitiates its practical political force and the left is in precisely the predicament that Marx criticized in Utopianism.

We therefore take an empirical approach to determining what the distinguishing characteristics of socialist society have been.

- Widespread use of electrical energy.
- Agricultural productivity sufficient for a large urban populations.
- The absence of a class of wealthy private proprietors in agriculture or industry.
- Widespread use of machinery and applied science.
- Public or cooperative ownership of most of the economy.
- A system of state planning that determines the scale of the surplus product by the relative priorities it assigns to consumption versus other goods, with allocation of instruments of production by means of a system of state directives.
- A consequent absence of capital goods or raw materials markets. (Indeed one may question the meaning of the term "capital goods" in these societies.)
- The continuation of household economy as a site for the preparation and consumption of food and the raising of children, which gives rise

  to:

  - The formal existence of a consumer goods market subject to the constraints that:
  - A significant portion of consumer goods were distributed by means other than purchase or sale.
  - The price mechanism in the consumer goods market was generally

non-operative.

- The absence of a market in land, and the absence of rent as an economic category.
- A lower variance of incomes from the mean than was the case in capitalist countries at an equivalent stage of industrial development.
- A distinct mode of extraction of the surplus product, that is, the politically determined division of the concrete forms of the social product between the categories of current consumption, accumulation, and unproductive consumption.
- Formal appropriation of the surplus product as tax but the relegation of taxation from a means of extraction of a surplus to means of securing monetary stability.
- The existence of money and wage labor.
- The absence of a reserve army of unemployed, often associated with chronic labor shortages.

These are the significant structural features that marked off the socialist world from the capitalist. These are also the features that the advocates of capitalism in these countries wish to abolish.

Those socialists to the left of social democracy who deny that socialism has ever existed do not generally specify which of them are incompatible with socialism. One has to assume that the socialist systems they advocate would share most of these features.[111]

Socialist economies have the same basic mode of production as capitalism: machine industry and agriculture. What distinguishes them are the forms of property and the way in which the surplus product is determined.

Actual countries have shown mixtures of socialist and other production relations. Socialism may exist as a subsystem within countries that are predominantly capitalist, and capitalism or domestic peasant economy may exist as subsystems in predominantly socialist economies. Though political revolutions may permit changes in property relations, they are, at least in the short term, powerless to effect a change in the mode of production. The 1917 Revolution was no more able to establish the socialist mode of production than the revolutions of 1776 or 1789 were able to establish the capitalist mode of production. The establishment of socialism in Russia, as with the establishment of capitalism in North America and France, came later with a sequence of changes in production technologies and economic relations. It took France until 1900, over a century after the revolution, to achieve the degree of urban industrial development that Russia achieved in less than a quarter-century after 1917.[112] Arguably the transition to capitalism in France and that to socialism in Russia was not complete until the 1960s. That these changes in the mode of production took place much faster in the Russian case does not obscure the fact that changes in the mode of production take time. If capitalism and socialism's shared mode of production already largely exists, as in Germany or Czechoslovakia post-1945, the change to socialism can occur much faster.

Socialism was born from political successes by working-class and peasant movements, not spontaneous economic development.

It was produced by movements that had socialism as an objective. But this is not so different from capitalism in most of the world. The socialist movement had its economic theorists, whose ideas in their turn influenced socialist governments. But this is not so different from capitalist governments. They too have been influenced by economists advocating an ideal type of capitalist society. The theory of free-market capitalism developed well before capitalism was established as an international system. Its spread, by British bayonets and gunships, showed the Chinese in the generations before Mao where the political power needed for social transformation came from.

6.2 POWER

> Communism is Soviet power plus the electrification of the whole country.
>
> — LENIN 1965B, VOL. 34

Political power grew from the barrels of guns, but what about real power?

Capitalism progressed from water and wind power to steam for motive power, but communists, from the outset, plumped for electricity. German author Liebknecht [1901], writing in the 1890s, described having met Karl Marx in the 1850s after he had seen a model electric train. Marx enthused that just as steam had created capitalism, electric power would create a new economic and social order. Liebknecht remarked sardonically that in the ensuing forty-five years there had been no signs of electricity taking over yet. The trains were still steam, and the few electric tramcars were of no significance.

Looking back from the twenty-first century, Marx appears to have had the more acute sense of the promise of electric power. You have to take the long view when looking at the development of technology.

> Revolutions are not accomplished in a sleight-of-hand fashion. Only the sensational shows in politics are called revolutions by the wonder-working rustic faith. And whoever prophesizes revolutions is always mistaken in the date. [Liebknecht, 1901]

We know that electricity has turned out to be quite important, as Marx suspected, but why was it seen as so crucial that Lenin should have singled it out as the very key to Soviet industrialization?

Human labor is a universal, abstract productive capacity. Our energy output may be modest at under 100 watts, but it can be applied in any trade or profession. The first available alternative to human effort was that of our brute servants the ox and horse. Strong as these companions are, their skills are limited. They helped us draw vehicles or pull plows, but they could not help crew ships, lay bricks, or spin wool. Steam went to sea with us, supplanting half a crew, replaced our beasts in traction, turned spinning mills and cut stone for our cities. But the steam engine was heavy, inflexible, and produced only motive force. It could not sing, wash, or see for us. With electricity we harnessed for the first time a power that rivaled that of human labor in flexibility, while vastly surpassing it in magnitude. Electricity wrote for us, then spoke for us then saw for us in telegraphs, telephones, and televisions. Its motors range in size and power from our little fingers to that of 50,000 horses. It lights our darkness, heats our homes, stores our records, reasons and calculates. It becomes power in the abstract, the General Watt.

We have become so accustomed to electric power that we have difficulty relating it to real effort so it is worth relating it to human power. A trained human cyclist, peddling hard, generates only enough power for one incandescent light (see Figure 6.1).

To become abstract general power, electricity requires networks of supply, initially urban, then national, continental, and in the future, world girdling. In the construction of these networks, competition of multiple private firms was counterproductive. Initially, with competing suppliers, there was no standardization of voltages or connectors, which slowed the uptake of anything more complicated than simple electric lighting. Providing power mains to a city or region is expensive, making it uneconomic for multiple competing companies to lay their own wires down every street. Electricity trends to monopolies. Even in capitalist countries the state had to take on a directing or ownership role in its supply. Thus the state either built the national grids and power stations or at the very least set technical standards and regulated prices for private suppliers. Because of its integrated character and because of the forward investment it required, electricity became one of the first industries for which long-term national plans were made. Even after the Thatcher government in Britain privatized electricity, it proved impossible for the state to relinquish its directive role in regulating price and enforcing the development of wind and nuclear generation. When the British state required new nuclear power stations it had to turn to the state-owned French electricity monopoly to supply them.

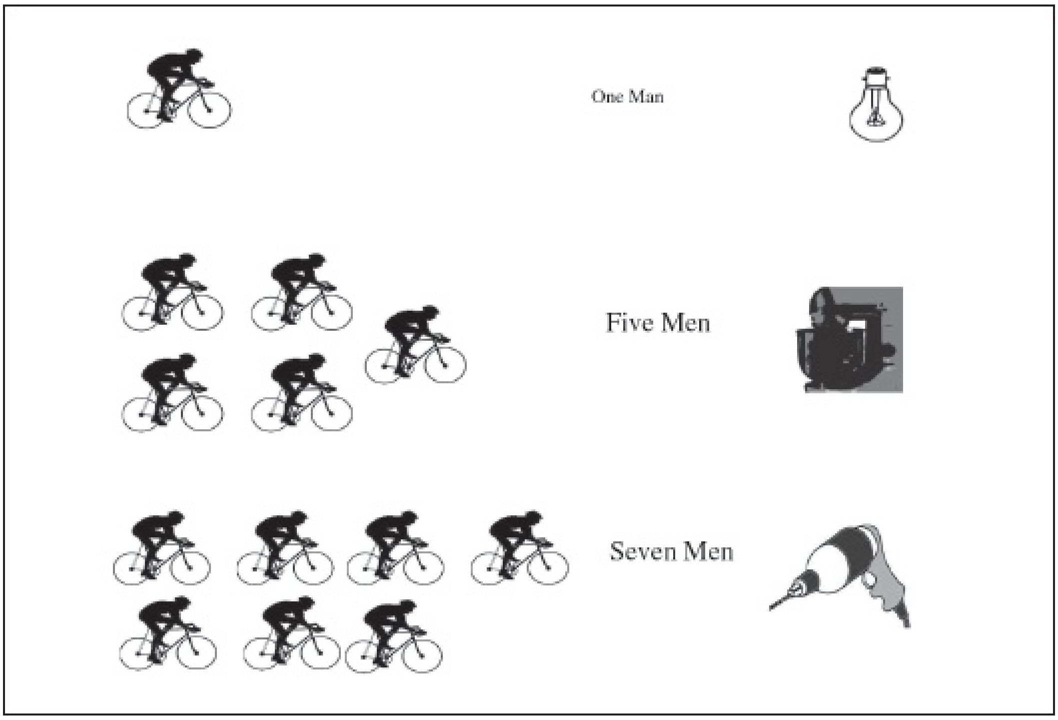


Figure 6.1. Comparison between human power output and the electricity used in common appliances.

It is no surprise then that the leaders of Soviet Russia saw electricity not only as an enabling technology for industrialization and the development of the countryside, but also as the paradigmatic example of where central state planning could steal a march on competitive capitalism. When a socialist government was elected in Britain in 1945, it too immediately set about the establishment of a nationalized system of electricity supply, including a state Hyroelectric Board.

As a general rule internationally, the state was needed to embark on huge capital-intensive electricity projects like building dams across major rivers.

Figure 6.2. Socialist economies have embraced hydropower despite the high initial costs of this technology in dams over the Dnieper and Yangtze rivers.

Figure B.1 shows that, in a capitalist country, the rate of profit is widely divergent between different industries. The industries in which labor costs are a small fraction of the advanced capital tend to have a lower rate of profit, which is what one would expect from the labor theory of value. Private industry is reluctant to embark on capital-intensive projects like hydropower or tidal and are even reluctant to use nuclear energy unless given state financial incentives. The U.S. electricity industry was a partial exception to the general trend for highly capitalized industries to have a lower rate of return. The combination of a natural monopoly and public regulation ensured that it earned a rate of profit somewhat above what its capital composition would predict [Cockshott and Cottrell, 2003b], though still well below the average rate of return in the United States. So even there, the large-scale development of hydropower was undertaken by the government owned Tennessee Valley Authority in the 1930s.

The Soviet government's first economic planning body was GOELRO, responsible for drawing up the comprehensive electrification program. Construction of three large hydropower plants rapidly took place from the mid-1920s, and by 1932 the Dnieper hydro-station was producing 560MW, for its day the biggest electric generator in the world. The Communist government in China showed similar enthusiasm for hydroelectricity. The Three Gorges Dam across the Yangtze becoming in its turn the world's largest power plant, but at a vastly greater scale, 22,000MW in this case. By the end of the Soviet period in 1990, hydropower made up 18 percent of electric generation, nuclear 12 percent, with the remainder being from fossil fuel sources [Rudenko, 1993].

To get some sense of the scale of the electric energy available to economies like the mature USSR, China and other countries around the time of writing, see Tables 6.1 and 6.2.

The first thing to note is that contemporary China has access to almost the same order of magnitude of energy per head as the USSR had twenty-five years earlier, and that both of these were similar to the per capita energy use of Europe in 2014. The tables also reproduce the data for energy use for Britain in 1907 (from Table 5.5) for comparison. This shows what a huge increase in energy use took place during the electrical revolution of the twentieth century. Britain in 1907 was one of the three richest and most highly mechanized countries in the world. For each man, woman, or child within its coastline it had steam power equivalent to the efforts of seven human workers. By 2014 that had risen to the equivalent of 24 people. But a quarter of a century earlier, the USSR was already using the electrical equivalent of 27 humans for each citizen.[113]

TABLE 6.1: Comparison of Power Available to Different Economies

Country	Year	Average GW
China	2014	663.3
U.S.	2014	494.6
EU	2014	361.4
USSR	1990	197.3
GB	2014	38.6
GB	1907	7.0

For all but the GB 1907 figure, which comes from Table 5.5, these are figures for average electrical power use computed from the annual number of billion KW hours produced. The figures, except for GB 1907, are for average power delivered for each hour in the year, and will be somewhat below the installed capacity. The figure for the UK in 1907 is given for continuity with Figure 5.7. Source: For recent data, *Global Energy Statistical Yearbook 2016;* Soviet data from Rudenko, see bibliography, 1993.

TABLE 6.2: Comparison of Power Available to Different Economies Converted into Human Labor Effort Equivalents per Head of Population

Country	Year	GWh	Human Labor Equivalent per Head
China	2014	5,665,000	19.2
U.S.	2014	4,331,000	63.1
EU	2014	3,166,000	19.7
USSR	1990	1,728,000	27.3
USSR	1940	48,000	1.2
USSR	1931	8,000	0.3
Russia	1913	1,900	0.0
GB	2014	338,000	24.8
GB	1907	61,320	7.3

Assumption is that a manual worker could do 216 KWh per year of work.

Production of electricity from heat inevitably involves energy losses in the form of waste heat, both in the flue gases and in the warm water that has been used to condense steam from the turbines. Efficiency is measured in amount of heat used to produce a kilowatt hour of electricity. In these terms the USSR had overtaken the UK by 1963, using 12,200 BTU/KWh against 12,400 in the UK [Anon., 1965], but was still some way behind the United States, which used only 10,500. A significant difference between the power plants in the socialist and capitalist countries was the widespread use of combined heat and power in the former [Diskant, 1979]. In these systems the waste heat from thermal power plants was taken in pipes to heat whole city districts. Moscow had 1,800 miles of such piping. The overall efficiency of energy use was thus considerably higher than the simple BTU/KWh figures would imply.

The Soviet practice was to heat new housing developments using local thermal heating plants, whose heat output was thermostatically determined by the outside air temperature. Once the development had reached a sufficient size, heat would be piped into the main hot water network from thermal power plants. After this, the original local thermal plant was kept as a backup. The USSR achieved economies of scale by using standardized modular thermal power plants, though such standardization may have slightly slowed down the improvement in thermal efficiency.

That this district heating was supplied unmetered was held up by the American press as a terrible example of inefficiency [Paddock, 1997]. Russians would, it was said, simply open their windows rather than turn down a thermostat if their room got too hot. This ignored the fact that in New York City the heat that would, in Moscow, have heated flats, was simply dumped into the Hudson River by the power company.

Electricity is not a primary energy source. It depends on other primary sources such as the flow of rivers, burning oil, or splitting atoms. In Section 5.4.4 I argue that water power alone could not have provided sufficient energy to sustain even late-Victorian capitalism. With much bigger rivers than Britain, the USSR made more extensive use of hydropower. If, however, they had only used this source of energy, the amount of mechanical power available per head would have been less than was used in late-Victorian England. Instead the economy relied heavily on fossil fuels, in the late USSR mainly gas and oil. According to Allen [2003], one reason for the slowdown in Soviet economic growth from the 1970s was that the continued expansion of energy use could only be achieved by accessing oil and gas from Siberia, a much more costly task than getting it from the Caspian Basin.

The hitherto existing industrial mode of production, variants of which both historical capitalism and socialism have shared, depends on sunlight long sequestered in fossil form. Any such mode of production is self-limiting, destroying its own conditions of existence. This limitation lies, in a sense, below even the demographic constraints we already analyzed for capitalism. Their dependence on resources which, by the scale of human history, will quickly be exhausted, marks out their mode of production as transitory. It will not be the first mode of production to exhaust its resources. Mesolithic hunting seems to have done the same, precipitating the Neolithic Revolution in agriculture. Peasant feudal economy, in contrast, was relatively self-sustaining, if stagnant. If necessity again proves the mother of invention, a similar revolution to a more sustainable mode of production will take place. A key element of this will be the shift from fossil fuels to other modes of energy production.

TABLE 6.3: Chinese Electricity Sources in 2015 and as Projected in the 13th 5-Year Plan

Source	GW 2015	GW 2020	Percent 2015	Percent 2020
Fossil	990	1,210	66%	63%
Hydro	319	340	21%	18%
Wind	129	210	9%	11%
Solar	43	110	3%	6%
Nuclear	26	58	2%	3%
Total	1,507	1928	100%	100%

China, which up to now has relied preponderantly on coal to fuel its power stations, uses far less nuclear than the USSR did. Benefiting though from a quarter-century of technical development it was by 2015 using much more recyclable sources of energy. But even allowing for a very rapid growth in solar, wind, and nuclear energy in the 5-year plan to 2020, fossil fuel generation is so big that it will still produce over 60 percent of electricity.

Chinese nuclear power, like that of the USSR, has been based on water-cooled designs. It is arguable that such reactors are inherently more dangerous than gas-cooled ones, since there are inherent explosion risks on overheating with water cooling. The serious accidents at Chernobyl and Fukushima were with different variants of water-cooled reactors. Development of safer high-temperature gas reactors has been set as a high-priority technical goal in China.

Fast neutron reactor technology, which makes far more efficient use of nuclear fuel, is also being developed [News, 2010].[114] Ambitious plans to install hundreds of GW of these exist, but whether the Chinese economy in the twenty-first century is any more successful with them than the aborted plans that the UK, France, and Japan had for fast reactors in the past, remains to be seen. The technology has in the past proven very difficult to master, but China may have the resources of scale and population needed to make it work.

6.3 REPRODUCTION AND DIVISION OF LABOR

> We are now approaching a social revolution in which the economic foundations of monogamy as they have existed hitherto will disappear just as surely as those of its complement prostitution. Monogamy arose from the concentration of considerable wealth in the hands of a single individual man—and from the need to bequeath this wealth to the children of that man and of no other. For this purpose, the monogamy of the woman was required, not that of the man, so this monogamy of the woman did not in any way interfere with open or concealed polygamy on the part of the man. But by transforming by far the greater portion, at any rate, of permanent, heritable wealth—the means of production—into social property, the coming social revolution will reduce to a minimum all this anxiety about bequeathing and inheriting. Having arisen from economic causes, will monogamy then disappear when these causes disappear?
>
> One might answer, not without reason: far from disappearing, it

> will, on the contrary, be realized completely. For with the transformation of the means of production into social property there will disappear also wage-labor, the proletariat, and therefore the necessity for a certain—statistically calculable—number of women to surrender themselves for money. Prostitution disappears; monogamy, instead of collapsing, at last becomes a reality—also for men.
>
> — ENGELS AND HUNT, 2010

Societies have characteristic family ideologies and family laws structured by their economies. This was a basic thesis of Engels and Hunt [2010], who used this premise to try to predict how the family would change in a post-capitalist society. The nice point is that this theory of the history of the family then itself became part of the ideological foundation of socialist family relations.

The professed aim of the Communists was to reform the relations between the sexes along the lines advocated by Engels. The universal participation of women in public industry would have as a consequence the abolition of the monogamous family as the basic economic unit of society. Private household work would be transformed into a social industry and society as a whole would take responsibility for the care and education of all children whether born in or out of marriage.

With considerations of property removed, marriage would be based on mutual love alone. Arranged marriage would vanish. We tend to think of arranged marriages as something oriental, but the underlying principle, of the marriage being a matter of passing down and accumulating property, was widespread. Even in nineteenth-century England, marriages among the upper class centered on the property motive: “It is a truth universally acknowledged, that a single man in possession of a good fortune, must be in want of a wife” [Austen, 1994].

Only the poor, Engels maintained, could afford to marry for love. But in the socialist future, love would become the sole basis for marriage.

Under the influence of radical legal theorists [Pashukanis, 1989], the Soviets at first envisaged that marriage law, like other contractual law, would be phased out in socialist society. The only interest the state would have in people’s cohabitation would be to register it for statistical purposes along with births and deaths [Berman, 1946]; so the RSFSR 1926 Family Code treated sex, marriage, and divorce as a private matter in which the state did not interfere. This liberal attitude extended to not prohibiting incest, bigamy, homosexuality, or marriage with post-puberty minors. Bigamy or polygamy, though not prohibited in marriage law, insofar as these involved economic exploitation of women, could be criminally prosecuted under the heading of exploitation. While contemporary Western commentators largely approve of the liberal attitude of the early Soviet state to homosexuality, they are more silent on its liberalism toward incest, bigamy, and other practices that would now be frowned on.

In 1920 free abortion had been introduced, which produced a rapid decline in the birth rate in urban areas. During the 1920s the Moscow birth rate fell from 30.6/1000 to 21.7/1000, while abortions rose from 5.7/1000 to 35.2/1000 [Berman, 1946]. Given that the overall death rate in the mid-1920s for the RSFSR was 21/1000 this appeared to represent a potential fall to below replacement birth rates [Engelman, 1932]. The birth rate in Moscow was unrepresentative. In rural areas where state hospitals providing abortion did not exist, that is, for the majority of Russians, the birth rate was much higher at 44/1000 for the greater Russian population. Clearly there was no general threat to reproduction in the 1920s, but projecting forward for a rapidly urban population in the mid-1930s, or a population vastly depleted by war in the mid-1940s, the outlook may have seemed different. Such a projection failed to take into account the fall in the death rate that could be anticipated to follow rising living standards. On the other hand, given the international environment, a sharp rise in deaths due to enemy action may have been anticipated. The subsequent 1936 law severely restricted abortion to cases of danger to maternal health or genetic disorder, and at the same time introduced substantial subsidies to women with large families. For the sixth and each subsequent child a stipend of 2,000 rubles a year, equivalent at the official exchange rate to $2,300, was introduced. Given that the average annual wage at that time was 2,700 rubles [Petroff, 1938], this was a large benefit. Paid maternity leave of 112 days was introduced along with birth benefits. One could either see these measures as natalist, or alternatively as being to protect mothers and children. They introduced, albeit partially, the principle that Engels had advocated: that the cost of raising children should be borne by society as a whole. If it is a social obligation then it applies to all members of society. Those who have no children have to support the costs of those with children, and by paying a penalty, be encouraged to have kids themselves.

A 1941 law [Nakachi, 2006] sought to make this economic obligation explicit by introducing a tax on bachelors, single, and childless citizens of the USSR. The socialization of childcare costs was still partial because even as late as 1960 the regular child benefit was paid only to unmarried mothers or mothers with large families [Lantsev, 1962]. The principle that children were to be supported by the joint earnings of the parents for smaller families was thus not questioned, and marriage continued to have an economic role even before the division of domestic labor between husband and wife was taken into account.

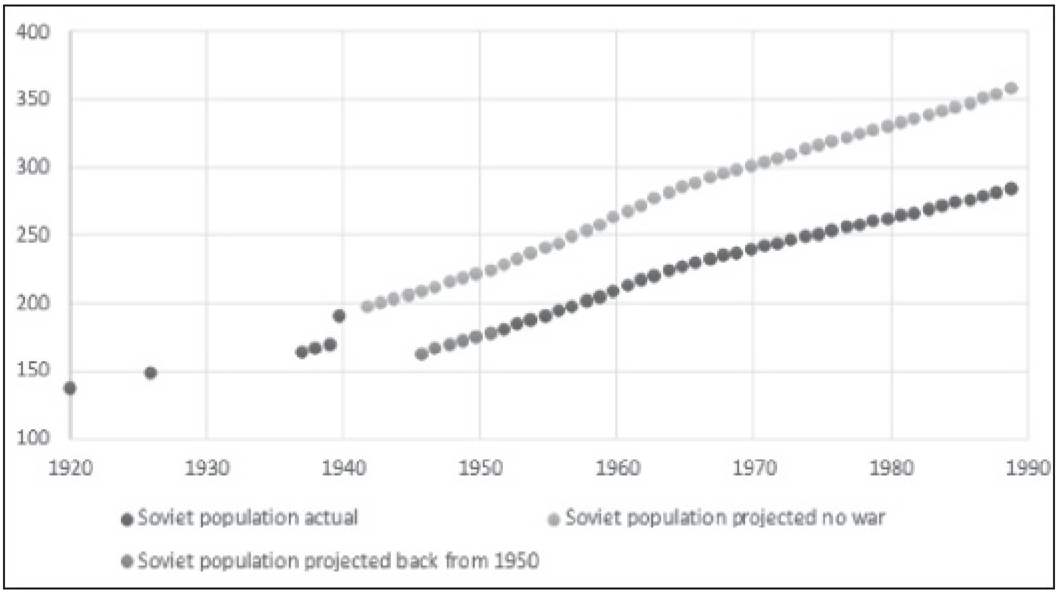


Figure 6.3. Soviet population suffered a huge demographic setback due to the German-Soviet war of 1941–45. Source: Pockney, 1991.

The German-Soviet war of 1941 to 1945 caused a huge demographic shortfall—initially of the order of 40 million, rising to around 70 million by the end of the Soviet period, as can be seen in Figure 6.3, which projects what the Soviet population would have been on prewar growth trends. But throughout the Soviet period the population continued to grow, probably as a result of social policy. The effect of the war on the sex ratio was drastic, with the ratio of men to women of reproductive age falling as far as 19:100 in rural areas [Nakachi, 2006]. This led to changes in family policy oriented toward: encouraging families with only two children to have at least one more, legitimizing single motherhood, and making benefits available to those women.

These goals were encoded in the 1944 Family Law. The bachelor tax was increased and also levied at a rate of 1/3 on couples with only one child.[115] Child support benefits were also made available to those single mothers who were not claiming child support from the father. Single mothers included both millions of war widows and unmarried mothers. Given a shortage of young men brought about by the war, single mothers were expected to be a significant fraction of all mothers.

The USSR underwent its primary demographic transition between the late 1930s and late ’50s. The main component of this was a shift from the high infant mortality rate of around 200 per 1,000 live births at the end of the ’30s to around 50 in the late 1950s and down to 25 in the mid-1960s [Shkolnikov and Meslé, 1996]. The decline was largely due to reductions in infectious diseases, particularly food and water-borne infections. As a result life expectancy at birth rose by 24 years in males and 27 years in females between the end of the 1930s to the mid-1960s. Overall birth rates and death rates declined sharply during the transition, reaching a minimum for death rate in the mid-1960s, and for birth rate around 1970 (Figure 6.4). After that both rates increased. Allen [2003] argues that the fall in the birth rate was critical to ensuring that food production per head rose, and that the growth in population was significantly slower than would normally have been expected in an industrializing country.

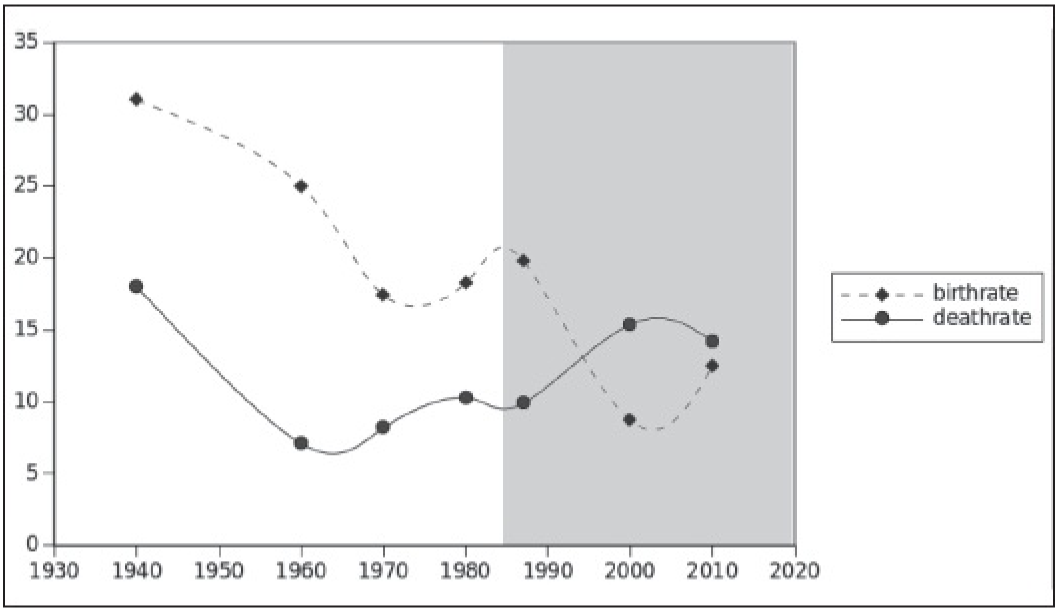


Figure 6.4. Evolution of Russian birth and death rates in Soviet and post-Glasnost periods. Source: Pockney, 1991; and UN Demographic Yearbooks.

The increase in death rate from the 1970s was most marked in men. It was largely due to a rise in heart disease, accidents, suicide, and interpersonal violence. A factor producing the minimum in male death rate in the late 1960s was that during the ’50s and ’60s the age structure of the population was skewed toward younger men. So many who reached maturity in the ’30s and early ’40s had been war casualties, that the number reaching the age when heart diseases strike was unusually low.

The birth rate remained well in excess of peacetime deaths throughout the first demographic transition giving a steady increase in population.

The transition from socialism to capitalism in the USSR in the late 1980s early 1990s induced a second, far more drastic demographic transition. The birth rate fell sharply into the range typical for developed capitalist countries. But, whereas in many capitalist countries the birth rate falls below the death rate, both are normally on a downward trend. In Russia the death rate rose sharply (Figure 6.4 and Table 6.7). A rise of this scale in peace was at the time unprecedented in a developed country. Those without university education, that is to say the manual workers and farmers, suffered increased mortality [Shkolnikov et al., 2006]. The intelligentsia experienced no decline in mortality. Subsequently Case and Deaton [2015] have pointed out that the same has been happening to white working-class men in the United States with similar causes: mass unemployment and de-industrialization [Stuckler et al., 2009]. As Figure 6.5 shows, this demographic crisis was a general phenomenon affecting the ex-socialist countries. The onset of capitalism and the deterioration of social conditions that followed meant that the region as a whole went into demographic decline.

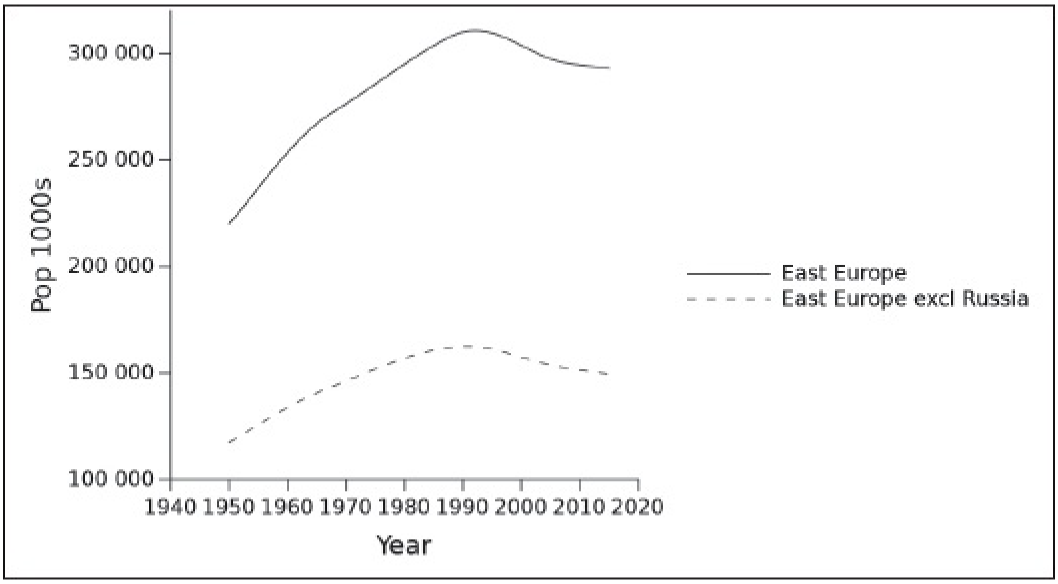


Figure 6.5. The whole socialist area of Europe experienced steady population growth until the transition to capitalism, after which population

declined sharply. Source: UN World Population Spreadsheet, 2015.

Figure 6.6. German fertility rate per woman. Souce: German Federal Statistical Office.

The contrast between capitalist and socialist family policy is best illustrated by a comparison of East and West Germany. Both Germanys experienced declines in fertility following the availability of modern contraceptive technology in the 1960s. By the early 1970s fertility had fallen below replacement levels in both East and West (Figure 6.6). But the birth rate in East Germany recovered to around replacement level by the late 1970s following the 1976 introduction of policies to socialize a considerable part of the burden of child raising [Salles, 2006]. Single mothers had priority access to kindergarten places. If no place was available they could go on sick leave at half pay, with the return of their job guaranteed as soon as a place became available. One year of paid parental leave was available for single women on the birth of their first child. For married women this was available only for subsequent children. Along with free nursery schools, birth bonuses, workplace childcare and workplace canteens all helped parents.

These policies clearly worked (Figure 6.6). The overall effect was to increase the birth rate in the East above the contemporary rate in the West. The availability of maternal benefits to single mothers increased the proportion of babies born to them, and led to greater social acceptance of their situation. Rents were low, but waiting lists for flats gave priority to single mothers and married couples. A common family pattern emerged of women having their first child before marrying and a second one after marriage [Salles, 2006].

With the union with West Germany, this benefit system was withdrawn and the consequent demographic shock led to East German fertility rates falling as low as 0.7 before converging on the all-Germany average of 1.4. This is still well below replacement level.

It was argued in Sections 5.6 and 5.8 that the combination of capitalist and domestic economies is antagonistic. Capitalist mass production replaces one economic function of the household after another: spinning, weaving, growing food, sewing clothes, baking, etc. The demand for skilled and educated adult workers converted children from being part of the domestic labor force to economic dependents, creating an incentive to limit family size. The development, by the chemical industry, of contraceptive technology then made this possible. The continuing demand for more labor then drew an increasing fraction of women into capitalist employment, which for a few decades allowed the workforce to go on growing. It then became necessary for both parents to work and the cost of private childcare becomes more of a disincentive to have large families or even have families at all.

Socialist states have had the aim of improving the status of women through their participation in the social economy. As such they could have been faced with the same spontaneous tendency toward below-replacement fertility. They avoided this because women’s participation in the socialist sector went alongside a deliberate policy of socialization on childcare.

A socialist economy does not face the same problem of a demographically induced falling rate of profit that affects capitalism. The state can choose to continue to invest even if the rate of return falls to levels at which capitalists would stop investing. But the rising share of old people in a rapidly shrinking population, as implied by very low birth rates, is a problem whatever the economic system.

Turning from Europe to Asia we see an inverse problem. Socialist governments, instead of trying to hold the birth rate up, tried to reduce it. Across the continent, the 1950s and ’60s launched a process of two demographic transitions:

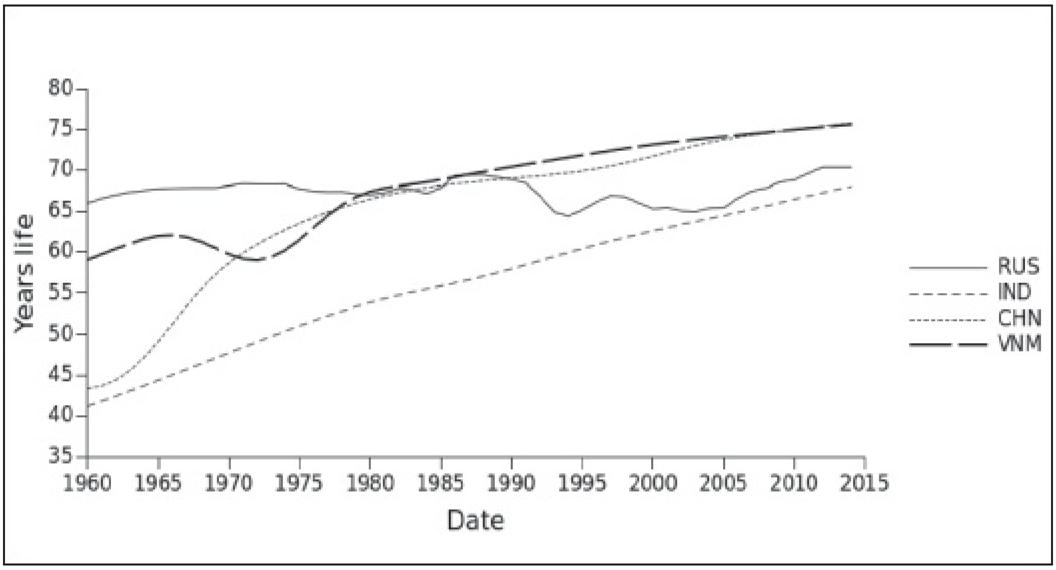


Figure 6.7. Life expectancy in India, China, Russia, and Vietnam. Source: World Bank.

1. From a high birth rate high-mortality society to a high birth rate low-mortality one.
2. From a high birth rate low-mortality society to one where both birth rates and mortality were low.

If we look at big developing Asian countries, we see that the socialist ones were the most successful in bringing about the demographic transitions. On life expectancy (Figure 6.7), Asian socialist countries have been very successful, overtaking the USSR just before that state collapse, and being well ahead of non-socialist India. The decline in life expectancy in Vietnam from the late 1960s coincided with the most intense period of the Vietnamese-American war. In China the most rapid improvement in life expectancy was during the Maoist period when initiatives like the mass training of medical auxiliaries to improve rural health care were rolled out.

A consequence of the rising life expectancy was to create a danger that there would be more people than could be fed on China's limited arable land, so from the 1970s the government had an active birth control program [Banister, 1984]. This was remarkably effective. The rapid rise in life expectancy in the 1960s was followed by an equally dramatic fall in fertility during the 1970s (Figure 6.8). The government population policy culminated in restricting most families to have only one child, with the restriction lasting thirty-five years from the end of the 1970s. As Figure

6.8 shows, current fertility falls below the reproduction level. By 2010 the fertility rate was down to 1.5.[116]

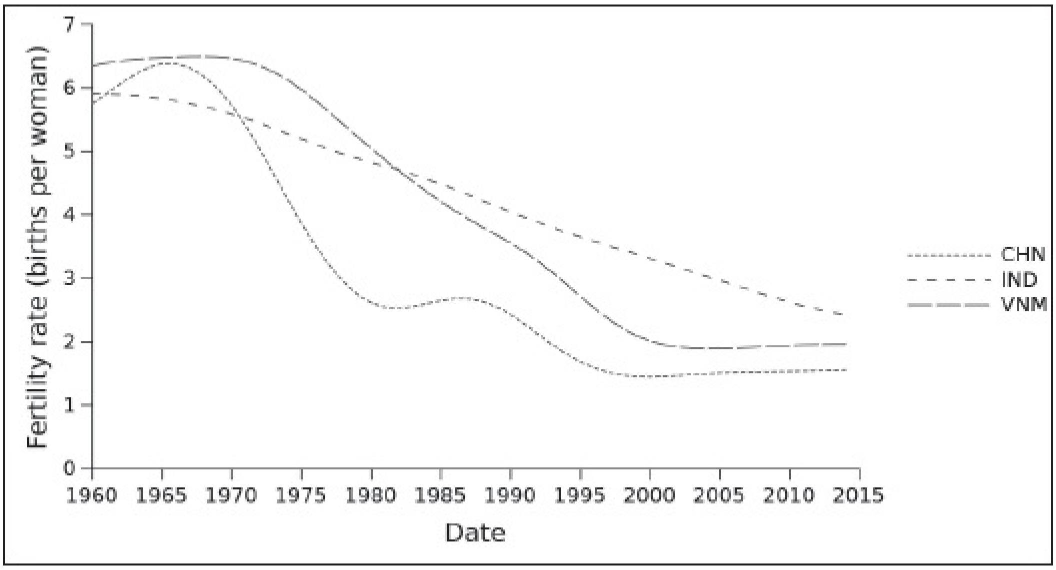


Figure 6.8. Fertility in India, China, and Vietnam. Source: World Bank database.

The effective female fertility rate, the number of daughters per woman, is what determines long-term population dynamics. It must be at least 1 for steady reproduction. In China, preference for boys has skewed the population by several mechanisms: selective abortion of female infants, higher mortality of girls due to neglect [Banister, 2004], and a lower likelihood of having a second child if the first is a boy. As a result the male/female ratio in China is 117/100. So each woman in China was, by 2010 giving birth to on average only 1.5 × [100/217] = 0.69girls.

The official abandonment of the one-child policy indicates that the government considers that the birth rate has fallen too far.

Between the 1980s and the 2010s China enjoyed what some economists call a demographic dividend [Fang, 2010]. The birth rate had fallen so the number of children supported by each adult was lower while there were still plenty of young adult workers born during the baby boom and low infant mortality of the 1960s. This accelerated the expansion of an industrial urban economy [Cockshott, 2006a]. The productive workforce grew disproportionately fast compared to the overall growth of population.

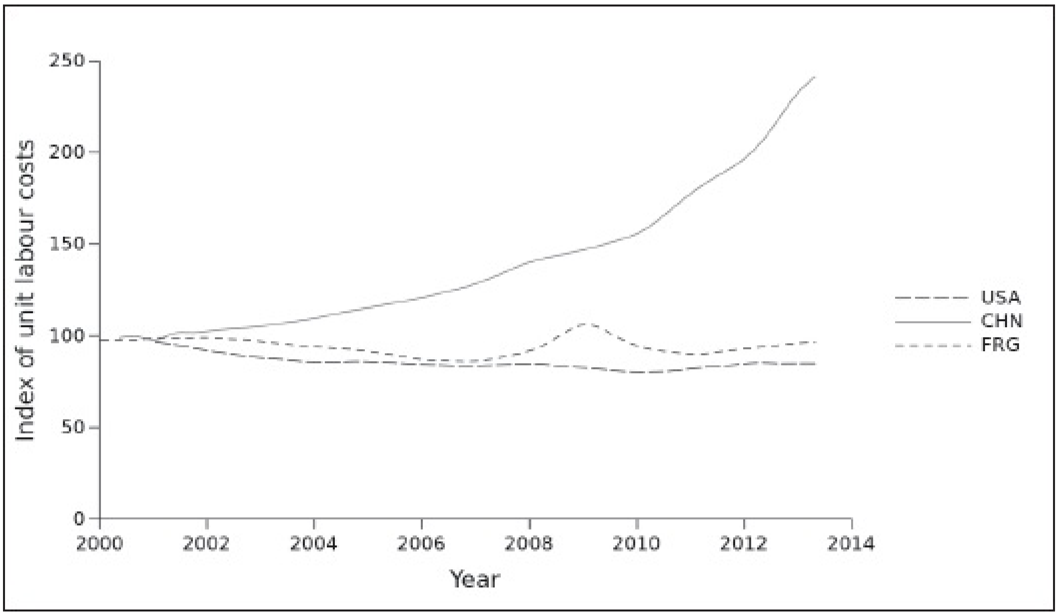


Figure 6.9. Movement in relative unit labor costs in Germany, United States, and China. National labor cost in year 2000 is taken as 100.

By the middle of the 2010s the productive share of the Chinese population startsed to decline [Banister et al., 2012]. Some growth of the urban population will continue as a result of the continued mechanization of agriculture, but overall the dependency rate will rise. Given that China has a high ratio of population to agricultural land, there may be some justification for a slow and managed decline in its population. In the long term a somewhat lower population density should make a sustainable form of economy easier to achieve. But that sort of managed decline would imply an effective female fertility rate closer to 0.9 than 0.7. If population is to be either stabilized or allowed to shrink more gradually China will have to adopt mother-friendly reforms similar to those introduced by the DDR in 1976 and to carry out a big cultural campaign to raise the perceived worth of baby girls.

China in the 1980s developed a mixed economy that combined state-owned industry alongside semi-private agriculture and private capitalist firms. The position of workers, whether in state firms or private capitalist firms, was similar. They were employed for a wage and lacked long-term security of employment. The level of wages was determined by supply and demand on the labor market. In these circumstances the one-child family policy acted to favor the labor interest. It reduced the number of young workers entering the labor market and, by the 2010s, was strengthening the bargaining position of workers. When combined with the rapid rate of investment in China this allowed wages to rise very fast (Figures 6.9 and 6.10). A policy introduced when the socialist economy was dominant operated a generation and a half after its introduction to strengthen the position of workers at a time when the private sector was just becoming the dominant element of the economy. The long lags associated with any demographic feedback means that social relations may change considerably before the feedback takes effect.[117]

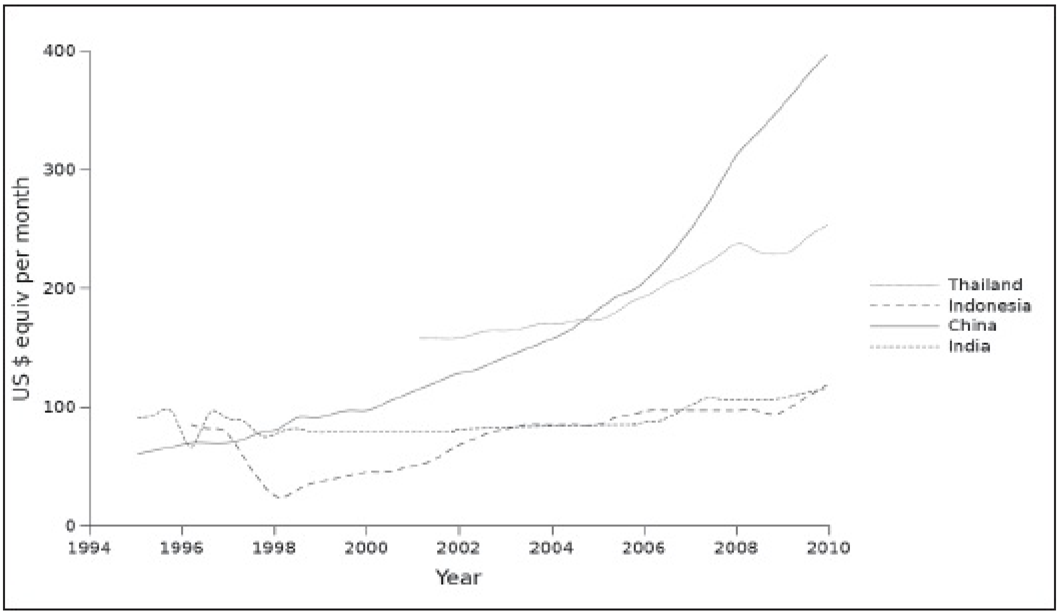


Figure 6.10. Movement in monthly wages in India, Indonesia, Thailand, and China. Money wages in equivalent $USD.

The social relations of any economic system have to ensure the reproduction of the society from year to year. I have written in the last part about the most fundamental function of any economy: human reproduction. Let us now look at the reproduction of the non-human aspect of the economy.

Any economy must schedule regular productive activities and ensure that the non-human environment is prepared for these activities. Some of this preparation is carried out by nature, by the cycle of the seasons, and the flow of elements and life through the ecosystem. Some of it is prepared by human activity itself, plowing and weeding land, setting aside seed corn, preparing stocks of fuel, raw materials, and tools for future production.

Even a relatively simple peasant economy needs to have a specialized branch of the division of labor responsible for organizing such scheduling.

The rise of calendar priesthoods in the Neolithic is an example of such a temporal coordination branch of the division of labor. With rises in the density of population in places like Egypt, the functions of such priesthoods went beyond saying when crops should be sown and land plowed to maintaining and distributing buffer stocks of grain.[118]

With the development of more advanced industrial production, the preparation of the portable conditions of production won importance. The land stays there to be plowed each year, but the raw materials and tools of industry must be delivered to where they are used. Delivery depended in turn on the harnessing of beasts, the conquest of the wind, and the taming of steam. The masters of these forces, the classes first of merchants, then merchant capitalists, and finally industrial capitalists, then assumed control of the conditions of production. The industrial capitalist had to organize both the human and the inanimate resources needed for his factory. He had to order in and schedule the delivery of the machinery, buildings, and raw materials for the workers he hired. Unlike the priest who had only to adapt to the regular movement of Apollo and the helical rising of Venus, the capitalist had to attend more numerous and capricious gods. The manager of the Riihimaki-Saint Petersburg Railway had to order his locomotives from Neilson and Company in Springburn, Scotland, his steam coal from the mines of Wales, sleepers cut from local timber, etc. In all cases he had to be sure that the goods met his technical specification and that they would be available on time, delivered to the right place. This presupposes a developed commercial correspondence. The suppliers and users have to exchange letters, telegrams, and later emails that inform one another about technical specifications, likely delivery times, quantities, prices offered and prices agreed. I will call all the information about the physical properties of the goods the "use-value channel" in this information flow, and the information about prices the "exchange-value channel." The use-value channel is needed in any industrial system, whether it is a mass of independent firms, a big multinational with component parts spread around the world, a state organizing in wartime production, or a socialist planned economy. The comparative importance of an exchange-value channel has been disputed.

Hayek [1945 and 1955] laid great store on the importance of the exchange-value channel, scarcely acknowledging the existence of the other channel.[119] His fellow countryman Neurath [1919, 1917, and 2004; Uebel, 2005] claimed that real industrial coordination depended overwhelmingly on the use-value channel. Basing himself on his practical experience of wartime industrial planning, he emphasized that wars were not won by calculations about bond prices, but by the logistics of food, munitions, and supplies. Efficiency in war economy depended on calculations in physical terms along with controls and rationing of physical products and labor. By applying these methods, it was possible for the Central Powers to overcome shortages and obstacles such as the British blockade that would otherwise have proven fatal at an early period of the war. Neurath believed that after the war the organizational structure used by the war economy would be readily adapted for a peacetime socialist economy. Neurath briefly attempted to put these principles into practice in the short-lived Bavarian socialist republic of 1919, before being imprisoned on its suppression. Similar sentiments about the peaceful application of wartime planning, which Neurath termed state capitalism, were expressed by Lenin [1965a],[120]

War was key to the transitions to socialism, whether the revolutionary civil wars in Cuba, China, Vietnam or the great world wars of the twentieth century. The world wars disrupted many capitalist states through invasion or mutiny and fostered war economies which were halfway to socialism.

6.4 DETERMINATION OF THE SURPLUS PRODUCT

In capitalist war economies, production, by and large, still took place in privately owned firms. There were state munitions factories like the Royal Arsenal (Figure 5.35) or the Oak Ridge and Los Alamos atomic weapons plants, but these were exceptions. The state directed labor by conscripting it into the army, and by conscripting women and men in key trades into essential war work. It also rationed the supply of key materials, fuels, and foodstuffs. Firms were subject to negotiated direction to produce only munitions, or restricted ranges of utility products [Edgerton, 2011a]. Money was still used to pay for the munitions delivered, and to pay workers. Buying food required both money and ration cards. Money alone was not enough, either for the consumer or for firms. In peace, money as the universal ration constrains everything. Shortage of it constrains the working-class consumers and uncertainty about future revenue constrains even those firms who have good cash reserves. Because the constraint on production comes via the exchange-value channel, not the use-value one, peacetime capitalist economies typically operate somewhat below full capacity. In war, national survival dictates that every available resource be put to use. The economy operates at the limits of its physical resources in materials, people, and machines.

The state as primary purchaser has to look not just at the projected costs of ships, aircraft, etc. it is ordering, but at all sorts of material constraints. In deciding what type of destroyers to order the navy first takes into account the requirements of their admirals for the ships to carry guns of different types, torpedoes, and anti-submarine weapons—all technical not financial issues. They then had to take into account the number of shipyards in the country able to build ships of different sizes, the delivery schedules for different kinds of projected weapons and ship machinery, the availability of metals and alloys of different weights and strengths. They then have to ask whether the demands on skilled labor would require the cancellation or postponement of other orders.[121] Money was a relatively secondary concern. The availability of state credit, at least within the domestic economy, that was effectively unlimited removed money as a constraining resource [Keynes, 2010]. The same point about money applied *a fortiori* to the socialist economies.

Keynes's [2010] essay on war economy is extraordinarily important for giving English-language readers an insight into the common problems facing both war economies and socialist ones. He starts by posing the basic question:

> We shall, I assume, raise our output to the highest figure which our resources and our organization permit. We shall export all we can spare. We shall import all we can afford, having regard to the shipping tonnage available and the maximum rate at which it is prudent to use up our reserves of foreign assets. From the sum of our own output and our imports we have to take away our exports and the requirements of war. Civilian consumption at home will be equal to what is left. Clearly its amount will depend on our policy in the other respects. It can only be increased if we diminish our war effort, or if we use up our foreign reserves.
>
> It is extraordinarily difficult to secure the right outcome for this resultant of many separate policies. It depends on weighing one advantage against another. There is hardly a conceivable decision within the range of the supply services which does not affect it. Is it better that the War Office should have a large reserve of uniforms

> in stock or that the cloth should be exported to increase the Treasury's reserve of foreign currency? Is it better to employ our shipyards to build war ships or merchant-men ? Is it better that a 20-year-old agricultural worker should be left on the farm or taken into the army? How great an expansion of the Army should we contemplate? What reduction in working hours and efficiency is justified in the interests of A.R.P.? One could ask a hundred thousand such questions, and the answer to each would have a significant bearing on time amount left over for civilian consumption.

Keynes argued that under wartime conditions there was a permanent shortfall of supply of consumption goods. While the normal effect of this was to induce inflation, the effects of wartime legislation such as Excess Profits Taxes were to suppress the inflation in the short term. In wartime the size of the civilian cake was fixed. Working harder increased the surplus for war production but not for consumption "If we work harder, we can fight better. But we must not consume more."

Assuming people worked longer hours, there would be more going out in wages. In the long term inflationary pressures would break through. In the absence of a common plan by the government, the effect would be that prices would rise to absorb the additional wages. So all the extra money paid out for the longer hours worked would end up in the accounts of the capitalist class and workers would experience no rise in real wages. The capitalists would then lend their increased profits to the government to finance the war, or perhaps spend some of them on personal consumption, further reducing the share available to workers. If they lent the money to the government, they would end up owning even more of the national debt, giving them thereby a claim on postwar resources.

But of course not only goods were in short supply. So was labor. This put trade unions in a position to bargain for higher wartime wage rates. But given the actual fixed output of consumer goods, no increase in real wages would result, simply more inflation. To avoid inflation it was therefore necessary to remove from circulation and transfer back to the government the extra money that it was spending on the war. Were this done simply by increasing income taxes and indirect tax, the money would be removed, but workers would see no benefit from their extra work. Instead Keynes proposed a scheme of deferred pay. A graduated scale of enforced savings, analogous to progressive income tax, would be imposed. Workers would get war bonds that could be redeemed for cash after the war.

Keynes notes that in war, in the face of rising costs, there was strong pressure both to subsidize essential foodstuffs and to introduce to the UK family benefits of the sort discussed earlier in the context of the USSR and the DDR. He warns that such policies, aimed at greater equality, would only be viable in the context of the deferred wages scheme, since otherwise they would have led to further inflationary pressures.

6.5 SOCIALIST ECONOMIC GROWTH

Peacetime socialist economy shares many of the attributes of a war economy: tight resource and labor constraints, money no longer a constraint, suppressed inflation, controls over the allocation of physical resources. The suppression of inflation was more effective in socialist economies, since the large bulk of the consumer goods market was served by state enterprises whose output was sold at planned prices. The Keynesian solution to suppressed inflation was not really available. People ran up balances in their savings accounts, but the idea of forced saving into bonds that would be redeemed for consumption at a later date was not feasible in the long term. It only works if the period of increased labor output and restricted consumption is going to be relatively short. There has to be a reasonable prospect that at a later date circumstances will be more relaxed. The socialist growth theory of Feldman [1964] had something of this character. It proposed that there would be a period of sacrifice while a larger share of national income went into the production of means of production. This would lead to a larger possible output of consumer goods since the expanded machine producing sector could supply the consumer goods sector with the means to increase its output.

> The rate of growth of income increases as a function of the industrialization of the country at every stage of its development, for the ratioKu/Kp is undoubtedly one of the primary indicators of the level of industrialization of the country, by virtue of the constantly increasing significance of industry in the contemporary economy. Thus an increase in the rate of growth demands considerable industrialization. In order to raise the constant increment of income from 10 percent to 15.7 percent it is necessary to almost double Ku/K - p.

Thus an increase in the rate of growth of income demands industrialization, heavy industry, machine building, electrification. [194]

In the quote above, Ku/Kp refers to the ratio of capital in Sector I producing means of production to Sector II producing consumer goods.

The basic equation of the Feldman growth model is

$$D' Sf = Du/D$$

where: *D '* is the overal rate of economic growth; *Sf* is the index of capital effectiveness or the output to capital ratio (using the subscript *f* to distinguish it from Marx's variable S); D is the overall output in the current period of the economy; *Du* is the net output of the capital goods sector, analogous to Marx's sector I, but net also of the capital consumption in sector II.[122]

Given Marx's labeling of reproduction as

$$O_1 = C_1 + V_1 + S_1$$

$$O_2 = C_2 + V_2 + S_2$$

Where suffix 1 indicates producer goods and suffix 2 consumption goods, Ci is capital goods consumed in sector i and Vi wage goods consumed in sector i.

We can obtain Feldman's *Du* as $D_u = O_1 - (C_1 + C_2) = S_1 + V_1 - C_2$.

Although Marx's reproduction schemes only deal with flows of wage goods and producer goods, the Feldman model uses a variable *S* which is the annual output, in rubles, produced per each ruble of producer goods in use. It thus has dimension time^{-1} as is required of any rate of growth (see also discusssion in Section 5.9).

Marx's variable C refers to *flows* of producer goods, but it is common to use another variable K to stand for the stock of capital goods when discussing capital composition and the rate of profit. The organic composition of capital which Marx showed to be inversely related to the rate of profit is then [K/V]; Feldman's capital effectiveness can then be defined as ***Sf*** [(S + *V* + *C)/K]*.

If we assume that in a socialist economy there is no luxury consumption by capitalists, then the entire surplus is directed into building up the stock of means of production. Further, since this is a socialist economy in expansion, Marx's basic static equilibrium condition that $C_2=V_1+S_1$ does not hold. First because of the accumulation, and second because the two sectors are not financially independent properties balancing their trade with one another. They are instead seen as both parts of the same unified property. Transfers between them therefore do not have to take the form of equivalent exchange.

In Marx's analysis there is an assumption that the same variable symbol can stand for different things as a consequence of commodity trade. So his symbol V stands initially for a sum of money advanced to buy labor power. But later it stands for the labor time required to make the wage goods bought by the workers under the assumption that the value of the wage goods will be the same as the value of the money paid for them.[123]

But how are we to relate this to the Feldman model, which historically appears to have been the original guiding theory behind Soviet industrial policy [Clark, 1984]? What are the units in which the growth is expressed? The simple answer is that the units are monetary, but how do these money quantities relate to physical output and to labor hours?

By its nature a growth theory is talking about development over time. For a snapshot view, as in Marx's reproduction theory, we can abstract from changes in the value of money; over periods of several years this is no longer safe. We would expect that in an industrializing economy the productivity of labor will rise, so that either or both of the ratios:

$$\frac{\text{money}}{\text{use values}}$$

or

$$\frac{\text{money}}{\text{labor time}}$$

will change. But for the moment let us assume that we are looking at a sufficiently small interval for these changes to be insignificant. It would then be valid to treat all of the quantities in the Feldman model as measures in terms of labor time. Let us see what this implies.

1. The variable D' is rate of growth of money national income. National income is in millions of rubles (P) per year so its units would be [P/yr], and the growth of national income AD would be in [((P/yr))/yr] = [P/

(yr^2)]. The proportionate rate of growth is then obtained by dividing through by national income D G [P/yr].

Assume for the sake of argument that in those days a ruble was the product of one person hour of labor, what the growth of national income converts to is a measure of [(Persons × hrs)/(yr2)]. But since years and hours are both time, they cancel out, and the final measure is equivalent to ΔD [Persons/yr].

What does this tell us?

It says that if we assume that over the short term labor values do not change, the Feldman equation is actually giving us a measure of the number of new people added to the economy each year, that is, the growth of the industrial labor force. The growth Feldman is concerned with is the proportionate growth of the labor force since he divides Δ D through by existing national income, *D* which is a flow of value, and in dimensional terms a flow of value is equal to a number of persons—more strictly it is equal to a number of people working average full-time hours.[124] So dividing through by national income is dimensionally equivalent to saying the *D* expresses the rate of growth of the workforce. We can check the rationality of this by looking at the other terms of his formula.

2. The term [(D_u)/D], by the rule that a flow of value is a number of persons, expresses the fraction of the workforce devoted to the net production of means of production.
3. The "effectiveness of capital" index S measures the flow of output value made possible by a unit investment in means of production. If our unit of means of production is one person year, and the units of value flow are persons as before, this expresses how many years a worker would have to work to produce the means of production needed for one more worker.
4. I leave it to the reader to check that after translation into the language of the labor theory of value, both sides still have dimension [1/yr].

So Feldman's formula, once you strip it of its monetary form, is relating the rate of growth of the productive labor force to the share of the labor force making means of production, via a constant of proportionality. One can view Feldman's as a master equation governing the dynamics of socialist economy for the dynamics of capitalism. Let us next look at some of its implications in the short, medium, and longer term.

The equation above indicates that the larger the proportion of output devoted to new means of production the faster will be the rate of growth. To move to a high growth mode a socialist economy had to raise the relative size of Sector I compared to Sector II. Once this shift had been achieved, both sectors could grow more rapidly.

Allen [2005, 2003] presents evidence that the early years of the Soviet planned economy fitted this Feldman pattern rather well. As Figure 6.11 shows, over the first 5-year plan (which ran 1928 to 1932) real consumption per capita fell. This is consistent with overwhelming emphasis being devoted to the machine-building industries, and little investment going into consumer goods industries. This produced a shift in the relative proportions of Sectors I and II. But in the subsequent plan, where the output of the machine building could be directed into increasing the capital stock of consumption industries, there was a rapid rise in real per capita consumption.[125] It can be seen that in the period of overlap the two trends are very similar, which validates Allen's data. The underlying point is that the rate at which children grow will be closely dependent upon living standards, particularly the available diet.

This did not necessarily mean that urban real wage rates rose rapidly; rather, a larger portion of the population moved from the countryside to the cities, and urban living standards were substantially above the primitive levels of peasant life. Thus, averaged across the whole population, real consumption rose, and the corollary of this is that production of consumer goods rose rapidly. The critical point is that without first raising the relative size of Sector I it would be impossible to have ever achieved a rapid growth rate, since it is the net product of Sector I (D_u) that constrains the whole process.

What is the precondition for the Feldman model working?

Since, at least instantaneously as a derivative, it is an equation that, once translated to the labor theory, is about the growth of the workforce, it must depend on such growth being possible. It is, more specifically, a theory about the growth of the industrial economy—the two-sector model on which it is based assumes an industrialized structure with capital goods and consumer goods industries.

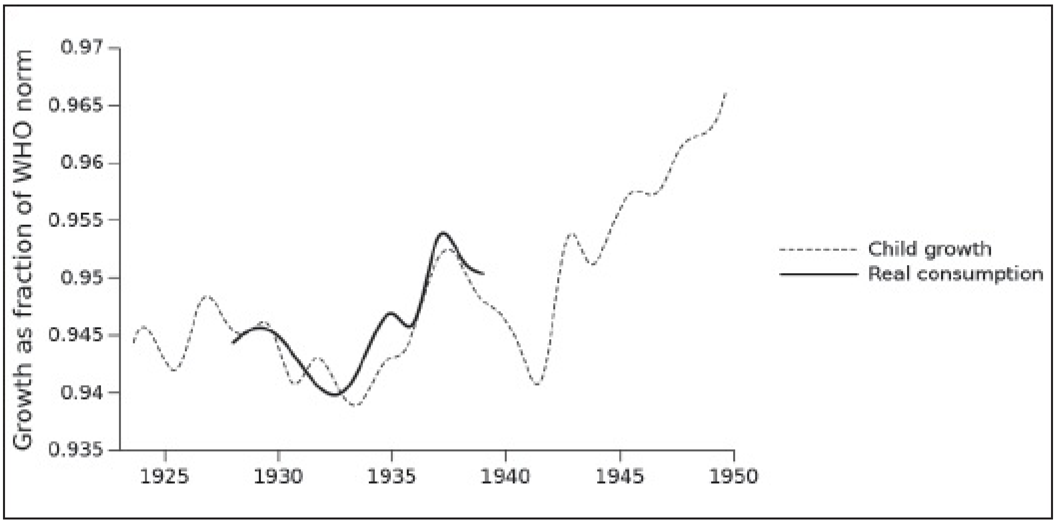


Figure 6.11. (top): Movement in real consumption per capita in the USSR during first phase of planned industrialization, as of 1928. Source: Allen, 2005. (bottom): Data from above are superimposed on time series of Soviet child growth rates. Source: Pelkonen and Cockshott, 2017.

The industrial economy can grow its workforce in several ways: through natural population growth, through immigration from other nations, or by internal migration from the countryside. All of these occurred during capitalist industrializations, only the first and the last during socialist ones. A previous section discussed the measures taken by European socialist countries to ensure that they continued to have a growing population. But natural population growth was relatively slow—of the order of 2 percent a year in the USSR. This would only support a modest rate of economic growth.

Figure 6.12 shows a Feldman growth path for an economy like the USSR starting out with an industrial population of 18 percent. Initially I assume that 90 percent of all investment was channeled into Sector I, which is not enough to compensate for depreciation in Sector II, so consumption per capita falls during the first plan period—as it actually did. In subsequent plans I assumed that 60 percent of investment went to sector I. Assumptions about initial population distribution are realistic. The relative size of sector I grows to a peak at the end of the first plan and then falls and levels off during the subsequent ones. Clearly this would have been a very rapidly growing economy. Equally clearly, this growth path could not have continued, since urbanization would have approached 100 percent by the end of the 1940s. In the model, it is assumed that migration into the cities stops once urbanization reaches 80 percent. This has the effect of sharply slowing the rate of growth of per-capita consumption. In reality the slowdown did not occur that sharply, but slid in gradually at the practical limit of urbanization was gradually reached.

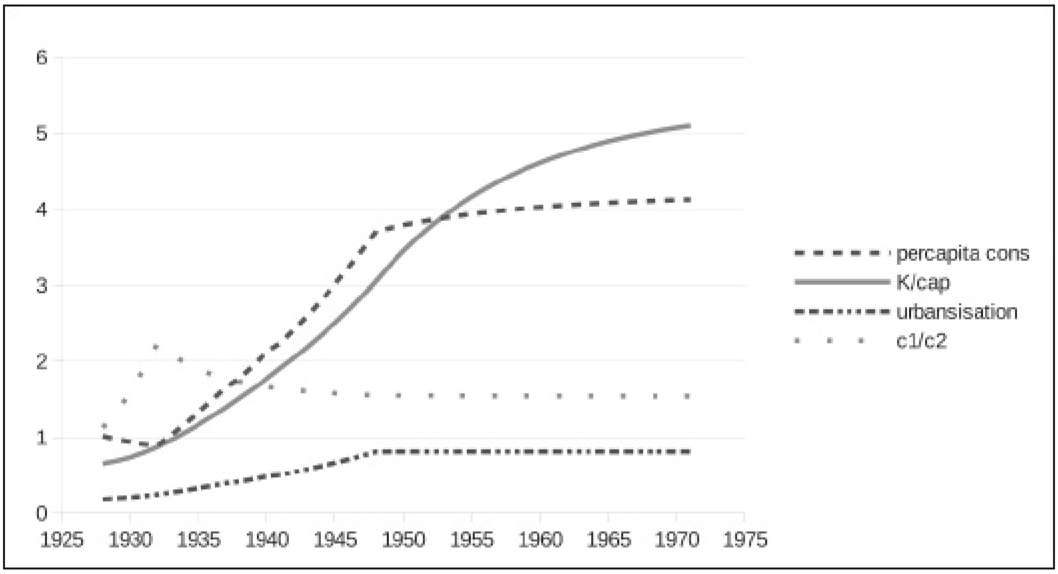


Figure 6.12. Simulation of a Feldman model applied to USSR from 1928.

We know that the real economic history of the USSR was much like this, modified by the effects of urbanization being more gradual, and with an almost ten-year delay produced by the war. As time went on, and as the stock of means of production measured in person years per capita rose, then even the possibility of further investment became blocked off. If plant and machinery has a fixed life, say twenty years, then more and more of the output of Sector I has to be devoted to simply replacing existing machinery. If Sector I makes up half the economy, then it would be impossible to sustain a long-term K/cap of more than ten person years. At that level, even when working flat out, sector I could only make good the annual wearing out of plant. All the measurements in Figure 6.12 are in terms of labor value—person years.

It is evident that the law of the declining rate of profit is just a particular capitalist social form of a more general law that affects the industrial mode of production, whether socialist or capitalist, as the ratio of embodied to living labor rises over time. Socialist economy, however, avoids certain of the worst effects of this process while being susceptible to others. It avoided the recessions, unemployment, and pressure to drive down real wages that affected the capitalist world on and off since the 1970s when the high organic composition of capital became a general problem. On the other hand, the slowdown in the rate of economic growth in the socialist world produced a much more severe ideological and political crisis than that which hit the West in the economic crises of the 1970s and post-2008.

Calculations in terms of labor values are the same basis that one uses to arrive at the law of the falling rate of profit. The leveling off in value terms may still be compatible with an increase in use-value terms, but it does enable you to show that the end state must be one in which simple reproduction occurs in value terms.

In contrast to labor value calculations, measurement in use-value terms is difficult. You are comparing incomensurables—quantities of different use-values at different times. While growth in terms of labor values uses a unit—time expended by a human body—that does not vary from year to year, the physical mix of outputs produced by the USSR in 1930 and 1980 was very different. There were no jet airliners, no TVs, no nuclear power plants, no computers in 1930, no horse-drawn reapers in 1980. Output in each year can be represented by a list of how much of each type of good was produced: 60×2 engined jets, 8×4 engine jets, 1,600,000 GHhrs electricity, 1,506,000 Lada cars, etc. The problem is not just that there will be items produced in later years that were never thought of in the earlier years; even over shorter periods like five years comparison is hard. Suppose that over a 5-year plan there is a predefined categorization of products, which we could set up as a column of labels in a spreadsheet. In 1975 we list how much of each product was produced in the USSR as a column of figures, and do the same for 1979. How much did the USSR then grow between 1975 and 1979?

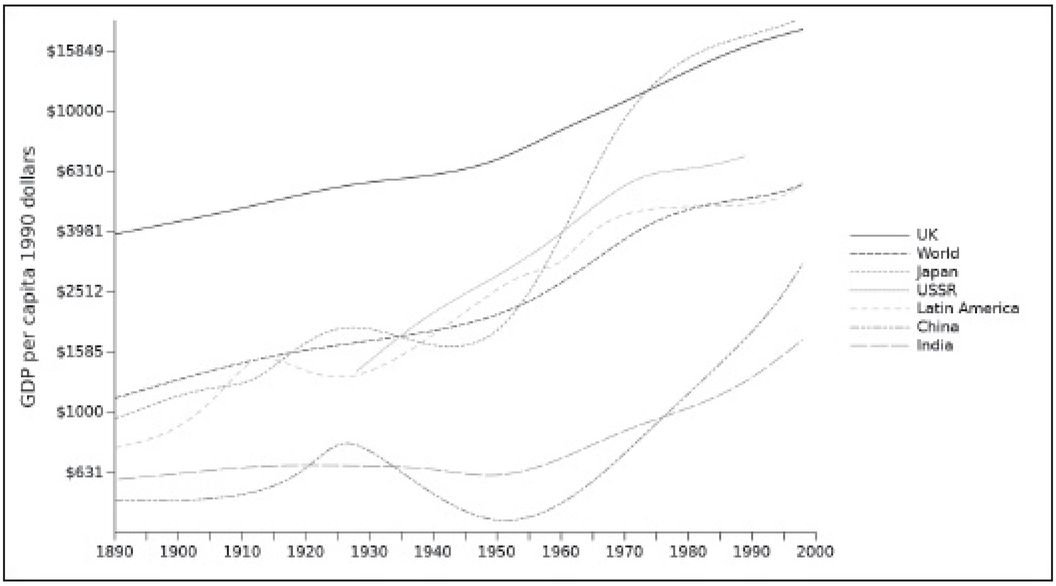


Figure 6.13. GDP per capita figures for some world regions over lifetime of USSR. Source: Maddison, 2001.

There is no definite answer unless all industries grew at the same rate. If for every product code, output in 1979 was 24 percent greater than in 1975 then the economy unambiguously grew at 24 percent. But what if car production grew 50 percent, aircraft production 20 percent, and electricity by 17 percent?

All you can definitely say is that growth was between 17 and 50 percent.

You can try to attach a more precise figure to it by giving all outputs a nominal ruble value and adding these up, but the resulting growth rate will depend heavily on the relative prices you use, and the change in the value of the ruble between 1975 and 1979.[126]

If, instead of inconstant monetary units, you value the output in each year in terms of labor values, you avoid the problem of price inflation, but you are back to the situation of the overall economic growth rate being equal to the growth rate of the hours worked that we have in the simple Feldman model. If technology improves over time, this means that hours worked might fall while the physical output of most industries rose. In terms of labor values the economy would be shrinking even if, in physical terms, it was growing. From the standpoint of state propaganda aimed at showing economic growth, this might be unwelcome.

GDP growth figures combine three processes. First is the movement of labor between the domestic and industrial modes of production. Second, there is the effect of absolute population growth. Third, new technology increases the physical production by each person. If one measures output in terms of GDP per head, this at least compensates for population increase but it still conflates technological innovation with shifts between modes of production.

It is widely believed that at the time the USSR broke up, its GDP per capita was substantially below that of the UK. The contrast between the living standards of the Soviet professional classes compared to their British and other Western counterparts is thought to have discredited the socialist economy. Although Western Europe was an immediate geographical neighbor, in terms of economic history, Latin America or Japan would have been better reference points. Figure 6.13 shows, using data published by the OECD [Maddison, 2001], that in the late nineteenth-century Japan, Latin America, and the then Russian Empire were clustered around the world average in terms of income per head. They fell into a middle-income group, well ahead of China and India, but were far poorer than the UK. Compared to the world average, the Soviet planned system did pretty well. Planning started at the end of the 1920s and finished at the end of the 1980s. The USSR started the period of planned economy with 4/5 the world average income per head, level with Latin America. It ended it 1 1/3 world average. Latin America had tracked the world average. Soviet income per head was 25 percent of the UK level in 1928 but had climbed to 45 percent by 1960. In the next thirty years Soviet incomes roughly tracked UK growth ending at 43 percent of UK levels.

According to the OECD, Soviet long-run rates of income growth were better than those of the UK for most of the USSR’s life, slipping back slightly in the 1980s. Internationally the really big success stories were Japan and China. Japan moved from being a middle-income country to overtake the UK by the 1970s despite the severe setback caused by wartime bombing that had razed most of its cities [O’Brien, 2015].

Estimates of the long-term growth of the USSR or estimates of the comparative sizes of the U.S. and Soviet economies in, say, the 1980s are inevitably controversial, with proponents of different political views giving divergent estimates depending on the pricing models that they choose to adopt. Thus the Bezier curves in Figure 6.13 should be interpreted as giving the rough shape of what happened. There are no totally objective answers to these questions. The very idea of precise comparisons between the overall national products of different countries, or different periods, is a monetary illusion.

If instead of looking at monetary estimates of output per head we look at statistics for physical production and consumption we get a rather different picture. Let us look first at food production. Figure 6.14 (top) shows the growth in Soviet production of four big food categories for benchmark years in successive decades. From 1950 to 1970 all categories expanded rapidly. Grain and milk production then leveled off while meat and egg production continued to grow rapidly. The leveling off of grain production appears initially to be a failing, but if we compare the Soviet performance with the United States the long-term trend of grain production is very similar (Figure 6.14, bottom). As countries become richer they tend to shift their agriculture from starch production to higher-quality protein foods. We see that Soviet output high-quality foods continued to grow after 1970.

But hold on. Figure 6.14 gives only the proportionate growth of output. A rapid growth from a very low base could still leave the USSR with a relatively poor supply of food. How did Soviet food production per person stack up by international standards?

Figure 6.13 shows that monetary estimates of output per head put the early USSR level with South America rather than the UK or the United States. How did things compare in real terms by the end of the USSR?

If we look at production of protein foods per head in Brazil and the USSR in 1988 (Table 6.4) we see that the USSR was substantially ahead for meat, milk, and eggs. That is not surprising. What is surprising, given the poor image that Soviet agriculture had in the West, is that Soviet supplies of these foods had also overtaken the UK and the United States.

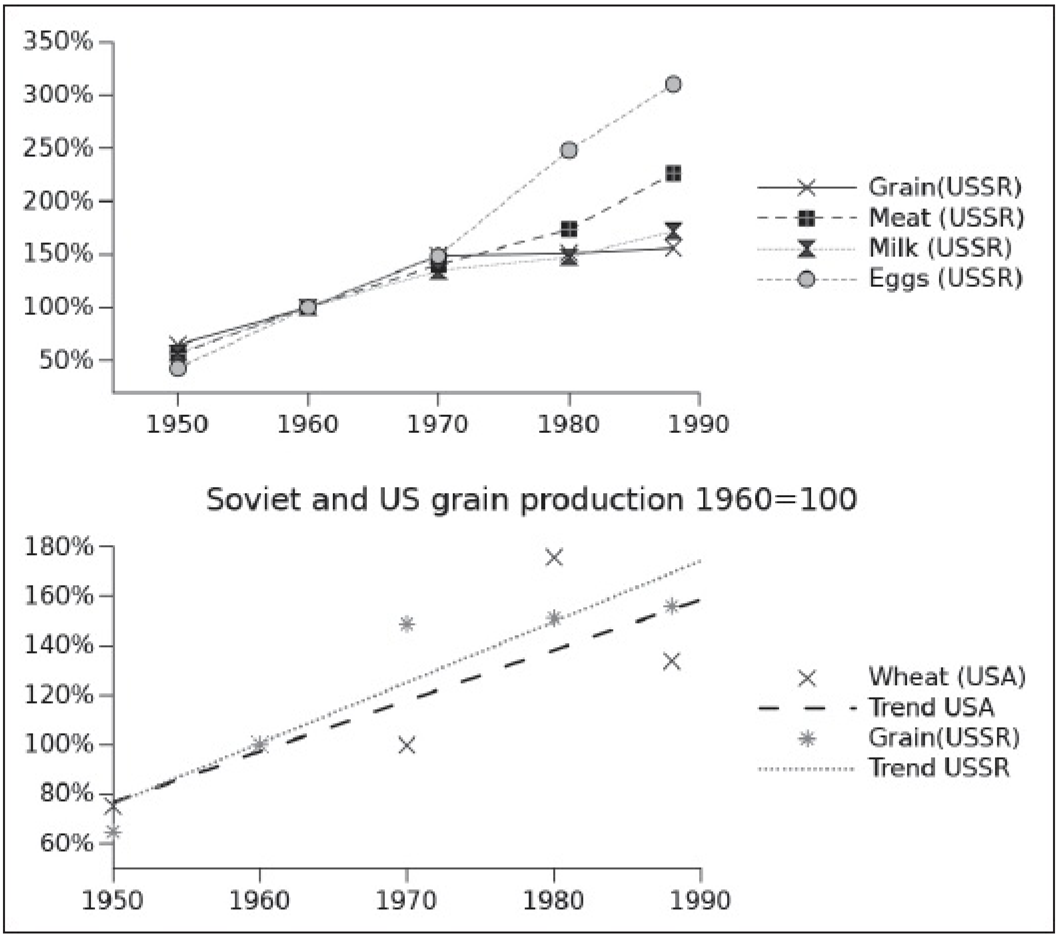


Figure 6.14. Despite the USSR having a reputation for food shortages, agricultural output actually grew rapidly. The growth trend for grain was similar to that of the United States. Source: Pockney, 1991; and USDA database.

TABLE 6.4: Comparison of Late Soviet with UK, Brazil, and U.S. Annual per Capita Output of Major Protein Foods

Country	Year	Meat (Kg)	Milk (Kg)	Eggs (units)
USSR	1988	69	375	299
Brazil	1988	49	96	163
UK	1988	55	265	201
U.S.	1988	58	-	-
U.S.	1990	-	-	236
U.S.	1995	-	259	-

Note that for all categories, the late USSR had better figures. Sources: Pockney, 1991; FAOSTAT and USDA databases.

The Soviets were also relatively successful in the production of consumer durables. Production of TVs, washing machines, and refrigerators increased exponentially in the 1950s and ’60s, expanding hundredfold or thousandfold. Then from the late ’60s durables stabilized at levels of several millions a year. But that is not surprising with new products. They start out from a base of zero, and stabilize at a level sufficient to replace wear and tear. Soviet production levels of a range of products stabilized at levels that would allow the majority of households to have a TV, a radio, a washing machine, etc. Compared to the West, the biggest shortfall was in the production of cars. This leveled off at a production level of 1.3 million a year, which was far too low to allow car ownership to be general. At the end of the Soviet period they were producing only about 1 car per 200 inhabitants.

The relative underdevelopment of the car industry in the 1960s can be ascribed to ideological imperatives—the view that private cars were a bourgeois form of transport and that the only acceptable socialist form of car was the public taxi. In the age of global warming, an opposition to widespread car use may again come to seem rational, but in the 1970s with fossil fuels still plentiful, the decision was taken to mass-produce cars. With the ideological objection gone, the default assumption became that in due course every family would have one. The long waiting lists for cars then became a source of discontent, evidence that socialism could not mass-produce cars the way capitalism could.

The failure of the USSR to provide general car ownership was real, and if you accept that car ownership is praiseworthy then the failure was a legitimate ground for complaint. But that does not explain why loaves, not Ladas, loomed large as a grievance. The Soviets actually produced more food per head than in the West, so why the discontent?

It comes down to money, and prices. Food was systematically under-priced, with consequences we will describe below.

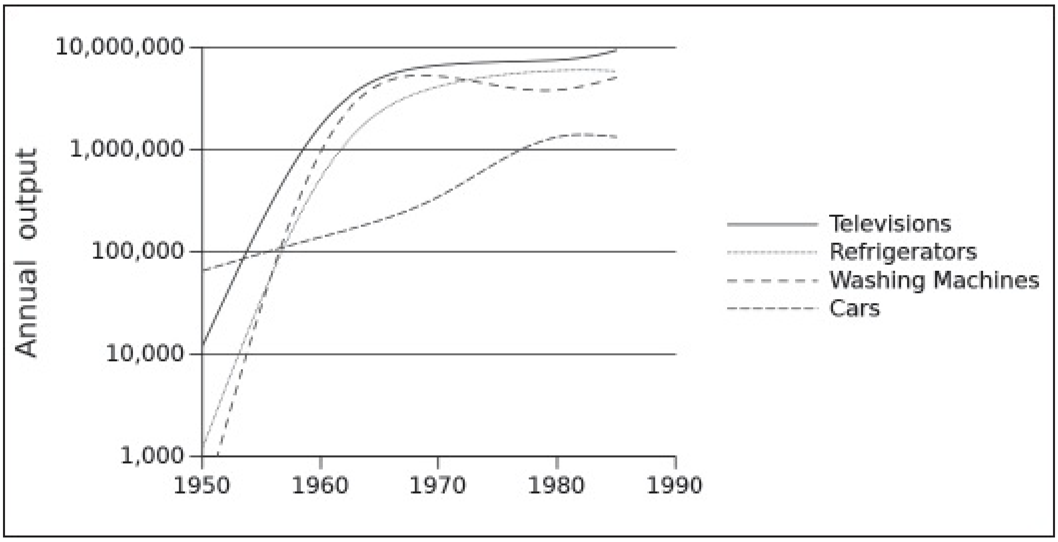


Figure 6.15. Soviet production of major consumer goods. Source: Pockney, 1991.

6.6 WHY THE SOCIALIST ECONOMIES STILL USED MONEY

This leads us on to the question of why socialist economies like the USSR still used money. Money was a

- way of integrating national accounts.
- a means of preparing the accounts of individual factories.
- a means of distributing income to workers.

The official doctrine from Preobrazhenski [1973] to Stalin [1952] was that money was due to be abolished and that it remained only as an auxiliary mechanism of use in state budgeting and trade with the as yet unsocialized sections of the economy.[127] It is easy to see that the overall state budget required some sort of scalar unit of calculation. If you want to make decisions about the overall proportions in which resources are to be distributed between consumption and investment, between civilian and military production, between health and education, you need some unit in which these proportions could be expressed. Money provided that. In principle a socialist economy might have followed Marx's suggestion [1970] and used labor directly as its unit of account, but Preobrazhenskii [1973] was dismissive of this possibility: "Under the mixed system of economy money had a great advantage, and could not be replaced by any 'labor-units' or other artificially conceived methods of calculation."

This is not entirely convincing, since it is hard to see why labor units would have been more artificial than printed paper sheets with numbers of rubles written on them. The state could equally well have issued notes with hours of labor written on them (see Figure 5.20).

Marx had made the slightly enigmatic statement that such notes were no more money than a theater ticket:

> The question: Why does not money directly represent labor-time, so that a piece of paper may represent, for instance, x hours' labor, is at bottom the same as the question why, given the production of commodities, must products take the form of commodities? This is evident, since their taking the form of commodities implies their differentiation into commodities and money. Or, why cannot private labor—labor for the account of private individuals—be treated as its opposite, immediate social labor? I have elsewhere examined thoroughly the Utopian idea of "labor-money" in a society founded on the production of commodities [1847]. On this point I will only say further, that Owen's "labor-money," for instance, is no more "money" than a ticket for the theater. Owen presupposes directly associated labor, a form of production that is entirely inconsistent with the production of commodities. The certificate of labor is merely evidence of the part taken by the individual in the common labor, and of his right to a certain portion of the common produce destined for consumption. But it never enters into Owen's head to presuppose the production of commodities, and at the same time, by juggling with money, to try to evade the necessary conditions of that production. [1954, chap. 3]

The implication of this passage from Marx was that he thought that labor notes were practical in the situations where production was "directly associated," which in the Soviet context would mean once the whole economy was nationalized: once private firms and collectives had been replaced by state farms and private handicraft no longer existed. The argument of Preobrazhenskii, and later Stalin, was that these conditions did not exist in either the 1920s or the 1950s, though that does not dispose of the issue. We need to ask why the existence of commodity trade with private or semi-private producers excludes the use of labor units.

Marx's answer [1847] in his polemic against Proudhon had been to argue that in a commodity-producing society without overall direction and planning there was no reason to suppose that overall supply and demand for each commodity will balance. Hence even if a tailor expended 4 hours on a pair of trousers, there is no guarantee that it will sell for 4 hours. If demand is slack he may have to accept a lower price.[128]

This is fair enough as an argument as to why fluctuations in supply and demand must lead to prices oscillating around their labor values, but it does not say why labor units could not have been used in the USSR by the 1970s or somewhat earlier in, for example, East Germany. Nor, more interestingly, does Marx's argument explain why the paper notes issued by the East German and Soviet states were labeled marks and rubles, not hours. At one level the signs on the pieces of paper are arbitrary. With an appropriate monetary and price policy it would have been possible to reissue new currency marked in hours such that, taken on average across the economy, goods sold in the shops for one hour of notes actually had, again on average, required one hour to make.

This would still be money, it would have circulated and could have supported a private or black market. There would have been nothing to prevent it passing from hand to hand like any other paper money. It would thus not have fully met Marx's criterion of being certificates issued to individuals certifying their part in common labor, but the unit of account would at least have ceased to be arbitrary, and the social relations of the economy would have become a bit clearer. But clarity would have been unwelcome to Preobrazhenskii and Stalin. The former developed the policy of "primitive socialist accumulation" under which the the rapid growth of heavy industry was to be funded by forcing the agricultural sector to sell its output at below value. Industrial products were to be sold back above value. If the currency had been denoted in hours it would have been blatantly clear to collective farmers that the state was cheating them. They were being paid for only a fraction of the time expended growing grain.

Marx's objection to Proudhon showed that even were you to denominate the currency in hours, you would still have to leave some leeway for prices oscillating. But that was only part of what the Soviet theorists were alluding to when they said that the prevalence of a collective farm or peasant sector forced them to use money. The real problem was that labor units would have exposed the exploitation of collectives.

There were other more technical problems with the idea of labor certificates. Marx clearly envisaged them being used in an economy in which private trade had been totally eliminated, but if the certificates had just been transferable sheets of paper, they could still have been used for private transactions. Marx seems to have been thinking in terms of some sort of individual nontransferable labor certificate. With modern information technologies it is not hard to see how to do this. Smart cards, terminals, databases keeping the records and software that prohibits transfers between private accounts would do it. But it is quite a lot harder to see how such a system could have been made to work with paper and pencil technologies and a population that was not yet 100 percent numerate.

Something similar to checking accounts would have worked, with people being issued labor checkbooks and writing checks to public stores against their purchases while having their accounts credited by the hours work they had done. But the labor associated with maintaining such a system with paper ledgers and paper reconciliation of accounts each week would have been massive. Paper checks only worked in the capitalist world so long as a) they were used for large purchases, small ones being in cash; b) only a minority of the population had bank accounts. It took computers and databases before it became practical for everyone to have accounts and to pay even for a cup of coffee with an electronic bank payment.

Social relations are always constrained by technology. In the historical socialist economies, possible social relations were constrained by the then existing state of information technology. Coins and banknotes were a much simpler low-tech solution.

It is easy to forget how important it is to have systems of accounting that prevent fraudulent diversion of resources. Socialist economies had to operate what Lenin termed the strictest accounting and control to try to prevent public resources being diverted into private pockets. Take the horrendously complicated payment system in large Soviet shops: the customer picked items they wanted, and the sales assistant gave them a chit, which they took to a cashier’s booth elsewhere in the shop. Here they paid for the goods and in return got a receipt which they took to the pickup point and exchanged the receipt for the actual goods. Compared to the way business was done in British or American shops by the 1980s, the USSR seemed to use a system of Byzantine complexity. Not only did you have to interact with staff three times, but the calculations often seemed to use an abacus. Why have such a system?

Such systems were not unknown in the West; some high-class butchers in the UK used it, and the motive in that case was clear. It was for hygiene, since it prevented the counter staff from handling both meat and money. In the USSR, though, it was to provide a paper trail whereby the honesty of the cashier could be checked. At the end of the day the chits and receipts could be reconciled with the cash in the cashier's drawer. The low technology of the abacus and the complicated paperwork were related.

Prior to the development and mass production of cash registers, checking on the honesty of cashiers was a universal problem. In smaller shops, the owner would make sure that he or a close family member worked the till. Large capitalist department stores used the Moscow system. In more advanced ones, the customers did not have to walk up to the till; instead the chit and the cash were dispatched to cashiers in the basement using pneumatic tubes. It was the invention of cash registers that allowed firms to trust their cashiers, since the machine automatically accumulated all transactions, and only opened the till drawer at the end of the transaction. Any dishonesty was revealed at the end of the day by comparing the total on the machine's register with what was in the till.

If they made too few cash registers, then the Soviets had to keep the old paper system. This is partly a reflection of the low priority assigned commercial activity, and thus to its technology. There was a pre-revolutionary history of disdain for trade in Russia, an association of trade with the despised Jews, and an almost complete breakdown of retail organization during the 1920s. Although an attempt was made to modernize and mechanize it in the second 5-year plan, it remained a low priority sector [Randall, 2008]. But the lack of mechanization in trade was symptomatic of a more general slowness in adopting labor-saving techniques.

Labor was not used as efficiently in Soviet industry as it was in the United States or West Germany. In one sense, of course, the USSR used labor very effectively: it had no unemployment and the proportion of women in fulltime employment was higher than in any other country. But a developed industrial economy has to be able to transfer labor to where it can be most efficiently used. Under capitalism this is achieved by the existence of a reserve of unemployment, which, though it is inefficient at a macroeconomic level, does allow rapid expansion of new industries.

The Soviet enterprise tended to hoard workers, keeping people on its books just in case they were needed to meet future demands from the planning authorities. This was made possible both by the relatively low level of money wages and because the state bank readily extended credit to cover such costs. The low level of money wages was in turn a consequence of the way the state raised its revenue from the profits of state enterprises rather than from income taxes.

6.7 SOCIALISM OR STATE-OWNED CAPITALISM

This relates to what has long been a controversial issue: Was the Soviet economy a new socialist form of organization or simply a state-owned capitalist one? In Marxist discussions this has been posed in terms of whether the USSR had a new mode of production or not.

Scholars like Hillel Ticktin [2011] hold that socialism is, in principle, a new mode of production but that the existing socialist economies did not have this mode of production and the USSR had no mode of production:

> In socialist and Marxist theory this is both theoretically and technically impossible, as socialism is a global system, a mode of production succeeding capitalism, which can only be implemented on a world scale. Hence any statement that the USSR, China, Venezuela or Cuba were building socialism does not make sense, unless the building of socialism is implicitly or explicitly re-defined away from Marxism and practically any socialism within the Marxist tradition.

I think that there are many problems with this. First, there is a highly selective narrowing of the Marxist tradition. Ticktin may think that no Marxist would ever have seen the Soviet bloc or China as socialist. But he can only hold that by defining out of existence all those millions who have been members of Communist parties in these countries and who considered themselves to be Marxist. These people were apparently “not part of the Marxist tradition.” In effect he is saying nobody who agrees with me could possibly disagree with me.

Well, yes.

At best it is no more than an appeal to authority, and a dubious one at that. It is questionable that Marx even proposed such a thing as a socialist mode of production.[129] He certainly never published any theory of such a mode of production, far less any argument that it could only exist globally. Even if he had argued that, how would he have known that socialism could only exist globally?

There could have been no empirical backing for this alleged theory in the nineteenth century. What is the empirical evidence now to back up such a theory?

This comes down, in part, to what people mean by mode of production. How could any society exist without a mode of production?

If we ask the question "What mode of production did the USSR have?" in the sense of a mode of material production, then it is clear that the mode was electrified machine industry. But we know that this was also the mode of material production in the United States at the same time. So the mode of material production is either not enough to distinguish capitalism from socialism, or socialism must have required some radically different technologies. Ticktin could be arguing the latter—that some as yet unknown technology which can only operate at a global scale is required for socialism. Any claims about technologies yet to be thought of must be rather speculative and would not sit with Ticktin's claim that the USSR had no mode of production at all. Instead, what he means is that a mode of production was something self-sustaining and stable with a unique mode of extracting a surplus product.

I argue that Tictin is fundamentally wrong, the USSR did have a distinct mode of surplus extraction. All societies beyond subsistence level need to produce a surplus and socialist societies are no exception. If we accept Marx's argument that the different economic forms of society are distinguished by the means by which the surplus is produced, then socialist society must have its own form of surplus extraction. It is by looking at actual socialist societies like the USSR that we can grasp what this is.

Socialist planned economy does indeed have a distinct form of surplus extraction. The magnitude of the surplus is determined by the planned allocation of labor between that for the reproduction of the working population versus other activities. This is the inverse of the mechanism that operates under capitalism where the monetary division of the value added between wages and profits comes first. In a capitalist economy the allocation of labor between reproduction and other activities occurs as a second-order effect when the wages and profits are spent. In a socialist economy it is the allocation of labor that comes first. Keynes [2010] was focusing on just this issue with respect to war economy in the passage I cited earlier. He makes it even more clear in another passage from his essay:

> This leads up to our fundamental proposition. There will be a certain definite amount left over for civilian consumption. This amount may be larger or smaller than what perfect wisdom and foresight would provide. The point is that its amount will depend only to a minor extent on the amount of money in the pockets of the public and on their readiness to spend it.

A socialist economy, because a determining part of its economic calculation and control is performed in physical rather than monetary units, has something in common with other economies that were either non-monetary or had limited use of money. The easiest comparison is with classical European feudalism where the labor performed for the lord was distinct in time and space from the work the peasants did for themselves. Money had no influence over it. The peasants' obligations were specified in terms of time or material products. Given the dwarf scale of the feudal division of labor this appears as a direct interpersonal relation between the peasant and the lord. For the socialist economy the determination was impersonal and vast, operating at the scale of a whole continental economy, via the allocation of millions of workers to tens of thousands of branches of production.

Once the amount of labor allocated in the plan to making consumption goods is fixed, no changes in wages, etc., can alter the overall ratio of surplus to necessary labor. If money wages rise without the labor allocation going to consumer goods rising, then the effect is the accumulation of money in people's bank accounts that will ensure a "tight" market in consumer goods. Goods would fly off the shelves but there would be no overall rise in real wages.

The existence of planning introduces a disconnect between monetary relations and value relations, understood as quantities of embodied labor. Money ceases to be a general form of command over labor. For a start, socialist economies have often explicitly prohibited the private employment of workers. In addition, a rise in monetary demand for consumer goods versus means of production will not cause a shift in labor toward consumer goods production. Wages and prices policies then become a matter of controlling monetary demand to make it fit the real product of the consumer goods industries.

6.8 WHY THE LAW OF VALUE APPLIES IN SOCIALIST ECONOMIES

The issue of the role of commodities and money in socialist economies was debated by the Communists in terms of what they called the Law of Value [Stalin, 1952]. The term had exoteric and esoteric meanings. The exoteric, or superficial, meaning is that in a capitalist-type economy, relative labor values will act as attractors for relative prices. The esoteric meaning is that the distribution relations in all societies are constrained by the distribution of labor.[130]

In a capitalist economy the great branches of production subsist by trade and their respective revenues must at least be roughly proportional to the populations they support.

Although in a socialist economy the great bulk of the economy is publicly run, the distribution of the population accross sectors of the economy continues to exert an influence as does the fact that the population still lives in households. This may seem an unexceptional observation, but communist organizations that grew up within previous class societies dispensed with the household as an institution. Think of a monastic community or Owen’s New Harmony. In such householdless communities there would be no personal property, as opposed to community property. Food preparation was communal, and childcare was either abolished as in monastic orders or carried out communally. But if you have households then private property of the household is distinct from community property. Since the composition and consumption needs of households differ, it is impractical to give all households a uniform ration of goods. An old couple would have little need for children’s shoes or toys, for example. So a socialist economy with households has to allow some flexibility in consumption, which they achieve by distributing a portion of people’s income in money. In principle they could have used something other than coins and notes. They could have kept social credit accounts or labor accounts for people, but in all cases many goods for household consumption would have something very like a price.

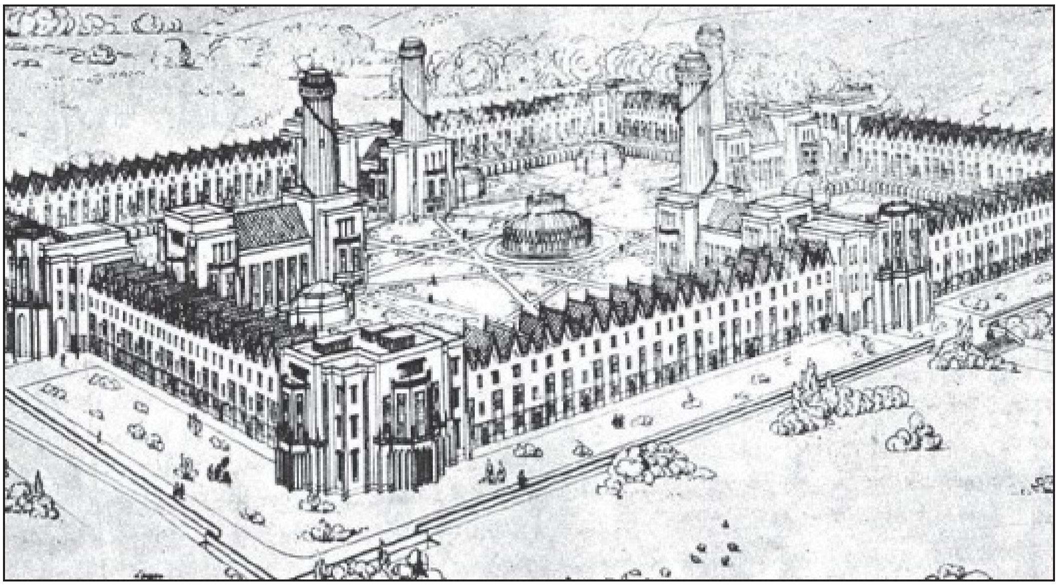


Figure 6.16. The New Harmony utopian community in Indiana, designed by Robert Owen in 1825.

In a socialist society, then, with households, how does the esoteric aspect of the law of value, the underlying constraint posed by the social division of labor, express itself?

6.8.1 Intersectoral relations

I shall divide the socialist economy into three sectors:

1. The production of means of production.
2. The production of articles of personal consumption that are distributed for sale or charge to individual workers' families. At this point it makes no difference whether the articles are sold for actual money or against the debit of a labor account.
3. The provision of uncharged services such as education, health care, defense, and public infrastructure. This is not to say that being conscripted into the army is not a charge on the conscript, but that they do not individually have to pay in cash or labor credits for their military service. Similarly, education costs adult society time and resources, and costs the pupils a keenly felt loss of playtime, but it is assumed that there are no school fees.

I will use the numbers 1, 2, 3 to denote these sectors. Sectors 1 and 2 produce physical outputs, that is to say, they are materially productive in the sense of Adam Smith's use of the term productive. I will call the output of sector 1 machines, though it also includes all other means of production, and will use the symbol m, in lowercase, to indicate a flow, for the gross output of machines and the stock of machinery and equipment used in the sectors as M_1, M_2, M_3.

Machines wear out. I assume that a fraction (δ) of them wear out each year. So for the sectors the flow of new machines needed to simply stand still is given as δM_1, δM_2, δM_3. If the economy is growing there will be some surplus flow of machinery over wear and tear, set asside for growth, which I will call m_g :

$$m_g = m - (\delta M_1 + \delta M_2 + \delta M_3)$$

I will assume that the working population is P divided into P_1, P_2, P_3 working in the three sectors, and that for each year of work the government credits a person with a wage of w, either by paying them cash or by recording some units into their personal consumption account in a database. The state also, for budgetary purposes, has to account for the usage of machinery and equipment in different sectors right down to the individual factories, hospitals, etc. The accounting unit for such charging is assumed to be the same, either money, labor hours, or concievably energy, as is used for personal consumption accounts. I will use c for the charging rate for a machine. This then gives the current accounting costs C_i of each sector, assuming that the government does not charge itself interest, of

$$C_1 = c\delta M_1 + wP_1$$

$$C_2 = c\delta M_2 + w P_2$$

$$C_3 = c\delta M_3 + w P_3$$

The accounting costs of each sector are made up of the charge for the use of publicly owned machinery, and the payments to the people working there. The first is a charge internal to the public sector, but the government has to carry out such sectoral charging if it is to make overall budgetary decisions about the scale of the sectors. The only point at which an actual sale happens, with change of ownership, is when the output of the consumer goods industry is sold to the working population. I will call this the bread or baking industry and label the total output of the industry b and the price of bread p. If we assume for the moment that there is no mechanism by which the working population can save, then we have

$$pb = w(P_1 + P_2 + P_3)\,(1-t)$$

where *t* is the income tax rate. That is to say, the price of bread times the bread output equals the after-tax income that the working population gets. This is their money wage, but in addition they consume a social wage of education, health care, etc., provided by public sector 3. The equation above gives the price of bread as a function of the money wage.

It is not so obvious how the government should set the charge for machinery used by the public sector, but one simple way is to charge machines at their imputed cost of production:

$$c = C_1 / m$$

The tax revenue plus any profit on sales of consumer goods is then used to cover the cost of the free public services and the net accumulation of new machinery:

$$cm_g + C_3 = tw(P_1 + P_2 + P_3) + pb - C_2$$

We now have 7 equations with 8 unbound variables m_g, c, w, t, p, C_1, C_2, C_3. I assume that m, b, M_1, M_2, M_3, P_1, P_2, P_3, δ are fixed by the actual structure of activity, so in principle the government could fix either the tax rate or the wage rate, but having done that, all the other variables are constrained. Let us look at options. If the socialist country retains money, but delivers many services free, it has to balance the monetary demand in the hands of workers from their wages with the amount of social labor going into consumer commodities. Since a part of the socialist working day had been allocated to producing free goods and services, and another part to the accumulation of new buildings, infrastructure and machinery, the disposable income of the working class had to be limited to the money equivalent of the number of hours spent making consumer commodities. There are, in principle, a number of ways this could be done:

1. By levying an income tax or poll tax on employees [Marx and Engels, 1977; Marx, 1970; Marx and Guesde, 1880].
2. By levying a sales tax, that is, one that is raised as a percentage of the selling price like VAT.[131] Both this and the turnover tax are indirect

taxation; they differ in where they are collected: at production or at sale.

3. By pricing all goods at a markup or profit. This profit, since it accrues to state factories, can then become government revenue and be used to fund free services, accumulation, etc. In the USSR this was formalized as a turnover tax levied on all government factories.

There are strong arguments to favor the first option [Cockshott and Cottrell, 1992]. It may initially have been politically popular to claim that under socialism there was no need for income tax, but that is dishonest, since indirect taxation remained. Wages were still held down to a level that would allow the turnover tax to fund government services, so in terms of take-home pay people were no better off. A direct deduction of income tax is more visible, but the converse is that something visible is easier to understand, and as a result easier to make open democratic decisions about.

I will present a simple example and compare the effect of different wage and tax policies.

The technical structure of the economy is assumed to be as given in Table 6.5. We assume machines are depreciated over ten years, so that the current cost of using a machine is machine price ÷ 10.

1. The wage is fixed at 1, this ends up equivalent to valuing things at labor values, no profit is made on the sale of consumer goods, and income taxes are adjusted to meet the cost of the public services and accumulation.

   Solving the equations gives us:

p	c	t	income tax revenue
0.0073	53.3	51%	₽7,666,570

2. In this scenario income tax is abolished and the price of the consumer goods have to rise to cover the shortfall in government revenue. Given that the physical output of consumer goods stays the same, the only effect of reducing income tax is to increase prices. The net effect is that the government raises most of its income from what can either be viewed as a tax on consumer goods or on the profits of nationalized industry. Wages turn out to be the same, as does the charge for means of production, but consumer goods cost almost twice as much.

   Solving the equations gives us:

p	c	t	sales tax revenue
0.015	53.3	0%	₱7,666,570

The relative prices of machinery and bread now diverge significantly from labor values, with bread being sold at a premium due to the tax being levied on it.

3. In the turnover tax variant—which the USSR used—the tax is levied in both sectors 1 and 2. The tax is determined by the equations:

TABLE 6.5: The Technology Structure Used in the Worked Example of Socialist Reproduction

Sector	People [P]	Machines [M]	Output
1	4,000,000	250,000	100,000 machines
2	6,000,000	250,000	1,000,000,000
3	5,000,000	250,000	no physical output

$$c = (1 + r)\, C_1 / m$$

$$p = (1 + r)\, C_2 / b$$

The key point is that the tax is levied on both sectors rather than just at the point of sale of consumer goods. This means that the accounting price of means of production is raised by the turnover tax.

Solving the equations gives us:

p	c	t	turnover tax revenue
0.015	117	0%	₱1,086,640

Note that the price of machinery has more than doubled here. The final selling price of bread remains what it would have been under the sales tax variant. Thus the revenue collected from workers remains the same in all cases, but now the government also collects revenue from its factories in sector 1. The revenue collected internally in sector 1 is then all spent internally on the higher costs that sector 3 has to charge for the machines it uses and higher cost of the new investment goods. Because machinery is now more expensive at book prices, the total apparent cost to the government of providing free public services and new investment is substantially higher than before, and needs a correspondingly higher tax revenue.

In all three scenarios the same flows of goods exist, but there are three different sets of relative prices. The extent to which a socialist government can disregard labor values is constrained by the level of tax it levies. If they rely on income tax for public revenue, then sector prices will be proportional to labor values. If they attempt to curtail income tax to a level too low to support public services, then the price of consumer goods has to be raised in what amounts to a sales tax to prevent the accumulation of purchasing power in the hands of the public, and thus suppress inflation. The use of a turnover tax has a generally inflationary effect, which, as we shall see later, holds back the development of labor-saving technology.

But more serious than this, the policy of holding down wages and funding public services out of what can either be considered a turnover tax, or a rate of profit in public factories, had adverse effects on economic efficiency.

In scenario 1 above, where accounting prices are proportional to labor content, the investment charge for a machine was 53 units of labor. If machinery was priced at full value, a rational factory management would cost 5.3 units of labor, the same as one machine, whereas in the turnover tax case a machine is costed at 117 units of labor and a rational manager would treat the use of one machine for a year as equivalent to 11.7 units of labor.

In sector 1, a factory with a technology that uses 960 people and 60 machines to produce 24 new machines. With the income tax the total cost of that technique is booked as 1278, with the turnover tax the booked cost is higher at 1662. For full details, look in Table 6.6.

Suppose a new technology comes along that can make 24 new machines using 140 machines and 200 people. If we cost this out according to the income tax scenario, that is, in terms of labor values, the new technique gives a 26 percent saving. Total booked cost falls from 1,278 to 942, so it is clearly advantageous to switch to the new way of making machines. But with the turnover tax, machines are more than twice as expensive. The cost of additional machines outweighs the big laborsaving the machines bring about.

Note in Table 6.6 that under the income tax scenario the new and highly mechanized technique is cheaper, but under the turnover tax scenario it would appear to be more expensive. Under the turnover tax scheme, a more manual process, of greater social cost will be preferred to the mechanized one. Use of direct labor time calculation would of course have revealed the right answer.

TABLE 6.6: Relative Cost of Two Techniques under the Income Tax and Turnover Tax Scenarios

Machine Cost	Machines	People	With Income Tax 5.3% Total Cost	With Turnover Tax 11.7% Total Cost
Table 6.5 Technique	60	960	1,278	1,662
New Technique	140	200	942	1,838
Saving			26%	–11%

Note that under the income tax scenario, the new and highly mechanized technique is cheaper, but under the turnover tax scenario, it would appear to be more expensive.

The Soviet solution of a turnover tax was short-term populism that hampered efficiency. In the long run it encouraged the wasteful hoarding of labor by factories since the combination of low wages and subsidization of services and essentials meant that the true cost of labor was hidden. As more free social services were provided, funded by the turnover tax, the wage came to represent a smaller and smaller part of the necessary labor time—the rest being provided free. But this made labor appear cheap and new machinery appear expensive. Rational managers would not replace labor-intensive processes with machines, because using lots of workers seemed more cost effective. Hence chronic overstaffing and poor uptake of more efficient techniques.

The combination of labor value calculation and income tax would have been a much sounder basis for rational economic calculation.

6.8.2 Intra-sectional constraints

Even if you assume that the number of people allocated to make consumption goods does not change, that still leaves considerable flexibility in which consumer goods are made. Asume the intention is to adjust output to consumer wants as expressed by the goods they choose to spend their social credits on. What does this imply for the relative prices of goods?

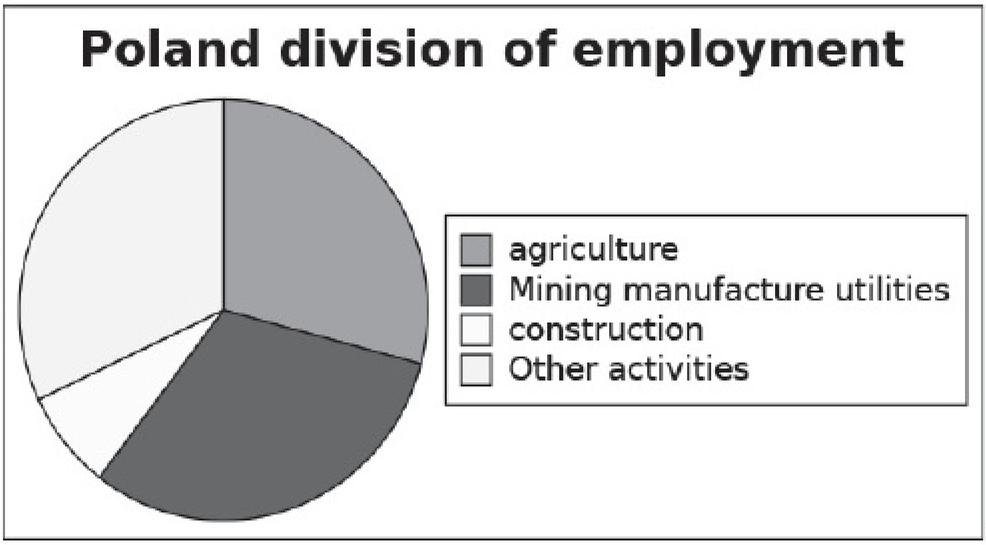
Should these relative prices correspond to relative labor values?

Yes, they must, for it is only under this condition that the attempted adjustments people make in their consumption will be compatible with the predetermined number of people working making consumer goods. Suppose that one group of goods—say furniture—is systematically undervalued compared to another group of goods, let us say clothes. Suppose clothes are priced at par for labor values and furniture is sold at a 50 percent discount with respect to its labor value. Note that it does not matter if the social credits are measured in hours or in some arbitrary currency units, there will always be some quantity of the currency that, averaged across all prices, represents an hour of embodied labor. Consumers then attempt to shift part of their clothes consumption to furniture. Suppose they cut clothes consumption by the equivalent of 100 million hours of credits, and switch these credits to furniture. Since the furniture is being marked at a 50 percent discount, these 100 million hours of credits switched from clothing appear to be enough to buy furniture that took 200 million hours to make. Even if the workers who in the past worked the 100 million hours in the clothing industry were shifted to make furniture, that would not provide enough additional labor to make 200 million hours' worth of chairs, tables, etc.

More generally, if prices are not proportional to labor values, then shifts in purchases from one good to another will lead either to patterns of demand that are too big to be met with the existing workforce, or if the demand shift goes from undervalued to overvalued goods, to unemployment and parttime working in the consumer goods industry. Some of the socialist states in twentieth-century Europe had chronic problems associated with serious divergences between relative prices and relative labor values. This was particularly prevalent with agricultural products. The great political influence of the urban working classes in socialist societies made it very hard for governments to raise the prices of basic foodstuffs. The Polish protests of 1956, 1970, and 1976 all focused on this issue and in all cases the government backed down and resorted to holding food prices down, in 1976 this was combined with the reintroduction of rationing. In general we can say that if prices do not correspond to values, the excess demand for undervalued items will be greater than what it is possible to produce with the available labor force, technology, etc. In consequence there will be evident shortages that can only be curtailed by rationing.

Figure 6.17. Workers demonstrate with the demand for cheap bread in Poland 1956.

The Polish case was complicated by the particularly backward state of agriculture there, which right into the 1980s continued to be based on small peasant farms with the low levels of mechanization and high labor intensity that goes with that mode of production. The labor required to produce food was thus relatively high, and a large portion of the population was still tied up in growing it. Look at Figure 6.18 and see the discrepancy between labor used and value added in Polish agriculture. Note that the monetary value added by agriculture is disproportionately low compared to the workforce engaged in it. It is clear that agricultural products were sold well below their values in terms of domestic labor. One can interpret this in two ways:



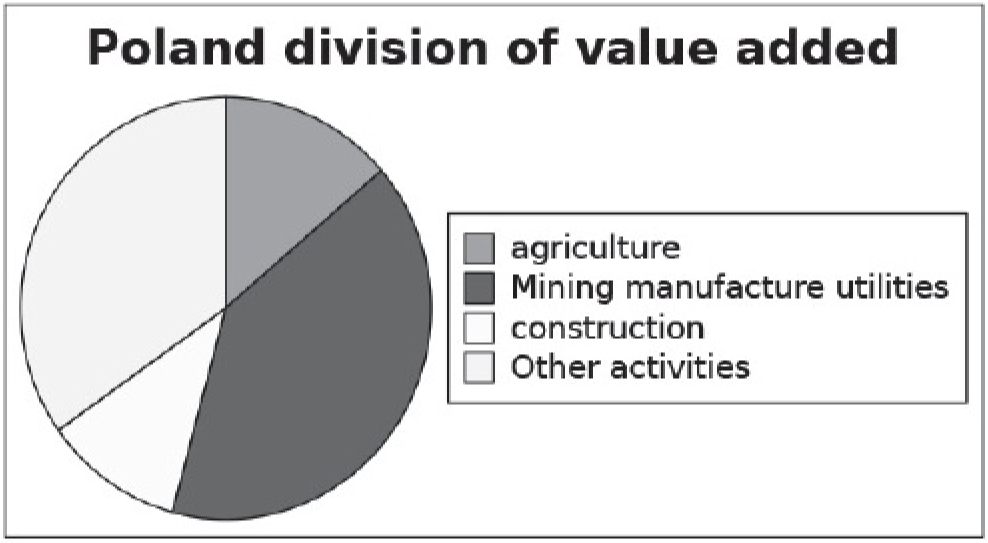


Figure 6.18. Comparison of the distribution of the labor force in Poland in 1981 with the distribution of value added. Source: UN statistical databases.

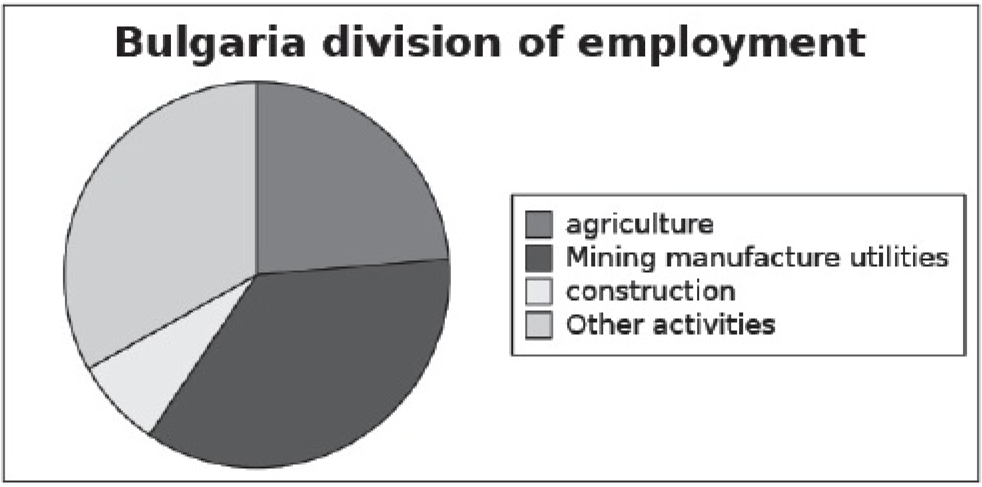
1. Political pressure from the urban working class held food prices down below what they should have been, given the labor used.
2. The efficiency of Polish agriculture was low by international standards, hence the low value added per unit of labor used. This would presuppose that the international prices of food imports also entered into the calculations made by the government when it set domestic prices.

Whatever the mix of these two causes, the agricultural sector in Poland was selling its output at only 47 percent of its real value in 1981. Poland was a particularly critical example of a socialist country where prices diverged drastically from values. If we compare it with Bulgaria (Figure 6.19), we see that Bulgaria had a much smaller disparity between agricultural prices and agricultural values. Bulgarian agriculture was still undervalued, since its products sold at 74 percent of their true value, but the discrepancy was far lower than in Poland. Unlike Poland, where agriculture was still based on the peasant mode of production, Bulgaria had large-scale socialist agriculture, which was markedly more efficient in its use of labor. I traveled in both countries during the early 1980s and it was very evident that while food appeared to be in very short supply in Poland, it was plentiful in Bulgaria. The food shops in Poland were relatively bare, whereas those in Bulgaria seemed loaded with produce. Political discontent about food was a repeated occurrence in Poland, and absent in Bulgaria.

It is the development of the productive forces and forms of cooperation that determine the values of goods. The available technology determines the minimum amount of labor that society has to use to make something and this will hold true even if property relations change. If a political revolution occurs in a country, there is no corresponding change in either technology or in cooperation. That can only come later as the new property relations shape the introduction of technology or cause the rise of new types of cooperative work—like collective farms or People's Communes.

So we are talking about the long term, over which new forms of cooperation and technology are introduced. In a socialist economy the really big decisions about this are political not economic. Collectivizing agriculture and introducing tractors, combine harvesters and so on in Bulgaria was a political decision. Forming People's Communes in China and engaging in large-scale irrigation and land reclamation was a political decision. These decisions led to improvements in productivity but it was not the discipline of the market that brought it about. The actual labor productivity in a sector will be a random variable. If the minimum labor required shifts due to new technology then, unless the dispersion of the random variable increases over time, the mean also goes down. I emphasize minimum as the leading edge of technical change shifts the minimum requirement. But on accounting grounds you have to charge goods at the average labor content, not the minimum content.

On the other hand, in countries where a reverse political decision was made, as in Poland in 1956 where Gomulka decided to abandon collectivization, as a result agriculture remained peasant farms. I recall flying over the country in 1980 and saw two types of fields from the air. In areas that prior to 1945 had been part of Prussia, there were large square fields of the former aristocratic estates, but over most of the country one saw strip field systems characteristic of agriculture from the Middle Ages. This form of property relations could not develop the productivity of labor effectively. In consequence a large part of the overall social working day was devoted to growing food (see Figure 6.18). Roughly a third of the total working day went on that.



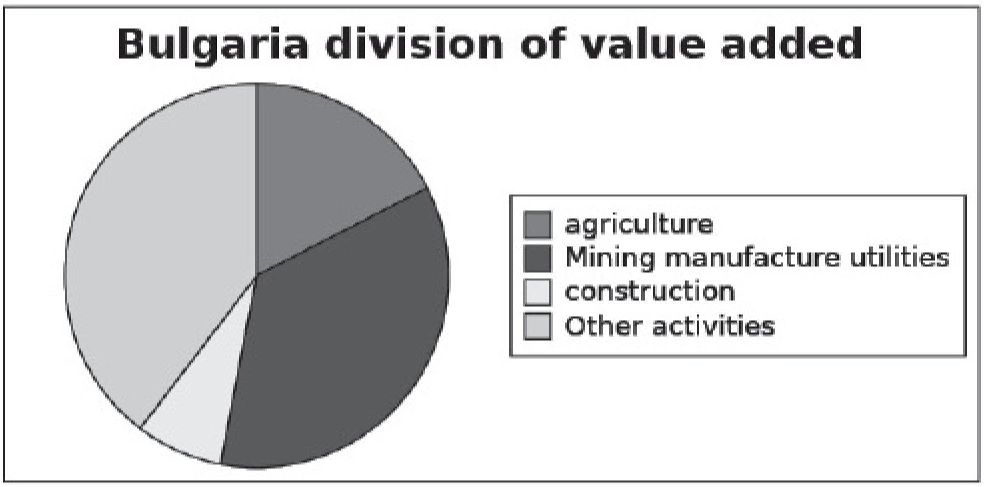


Figure 6.19. Comparison of the distribution of the labor force in Bulgaria in 1981 with the distribution of value added. Source: UN statistical databases.

On the other hand political pressure from the working class meant that food had to be sold cheaply—I remember that in 1980 the prices were ridiculously low by our standards. This meant that in terms of the selling prices, the farming sector—one-third of the economy—sold its output at well below its value. In selling price, the apparent value added by agriculture was around 12 percent of the GDP. So there was a big discrepancy between price and true labor value. If the population attempted to devote 20 percent of total income to food, which was easily affordable at the prices prevailing, then peasant agriculture could not have supported that. An expenditure of 20 percent of income would be a rise in demand by two-thirds and would have required two-thirds more labor on the land to produce it—quite impossible.

I give Poland as an example because it is the most striking instance of a socialist government attempting to ignore value in setting prices in the state shops. That was a political decision, and the effects it produced were also political—chronic shortages as shops were quickly sold out of meat. This in turn produced discontent that could be harnessed by those arguing for the return of a full capitalist system. The irony was that the consumption of meat per capita in Poland was actually greater than in Scotland at the time, and there were no complaints about meat shortages in Scotland. The point I am making is that the temptation to say you can ignore labor value in a socialist economy should never be given way to. Its results are politically disastrous.

How can you plan with the Law of Value?

The answer depends on whether you are talking about the exoteric or esoteric interpretation of the term. The esoteric interpretation is that the law of value is an expression of something deeper—the proportions in which the social workforce is distributed between different concrete activities. Planning with the law of value is in this sense planning the distribution of social labor, and ensuring that the social labor is used effectively.[132] As compared to the traditional Soviet techniques this would have involved several important differences:

1. Accounting for all products in terms of embodied social labor and ensuring that the selling prices of consumer goods is proportional to the labor embodied. It is only under these circumstances that shifts in consumer demand between products is labor conserving.
2. Using labor time as the general unit of account, with some form of nontransferable personal labor accounts.
3. Charging factories for the total labor used by abolishing the distinction between labor and labor power. If money wages are paid then labor appears undervalued since labor power has a lower value than the labor

itself. This biases the choice of techniques toward inefficient labor-intensive ones.
4. Setting goals for output of consumer goods modulated by the shifts in spending of labor tokens.
5. Giving factory collectives hard labor budgets. They would have a budget in hours to achieve a given physical output, but they would be free to select between using living labor or machinery evaluated at its labor content to do so. If they overused their budget they would face staffing transfers, with individuals being transferred to other collectives where their labor was more socially necessary.

Labor time accounting demystifies or de-fetishizes social relations. Rather than relations appearing to be between people and an objective thing called money, they make it evident that what is involved are people's lives. If I get one hour of social credit for each hour I work, and can for this credit acquire goods that took an hour to make, then it is clear that I am participating as an equal in social exchange. If I am only credited with 40 minutes' time for working an hour, it is clear that there is something odd going on. If the difference is made of a 33 percent income tax that I had a chance to vote on, that is one thing. If instead I see that someone else is getting credited with more than an hour for each hour that they work, I am going to be asking some hard questions.

Labor time accounting has a presumption of equality and equity. If one person gets credited more than they actually work, the *a priori* implication is that there is something dodgy about it. Its adoption would thus involve a big pressure toward leveling: between different categories of work and leveling between men and women. It of course eliminates completely the possibility of unearned capital income. It makes the moral presumption that labor is the only legitimate source of income. Any other income, to the old, the sick, to families with children, has to be an explicit voluntary deduction from the incomes of those who work.

The significance of labor tokens is that they establish the obligation on all to work by abolishing unearned incomes; they make the economic relations between people transparently obvious; and they are egalitarian, ensuring that all labor is counted as equal. It is the last point that ensured labor tokens were never adopted under the bureaucratic state socialisms of the twentieth century. What ruler or manager was willing to see his work as equal to that of a mere laborer?

There is nothing terribly original in this scheme, which is set out briefly here, but in much more detail elsewhere. It is simply a detailed and literal elaboration of the proposals Marx [1970] made in his comments on the draft of the 1875 program of the German Socialists.

The assumption is that people would have electronic labor credit cards whose credits could only be cancelled out, not circulated. You could not pay credits into somebody else’s account but you could get things from communal stores. This completely eliminates the possibility of a black market.

It is absolutely essential that distribution labor values of goods be realistic. A socialist government must avoid the temptation to undervalue necessities in the communal stores. If they are undervalued, there will be excess purchasing power in terms of labor credits. If bread used 300 million person hours to make but was sold for 100 million hours, an excess of 200 million credits would have been issued to the bakers, millers, farmers, etc. Such undervaluation, we know from bitter experience, just leads to queues and apparent shortages.

If prices are equal to labor content, then deviations of sales from actual production can be used to adjust plan targets on a real-time basis, reallocating labor from products whose demand falls short of production to those that are selling out.

Deviations of distribution price from labor content would, however, still occur in a planned economy for environmental reasons. If the planning system had a constraint that total production of fossil fuel had to decline by 2 percent a year, then the planning authorities would be forced either to raise the distribution price of fuel above its labor content or to ration petrol. If petrol was distributed at a premium, goods that did not contain fossil fuels would have to be distributed to consumers at a discount. There might be a case for the environmental premiums or discounts being displayed on the label.

Free distribution of goods and services is only viable for those goods or services for which certain special conditions are met. The actual allocation can be rationed by deliberate decisions or by queues—this is how the NHS is able to function. You can get free treatment but only if a doctor decides you need it and you are willing to wait your turn. This rules out, for example, resources being wasted on penis or breast enlargement surgery, where the actual usage is easily calculable. We know that demand for primary schooling is set by the number of children reaching school age.

Making schools free increased demand up to this limit and no further. The resources being used would otherwise go to waste. Examples are the free district heating provided in the USSR from waste heat of power stations; providing free travel to pensioners outside of rush hours; free use of Internet once the basic infrastructure has been installed.

6.9 CRISIS OF SOCIALISM AND EFFECTS OF CAPITALIST RESTORATION

The main criticism leveled at the socialist economies was that a planned economy was inherently less efficient than a market one, due to the sheer scale of the bureaucratic task involved with planning a major economy. If there are hundreds of thousands, or perhaps millions, of distinct products, no central planning authority could hope to keep track of them all. Instead they were forced to set gross targets for the outputs of different industries. For some industries like gas or electric power, this was not a problem. Electricity and gas are undifferentiated, a kilowatt is a kilowatt—no argument. But even for another bulk industry like steel, there was a wide variety of different rolled plates and bars, different grades of steel with different tensile strength, etc. If the planners could not keep track of all these different varieties and just set rolling mills targets in tons, the mills would maximize their tonnage of whatever variety was easiest to produce.

The steel example is a little forced, since this degree of differentiation was still fairly readily handled by conventional administrative means. Tonnage targets could still be set in terms of distinct types of steel. But when you turn to consumer goods—clothes, crockery etc., the range of products was too big and targets were started set in terms of monetary output.

The plan would specify a growth in the value of output of clothing, furniture, etc. What this translated to then depended on the price structure. In order to prevent other forms of gaming the plan by enterprises it was important that the prices were economically realistic. If the price for chairs is set too high compared to tables, it becomes rational for factories to concentrate on chair production.

By resorting to monetary targets, the socialist economies were already conceding part of Mises's argument. They were resorting to the monetary calculation that he had declared to be vital to any economic rationality. Liberal economists argue that it was impossible for planners to come up with a rational set of prices, as only the competitive market could do so.

Planning required aggregation. Aggregation implied monetary targets. Monetary targets required rational prices. Rational prices required the market. But if you had the market you could dispense with planning. Planning dialectically implied the supersession of planning.

It is worth noting that this is a largely theoretical argument. It was, in late Soviet days, backed up with lots of anecdotal evidence, but empirical evidence for the greater macroeconomic efficiency of markets even when compared to classical Soviet planning is on much thinner ground. As Allen [2003] shows, the only capitalist economy whose long-term growth rate exceeded that of the USSR was Japan, whose own model was some way from unplanned capitalism. Compared to other countries starting out at the same economic level in the 1920s, the USSR grew considerably faster. One could argue that this was due to marcroeconomic advantages of planning, that is, by removing uncertainty about future market demand it encouraged a higher level of investment. It is possible that this macroeconomic advantage outweighed any microeconomic inefficiency associated with plans.

The strongest evidence that markets may perform better than plans would come from China, and that certainly is the orthodox Chinese view. Their claim is that a socialist market economy avoids the macroeconomic instability of capitalism while harnessing the microeconomic efficiency of the market. As evidence they cite a higher rate of growth after Deng's restructuring. But China since Deng has followed a mercantilist road. It has the effect of beggaring the workers of China whose products are exported to the United States in return for U.S. paper. The latter is of no benefit for the Chinese workers, though it does enable private Chinese companies to buy up assets in the United States. From the standpoint of the Chinese state it is a more nuanced issue. On the one hand Chinese state companies can buy up overseas firms, but whether this is a long-term advantage is a moot point since real goods which could have been used to improve the Chinese economy and living standards have been sacrificed.

Historically the process of having an export-led economy allowed China to avoid the technology bans that the West imposed on the USSR, allowing rapid catch-up in manufacturing techniques. Now that China is overtaking the United States in some areas of mass production, that advantage is less clear, and a shift toward higher domestic consumption and higher wages makes sense, and is indeed being followed in China, unlike Germany. It could be that the growth advantage that China experienced post-Deng owed a lot to a new ability to import the latest productive techniques instead of microeconomic efficiency. But what is abundantly clear is that the pro-market restructuring had the effect of drastically widening economic inequalities and giving rise to a new domestic billionaire class. This in turn produces political pressure to extend private ownership and undermine the still dominant position of state industry.

So the question arises, could a planning system work in a modern economy with a highly diversified product range, and how would it overcome the socialist calculation argument of Mises? I and others have since the late 1980s been arguing that the answer is yes.

The Mises critique of socialism focused on the need to compare the costs of alternative ways of making things. Unless you can do that you cannot choose the most efficient. Our response has been not only that labor time in principle is an alternative, which Mises conceded, but that with modern computer technology it is perfectly possible to maintain up-to-date figures for the labor cost of each input to the production process. Using these, workplaces will have data that are as good as prices for choosing between techniques.

There are limitations to labor values as there are to any scalar measure like price, since the constraints on production are multifactorial. Not only labor power, but also natural resources and ecological considerations constrain what we can make. No single scalar measure can handle this. But the problem of how to deal with multiple constraints like this was already solved by socialist economics way back in the 1930s. Kantorovich came up with a completely general technique for how to meet a socialist plan subject to constraints additional to labor time.[133] Kantorovich's method is a form of in-kind calculation, that is, non-monetary. It was not practical to use it at the level of the whole Soviet economy during his lifetime as the computing resources were too poor, but by the 1990s computers were up to the job.[134]

So the basic problem of socialist economic calculation without money had been solved since Mises wrote. It was impractical in the USSR for two reasons: 1) the computer technology was not there; 2) it would have involved replacing money calculation and payment with nontransferable labor accounts. This would have been a radical step toward greater social equality.

The collapse of the Soviet and later the Russian economy under

Gorbachev and then Yeltsin was an economic disaster that was otherwise unprecedented in time of peace. The world's second superpower was reduced to the status of a minor bankrupt economy with a huge decline in industrial production and in living standards. Nothing brings out the scale of the catastrophe better than the demographic data that show a huge rise in the mortality rate brought about by the poverty, hunger, homelessness, and alcoholism that these brought in their wake (Table 6.7).

In determining what caused this one has to look at long-term, mediumterm and short-term factors that led to relative stagnation, crisis, and then collapse. The long-term factors were structural problems in the Soviet economy and required reforms to address them. The actual policies introduced by the Gorbachev and Yeltsin governments, far from dealing with these problems, actually made the situation catastrophically worse.

6.9.1 Long term

During the period from 1930 to 1970, and excluding the war years, the USSR experienced rapid economic growth. There is considerable dispute about just how fast the economy grew, but it is generally agreed to have grown significantly faster than the UK between 1928 and 1975, with the growth rate slowing down to the UK level after that. This growth took the USSR from a peasant country whose level of development had been comparable to Brazil in 1922 to becoming the world's second industrial and technological and military power by the mid-1960s.

A number of reasons contributed to this relative slowdown in growth in the latter period.

It is easier for an economy to grow rapidly during the initial phase of industrialization when labor is being switched from agriculture to industry. Afterward growth has to rely upon improvements in labor productivity in an already industrialized economy, which are typically less than the difference in productivity between agriculture and industry. I discussed this earlier in the context of the Feldman theory.

A relatively large portion of Soviet industrial output was devoted to defense, particularly in the latter stages of the Cold War, when they were in competition with Reagan's "Star Wars" programs. The skilled manpower used up for defense restricted the number of scientists and engineers who could be allocated to inventing new and more productive industrial equipment.

The United States and other capitalist countries imposed embargoes on the supply of advanced technological equipment to the USSR. This meant that the USSR had to rely to an unusually high degree on domestic designs of equipment. In the West there were no comparable barriers to the export of technology so that the industrial development of the Western capitalist countries was synergistic.

Although Soviet industrial growth in the 1980s slowed down to U.S. levels, this by itself was not a disaster; after all the United States had experienced this sort of growth rate (2.5 percent a year) for decades without crisis. Indeed, while working-class incomes in the United States actually stagnated over the 1980s, in the USSR they continued to rise. The difference was in the position of the intelligentsia and the managerial strata in the two countries. In the United States income differentials became progressively greater, so that the rise in national income nearly all went to the top 10 percent of the population. The bulk of the working class in the United States has seen its income stagnate for half a century (Figure 5.14). In the USSR income differentials were relatively narrow, and while all groups continued to experience a rise in incomes, this was much smaller than had been the case in the 1950s and 1960s. This 2.5 percent growth was experienced by some of the Soviet intelligentsia as intolerable stagnation—perhaps because they compared themselves with managers and professionals in the United States or Germany. A perception thus took root among this class that the socialist system was failing when compared to the United States.

Again, this would not have been critical to the future survival of the system were it not for the fact that these strata were disproportionately influential within the USSR. Although the ruling Communist Party was notionally a workers' party, a disproportionately high proportion of its members were drawn from the most skilled technical and professional employees, and manual workers were proportionally underrepresented.

The slowdown in Soviet growth was in large measure the inevitable result of economic maturity, a movement toward the rate of growth typical of mature industrial countries. A modest program of measures to improve the efficiency of economic management would probably have produced some recovery in the growth rate, but it would have been unrealistic to expect the rapid growth of the 1950s and 1960s to return. What the USSR got, however, was not a modest program of reform, but a radical demolition job on its basic economic structures. This demolition job was motivated by neoliberal ideology. Neoliberal economists, both with the

USSR and visiting from the United States, promised that once the planning system was removed and once enterprises were left free to compete in the market, then economic efficiency would be radically improved.

TABLE 6.7: Excess Deaths as a Consequence of the Introduction of Capitalism in Russia

Year	Thousands Deaths	Excess Relative to 1986
1986	1,498	0
1987	1,531	33
1988	1,569	71
1989	1,583	85
1990	1,656	158
1991	1,690	192
1992	1,807	309
1993	2,129	631
1994	2,301	803
1995	2,203	705
1996	2,082	584
1997	2,105	607
1998	1,988	490
1999	2,144	646
2000	2,225	727
2001	2,251	753
2002	2,332	834
2003	2,365	867
2004	2,295	797
2005	2,303	805
2006	2,166	668
2007	2,080	582
2008	2,075	577
2009	2,010	512
Total	48,388	12,436

Figures amount to some 12 million deaths over 20 years. Source: Successive *UN Demographic Yearbook(s)*, Table 18.

6.9.2 Medium term

The medium-term causes of Soviet economic collapse lay in the policies that the Gorbachev government embarked on in its attempts to improve the economy. The combined effect of these policies was to bankrupt the state and debauch the currency.

One has to realize that the financial basis of the Soviet state lay mainly in the taxes that it levied on turnover by enterprises and on sales taxes.

In an effort to stamp out the heavy drinking that led to absenteeism from work and to poor health, the Gorbachev government banned alcohol. This and the general tightening up of work discipline led, in the first couple of years of his government, to some improvement in economic growth. It had, however, unforeseen side effects. Since sales of vodka could no longer take place in government shops, a black market of illegally distilled vodka sprang up, controlled by the criminal underworld. The criminal class that gained money and strength from this later turned out to be a most dangerous enemy.

While money from the illegal drinks trade went into the hands of criminals, the state lost a significant source of tax revenue, which, because it was not made up by other taxes, touched off an inflationary process.

Were the loss of the taxes on drinks the only problem for state finance, it could have been solved by raising the prices of some other commodities to compensate. But the situation was made worse when, influenced by the arguments of neoliberal economists, Gorbachev allowed enterprises to keep a large part of the turnover tax revenue that they owed the state. The neoliberals argued that if managers were allowed to keep this revenue, they would make more efficient use of it than the government.

What actually ensued was a catastrophic revenue crisis for the state, which was forced to rely on the issue of credit by the central bank to finance their current expenditure. The expansion of the money stock led to rapid inflation and the erosion of public confidence in the economy. Meanwhile, the additional unaudited funds in the hands of enterprise managers opened up huge opportunities for corruption. The Gorbachev government had recently legalized worker cooperatives, allowing them to trade independently. This legal form was then used by a new stratum of corrupt officials, gangsters, and petty businessmen to launder corruptly obtained funds.

6.9.3 Results

Liberal theory held that once enterprises were free from the state, the “magic of the market” would ensure that they would interact productively and efficiently for the public good. But this vision of the economy greatly overstated the role of markets. Even in so-called market economies, markets of the sort described in economics textbooks are the exception restricted to specialist areas like the world oil and currency markets. The main industrial structure of an economy depends on a complex interlinked system of regular producer-consumer relationships in which the same suppliers make regular deliveries to the same customers week in, week out.

In the USSR this interlinked system stretched across two continents, and drew into its network other economies: East Europe, Cuba, North Vietnam. Enterprises depended on regular state orders, the contents of which might be dispatched to other enterprises thousands of miles away. Whole towns and communities across the wilds of Siberia relied on these regular orders for their economic survival. Once the state was too bankrupt to continue making these orders, once it could no longer afford to pay wages, and once the planning network that had coordinated these orders was removed, what occurred was not the spontaneous self-organization of the economy promized by liberal theory, but a domino process of collapse.

Without any orders, factories engaged in primary industries closed down. Without deliveries of components and supplies secondary industries could no longer continue production, so they too closed. In a rapid and destructive cascade, industry after industry closed down. The process was made far worse by the way the USSR split into a dozen different countries all with their own separate economies. The industrial system had been designed to work as an integrated whole; split up by national barriers it lay in ruins.

TABLE 6.8: Output of Selected Branches of Industry in Russia in 2003 Compared to 1998 (1990=100)

Industry	Output
Total Industry	66
Electric Power	77
Gas	97
Oil extraction	94
Oil Refining	70
Ferrous Mettallurgy	79
Non-Ferrous Metallurgy	80
Chemicals and Petrochemicals	67
Machine Building	54
Wood and Paper	48
Building Materials	42

Light Industry	15
Food	67

Source: Goskomstat, 2004, Table 14.3.

The figures in Table 6.8 show how far the economy had regressed in 2003. These figures show how little recovery there had been, even after 13 years of operation of the free market.

If the economy had continued to grow even at the modest rate of the later Brezhnev years, say 2.5 percent, then industrial production would, on this scale, have stood at 140 percent of 1990 levels. The net effect of thirteen years of capitalism was to leave Russia with half the industrial capacity that could have been expected even from the poorest performing years of the socialist economy.

CHAPTER 7

Future Economies

In the social production of their existence, men inevitably enter into definite relations, which are independent of their will, namely relations of production appropriate to a given stage in the development of their material forces of production. The totality of these relations of production constitutes the economic structure of society, the real foundation, on which arises a legal and political superstructure and to which correspond definite forms of social consciousness. The mode of production of material life conditions the general process of social, political and intellectual life. It is not the consciousness of men that determines their existence, but their social existence that determines their consciousness. At a certain stage of development, the material productive forces of society come into conflict with the existing relations of production or this merely expresses the same thing in legal terms with the property relations within the framework of which they have operated hitherto. From forms of development of the productive forces these relations turn into their fetters. Then begins an era of social revolution. The changes in the economic foundation lead sooner or later to the transformation of the whole immense superstructure.—MARX ET AL., 1978, PREFACE

What distinguishes a utopian approach to social transformation from a materialist one is that the latter must start with the real contradictions that exist between technological imperatives and the social forms that currently exist. These specify not a future that might be desired, but what may be required.

One therefore has to start with technology complexes and demographics since all social formations combine a particular set of technologies with a particular density of human population. Only some technology complexes are compatible with a given population density. Our current population could not survive on the basis of pastoralism; so much is obvious. Nor can the present population long survive on the basis of an extractive fossil-fuel economy.

The consequences of the existing economy for climate change, food security, and health are so severe that even with the existing social relations, something historically unprecedented is happening. International organizations, particularly the IPCC (International Panel on Climate Change) are embarked on a coordinated scientific investigation of how, at a broad level, the technology complex of the world would have to be shaped to allow a world economy that is sustainable in terms of climate, health, and food security. This involves a huge effort to build complex, in natura, models of the world economy,[135] the sort of thing that Neurath [1919] speculated about one hundred years ago.

Several scenarios, called Representative Concentration Pathways (RCP), have been modeled, depending on the radiative forcing per square meter[136] involved with different concentrations of greenhouse gases. So, for example, the hottest model is RCP8.5 involving an 8.5 watt per square meter forcing by 2100. The model that would, it is hoped, keep temperature rises under 2 degrees is RCP2.6, which requires significant emission reductions, essentially ending all net fossil fuel emissions by the end of the century, with an immediate start to reductions this decade. Van Vuuren et al. [2011] claim that there is sufficient technical potential to achieve these emission reductions. CO_2 emissions could, they suggest, be reduced by a combination of energy efficiency, use of renewables, a lot more nuclear power, and most critically, bioenergy with carbon capture and storage. In principle, bioenergy with carbon capture could actually start reducing atmospheric CO_2.

I will take the targets of RCP2.6 as a starting point for discussion, before examining the plausibility of actually achieving them with the proposed technical means and policy mechanisms.

7.1 TECHNOLOGY COMPLEX

Contemporary capitalism is heavily dependent on fossil fuels. Almost 90 percent of world primary energy comes from these sources, and the percentage coming from nuclear and renewable sources has if anything tended to fall slightly in recent years. Industry and commerce use about 60 percent of all primary energy; transport and residential use around 20 percent each.

The current mature alternatives to fossil fuels are nuclear energy and hydropower. The latter has severe geographical limitations. The limitations to the use of nuclear power are on the one hand political opposition, and on the other the small number of countries and firms that have the ability to commission nuclear plants. In terms of cost it is already competitive with coal power for electricity.[137]

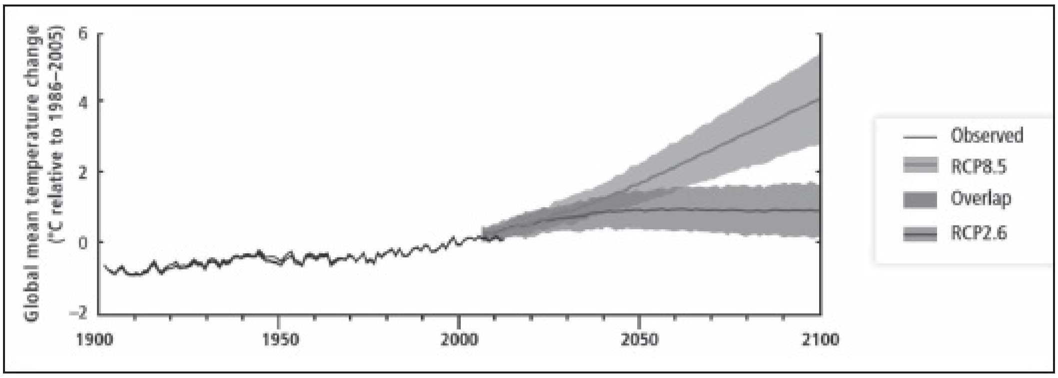


Figure 7.1. High and low RCP projections. Lower projection is necessary to keep anthropogenic climate rise below 2 degrees. Source: Field et al., 2014, Fig. SPM.4.

The the two rapidly maturing alternative energy sources are solar and wind power. Prices of both of these have been falling rapidly and in the United States are already competitive with coal for electricity generation when measured as levelized costs. Both of these depend for their yield on the local wind and sunshine, and so will vary from place to place.

Although Van Vuuren et al. [2011] put great emphasis on carbon capture and storage as a mechanism that will allow green house gas emission targets to be met, this is one of the least developed techniques so far. Although there is experience of injecting CO_2 into oil reservoirs for enhanced recovery, there is as yet little practical experience in operating full-scale coal-fired power stations far from oil reservoirs, extracting the CO_2, and then piping it to appropriate injection sites. The components are plausible, but the working experience that, for example, nuclear power has, is absent. There are clearly hazards associated with the subsequent escape of carbon dioxide from subterranean reservoirs, as shown by the Lake Nyos disaster [Baxter et al., 1989] where 1,700 people were killed by a sudden escape of the gas.

However, given the good progress being made in other areas, it seems plausible that, at least for electricity generation, a combination of nuclear, solar, and wind power could replace a large part of current dependence on coal.

Marx claimed that the stage of development of technology is what ultimately determines the bounds on social relations. He believed that communism was the likely future of industrial society and that coal-powered steam engines were the foundation of capitalist economy. Is there anything about the transition to a post-fossil fuel economy that would favor communism over capitalism?

The USSR depended heavily on large-scale integrated production both of energy and other products. The economic regression that followed the establishment of capitalism made it clear that capitalist property relations were incapable of sustaining this form of the productive forces. The one industry that did relatively well in the new capitalist Russia was fossil fuel extraction.

The USSR did have long-term plans for non-fossil energy sources: nuclear, thermonuclear, and orbiting solar power stations. All of these are post-capitalist forms of energy production in the sense that their development has depended on socialist economy in the East or in the West on state-sponsored development: AEC in the United States or the AEA in the UK for nuclear power. Thermonuclear power research has been overwhelmingly state-funded, and the most promising reactor design, the Tokamak, was invented in the USSR and forms the basis for the international ITER experimental power reactor [Azizov, 2012]. Orbiting solar power stations [Glaser et al., 1974] were a futuristic technology much talked about in the 1970s and 1980s. They would overcome the limitations of day and night and bad weather by being bathed in permanent sunlight, and would beam energy to Earth as microwaves. The ultimate Soviet space launcher, Energiya, was seen as the tool to build such orbiting stations [Hendrickx and Vis, 2007].

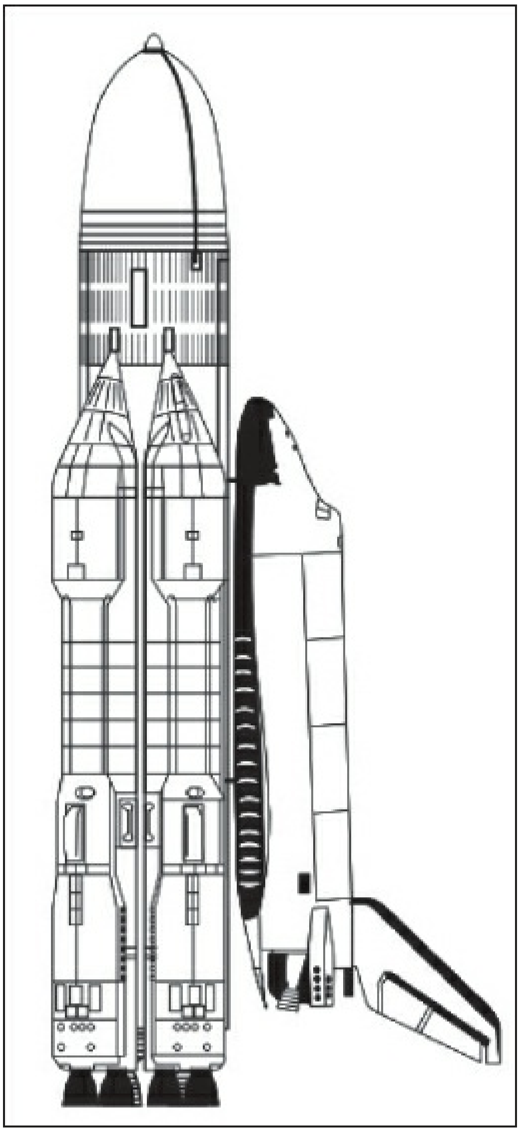


Figure 7.2. The Soviet Energiya launcher, designed to release orbiting solar power plants. The *Buran* shuttle is shown attached.

So we could hypothesize that the energetic basis of Communist economy would be orbiting solar power stations and huge Tokamaks able to supply essentially limitless energy from the deuterium in sea water. This is a pair of technologies that private capital has been unable to develop because of the huge initial investment, over many decades, before any possible profit could be returned. It would moreover, be a highly capital-intensive path and, as I have established in Section 5.9, high-capital intensity is associated with low profitability, which deters private firms.

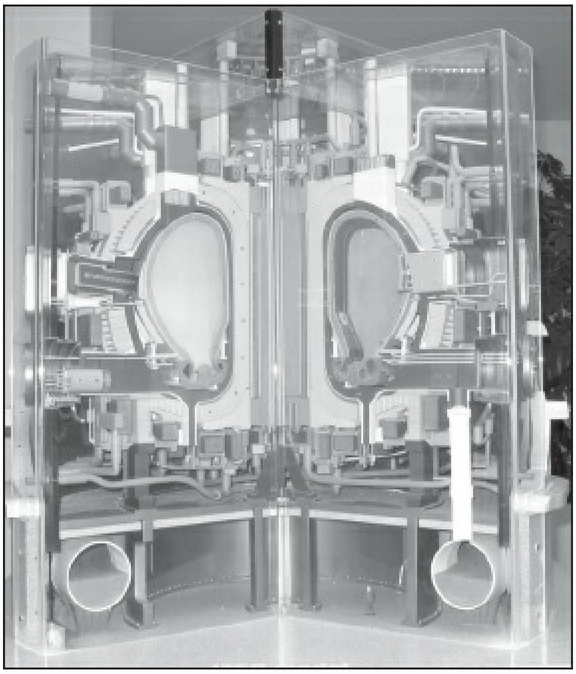


Figure 7.3. Model of the ITER reactor. Note tiny human figure for scale. Photo: Stephan Mosel, Creative Commons.

The development costs of the scale associated with thermonuclear power are so large that they are beyond even what individual nations can afford. The only practical project to build a thermonuclear reactor, ITER, is being constructed by a consortium of 35 states. ITER was started at the initiative of the USSR at the Geneva Superpower Summit in November 1985. Design work took from 1988 to 2001. In 2005 it was agreed that the site of the reactor would be in France. In 2010 construction started near Aix-en-Provence. It will be the largest and most complex machine ever constructed. The first plasma is scheduled to be generated in 2025 but it is not anticipated to use actual deuterium/tritium plasma to generate useful power until 2035. The whole project will thus have taken fifty years to yield power. But prior to ITER being formed there had already been a 35-year Soviet history of development of the technology since Sakharov and Tamm initially proposed the design in 1950.

The development of thermonuclear plasma reactors is something that private capitalism could not have done. It required foresight based on an appreciation of future human needs that only public bodies, indeed a world public body, could undertake.

Solar and wind power can, in contrast, be developed piecemeal with relatively modest capital costs. A such, private firms are quite willing to invest, given modest initial government incentives. We do not know yet whether these lower-tech approaches to alternative energy will be enough to power future civilization. If they are enough, then other than international political sanctions restricting fossil fuels, there will be nothing in the energy base that militates against the perpetuation of private ownership. If it turns out that the supply of energy from wind and sun is too intermittent, too dependent on the seasons, or too deficient at night, then fusion power will be the most plausible way of providing base load power. If energy storage technologies, either batteries, pumped storage, compressed air storage, or even flywheel storage, develop fast enough, fusion may not be needed.

This possibility gives rise to fantasies about self-sufficiency and a society of people who are economically self-sufficient, living off-grid. The idea breaks down as soon as it is examined in detail. Solar power only brings an element of self-sufficiency to those with enough capital to buy the panels, and enough roof area or free land to install it on. It is not an option for urban dwellers in rented flats or for those who cannot afford the initial capital. While owners of houses with big roofs will be able to reduce their electricity purchases, electric grids will still be needed for industry, telecoms, offices, electric railways, and the like.

7.1.1 Materials

Industrial society is heavily dependent on materials whose production either uses fossil fuel or unavoidably emits carbon dioxide. In the nineteenth-century industrial buildings and housing in industrialized nations were largely built from brick. Brick production involved the mixing of clays with ground coal which was then dried and sintered in kilns, with the coal in the mixture providing a large part of the fuel.

In the twentieth century concrete became the main building material. But this too involves a lot of energy in its construction. Concrete is a mixture of sand, stones, and cement powder. Cement powder is the biggest energy consumer here. The process involves heating limestone to disassociate the $CaCO_3$ it contains to produce $CaO + CO_2$. This obviously involves a direct release of carbon dioxide. The process requires between 4GJ/ton and 7GJ/ton of energy [Worrell et al., 2001]. This energy is currently supplied by fossil fuels with on the order of 5 percent of world industrial energy involved in the process. Worrell estimated that in 1994 around 5 percent of total carbon dioxide emissions worldwide came from cement production. For China something between 7 percent and 9 percent of all emissions are from cement making. [Liu et al., 2015]

It is in principle possible to produce cement without carbon dioxide by a combination of solar heating to melt limestone and then electrolysis by the Solar Thermal Electrochemical Process (STEP) [Licht et al., 2012]. By choice of temperature one can obtain the electrolytic transformation $CaCO_3 \rightarrow CaO + C + O_2$ with elemental carbon and oxygen being released. Assuming that the carbon produced was buried, the overall process would be carbon neutral.[138] If operated in a strictly carbon-neutral fashion the cost of cement produced this way would be two to three times as great as with current methods.

Steel has been the fundamental metal of industrial society, used in making machinery, ships, bridges, cars, and in the construction industry. Today steel production comes from the basic oxygen process and the electric arc process. The basic oxygen process refines pig iron produced in blast furnaces into structural steel, though a portion of the feedstock is recycled scrap steel. Electric arc furnaces work entirely with recycled scrap. In the United States around 70 percent of all steel output is from recycled sources. The remaining 30 percent comes from the processing of iron ore. The iron oxide in the ore is reduced to metallic iron using carbon, currently in the form of coke, though charcoal was used in the past. As such the process inevitably emits carbon dioxide: the coke provides the fuel to heat the furnace, and because carbon monoxide, produced by burning the coke, is the reducing agent.

If we assume that the world will require drastic reductions in CO_2 emissions, this implies:

- That the steel industry will have to become overwhelmingly based on recycling, supplemented with only such small amounts of basic steel as can be produced from charcoal.
- That other metals, most likely aluminum, will have to substitute for steel in many uses. Aluminum is produced by an entirely electrolytic process, with a relatively small carbon dioxide emission from the erosion of the carbon electrodes.

Per ton, in 2017, aluminum cost about five times as much as steel. It is also weaker than steel so aluminium structural members have to be thicker than the corresponding steel ones. But given its lower density these effects partially cancel out, and corresponding aluminum parts will weigh only about 60 percent of steel parts. Overall, then, the use of aluminum instead of steel is about three times as expensive.

So it is likely that the two fundamental construction materials of industrial civilization, concrete and steel, will have to be replaced by alternatives that are around three times as expensive. Cheap concrete has been the foundation of world urbanization [Edgerton, 2011b], and cheap steel of mechanization.

Stone will remain available as a low-carbon building material when carbon emissions restrict brick and concrete. Smout [1986] attributes the greater overcrowding and worse slum housing conditions in industrial Scotland to the statutory requirement, up to the 1930s, to use expensive stone in residential accommodations in Scotland whereas cheap brick could be used in England.

The old stone tenements of Glasgow are appreciated for their aesthetics, in comparison to the brick and concrete housing that went up in the 1950s. But if the billions of new urban dwellers accross the world will have to depend on the building of stone housing, then overcrowding will persist. Overcrowding brings exploitative landlords and reinforces the dominance of the propertied classes. On the other hand, once population growth slows down, the durability of stone construction is an advantage. Over time, with a static population, relatively high standards of housing could be achieved using stone. In the shorter term it may be necessary for mass-produced aluminum units to stand in for the poured concrete flats of twentieth-century urbanization.

7.1.2 Transport

As Smil [2010] says, the two engines of globalization are the high bypass turbine and the high compression diesel. One powers aircraft, the other ships, trains, trucks, and buses. MAN and Wärtsilä diesel engines drive the vast ships linking Asia, Europe, and America. Diesel trains carry more than half of America’s goods. Turbines power all air freight. All run on oil; without oil, most world transport stops.

Oil is not going to run out or be banned overnight, but it will become progressively less available over a few decades, either due to resource exhaustion or international restrictions of fossil fuel use. How then is a transport system, and behind that, a whole global capitalist division of labor, going to respond?

Looking first at shipping, it is clear that costs will rise. Today we have diesel-powered steel ships. At the end of this century what will ships be built of and powered by?

Before steel ships we had wooden ones, and sail power hung on into the early twentieth century, so international trade would still be possible by a reversion to earlier technologies. But this would mean both a severe reduction in trade volume and a rise in carrying costs. Vessels of modern size cannot be built of wood. Wooden construction implies ships of at most a couple of thousand tons, about a hundredth of the size of the largest contemporary container ships and a tenth the size of the most common bulk carrier. Costs would be much higher because of the large crews needed to handle sails.

But there are obvious alternatives. Aluminum has been extensively used in warship construction, and could be used for merchant shipping were owners forced to pay the higher construction cost. But nobody has yet built large aluminum ships. The largest have been around 100 meters whereas current freighters run up to four times that length.

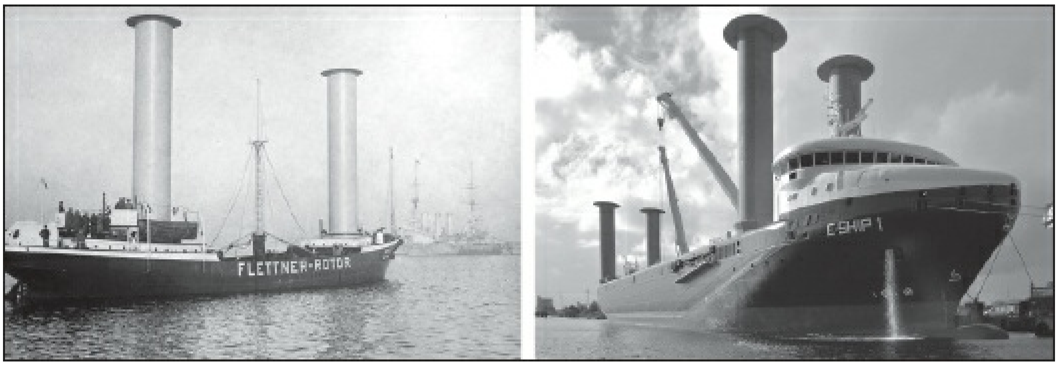


Figure 7.4. The Flettner rotor ship. The original ship is on the left with the modern experimental Eship1 on the right.

Aluminum ships have been plagued by corrosion problems. As a highly electo-positive metal, any contact with other metals like bronze or steel sets up a battery on contact with water. The consequence is electrolytic corrosion that eats away at the aluminum. In principle this can be avoided by using only aluminum in the hull. Designs have existed for bulk cargo ships of this type for decades, but have been uneconomic [Altenburg, 1971]. Overall, and over decades, however, there seems little doubt that the technology of building such ships can be mastered. Propulsion is the bigger problem.

Batteries and solar power are ruled out. Batteries, which have long been used in submarines, do not last long enough for ocean voyages, and solar power provides too little energy for a large heavy vessel. Wind remains the most likely alternative. Designs do exist for cargo ships with conventional masts and sails, but the crew required to handle sails, even with some form of power assist, is likely to be more than would be needed for a motor vessel. A promising alternative is the Flettner rotor.[139] This relies on wind that will exert a perpendicular force on a spinning cylinder. It requires a modest power to rotate the cylinder but, by harnessing the wind, yields much more propulsive power than is put in. Such ships do not need big crews. A couple of cargo ships using this were built in the 1920s (Figure 7.4), but at that time they proved uneconomic in comparison to diesel. Given that diesel ships have improved a lot since then, they remain uneconomic in the absence of controls on the use of fossil fuels.[140]

Another possibility is that nuclear energy, long used in warships, might be applied to cargo vessels. There is no doubt that it works, and can drive ships very fast. But there is a big difference between operating nuclear energy in an environment where cost is no object, with highly trained crews, and using it in a commercial ship. Of the four experimental atomic cargo ships, *Savannah* (US), *Otto Hahn* (German), *Mutsu* (Japanese), and *Sevmorput* (Soviet) only the last was a success. Cost, reliability, and safety considerations have prevented a general uptake of the technology.

So the conclusion to take from this is that the end of the fossil fuel era is likely to lead to a significant increase in shipping costs. Ships will cost more to build, more to operate, and probably be slower.

This will substantially undermine the current model of globalization. Higher shipping costs will favor local producers compared to global ones, and land links rather than sea links. Rail freight is still heavily dependent on diesel in many countries, but electric railways are an old and well-tried technology. It is expensive to put in the wires and to buy new locomotives, but running costs subsequently are similar. Even with the current structure of electricity generation electric trains release less carbon than diesel [Givoni et al., 2009]. As the electricity generation system moves toward renewables and nuclear, this advantage will become more pronounced. Electrification tends to be high in countries like China where the railways are state owned and planned and low in countries like the United States where the infrastructure is private.

China’s rail transport volume is one of the highest in the world, having a 93,000km network of which 46,000km is electrified [Ministry of Railways, China, 2012]. The rate of electrification increased gradually: in

1975 it was only 5 percent, by now it is about 40 percent as a result of a conscious central planning [Juhász et al., 2013].

In contrast, only 1 percent of the U.S. network is electrified. We discussed earlier how, in capitalist economies, high capital-intensive industries have a low rate of profit, which discourages investment in them. The contrast between U.S. and Chinese railways is a particularly stark example. The electrification of the railways in large countries like the United States is technically feasible as China shows, but it is held back by private ownership. Thus, the need to convert to electric trains will tend to favor the replacement of private with public railways.

The percentage of freight carried by trains may well rise, because in the absence of diesel engine trucks, long-distance trucking is likely to be unviable. The best electric heavy trucks have a range of only 100km and take several hours to charge. The goods transport system is likely to have electric trucks being used only for final delivery within cities.[141]

For urban transport, electric cars with lithium batteries are certainly a viable replacement for fossil fuel ones. There are questions associated with the long-term availability of lithium for the batteries [Kushnir and Sandén, 2012]. If the whole world were to attain the current European levels of car ownership, and these all used lithium batteries, it is questionable whether world lithium resources are sufficient, though that is a relatively extreme projection of future use. Gaines et al. [2009], using more modest projections of future car use, conclude that lithium resources are unlikely to be a big constraint.

Lithium is geographically concentrated with the top four producing countries having 90 percent of world reserves. In the event of it being used in all cars, these countries would be in a position to gain rent revenues analogous to the leading oil producers today. On the whole, though, these are likely to be smaller than the oil rents in the current world economy, because lithium can be recycled, but unlike oil it will not be a primary energy source.

There are no serious engineering problems with converting the aviation industry to use non-fossil fuels. Liquid hydrogen is a viable alternative [Koroneos et al., 2005; Contreras et al., 1997] and has a much better energy-to-weight ratio than existing fuels. Its main drawback is that it is much less dense, so that a substantial part of the fuselage volume would have to be given over to fuel tanks. Designs exist for modified Airbus and Boeing jumbo jets powered by hydrogen [Price, 1991]. The Boeing design had the upper deck extended to the length of the fuselage and entirely filled with liquid hydrogen tanks. In 1988 Tupolev actually built a modified Tu155 that flew on hydrogen [Pohl and Malychev, 1997], the back part of the passenger cabin having to be occupied by the fuel tank.

Although the conversion is possible, it will come at the cost of more expensive flights. Because the fuel is so bulky, the aircraft will be able to carry fewer passengers than a conventional one of the same size. The fuel is also more expensive. Although photovoltaic electricity is begining to rival fossil fuel electricity in lifetime costs, this does not imply that hydrogen produced by electrolysis from solar power is as cheap as kerosene.

Producing electricity from oil proceeds thus:

(a) *oil (40 percent efficient)* → *electricity*

Producing hydrogen by electrolysis starting with oil fuel progresses thus:

(b) *oil (40 percent efficient)* → *electricity (70 percent efficient)* → *hydrogen*

Because of the thermodynamic loss in electrolysis. If we substitute this with photovoltaic we have:

(c) *photovoltaic electricity (70 percent efficient)* → *hydrogen*

The hydrogen or kerosene aviation fuel then has to be turned into motive power:

(d) *aviation fuel (40 percent efficient)* → *motive power for flights*

Suppose photovoltaic electricity costs the same as process (a). Thus photovoltaic electricity is of the same cost as flight motive power in process (d) where the aviation fuel is kerosene. But if we have to generate hydrogen and then burn it in a turbine, the overall subsequent efficiency is 70 percent × 40 percent = 28 percent. So even if photovoltaic electricity is as cheap as fossil fuel electricity, as a source of aviation fuel it will still be more than three times as expensive as kerosene.

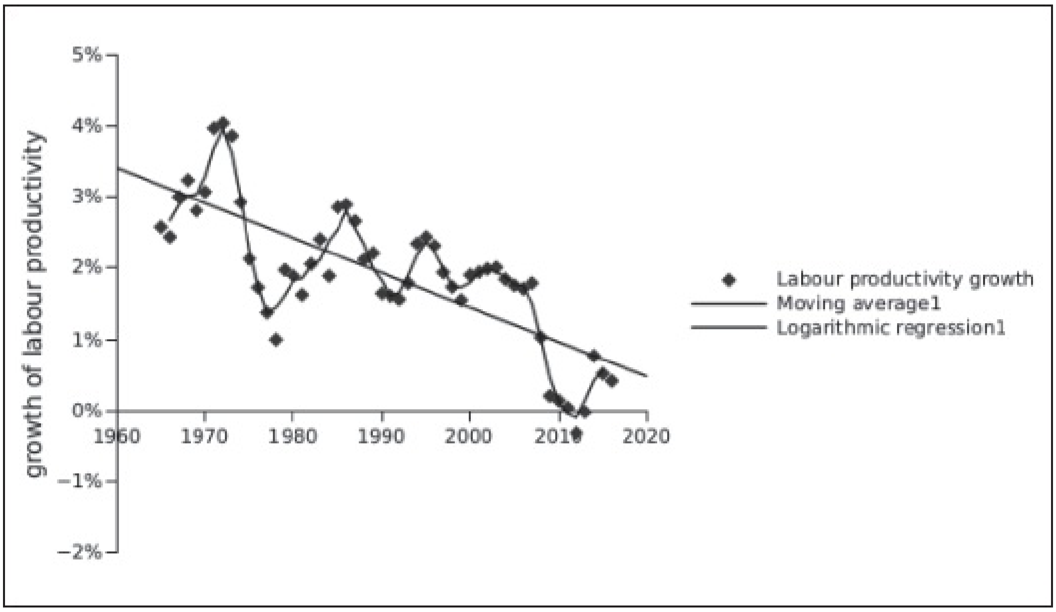


Figure 7.5. Growth of labor productivity over the last half-century in the UK. Growth rates computed as moving average over last 5 years for output per worker for the whole economy. Source: ONS data.

Lower passenger capacity and lower thermodynamic efficiency mean that cost per passenger mile will rise substantially.

The change to a non–fossil fuel economy involves big increases in costs in a number of areas: materials, transport, process heating. In air and sea transport this could amount to a doubling or more of costs assuming current labor productivity.

Throughout the Industrial Age labor productivity has risen, so one might hope that once human ingenuity is devoted to increasing the productivity of wind-powered aluminum ships or hydrogen planes the initial loss will soon be recovered. The changeover will take decades. Will this not leave plenty of time for productivity rises to offset the loss?

There are several problems with such an optimistic view. The first is that labor productivity growth has been declining over the last half-century (Figures 7.5, 7.6). We should expect late industrializing economies that are importing the most advanced techniques to have more rapid productivity growth than those that are already industrialized. That labor productivity growth should decline in countries like Japan and Italy, which had not completed industrialization in 1960, is not surprising, but even economies like the UK, fully industrialized in 1960, show the same trend. Even before the 2008 recession, the bulk of industrial economies were improving their productivity at under 2 percent a year, and, if current trends continue, productivity growth will stop generally in the next decades.

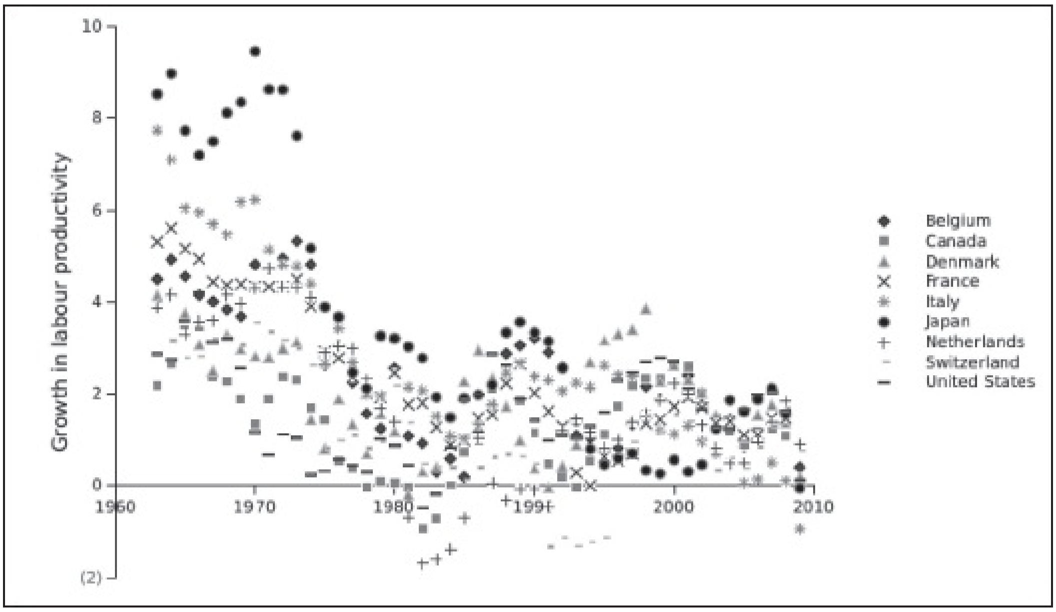


Figure 7.6. Decline in productivity growth, up to the start of the 2008 recession. Sourc: Extended Penn World Tables.

If productivity grows at 2 percent a year, it would take 35 years to offset a doubling of costs of air and sea transport. If growth shrinks to 1 percent it would take 70 years. This, however, may not be enough to save globalization. The figures of 1 percent or 2 percent are average increases in productivity across the whole economy.

It currently pays to fly prawns caught off the cost of Britain to Thailand to be shelled and then fly them back to supermarkets here. This is only viable with cheap air freight. Suppose air freight charges doubled and the business became unprofitable. Suppose that in 2067, the general improvement in UK labor productivity is such that the initially doubled air freight charges have now fallen, in terms of labor time, to the same number of worker days as now. Would we expect the flying of prawns to Thailand to resume?

No. For one thing the cheap labor to be had in Thailand today is unlikely to be available after half a century of development there. For another, labor productivity in the UK prawn-shelling business can be expected to have increased as well. If it grows the same way as the rest of the economy, it too will have doubled. So the comparative advantage of shelling in Thailand would not reappear.

People are being overconfident about the rate of technical change. I am old enough to have seen the rate of technical change slow down a lot within my own lifetime. I remember that it was in the late 1970s that Greg Michaelson and I first noticed this slowdown happening and started to discuss it. Technical change is nothing like as rapid as it was in the 1950s or 1960s, let alone between 1890 and 1914. The tendency is for labor productivity to slow down.

Perhaps our grandchildren will be using magnetic levitation trains, but in the 1960s we expected linear induction monorail trains to be in use by 1980. After all, they were building a prototype in East Anglia. High-speed tilting trains were being developed by British Rail in the late 1960s and were scheduled for use in the ’70s along with 125 mph diesels for other lines.[142] Current Virgin Train diesels are no faster than those HSTs. In 1975 I could go from Edinburgh to London in 4 hrs 20 mins; it is no faster today, forty years later. Where are the flying cars, personal jetpacks, and 15-hour working weeks we were promised?

In some areas transport and technology have regressed considerably. Nineteenth-century-style bicycle delivery boys are back on the streets, “badge engineered” by Deliveroo. In the ’70s Britain could, build supersonic airliners, the Americans could land people on the moon. Neither of those technologies are available now. In the 1950s the UK could from a complete standing start, build a whole series of nuclear power stations, with each one taking about five years. Now we have to import the technology at vast expense from China and France, and it takes over a decade.

During my grandfather’s lifetime, travel went from horse transport in towns and the only form of flight being by balloon to generalized use of cars and mass jet transport. Entertainment went from magic lantern shows to cinema, and then television. There was no telephone system when he was born, let alone computers, but in his old age he came and saw the workstation I was using (an ICL PERQ) and was immediately able to understand the Unix filing system.

Is this because of some inherent property of the development of technology, or is it evidence that Marx was right about social forms eventually becoming a fetter on the development of new technologies?

We know that many individual technologies develop with a logistic or S curve like that shown in Figure 7.7. For example, the diffusion of steam engine technology in Britain developed this way [Nuvolari et al., 2011]. But, as Modis [2013] showed, the overall development of productivity in leading industrial economies also has this shape. Japanese GDP growth almost exactly fits a logistic curve, with GDP per capita having leveled off and been stagnant since 1990. In the early stages of logistic growth, it looks exponential, then it slows down and eventually tends toward an upper bound. So for countries like India or China we cannot tell if the growth is logistic or exponential. If we concentrate on the countries that do show a logistic pattern, what is happening?

There are two possible answers. It may be that the basic technology complex of industrial society is drawing close to its limit. Alternatively, capitalist social relations have become an absolute fetter on productive forces. If that is the case, we could attribute the leveling off of growth to the fall in the rate of profit, shown for example in Figure 5.25. This fall in profit rates would, in this interpretation, curtail investment. Because of the decline in investment, then, the rate of technical progress would have slowed down.

This is a plausible explanation as there does appear to be a decline in net investment per worker over the period shown in Figure 7.8. Here data is computed as (i-d)/x for net investment and i/x for gross investment, where d is estimated depreciation per worker in 2005 purchasing power parity, i is investment per worker-year in 2005 purchasing power parity, and x is GDP per worker in 2005 purchasing power parity.

It is noticeable that gross investment is not declining. A rise in the capital stock per worker implies that depreciation eats up more and more of gross investment [Zachariah, 2008]. The decline in net investment is thus expected whatever the property relations prevailing.

Whether it is the whole story is another matter. Even when net accumulation of value declines, there is still a process of replacement of old machinery with new as it wears out. Even if the new machinery is of the same value as what it replaced, since it was more modern it should be more effective. It should, as a result, still raise the productivity of labor.

Stagnation in that case is compatible with a continued modest growth in productivity.[143] The productivity gains would then be eaten up by the aging of the Japanese population. A shrinking workforce, getting slowly more productive, might just be enough to hold GDP per capita constant. The logistic in GDP per capita would then be the combined effect of zero net accumulation and changing demography.

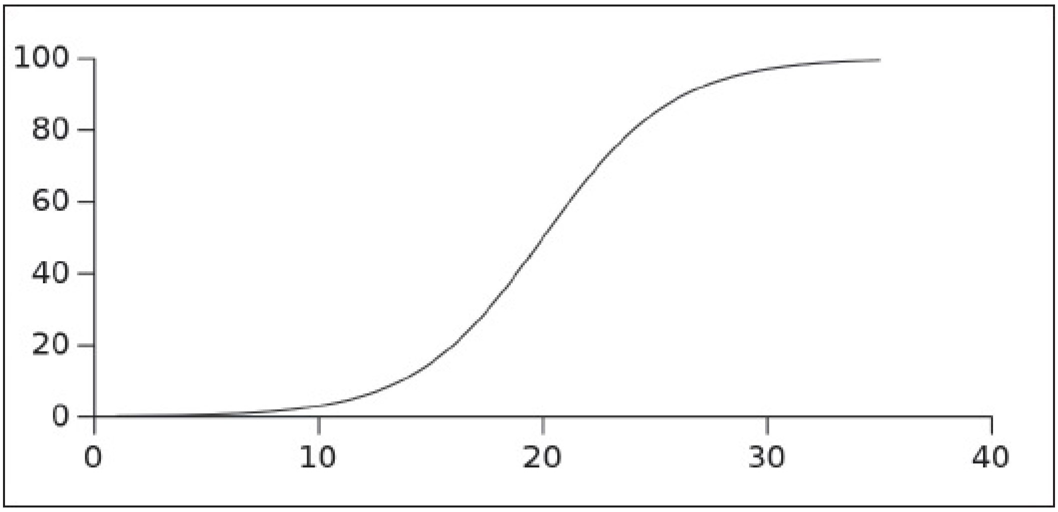


Figure 7.7. The logistic curve, which initially looks like exponential growth.

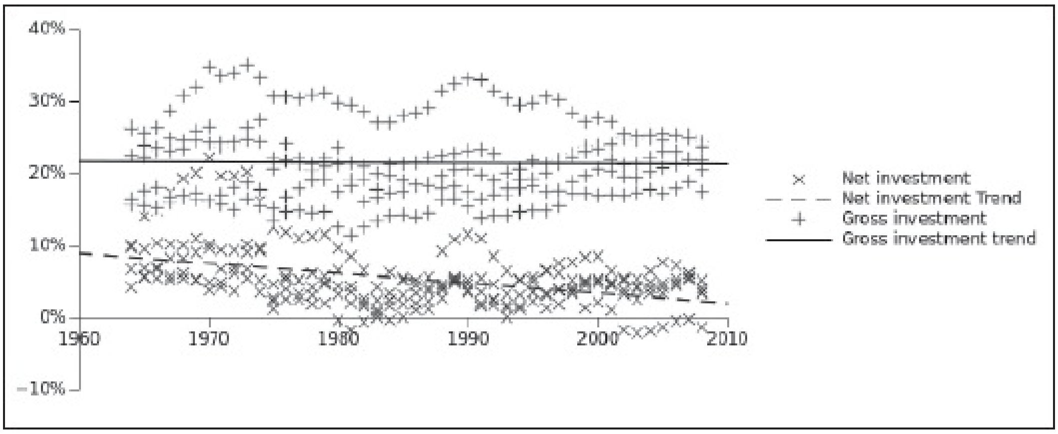


Figure 7.8. Long-term trend of net investment per worker as a share of output per worker is declining in this data for UK, United States, Italy, France, Japan. Source: Extended Penn World Tables.

But we should still be cautious about saying that the decline in labor productivity is simply an artifact of capitalist property relations. Even if these are a proximate cause, my analysis of Feldman growth theory showed that there were analogous, ultimately demographic, constraints on socialist growth. As society raises the stock of means of production, an increasing portion of the labor force has to work replacing and updating this stock. So net accumulation also slows down under socialism, as the history of the USSR showed.

This implies that the industrial mode of production that underlies both capitalism and socialism has its own inherent limitation. Producing by means of machinery that must wear out, along with a demographic transition that slows population growth, means that the value of machinery built up per worker hits limits. This holds whatever the property relations.

A capitalist economy will be more seriously affected. The consequence of a falling rate of profit is a slackening of accumulation, which leads to unemployment, unused capacity, over indebted firms, and a generalized slump. A socialist economy, where investment is not carried out for private gain, can go on investing even when the growth rate slows down. Capitalist economies also go through additional cycles driven by the expansion and contraction of credit. In Figure 7.5 these cycles are clearly visible, overlaid on a secular declining trend.

So I have given an explanation relating to the capitalist social relations plus an explanation relating to the industrial mode of production. There are other possible explanations relating to innovation, the relationship between society and nature, or to inherent thermodynamic limits of technology. Perhaps the problem is the exhaustion of the innovations on which twentieth-century growth was powered, without sufficiently radical new ones coming onstream. Maybe the last thirty years have just not seen any innovations as radical as the steam engine, electricity, the railway, or powered flight. We have had cellphones and smartphones, but do these compare in significance to the initial development of the telephone and wireless?

A smartphone combines telephony, computing, wireless, and a screen with moving pictures, but these are all classic twentieth-century technologies. The innovation was to shrink them and mass-produce them. The iPhones may seem like bright stars in our sky, but they are nothing like the constellations of innovation that transformed life in the nineteenth and twentieth centuries. The modern world has nothing like the dizzying speed of technical and social change that Wells conveyed with such immediacy [2005a; 2005b; 1930; 1914; Wells and Parrinder, 2005]. The rapid growth of the twentieth century combined, or superposed, the exponential stage of the S-curves of many different technologies. As these curves shift into their asymptotic phases, growth slows down unless a large number of entirely new technologies start on their own S-curves. The individual S-curves have that shape for two reasons:

1. *The diffusion process of a technology is S-shaped*.
   Initially a few people had handmade cars. Ford's production line allowed their mass production. Then all manufacturers switched to

production lines, and car use grew exponentially. Eventually the majority of families had cars and growth slowed down to replacement levels.

2. *Technologies hit limits set by natural law.*
   Steam-engine efficiency grew exponentially from the late eighteenth to the mid-nineteenth century. Double then triple expansion engines were introduced. Then came the Parson's turbine. But there is an ultimate limit to the efficiency of all these Rankine cycle engines. In theory their maximum efficiency is in the 60 percent range, but in practice the best power stations hit only 42 percent. To get higher efficiency they would need hotter steam. Higher steam temperatures would weaken the steel used in their turbines, so the efficiency has plateaued.[144]

We have already touched on the relationship between society and nature in identifying the end of fossil fuel as a looming issue, saying that it implies a rise in real costs, that is to say labor costs, across all energy dependent branches of production. But the effects are already being experienced. Shifts to non–fossil fuel sources of power are already having impacts on power costs. The production of biofuels withdraws land from food production and raises food prices. Even without the Kyoto Protocol and Paris Agreement, the growth in demand for oil had enabled the price to be raised in two great waves, in the 1970s and again the 2000s (Figure 7.9). This represented an increase in the amount of labor that had to be exchanged for a kilowatt hour of power. These waves of high prices coincided with clear slowdowns in the rate of labor productivity growth internationally (Figure 7.6).

Improvements in productivity had been dependent on substituting energy for labor. When the amount of labor required to acquire a given amount of energy rose, that made it much harder to increase the productiveness of labor. What made things worse was that the increase in costs was largely in the form of rents to the oil states, which were then spent unproductively.

Green lobbyists talk enthusiastically about the number of future jobs to be had from alternative energy. This is a tacit admission that alternative energy will cost more labor. With green energy, the extra cost translates into revenue for labor and capital rather than ground rent as at present, but overall it is still a real economic cost.

The argument that I have been making about the slow rate of modern technical advance is intended, in part, as a counter to the idea that automation and robotics are advancing at unprecedented speed threatening a jobless future [Martin, 2015]. In fact, the labor productivity figures show a slowdown, at the same time as changing demographics threaten a labor shortage. But the figures are for *real* productivity, where real productivity in the national statistics is this monetary productivity divided by a deflater for the rate of inflation. It only measures the productivity of labor in producing commodities. What if the *real* change brought on by automation is in something not measured in these statistics?

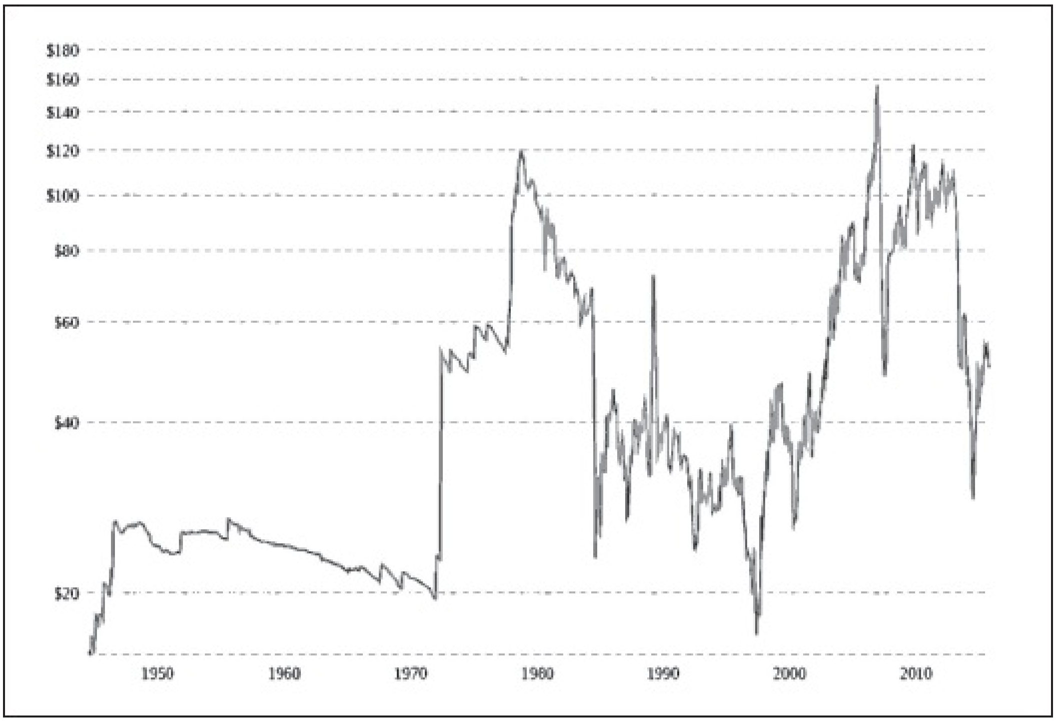


Figure 7.9. Long-term trend in crude oil prices. Source: www.macrotrends.net

7.1.3 Information

The biggest impact of automation has been on the dissemination of information rather than on the production of physical objects. When you interact with the Internet, your computer communicates with a plethora of other computers: an ADSL modem and wireless router, routers in the local telephone exchange building, switches at major hubs, and server farms owned by big companies like Google, Apple, or Microsoft. These all respond automatically and without any human intervention to deliver the information you request. People worked to build the equipment, to set it up, to write the software it uses, and to generate the electricity on which it depends. That is all in the background, prior to and independent of your particular interaction. The actual information that the web delivers to you is not foreseen by or dependent on the enabling work that people did. It is hard, even in principle, to associate any quantum of human labor to the quanta of information you get back. All we can be sure of is that the fraction of an hour of labor per bit delivered will be tiny.

In consequence, the bits are not commodities.

GDP measured in monetary transaction hardly grasps this activity. All that appears in the accounts are the fees paid to access the Net, and the fees that advertisers pay Google.

From an accounting standpoint, Google is in business to sell ads, and its labor productivity can only be measured in terms of the dollars of advertising sold in comparision to the number of people it employs. But this misses the real utility of the Web, the rapid discovery of information, and substitutes an adventitious measure, one born out of the funding model used to support it. In principle, governments could put out tenders to supply ad-free Web indexing and social media services. The productivity in terms of service delivered to end users would probably be higher. Much of the software development effort by Google and Facebook goes into identifying better leads for advertisers rather than improving services to end users.

The capitalist Web develops via a curious mutual parasitism, in which the value form abolishes itself. The end users parasitize the free services offered. But the providers of these free services in turn parasitize the end users by selling information about their activity and interests to third parties. But the very possibility of Google being able to offer a useful indexing service depends on there being lots of free information. It depends on people being willing to write blogs, post news about themselves, take and upload videos, make their own audio recordings, etc. It depends on scientists being willing to post their research on free archive sites, on public bodies making statistics and reports freely available. Free information on this scale is something qualitatively new. Some free knowledge has always existed. That taught in schools belonged to nobody. Scientific results have been the common property of scholars. Folksong belonged to the community of musicians. But their encoded distribution, as books, sheet music, phonograph records, etc., took commodity form.

The work individual people do posting stuff on the web is communism in action: work done for self-realization, unalienated labor, uncommodified labor. Even the means of web production escape, in the main, value relations. Much of the edifice rests on free open-source software. Some open-source software is written during paid working hours by employees of firms that, for their own business reasons, choose to release the software open-source. But another large part is written by people in their free time, or by people at educational or research institutes, with no commercial motive. The existence of these new productive forces gives rise to a new form of communist ethic among those who work them, summarized in the slogan: *information wants to be free* [Brand, 1987].[145]

This nascent non-commodity distribution is restricted to information goods rather than physical ones, and further restricted by intellectual property rights. Personal computers are the means by which multiple copies of software, music, books and so on can be produced by minimal labor. But if people engage in such production they are labelled *pirates*. Thus a label originally applied to violent criminals who seized ships and killed their crews is attached to people engaged peacefully in production. Here we have a clear example of property relations holding back production. If pirates grab the cargo of a ship, they deprive others of it. If a hacker distributes copies of a song, nobody is deprived of it. Indeed more people get to hear it. The only deprivation is that of the copyright holders who forgo some of their monopoly profit.

A whole series of technical and legal measures are enacted to prevent copying. Digital Rights Management (DRM) watermarking is used to try to make copies of e-books unreadable. Laws are passed to ban the circumvention of these provisions. In the end the technical attempts to protect digital property rights are all circumvented. The monopolists are forced to rely on the courts to imprison those who create the indexing tools and sites that allow free file sharing.

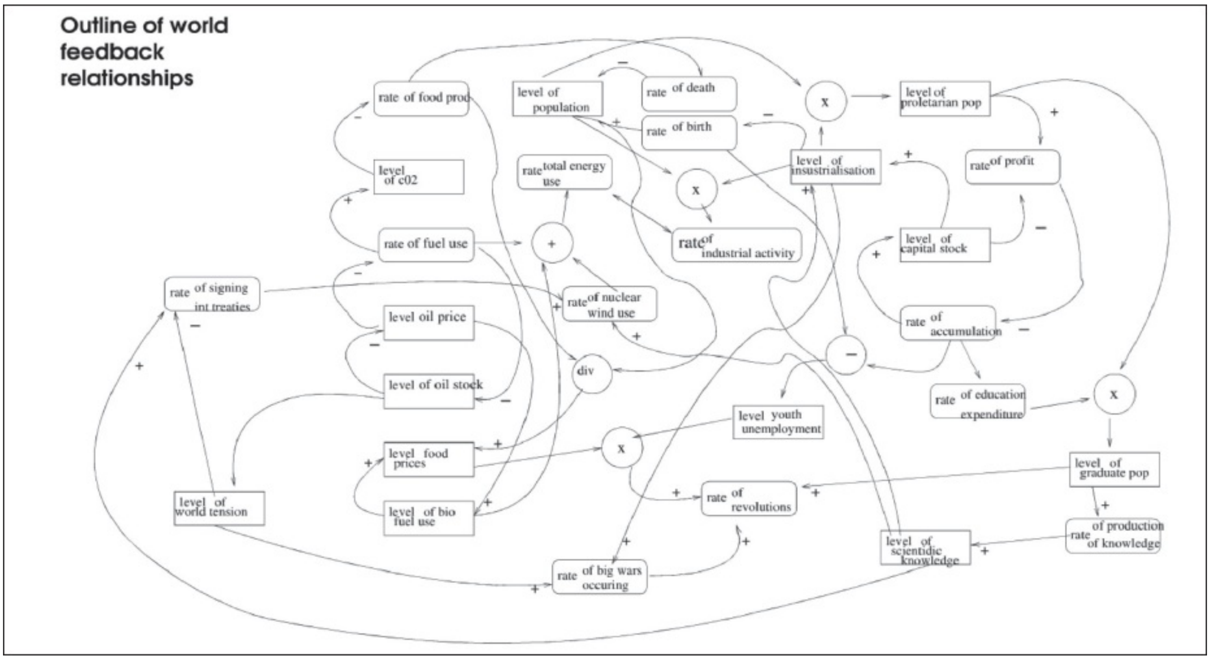


Figure 7.10. Environmentally driven feedbacks in the world sociopolitical system.

PREDICTION IS A RISKY AFFAIR, especially, one might add, when applied to the future. The best one can do is make rational extrapolations from apparent causal processes. We know that technological change and labor productivity have been slowing down for fifty years. The transition to a post–fossil fuel economy will put further pressure on labor productivity and particularly on transport costs. It may be that this portends the inherent limits of industrial civilization and its mode of production. Alternatively, maybe it is the capitalist structure of the world economy that is to blame. I have identified several areas of technology, in energy production and information distribution, where capitalism appears to hold things back.

A social compromise in which the income of all classes continues to rise becomes harder to establish. Political economy becomes more of zero sum game that pressages an intensified class struggle over the distribution of income.

7.2 POPULATION

From the 1980s, alongside a slowing in the growth of labor productivity, there was an increase in exploitation across the industrialized capitalist countries. The productivity growth that did occur went disproportionately to the upper classes. There were immediate political reasons for this. The pioneering of neoliberal policies in Chile during the 1970s, after the military coup, heralded their spread to other countries via Thatcher and Reagan and their generalization following the fall of the USSR. But these are secondary phenomena. The driving forces were demography and technology. Vast reserves of labor power were being thrown onto the world market in Asia at a time when improvements in transport, large diesel container ships, were driving down shipping costs.

The economic and political weakness of labor relative to capital was due to there being a glut of labor in a more unified world market. All the other measures of trade liberalization were predicated on this basic fact.

As I write in 2017, we are passing the inflection point of the S-curve that governs this process. World fertility levels are approaching simple reproduction (Figure 5.31), with the decline in Asia being even more rapid. Already in China this is leading to fast rises in wages (Figure 6.10). India and Africa remain as reserves of labor but, with East Asia, Europe, and North America now industrialized, the ratio of labor reserves to capital generation is shifting to favor labor.

Absent the disruption that would be caused by another world war, a tightening labor market and a slowdown in technical change will lead to a more intense struggle over the distribution of income. The first response of the business class to this labor shortage is to encourage immigration, an effective means of increasing exploitation (see Figure 5.28). Eventually the pool of cheap labor will be exhausted, but well before that, working-class support for anti-immigrant populism is likely to block the process.

Developed economies will increasingly face the constraint of a shrinking working population. I showed earlier that under these circumstances capital accumulation becomes impossible. The equilibrium rate of profit tends to zero with a stable population. If the working population shrinks, then accumulation must become negative, and if you take into account losses on capital account, then the whole economy ends up running at a loss.

At this point the issue of how the economy itself is organized will become more and more an issue of politics. The questions of how economic decline and population decline can be halted will be increasingly asked.

These issues will be raised in a society that is already highly polarized between a wealthy elite and a majority whose standards of living are falling. The elite response will be to raise profitability by attacking the living standard of the majority. But, with a stagnant population, there are insufficient opportunities for profitable investment. The elites boost their share of national income but increasingly spend it on unproductive luxuries. Insulated by their burgeoning share of national wealth, the elites continue to live in the illusion that all is well, until social pressures become insufferable.

7.3 POLITICS

The coming era of social conflict could well result in nothing more than the mutual ruin of contending parties. None can predict the final outcome of these contests. But it is certain that socialist ideas will return from their post-Soviet exile to the center of national debate. Premonitions have already been seen in the Americas and Europe. For socialist ideas to succeed not only in winning government but in guiding the economy once in power, they will have to coalesce around a set of answers to the problems of this century. Socialist ideas will become practical common sense for the mid-twenty-first century just as they were sixty years ago.

Unless rapid and drastic steps are taken to limit fossil fuel use contemporary civilization faces a terrible crisis. Earth is not threatened by climate change; it has survived all sorts of vicissitudes of climate in the past. But for species, including our own, it is a real threat. Humanity is faced with famine and climate strains of an entirely new scale. Studies using a variety of climate and economic models all predict falls in food output and rises in world food prices [Nelson et al., 2014a; 2014b]. Averaging across many models, the mean projected effects on key grain crops are for drastic falls in output in hot countries, whereas cold countries, particularly Canada and Russia, will see marked improvements in yields [Rosenzweig et al., 2014]. Since the hot countries are poor and the cool countries tend to be relatively rich, those who are already struggling to survive would be the hardest hit if CO_2 goes on rising. Estimates of food price increases range from 20 to 100 percent depending on the climate model and economic model chosen. Such price rises would be enough to threaten the survival of hundreds of millions. The effects can only be worsened if biofuels become widely used, since these divert crops from feeding people to feeding cars. It follows that a central goal of a socialist politics today has to be to bring about rapid reduction in fossil fuel use, provided that food crops are not sacrificed in the process.

Rather than ideas like carbon taxes or emissions trading, a socialist policy would be expressed in terms of quantitative limits to the amount of coal being mined, and oil being pumped. Carbon taxes tend to be regressive and uncertain in their effect. It is not known in advance what level of carbon tax would be needed to produce, for example, a 20 percent reduction in emissions. Emissions trading schemes, as used by the EU, reward existing polluters by giving them property rights in emissions. The greater the pollution a firm starts off with, the more rights it gets. They act, therefore, to transfer rent income to big firms.

A socialist planned economy always has to set various constraints on its overall plan, such as the length of the working day, number of people available, and attempts to maximize some measure of social welfare subject to these constraints. If the planning process uses mathematical methods for this optimization, as developed by Kantorovich [1960, 1965], it is straightforward to add environmental constraints to those being set by population, existing stocks of machinery, etc. [Cockshott, 2006b]. Society could make a 20 percent reduction in carbon use an explicit plan objective. This would constrain the plan algorithm to select technologies for development that would fall within that goal. But that only becomes possible in an economy that is already subject to directive planning. In mixed economies, like the Chinese one, or in purely capitalist ones, direct quantitative control of carbon emissions is still possible by explicit rationing. Something similar to the U.S. Standby Rationing Plan for Gasoline, developed in the 1970s, could be used:

> The Department of Energy will establish different allotments for different types of vehicles. Allotments will be based on an average annual fuel consumption of vehicles in various categories and will be made for each type of vehicle. All vehicles within a given category (for example, all passenger cars) will receive the same ration allotment in a given state regardless of fuel efficiency. This will give a significant advantage to fuel-efficient vehicles and should provide an incentive for their use during a period of rationing….
>
> Under the standby plan, ration coupons that have not been redeemed will be freely transferable on a white market. There will be no regulation of the price at which they are transferred. Hence, those who wish to exceed their allocated ration may do so by purchasing coupons from willing sellers. [Crompron and Gitelson, 1981, 28]

This U.S. legislation, which is only put into effect in time of emergency, is surprisingly egalitarian. The effect of distributing tradeable rations to all car users, thus to a large portion of the whole population, is leveling. If the wealthy want to drive big gas-guzzling SUVs they have to purchase tokens from those with smaller cars, producing net transfer of income.

A similar mechanism could be applied to carbon rationing. All citizens would get ration books which they could use when they buy fuel for cars, oil and gas for heating, etc. Government inspectors at the refineries and coal mines would ensure that coupons handed over by the oil companies matched the deliveries from the refineries. Haulage companies, airlines, and other industrial users of fossil fuel would have to purchase coupons on the open market from citizens. The net effect would be to ensure that the environmental target was met without regressive effects on income.

If, as seems likely, climate change leads to general shortages of food, some similar form of food rationing may be necessary. In general a socialist government should avoid rationing. It is better to meet egalitarian goals by means of full employment and narrowing of pay differentials. But rationing is the least worse option if the economy is not yet fully socialized and if big income differentials still exist. The U.S. principle, that ration cards be transferable, is essential if the full egalitarian potential of rationing is to be achieved.

Insofar as private ownership of industry had a historically progressive role it rested on the process of capital accumulation. It was this that allowed Western societies to industrialize. This was not the only possible route to industrialization, as the history of the twentieth century showed. The process of accumulation itself is fundamentally a disequilibrium phenomenon. Steady accumulation is dependent on a steady growth of the population or, as Marx put it, accumulation of capital is growth of the proletariat.

With that process coming to an end, the sustainability of private ownership is undermined. It no longer has an objective economic justification, relying instead on politically supported monopoly power. But the growing imperative of climate control amounts to an implicit undermining of property rights. Restricting carbon emissions implies the abolition of the ground rent of the oil states—one of the most important single rivers of surplus revenue. The vituperative opposition of much of the property-owning classes to climate control measures, extending to funding climate change denial, is based on a recognition that the whole process is a threat to property rights. It posits the general interest of humanity as a whole overriding private rights. A thorough program of curtailing fossil fuel use requires the political defeat of fossil fuel interests. The implementation of a transition to a non–fossil fuel economy progresses most rapidly where the entire energy economy is publicly owned, as in China. From the standpoint of the Chinese state it makes no pecuinary difference whether it generates fossil fuel electricity or uses solar, nuclear, or wind power.

Let us set aside for the moment whether the twenty-first-century crisis will progress toward a socialist outcome or instead a victory of existing propertied interests that leads to general climate catastrophe. Let us look at what type of property relations a future socialist economy might have. Allin Cottrell and I set out a model for this twenty-five years ago [Cockshott and Cottrell, 1995]. Developments since then have confirmed our conviction that the basic model we outlined remains valid. It is a view of an economy that is publicly owned and planned using modern computer technology to handle the sheer volume of data—on which the old Soviet planning system foundered. Within this model, the labor theory of value occupies a crucial position. It provides an answer to the old objection of Mises [1935] that without money there was no practical way of comparing the costs of different alternatives. Empirical research since then has strongly validated the labor theory of value, confirming the soundness of the basic proposal. [Petrovic, 1987; Shaikh, 1998; Cockshott and Cottrell, 1997e, 2005; Zachariah, 2006; Fröhlich, 2013]

There have been big advances in computerization since the end of the 1980s, which make the task of operating a cybernetic moneyless economy even more practical. Google solves everyday systems of linear equations far bigger than those required for continental-scale economic planning [Widdows, 2004]. The huge bandwidth Internet now makes the modified 1980s broadcast technology that we proposed to use for disseminating planning information redundant.

In our proposal people would be paid not in money but with nontransferable electronic work accounts. Purchases would be made with smart cards as they are today, but with the difference that the only way people could accumulate work credits would be by actually working. The more hours you work the more credits you get. Goods in the shops would then be priced in hours, and the exchange principle is basically one for one. For one hour of work you get goods that took one hour to make.

Contrary to the dreams of futurists, human labor remains essential to the economy.[146] It is humanity's fundamental resource limit. Calculation in terms of human time allows public finance to be divested of the fetishism that money engenders. It becomes clear that decisions about public spending are in reality decisions to allocate a finite working population to different tasks. In combination with modern communications technology, the unfetishized nature of time decisions allows broad democratic participation. The broad headings of public expenditure can be settled by a process of participatory consensus.[147]

In Section 6.4 I explained how the system of surplus production operates in a planned economy and argued that one of the big failings of the twentieth-century socialist systems was that they relied on various forms of indirect taxes to fund free public services. I showed how this system systematically biases economic decision-making against socially rational technologies. It is important that the twenty-first-century socialist movement not repeat this mistake. By far the most rational and equitable approach to public finance is to rely on income taxes.

I argued in Section 5.9 that the fundamental constraint on capitalist profitability is the falling birth rate. Across much of the developed world this has sunk well below reproduction levels. In the short run, this may be favorable to the labor interest, since labor shortages could allow the price of labor power to be bid up. In the long term it poses a serious problem in whatever form of economy. A rapidly declining population bears a heavier burden of caring for the old, and will have difficulty sustaining the basic infrastructure of the economy in the face of wear and tear. So socialist family policy aims for a population that is roughly stable. I recounted how socialist economies in the past sought to reduce the burden of having children by providing free education, free childcare, and substantial financial allowances to mothers. This included full benefits to single mothers, who contemporary Western society tends to stigmatize as "welfare queens," etc. Whether such measures will be enough in the future is an open question. For my part I suspect that once the bonds of patriarchy are loosened, and the constant destabilizing effect of men and women having to move long distances to find insecure jobs has been removed, we may revert to long forgotten, but more natural, forms of matriarchal extended families.

APPENDIX A

Showing Which Sectors Are Productive

A useful way to understand which employees can produce surplus value is to use the reproduction schemes that Marx developed in volume 2 of *Capital*.

He divides the whole economy into three sectors. Sector I produces means of production, that is, machinery, industrial fuel, and raw materials. Sector II produces actual consumer goods. He further breaks down Sector II into Iia, which produces goods consumed by the working class, and sector IIb, which meets the consumption needs of the capitalist class. He then constructs what amounts to notional tables of national accounts based on these sectors (Table A.1).

We can assume the numbers in this table are £billion per year. The important thing is that the output of Sector I has to equal the total constant capital (c) used in all sectors, the output of Sector IIa has to equal the total wages (v) used in all sectors, and the output of Sector IIb has to equal the total profits (s) over all three sectors.

Table A.1 was produced using a spreadsheet that incorporates all of the constraints that Marx assumes for his reproduction schemes. The spreadsheet contains the formulae shown in Table A.2.

Marx assumes a steady state or simply reproducing economy at first, so that there is no surplus being accumulated. The important point is that the reproduction schemes, and with them the actual reproduction of a real economy, is a highly constrained process. You cannot simply write down a reproduction scheme willy nilly; the equational constraints have to be observed. If you look at Table A.2 there are actually only four degrees of freedom to it: the cells with numbers in them. All other cells have formulae in them.

TABLE A.1: Starting Reproduction Table

Sector	c	v	s	Living Labor	Total Output
I	100	50	50	100	200
IIa	50	100	100	200	250
IIb	50	100	100	200	250
Total Used	200	250	250	500	
				Wage Rate:	0.5
				Rate of s/v:	1.0

TABLE A.2: Spreadsheet Used for Reproduction Tables

	A	B	C	D	E	F
1	Sector	c	v	s	Labor	Output
2	I	**100**	*F6xE2*	*E2–C2*	**100**	*B2+E2*
3	IIa	*C2*	*F6xE3*	*E2–C3*	**200**	*B3+E3*
4	IIb	*D2*	*F6xE4*	*#r–C4*	**200**	*B4+E4*
5	Total	*F2*	*F4*	*F4*	*Σ(E2:E4)*	
6					Wage:	*[F2/E5]*
7					s/v:	*[D5/C5]*

The particular way you choose to enforce this four-degrees-of-freedom constraint is arbitrary. By a series of algebraic manipulations you could choose a different set of 4 cells to contain data and have the remaining ones filled with formulae.

In the examples that follow the formulae are unchanged, and only data cells are altered. The formulae then enforce changes in the remaining cells. This property of reproduction as a constrained system is further developed in Appendix B.

The theory of relative surplus value is that a larger share of surplus value can only come about by reducing the labor time required to reproduce the real wage. Now assume that there is an improvement in labor productivity in Sector IIa so that the same physical output can be produced with half the living labor. Let us assume that the redundant workers emigrate and wages for them no longer appear in the accounts. We then arrive at Table A.3.

The effect is that the rate of surplus value doubles, so clearly Sector IIa can produce relative surplus value.

Now suppose we do the same experiment with Sector IIb and reduce the amount of living labor required to produce its output by half; we now get Table A.4.

The effect of this is to actually lower the rate of surplus value to half. It is relatively easy to see why, since a saving in labor in Sector IIb means that less labor is being spent to support the upper classes, so both the total mass of surplus value and the rate of surplus value fall. Sector IIb includes luxury goods production, advertising, commercial law, armaments production, banking, etc.

TABLE A3: Less Labor Used in Sector IIa

Sector	c	v	s	Living Labor	Total Output
I	100	33.3	66.7	100	200
IIa	33.3	33.3	66.7	100	133.3
IIb	66.7	66.7	133.3	200	266.7
Total Used	200	133.3	266.7	400	
				Wage Rate:	0.333
				Rate of s/v:	2.0

TABLE A4: Less Labor Used in Sector IIb

Sector	c	v	s	Living Labor	Total Output
I	100	66.7	33.3	100	200
IIa	66.7	133.3	66.7	200	266.7
IIb	33.3	66.7	33.3	100	133.3
Total Used	200	266.7	133.3	400	
				Wage Rate:	0.66
				Rate of s/v:	0.5

If for all these activities the amount of living labor used fell by half, this is what would happen. The rate of surplus value would have to be lower since less social labor was now being expended on the consumption of the upper classes.

Consequently, the effect of improvements in labor productivity in Sector IIb is to reduce the rate of surplus value, hence no relative surplus value can be produced here, which means the whole sector is unproductive. Changes in labor productivity in this sector have the opposite effect to changes in Sector IIa.

You cannot tell whether a given group of employees are productive just by looking at the formal legal contract of employment they have with their employers. It depends on their position within the structure of social reproduction. The production of relative surplus value, the characteristic surplus under capitalism, is a process that takes place at the level of social reproduction as a whole.

Modern capitalism with its huge unproductive sectors looks more and more like the feudalism that Smith critiqued.

APPENDIX B

Illusions Engendered by Averages

In this appendix I examine the problem of how to reconcile the determination of prices by labor with the existence of an average rate of profit. In previous chapters I have used a simple labor theory of value to analyze commodity exchange. I have ignored what is called the "transformation problem" between labor values and actual prices. This has long been a controversial topic and the position I have taken, that one can simply ignore it, needs some justification. My case inevitably involves a certain amount of mathematical argument. As such it is better in an appendix that you can read at will, rather than being in the main text of the book.

Although Smith, Ricardo, and Marx all hewed to a labor theory of value, they all seem to have thought that this theory was too simple. They introduced amendments to their initial bold statements to account for what they took to be a self-evident truth about capitalism, that capitals in all branches of production would tend to earn an average rate of profit. This led them to formulate modified theories of prices to take profit into account. Smith called these natural prices and Marx termed them production prices.

They were all writing before the science of statistics had been developed, and it can now be seen that their misgivings about the simple labor theory of value rested on a couple of statistical misunderstandings. But before I explain these, let us first try to understand why the classical economists thought that there was a problem.

In Table B.1 we see the accounts of two firms. Firm A splits its advanced capital equally between component costs and wages, but for Firm B components make up 2/3 of its expenditure. If they both compute their selling price with the same markup on labor costs, then Firm A earns a higher rate of profit on its advanced capital. Since the classical economists assumed that this kind of variation in component cost ratios would be common, the implication for prices appeared to contradict the commonsense wisdom that there was a prevailing average rate of profit. Surely a situation with the two firms earning a different rate of profit could not be stable?

TABLE B.1: Capital of Different Compositions Earns Different Profit Rates

Firm	Components	Wages	Markup	Selling Price	Capital Advanced	Profit Rate
A	$2,000	$2,000	150%	$5,000	$4,000	28%
B	$8,000	$4,000	150%	$14,000	$12,000	16.7%
Average	$10,000	$6,000	150%	$19,000	$16,000	18.7%

Firm B must either raise its markup to make the same rate of return as Firm A, or diversify and start producing a product that competes with that of A in the hope of earning more. The only stable situation would be one where the markups on wages were adjusted to allow each firm the same rate of profit.

What is wrong with this argument?

1. The existence of an average profit rate does not imply that every firm will have this average rate. There is an average height for men in the European Union, but that does not mean that all men are of average height.
2. The idea that there should be an almost uniform rate of profit on capital is fostered by the operation of the stock market. If we go back to Table B.1, shares in Firm A would sell at a premium and those of Firm B at a discount. If $1 shares in A sold for $1.33 and those of B sold at $0.89 then the rate of return on shareholders' capital would be equalized. This feature of profitable company shares selling at premium is at the heart of the stock market. Changes in share prices bring about an equal rate of return for investors but do not require that firms alter their final selling prices.
3. The idea that firms can diversify their capital out of less profitable lines of business is often false. Consider Eurotunnel Ltd. It was floated to build a railway tunnel from France to England. It raised capital to build the tunnel which cost £9 billion. However, the rate of return on the investment was very low. There was no way that Eurotunnel could decide to take its capital out and shift into running a low-cost airline

between Paris and London. The capital was literally sunk under the sea. If the company's capital was fixed, the original shareholders were in no better position; their shares depreciated to a fraction of their issue price. The mobility of capital was presupposed by the classical theory of a near uniform rate of profit.

4. Finally, and most seriously, the empirical data shows that the assumption of a uniform rate of profit operating accross different industries is false. Figure B.1 shows that:

- The rate of profit is widely divergent between different industries.
- Industries in which labor costs are a small fraction of the advanced capital tend to have a lower rate of profit than those for which labor costs make up most of the advanced capital. This is consistent with the simple labor theory of value. It is inconsistent with the theory of Natural Price or Production Price.

Over the last two hundred years much ink has been devoted to debating how to construct a consistent theory combining the classical insights about labor being the source of value with an assumed equal rate of profit. The whole debate was a testimony to the dogmatism of Marxist and Ricardian economists who have preferred to construct the most elaborate mathematical models without bothering to look at empirical data. They shared with the neoclassical school a preference for beautiful math over messy reality. They succumb to the illusion that their equations are the real world. Although some commentators argued that prices of production tended to undermine the theory of labor values and exploitation [Samuelson, 1973; Steedman, 1981; Hilferding, 1951], the basic hypothesis of a law of an equal rate of profit was accepted until the publication of the pioneering econophysics work *Laws of Chaos* [Farjoun and Machover, 1983]. This argued on probabilistic grounds that the distribution of prices was more likely to follow a simple labor value model than a price of production model. More recently Greenblatt [2014] has also proposed a stochastic model in which labor values appear as an emergent property along with a spread of profit rates.

Multiple empirical studies have indicated that production prices are not systematically better at predicting actual market prices than simple labor values [Cockshott and Cottrell, 1998a, 1997b; Shaikh, 1998; Zachariah, 2006; Sánchezc and Montibeler, 2015; Fröhlich, 2013]. It has also been shown that Marx's basic assumption that the rate of profit is the same in high and low organic composition industries is not borne out empirically today [Zachariah, 2006, 2008], whatever the case had been in the nineteenth century. However, this empirical work does not help us to say whether the observed relationship between labor values/production prices and market prices is close. The studies reproduced in Table B.7 show mean absolute errors of the order of 10 percent between labor values/production prices and observed prices. But is 10 percent close or distant?

We can only say that if we have some *a priori* estimate of just how close we should expect the market price vector to be to labor values/production prices in the absence of the operation of a law of value, or Marx's law of the equalization of profit rates.

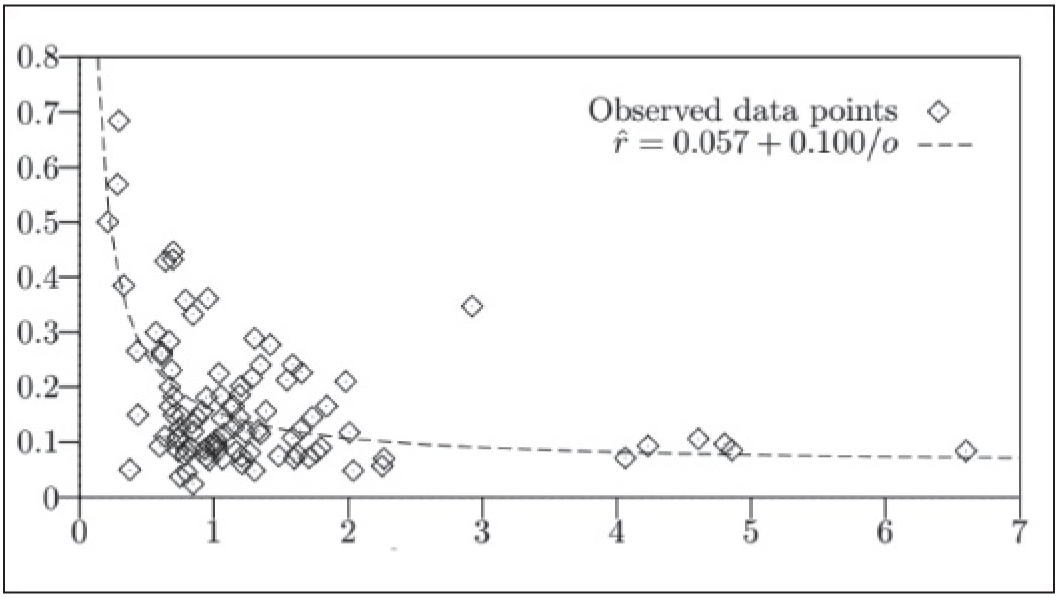


Figure B.1. The rate of return on capital tends to vary inversely with the capital-to-labor ratio. Each diamond represents a whole UK industry. Horizontal axis measures Component Cost/Wage Cost, denoted by the variable o; vertical axis measures the rate of profit r; dotted line represents the best-fitting equation for the data. Source: Cockshott and Cottrell, 1998b.

Although Marx is conventionally taken to have formulated two different theories of price in the three volumes of *Capital*, labor values in volume 1 and prices of production in volume 3, there is actually a third theory, hidden inside the reproduction schemes of volume 2. This theory is not explicit, but can be logically deduced from the constraints he presents on simple reproduction. It is not a theory of individual prices, but a theory of relative sectoral prices.

This theory of sectoral prices allows us to make probabilistic arguments about the relative likelihood that either production prices or labor values will operate at the level of reproduction schemes. In chapter 20 of the second volume of *Capital* Marx introduced reproduction schemes, matrices of intersectional flows of commodities that had to occur if the economy was to reproduce itself.

The matrices have four column vectors:

C: constant capital, his term for expenditure on capital goods and raw materials.
V: variable capital, his term for expenditure on wages.
S: surplus or profit.
O: output

TABLE B.2: A Stationary State Specified in Money

	C	V	S	O
I	£100	£50	£5	£200
II	£100	£150	£150	£400

We give an example in Table B.2 of a 2 x 4 matrix, with the row labeled I representing the production of capital goods and raw materials, and row II the production of consumer goods. In Marx's tables all quantities are in terms of money rather than in terms of use values.[148]

For accounting reasons the relation O= C + V + S must hold.

Further $\Sigma C = O_1$, that is to say, consumption of capital goods equals their production, and $\Sigma(V+S) = O_2$. Together this implies that Sector I of the economy must trade $O_1 - C_1$ in capital goods for C_2 worth of consumer goods produced in Sector II. So we have an equilibrium equation:

$$C_2=V_1+S_1$$

This is the equilibrium condition of an economy in a stationary state where it simply reproduces itself, neither growing nor shrinking. The basic analysis in this appendix will assume this stationary state. Real economies may grow or shrink, but the rate at which they do this is typically quite small. A developed industrial economy like that of the United States can go long periods in which the rate of growth averages only 3 percent a year or less, so analysis of price systems in a stationary state is a reasonable first approximation.

Although it is not done by Marx, one can in principle construct a dual table like Table B.3 in tons of consumer goods (corn) and tons of capital goods (coal). In this table the first column represents the coal used up productively by the two industries, and next come the consumer goods (corn) consumed by the workers and employers in the two sectors. Again we have the requirement that the total consumption and total production of each good must balance, 160 tons of corn and 20 tons of coal.

It is clear from this table that the coal industry must sell 10 tons of coal to the corn industry and get back in return 40 tons of corn, which in turn implies that the relative price of a ton of coal must be four times the price of a ton of corn. Referring back to the first table and comparing it with the second we see that indeed the price of a ton of coal was £4 but a ton of corn cost only £2.50. The important point here is that given the physical table, the relative prices necessarily follow.

The example is artificial in that in practice Sectors I and II would each produce a whole vector of outputs, but given the constants of proportionality between the elements of these two vectors, the exchange relation between them establishes relative sectoral prices.

TABLE B.3: A Stationary State Specified in Tons Matter

	Coal	Corn Wage	Corn Profit	Output	
I	10	20	20	20 tons	Coal
II	10	60	60	160 tons	Corn
Total	20 tons	80 tons	80 tons		

Marx later extends the scheme to three sectors, by dividing consumer goods into necessities (IIa), which are assumed to be bought out of wage incomes, and luxuries (IIb), which are bought out of property incomes. If we retain the label II for necessities and use III for luxuries, we have the three-way trade between sectors in Figure B.2.

The tables are given in money terms, much as modern national accounts are, but the assumption explicitly remained that these quantities of money are proportional to quantities of labor [Marx and Engels, 1974, chap. 21, sec. 7]. But in principle other pricing structures are possible so long as they allow the trade pattern in Figure B.2. The reproduction schemes themselves imply a distinct set of price configurations and these price configurations only partially overlap with those presupposed by either labor values or prices of production.

In what follows a probabilistic technique using reproduction schemes is presented to evaluate the known empirical closeness of labor values to market prices. The basic intuition is that one can systematically count which fraction of possible reproduction schemes is consistent with prices of production or labor values. An initial example of how to estimate such proportions can be demonstrated without recourse to the reproduction schemes.

Consider independent industries A and B. These industries may be of very different sizes, but we would like to know whether it is more likely that they both will have the same s/v or whether it is more likely that they will both have the same: s/(c+v). Since the industries may have very different turnovers, let us normalize them by, in each case, expressing their v and c as percentages of their respective s.

Suppose further that we only allow c and v to take on the values either 100 percent or 200 percent of s. Clearly there are 16 possibilities shown in Table B.4.

For each possibility I list the c and v for each industry, and in the columns *lv* and *pp* indicate if this combination is compatible with the assumptions of the labor theory of value or the assumptions of price of production theory. In 8 cases out of 16 the assumptions of the labor theory of value are compatible between the two industries, and in 6 cases the assumptions of prices of production are met. So this seems to indicate that prices of production are less likely in this simple case.

TABLE B.4: A Simple Two-Sector Discrete Model of the Relative Probabilities of Prices of Production and Labor Values

A		B			
c	v	c	v	lv	pp
100	100	100	100	y	y
100	100	100	200	n	n
100	100	200	100	y	n
100	100	200	200	n	n
100	200	100	100	n	n
100	200	100	200	y	y
100	200	200	100	n	y
100	200	200	200	y	n
200	100	100	100	y	n
200	100	100	200	n	y
200	100	200	100	y	y
200	100	200	200	n	n
200	200	100	100	n	n
200	200	100	200	y	n
200	200	200	100	n	n
200	200	200	200	y	y
		Total	yes	8	6

If we allow a greater range of discrete values for c and v this discrepancy becomes more pronounced. If we allow each to take on three possible values, we have 81 cases, of which 27 meet *lv* and 19 meet pp. The intuition one gets from this sort of simple two-industry model is that labor value examples make up a larger fraction of cases and are hence more likely.

But these are examples of independent industries, where we are free to vary the capital components of each industry, which is not the case once we look at the three industrial sectors in a reproduction scheme. These have constraints between capital components in different sectors that have to be met. These constraints make it unsafe to generalize from the sort of example in Table B.4. We will examine these constraints more formally below, and show that the constraints themselves tell us what market prices have to be in a system of simple reproduction.

Tables B.2 and B.3 show that from the physical flow between sectors one could work out the relative sectoral prices. The aim here is to show how one can start out from a physical flow pattern for a 3-sector economy and deduce the relative sectoral prices that must correspond to it.

We will use G, for Goods, to stand for our 3x3 matrix of flows of goods in kind, so that the first column corresponds to the in-kind flows of capital goods that Marx denotes by his C column vector; the second column to the in-kind flows of wage goods corresponding to the column vector V; and the last column to the flows of luxuries denoted by the column vector S.

We stipulate that all elements are positive non-zero and that each column of G adds up to 1, that is, the elements of each column in G are expressed as fractions of the total output of the coresponding sector. In other words we normalize the columns. A concrete example is given in Table B.5. For the purposes of studying the relation between physical flows on sectoral prices it is convenient to to express the flow elements as numbers between 0 and 1. We do this by normalizing a physical flow table, dividing each column element by the total of the column.

We denote the elements of G as g_ij for i, j:1..3.

If ***p*** is a 3-element price vector for capital, wage, and luxury goods, then in order to have only 3 prices when in fact each sector makes a wide variety of goods, we assume that the prices are index prices defined over bundles of capital, wage and luxury goods. Given the actual physical flows in G then the trade pattern in Figure B.2 establishes price constraints:

TABLE B.5: Physical Flow Table

	Coal	Corn	Caviar	Outputs
I	16,047	2,801	14,151	20,004 tons of coal
II	464	11,898	3,573	20,017 tons of corn
III	3,493	5,318	2,286	20,011 tons of caviar
Totals	20,004	20,017	20,010	

THE EQUIVALENT G MATRIX

0.80	0.14	0.71
0.02	0.59	0.18
0.17	0.27	0.11

For the purposes of studying the relation between physical flows on sectoral prices, it is convenient to to express the flow elements as numbers between 0 and 1. We can do this by normalizing a physical flow table, dividing each column element by the total of the column.

$$p_1\, g_{3,1} = p_3\, g_{1,3}$$

$$p_3\, g_{2,3} = p_2\, g_{3,2}$$

$$p_2\, g_{1,2} = p_1\, g_{2,1}$$

Where P is a 3-element price vector whose elements are written pi. For example, given the G matrix in Table B.5 we can use the above equations to solve for the relative prices deriving:

$$P= [2.123,0.352,0.524]$$

from which we can derive the corresponding monetary relations given in Table B.6.

Note that since the first equation fixes the ratio p1/p3 and the next fixes p2/p3 then this implies p1/p2 is also fixed, so we have to interpret the last of the three equalities as a constraint on what kind of physical flow matrix is compatible with inter-sector trade. The price constraints set by the G matrix define market-clearing prices for a system in which all sectors are self-financing, that is, there is no credit provided by one sector to another. This was an implicit assumption of Marx's analysis in volume 2 of *Capital*. But these reproduction constraints impose restrictions on the structure of the G matrix. Not all normalized G matrices are compatible with self-financed simple reproduction.

Volumes 1, 2, and 3 of *Capital* actually provide three distinct price models that partially overlap. Figure B.3 illustrates the volumes of configuration space that we are interested in. Reproduction schemes define, by equation B.1, a set of market-clearing price configurations—the large circle. Smaller circles denote the volumes of configuration space compatible with prices of production and labor values. Not all configurations that are compatible with labor values or prices of production are compatible with simple reproduction. By being compatible with prices of production we mean that the prices derived from Equation B.1 result in rates of profit that are equal, or very nearly equal, in all sectors. By being compatible with labor values we mean that the prices from the first equation above lead to nearly equal ratios of wages to profits in each sector.

TABLE B.6: An Example of a Three-Sector Economy in a Stationary State

	Constant Capital C	Wages V	Profits S	O
I	£34,067	£986	£7,415	£42,468
II	£986	£4,188	£1,872	£7,046
III	£7,415	£1,872	£1,198	£10,485
Total	£42,468	£7,046	£10,485	£60,000

Sector II now produces wage goods and sector III, luxuries. This should be read in conjunction with figure B.2. Note the symmetry of the table around the diagonal corresponding to the trade pattern in the figure. This monetary table is derived from table B.5 by solving equation set B.1.

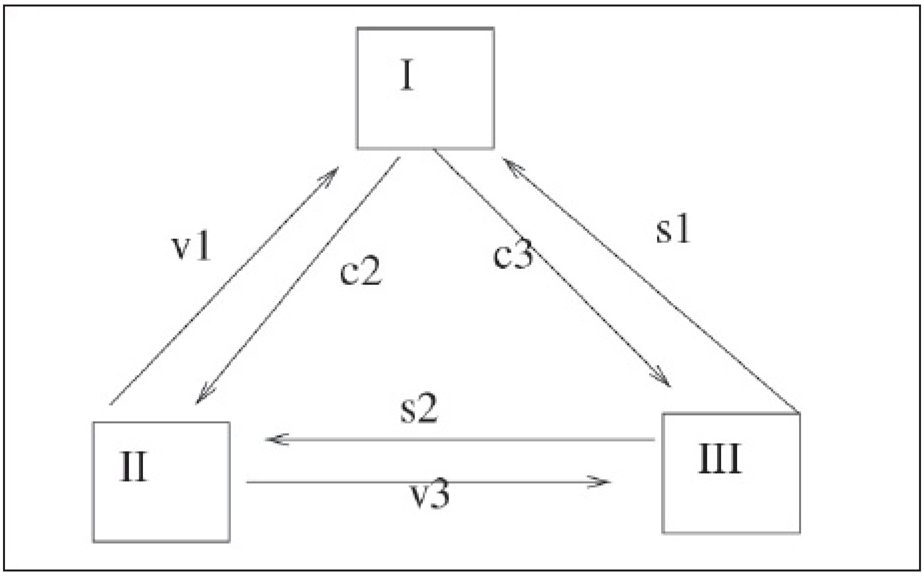


Figure B.2. Three-way inter-sector trade. Sector II sells sector I wage goods worth v1 and buys back in return means of production c2.

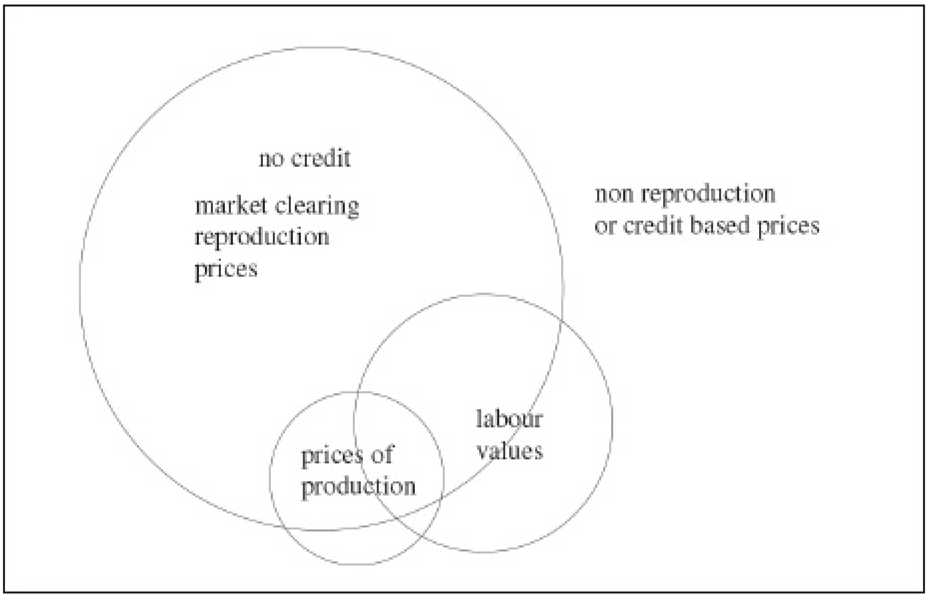


Figure B.3. Set of price systems restricted to market-clearing reproduction prices without credit.

B.1 CONSTRAINTS ON REPRODUCTION SCHEMES

Let us first examine how the structure of the G matrix is constrained by reproduction.

Given g3,1, g1,3, g2,3, g3,2, g1,2 we can derive g2, 1as follows:

$$p_1/p_3 = g_{1,3}/g_{3,1}$$

$$p_3/p_2 = g_{3,2}/g_{2,3}$$

$$p_1/p_2 = (p_1/p_3) \times (p_3/p_2) = (g_{1,3}/g_{3,1}) \times (g_{3,2}/g_{2,3})$$

But from the original trade relation we have:

$$p_1/p_2 = g_{1,2}/g_{2,1}$$

so

$$g_{1,2}/g_{2,1} = (g_{1,3}/g_{3,1}) \times (g_{3,2}/g_{2,3})$$

and

$$g_{1,2} = g_{2,1} /((g_{1,3}/g_{3,1}) \times (g_{3,2}/g_{2,3}))$$

Alternatively the constraint can be expressed in terms of elements of the other two columns:

$$g_{2,3} = g_{2,1} \times (g_{1,3}/g_{3,1}) \times (g_{3,2}/g_{1,2})$$

or

$$g_{1,2} = g_{2,1} \times (g_{1,3}/g_{3,1}) \times (g_{3,2}/g_{2,3})$$

Taken along with our constraint that the columns of G sum to 1, we have 4 constraints on the 9 elements of the matrix leaving only 5 degrees of freedom to the configuration space of reproduction schemes. That is, simple reproduction schemes are samples drawn from an underlying 5-dimensional vector space. Given such a space we can systematically sample it.

B.2 FIRST EXPERIMENT

A program was developed that created successive random samples of the configuration space of reproduction schemes. First the elements of G were assigned random values > 0 and < 1 such that the totals on column 2 were each 1, and the expected value of each element was 1/3. Then with equal probability one of the second to fourth equations above was used to override the previous random variable assignment to one of the elements. This constraint, however, is not guaranteed to satisfy the condition that the column must sum to 1, but that is achieved by subsequently altering the diagonal elements of the matrix to ensure that all columns sum to 1. The diagonal elements do not enter into inter-sector trade and hence can be altered without disturbing the relations established in these equations.

The mean of G over 120,000 samples to two decimal places was

0.40	0.28	0.32
0.25	0.40	0.28
0.35	0.32	0.40

This implies that the expected values for the organic compositions of capital, for reproduction schemes meeting the second equation, will differ between departments. This means we are not encountering a simple situation of uniform expected organic compositions. This can be seen in the distribution of relative organic compositions in Figure B.4.

For each reproduction scheme configuration the market price vector was set by constraint of the first equation above.

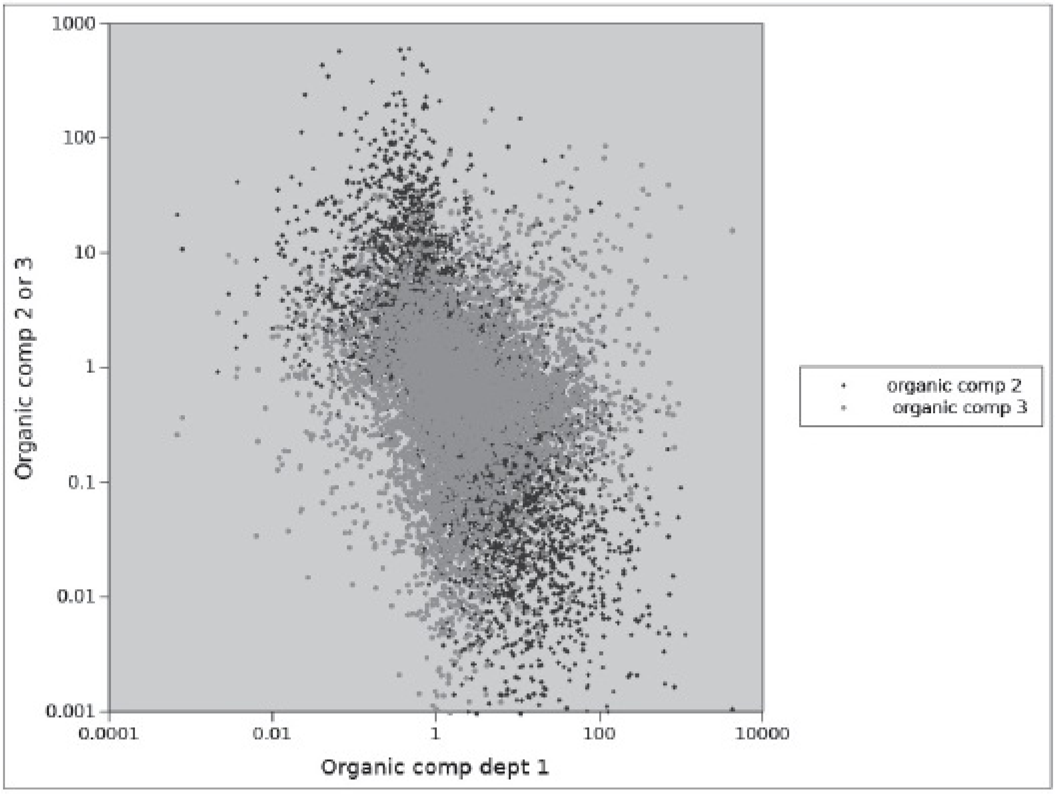


Figure B.4. Spread of relative organic compositions over the entire sample set with the sub-sampling technique.

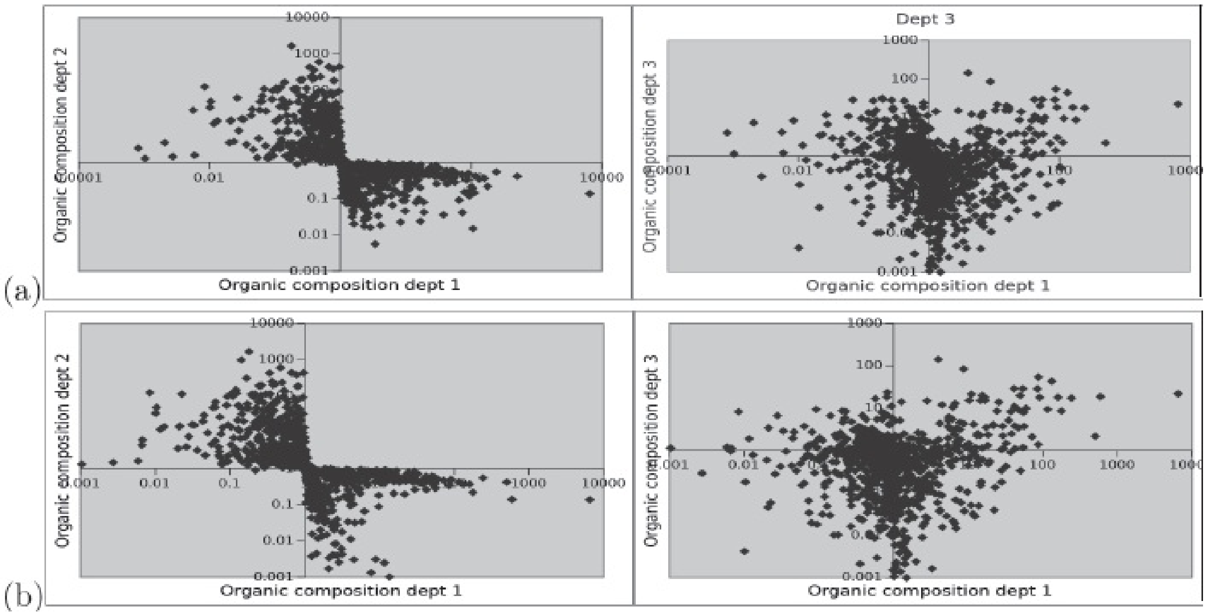


Figure B.5. Plot of the relative departmental organic compositions of reproduction schemes in which market-clearing prices were within 10 percent of (a) labor values; (b) prices of production. The characteristic “bow tie” configuration for the left plots also appears in the overall sample in Figure B.4, but though the first and third quadrants are empty here, samples were present in these quadrants in Figure B.4. This indicates that these quadrants of configuration space are incompatible with either prices of production or labor values.

Labor values were computed as follows:

$$v_1 = g_{1,2}/(1-g_{1,1})$$

That is, divide the real wage in Sector I by its net output. The assumption made is that the labor used in each sector is proportional to the flow of wage goods consumed.

$$v_2 = g_{2,2} + v_1 g_{2,1}$$

$$v_3 = g_{3,2} + v_1 g_{3,1}$$

At the end of this we have v as vertically integrated labor coefficients, derived from wages.

$$\sum v = 3$$

The last is a normalization condition used to ensure that under all price models the sum of prices is the same. If we do not apply this, we would have a sum of values < 3, in effect ignoring surplus value. But we are free to apply this linear rescaling to v because the assumption Marx makes is that the rate of surplus value is the same everywhere. The implicit assumption here is that the real wage is the same in all sectors.

An iterative estimation is used for prices of production. We first set all prices to 1. Then we repeatedly perform the following steps. Set r to one plus the rate of profit:

$$r \leftarrow 1 + (p_3 /(p_2 + p_1))$$

This works because the physical output of each industry is unity by virtue of using a normalized G. Next set a new estimate of the price vector *np;*

$$np \leftarrow (\ r \times (p_2\, g_{i,2} + p_1\, g_{i,1}))$$

Finally we normalize the sum of prices to be 3, the same as before.

$$p \leftarrow 3 \times np/\Sigma np$$

Runs were made with many reproduction schemes. The cumulative total number of resulting reproduction schemes was recorded along with the number of schemes that conformed either to labor values or to prices of production. Results are shown in the above equation.

Conformance of either labor values or prices of production was determined by measuring whether their mean absolute deviation (MAD) from market prices was below a specified threshold. The experiment used a 10 percent threshold since that is of the right order for the best that is observed empirically. In addition the program records the mean of the MADs between exchange-values and the two pricing theories.

B.2.1 Results

From the random sampling of reproduction schemes it appears that the mean spread of prices of production from market-clearing prices is smaller than the mean spread of labor values. This is incompatible with a number of empirical studies as shown lower in the table where the relationship is the reverse. However, the observed spreads of both values and production prices from market-clearing prices are lower than found in our *a priori* estimation. This may be a result of the empirical data typically using longer price vectors with 30 to 60 elements rather than just 3, with resultant reversion to a mean. This was essentially Farjoun's argument [1984] for why empirical dispersions of prices to market values would be smaller than those obtained in toy examples using reproduction schemes.

B.3 DISCUSSION

Sraffa [1960] showed that given

1. An assumption of an equal rate of profit
2. A technology matrix
3. A specification of the real wage

it was possible to deduce a price system that would reproduce both the material conditions of production and the class distribution of income. This appendix shows that the G matrix, a use-value dual of Marx's reproduction schemes, can also define a price system that will reproduce the material conditions of production and the class distribution of income.

The G matrix plays both the role of Sraffa's technology matrix and his real wage, but Marxian reproduction schemes do not necessitate a uniform rate of profit, nor do they require that prices are proportional to labor values. Reproduction schemes can exist with these properties, but Table

B.7 shows that both labor-value conforming schemes and price of production conformant schemes make up a small portion of the possible schemes. Even with a very lax definition of *conforming*, being within 10 percent of, less than 1/200th of all schemes meet this criterion. It would appear that labor-value conforming reproduction schemes are as common as price of production conforming ones. If one looks at Figure B.5 showing where the conforming instances occur in the planes of relative surplus value between sectors, the pattern is almost identical in both cases, with many of the same data points appearing in both rows.

TABLE B.7: Relative Frequencies and Spreads of Prices of Production and Labor Values

versus	Labor Value Market Price	Production Price Market Price	Production Price Labor Value
% of Schemes with MAD < 10%	0.44%	0.44%	6.84%
Mean MAD	28%	23.7%	14.8%
EMPIRICAL MAD:			
China [Sánchez and Montibeler, 2015]	14.2%	16.5%	12.0%
U.S. [Ochoa, 1989]	10.3%	12.6%	16.9%
Spain [Sánchez and Nieto Ferrandez, 2010]	12.2%	18.8%	19.0%
Germany (1978) [Zachariah, 2006]	16.0%	22.6%	-
France (1980) [Zachariah, 2006]	12.0%	18.2%	-

Figures are computed from sample of 100,000 reproduction schema and compared with empirical studies.

From Paul Sweezy onward it has been conventional for Marxian economists to present individual example reproduction schemes that either have prices proportional to labor values or prices given by an equal rate of profit. The statistical analysis here shows that in doing so economists have been using what are, on *a priori* grounds, rare exceptions to prove rules.

Three-sector reproduction schemes, however, capture something additional that is missing in Sraffa, which is the fact that different social classes have different consumption patterns. Marx dealt with the more general case where the capitalists divide their expenditure in some fixed proportion between necessities and luxuries, what would in modern terms be called a Leontief demand function. The analysis here has taken the simpler assumption that capitalist expenditure is exclusively on luxuries. Similarly we neglect that some commodities, for instance coal, may have been a means of production, a wage good, and have been bought by capitalists to heat their houses.

The simplification is arguably valid, since one could in principle divide the coal industry into three sub-industries, one supplying factories, one supplying workers' cottages, and one supplying mansions. These sub-industries would then be statistically aggregated into Sectors I, II, or III. But the intersectoral constraints may have implications for the feasibility of attaining prices of production.

Reproduction prices represent a static macroeconomic equilibrium condition. So long as there is no growth in production and no change in technology and no movement of capital between sectors, reproduction prices will keep the economy in an equilibrium. These are market-clearing prices given the technology and income distribution. On the other hand, the alternative concept of equilibrium present in volume 3 of *Capital* and further developed in *Production of Commodities* [Sraffa, 1960] assumes capital mobility between sectors. Borkiewicz's criticism [Hilferding, 1951] of volume 3 was based on arguing that the procedure presented for transforming labor values to prices of production was statically incompatible with reproduction prices. But the dynamic question remains open. If you start off in a macroeconomic equilibrium with reproduction prices operating, but with divergent profit rates as shown in Table B.6, can capital movements produce a new equilibrium with a price structure that both achieves reproduction and profit rate equalization?

On the one hand the structure of reproduction is so finely balanced, with such intricate interdependence between the elements of the reproduction table that perhaps any movement in capital would throw the whole system into a catastrophic crisis. Alternatively, one may argue that even if one keeps technology and labor supply, and money capital constant, the system has still got some degrees of freedom left in terms of the relative sizes of three sectors.

We can see that capital movement is very likely to result in a change in the class distribution of income. A movement of capital in or out of Sector II means a bigger or smaller real wage, and in consequence reduces or increases the real quantity of luxuries being consumed by employers. So a movement into row 2 of the table must go along with balancing changes in columns 2 and 3, but whether these will be dynamically achievable is harder to say. It may depend both on the adjustment process and on the initial starting structure of the table.

B.4 SECOND EXPERIMENT

In order to investigate the dynamic process of capital movement from initial reproduction states, a second experiment was carried out. Like the first experiment it used a sample of reproduction schemes, prepared in the same way as in the previous experiment. It combined these with rules for capital mobility, for price adjustment, possible buffer stocks, and adjustment of sectoral outputs. The time evolution of the economies represented by the initial reproduction schemes was then evaluated for 150 time steps. The model is stock flow consistent both in money and in use values.

Initialization. A G matrix is prepared as in the first experiment. An initial price vector is derived and a resulting initial monetary reproduction scheme is derived. From an assumed money wage of £2 an initial vector of labor allocation λ is derived. In conjunction with the labor vector the G matrix is used to derive a linear production function for each sector. Each sector is allocated sufficient cash to pay wages and buy means of production at current prices and the current scale of production.

Simulation cycles start at the point where production has just finished, so the firms in each sector have a stock equal to what was produced, plus any unsold stock from the previous period. Stocks of goods held are recorded in the A (for available) matrix.

Capital allocation rule. Let *s* be the sector with the highest rate of profit. For each sector x ≠ s if the rate of profit in x is more than 1 percent below the rate in s, then sector x will transfer 1 percent of its money capital to sector x. Each sector divides its money capital into constant and variable capital in the same ratio as its final allocation in the previous period. We thus get new column vectors V_t, C_t for variable and constant capital for time t. **Wage and labor rule.** Wage rates are then set such that

$$w_t \leftarrow \sum V t / \sum \lambda_{t-1}$$

and the new wage rate and new V_t is used to reallocate labor so that

$$\lambda_t \leftarrow V_t / w_t$$

Prices sectors I and II. The total requirement for means of production for each sector given λ is then determined using the production functions. If this exceeds the total stocks of means of production held by all sectors then we have a seller's market in means of production whose prices rise to a market-clearing level.

$$p_1 \leftarrow \Sigma c_\iota / \Sigma_\iota A_{\iota,1}$$

Otherwise if stocks exceed requirements, we have a buyer's market and the price of means of production is reduced by 3 percent. The price of wage goods is then set as

$$p_2 \leftarrow w \Sigma \lambda / \Sigma_\iota \, {}_{\iota,2}$$

Sectors then pay wages and workers spend their wages on the output of Sector II at the current p_2. Each sector then purchases its requirement of means of production from Sector I at price p_1.

Demand for luxuries. For Sectors I and II we now know their total sales and their total cost of production. By subtracting purchases from sales we get their profits, which are assumed to be entirely spent on luxuries. For the capitalists of Sector III we have the odd situation where, as Marx points out, profits are self-financing. Whatever they spend on luxuries will return to them as additional profit. The simulation thus adopts the parsimonious assumption that their expenditure on luxuries will remain constant in money terms. The price of luxuries is then set to clear the market given the physical stocks available.

Production. Production takes place constrained either by the available labor in each sector or the available means of production, as per the linear production function. If labor is the limiting factor this may result in some unused stock of means of production that are carried over to the next period.

B.4.1 Results

Figure B.6 shows the results of the simulation in terms of the initial and final standard deviations of the rate of profit. A simulation run is represented as a point whose x position is given by the starting spread of its profit rate and its y position by its terminating profit rate spread. A point on the 45-degree diagonal represents a system that has undergone no profit rate convergence during the simulation. A point close to the x axis indicates a system that has undergone convergence.

One can clearly see that the simulated systems fall into two distinct clusters—one just below the 45-degree line, and one close to or below the 1 percent line. Provided that profit rates are within 1 percent they are taken to have converged, since only discrepancies bigger than this are assumed to trigger capital flows.

Detailed examination of the final sectoral output figures for the simulations run showed that many simulated economies had undergone a drastic contraction in terms of physical output. Since the amount of money circulating does not change during the simulation, rises in prices obscure this effect if one looks only at the figures for output in money terms.

We define an economy to be healthy under capital movement if the final value of output measured in the prices operating at time t0 are >98 percent of the starting value of output. We define an economy as having collapsed if output is less than 50 percent of its starting value. One can see in Figure B.6 that there is no particular relationship between the economy being healthy and its profit rate converging. Some of the economies whose profit rates equalize are healthy and some are collapsing. Conversely, some healthy economies retain dispersed profit rates even in the presence of capital movements that, according to accepted theory, should result in an equalization of the rate of profit.

TABLE B.8: Geometric Mean of Initial Organic Compositions by Sector and Group for the Economies Simulated in Figure B.6

Sector	I	II	III
Collapsing	2.16	0.59	1.18
Healthy	1.23	0.65	1.88
Converging	1.60	1.31	2.21
Non-Converging	1.96	0.47	1.15

Table B.8 does show, however, that the collapsing economies tend to be characterized by greater sectoral disparities in organic composition, and higher organic compositions in Sector I. Systems that do not converge their rates of profit are characterized by particularly low organic compositions in Sector II.

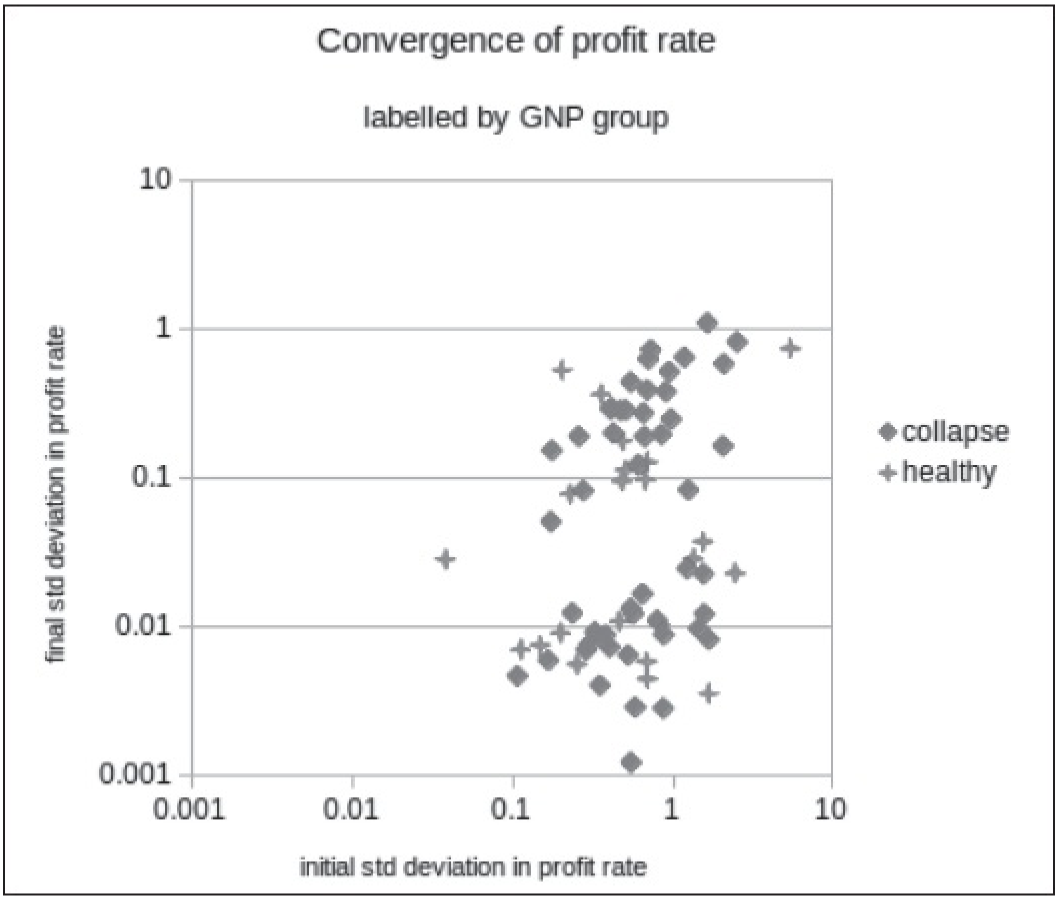


Figure B.6. When simulated over time, some reproduction schemes can converge toward an equal rate of profit. The population of schemes forms two distinct clusters, one capable of converging and one that does not converge. Schemes that show no convergence over time would lie on a line at 45 degrees going through the origin of this plot. Healthy models are those in which GNP remains constant or grows; collapse models are those whose GNP has fallen by more than 50 percent at the end of the simulation.

B.5 FURTHER DISCUSSION

The first experiment shows that only a very small fraction of possible self-reproducing capitalist economies are characterized by equal rates of profit. Similarly, only a very small fraction of possible reproduction schemes have price structures close to labor values. The existing literature on the *transformation problem* relates to either logical or temporal transition between the small subset of the value-conformant reproduction schemes and the small subset of price of production-conformant schemes.

The second experiment indicates that one cannot simply assume that the mechanism that is supposed to bring about an equal rate of profit will, in general, work. For some starting points, combinations of technology and distributions of income, the hypothesized convergence mechanism fails. In these cases the system either remains healthy with a continuing spread of profit rates, or the economy shrinks catastrophically.

The exact nature of the dynamics that produce this result are at present unclear, but it appears that in the cases of catastrophic contraction, the problem arises due to insufficient means of production being produced, which acts as a constraint on all subsequent output. If the economy moves to a labor distribution where more means of production would be used by the current distribution of the labor force than it can produce, then clearly it must undergo contracted reproduction.

In the case of simulated economies that fail to converge on a uniform rate of profit, one hypothesis is that if Sector II has a particularly low organic composition of capital, then a movement of capital into Sector II leads to a net increase in the demand for labor power. This raises wages and increases demand for Sector II, so rather than the price of necessities falling consequent on inward capital movement, wage goods may rise in price. Another possibility is that the distribution of profit rates may undergo oscillations. Further investigation into detailed trajectories of prices and profit rates of individual sectors would be required to test these hypotheses.

B.6 MODEL AND REALITY

We know that real capitalist economies do not often go into catastrophic collapse due to inadequate production of means of production, though the collapse of industrial production in the former USSR after conversion to capitalism may be an instance of this. Why is this?

It may be that some version of the Anthropic Principle is in operation. We do not see these collapses because the collapses are history sensitive, and the economies starting out in technological and income configurations that would result in collapse are eliminated. That may apply to the former socialist economies being suddenly exposed to a profit maximizing principle; they contracted until the technical structure of the economy changed. The end result would be that at any given time, the population of capitalist economies would have been purged of those with technical structures that would lead them to collapse under free capital movement.

TABLE B.9: Mean Price and Value Vectors

Sector	Capital Goods	Wage Goods	Luxuries
Mean Labor Values	0.95	1.11	0.93
Mean Production Price	1.08	1.02	0.90
Mean Market-Clearing Price	1.00	0.92	1.07

Alternatively, the basic market-clearing price mechanism used in the model may not be realistic. The model basically assumes unit elasticity, a 1 percent fall in output, other things being equal, raises prices by 1 percent. Perhaps capitalist economies are only stable against collapse given nonlinear price responses.

Instead of looking at the problem of collapse, consider that a substantial fraction of healthy models fail to attain an equal rate of profit. This is less of a problem since it accords with what we observe in reality. We know that typical capitalist economies have a dispersion of profit rates [Fröhlich, 2013].

All reproduction schemes meeting the constraints described in Section B.1 define a set of market-clearing prices for economies with no credit operations. Real economies have credit and therefore the set of actual market prices we observe will be less constrained than is implied by reproduction schemes. However, reproduction schemes do have the virtue of allowing us to generate a large sample of simple economies and associated price structures sans any assumptions about the underlying price mechanism of the economy. They allow us to explore the space of possible self-reproducing economies and the price structures associated with them.

The input-output tables used in empirical studies are approximations to systems of simple reproduction. They are only approximations, since they depict economies that are typically growing, but the growth rate is typically small, and the conventions associated with the construction of input-output tables impose similar balance constraints to those seen in reproduction schemes. The existence of credit transfers between industries in the input-output tables will, however, introduce a complication absent in the simple Marxian schemes.

Using unbiased samples from the space of reproduction schemes we can determine the probability of different pricing theories. That is, the probability that such pricing theories would be true if real economies were distributed with equal probability over all possible positions in configuration space. We are assuming, in effect, that if economies undergo a random walk through configuration space, the probability of their transiting from one macro-state to another is proportional to the volume occupied by these macro-states.

The macro-state defined by market prices being within 10 percent of labor values has a similar volume to the macro state with market prices with 10 percent of prices of production. *A priori*, we should expect a reproducing economy to be this close to a labor value–conformant configuration as to a price of production-conformant one.

If, on the other hand, there is some bias in the random walk, so that economies end up closer to either of these pricing systems than one would expect, then this is analogous to evolution in a space with a potential defined over it. The discrepancy between observed and *a priori* probability distributions should then enable one to estimate, via some appropriate negative exponential law, the depth of potential wells. Conversely one could say how strong the potential field would have to be to produce a world in which either labor values or production prices were the operational laws. Even without a deeper analysis, though, it appears from these results that the assumption of prices of production as an operational law implies a weaker potential well favoring it than need be assumed for labor values. The expected *a priori* dispersions of labor values are wider than those for prices of production. The fact that this is not what is empirically observed implies that the potential well associated with prices of production is weaker than that associated with labor values. Possibly this is an effect of labor being more mobile than capital. It is easier for steel workers to move into catering jobs than to convert steel mills into restaurants. Alternatively, the obstacles to profit-rate equalization shown in the second experiment may act as a frustrating factor effectively reducing the potential well around prices of production.

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Notes

1. "Every child knows a nation which ceased to work, I will not say for a year, but even for a few weeks, would perish. Every child knows, too, that the masses of products corresponding to the different needs required different and quantitatively determined masses of the total labor of society. That this necessity of the distribution of social labor in definite proportions cannot possibly be done away with by a particular form of social production but can only change the mode of its appearance, is self-evident. No natural laws can be done away with. What can change in historically different circumstances is only the form in which these laws assert themselves. And the form in which this proportional distribution of labor asserts itself, in the state of society where the interconnection of social labor is manifested in the private exchange of the individual products of labor, is precisely the exchange value of these products." (Marx and Engels 1949, p. 418.)
2. The older political economy of Smith and Marx recognized that these institutional forms were just one of many that the human race has experienced.
3. "The instruments of this labor, or the bodily means of production implicitly referred to in this concept, are the hands and the head, but never the womb or the breasts of a woman. Thus, not only are men and women differently defined in their interaction with nature but the human body itself is divided into truly 'human' parts (head and hand) and 'natural' or purely 'animal' parts (genitalia, womb, etc.). This division cannot be attributed to a universal sexism of the men as such, but is a consequence of the capitalist mode of production which is only interested in those parts of the human body which can be directly used as instruments of labor or which can become an extension of the machine." (Mies 1981, p. 4.)
4. Alates are unmated winged male and female termites.
5. Men, of course, have been physically disabled from the two most important branches of social labor: producing and feeding babies, until recent years relaxed the constraint on feeding.
6. "But there is this great difference between his actions and many of

those performed by the lower animals, namely, that man cannot, on his first trial, make, for instance, a stone hatchet or a canoe, through his power of imitation. He has to learn his work by practice; a beaver, on the other hand, can make its dam or canal, and a bird its nest, as well, or nearly as well, and a spider its wonderful web, quite as well, the first time it tries as when old and experienced." (Darwin 1871, chapter 2.)

7. "It has often been said that no animal uses any tool; but the chimpanzee in a state of nature cracks a native fruit, somewhat like a walnut, with a stone. (Savage and Wyman in *Boston Journal of Natural History*, vol. iv. 1843–44, p. 383.) Rengger *(Saugethiere von Paraguay*, 1830, s. 51–56.) easily taught an American monkey thus to break open hard palm-nuts; and afterwards of its own accord, it used stones to open other kinds of nuts, as well as boxes. It thus also removed the soft rind of fruit that had a disagreeable flavour." (Darwin 1871, chapter 2.)

8. "In the social production of their existence, men inevitably enter into definite relations, which are independent of their will, namely relations of production appropriate to a given stage in the development of their material forces of production. The totality of these relations of production constitutes the economic structure of society, the real foundation, on which arises a legal and political superstructure and to which correspond definite forms of social consciousness. The mode of production of material life conditions the general process of social, political and intellectual life. It is not the consciousness of men that determines their existence, but their social existence that determines their consciousness. At a certain stage of development, the material productive forces of society come into conflict with the existing relations of production or this merely expresses the same thing in legal terms with the property relations within the framework of which they have operated hitherto. From forms of development of the productive forces these relations turn into their fetters. Then begins an era of social revolution. The changes in the economic foundation lead sooner or later to the transformation of the whole immense superstructure." (Marx et al. 1978, Preface.)

9. "The archeological evidence, such as it is, also supports the contention that agriculture is not a difficult concept to develop, that it

has in fact been developed many times, and that it was not primarily ignorance which prevented human populations from becoming agricultural sooner than they did." (Cohen 1977, p. 24.)

10. Diamond and Ordunio (1997) argue that none of the wild grasses of Australia bore large enough seeds to be worth collecting.

11. "Some of our strongest scientific evidence about the relative status of men and women in the early and middle levels of Çatalhðyuk concerns diet. If women and men lived notably different lives, and if one or the other was dominant, then we might expect to uncover disparities in diet, with the dominant group having more access to certain foods, such as meat or better joints of meat. So we have searched hard for such evidence, but we have not uncovered clear differences." (Hodder, 2004.)

12. The model we present draws heavily on Meillassoux (1981).

13. The assumption we make of a 50 percent pre-adult mortality is plausible. The earliest parish registers indicate this level, as do some ancient cemeteries. Although other ancient cemeteries show lower levels of infant death this can plausibly be attributed to poorer preservation of semi-mineralized infant bones (Guy et al. 1997).

14. This is on the assumption that the work falls into the category the FAO calls an *Active Life*. They give examples of such work: "Other examples of moderately active lifestyles are associated with occupations such as masons and construction workers, or rural women in less developed traditional villages who participate in agricultural chores or walk long distances to fetch water and fuelwood" (Tontisirin and de Haen 2004, p. 39). If the work is that of farmers working entirely with hand tools, without draft animals or mechanical power, then the FAO category of *Vigorous Life* might apply. They describe this as: "non-mechanized agricultural laborers who work with a machete, hoe or axe for several hours daily and walk long distances over rugged terrains, often carrying heavy loads." In the latter case the subsistence calorie production per adult worker would rise to around 1.75 million calories per year.

15. "If we suppose them moving from one place to another, 4 or 5 miles every day, we can set no bounds to the number which might enter into such an expedition. If then one clan of Tartars (for instance) should, setting out on an expedition, defeat another, they would necessarily become possessed of every thing which before belonged

to the vanquished; for in this state when they make any expedition of this sort wives, children, and flocks and every thing is carried along with them, so that when they are vanquished they will lose their all. The far greater part therefore will follow these and join themselves to the victor, tho some perhaps might still adhere to the vanquishd chief. If this combined army should be in the same manner successfull against a 2nd, a third, [and] a 4th tribe, they would soon become very powerfull, and might in time subdue all the nations of their country about them and become in this means immensely powerfull." (Smith 1978, p. 196.)

16. "In a nation of hunters and fishers few people can live together, for in a short time any considerable number would destroy all the game in the country, and consequently would want a means of subsistance. Twenty or thirty families are the most that can live together, and these make up a village, but as they live together for their mutual defence and to assist one another, their villages are not far distant from each other." (Smith, 1978.)
17. "Hunting supposes a nomadic life; and the hunter, who roams over vast tracts of land in pursuit of his game has not much opportunity to watch the movements of his slave who may be apt to run away at any moment" (Nieboer 1971, p. 194), and later: "hunting requires the utmost application of strength and skill; therefore a compulsory hunting cannot exist" (ibid., p. 197).
18. For a survey of the evidence for the existence of a well-developed system of commodity markets in the Roman Empire, see Temin (2001).
19. For example, the clocks of Archimedes or the Antikythera computer recovered from a shipwreck of the Roman republican era de Solla Price (1959), de Solla Price (1974), and Freeth et al. (2006).
20. Russo (2013) gives an example of a two-cylinder pressure pump with crank and poppet valves similar to those of a Corliss steam engine (Rosenberg and Trajtenberg 2004) excavated from a Roman well.
21. "It seems likely that all of these features would have allowed Mediterranean sailors in the first millennium AD to sail on both upwind and downwind courses…. Likewise the invention and use of a small foresail or *artemon* on the Mediterranean rig is indicative of an ability to sail on an upwind course—the *artemon* being only of limited use on other sailing courses.

Textual evidence survives from the ancient world which provides a further indication of the ability of Roman sailing ships to make windward.” (Whitewright 2007, p. 84.)

22. Harper (2011, chapter 1) argues that Finley’s estimate is too high, and that a more realistic figure for Rome is between 10 percent and 20 percent, but this range is highly sensitive to the numbers of slaves held by the richest slave-owners, since ownership was highly concentrated.

23. “The specific economic form, in which unpaid surplus-labor is pumped out of direct producers, determines the relationship of rulers and ruled, as it grows directly out of production itself and, in turn, reacts upon it as a determining element. Upon this, however, is founded the entire formation of the economic community which grows up out of the production relations themselves, thereby simultaneously its specific political form. It is always the direct relationship of the owners of the conditions of production to the direct producers—a relation always naturally corresponding to a definite stage in the development of the methods of labor and thereby its social productivity—which reveals the innermost secret, the hidden basis of the entire social structure and with it the political form of the relation of sovereignty and dependence, in short, the corresponding specific form of the state. This does not prevent the same economic basis—the same from the standpoint of its main conditions—due to innumerable different empirical circumstances, natural environment, racial relations, external historical influences, etc. from showing infinite variations and gradations in appearance, which can be ascertained only by analysis of the empirically given circumstances.” (Marx 1894.)

24. At least in the main they are not; in Rome a minority of slaves had their purse *peculium* from which some purchases could be made. New World slaves generally did not.

25. The successful slave revolt in Haiti, where black slaves outnumbered free whites by ten to one, is a striking proof of the inability of a slave state without a substantial free population to survive.

26. “In a constitutional government the fighting-men have the supreme power, and those who possess arms are the citizens.” (Aristotle 1983, Book 3:7.)

27. “Whether in oligarchies or in democracies, the number of the

governing body, whether the greater number, as in a democracy, or the smaller number, as in an oligarchy, is an accident due to the fact that the rich everywhere are few, and the poor numerous. But if so, there is a misapprehension of the causes of the difference between them. For the real difference between democracy and oligarchy is poverty and wealth. Wherever men rule by reason of their wealth, whether they be few or many, that is an oligarchy, and where the poor rule, that is a democracy. But as a fact the rich are few and the poor many; for few are well-to-do, whereas freedom is enjoyed by all; and wealth and freedom are the grounds on which the oligarchical and democratical parties respectively claim power in the state." (Aristotle 1983, Book 3:8.)

28. Our word servant derives from the Latin *servus* for slave, and one should read the implication of slavery into the English word servant when used in translations of old texts.

29. The UN Draft Convention against Sexual Exploitation defines sexual exploitation as follows:

Article 1: Definition of Sexual Exploitation

Sexual exploitation is a practice by which person(s) achieve sexual gratification, or financial gain, or advancement, through the abuse of a person's sexuality by abrogating that person's human right to dignity, equality, autonomy, and physical and mental well-being.

Article 2

Sexual exploitation takes the form of, but is not limited to:

- The denial of life through female infanticide and the murder of women by reason of their gender, including wife and widow murder.
- Subjection to cruel, inhuman and degrading treatment through the following: battering, pornography, prostitution, genital mutilation, female seclusion, dowry and bride price, forced sterilization and forced child-bearing, surrogacy, restricting the reproductive freedom of women, the use of women's reproductivity for third parties (the use of women's reproductivity for the purpose of sexual or commercial exploitation), sexual harassment, rape, incest, sexual abuse, and human trafficking.
- Subjection to sexual abuse and or torture whether perpetrated by State or non-State actors, overt or covert, including sadistic, mutilating practices.

- Temporary marriage, child marriages, or marriage of convenience for the purpose of sexual exploitation.
- Sex predetermination.

30. “If all this has been established, it should be further known that the capital a person earns and acquires, if resulting from a craft, is the value realized from his labor. This is the meaning of ‘acquired (capital).’ There is nothing here (originally) except the labor, and (the labor) is not desired by itself as acquired (capital, but the value realized from it).

    “Some crafts are partly associated with other (crafts). Carpentry and weaving, for instance, are associated with wood and yarn (and the respective crafts needed for their production). However, in the two crafts (first mentioned), the labor (that goes into them) is more important, and its value is greater.

    “If the profit results from something other than a craft, the value of the resulting profit and acquired (capital) must (also) include the value of the labor by which it was obtained. Without labor, it would not have been acquired.

    “In most such cases, the share of labor (in the profit) is obvious. A portion of the value, whether large or small, comes from (the labor). The share of labor may be concealed. This is the case, for instance, with the prices of food stuffs. The labor and expenditures that have gone into them show themselves in the price of grain, as we have stated before. But they are concealed (items) in regions where farming requires little care and few implements. Thus, only a few farmers are conscious of the (costs of labor and expenditures that have gone into their products).

    “It has thus become clear that gains and profits, in their entirety or for the most part, are value realized from human labor. The meaning of the word ‘Sustenance’ has become clear. It is (the part of the profit) that is utilized. Thus, the meaning of the words ‘profit’ and ‘Sustenance’ has become clear. The meaning of both words has been explained.” (Khaldün et al. 1969, Book 1, chapter 5, section 1.)

31. “If a man can bring to London an ounce of Silver out of the Earth in Peru, in the same time that he can produce a bushel of Corn, then one is the natural price of the other; now if by reason of new and more easie Mines a man can get two ounces of Silver as easily as formerly he did one, then Corn will be as cheap at ten shillings the bushel, as it

was before at five shillings caeteris paribus.” (Petty 1679.)

32. “At all times and places, that is dear which it is difficult to come at, or which it costs much labor to acquire; and that cheap which is to be had easily, or with very little labor. Labor alone, therefore, never varying in its own value, is alone the ultimate and real standard by which the value of all commodities can at all times and places be estimated and compared. It is their real price; money is their nominal price only.” (Smith 1974, p. 136.)

33. “As the exchangeable values of commodities are only social functions of those things, and have nothing at all to do with the natural qualities, we must first ask: What is the common social substance of all commodities? It is labor. To produce a commodity a certain amount of labor must be bestowed upon it, or worked up in it. And I say not only labor, but social labor. A man who produces an article for his own immediate use, to consume it himself, creates a product, but not a commodity. As a self-sustaining producer he has nothing to do with society. But to produce a commodity, a man must not only produce an article satisfying some social want, but his labor itself must form part and parcel of the total sum of labor expended by society. It must be subordinate to the division of labor within society. It is nothing without the other divisions of labor, and on its part is required to integrate them.

“If we consider commodities as values, we consider them exclusively under the single aspect of realized, fixed, or, if you like, crystallized social labor. In this respect they can differ only by representing greater or smaller quantities of labor, as, for example, a greater amount of labor may be worked up in a silken handkerchief than in a brick. But how does one measure quantities of labor? By the time the labor lasts, in measuring the labor by the hour, the day, etc. Of course, to apply this measure, all sorts of labor are reduced to average or simple labor as their unit. We arrive, therefore, at this conclusion. A commodity has a value, because it is a crystallization of social labor. The greatness of its value, or its relative value, depends upon the greater or less amount of that social substance contained in it; that is to say, on the relative mass of labor necessary for its production. The relative values of commodities are, therefore, determined by the respective quantities or amounts of labor, worked up, realized, fixed in them. The correlative quantities of commodities which can be produced in the same time of labor are equal. Or the value of one commodity is to the value of another commodity as the quantity of labor fixed in the one is to the quantity of labor fixed in the other." (Marx 1910, section 6.)

34. Mirowski (1989) argues that it deliberately borrowed from the then relatively modern Lagrangian formulations of physical field theory.

35. These tend to be to the effect that the class must distinguish between the short-term equilibrium of supply and demand shown in the diagram, and long-term processes which involve something quite different, a *shift* in the supply line to the right. This is a classic example of what historians of science call adding an *epicycle* to a theory to cover up embarrassing conflicts with evidence.

36. "We are to admit no more causes of natural things than such as are both true and sufficient to explain their appearances.

"To this purpose the philosophers say that Nature does nothing in vain, and more is in vain when less will serve; for Nature is pleased with simplicity, and affects not the pomp of superfluous causes" (Newton 1999, Rule of reasoning I).

37. Since Fourier we have known that any function can be well approximated by a sum of sine waves. We use this routinely now in things like digital TV. What adding epicycles to an astronomical model does is put in additional harmonic components. Since you can approximate any function by such harmonic components, with enough epicycles upon epicycles you can, by Fourier's theorem, get an arbitrarily good approximation of any apparent celestial motion. For a discussion of this, see Russo (2013).

38. If we assume straight-line functions then we have two equations: p = a - dq for demand and p = b + sq for supply, where d and s are the absolute gradients of the curves, and a and b the positions where they intercept the Y axis. Clearly these equations have 4 parameters.

39. Some of them also argued for some systematic, non-random deviations. We will discuss these later.

40. Studies showing the closeness of labor values to market prices are: Michaelson et al. (1995), Cockshott and Cottrell (1997a), Cockshott and Cottrell (1998a), Cockshott and Cottrell (1997b), Cockshott and Cottrell (2003a), Fröhlich (2013), Ochoa (1989), Petrovic (1987), Sanchez and Nieto Ferrandez (2010), Sánchez and Montibeler (2015), Tsoulfidis and Paitaridis (2016), Shaikh (1984), Shaikh

(1998), Tsoulfidis and Maniatis (2002), Valle Baeza (2010), Zachariah (2004), Zachariah (2006).

41. Division is the hardest of the four basic arithmetic operations to do. Even on a modern computer it is much slower than addition. The paper and pencil division you learned at school relies on algorithms that were not known until the Middle Ages; division in Babylonian times was done using complicated tables of inverses followed by multiplication. Fast computers still resort to this, for example the RCPSS-Scalar Single-Precision Floating-Point Reciprocal used by Intel computers.

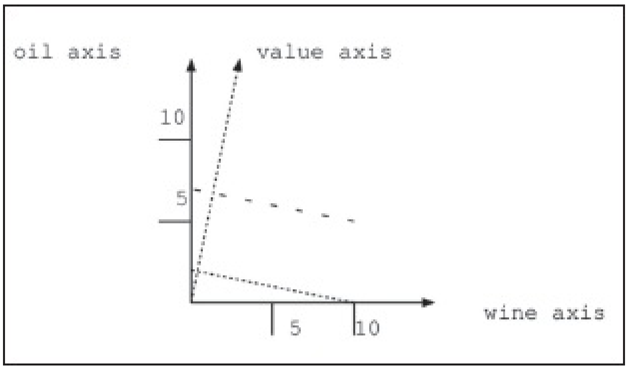
42. In maths we call a table with a single column of numbers a vector. This is slightly confusing if you came across the notion of vectors initially in school physics, where a vector is taken to mean a direction in space. But this meaning you got in school physics is just a special case of the mathematical vector. A direction in three-dimensional space—for instance, the direction of an electrostatic field—can be expressed as numbers in an x, y, z coordinate system. The line from the origin to position [x, y, z] is the direction we are interested in. So we can encode a direction in space as a column of three numbers. But suppose we have a fifty-dimensional space; how would we describe a direction?

Clearly, by a column of fifty numbers giving a position in this fifty-dimensional space. If we have fifty distinct types of goods, then we have a potential fifty-dimensional space. A basket containing specific amounts of each of these goods defines a point in this fifty-dimensional space.

So higher dimensional vectors are a relevant tool for the theory of value. A price list is a high dimensional vector. Such a list encodes values and it does not matter what the unit used for the encoding is. We can obviously express all prices in pennies as well as in pounds, all that changes is that we multiply the vector by 100. Similarly, one can use any one of the commodities themselves as the standard of value, what economists call the numeraire. We could use wine or eggs in the example we gave. In any case, a change of numeraire just involves an appropriate multiplication of the vector.

We said that a vector defines a direction in a multidimensional space. The price vector in Roman coins for oil, eggs, and wine that we gave in our table (A) points in a direction in this space, but what does that mean?

The direction the price vector points is the direction of value. Consider the diagram below. It shows two dimensions of the value space. We know that two measures of oil are worth ten of wine. The line joining two oil to ten wine indicates this. The set of lines parallel to this are the isovals. All points on these lines have the same value. The axis of value is at right angles to these isovals. Any point on the oil wine plane, i.e., any combination of wine and oil that a person owns can be projected onto the value axis along one of these parallel isovals. The diagram illustrates this for the point ten wine, five oil. The illustration is only for two dimensions, but the same geometric principle extends to arbitrary numbers of goods and thus arbitrary dimensions. The isovals are then hyperplanes and the value axis is the line through the origin perpendicular to the isovals. For a more detailed discussion of the formal properties of value, see Cockshott et al. (2008), chapter 11.



What I have called a swap table is a matrix produced by an outer divide operation. If S is a swap table and p is the price vector that is consistent with it then for all elements s_{ij} in S we have sy= [(pi)/(pj)].

43. For a more detailed discussion of the computational techniques used by the Mesopotamians and Romans, including how the latter did economic calculations on reckoning tables, see Cockshott et al. (2012), chapter 2.

44. On the point that money did not arise from barter exchange, Davies (2010, p. 44) says: “On one thing the experts on primitive money all agree, and this vital agreement transcends their minor differences. Their common belief backed up by the overwhelming tangible evidence of actual types of primitive moneys from all over the world and from the archaeological, literary and linguistic evidence of the

ancient world, is that barter was not the main factor in the origins and earliest developments of money. The contrast with Jevons, with his predecessors going back to Aristotle, and with his followers who include the mainstream of conventional economists, is clear-cut."

45. The cowries persisted in use up until the twentieth century, the British colonial authorities attempted to eliminate them as early as 1880 and officially demonetized them in 1904 (Falola and Adebayo, 2000). Attempts to demonetize the manilla were made from 1902, but remained in circulation until at least 1949. The origins of the manilla are unclear but they may date back as far as Phonecian trade with West Africa (Davies, 2010).
46. A couple of reasons are given for the Chinese having coins with holes. The hole both allowed coins to be strung together into blocks of higher value, and was an aid to manufacture. A rod was passed through a stack of coins allowing them all to be filed simultaneously to the same size. This pattern of a copper coin with a central hole was also adopted for British colonial coinage.
47. Marx develops this argument about money in the first chapters of *Capital* (Marx 1954).
48. It is easy to verify that British coinage is not what it seems. Try picking a penny up with a magnet.
49. We find this sort of tendency to explain commodity production by its numismatic relics in Hirst and Hindess (1975), who argue that the outflow of gold to the East in the late Roman period led to a shortage of currency and thus to a collapse of commodity production and monetary economy. This, they claim, led to the bureaucracy's dependence on income in kind and devolution into a sort of feudal aristocracy. In a more sophisticated form, we see it in Banaji's emphasis on the importance of gold coinage in the late empire as evidence of the opposite of what Hirst argued, that there was in fact a reflorescence of commodity production in this period.
50. The question of whether a coinage is made up of low intrinsic value tokens or fine gold coins may be better understood from the standpoint of class struggle. Creditor classes, whether the late Roman aristocracy studied by Banaji, or U.S. bankers in the late nineteenth century, are likely to favor gold coins as the only acceptable means of settling debts. This protects the real value of their debts in terms of labor. Debtors, whether indebted states in the modern period or

indebted farmers throughout history, will favor a more readily available currency: silver or debased coins, or state paper. These make the paying off of debt easier, and if they depreciate, reduce the real value of debt obligations.

The fact that a number of major ancient states, Athens, the Macedonian, Roman, or Spanish empires did rely on a silver coinage indicates both the supplementing of tax revenue by minting of coin from state-controlled silver mines, and to a persistent trade deficit in manufactures that could only be met by the export of specie.

51. The fable of Midas or the economic theory of Aristotle Meikle (1997) address the contradiction between exchange value and use value. This is to point out a confusion at a relatively mundane level of thought. There is a deeper confusion present in commercial language which speaks of value being “realized” when a commodity is sold as money. But this metaphor is even more naive and, in Marx’s terms, “fetishistic” than the desires of Midas. When a state operates a system of token money, either base metal coins of paper notes, then the sale of a commodity is better seen as the idealization value. A commodity embodying real labor, and thus the real substance of exchange value, is exchanged for a mere sheet of paper bearing the symbol or idea of value. The real value has passed into the hands of the purchaser, the seller is left with state paper. If Joe in the United States sells a TV for $100 he can at least settle his U.S. tax debts with it. If TCL Corporation of Guandong sells 10,000 TV sets for $1 million, they are left with a U.S. credit that may in the long term be unrealizable in terms of anything of either use value or labor value.

52. Markov models are named after the Russian mathematician who introduced the idea in a study (Markov 2006) of the statistics of sequences of letters in text.

53. Constructing a parameterized Markov model of historical materialism would be a nice PhD thesis for someone.

54. Representation as a simple Markov model, while an advance on the standard Marxist presentation, is still a considerable oversimplification, since it abstracts from geography and the interaction between adjacent societies. There are methods by which one can extend Markov modelling to represent multiple local systems which undergo evolution as a result both of their own internal

dynamics and their interaction with one another. The work of Shaw and Cockshott (1994), Shaw et al. (1996), and Hillston (1995) may well provide a starting point for this. She shows how you can compose descriptions of multiple processes evolving stochastically and in communication with one another to derive an overall Markov model of the whole ensemble. Such overall models formed by composition are defined over the tensor space of the original state spaces. The class of models required to formalize this would be the two-dimensional extension of Markov models known as Markov Random Fields (Kindermann and Snell 1980). Application of such models integrating geographical, demographic, and other constraints within historical materialism is obviously a considerable research project.

55. The position this chapter takes has a lot in common with that of Rudra (1988) in that I would class both Europe and Anatolia in the Middle Ages as instances of feudal societies, but I do not accept the definition of a mode of production that he uses. It is in essence a repetition of Hirst and Hindess's (1975) idea that a mode of production is a combination of forces and relations of production. Rudra is critical of other historians like Wickham for underplaying the role played by technology. I go even further than Rudra. I treat a mode of production as being irreducibly determined by technology, so that for me the capitalist mode of production *is* machine industry, and the feudal mode of production *is* peasant agriculture. But not all instances of peasant agriculture are feudal, since France in 1812 or China in 1955 were still peasant economies but non-feudal. So the mode of production in all societies with feudal social relations is peasant agriculture, but not all societies with peasant agriculture are feudal.

Hindess and Hirst were in turn relying on Althusser who relied on Stalin for his definition of a mode of production as being a combination of forces and relations of production:

"What, then, is the chief force in the complex of conditions of material life of society which determines the physiognomy of society, the character of the social system, the development of society from one system to another?

"This force, historical materialism holds, is the method of procuring the means of life necessary for human existence, the mode of production of material values—food, clothing, footwear, houses, fuel, instruments of production, etc.—which are indispensable for the life and development of society.

“In order to live, people must have food, clothing, footwear, shelter, fuel, etc.; in order to have these material values, people must produce them; and in order to produce them, people must have the instruments of production with which food, clothing, footwear, shelter, fuel, etc., are produced, they must be able to produce these instruments and to use them.

“The instruments of production wherewith material values are produced, the people who operate the instruments of production and carry on the production of material values thanks to a certain production experience and labor skill—all these elements jointly constitute the productive forces of society.

“But the productive forces are only one aspect of production, only one aspect of the mode of production, an aspect that expresses the relation of men to the objects and forces of nature which they make use of for the production of material values. Another aspect of production, another aspect of the mode of production, is the relation of men to each other in the process of production, men’s relations of production.” (Stalin 1943.)

56. The Domesday Book is a very detailed survey carried out in 1086 of all estates in England for tax purposes. It lists population, area, livestock, plow teams, mills, fish-ponds, and other resources of each manor. It is the most detailed statistical account still available of any feudal economy.

57. By way of comparison with feudal manor sizes, data from the 1870s covering the same part of England, Essex, as table 4.1, shows that by then average individual tenant farms were comparable in size to entire manorial estates. Hunt and Pam (1995) give as an example of farm sizes that: “Lord Petre’s 18,000 acre Thomdon estate, for example, had 49 tenants in 1860 and 47 in I870.” Which implies that an average Victorian tenant farm in Essex was equivalent to the entire area of a median Saxon manorial estate, peasant plots included.

58. The original Soviet source for the technique of linear optimization is available in translation as Kantorovich (1960), Kantorovich (1965). Klein (2007) recount how similar techniques were independently developed by French hydraulic engineers and U.S. military logistics

experts before being widely applied in U.S. industry from the 1950s. For an account of how linear optimization invalidates the claims of von Mises (1949), see Cockshott (2006b).

59. The reference is to Felix Haber, inventor of both chemical warfare and the catalytic fixation of nitrogen, originally to make explosives, later the main source of ammoniacal fertilizers.

60. "We can divide the basic activities of social reproduction into two mutually exclusive and exhaustive groups: production and non production The difference between the two is crucial: while production results in the creation of new use values (wealth), non production uses up wealth without creating new wealth. Non production activities can, in turn, be divided into three mutually exclusive and exhaustive groups: distribution, social maintenance and personal consumption. Distribution involves activities that transfer use values, titles to use values or money from one set of economic agents to another. Social maintenance refers to all activities that are geared toward the maintenance and reproduction of the social order. Personal consumption includes all activities involved in the maintenance and reproduction of individuals within the social order. All schools of economic thought distinguish between production and consumption. Moreover they agree that production creates wealth and consumption uses up wealth. The difference between the neoclassical and classical Marxian traditions arises from the characterization of the activities of distribution and social maintenance. For the neoclassical (and Keynesian) tradition, these activities are understood as production as long they are marketable and some entity is willing to pay for the activity." (Deepankar 2015.)

61. "The proportion between those different funds necessarily determines in every country the general character of the inhabitants as to industry or idleness. We are more industrious than our forefathers; because in the present times the funds destined for the maintenance of industry are much greater in proportion to those which are likely to be employed in the maintenance of idleness than they were two or three centuries ago. Our ancestors were idle for want of a sufficient encouragement to industry. It is better, says the proverb, to play for nothing than to work for nothing. In mercantile and manufacturing towns, where the inferior ranks of people are

chiefly maintained by the employment of capital, they are in general industrious, sober, and thriving; as in many English, and in most Dutch towns. In those towns which are principally supported by the constant or occasional residence of a court, and in which the inferior ranks of people are chiefly maintained by the spending of revenue, they are in general idle, dissolute, and poor; as at Rome, Versailles, Compiegne, and Fontainebleau." (Smith 1974, II.3.9.)

62. The point made by Smith that the accumulation of capital leads, via a higher capital to output ratio, to a lower rate of profit already contains the essence of Marx's later arguments about the effects of a rising *organic composition* of capital.

63. In working notes on Adam Smith, Marx (1999) wrote that he disagreed with Smith's idea that productive labor need produce a physical output. Instead, he then thought, it was sufficient for the workers to be directly employed out of capital rather than revenue. Any worker paid out of capital would then count as productive, whatever they did.

Elsewhere, Marx recognized that no transformation of social form can convert a previously materially unproductive activity into a productive one:

"If by a division of labor a function, unproductive in itself although a necessary element of reproduction, is transformed from an incidental occupation of many into an exclusive occupation of a few, into their special business, the nature of this function itself is not changed.

"One merchant (here considered a mere agent attending to the change of form of commodities, a mere buyer and seller) may by his operations shorten the time of purchase and sale for many producers. In such case he should be regarded as a machine which reduces useless expenditure of energy or helps to set production time free.

"In order to simplify the matter (since we shall not discuss the merchant as a capitalist and merchant's capital until later) we shall assume that this buying and selling agent is a man who sells his labor. He expends his labor power and labor time in the operations C → M and M → C. And he makes his living that way, just as another does by spinning or making pills. He performs a necessary function, because the process of reproduction itself includes unproductive functions. He works as well as the next man, but intrinsically his labor creates neither value nor product. He belongs himself to the faux frais of production. His usefulness does not consist in transforming an unproductive function into a productive one, nor unproductive into productive labor. It would be a miracle if such transformation could be accomplished by the mere transfer of a function. His usefulness consists rather in the fact that a smaller part of society's labor-power and labor-time is tied up in this unproductive function." (Marx and Engels 1974, chapter 6)

I argue in section 5.10 that to determine if something is productive one has to look at the whole economy. This is closer to Smith's position and to that of Marx in *Capital*, volume 2, than it is to what Marx wrote in *Theories of Surplus Value*.

64. On the elements of capitalism arising: "I posit that the emergence of capitalist from feudal social-property relations will occur only as an unintended consequence of lords and peasants pursuing feudal type economic behaviour in order to achieve feudal goals" (Brenner 2001).

65. See also the discussion of how this relates to scientific concepts of process in Cockshott (2013b).

66. Cato advises estate owners to be sellers not purchasers, to make what they can on their own estate.

67. Measured values for the CV of prices to labor ratios in the UK economy in 1984 were in fact around 10 percent (Cockshott and Cottrell, 1998b). The argument so far has depended on the assumption that only 1 percent of firms will be making a loss at any one time, but because of the shape of the bell curve, the result would not be much different if I assumed it was either 0.5 percent or 2 percent.

68. This form of argument was pioneered by Farjoun and Machover (1983).

69. With respect to table 5.2, if prices corresponded to the simple labor theory of value, we would expect to find a positive linear relationship between profit rate and the inverse of organic composition (in other words, the relationship between profit rate and organic composition would be inverse, rather than negative linear), so the correlation coefficient between s /C and v /C is very telling: at 0.780 it has a p-value or marginal significance level <0.0001. Note also how the spread of profit rates and the spread of markups is very similar, and

the narrow dispersion of capital compositions. Arguably the inverse relationship between capital intensity and profit will act to curb the spread of capital intensities. This narrow dispersion of capital intensities in the United States appears to be robust and lasting, and more recent work, Torres (2017) has confirmed it.

70. Reifferscheidt and Cockshott (2014) shows that the number of inputs to an industry grows proportionally to the logarithm of the number of industries in the economy. Inverting this relation, it follows that the number of other industries in the economy grows exponentially with the number of inputs to the average industry.

71. "Wealth, as Mr. Hobbes says, is power. But the person who either acquires, or succeeds to a great fortune, does not necessarily acquire or succeed to any political power, either civil or military. His fortune may, perhaps, afford him the means of acquiring both, but the mere possession of that fortune does not necessarily convey to him either. The power which that possession immediately and directly conveys to him, is the power of purchasing; a certain command over all the labor, or over all the produce of labor, which is then in the market. His fortune is greater or less, precisely in proportion to the extent of this power; or to the quantity either of other men's labor, or, what is the same thing, of the produce of other men's labor, which it enables him to purchase or command." (Smith 1974.)

72. This phrase is widely used by Marxian economists. Some have taken it to simply mean contractual equality between agents in the market (Bordiga 1975; Bordiga 1954), but more generally they seem to mean the law that labor time determines price.

73. Actual inequalities, which are of course massive, arise with contractual enforcement.

74. The markup I have used in earlier discussion is similar to what Marx called rate of surplus value which he denoted by s/v where s is property income, and v is wage income. Our markup is not exactly the same but it can be derived from Marx's rate of surplus value. The markup used in section 5.1 is given by *markup = 1 +(s/v)*.

75. "Hold back your hand from the mill, you grinding girls; even if the cock crow heralds the dawn, sleep on. For Demeter has imposed the labors of your hands on the nymphs, who leaping down upon the topmost part of the wheel, rotate its axle; with encircling cogs, it turns the hollow weight of the Nisyrian millstones. If we learn to

feast toil-free on the fruits of the earth, we taste again the golden age.” (Anitpater of Thessalonika. *The Greek Anthology*, vol. 1. Cambridge: Cambridge University Press, 1960, p. 63.) Note that this was an overshoot mill, but these did not become the general design until the early states of capitalism.

76. Finer yarns weigh less, so productivity in pounds is lower.

77. The initial solution to generating rotary motion from steam was to use a steam engine to pump water up which was then used to turn a water wheel (Ferguson 1962).

78. A proof of the correctness of Watt’s design was not long in coming. It was made in 1797 by De Prony, the French mathematician whose work on the division of mathematical labor inspired Babbage to invent the computer. Further evidence that what appears now to be a mundane improvement was actually related to the most advanced theoretical science of the day.

79. Traditional iron making reduced the ore in a solid state to produce a bloom; it was not until blast furnaces became available that the output was molten iron. A transitional technology capable of producing molten iron with a single manually operated furnace is described in David et al. (1989).

80. A description of a fifteenth-century Italian ironworks is given by a contemporary engineer known as Filarete:

“But I will tell you how there was one which I saw, being at Rome, the which was about 12 miles from Rome at an abbey called Grottaferrata where there were monks officiating in the Greek manner…. the spot is wild and there are thick woods in it…. the place of this large hammer is a little outside the path of the water, which runs through the site, which comes [from] a little way up the mountain … where this water runs through the valley, adapted by a canal in such a way as to move wheels, one of which blows the bellows and the other makes the hammer beat. The manner of this is not that of the furnace where it is melted [not a blast furnace], but only a pair of bellows like those that smiths use, and there is a hearth … and in this the iron is remelted, and pieces thrown in such as they wish to do, and with that hammer and the water they beat it, and it comes out almost in that form as one sees it here.” (Quoted in Williams 2003, p. 883.)

It is interesting to note that Althusser (2006) claims that fifteenth-century Italy was one of the occasions when nearly all the required ingredients of capitalism were present: wage labor, money capital, hydraulic powered machines, but still capitalism did not take. Was the absence of supplies of fossil fuel critical here?

81. The *man* in both manufacture and manual labor derives from the Latin *manus*, for hand.

82. The concept of the articulation of modes of production was developed and popularized in Rey (1973). Although Rey is little known to Anglophone readers, his ideas (sometimes misattributed to Althusser) are crucial and have had an influence on other thinkers.

83. "By the 1830s in England hand loom weaving of cottons was largely superseded by power looms in factories, even though the wages of hand loom workers were only about half those of factory workers. Yet 170 years later the hand loom sector in India is still very large, particularly in cottons. Indeed the output of the hand loom sector has grown steadily since 1900 when statistics were first gathered. In 1997, output of woven cloth from hand looms in India was about 10 times as great as in 1900. In 1997–8 25 percent of cloth production in India was still from hand looms." (Clark and Wolcott 2003, pp. 70–71.)

84. "At a brick kiln in Gautam Budha Nagar in Uttar Pradesh, near Delhi, 180 bonded laborers (53 men, 36 women and 91 children) were rescued in February 2000. The condition of the workers came to light when one of the women workers was raped, and her husband and a child were killed in gunfire by the employer and his henchmen when they resisted. The workers were prevented from leaving through threat and intimidation. The employer retained more than half their wages and gave them only a small sum for subsistence." (Srivastava 2005.)

85. Blackmon (2009) argues that the enforcement of legislation against peonage in the United States was made necessary for ideological reasons during the war against the Nazis.

86. Forcing people to work longer hours was not unique to capitalism. Slaves in nineteenth-century Alabama or first-century Sicily were similarly overworked.

87. "The Facts about the Gender Wage Gap in Canada," Canadian Women's Foundation, http://canadianwomen.org/facts-about-the-gender-wage-gap-in-canada.

88. The theory of Dragulescu (2003) and Dragulescu and Yakovenko (2002), developed further in Cottrell et al. (2009) and Shaikh et al. (2014), is that the distribution of income will have a negative exponential form for labor income, and a power law form for property income. However, the arguments given for this form of distribution in the literature are not necessarily convincing when applied to an employed workforce, though they are perhaps plausible for a workforce of small traders. It is not clear that for instance Shaikh et al. (2014) have adequately excluded the possibility that the distribution may be log normal rather than strictly negative exponential.

89. "The minimum limit of the value of labor-power is determined by the value of the commodities, without the daily supply of which the laborer cannot renew his vital energy, consequently by the value of those means of subsistence that are physically indispensable. If the price of labor-power fall to this minimum, it falls below its value, since under such circumstances it can be maintained and developed only in a crippled state. But the value of every commodity is determined by the labor-time requisite to turn it out so as to be of normal quality." (Marx 1887, chapter 6.)

What is being said here is that the lower tail of the wage distribution is set by a wage so low that a person can only survive in a state crippled by ill health, a level just above that at which they will starve. But in the labor theory of value, the value of a commodity is determined not by the lower limit of its cost but by its mean cost. So if a person is paid the subsistence limit they are paid below the mean, and thus below the value of labor power.

90. Let m(w) and f(w) represent the male and female wage distribution probability density functions.

m(w), f(w) are both constrained to be log-normal.

Lower bounds of each distribution are set by the survival wage of a single person

$$\int_{ws}^{\infty} m(w)dw = \int_{ws}^{\infty} f(w)dw=1$$

Slightly higher up is the subsistence minimum wage for a family wf.

Since a larger portion of men than women are the sole earners in a household, a smaller portion of men can be employed at levels below the family subsistence level:

$$\int_{ws}^{wf} m(w)dw < \int_{ws}^{wf} f(w)dw$$

Thus the standard deviation of the male wage am > af.

Thus the mean of the male wage distribution must also be greater, |im > |if

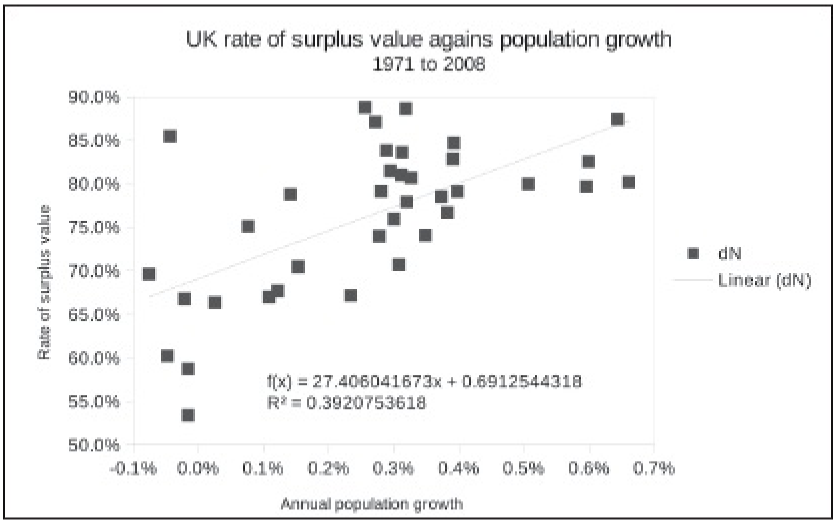
91. "The owner of labor-power is mortal. If then his appearance in the market is to be continuous, and the continuous conversion of money into capital assumes this, the seller of labor-power must perpetuate himself, in the way that every living individual perpetuates himself, by procreation. The labor-power withdrawn from the market by wear and tear and death, must be continually replaced by, at the very least, an equal amount of fresh labor-power. Hence the sum of the means of subsistence necessary for the production of labor-power must include the means necessary for the laborer's substitutes, i.e., his children, in order that this race of peculiar commodity-owners may perpetuate its appearance in the market." (Marx 1894, chapter 6.)

92. "What is bought with money or with goods is purchased by labor, as much as what we acquire by the toil of our own body. That money or those goods indeed save us this toil. They contain the value of a certain quantity of labor which we exchange for what is supposed at the time to contain the value of an equal quantity. Labor was the first price, the original purchase-money that was paid for all things. It was not by gold or by silver, but by labor, that all the wealth of the world was originally purchased; and its value, to those who possess it, and who want to exchange it for some new productions, is precisely equal to the quantity of labor which it can enable them to purchase or command." (Smith 1974, p. 133.)

93. This is the assumption made by Keynes that national income should be measured in employment quantities: "In dealing with the theory of employment I propose, therefore, to make use of only two fundamental units of quantity, namely, quantities of money-value and quantities of employment … if E is the wages (and salaries) bill, W the wage-unit, and N the quantity of employment, E=N×W" (Keynes 1936, p. 35.)

94. The correlation between immigration levels and exploitation is stronger than that between population growth and exploitation. It is positive in both cases, but the lower correlation for population

growth is probably because population changes include changes in the number of children and retired people who do not compete for jobs. The following figure (p. 361) shows the relationship between population and exploitation.



95. “The reproduction of a mass of labor power, which must incessantly re-incorporate itself with capital for that capital’s self-expansion; which cannot get free from capital, and whose enslavement to capital is only concealed by the variety of individual capitalists to whom it sells itself, this reproduction of labor power forms, in fact, an essential of the reproduction of capital itself. Accumulation of capital is, therefore, increase of the proletariat.” (Marx 1887, chapter 25.)

96. “The great mass of so-called ‘higher grade’ workers—such as state officials, military people, artists, doctors, priests, judges, lawyers, etc.—some of whom are not only not productive but in essence destructive, but who know how to appropriate to themselves a very great part of the ‘material’ wealth partly through the sale of their ‘immaterial’ commodities and partly by forcibly imposing the latter on other people—found it not at all pleasant to be relegated economically to the same class as clowns and menial servants and to appear merely as people partaking in the consumption, parasites on the actual producers (or rather agents of production). This was a peculiar profanation precisely of those functions which had hitherto been surrounded with a halo and had enjoyed superstitious veneration. Political economy in its classical period, like the bourgeoisie itself in its parvenu period, adopted a severely critical attitude to the machinery of the State, etc. At a later stage it realized

and—as was shown too in practice—learnt from experience that the necessity for the inherited social combination of all these classes, which in part were totally unproductive, arose from its own organization.” (Marx 1999, chapter 4.5.)

97. If we divide the economy into 3 sectors:

1. Produces means of production.
2. Produces workers’ consumption goods.
3. Produces articles of capitalist consumption, weapons for the army, etc.

It is relatively easy to demonstrate that labor in department 3 is not productive of relative surplus value. By relative surplus value production is meant any increase in the surplus value brought about without altering real wages or increasing the workforce. We can model the gross product of these industries with the vector v = [v1, v2, v3] where vi is the mean number of person seconds of labor performed in sector i for each second of the year. The vi thus have dimension person.

For each sector the gross value is made up of two components, direct and indirect labor, which we will denote by the vectors l and c. All these have dimension person seconds per second.

We have v = l+c.

Associated with each sector is a capital stock which we denote by the vector k. We will denote economy wide totals by the corresponding capital letters.

$$K = \Sigma k_i,\ V = \Sigma v_i,\ C = \Sigma c_i,\ L = \Sigma l_i$$

We will denote wages in each sector by the vector w and profits by the vector s, with corresponding economy-wide totals W, S.

For the economy as a whole we have it that newly created value is entirely divided between wages and profits, hence $L = W + S$. We will assume that sectoral outputs sell at their values so this scalar equation generalizes into the vector equation $l = w + s$, which says that the newly created value in each sector is divided between wages and profits in that sector. Let us for now assume that the working population is fixed as is the length of the working day, hence $dL/dt = 0$, but that accumulation of constant capital is occurring $dK/dt > 0$. We thus have that the gross output of sector 1 is equal to capital consumption plus accumulation $v_1 = C + dK/dt$.

If we further assume that workers do not save or borrow we have the total wage bill equal to the total output of sector two: $W = v_2$. Total profit is then equal to accumulation plus capitalist consumption $S = v_3 + dK/dt$.

Suppose that there is an improvement in labor productivity in sector 3. Does this have the potential to increase total surplus value? No, as v_3 is unaltered, all that changes is the quantity of use values that the capitalists get in their consumption. Thus there is no room for production of relative surplus value here.

98. For an account of the role of Armstrong in the development of naval guns, see

Parkes (1966).

99. "The Royal Navy was probably the largest single item in the British national budget of the time. William Gladstone, the Liberal prime minister during much of the late nineteenth century, was an ardent anti-imperialist hostile to naval spending." (Friedman 2012.)

100. "However, we must make the same distinction between him and the wage-workers directly employed by industrial capital which exists between industrial capital and merchant's capital, and thus between the industrial capitalist and the merchant. Since the merchant, as a mere agent of circulation, produces neither value nor surplus-value (for the additional value which he adds to the commodities through his expenses resolves itself into an addition of previously existing values, although the question here poses itself, how he preserves this value of his constant capital?) it follows that the mercantile workers employed by him in these same functions cannot directly create surplus-value for him." (Marx 1971, p. 293.)

101. "Now let's turn to the purpose of banks in a capitalist economy. Finance is an intermediary good: You cannot eat it, experience it, or physically use it. The purpose of finance is to support other activities in the economy. Banks are meant to allocate capital (funds) to the best possible use. In a capitalist economy, this means allocating money to the people or entities that will create the greatest wealth for the overall society. At the same time, risk management is supposedly a primary skill for bankers. When capital is allocated well and available to wealth creating entities, societies flourish. When capital is poorly allocated, economies can collapse." (Judson 2012.)

102. "Wealth, as Mr Hobbes says, is power. But the person who either

acquires, or succeeds to a great fortune, does not necessarily acquire or succeed to any political power, either civil or military. His fortune may, perhaps, afford him the means of acquiring both; but the mere possession of that fortune does not necessarily convey to him either. The power which that possession immediately and directly conveys to him, is the power of purchasing a certain command over all the labor, or over all the produce of labor which is then in the market. His fortune is greater or less, precisely in proportion to the extent of this power, or to the quantity either of other mens labor, or, what is the same thing, of the produce of other mens labor, which it enables him to purchase or command." (Smith 1974, chapter 5.)

103. "This disposition to admire, and almost to worship, the rich and the powerful, and to despise, or, at least, to neglect persons of poor and mean condition, though necessary both to establish and to maintain the distinction of ranks and the order of society, is, at the same time, the great and most universal cause of the corruption of our moral sentiments. That wealth and greatness are often regarded with the respect and admiration which are due only to wisdom and virtue; and that the contempt, of which vice and folly are the only proper objects, is often most unjustly bestowed upon poverty and weakness, has been the complaint of moralists in all ages." (Smith 1790, p. 53.)

104. The growth of the world gold stock has been relatively slow, below 1 percent a year in the nineteenth century, and around 1.5 percent a year in the twentieth century (Cockshott et al. 2008, p. 238). This is markedly slower than the growth of the world economy.

105. "The bank therefore creates its own funding, deposits, in the act of lending, in a transaction that involves no intermediation whatsoever…. if the loan is for physical investment purposes, this new lending and money is what triggers investment and therefore, by the national accounts identity of saving and investment (for closed economies), saving. Saving is therefore a consequence, not a cause, of such lending. Saving does not finance investment, financing does. To argue otherwise confuses the respective macroeconomic roles of resources (saving) and debt-based money (financing)." (Jakab and Kumhof 2015.)

106. For nineteenth-century interest rates, see Barro (1987). Five percent for 1800 is realistic, though this was a peak brought about by high wartime borrowing.

107. “If all land had the same properties, if it were unlimited in quantity, and uniform in quality, no charge could be made for its use, unless where it possessed peculiar advantages of situation. It is only, then, because land is not unlimited in quantity and uniform in quality, and because in the progress of population, land of an inferior quality, or less advantageously situated, is called into cultivation, that rent is ever paid for the use of it. When in the progress of society, land of the second degree of fertility is taken into cultivation, rent immediately commences on that of the first quality, and the amount of that rent will depend on the difference in the quality of these two portions of land.” (Ricardo 1951, chapter 2.)

108. Marx (1971, chapter 45) argued that even the worst land bears a rent as a consequence of private ownership. He called this rent which applied to the worst land “absolute rent” to distinguish it from the differential rent identified by Ricardo.

109. The term *scot-free* originally meant land held without a levy. The origin is the Scandinavian root *skat* rather than a reference to the Scottish.

110. There is obviously a vast literature discussing what type of society the USSR was, and whether it was a class society. A good overview is provided in Nove (1983a).

111. Exceptions to this are perhaps the Bordigist International Communist Party, who argue that the continued existence of money was a decisive factor in preventing the USSR, etc. from ever having been socialist.

My view is that although it is fruitless to question whether the USSR was socialist, it does not follow that one has to accept the political and economic policies followed by its government. If one abandons the utopian viewpoint and sees socialism as a concrete form of society with its own contradictory forms of development, then one can start to ask just what economic and social policies should be followed in a socialist state. Any real society is fraught with contradictions, and is either destroyed by them or develops by resolving them.

112. We can take urbanization as a proxy for the change in the mode of production from a peasant economy to an industrial society. Russian urbanization grew from 14 percent just before the revolution to 34 percent in 1939 (Becker 2012); France was at 12 percent in 1800 and

had reached 35 percent in 1900 (Bairoch 1985).

113. In 1913 Russia had generated only 1300GWh of electricity, less than one-tenth of a person power per head. This was so far behind the power usage of Great Britain and other Western industrial nations that some in the Soviet government doubted that the country could carry out an unaided socialist industrialization. The scale of Soviet power output in 1990 shows, in retrospect, that this was an overcautious estimate of what would be possible.

114. More than 99 percent of uranium is made of the U238 isotope, which cannot be used as an energy source in conventional reactors. Fast neutrons can convert this into Pu239 fuel. Fast neutron reactors use Pu239 fuel and run at such high energy fluxes that they need liquid metal cooling. In the past sodium has been used for cooling with all the attendant fire hazards associated with leaks of this metal.

115. A Soviet-type bachelor tax could potentially address the gay economic privilege.

116. Figure 6.9 drawn from data published by Economics and Statistics Administration, using data from Bureau of Labor statistics and National Bureau of Statistics China. Published at https://acetool.comerce.gov.

117. Figure 6.10 drawn from data published at Caixin Global (http://caixinglobal.com) using data from ILO Global Wage Database, U.S. Bureau of Economic Analysis, and World Bank. Published at http://acetool.comerce.gov/labor-costs.

118. Advances in technology, in particular the development of accurate calendars that could be worked by symbolic techniques, meant that priesthoods need no longer actually observe the sky. Church buildings were of little use for predicting the seasons, but the regular church festivals were. With the practical distancing of the priesthoods from astronomy could go ideological shifts which dispensed with the heavenly bodies as incarnations of deities, to a system where the gods became apotheoses of either real historical figures (the idea of Sanchuniathon [Kaizer 2014] known through Eusebius [Kofsky 2002]), or imagined emperors, Kings of the Jews, etc.

119. For a detailed critique of Hayek's conception of the price system as a communications network, see Cockshott and Cottrell (1997c).

120. Note that for orthodox communists like Lenin or Mao the term *state*

capitalism refers to a situation where private capitalist firms are subjected to state control, as in the British and German war economies or in China in the 1950s. It does not refer to state-owned companies.

121. Friedman and Baker (2009) give several examples of scheduling constraints on new gun mountings, and slip sizes affecting UK destroyer construction plans in the Second World War. Friedman (2015) gives the example of construction of the Admiral class capital ships being postponed due to insufficient shipbuilding labor to build both them and destroyers in 1917. For large scale shipbuilding programs, even in peace, similar forward planning of physical constraints has to be done by the state (Arena et al. 2005).

122. I have used the notation D' for Feldman's original T and D for his ND, D-u for his ND.

123. For a general discussion of the Feldman model and its relation to reproduction scheme analysis, see Clark (1984). For worked examples of how a Feldman model is in theory optimal for growth, provided Soviet-style national accounts are used, see Földvári et al. (2015).

124. Why is a flow of money value a number of persons? Because in terms of the labor theory, a flow of money is the representation of a flow of labor, and a flow of labor is measured in [(persons×hrs)/yr], and hours and years are both time measures, so that in dimensional terms they cancel out. So the flow of value is measured in persons, the number of people having to be devoted to the production of that value flow of output.

125. Allen's data have been questioned by Wheatcroft (2009) who gives much more pessimistic estimates of consumption growth. But Allen is strongly supported by other entirely independent sources. Hunter and Szyrmer (2014) give very similar trends for consumption over the same period and Pelkonen and Cockshott (2017) show that child growth rates correlate very closely with the consumption estimates of Allen.

126 A way around it is to give two estimates of growth rate, one based on prices in 1975 and another based on prices in 1979. You work out what the total physical output produced in 1975 would have sold for in terms of 1979 prices and compare that to what the 1979 output actually sold for, and vice versa using 1975 prices.

127. “In general, the abolition of money is inevitable in Communist society, where there is no individual or group accounting of who takes what and how much. Socialism, however (because it is socialism and not communism), does have this accounting, though eventually it is applied only to a section of the products distributed. Moreover, socialism does not completely exclude the market for those branches of the economy, for example, for petty production—which are not yet socialized. True, these branches, and the market with them, gradually wither away under socialism. But they wither away gradually, as socialism gradually turns into communism—being, as it is, merely unfinished, undeveloped communism. Finally, under socialism voluntary, amateur industry and art develop, activities in which the workers under the socialist state engage after they have fulfilled their obligatory spell of work, and the products of which are exchanged for money, as happens now. But of course the role of money in these conditions is not at all the same as under the capitalist or commodity-socialist systems. In these latter, money served as the yardstick of the value of commodities, the means of circulation and the means of payment. It was one of the means whereby the spontaneous regulation of the process of production and exchange took place. When, however, all decisive branches of the economy became subject to planning, and when, consequently, exchange between these branches also became subject to planning, with planned accumulation and planned distribution of consumer goods, then money was transformed into a mere auxiliary instrument of planned distribution. It retained its former status only for the non-socialized part of the economy, and even there not for the whole but only for its market in the narrow sense of the word, that is, for the market in which exchange within the non-socialized part of the economy took place.” (Preobrazhenski 1973, Lecture 11.)

“Today there are two basic forms of socialist production in our country: state, or publicly-owned production, and collective-farm production, which cannot be said to be publicly owned. In the state enterprises, the means of production and the product of production are national property. In the collective farm, although the means of production (land, machines) do belong to the state, the product of production is the property of the different collective farms, since the labor, as well as the seed, is their own, while the land, which has been turned over to the collective farms in perpetual tenure, is used by them virtually as their own property, in spite of the fact that they cannot sell, buy, lease or mortgage it.

The effect of this is that the state disposes only of the product of the state enterprises, while the product of the collective farms, being their property, is disposed of only by them. But the collective farms are unwilling to alienate their products except in the form of commodities, in exchange for which they desire to receive the commodities they need. At present the collective farms will not recognize any other economic relation with the town except the commodity relation—exchange through purchase and sale. Because of this, commodity production and trade are as much a necessity with us today as they were, say, thirty years ago, when Lenin spoke of the necessity of developing trade to the utmost." (Stalin 1952, chapter 2.)

128. "Everyone knows that when supply and demand are evenly balanced, the relative value of any product is accurately determined by the quantity of labor embodied in it, that is to say, that this relative value expresses the proportional relation precisely in the sense we have just attached to it. M. Proudhon inverts the order of things. Begin, he says, by measuring the relative value of a product by the quantity of labor embodied in it, and supply and demand will infallibly balance one another. Production will correspond to consumption, the product will always be exchangeable. Its current price will express exactly its true value. Instead of saying like everyone else: when the weather is fine, a lot of people are to be seen going out for a walk. M. Proudhon makes his people go out for a walk in order to be able to ensure them fine weather.

What M. Proudhon gives as the consequence of marketable value determined a priori by labor time could be justified only by a law couched more or less in the following terms:

Products will in future be exchanged in the exact ratio of the labor time they have cost. Whatever may be the proportion of supply to demand, the exchange of commodities will always be made as if they had been produced proportionately to the demand. Let M. Proudhon take it upon himself to formulate and lay down such a law, and we shall relieve him of the necessity of giving proofs. If, on the other hand, he insists on justifying his theory, not as a legislator, but as an economist, he will have to prove that the time needed to create a commodity indicates exactly the degree of its utility and marks its proportional relation to the demand, and in consequence, to the total amount of wealth. In this case, if a product is sold at a price equal to its cost of production, supply and demand will always be evenly balanced; for the cost of production is supposed to express the true relation between supply and demand." (Marx 1847.)

129. Marx ridiculed the idea that he proposed any system of socialism in a one-line aside in his notes on Wagner (Marx, 1975).

130. There is some dispute amongst Marxists about whether the "law of value" only applies to the production of commodities; even those who limit it to commodity production usually see it as related to a more general law of the distribution of labor-time among different production processes (Littlejohn, 1979). If the latter, more general law is also referred to as the law of value, then the concept expresses the proportion of the total labor-time available to a society (within a given time-period, say a year) which is devoted to a particular production process. Each of the products of that production process thus embodies a value which is a fraction of the proportional labor-time devoted to that production process. In other words, if one thousand products are produced in a year, then each product embodies one-thousandth of the value of that production process. If two thousand products are produced, then the value of each product is halved. Thus the value of each product is inversely proportional to the productivity of the production process associated with it. The value of a product thus refers to the amount of labor time (as a proportion of the total socially available labor-time) which is necessary (Hirst 1977; Hindess 1978). to produce it: the value of a product is the embodiment of the socially necessary labor-time required to produce it, and the socially necessary amount of labor-time depends on the productivity of the particular production process and its economic relation to other production processes. In the case of commodity production, according to Marx, where the fact that commodities are exchanged has an effect on the social distribution of labor-time between different production processes, the absolute amount of labor-time embodied in a product is not measured. Only the relative amount of labor-time is measured, and this occurs in the process of commodity exchange where the relative amount of labor-time is expressed by the ratios in which the commodities exchange

for each other. If one pound of sugar regularly exchanges for ten pounds of potatoes, then for Marx this is because these physical quantities of the products each take the same amount of socially necessary labor-time to produce. Whether that labor-time is one hour or five days cannot be directly measured by this exchange ratio of one to ten, which only indicates the relative value of the products. This "exchange value," as Marx calls it, forms the basis for the price of commodities, once money becomes an integral part of commodity exchange. According to Marx, this occurs on the basis of one commodity becoming a socially acceptable measure in terms of which all the other exchange ratios are established (Littlejohn 1981, p. 20).

131. Note that the European Union–mandated VAT is called *mehrwertsteuer* in German, literally "surplus value tax."

132. Along with Allin Cottrell I have written extensively on the policy proposals alluded to briefly here. See in particular Cockshott and Cottrell (1989), Cockshott and Cottrell (1992) or Cottrell and Cockshott (1993).

133. The original paper was Kantorovich (1960); I explained for a modern readership how his technique worked in Cockshott (2006b).

134. You can get a good lay person's introduction to the use of computers in Soviet planning in the novel *Red Plenty* (Spufford, 2010).

135. "The global energy model TIMER looks into long-term trends in the energy system. The model describes the demand and supply of nine final energy carriers and ten primary energy carriers for 26 world regions. The demand sub-model of TIMER determines demand for fuels and electricity in five sectors (industry, transport, residential, services and other) based on structural change, autonomous and price-induced change in energy intensity (energy conservation) and price-based fuel substitution. The demand for electricity is fulfilled by fossil-fuel or bioenergy based thermal power, hydropower, nuclear power and solar or wind." (Van Vuuren et al. 2011.)

136. Radiative forcing is the difference between energy arriving from the Sun and the energy being re-emitted as infrared to space. Any excess causes warming of the oceans, melting of ice, etc.

137. Data from U.S. Energy Information Administration, Annual Energy Outlook Report 2015.

138. Licht et al. (2012) claim that their proposed STEP process would

actually be cheaper than the current method of cement production. But their costings depend on operating the process at a higher temperature at which the outputs would be CO and O_2 rather than elemental carbon and oxygen. They then propose to sell the carbon monoxide as a feedstock for plastic production. But this process would not be carbon neutral, as part of the plastics would eventually end up being burned and entering the air.

139. I recall my grandfather describing to me the sight of one of these ships in the 1920s. At the time I could not understand how it could work.

140. Restrictions on fossil fuel for ships may first come as bans on the use of high sulfur oil. The threat of this has alone been enough to spur the revived experimental work on wind power.

141. This is similar to the model of delivery that existed in the United Kingdom in the period immediately after nationalization of the railways and road transport in 1948: railways for long distances; small trucks for final delivery.

142. For an idea of what was anticipated for transport in the early 1970s, see Ellison and Bahmanyar (1974) and Ross (1973).

143. Close examination of figure 7.6 shows that while Japanese productivity growth fell almost to zero in the late 1990s, it recovered to about 2 percent in 2007.

144. Similar thermodynamic constraints affect other heat engines. Less obviously, thermodynamics also limits the performance of computers, as we showed in Cockshott et al. (2012).

145. "On the one hand information wants to be expensive, because it's so valuable. The right information in the right place just changes your life. On the other hand, information wants to be free, because the cost of getting it out is getting lower and lower all the time. So you have these two fighting against each other." (Brand 1987.)

146. The idea that human labor is now obsolete is particularly pernicious. All the evidence from trends in productivity is that human labor is being dispensed with far more slowly than it was in the mid-twentieth century.

147. One possible protocol for participatory direct democracy is the Handivote system (Cockshott and Renaud 2010; Cockshott and Renaud 2009; Renaud and Cockshott 2010) that we have developed, but there are certainly many others that could be used, for example

Liquid Democracy (Paulin 2014).

148. They thus differ from the technology matrices of Morishima (1973), though as we shall see, there is an underlying relationship between the two.