ECONOMIC DEVELOPMENT & INSTITUTIONS

EDI WORKING PAPER SERIES WP16/09.1

TECHNOLOGICAL CHANGE, MARXIST CONTRADICTIONS AND INSTITUTIONAL REVOLUTIONS: A HISTORICAL PERSPECTIVE

Robert Allen
University of Oxford

August 2016

Oxford Policy Management · UKaid from the British people · Université de Namur · Paris School of Economics – École d'économie de Paris · ADE Analysis for Economic Decisions

Abstract

The paper discusses Marx's view on the relationship between technological change and institutional change as presented in the famous preface to *A Contribution to the Critique of Political Economy*. What Marx meant by a contradiction between the base and the superstructure is explained. Marx used this framework to explore the evolution of technology and institutions in English agriculture and manufacturing from the middle ages to the industrial revolution. The paper reviews recent research in these areas and concludes that much of what happened can be described with Marx's vocabulary. However, it is also argued that the discussion was incomplete as Marx left it, since he did not have much to say about the origins of new technology. The paper argues that induced innovation provides a useful point of departure. This approach is also useful, for it ties in with another great Marxist theme–the immiseration of workers during the Industrial Revolution. The paper claims that the average real wage of manual workers did not keep pace with the rise in output per worker during the first half of the nineteenth century, and that many workers experienced falls in income as machine production destroyed handicraft manufacturing. It was the great expansion of the handicraft manufacturing sector in the seventeenth and eighteenth century that led to the high wages that promoted the invention of machinery during the industrial revolution, and average wages did not rise until that sector was liquidated. Since it was so large, destruction took a long time, which is why the 'standard of living' question is such a prominent feature of the British industrial revolution.

About Economic Development & Institutions
Institutions matter for growth and inclusive development. But despite increasing awareness of the importance of institutions on economic outcomes, there is little evidence on how positive institutional change can be achieved. The Economic Development and Institutions – EDI – research programme aims to fill this knowledge gap by working with some of the finest economic thinkers and social scientists across the globe.

The programme was launched in 2015 and will run until 2021. It is made up of four parallel research activities: path-finding papers, institutional diagnostic, coordinated randomised control trials, and case studies. The programme is funded with UK aid from the UK government. For more information see http://edi.opml.co.uk.

UKaid
from the British people

Marxist Contradictions

Much recent research by economists has tried to explain economic growth in terms of fundamentals, which are taken to be geography, culture, and institutions (Acemoglu 2008, p. 20). The institutional explanation has been extensively investigated and is widely supported. It has not always been so. Classical economists beginning with Adam Smith thought that institutions evolved as the mode of production developed. The most fully worked out theory that treated technology as the ultimate fundamental was Karl Marx's theory of history. Marx's theories have fallen out of favour due to the collapse of communism in Europe (probably an irrelevancy), because of the rise of neoclassical economics, because many of his long term predictions have failed to come true, and because some Marxist explanations of historical change are unconvincing. This essay will argue that the rejection of Marx's ideas has gone too far. When they are properly interpreted, they fit many facts of English economic history–always Marx's 'classic case.'

The qualification 'properly interpreted' has two sense. First, Marx wrote many thousands of words advancing many ideas, and, as a result, and there are many interpretations of what he 'really' meant. I adopt one interpretation of Marx, which will be explained, and that is the first sense in which I mean that Marx must be properly interpreted. Second, Marx envisioned a feed back process between technological and institutional change, but he did not exhaustively analyse the interrelationships. When we confront his views with the English historical record, we see how his views might be elaborated to improve the fit between fact and theory. Augmented in this way, Marx has much to offering in explaining the evolution of institutions in response to the development of the economy–rather than the other way around.

The confrontation of Marx with English history is important for the light it throws on another issue, namely, the relationship between technical change and the distribution of income. Although Marx's famous prediction that capitalist economic development would not generate a rising real wage has not been born out by experience, historians have debated what happened to working class living standards during Marx's lifetime–the Industrial Revolution.[1] Views on this have varied widely, and research on this question has been influenced subliminally, if not consciously, by general expectations about income distribution

[1] An acrimonious debate, that began in the late 1950s and which generated a vast literature, reached a culmination with Feinstein's (1998) real wage index, which has been widely accepted. See Allen (2009b) for comparison of the Feinstein index with the growth in output per worker.

and economic growth. For a long time, it looked like the Solow (1956) growth model captured the essential fact that wages and output per worker rose in step with each other. When this view prevailed, evidence of flat or falling real wages were regarded as anomalies in the larger scheme by everyone except the committed Marxists. Now that real wages in the West have been flat for a generation, the middle class is shrinking, and the gains of growth have gone disproportionately to the top 1%, maybe it is time to another look at Marx's ideas about inequality in the industrial revolution.

What Marx meant

Marx wrote different things in different places about how society progressed. One of his most famous passages was at the beginning of the *Communist Manifesto*: "The history of all hitherto existing societies is the history of class struggles. Freeman and slave, patrician and plebeian, lord and serf, guild-master and journeyman, in a word, oppressor and oppressed, stood in constant opposition to one another, carried on an uninterrupted, now hidden, now open fight, a fight that each time ended, either in a revolutionary reconstitution of society at large, or in the common ruin of the contending classes." Marx certainly believed that much of what happened in the social and political spheres was 'class struggle.' This aspect of history has been probed by many historians, and the concept of class struggle has served as a framework for explaining what happened. However, the prominence of the class struggle does not prove its primacy as the cause of historical change.

My approach to Marx is informed by G.A. Cohen's *Karl Marx's Theory of History: A Defence*, which defends the 'primacy of the productive forces' in explaining social and economic change. Cohen's defence is based on the Preface to the *A Contribution to the Critique of Political Economy* (1857), which provides a succinct statement of Marx's view on the relationship between technology and social institutions and on the causes of economic progress. The argument is contained in the following assertions, which are separated to allow commentary:

1. In social life, "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 ‘definite relations’ are the so-called ‘social relations of production,’ a term refers to the type of property rights (e.g private, communal) and labour organization (slavery, serfdom, wage labour, etc). The social relations are contrasted with the ‘material forces of production,’ which refers to the technology employed. The technology determines the social relations of production since the latter must be ‘appropriate’ to the former.

2. “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 material forces of production and the social relations of production together constitute ‘the economic structure of society.’ This is often referred to as the ‘economic base’ or the ‘mode of production’ (e.g. feudalism, capitalism, or socialism). The economic base determines the legal and political system as well intellectual life in general. Causation runs from technology to the property and labour systems to political and social institutions. This is technological determinism Big Time!

3. “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.”

Technology develops over time–Marx does not tell us here why that happens, and the explanation will occupy us later–and eventually reaches a point at which the property and labour systems frustrate its further development rather than supporting it, as previously. The conflict between technological advance and the basic social institutions is known as a contradiction. It is not just existing productive forces that are ‘fettered’ in a contradiction, but the development or introduction of improved technologies is hindered.

4. “Then begins an era of social revolution.”

The contradiction is resolved through a change in the social institutions of property and labour organization. That change leads to knock-on changes in political organization and intellectual life via point 2.

5. “No social order is ever destroyed before all the productive forces for which it is sufficient have been developed, and new superior relations of production never replace older ones before the material conditions for their existence have matured within the framework of the old society.”

This claim looks like a serious overstatement that is contradicted by communist revolutions in backward countries like Russia and China and much else besides. Better to replace it with the more circumspect claim that:

5R. “one mode of production is replaced by another, if and only if, the new mode generates sufficient improvement in the productive forces to cover the costs of the replacement process.”

The replacement incorporates costs, which are ignored in Marx’s formulation and only requires that the new mode is more productive than the old–not that all possibilities have been realized by the old.

These propositions can be interpreted at different levels of generality. At the most abstract, the modes of production are the familiar stages of social evolution–primitive communism, slavery, feudalism, capitalism, and socialism. Broad changes in technology led to these dramatic shifts in social organization. “The windmill gives you society with the feudal lord; the steam mill, society with the industrial capitalist.” Marxist writing at this level seeks to explain great events like the French Revolution and the First World War. Arguments along these lines are always debatable and inconclusive and will be not be pursued here.

Marx also used his basic scheme to explain more specific changes like the decline of the guilds, the rise of the factory, the enclosure of the open fields. This is the level of generality at which we will operate in this essay. Questions like these have been intensively researched and we can assess how well Marx’s schema fits the facts, how much his views need to be augmented, and how helpful his theory is in understanding institutional change. We will focus on agriculture and industry from the end of the middle ages through the Industrial Revolution.

The discussion of the industrial revolution will also consider the questions of who gained and who lost because of the technological change. Marx, in common with the other classical economists, believed that economic growth benefited capitalists rather than

workers. Marx contended that technological change destroyed more jobs than it created. The ‘reserve army of the unemployed’ competed for jobs, and the wage was kept at subsistence. The capitalists reaped the increase in GDP as rising profits. Is this what happened in the Industrial Revolution?

Agriculture

Marx's account of the transition from feudalism centres on English agrarian history, for "In England alone, which we take as our example, has it the classic form." (VIII, 26) On the theoretical plane, the transition was described thus:

> In themselves money and commodities are no more capital than are the means of production and of subsistence. They want transforming into capital. But this transformation itself can only take place under certain circumstances that centre in this, viz., that two very different kinds of commodity-possessors must come face to face and into contact; on the one hand, the owners of money, means of production, means of subsistence, who are eager to increase the sum of values they possess, by buying other people's labour power; on the other hand, free labourers, the sellers of their own labour power, and therefore the sellers of labour. Free labourers, in the double sense that neither they themselves form part and parcel of the means of production, as in the case of slaves, bondsmen, &c., nor do the means of production belong to them, as in the case of peasant-proprietors; they are, therefore, free from, unencumbered by, any means of production of their own. With this polarization of the market for commodities, the fundamental conditions of capitalist production are given. The capitalist system presupposes the complete separation of the labourers from all property in the means by which they can realize their labour. As soon as capitalist production is once on its own legs, it not only maintains this separation, but reproduces it on a continually extending scale. The process, therefore, that clears the way for the capitalist system, can be none other than the process which takes away from the labourer the possession of his means of production; a process that transforms, on the one hand, the social means of subsistence and of production into capital, on the other, the immediate producers into wage labourers. The so-called primitive accumulation, therefore, is nothing else than the historical process of divorcing the producer from the means of production. It appears as primitive, because it forms the prehistoric stage of capital and of the mode of production corresponding with it.

Since agriculture was the largest sector of the late medieval economy, “the expropriation of the agricultural producer, of the peasant, from the soil, is the basis of the whole process.” How was that accomplished in England?

Primitive accumulation was a two step process. The first step was the abolition of serfdom. In the thirteenth century, much of England was owned by great manorial estates whose demesnes were cultivated with the unpaid labour of the estates’ serfs. Serfdom disappeared in England shortly after the Black Death in 1348/9 (Bailey 2014), and that was the first step in the transition to capitalism. The demesnes were leased to farmers who operated them with wage labour and the small holdings that were once possessed by the serfs were cultivated by free peasants using the labour of their families. Capitalism grew out of the regime of peasant proprietorship, and that was the second step in the transition to capitalism.

Marx lists a number of events that ‘deprived the peasant of the ownership of the means of production,’ but the crucial one in his mind was clearly the enclosure of the open fields. Agriculture in the English midlands was organized in open fields during the high middle ages. Villages were nucleated settlements surround by farmland. Individual holdings consisted of strips scattered across the fields, so the holdings of the villagers and often the manorial lord were ‘promiscuously intermingled.’ There was also meadow where hay was mown and a common of rough pasture for grazing the village herd. The arable lands of the village were divided into several fields for purposes of cultivation. Mostly commonly there were three fields, and they served as units in a three year crop rotation. Wheat was planted in the first year as a winter crop, a spring crop (barley, oats, beans) was grown in the second year, and in the final year the field was fallow. Individual strips were not fenced, and everyone had to follow the same rotation since the village herd was put on the land to weed and manure it when it was not growing a crop. The system was administered by the villagers meeting as the court of the manorial lord.

Today only one such village (Laxton, Notts) remains in England. The rest were ‘enclosed’ between the late fifteenth century and the nineteenth. The first enclosures were effected by manorial lords who expelled their tenants, destroyed the villages, and let the land to capitalist graziers who turned the fields into pasture for sheep. Where once a community of small farmers stood, only a shepherd and his dog remained. The ‘freed labour’ boosted manufacturing output as it was redeployed to towns where it swelled the workforce. Capitalism was created at the same time the land was enclosed. For Marx, this was the archetype of all enclosures.

About 10% of the midlands was enclosure before 1520 in this manner (Allen 1992). This was possible since the peasants at that time had no legally enforceable right to their customary land. They acquired property rights in the sixteenth century as the Chancery court of the Crown began to enforce customary rights. (It is ironic that eviction enclosures, which were the greatest threat to private property in late medieval England, were eliminated through arbitrary actions of the monarch that strengthened property rights.) Later enclosures were more benign. Enclosures in the seventeenth century were giant conveyances. The village was mapped and all properties identified. Then lands were reassigned to create consolidated properties. Each owner received property in proportion to his or her holdings in the open fields. These so-called enclosures by agreement required the unanimous consent of all owners, so a single individual could obstruct the process. Property rights were weakened after the Glorious Revolution in 1688 as parliament, which was controlled by large landowners, began to pass Enclosure Acts. These acts empowered commissioners and surveyors to map, value, and enclose the land as in an enclosure by agreement. Local views were consulted but unanimity was not required: An enclosure could proceed as long as the owners of about three quarters of the land were in favour. In the words of J.L. and B. Hammond (1919, p. 49), “the suffrages were not counted but weighed.” Enclosures proceeded even when a majority of the villagers opposed them. However, all *legal* rights were recognized and compensated–but not all customary practices. Parliamentary enclosures did not usually result in emigration from the village.

Enclosures by agreement or parliamentary act did not catapult a village into capitalism as the fifteenth century eviction enclosures had done. Instead, capitalism emerged within the open fields. Great estates bought up small holdings and amalgamated them into large farms operated with wage labour. Sometimes this was done to make it easier to get an enclosure by agreement. Larger properties were also formed as successful peasants bought out their less successful neighbours. This process was similar to the ‘peasant differentiation’ that Lenin (1899) argued led to capitalist agriculture in Russian villages in the late nineteenth century. In any event, enclosure and the emergence of large scale farms were distinct
processes–contrary to Marx’s original schema.

Were the feudal social relations of production conducive to the development of the productive forces? Much contemporary comment was in the negative. I concentrate on the open fields. Arthur Young (1813, 35-6), a renown agricultural improver, contrasted “the Goths and Vandals” of the open fields with “the civilization of enclosures.” This assessment

was amplified by Lord Ernle (1912,1961, p. 248) in a sweeping and highly influential interpretation: “The agricultural defects of the intermixture of land under the open-field system were overwhelming and ineradicable,” and “no increased production or general adoption of improved practices could be expected under the ancient system.” Likewise, the large scale capitalist farms were supposed to have been more innovative than small scale peasant farms since the former had to generate the cash to cover their wage bill and their rent, while the latter often owned their land and relied on family labour so they lacked the need for money that pushed the large scale tenant forward.

Our understanding of these issues has been overturned by the research of the past fifty years. Many studies have focussed on cropping patterns. Ernle’s (1912, 1961,p. 199) extravagant claim that open field farmers were “impervious to new methods” can be tested by comparing the cropping patterns in open and enclosed villages. Such comparisons generally show that open field farmers adopted many features of improved practice. This is quite clear for the seventeenth century when peas and beans were coming into widespread cultivation, for open field farmers adopted them wherever they were appropriate. Clover and turnips were widely adopted in the eighteenth century. Ernle thought that only enclosed farmers cultivated those crops, but it is clear that open field farmers did as well.

Productivity indices can also be used to compare the efficiency of open and enclosed farmers c. 1800. Rather than simply comparing the two systems at one point in time, we can also investigate how much progress each had made with respect to medieval productivity levels.

Crop yields have been one of the most frequently used indicators of agricultural productivity, and Table 1 summarizes results for the English south midlands c. 1800. To distinguish the effects of farm management from those of geography, the yield data are arranged in three districts reflecting the character of the soil. In the middle ages, the average yields of wheat, barley, oats, and beans worked out to have been 10.7, 16.8, 11.7, and 10.0 bushels per acre, respectively. Evidently, yields more or less doubled by the beginning of the nineteenth century.

How did the increase in yields compare to the difference in yields between open and enclosed farms? The greatest difference was in the heaving arable district where poor drainage was a major issue. Wheat yields were similar in both systems, but with the spring grains enclosed farms had an advantage of close to one third. The overall advantage of enclosed farming was 15%. This differential corresponded to about one quarter of the gain

that enclosed farmers had made over medieval yields. In the light arable district, where clover and turnips were the road to improvement, the yield difference between open and enclosed villages was about 6%, and, in the pasture district, where a high proportion of land was laid down to grass following enclosure, yield differences were also moderate-about 8%. These differentials corresponded to 11% and 14% of the advance made by enclosed farmers over medieval corn yields. Ernle's judgement that open field farmers were “impervious to new techniques” is wide of the mark since they accomplished 76%, 86% and 89% of the advance of the enclosed competitors depending on the natural district (Allen 1992, pp. 133-7). This conclusion is not unexpected since open field farmers were leaders in cultivating peas and beans in the seventeenth century, and legumes were an important source of the nitrogen that pushed up crop yields (Allen 2008).

We can also compare open and enclosed farming in terms of labour productivity. This has been done for the districts in the south midlands just discussed. Labour productivity equals output per worker, and in these calculations “output” is the value (in 1806 prices) of farm production net of seed and feed. The workforce is measured by the cost (at average wages) of farm labour including the value of the farmer's time.

As with yields, the comparisons show enclosed farming to have been slightly more productive. In the heavy arable district, output per worker was 11% higher under the enclosed system. In the light arable district, the advantage dropped to 3%. In most pastoral areas, the differential ranged from a 6% lead for the open fields to a 12% advantage for enclosures. The only case where enclosed farming had a substantial advantage was some old enclosures where productivity was 81% greater than in the open fields. The basis of this performance was the intrinsic superiority of the grasslands rather than the character of the farming. Parliamentary enclosures could not match it.

These differentials need to be interpreted in terms of the aggregate growth in labour productivity, which jumped over 50% from 1500 to 1750. As with yields, enclosure accounted for little of the advance. In other words, open field farmers accomplished most of the growth in productivity that occurred in the country as a whole.

Total factor productivity is a third way to compare open and enclosed farms, and it has become widely used. TFP is the ratio of farm output to an index of all of the land, labour, and capital employed in production. One reason for its popularity is that it can be inferred from land rents, which are abundantly documented (McCloskey 1972, Clark 1998). Some extra economic assumptions must be made, however: If land markets are in equilibrium, then rent differences (adjusted for differences in input and output prices) indicate TFP

differences since more efficient farmers generated more surplus than less efficient farmers, and the surplus accrued to landlords as rent. Enclosed farms generally rented at higher rates than open field farms, but the implied TFP differences were small both in absolute amount and compared to the rise in TFP between the middle ages and the nineteenth century. Moreover, the rent differential between open and enclosed farms may have overstated the efficiency differential since the assumption that rental markets were in competitive equilibrium was particularly problematic for early modern agriculture. In that case, the rent increases at enclosure may have involved income redistribution as well as income creation (Alien 1992, pp. 171-187).

The enclosure of the open fields is the most famous process that Marx considered in explaining the transition from feudalism to capitalism. However, small farms were amalgamated in the open fields to form large capitalist farms operated by wage labour, so capitalism emerged without enclosure. This raises two questions. The first is why that happened. The root cause of the change was that large scale farms employed less labour per acre than small farms, so farm amalgamation raised agricultural income. During the middle ages demesnes were usually large enough to realize the scale economies. The question is why great estates divided much of their land into small peasant farms. The answer appears to be that this system guaranteed a supply of servile labour, but the issue deserves deeper consideration. The second question is whether the advent of capitalism in the open fields explains their good productivity record. The increasing share of land in capitalist farms did contribute to the rise in labour productivity in the open fields but does not explain all of the indicators we discussed. Crop yields are an important exception. It has been possible to put together a farm level data set to measure the impact of farm size on crop yields–a well tested research approach in development economics. This investigation shows that crop yields were independent of farm size (Allen 1992). Small farms in the open fields were just as successful as capitalist farms in boosting yields.

This review of the evidence indicates that ‘feudalism’ was conducive to the development of the productive forces in early modern English agriculture. That is one reason the open fields lasted as long as they did. But if they were so good, why were they enclosed? The answer is that they were not ‘appropriate’ to the adoption of all aspects of modern technology. Contradictions arose when features of the open fields prevented technical progress, and those contradictions triggered enclosure. I highlight three instances:

First, in many parts of the English midlands, the most efficient farming system, that is the system that maximized the rental value of the land, was grazing. When the land was enclosed, it could be let to the highest bidder, and, in that case, it was converted from arable

to pasture. Agricultural employment dropped sharply and the skills and implements suitable to growing field crops became valueless. These changes threatened the incomes of open field farmers, especially small scale farmers. Their incomes depended on the factors of production that they owned. In the most favourable case of owner-occupiers, they realized the rise in rent as a rise in income, but the gain was offset by a decline in labour income. The loss could easily outweigh the gain. In the open fields, the cultivators had the power to prevent the conversion to grass since the management of the land was vested in the farm community as a whole. In the fifteenth century, lords could break this blockage by evicting the entire village, as we have seen. Once, however, the Crown acted to protect the villagers, this course of action was precluded. The upshot was that corn cultivation persisted in many villages where the conversion to pasture would have been profitable. The open field farmers often made concessions to grazing by planting grass on some of their open field strips and removing them from the normal rotation. Nonetheless, the most efficient use of the land was prevented by the feudal structure. Many of these contradictions were not resolved until the parliamentary enclosures of the eighteenth century which allowed a few large scale property owners (whose income came from rent, not wages) to ignore the wishes of the small scale proprietors.

The second example is technical progress in the heavy arable district. Table 1 shows this was the one district where enclosure resulted in substantial yield increases. The technical reason is clear. The soil in this district was heavy clay, and it was frequently flooded in the spring. The strips in the open fields were divided by furrows that acted as drains, but they did not function well. The solution was to dig so-called ‘hollow drains’ below the ground. Some went below furrows, which were property lines, and they were linked up with drains that cut across strips and property lines. Building such a system was expensive (but effective in raising yields). It proved impossible to get agreement for an expensive investment project from all of the owners affected by it. The intermixture of property in the open fields, thus, proved an insurmountable barrier to constructing a system of hollow drains. Once again, this contradiction was resolved through enclosure.

The third example relates to the adoption of clover and turnips in the eighteenth century. While open field villages did introduce these crops, they did not go as far as enclosed villages on similar soils. The later often followed the famous Norfolk four year crop rotation of turnips, barley, clover, wheat. In contrast, cropping in open field villages looks chaotic. Rather than organizing the land in four great fields where everyone did the same thing, cropping was organized around furlongs, which were subdivisions of the fields. This allowed a greater variety of behaviour–some of it inefficient and outmoded.

There is a case that villages like these were also caught in a contradiction. When the village community were largely owner-occupiers, cropping innovations like clove and turnips raising soil fertility. Some changes were responses to the development of agriculture: better seeds were selected and marketed to farmers, and better implements were made.

Some of the most important technical improvements were even less novel when considered as inventions–e.g. shifting the structure of output towards livestock and draining heavy clay. What prompted their use were changes in prices. Land was shifted to pasture, which was less labour intensive than arable, after the Black Death when the population collapse and the real wage rose. Heavy clays were drained when wheat prices rose relative to farm wages during the Napoleonic Wars. That raised the profitability of the investment in draining. Thus, while Marx's formulations capture much of what was going on, technological progress was the result of many contingent factors rather than any inherent logic that led inevitably to the present.

The transition to capitalism in manufacturing

Marx also applied his theory of technology, contradiction, and institutional modernization to manufacturing. For Marx the industrial revolution meant production by machines in a factory setting. He saw that as the culmination of a series of stages in which technological advance precipitated institutional change through contradictions. I will review these links and argue that the basic framework applies as it did in agriculture. It is clear, however, that Marx's work must be extended with more attention to the sources of technological progress and the incentives to innovate. One advantage of these extensions is that they lead to a unified account of the origins of the industrial revolution and of the reasons that it led to so much poverty even as it was creating great abundance–another Marxist theme.

The Industrial Revolution was a consequence of the transition from feudalism to capitalism. The initial questions have to be: What were the material forces of production and the social relations of production in feudal manufacturing? Were the 'social relations' appropriate to the 'material forces' as Marx claimed? Did the social relations initially promote the development of technology? Did they eventually become fetters on that development? To fix ideas, we concentrate on textiles, which was the largest industry of the middle ages, but much of what we say applies to other industries as well.

We begin with the material forces of production. The basic technology was simple machinery propelled by the power of the operator. The wool was washed by hand, and then the fibres were aligned with hand held cards or combs. Next the wool was spun on a great wheel, then woven on a handloom, fulled by people stomping on it in urine, stretched on tenter hooks, beaten with dried heads of the teasel plant, and finally trimmed with shears. These were all hand or foot operations. The technology had a low ratio of physical capital to labour, but that meant that much skill (human capital) was required to produce quality products from such simple implements. Skills were passed from one generation to the next through apprenticeships, and the organization of apprenticeships gave rise to guilds, the characteristic form of medieval industrial organization. In the high middle ages before the Black Death of 1348/9, most manufacturing was carried on within chartered towns or cities. This was useful since guilds needed legal powers, and they were acquired through municipal government– indeed, Guild Hall was the town hall of the City of London. The efficient scale of each stage in the production process was the size of a family, and the head of each family was a master who was a guild member. To ensure a broad market for its products, it was necessary to secure a reputation for high quality, and the Guild performed the function of defining standards and inspecting output. Guilds had efficiency advantages that promoted the trade.

This system of social relations encouraged the development of the productive forces. Better implements could replace inefficient ones as long as the scale of production was not affected. The spinning wheel was probably invented in the eleventh century and introduced into Europe when it replaced the spindle and distaff. The treadle and the flyer were invented later and had come into general use by the sixteenth century. In the twelfth century, water powered fulling mills superceded foot stomping in many parts of England. This was a forward looking change but could be nonetheless incorporated into the medieval mode of production.

Eventually, however, the guild system became an obstruction to technical progress. According to Marx, *Capital*, Vol. I, chapter 14, section 4:

> The rules of the guilds ...by limiting most strictly the number of apprentices and journeymen that a single master could employ, prevented him from becoming a capitalist. Moreover, he could not employ his journeymen in many other handicrafts than the one in which he was a master. The guilds zealously repelled every encroachment by the capital of merchants, the only form of free

> capital with which they came in contact. A merchant could buy every kind of commodity, but labour as a commodity he could not buy. He existed only on sufferance, as a dealer in the products of the handicrafts. If circumstances called for a further division of labour, the existing guilds split themselves up into varieties, or founded new guilds by the side of the old ones; all this, however, without concentrating various handicrafts in a single workshop. Hence, the guild organisation, however much it may have contributed by separating, isolating, and perfecting the handicrafts, to create the material conditions for the existence of manufacture, excluded division of labour in the workshop. On the whole, the labourer and his means of production remained closely united, like the snail with its shell, and thus there was wanting the principal basis of manufacture, the separation of the labourer from his means of production, and the conversion of these means into capital.

We saw earlier how Marx believed that enclosure 'separated the labourer from the means of production," and the theme is repeated as manufacturing, a capitalist form of industrial production, emerged from feudalism.

Marx emphasized how the guild system promoted the development of handicrafts, which was necessary for the emergence of the division of labour within an enterprise. Why that perfecting was necessary, and why the transition to manufacturing could not have occurred earlier is not so clear.

Marx's age of manufactures spanned the two century run up to the Industrial Revolution. "That co -operation, which is based on division of labour, assumes its typical form in manufacture, and is the prevalent characteristic form of the capitalist process of production throughout the manufacturing period properly so called. That period, roughly speaking, extends from the middle of the 16th to the last third of the 18th century." (Marx, *Capital*, Vol. I, chapter 14, section 1) Businesses became larger as more employees were hired. The craftsman executing all of the stages in the manufacture of the product was replaced by a series of workers each specialized in a single stage of the process. These workers were located in large workshops, or they worked in their cottages in rural villages. The tools and equipment were not fundamentally different from those of the high middle ages, and skilled workers were necessary for many stages in the production process. "Since handicraft skill is the foundation of manufacture, and since the mechanism of manufacture as a whole possesses no framework, apart from the labourers themselves, capital is constantly compelled to wrestle with the insubordination of the workmen."

This system self-destructed in the eighteenth century. The reason was that the 'workshop mode of production' was applied to the manufacture of machines themselves. "This workshop, the product of the division of labour in manufacture, produced in its turn – machines. It is they that sweep away the handicraftsman's work as the regulating principle of social production. Thus, on the one hand, the technical reason for the life-long annexation of the workman to a detail function is removed. On the other hand, the fetters that this same principle laid on the dominion of capital, fall away." (Last section of 14).

There are two problems with this statement. The first is the elusive nature of the contradiction that Marx claimed to have apprehended. How does a workshop with its division of labour prevent the introduction of machines? Machines certainly were introduced into settings where there was a division of labour among hand workers. Second, the industrial revolution did not happen because workshops began to produce cheap machines. When Arkwright licensed firms to use his water frame, there was no engineering industry where the machines could be purchased. Would- be cotton manufacturers had to figure out how to make the machines themselves. The only development that looks like Marx's theory occurred in the watch industry. Watches driven by internal springs were invented in the seventeenth century, and a large industry to fabricate them developed in England. Watches needed precisely made gears, and inventors like Henry Hindley invented machines to cut gears. As it happens the cotton spinning industry was located in southern Lancashire, and gear makers from the watch industry were hired by cotton masters to make the gearing in Arkwright water frames. That is as close as Marx's account gets to historical reality.

We can argue that the Industrial Revolution was the result of a contradiction if we graft induced innovation onto Marx's theory. I continue to focus on the textile industries. Hobsbawm (1968, p. 56) once remarked that 'Whoever says industrial revolution says cotton," and, indeed, the invention of machine processes in the cotton industry revolutionized the British economy.

Why were Hargreaves' spinning jenny and Arkwright's water frame invented in Britain in the 1760s and 1770s? Why not in France or India? Why not in the sixteenth or seventeenth centuries? The short answer to the questions is that the first time and the first place that it became profitable to use the early vintage spinning machines was in Britain in the eighteenth century. It would not have paid to use spinning machines before the eighteenth century–hence, they were not invented earlier. Nor would it have paid to invent them elsewhere. These conclusions turn on the character of machine technology–it

increased the capital labour ratio compared to hand technology–and on the changing structure of inputs prices in Britain in the seventeenth and eighteenth centuries: As Marx's manufacturing era took off, labour markets in Britain tightened and wages rose relative to the price of capital. The rise in the price of labour made it profitable to use the initial, primitive versions of the jenny and the water frame. Once that occurred, it became profitable to do the experimental engineering that constituted 'invention' in the textile industries. Invention occurred in response to changing factor prices, and the first spinning machinery was invented to save on expensive British labour.

The story starts at the end of the sixteenth century. England had a large supply of cheap long staple wool, partly as a result of the early enclosures, and this wool was the raw material for a highly competitive weaving industry. Exports and output grew even more as the British empire expanded during the seventeenth and eighteenth centuries. Mercantilist polices and imperial warfare channel the demand from an every greater part of the globe onto Britain, and her manufacturing industries grew further. Marx, *Capital*, Vol. I, chapter 31, emphasized the importance of colonies and the imperial system for the growth of manufacturing in Britain, and he was right to do so.

In understanding the inventions, I do not draw a sharp distinction between cotton and other fibres like wool and linen. The first attempts to spin by machine were made on these fibres, and eventually all were spun by machine. In Marx's manufacturing era, spinning and weaving were done in peoples' homes rather than in workshops or factories, so I refer to the production system as the cottage mode of production.

The invention of spinning machinery in the eighteenth century was the result of the successful expansion of the cottage mode of production in the seventeenth. In 1600 all the wool spinning done in England could have been accomplished by 18% of the women working part time as spinners. Britain had a favourable supply of cheap long fibre wool that could be made into worsted cloth that had a buoyant market in the Mediterranean. As England acquired more colonies in the next century and a half, the wool market got much bigger. In the eighteenth century cotton spinning added to the labour demand, for much cotton was exported to West Africa to pay for slaves. Around 1700, Britain exported 40-60% of its woolen cloth. By 1770 the share of the women needed to spin all the wool had risen to 62%. This tightening of the labour market caused women's wages to rise sharply–from 30% of a man's wage around 1600 to 75% in 1770. This increase had a big impact on the incentive to invent machinery. The first spinning machines were an expensive way to save labour and not very good at it. Figure 1 shows what the rate of return would have been, had

early versions of the jenny and the water frame been introduced at different dates in the seventeenth and eighteenth centuries. In the seventeenth century when spinners' wages were low, the machines would have generated only a few percent of profit. The returns leaped to 20% - 35% per year in the eighteenth century, as spinners' wage rose. The machines were invented in the eighteenth century because that is when it was profitable to use them.

We can extend this analysis internationally by computing the rate of return to using spinning jennies and water frames in France and India. In both of the countries, the wage of spinners relative to the price of equipment was much lower than it was in England. As a result, the rates of return to using spinning machinery were negligible. The French were well aware of these machines. John Holker was an English Jacobite, who fled to France in 1750 where he established himself as a cotton manufacturer. In 1754, he succeeded in being appointed Inspector General of Foreign Manufactures, charged with importing foreign technology. In 1771 he sent his son to Lancashire to report on the new machines, and his son brought back a jenny. This was copied and made available to French producers; indeed, the state subsidized its use. It was installed in some large scale factories but was otherwise ignored by the cotton trade. In 1790, there were about 900 jennies in France–less than 5% of the number in England (Aspin and Chapman 1964, p. 49, Wadsworth and Mann 1931, p. 195-99, 503-4).

Many Englishmen responded to the opportunity by trying to invent spinning machines. Wyatt and Paul almost succeeded with roller spinning in the 1740s and 1750s, but their Birmingham mill ultimately went bust. Hargreaves perfected his jenny in the mid1760s, and it was the first successful machine. He was inspired by watching a spinning wheel rotate after it had fallen on its side. Afterwards, he contrived to run a row of vertical spindles off a common horizontal wheel using wooden clamps to pull the yarn in imitation of the spinner's fingers. In 1767, Arkwright hired John Kay, a clockmaker, to make a machine using rollers, which took five years to perfect. Both Hargreaves and Arkwright also invented carding machines to prepare the cotton for spinning. Arkwright established a factory at Cromford to house his machines. He improved the lay-out when he built his second mill, and it became the prototype for cotton mills in Europe and the USA. A decade later, Crompton combined elements from Haargreaves and Arkwright's designs to create the mule, which became the principal spinning machine in Britain in the nineteenth century. Once in operation, of course, they were improved through 'learning by doing' as engineers observed their operation and perfected them. Hargreaves' and Arkwright's machinery made Britain the

world's low cost producer of coarse yarn, and the mule made Britain the low cost producer of fine yarn as well.

History repeated itself in weaving. Hundreds of spinning mills were erected in the 1780s. The price of cotton yarn dropped sharply, and the weaving industry expanded to process all the yarn. Weaving, however, remained a cottage industry using traditional handlooms. Employment exploded, reaching a quarter million (10% of the adult male workforce) in the early nineteenth century. As with spinners a century earlier, the wages of the weavers also leaped up, and the 1790s and first decades of the nineteenth century witnessed 'the golden age of the handloom weaver.' The Reverend Edmund Cartwright thought it would be simple to design a weaving machine. He was inspired by automatons– the clockwork dolls that mimicked the movements of humans. If a mechanical woman could play a harpsichord, perhaps she could also weave calico? The task proved to be immensely complex. Cartwright wasted his fortune working on it for decades, and other inventors took up the challenge. It was not until the 1820s that the power loom was improved sufficiently to challenge the handloom weavers.

In both spinning and weaving, the cottage mode of production contained the seeds of its own destruction–a contradiction in Marxist terms. When the cost and demand situation was favourable, the cottage mode responded with large increases in employment and output. As employment approached the limits of the available labour force, the earnings of people with the necessary skills rose, and those high wages became the target of inventors, for the high wages meant that comparatively poorly designed machines could turn a profit. The contradiction was resolved as the factory mode of production superceded the cottage mode.

Was there 'trickle down' growth?

The transition from the cottage to the factory mode of production increased productivity and raised the national income. How widely were the gains to growth distributed? Marx famously argued that they would not 'trickle down' to the working class since rapid technical progress would create chronic unemployment. Competition for the jobs would permanently depress wages. Was this the story of the industrial revolution?

Figure 2 throws some light on the matter. The big divide was between workers, on the one hand, and the middle and upper classes on the other. The division is highlighted in

Figure 2, which plots the average real wage as well as real output per worker. While the latter doubled during the century of the Industrial Revolution, the former only increased 50%. Moreover, the rise in the real wage occurred at the end of the period. From 1770 to 1830 there was no discernible rise in the average real wage, and only a 5% increase in the 1830s. It was only after about 1840 that the average worker began to participate in the progress of the Industrial Revolution.

Why was that so? Marx (capital I, chap 15, section 5) attributed it to technical progress and particularly to the mechanization of production processes that had formerly been done with hand technology.

> The...machine...becomes a competitor of the workman himself ....So soon as the handling of [the] tool becomes the work of a machine...the workman becomes unsaleable, like paper money thrown out of currency by legal enactment. That portion of the working-class, thus by machinery rendered superfluous ...either goes to the wall in the unequal contest of the old handicrafts and manufactures with machinery, or else floods all the more easily accessible branches of industry, swamps the labour-market, and sinks the price of labour-power below its value.

The consequences were striking in the cotton industry The invention of the cotton spinning mill drove down the price of cotton yarn and made it unremunerative for women to spin. The earnings of domestic spinners dropped from 12 d. per day in 1770 to 5d. by 1795 (Feinstein 1998, p. 190). Most of these women were in the countryside, and there was nothing else for them to do. Family income dropped as a result. Male farm labourers rarely earned enough to keep their families at a ‘respectable standard of living’ (with a diet of white bread, beef, and beer), so the family had to subsist on cheaper sources of calories (oatmeal and potatoes) when men were the sole providers. This is shown in Figure 3 where the earnings of a southern agricultural labourer, assumed to work full-year, full-time are plotted. In the sixteenth and seventeenth centuries, his earnings were too low to purchase the respectable standard of living, and his wife’s were not substantial enough to close the gap. This is clear in Figure 3, where the wife’s earnings have been added to the man’s to show family incomel. The situation changed between 1700 and 1775 due to the rise in spinners’ wages. In this ‘golden age’ the family earned twenty percent more than necessary to purchase the respectability standard. After 1775, this favourable situation reverted to the earlier pattern of insufficiency, as the wife’s earnings collapsed. The political discourse of the time focussed on the plight of the agricultural labourer since his earnings were not

sufficient to keep his family at the respectable standard of living. The immediate cause of the problem lay not in agriculture, however, but in the collapse of cottage spinning. One of Marx's famous contentions is that technological change would lead to large job losses and immiseration. Hand spinning is the first example of that prediction coming true.

The technological unemployment resulting from machine spinning was a foretaste of more problems in the nineteenth century. Figure 4 shows how wage inequality exploded during the Industrial Revolution. I focus on the cotton hand loom weavers and building and agricultural labourers in Lancashire. Figure 4 shows the annual earnings of a fully employed worker deflated by the cost of a subsistence basket that kept a family at the famous $ 1 a day poverty line. In 1770, the difference in earnings among these groups was small: The building labourers, who received the highest wage, earned only about one quarter more than the handloom weavers, who had the lowest. The handloom weavers' earnings shot up at the end of the eighteenth century as the industry expanded to weave the yarn from the newly built spinning mills. These high wages marked the Golden Age of the handloom weaver. It was also their undoing for the high labour costs in weaving were the spur to the engineers who perfected the power loom. As the power loom got better and faster, the price of cotton cloth fell and with it the earnings of hand loom weavers. Their incomes slumped to bare bones subsistence after 1830. Marx thought the effects were catastrophic. "History discloses no tragedy more horrible than the gradual extinction of the English hand -loom weavers, an extinction that was spread over several decades, and finally sealed in 1838. Many of them died of starvation, many with families vegetated for a long time on 2½ d. a day."[2] By 1840, the labourers were earning three times what the hand loom weavers took in. The farm labourers occupied an intermediate position and realized a small increase in the real wage over the period. The clear winners were the building labourers whose real earnings doubled by 1850.

Throughout the first half of the nineteenth century, one hand trade after another was destroyed as machinery was adopted. Incomes fell in each trade as a consequence, and displaced workers were forced into other trades limiting wage growth. The average real wage showed little increase between 1780 and the 1840s, while real GDP per worker grew by 50%. This was the reality that Marx tried to model.

[2] Globalization spread the negative repercussions around the world. Marx quotes the Governor General of India who described the impact of machine made cloth on India in 1834-35: "The misery hardly finds a parallel in the history of commerce. The bones of the cotton-weavers are bleaching the plains of India

Conclusion

Marx's vision was that institutional change was the result of technological change. Traditional (feudal) institutions could accommodate a surprising amount of technical progress, especially in agriculture. However, there were limits to what could be changed. Some new technologies in agriculture and industry could not easily fit into the traditional institutions. This 'contradiction' was resolved by replacing the traditional institutions with modern, capitalist systems of organization. We have discussed many examples of these processes. To that degree, Marx's view is vindicated.

Marx said little about why new technology was invented or the incentives that might have led people to adopt it. Perhaps this is not surprising for a 'technological determinist,' although Marx was aware that new technology was the result of human actions. In the case of agriculture, we argued that some of the most important changes in technology were promoted by changes in wages and prices that raised the profitability of animal husbandry after the Black Death and sub-soil drainage during the wars between England and France around 1800. In the case of the textile industry, we argued that the invention of machinery was promoted by the profitability of using it (why invent something that would not be used?), and that profitability, in turn, depended on wage rates relative to the cost of capital. One wonders whether these emendations to Marx's schema are not really the crux of the problem. They have certainly occupied many economists and historians. Issues like the rise of the factory can be discussed without using Marx's jargon but not without considering how and why the factory became profitable when it did.

Marx's theory of contradictions slides easily into Schumpeter's well know theory of 'Creative Destruction,' partly, of course, because Schumpeter's theory was a meditation on Marx. Schumpeter's reformulation of Marx is useful since it brings out clearly the reasons that the Industrial Revolutin led to widespread poverty as well as progress.

Schumpeter (2003, pp. 82-3) emphasized that the important competition that capitalism unleashes is not between similar firms in the same industry producing the same product, but rather from the introduction of radically new processes and modes of production.

> The fundamental impulse that sets and keeps the capitalist engine in motion comes from the new consumers' goods, the new methods of production or transportation, the new markets, the new forms of industrial organization that capitalist enterprise creates...The opening up of new markets, foreign or domestic, and the organizational development from the craft shop and

> factory to such concerns as U.S. Steel illustrate the same process of industrial mutation...that incessantly revolutionizes the economic structure *from within*, incessantly destroying the old one, incessantly creating a new one. This process of Creative Destruction is the essential fact about capitalism.

The Industrial Revolution illustrates this dynamic: The Industrial Revolution was preceded by the expansion of the cottage mode of production. The first activity to be revolutionized was spinning, as we have seen. Once the cottage sector got large enough–and wages high enough–the incentives for the invention of the factory mode of production fell into place.

This new production system destroyed the cottage mode as it expanded and replaced it. “Progress entails..[the] destruction of capital values in the strata with which the new commodity or method of production competes.” ‘Destruction of capital values’ meant not only that outmoded spinning wheels were tossed in the back of the barn, but also that the women with the skills to operate them could no longer earn a living. Their incomes collapsed in the face of machine competition. It was a general problem in Britain: the spinners were the first example of mass technological unemployment. The loss of these earnings pushed up poverty in the late eighteenth century since many families could no longer afford bread, beef, and beer and had to make due with oatmeal and potatoes.

It was déjà vu all over again with the power loom. The supply of cheap yarn from the new cotton mills led to the expansion of handloom weaving to turn the yarn into cloth. As the sector expanded the earnings of weavers rose prompting inventors to try to save on the now expensive labour by creating the power loom. Once they succeeded, the handloom weavers were doomed. The power loom was improved throughout the 1830s and 1840s and relentlessly drove down the price of cloth. Fewer hours of labour were needed to weave a yard by machine than by hand, and costs were cut further by employing women as weavers in place of the men who wove in their cottages. The income of handloom weavers fell accordingly since they were paid for each yard they wove and their productivity did not increase. Poverty grew among the 250,000 handloom weavers, and gradually they were forced into other work where their competition exerted downward pressure on wages. Again poverty accompanied progress.

Technology evolved along the same lines, for the same reasons, and with the same results, in all of the hand trades. A big reason the Industrial Revolution had happened in Britain was because it had developed a very large handicraft manufacturing sector in the seventeenth and early eighteenth centuries. This led to the high wage economy that prompted the invention of the factory and labour saving machinery in general. The standard of living question was so extreme and working class living standards lagged for so long because the handicraft sector was so large. Evidently, when any particular trade was mechanized, earnings in that branch dropped, and that decline, in itself, lowered the average wage of workers. Over and beyond that, the displaced workers looked for jobs elsewhere, and their competition put a damper on wages across the economy. The traditional manufacturing sector was not liquidated until the middle of the nineteenth century, and only then did wages begin to rise generally. One of the virtues of Schumpeter's metaphor is that it unites the two faces of the Industrial Revolution: the progress was the 'creative' consequence; the poverty the 'destructive' consequence. That is certainly how Marx saw it.

It would be extremely valuable to test Marx's conclusions against the experience of developing countries to see which are true or how they should be modified to fit different circumstances. The following themes are central and worth investigating for the light they would throw on the present circumstances and future prospects of developing countries.

First, Marx, as we have seen, has a very endogenous view of institutions: Old institutions are replaced when they become obstacles to the adoption of new technology. How true is that? Agriculture provides at obvious arena for investigating this view since much land in Africa, for instance, has been communally owned and operated. This presents obvious parallels with the open fields and raises the question of whether the privatization of this land–its enclosure–affects technical change and productivity growth. To what degree is communal ownership compatible with modernization and to what degree does it present obstacles. If communal ownership inhibits agricultural modernization is it readily changed, which would be Marx's expectation, or does it persistent, blocking progress?

Second, we argued that much modern technology saved costs by substituting capital for labour, in which case, the profitability of adopting the improved methods depends on the price of labour relative to capital. The research question becomes: To what degree is the adoption of modern technology precluded by low wages in poor countries? Are there differences between sectors or between types of technology? How do relative

factor prices interface with institutions? Do outmoded institutions inhibit adjustments to factor prices or do prices trump institutions?

Third, a particularly important example is the weaving of cotton cloth. While the factory production of cotton yarn undercut hand spinning virtually everywhere by the middle of the nineteenth century, the advantage of factory weaving was much less pronounced. In the late nineteenth and early twentieth centuries in the Middle East and India, factory weaving and hand weaving were both viable in competition with imported British cloth. The factory was not productive enough to render hand weaving uncompetitive at the prevailing, low wage. Even today, in many poor countries–Bangladesh, for instance, and Ethiopia–weaving is still done by hand. Government policy plays a role since employment in handloom weaving is high. But is the persistence of hand technology solely driven by policy or do relative factor prices play a role. Is there any evidence that institutional rigidities are also important in the persistence of hand technology?

Fourth, did the shift from archaic to modern institutions have any systematic effect on the distribution of income? For instance, are societies with communal property ownership systems more egalitarian than those with private property, which was Marx's conjecture. Is the relationship between the property system and inequality mediated by technology or is it a direct one?

Fifth, does the Marx-Schumpeter analysis of inequality during the Industrial Revolution apply more widely. In other words, to what degree is poverty in poor countries today the result of new modes of production rendering old modes obsolete and their workforces impoverished?

Table 1

Crop Yields and Enclosure, c. 1800

	open bushels/ acre	enclosed bushels/ acre	enclosed relative open	enclosure gain relative to progress since Middle ages
Heavy Arable District				
wheat	19.7	20.2	2.2	5.3
barley	26.5	31.8	20.0	35.3
oats	23.5	33.0	40.4	44.6
beans	18.8	22.2	18.1	27.9
average	21.2	24.1	14.7	23.8
Light Arable District				
wheat	20.0	19.7	-1.5	****
barley	27.0	29.3	8.5	18.4
oats	26.5	32.5	22.6	28.8
beans	19.9	18.1	-9.0	****
average	23.4	24.7	5.6	10.9
Pasture District				
wheat	20.9	21.9	4.8	8.9
barley	28.0	32.2	15.0	27.3
oats	36.9	38.1	3.3	4.5
beans	22.4	23.4	4.5	7.5
average	24.7	26.7	8.1	14.2

Note:

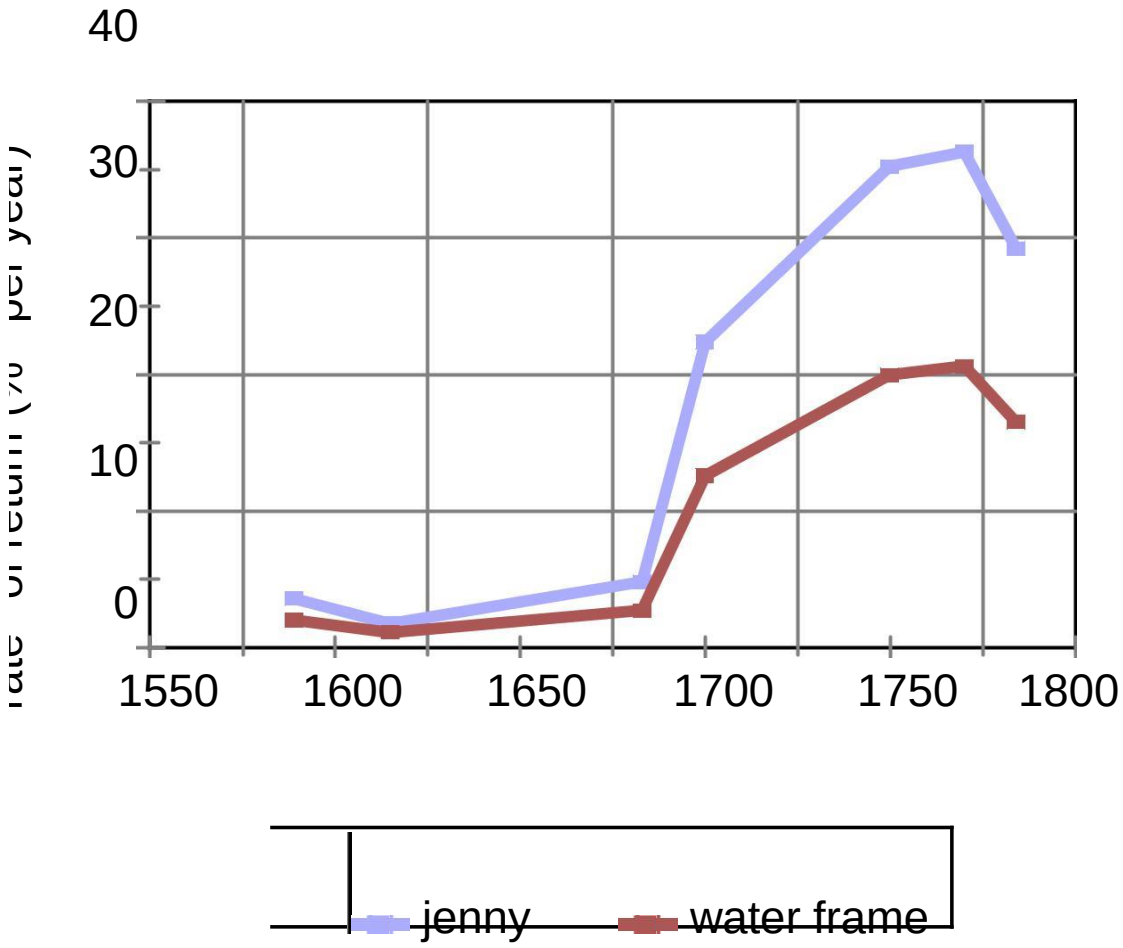
"Enclosure gain relative progress since middle ages" equals the difference between the open and enclosed yield divided by the difference between the enclosed yield and medieval yields. These were taken to be 10.7 bushels per acre

for wheat, 16.8 for barley, 11.7 for oats, and 10.0 for peas and beans. For the "average" medieval yield, I computed a weighted average using eighteenth century weights.

Source: Allen (1992, p. 136).

Figure 1

Profitability of using spinning machines at various dates



Source: Allen (2015).

Figure 2

GDP per Worker versus the Average Real Wage

Source: Allen (2016).

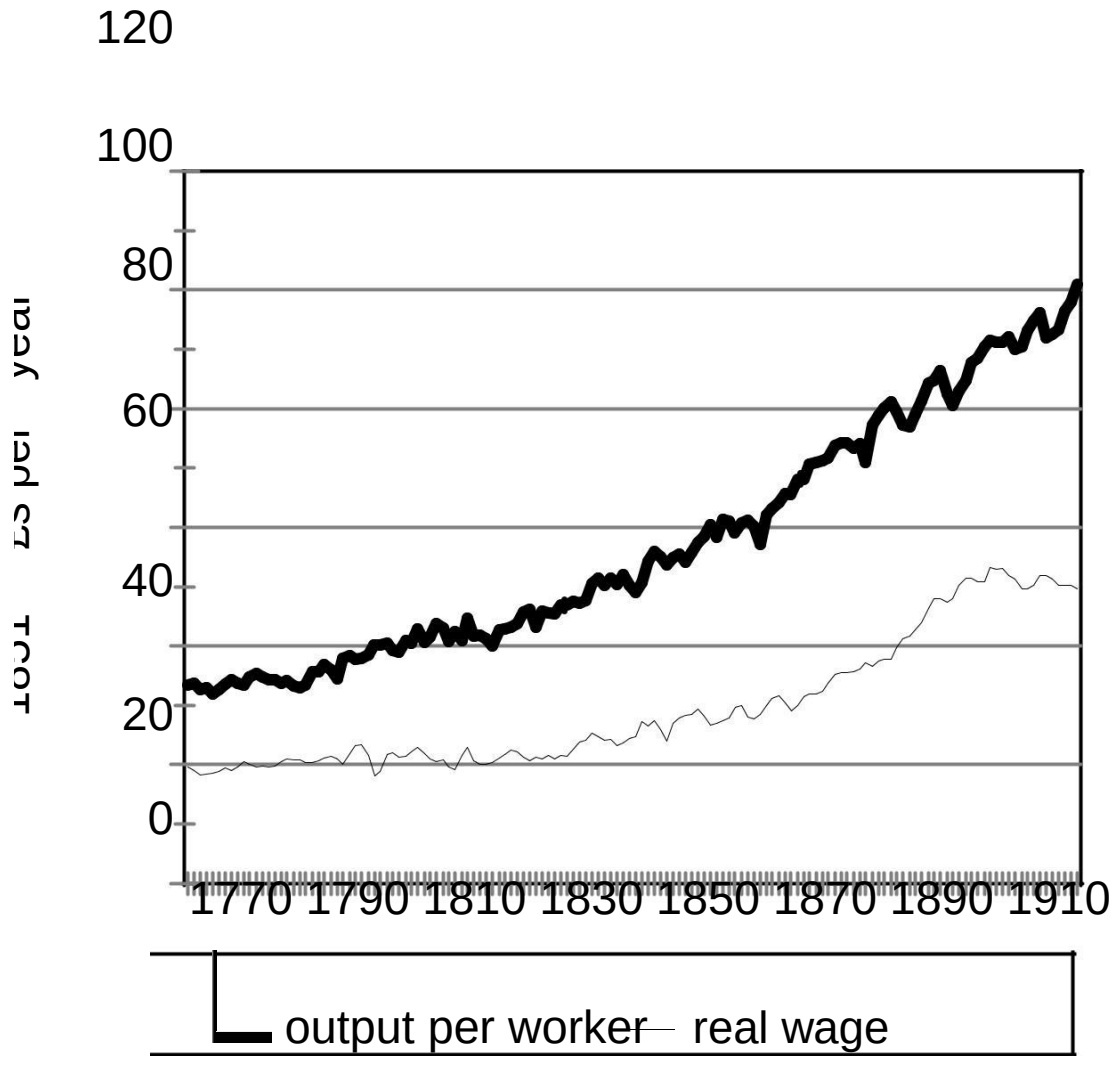
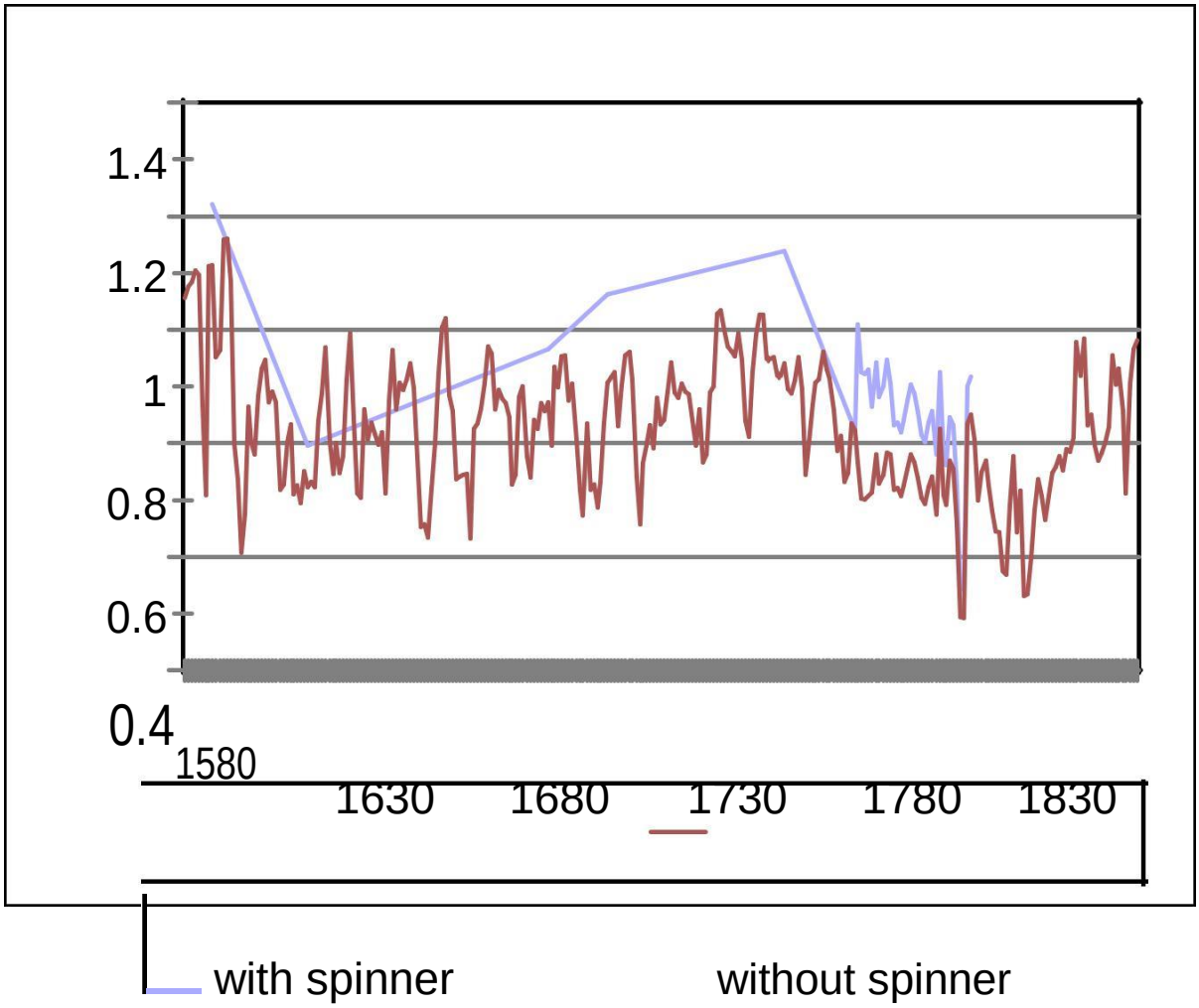


Figure 3

Family earnings relative to cost of ‘respectable’ standard of living

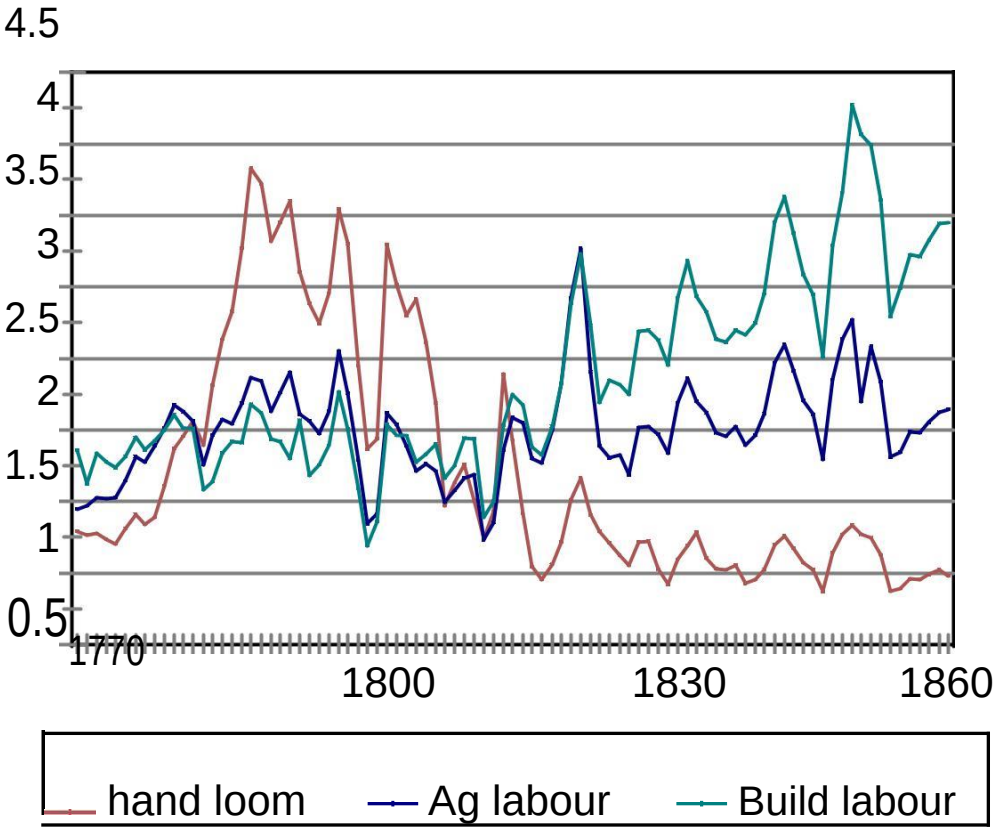


Source: Allen (2015).

Figure 4

Wage Inequality in Lancashire during the Industrial Revolution

(1 = World Bank Poverty Line)



Source: Allen (2016).

References

Acemoglu, Daron (2008). *Introduction to Modern Economic Growth*, Princeton, Princeton University Press.

Allen, Robert C. (1992). *Enclosure and the Yeoman*, Oxford, Clarendon Press.

Allen, Robert C. (2008). "The Nitrogen Hypothesis and the English Agriculture Revolution: A Biological Analysis," *Journal of Economic History*, Vol. 68, pp. 182-210.

Allen, Robert C. (2009a). *The British Industrial Revolution in Global Perspective*, Cambridge, Cambridge University Press.

Allen, Robert C. (2009b). "Engel's Pause: Technical Change, Capital Accumulation, and Inequality in the British Industrial Revolution," *Explorations in Economic History*, Vol. 46, Number 4, October, 2009, pp. 418-35.

Allen, Robert C. (2015). "The High Wage Economy and the Industrial Revolution: A Restatement," *Economic History Review*, Vol. 68, No. 1, pp. 1-22.

Allen, Robert C. (2016). *The Industrial Revolution: A Very Short Introduction*, Oxford, Oxford University Press.

Aspin, C., and Chapman, S.D. (1964). *James Hargreaves and the Spinning Jenny*, Preston, Helmshore Local History Society.

Bailey, Mark (2014). *The Decline of Serfdom in Late Medieval England: From Bondage to Freedom*, Martlesham, Boydell Press.

Clark, Greg (1998). "Commons Sense: Property Rights, Efficiency, and Institutional Change," *Journal of Economic History*, xx

Cohen, G.A. (1978). *Karl Marx's Theory of History: A Defence*, Princeton, Princeton University Press.

Ernle, Lord (1912). *English Farming: Past and Present*, London, Heinemann Educational Books Ltd and Frank Cass and Company Ltd, 1961.

Feinstein, Charles H. (1998) . "Pessimism Perpetuated: Real Wages and the Standard of Living in Britain during and After the Industrial Revolution," *Journal of Economic History*, Vol. 58, pp.625-658.

Hobsbawm, Eric (1968). *Industry and Empire*, London, Weidenfeld & Nicolson.

Hoskins, W.G. (1950). "The Leicestershire Farmer in the Sixteenth Century," in W.G. Hoskins, ed., *Essays in Leicestershire History*, Liverpool, pp. 123-183.

Hoskins, W.G. (1951). "The Leicestershire Farmer in the Seventeenth Century," in

W.G. Hoskins, ed., *Provincial England, London*, Macmillan & Co Ltd, 1963, pp. 149-169.

Lenin, Vladimir Ilyich Lenin (1899) . *The Development of Capitalism in Russia: The Process of the Formation of a Home Market for Large-Scale Industry*, from *Lenin's Collected Works*, 4th Edition, Moscow, Progress Publishers, 1964, Volume 3, pp. 21-608, internet: "Marxists Internet Archive"

Marx, Karl (1867). *Capital: A Critique of Political Economy*, Moscow, Progress Publishers, First English edition of 1887, Marx/Engels Internet Archive (marxists.org) 1995, 1999, Volume I.

Marx, Karl (1859). *A Contribution to the Critique of Political Economy*, Moscow, Progress Publishers, Marx/Engels Internet Archive (marxists.org)

Marx, Karl, and Engels, Freidrich (1948). *Manifesto of the Communist Party*, Marx/Engels Selected Works, Vol. One, Progress Publishers, Moscow, 1969, pp. 98-137; Marx/Engels Internet Archive (marxists.org) 1987, 2000.

McCloskey, D. (1972). "The Enclosure of Open Fields: Preface to a Study of Its Impact on the Efficiency of English Agriculture in the Eighteenth Century," *Journal of Economic History*, vol. 32, pp. 15-35.

Schumpeter, Joseph A.(2003). *Capitalism, Socialism, and Democracy*, Taylor & Francis e-library.

Wadsworth, Alfred P. and Mann, Julia de Lacy (1931). *The Cotton Trade and Industrial Lancashire, 1600-1780*, Manchester, Manchester University Press.

Yelling, J.A. (1977). *Common Field and Enclosure in England, 1450-1850*, Hamden, Connecticut, Archon Books.