Agricultural Productivity and Rural Incomes

in England and the Yangtze Delta, c. 1620- c. 1820

By

Robert C. Allen
Nuffield College
New Road
Oxford OX1 1NF
United Kingdom

Email: bob.allen@nuffield.oxford.ac.uk

2004

When did Europe pull ahead of China? Until recently, that was a settled question: Europe was always in the lead. The only question was why.

That was how the classical economists saw the matter. They took Europe's preeminence as a fact and explained it with their own theories. Thus, Adam Smith (1776, pp. 20, 72, 189, 206) thought that "rice in China is much cheaper than wheat is any-where in Europe," but wages were lower still. "The difference between the money price of labour in China and Europe, is still greater than that between the money price of subsistence; because the real recompence of labour is higher in Europe than in China." As a result, "the poverty of the lower ranks of people in China far surpasses that of the most beggarly nations in Europe." Malthus (1973, pp. 199, 128-9) shared this view for characteristically demographic reasons. He believed that early marriage lead to high population in China and India with the result that "the lower classes of people were reduced to extreme poverty...The population would thus be pressed hard against the limits of the means of subsistence, and the food of the country would be meted out to the major part of the people in the smallest shares that could support life." Marx and Engels emphasized the mode of production. The hot climate meant that "artificial irrigation is here the first condition of agriculture." (Quoted by Blaut 1993, p. 83) Large, bureaucratic states emerged in response. They owned the land, and they were the source of prosperity. "Oriental despotism" stifled individual initiative, and productivity stagnated.

Many subsequent historians have shared these views. Mark Elvin (1973, pp 215, 309) echoed the classical critique in his description of eighteenth century China. It had "a per-acre agricultural productivity that was already the highest in the world." That did not lead to mass prosperity, however, "for it was the expansion of the population which produced that combination of <u>high-level</u> farming and transportation technology with a <u>low</u> per capita income which perceptive economists since Adam Smith have recognized as the distinctive characteristic of China in the seventeenth and eighteenth centuries." In <u>The European Miracle</u>, Eric Jones (1981) traces Europe's lead a superior natural environment, more restrained fertility, the hydraulic state, and greater rationality. Most recently, David Landes (1998, pp. 22, n. *, 27) argued that the Han outbred other Asians. 'In effect, this pattern of maximum reproduction enhanced political power, in terms both of combat fodder and of material for territorial expansion. In the last analysis, this was the story of Chinese aggrandizement over less prolific societies.' As the Chinese occupied the great river valleys of central and southern China, they organized cultivation to maximize food production and population. Landes endorses Marx's hydraulic argument, as elaborated by Wittfogel (1957): 'the management of water called for supralocal power and promoted imperial authority.' Chinese history was like a 'treadmill' in which more people led to a bigger empire (in geographical terms), which led to more food, which led to more people. The result was always mass poverty.

This interpretation of global history has been called into question in recent decades. The reassessment has several strands. One emphasizes that coastal Asia all the way from the Persian gulf to Japan was more urbanized and produced higher quality manufactures than Europe throughout the early modern period (Adas 1989). Asia was the manufacturing powerhouse of the world economy, and Europe was a backward periphery. Europe's ultimate ascendancy is, then, often traced to the lucky discovery of America with its vast silver resources that financed the European take-over of Asian commerce and finally the governance of much of the continent itself (Frank 1998). Another strand consists of critiques of the theories of Smith, Malthus, and Marx as they have been elaborated by later historians (Blaut 1993). The precariousness of property, the despotic governments, the high fertility demography, and the hydraulic state have all been subjected to withering attack (Lee and Wang 1999, Pomeranz 2000, Wong 1997).

While the theoretical explanations of Europe's advance have been called into question, the factual basis of that advance has received less attention. Not that it has been ignored: One of the most provocative assertions in Ken Pomeranz's Great Divergence (2000, p. 49) is his claim that "it seems likely that average incomes in Japan, China, and parts of southeast Asia were comparable to (or higher than) those in western Europe even in the late eighteenth century." The opening phrase shows the tentativeness of this reassessment and is the motivation of this paper.

The Pomeranz generalization is certainly debatable. It conflicts with Maddison's (1995) estimates of real GDP per head in the early modern period, which put Europe far ahead of Asia. But Maddisons' figures are based on backward extrapolations from 1990 income levels and are, thus, contaminated by all the errors in the national growth rates as well as reflecting 1990s relative prices that differed considerably from those in early modern Europe and Asia. As Prados de la Escosura (2000) has shown, using early nineteenth century prices as weights can radically change the income levels. Parthasarathai (1998) has tackled the question by computing the difference in real wages between textile workers in England and India in the mideighteenth century. The comparisons do support the revisionist case, but much more evidence is needed to sustain the argument for Asia as a whole. Most of the case for Asia's parity with Europe rests on estimates of consumption that contain large doses of judgement. Certainly, Asia had large cities, skilled manufacturers, and dynamic entrepreneurs, but just how productive were they and how did their incomes compare to those of their counterparts in Europe?

This paper aims to expand the evidence for judging Asian performance by comparing productivity and incomes in agriculture. Agriculture was the largest sector of the early modern economy, so any judgement of overall performance hinges on farming. For that reason, agriculture has figured prominently in recent debates about Asian performance–for instance, the exchange in the Journal of Asian Studies between Huang (2002), Pomeranz (2002), and Brenner and Isett (2002). These comparisons are typically limited to a few crops–rice and wheat in the Yangtze and wheat in England. While these were important, agriculture in both regions was much more than carbohydrates. Meat, butter, and wool were produced by English farmers, and Chinese farmers also raised pigs and chickens and cultivated mulberry trees and cotton (the last has sometimes been included in intercontinental comparisons). A complete analysis of agriculture requires consideration of all of its products. The task is particularly important since the animal and vegetable activities reinforced each other synergistically in both Europe and China: In China, the pig and the water buffalo produced manure that fertilized the paddy field and, in turn drew nourishment from the rice and wheat straw, while, in England, sheep grazed the wheat stubble in the fallow fields manuring them as well. This paper attempts a comprehensive analysis of agriculture at the regional level to include all aspects of farm production. In addition, it addresses the complex index number problems that arise in intercontinental comparisons by using purchasing power parity exchange rates to convert Chinese to English money.

The questions can be approached from either a Eurocentric or a Chinacentric perspective. I begin with Europe. The literature on the comparative study of European agricultural productivity is very large. Figure 1 is my own attempt to delineate its broad patterns from 1300 to 1800 (Allen 2000). One can always debate the details and the methods underlying that figure, but the results are consistent with widely held views on the subject. The key question is which countries had agricultural revolutions.

Figure 1 distinguishes three trajectories of productivity growth. First, most of the continent exhibited low productivity modulated by population movements. The Italian series is representative. It shows a rise in output per worker following the Black Death, and then a persistent decline as population grew in subsequent centuries. There is no evidence of an 'agricultural revolution' before the nineteenth century. Second, in contrast, present-day Belgium had high labour productivity in the middle ages, and that advantage continued throughout the period although productivity sagged under the weight of population growth. Medieval Flanders was renowned for the efficiency of its farms and the density of its cities, and those leads are reflected in the Belgian figures. Third, two countries–England and the Netherland–had agricultural revolutions in the early modern period. In 1500, their productivity was not markedly higher than elsewhere, but by 1750 they had closed the gap with Belgium. The economies of northwestern Europe led the continent, and their high agricultural labour productivity was an essential ingredient of their success since it meant that each farm worker could feed and clothe several workers in commerce and manufacturing.

Where would China fit in Figure 1? Like Europe, China was diverse. Ideally, one would ascertain the distribution of good and bad regions in both continents and compute a weighted average of overall efficiency, but that is too ambitious a program for the moment. Instead, I concentrate on the Yangtze Delta. It was the most advanced region and was, thus, the counterpart of England or the Netherlands. There were about 7 million acres of cultivated land in the Yangtze–about one fifth of England's 34 million acres of arable, pasture, and meadow. On the other hand, the population of the Yangtze Delta was several times England's. The labour-land ratio was considerably higher in China than in Europe.

The comparison of England and the Yangtze Delta raises two questions–one of levels and one of trends. As to the first, in 1800, was output per farm worker in the Yangtze like that in England or in Italy or somewhere off the graph? As to the second, did Yangtze agriculture experience an agricultural revolution like England or the Netherlands or did productivity fall under the impact of population growth as in Italy? The only way to answer the questions is through a careful comparison of productivity levels at the two ends of Eurasia, and that is an objective of the present paper.

These questions also arise if we approach the comparison of Europe and China from the Chinese historiography. It contains sharply opposed characterizations of farm performance.

Involution is the most widely held view of Chinese agriculture[1], and its roots run back to the classical economists. In this view, technology is seen as essentially static. Over time, the population grew and farms were subdivided. Farmers worked more days on each hectare and, as a result, output per hectare rose. Perkins (pp. 1969, pp. 14-29) estimated that yields rose by almost half between 1400 and 1770, and that increase is consistent with involution. But the obverse of that growth was a fall in output per day of work as labour ran into diminishing returns. And lower labour productivity, in turn, implied a lower real income from farming. By the same token, falling farm income induced a redeployment of labour out of agriculture into cotton spinning and weaving. This was a sign of desperation rather than progress, and the flood of textiles lowered their price, so rural industry made scant contribution to family income. Population growth in China led to immiseration.

A spectrum of revisionist views challenge the hypothesis of immiseration. The most contrary is Li Bozhong's (1998) thesis that the Yangtze Delta experienced an English or Dutch style agricultural revolution between 1620 and 1850. According to Li, there was little change in the land under cultivation in the Yangtze Delta throughout the period: Farmed

[1]As most argued most recently by Brenner and Isset (2002) and Huang (1990, 2002).

land remained constant at about 45 million mu (3 million hectares). Population was about 20 million in 1620, dropped in mid century due to war and famine, and rebounded to 20 million c. 1690. From then until 1850, there was steady growth to 36 million. Land per farm family fell from 15 mu in 1620 to 9 mu in 1850 (Li 1998, pp. 19-27). Li defends the peasant family farm as a mode of production well suited for raising productivity. He estimated that rice yields jumped from 1.7 shi per mu to 2.5 over the period, and that the double cropping of wheat, soy beans, and rapeseed expanded from 40% of the rice area to 70% (Li 1998, pp. 139-40). Family labour was redeployed in cotton spinning and weaving. All of this is grist for the Involutionists' mill. Where Li parts company is in his treatment of farm labour. The increase in output per hectare was accomplished with only a minor increase in days worked, so the rise in output per mu translated into a rise in output per day worked–contrary to the Involutionists. "My conclusion is the opposite of the conventional view that 'heavy population pressure' reduced labour productivity in farming in early and mid-Qing Jiangnan. The reduced size of Qing farms did not reduce per worker labour productivity on the farm. On the contrary, labour productivity rose." While progressively more of the labour of Yangtze farm families was allocated to cotton spinning and weaving, Li maintains that these were well remunerated activities. Higher agricultural labour productivity and expanded incomes from textile production implied a rise in peasant living standards between 1620 and 1850–not a fall (Li 1998, pp. 152-3).

None of the other revisionists are as optimistic as Li. While Goldstone, Pomeranz (2000, 2002), and Wong (1997, p. 19) deny that output per worker was falling as the population was growing, they do not follow Li in claiming that labour productivity actually rose. Instead, the more widely held view is that Yangtze farmers improved their methods enough to offset the depressing effects of population growth on productivity but not enough to reverse them. Output per worker, in this view, remained constant in Yangtze farming over the seventeenth and eighteenth centuries.

Careful measurement is the only way to discriminate between these contending views. This paper attempts that task by comparing land and labour productivity in the English midlands and the Yangtze Delta c. 1820. Calculations for the Yangtze c. 1620 are also presented to assess trends over time and provide a comparison with the trajectories in Figure 1.

The calculations are quite detailed. Before plunging into them, it is important to highlight their overall structure. For each region, the land use pattern and number of farm animals is first specified. The gross output of each crop and animal product is calculated by multiplying area or number by yield. Costs of production are deducted to compute net output. Dividing total net production by land area gives output per hectare.

Output per worker is also computed, and that requires estimates of employment. These are based on the land use patterns, animal numbers, and production estimates. Employment is analyzed on a task-by-task basis. The labour for most tasks is specified on a per hectare basis, so the total days required for harvesting, for instance, equals the hectares to be harvested multiplied by the number of days per hectare required. Employment in threshing and husking labour, however, are functions of the gross production rather than the area planted. Totalling up the days of labour gives the total used in agriculture. Dividing total net production by total days of farm labour gives output per day.

The employment estimates developed here do not include labour outside of the farm sector that might, from a very broad point of view, be tallied as agricultural labour. Thus, the labour used to enclose land, plant hedges, maintain rural roads, scour water courses, and clean and maintain sluices, are excluded from the English estimates, as is the labour embodied in purchased farm machinery. Likewise, the Chinese estimates do not include labour to build dykes or public infrastructure (Wagner 1926, Elvin 2004). In both cases, the labour deployed by farmers in the course of their own operations to drain or irrigate their own land is included in the reckoning. It would be desirable to estimate the labour implicit in all of the related and supportive activities, but the task would be very difficult. As a first step, I concentrate on the work of farmers, their spouses and children, and their employees.

English productivity

The measurement of English productivity is based on a detailed analysis of agriculture in the south midlands around 1800. This region consisted of about 2.3 million acres of farm land–about 8% of the English total.[2] Particularly detailed information is available for this region, and that facilitates the international comparisons undertaken here. In addition, the overall character of farming in the south midlands–the mix of crops and livestock, for instance–was similar to that of English agriculture in general. The average rent of farm land in the south midlands, however, was about 20% above the national average in 1810-11 (McCulloch 1857, Vol. I, p. 551), and this suggests that total factor productivity in the south midlands exceeded the national average by about 7%.[3] An adjustment for this difference is made when the Yangtze record is juxtaposed to that of England in Figure 2.

In an earlier analysis of the south midlands, I divided its agriculture into three natural districts where soil and climate indicated differences in farm operations (Aqllen 1992). Each of these districts is divided in two for present purposes depending on either geographical or institutional factors. The overall picture of agriculture in the south midlands is therefore a weighted sum of six subdivisions defined as follows:

--The pasture district was the largest, and there the most profitable use of the land was dairying, raising sheep or fattening cattle, although grain production was also usually pursued as a subsidiary activity. In 1800, this district was almost entirely enclosed. Agriculture was more productive and more oriented to animal products in the more elevated parts of Leicestershire and Northamptonshire than in the lower land in Cambridgeshire or Buckinghamshire, so I distinguish an upper and a lower pasture district with a different model representing each.

–The light arable district was the second largest. The most profitable farming system required keeping about 80% of the land arable, and planting it with the famous Norfolk rotation (turnips-barley-clover-wheat). In 1800, about 60% of the district was enclosed, and the rest was open. While considerable modernization of cropping and yields had occurred in the open villages, they were not as wholeheartedly committed to the Norfolk rotation as were enclosed farmers, so I define separate models for the open and enclosed portions of the district.

–The heavy arable district was the third. As in the light arable district, the most profitable use of the land was as arable. However, the tenacity of the soil meant that drainage was a major problem. About 60% of the land was enclosed in 1800, and the enclosed farmers

---

[2]The south midlands, as defined here, contained 2.85 million acres (Allen 1992, p. 34) of which about 80% were arable, pasture, and meadow. The corresponding figure for England in 1800 was 29.1 million acres (Allen 1994, p. 104).

[3]If rent was one third of costs, a 20% rent premium implies a 7% (the cube root of 1.2) advantage.

reaped higher yields since they more frequently installed subsurface drainage. As with the light arable district, I have developed separate models for open and enclosed farmers.

The information on land use, livestock numbers, and crop yields was taken from Richard Parkinson's (1808, 1811) General View[s] of the Agriculture of Huntingdon and Rutland as well as a more limited survey for Buckinghamshire (Priest 1813). These reports were commissioned by the Board of Agriculture and had great authority although the authors approached their task in individual ways. Parkinson was a social surveyor, who conducted an agricultural census of his counties. He reported critical variables like land use, yields, and livestock numbers on a parish-by-parish basis. Cross classifying this information by soil type and enclosure status is the basis for the regional farming portraits. Table 1 provides summary information on the land use patterns, crop yields, and live stock numbers in the south midlands.

The estimate of net output involved a sequence of calculations. Each subdivision of the south midlands contained arable, pasture, and meadow, and the arable was broken down into acres of fallow, wheat, barley, oats, beans, clover, and turnips. Clover and turnips, as well as the hay from the meadow, were consumed by animals on the farm and so contributed nothing to net output. The production of wheat, barley, oats, and beans are calculated by multiplying the acreage of each by the yield.[4] Net output was then determined by deducting the volume retained for seeds and fed to animals as fodder. The farms also supported horses, cows, calves, beef cattle, pigs, and sheep. Horses produced no net output, but the other animals produced butter, beef, veal, pork, mutton, and wool, the production of which was determined by multiplying livestock numbers by yields. In most cases, livestock were bred on the farm, but in the cases where animals were purchased for fattening, output is defined as the value added on the farm–i.e. the cost of the animal to be fattened was subtracted from the value of its products.

Total output of the farm is the value of the net output of each of its nine products. Parkinson reports the average prices received by farmers for all of these products, and I use his prices to aggregate output.

The measurement of labour also presents practical and conceptual difficulties. Most English farming was done by large-scale, capitalist enterprises exclusively devoted to agriculture. They did not produce manufactures, so these farms present no problems in separating proto-industrial activity from agricultural. In the case of the English farms, we can compute the total number of days worked in each task from information collected by Thomas Batchelor's General View of the Agriculture of the County of Bedford (1808).

While Parkinson was a social statistician, Batchelor was an accountant. He devoted about 100 pages of his General View to working out the costs of farm operations. This was not an unusual exercise for the day. Arthur Young (1770) produced volumes of farm costs and notional income statements to analyze all manner of farm improvements. Batchelor, however, was exceptionally single minded in his endeavour. He paid great attention to detail

---

[4]The English farms never grew enough oats to feed the horses. Consequently, the net output of oats was negative. This is entirely appropriate: feed grains are treated in the same way as animals purchased for fattening. Farm output is net of intermediate inputs. (It may be that beans or other feed grown on the farm was given to the horses. Deducting the notional value of purchased oats has the same effect as estimating the utilization of beans as feed and subtracting it from the gross output of beans.)

and showed care in estimating the more variable elements of costs. He estimated the cost of shoeing horses and repairing their harness, for instance, 'by reference to some old blacksmiths' bills' (Batchelor 1808, p. 89). This care suggests his discussion deserves careful attention.

There are two other reasons for relying on Batchelor and Parkinson. First, the costs implied by their figures agree with other sources, namely, Arthur Young's (1768, 1771a, 1771b) survey of farms c. 1770 (Allen 1992, p. 162). In his tours of England, he reported the details of several hundred farms including their size and permanent workforce. By estimating the labour supplied by the farmer and his family and adding on the additional labour employed at the harvest, employment per acre can be computed. The result agrees with Batchelor's figures collected a generation later. The employment figures are plausible in terms of the size of a farm workforce. Thus, arable farms used 1600-1700 days of labour per 100 acres. If 300 days equal one year, then the average workforce of a 100 acre farm was between 5 and 6. There was a harvest peak, of course, and allowing for that would imply a somewhat smaller number of workers employed on a full time, continuous basis. These workers included the farmer and his family as well as hired employees.

Second, the Batchelor-Parkinson data imply an internally consistent representation of farming in financial terms. I have computed revenues and all costs for the average farms implied by Parkinson's survey (Allen 1992, pp. 176-9). Ricardian surplus–the difference between revenue and non-land costs–can be calculated and compared to rent and taxes. In general, rent plus taxes were of the same order as surplus, although there were discrepancies, particularly for pastoral farms with large amounts of farmer supplied capital (livestock). Either Batchelor's costing is less exact in these cases or farmers had a poor idea of their costs since most of them were implicit interest and depreciation rather than explicit payments as in arable farming. Probably both issues were involved.

Yangtze Delta

Tables 2 and 3 summarize land use and animal numbers in the 1820s (mid-Qing) and 1620s (late Ming) for the Yangtze Delta. The former is better documented–although many parameters are poorly established as we will see–and is the comparator for the English midlands in c. 1806. The figures used here are mainly derived from Li's Agricultural Development in Jiangnan, 1620-1850 (1998) and subsequent papers (Li 2002).

The Yangtze Delta was intensively cultivated. About 95% of its 45 million mu of farm land were divided into rice paddies in both 1620 and 1820. The remaining land was planted with cotton or mulberries. Some of the surface was double cropped with wheat, soy beans, and rapeseed.

The principal innovation transforming Yangtze agriculture from 1620 to 1820 was the increasing availability of beancake. It was the by-product of pressing soy beans to extract oil. The fibrous residue was rich in nutrients and served as fertilizer and fodder. The residue from pressing cotton seeds to extract their oil was a close substitute and had been available as long as cotton was grown. Imports of beancake into the Yangtze were modest in the sixteenth century, but rose dramatically in the seventeenth with the opening of trade with Manchuria. That province exported wheat and beancake to the Yangtze in exchange for cotton cloth and tea (Elvin 1973, p. 214). In the early eighteenth century, production of soy beans increased in northern China and a growing volume were shipped to the Yangtze by the Grand Canal. Imports from Northeastern China continued to grow after 1750 (Li 1998, pp. 113-4).

Northern and northeastern China were the "ghost acres" that transformed Yangtze agriculture in several ways. First, beancake was used as fertilizer and was responsible for a rise in the yield of rice. Throughout the Ming and Qing, farmers spread traditional fertilizers–human and animal manure, grass, mud, and green manure–on their fields before planting rice. The innovation of the seventeenth century was to apply a second dressing of oil cake as the rice was growing[5]. Oil cake was much more efficacious, kilogram for kilogram, than the traditional fertilizers. Farmers exploited this by shifting from early to late maturing strains of rice, which were more fertilizer responsive. While the traditional fertilizers were labour intensive, oil cake required little labour to cart and spread on the fields. On the other hand, oil cake had to be purchased for cash, whereas the traditional fertilizers were largely made on the farm.

The impact of beancake on rice yields has been the subject of considerable debate, but most of the discussion centres on the early seventeenth century[6]. There is surprisingly little disagreement among scholars as to the average yield of rice in the first half of the nineteenth–Li (1998, p. 125, 2002) has offered figures between 2.3 and 2.5 shi per mu, while Brenner and Isett (2002, p. 84) suggest a range of 2.0 to 2.5 shi per mu and plump for the middle–2.25 shi, a figure that Huang (2002) also accepts. These figures apply to husked rice. I use a figure of 2.3, which is in the middle.

The situation is far murkier c. 1620. Li Bozhong (1998, p. 125) suggests an average yield of 1.7 shi per mu–implying as much as a 47% increase to 2.5 c. 1800. This suggestion is based on a calculation of the consumption needs of the population rather than direct evidence. Citing Perkin's figures, Brenner and Isett (2002, p. 31) suggest a yield of 2.1 shi in 1600 implying a 27% increase, while noting that the work of Zhao Gang, Liu Yongcheng, Wu Hui et al. (1995) indicates an even small increase.

I have chosen to follow Li in this regard and work with a yield of 1.7 shi per mu c. 1620 implying a yield increase of .6 shi per mu in the following two centuries. This choice is based on consistency with other figures when they are evaluated in terms of the farm accounting model developed subsequently: in particular, a smaller yield increase (i.e. a higher yield in 1620) would not generate enough extra revenue to cover the cost of the additional fertilizer applied to the land in the midQing. This calculation includes changes in double cropping, labour use, livestock numbers, and so forth. One advantage of an explicit farm accounting model is that it helps narrow the options by imposing consistency among the elements of the calculation in this way.

Second, the greater use of beancake led to more extensive double cropping. Both Li (1998, p. 33) and Brenner and Isett (2002, p. 33) presume that 40% of the land was planted with wheat, beans, or rapeseed c. 1600 and 70% c. 1800. The increase in double cropping raised output per hectare for the farm as a whole. There is no evidence that the yields of these crops rose in this period. In the absence of much information, all scholars assume that

---

[5]Indeed, Brenner and Isett (2002) emphasize that many farmers were applying a second coating of beancake by the end of the eighteenth century. I suggest later that this was done by feeding the beancake to farm animals and then applying their manure to the land.

[6]The poor quality of the data is striking: Perkins (1969, pp. 309, 318-9) and Li Bozhong (1998, p. 214, n29) cannot even agree as to whether their early modern sources are reporting the yield of unhusked paddy or husked rice. Since a litre of unhusked paddy gave roughly half a litre of husked rice, the difference is of some consequence!

wheat, for instance, yielded 1 shi per mu and required .1 shi of seed. I do the same.

The third aspect of Yangtze agriculture to be transformed by beancake was animal husbandry. Few draught animals were used in 1620–almost all of the work of ploughing, harrowing, and land preparation were done by human labour. By 1820, oxen and water buffalo were widespread (Li 1998, pp. 43-46). The numbers shown in Table 3 were estimated from Buck's (1937, Vol. 3, pp. 133-4) survey data for the 1930s of farms of roughly 9 mu in area. On the face of it, the greater use of animals is hard to understand in view of the decline in farm size from 15 to 9 mu. The explanation, however, appears to be the much greater availability–and presumably lower price–of beancake in 1820 compared to 1620. The real pay-off to these animals was probably not in their work but in their manure, which was applied to the fields and helped push up the yield of rice.

The situation was probably similar for pigs. Few were kept in the late Ming, while many farms had them in the mid Qing. Beancake was their principal food. Their pork was a useful addition to the diet, but manure was their most valuable product. Batchelor (1808, p. 106) referred to sheep as "living dung carts," and the same could be said of Yangtze buffaloes and pigs.

The value of farm production is the sum of the net output of rice, wheat, beans, rapeseed, pork, raw cotton, and raw silk. Prices from the 1820s are used for both the late Ming and mid Qing to measure changes in the volume of production. The value of seed and purchased beancake are deducted to compute net output. There is debate about these costs. At one extreme is Li (1998, p. 139), who maintains that 'production costs per mu of rice were equivalent to about 1 shi of rice in both periods,' that is, the late-Ming and the mid-Qing. These costs were predominantly fertilizer costs, although they presumably also included other costs, which are hard to detect in historical documents such as the occasional renting of draught animals. These costs are high compared to those of other writers, and their magnitude is an essential ingredient for Li's agricultural revolution, as we will see. Brenner and Isett (2002, Appendix B) rely on Li Wenzhi's assertion that production costs were 15% of gross output which comes to .36 shi per mu with a yield of 2.4. Li also maintained that 'costs for wheat were about 1/4 of those of rice, or .25 shi of rice/mu, in the latter period.'[7] Brenner and Isett (2002) accept this figure.

Li's fertilizer costs appear too high: The fertilizer applied in the early seventeenth century was largely produced on the farm, in which case, the cash cost was zero. The work involved was included in the labour input. The beancake applied in the late eighteenth century cost about .6 tael (.35 shi of rice) per mu. This is consistent with Li Wenzhi's estimate that rice production costs amounted to 15% of output with a yield of 2.4 shi per mu. Fertilizer costs were negligible for the early seventeenth century.

To compute output per day worked, it is necessary to estimate the number of days worked in agriculture in the Yangtze in c. 1620 and c. 1820. Several approaches have been taken to this problem. In the case of wheat and rice, Li, Brenner, Huang, have estimated the days required to cultivate a mu and harvest and husk its output. Li Bozhong (1998, p. 217, n. 13) claims that 'rice cultivation in Ming-Qing Jiangnan, from preparing the soil through to harvesting, required about 10 work days/ mu. If we add the labour for pumping water and collecting and transporting fertilizer the total is 15 workdays/mu.' Transporting fertilizer

[7].25 shi of rice corresponds to .357 = .25/.7 shi of wheat. This includes seed, which Li (1998, p. 111) reckons at .1 shi per mu, so the fertilizer and other costs amounted to .257 shi of wheat per mu.

amounted to about 2 days,[8] so water pumping came to 3 days. Li thought that wheat required much less labour–only 3 days per mu. In addition, Li's (1998, p. 152) analysis of family labour utilization indicates that further labour was required 'for husking and braning'. Li computes this at the rate of one day per shi of rice or wheat expressed as rice equivalents (by multiplying a shi of wheat by .7). Brenner and Isett (2002) presumed that rice required 11 days per mu while Huang (2002) chooses 10 days. On the other hand, these authors tally the labour required for wheat production at 7-13 days per mu. Since much of the land was double cropped, especially in the eighteenth century, the higher rating for wheat compensates for the lower rating for rice implying similar totals c. 1800. These estimates apply to cultivation without draught animals. According to Li (1998, pp. 72-3), their use cut the labour time for rice by several days per mu.

A second approach to measuring labour requirements is Buck's (1937, Vol. 3, pp. 314-9) survey in the 1930s. He endeavoured to measure the number of days per acre required to cultivate all of the crops analyzed in this paper. These data reflect the use draught animals as in the early nineteenth century; indeed, the technology appears to have changed little, so early twentieth century data may give an accurate description of earlier employment. Buck's labour requirements are similar to those of Brenner and Issett and Huang once allowance is made, along the lines suggested by Li, for the economies in employment due to the use of water buffalo. My calculations use Buck's survey results since they encompass all of the crops, but the results for wheat and rice do not differ materially from those suggested by the work of other scholars.

While the crops are dealt with in this way, it should be noted that there is very little information about the labour devoted to pigs, chickens, and water buffaloes. I have estimated these requirements arbitrarily based on European information and common sense: for instance, Batchelor's data imply that the care of a horse required about 45 minutes a day, and I have applied the same requirement to Chinese draught animals. In the absence of any information, I posit that each Chinese farm family that kept chickens had three and spent 18 minutes per day feeding them and gathering their eggs.

Ynagtze Delta versus England: Productivity

To compare productivity in England and the Yangtze Delta, land, labour, and output must be measured commensurably. Land and labour can be measured in acres (or mu) and days. There is some uncertainty as to the length of the day–but little can be done about that–and measuring land by extent ignores differences in environmental capability. These are captured in the productivity measures with the result that they do not indicate which country had the better farmers. Output, however, presents special problems in view of the use of prices to aggregate the products.

The agricultural output of each country was computed by valuing the net output of every product using the money of that country–pence for England and copper cash for China. A conversion factor is necessary to make these monetary valuations commensurable. The exchange rate is an obvious candidate: in terms of the price of silver in each country, one

[8]Li (1998, p. 95) reports that the cost of transportation in rice cultivation was .125 taels per mu, which equalled about 2 days labour.

pence was worth 20.29 copper cash[9]. This ratio, however, is a misleading indicator of the value of money since 20.29 copper cash purchased much more in China than did one pence in England: for instance, one pence bought 259 grams of wheat in England, while 20.29 cash got 539 grams in the Yangtze (Table 4). This kind of problem frequently arises with exchange rates, so economists resort to 'purchasing power parity' (PPP) exchange rates for international comparisons of productivity and living standards. These exchange rates are indices of the relative prices of a basket of commodities in the two countries (Summers and Heston 1988, 1991, Maddison 1995, O'Brien and Keyder 1978).

In the case at hand, a PPP exchange rate has been computed using the prices of rice, wheat, beans, pork, and fibre. Wheat, beans, and pork were produced in both countries. Rice, of course, was not grown in England, but it was sold, so its price is observable. Farmers had the option of producing it, but chose not to since its cultivation would not have been profitable at that price under English conditions. For fibre, I use the price of raw wool in England and raw cotton in the Yangtze. As with rice, the calculations could be done using the price of raw cotton in England since so much was imported, but the results would scarcely change since the prices of wool and cotton were similar.

Table 4 shows the prices of these items in English and Chinese money. Rice was very expensive in England (and still not produced there!). For the three foods produced at both ends of Eurasia, the Chinese price in cash was 9 - 13 time the English price in pence. Only in the case of textile fibres was the ratio of the Chinese to the English price of the same order as the exchange rate, a point emphasized by Broadberry and Gupta (2003).

Table 4 also matches the price relatives to shares suggested by the structure of gross agricultural output shown in the Yangtze and English midlands in 1820 (Tables 1 and 2). Many index numbers can be computed with these shares, and they do not entirely concur. Table 4 shows weighted arithmetic averages of the price relatives using both south midlands and Yangtze shares. These Laspayres and Paasche indices are 7.0 and 10.0. The geometric average of these indices is the Fisher Ideal with a value of 8.3. The Fisher Ideal index has many desirable properties compared to the Laspeyres and Paasche, and for that reason has been dubbed a "superlative" index by Diewert (1976). Another superlative index is the Törnqvist or Divisia index, which is a weighted geometric average of the price relatives where the weights are average shares. This index is also shown in Table 4 and has a value of 7.4. The Fisher Ideal and the Törnqvist indices are the best choices and are closer to each other than the Laspayres and Paasche but still leave a range of values for the PPP exchange rate. Since a choice between the Fisher Ideal and the Törnqvist indices is arbitrary, I use an average of the two (a value of 7.9 copper cash per pence) in the comparisons that follow.

Using this exchange rate, Table 5 compares agricultural inputs and outputs for the English midlands and Yangtze Delta in the early nineteenth century. Days worked per acre were about eight times higher in China than in England, and output per acre was nine times higher. These disproportions would not have surprised Smith, Malthus, or Marx. What is perhaps surprising is how well China does when labour productivity is the standard of performance. Output per worker in the Yangtze was 84% of output per worker in the English midlands.

Table 5 also includes measures of agricultural output and inputs for the Yangtze in the

---

[9]This is exchange rate is implied by the weight of one tael (31.066667 grams of silver), one penny (.46 grams of silver), and the exchange rate of 1370 cash per Tael (Li 2002, ftnt 25). 20.29= .46/(1370/31.066667).

early seventeenth. Output is measured in prices of the 1820s to facilitate comparison. Population growth led to only a small increase in employment per acre over these two centuries. Evidently, there was little change in land or labour productivity.

In the introduction to the essay, I asked how the Yangtze Delta mapped into the European experience summarized in Figure 1. Land in the south midlands rented for 7% more than land in England as a whole [10] implying a 7% productivity advantage for the region vis-a-vis the country. Allowing for this implies that labour productivity in the Yangtze Delta was 90% of that in England in 1800. As Figure 2 shows, the Netherlands and England had a small lead on the Yangtze in 1800, but in 1600, the Delta was ahead of them and, indeed, of present-day Belgium. Throughout the seventeenth and eighteenth centuries, labour productivity in the Yangtze Delta exceeded that in France, Germany, Spain, Italy, and the other continental economies. The constancy of labour productivity in the Yangtze Delta over the seventeenth and eighteenth centuries confirms the views of the moderate revisionists like Pomeranz, Goldstone, and Wong. The finding contradicts the expectations of both the Involutionists, who expect falling labour productivity, and of Li, who expects rising productivity.

It is instructive to see why Li's agricultural revolution does not appear in Figure 2. Both his data and mine show gross production per mu rising from 1620 to 1820 as the yield of rice increased and double cropping expanded. Also, in both cases, there is little change in days worked per mu over the two centuries. Li and I agree, therefore, that gross output per day worked increased. What is relevant, however, is net output per day, and, to determine that, costs, in particular fertilizer costs, must be subtracted from gross output. In my calculations, nothing is deducted for fertilizer c. 1620, while a large deduction is made in 1820 due to the large volume of bean cake applied at that date. The cost of the beancake offset the rise in gross output producing constant labour productivity. Li, however, subtracted the same expense for fertilizer in both 1620 and 1820. Subtracting the same number from gross output in both years means that net output rises by Li's reckoning. Hence, his agricultural revolution. But, as I argued earlier, little fertilizer was purchased in 1620, so there is no fertilizer cost to deduct in that year. Hence, Li's increase in net output per day is spurious.

China versus England: The Income of the Rural Population

Agricultural productivity is important for understanding economic development, but it is only indirectly relevant to Pomeranz's contention that incomes in China c. 1800 were at least as high as those in Europe. To address that issue, I can use the data for measuring agricultural productivity to compare incomes in the Yangtze delta to those in the English midlands.

An important question is whose income should be compared to whose. Most of the farm land in England had passed from small scale family farms to large scale farms operated by wage labourers, and those labourers were far more numerous than the remaining small scale farmers. The situation was very different in the Yangtze where most of the population were peasant cultivators. If we want to compare the "bulk of the rural population" we should

[10] The average rental in Bedfordshire, Berkshire, Buckinghamshire, Cambridgeshire, Huntingtonshire, Leictershire, Northamptonshire, Oxfordshire, Rutland, Warwickshire exceeded that of England as a whole by 7% in 1814/15. See McCulloch (1857, Vol. I, p. 551) for the rents.

concentrate on English agricultural labourers and Yangtze peasants.

Despite the differences in the mode of production, there were similarities in the two situations that need to explored. In both the midlands and the Yangtze, men did most of the agricultural work, and their earnings comprised most of the family income. Women contributed to the family income in both regions through the domestic production of textiles. Overall family incomes can be compared as well as the earnings of men and women.

To compare English and Yangtze earnings, we must convent copper cash prices to pence. The same issues arise here as arose in the context of productivity comparisons. The solution is to construct an international consumer price index. Table 6 shows details. Six commodities are distinguished: rice, wheat, bread, beans, pork, and cotton cloth. Beans, pork, and cotton cloth were consumed in each country; however, there were marked differences in the carbohydrate portion of the diet. In the Yangtze, it consisted of rice and wheat porridge (Li 1998, p. 207, n.25). In contrast, bread was the staple in England. Prices are needed for all goods in both regions even if they were not consumed.[11]

Table 6 also shows Paasche, Laspeyres, Fisher Ideal, and Törnqvist indices. The average of the last two was 7.5 copper cash per pence, and that will be used to compare the purchasing power of earnings. This exchange rate differs little from the value of 7.9 worked out for the productivity comparisons.

Chinese incomes are the more complicated since they are earnings from business operations. By subtracting rent from net farm income, agricultural earnings per day can be derived from the estimate of output per day. Most Yangtze peasants in the early nineteenth century paid a rent equal to half of the rice crop. Peasant farmers produced 405 copper cash from each day's work, but only received 229 cash. The difference was rent.

How did this compare to the earnings of a farm labourer in the south midlands? In the early nineteenth century, men earned 50 d. per day during the 5 weeks of harvest, 27 d. per day during the 5 weeks of hay making, and 18 d. for the remaining 42 weeks of the year. The average wage over the year was, therefore, 22d. per day. The purchasing power of 229 copper cash was 30.5 (=229/7.5) pence per day. This calculation puts the Yangtze peasant considerably ahead of the English labourer. The matter, however, is a bit more complex. The Yangtze peasant cultivating 9 mu only worked 184 days per year. This short work year was the result of the subdivision of farms. In contrast, a fully employed farm labour in England could expect to work about 275 days per year. If we compare average daily earnings over the course of 365 days, the Yangtze peasant would make 15 pence per day (30.5*184/365), while the English labourer would earn 17 pence (22*275/365).per day. The Englishman had a small lead. No doubt, the Yangtze peasant did not spend half his year in idleness, but whether he could earn much money outside of agriculture or textile production (to be considered) is open to doubt. Based on agricultural earnings, male incomes in the English midlands and the Yangtze Delta look similar in the early nineteenth century.

Chinese women earned income from spinning and weaving cloth (Li 1998, pp. 152-3). The total labour devoted to these tasks can be calculated from the production of cotton (as shown in Table 1) in the Yangtze: the implicit assumption is clearly that there was no net importation of raw cotton into the region c. 1820, so the production of cloth was determined

[11]No bread price was available for the Yangtze Delta. I estimated a value using the "bread equation" in Allen (2001). This equation shows how bread prices in European cities depended on the price of wheat and the wage rate. Yangtze values were substituted into the equation to determine what bread would have cost had it been produced in the European way.

by the production of raw cotton. Li assumes that 3 catties of unginned cotton gave 1 catty of ginned cotton, which, in turn, yielded 1 bolt of cloth.[12] Each bolt of cloth required 6 days of labour around 1800. With these ratios, cloth production and manufacturing employment can be calculated from raw cotton production.

This estimating procedure, which is based on Li's aggregate calculations, implies less output and employment than Li (1998, pp. 151-5) estimated when he analysed family income. In that exercise, he subtracted the labour used in agriculture from his estimate of the family labour supply (300 days of male labour and 200 days of female.) These calculations, which assume full employment in the Yangtze and the allocation of all labour to textiles that was not used in agriculture, imply much greater production than was feasible given the estimates of cotton production in the Delta. Requiring consistency between the estimates of average family income and the production of raw cotton in the Delta implies lower family incomes than Li's calculations.

The production of cotton cloth must be valued and added to agricultural income to establish the well being of families. This result depends on the price of cotton cloth. Its history has been a very contentious issue. I follow Li (1998, p. 149) in assuming that net income from a bolt of cloth was worth 10 litres of rice (.255 Tael) c. 1820.

Whether this was a high or low value has been much debated. In the early nineteenth century, women earned 58 cash per day in cotton textile manufacture–about 8 d. per day at 7.5 cash per pence. At the same time, women in England earned half to two thirds of the daily wage of men–that is, 11-14 d. per day. This comparison of purchasing power indicates very low earnings for women in the Yangtze cotton industry.

How did overall family incomes compare in the Yangtze Delta and the English midlands? If we combine, average earnings from an average size farm, average employment in weaving and spinning cotton, and, in addition, include the entire value added of silk manufacture,[13] the implied value for family income, averaged over 365 days, is 140 copper cash per day or 19 d. per day at the exchange rate of 7.5 cash per pence. In the south midlands, agricultural labourers earned 17 pence per day averaged over the whole year. Horrel and Humphries (1992, pp. 855-9) and Horrell (1996, pp. 568-70) have used contemporary budget surveys to measure family incomes and expenditure patterns, and they find that the earnings of women and children increased family income 20% above the earnings of the labourer. Allowing for these earnings raises the family income to 20 d. per day. This is scarcely more than the earnings of the Yangtze peasant family. Pomeranz's revisionism is supported by these data.

Conclusion

The evidence on income and productivity surveyed here supports the revisionist

---

[12]The ratios are plausible since they imply that cloth weighed .3 pounds per square yard. See also Li (1998, p. 33). Pomeranz (2000, pp. 322, 330-3) also analysed cotton production and employment in the Yangtze, but his figures are less convincing than Li's since they imply peculiar input-output coefficients.

[13]Some of this work was done in cities (Li 1998, p. 141, Xu and Wu 2000, p. 203). If this source of income is eliminated entirely, the average income of the Chinese peasant family drops19 d per day to 18 d.

assessment of Asian economic performance. Output per worker in Yangtze farming exceeded labour productivity in the Netherlands and England in 1600 and was close to that of present day Belgium, the most advanced region of the late middle ages. Contrary to the involutionists, I find no significant evidence of falling productivity in the next to centuries, nor do I find evidence of rising labour productivity as claimed by Li Bozhong. Despite static labour productivity, the Yangtze's early lead was so great that its labour productivity was still on a par with that in the most advanced parts of Europe even after the English and Dutch agricultural revolutions. The Yangtze also does very well in income comparisons. The real income of the bulk of the population in 1800 was similar in the English midlands and the Yangtze Delta.

These findings are contingent on the data used for the analysis. The Chinese data, in particular, have many weaknesses. Even for the Yangtze Delta, key parameters are poorly established. Other regions need to be studied to establish comparisons between China and Europe in their entirety. And it would be greatly illuminating to extend the investigation to include supportive institutions like irrigation and water control. This paper is really only a first step.

While the findings of this study broadly support the revisionist view of Chinese economic performance, they also suggest different interpretations and raise disquieting questions. If the findings of this paper generalize to China and Europe as a whole, the 'great divergence' in income did, indeed, occur in the nineteenth century, but its roots extend back centuries. Europe, in this scenario, was behind China in 1600 but was on a trajectory that was accelerating rapidly. China's trajectory was not advancing. The paths may have crossed around 1800 when incomes and agricultural productivity were similar, but the European rocket had taken off two centuries before, and the sources of Europe's advance after 1800 must be sought in that earlier ascent.

This interpretative issue has a counterpart in the income of the Yangtze peasantry. The reason their income was as high as that of English labourers was the high productivity of agriculture. However, this was not an expandable feature of the economy. There were limits as to how many days of work could fruitfully be applied to the soil. In the calculations of this paper, that number is rigidly fixed with the result that men were devoting only 184 days of work per year to their small farms. Further population growth would reduce farm size and cut income for family. In reality, the opportunities for increasing the labour applied to the land may have been greater than the present model allows, but the prospects nonetheless look grim. The suggestion is that China was becoming a 'surplus labour economy' where a fertile soil kept a large population alive without absorbing all of its labour and where, consequently, people spent much of their time struggling to raise their incomes in unproductive activities. Only capital accumulation and industrialization would solve that problem.

Table 1

Agriculture in the South Midlands, c. 1806

	Acres or Number	yield	Gross product	price	Gross value (Million d.)
land use					
arable	944877				
pasture	1032913				
meadow	302902				
total	2280693				
arable use					
fallow	190631				
wheat	208324	20.5 bu	4265086	105.12	448.35
barley	147500	29.8 bu	4401479	51.12	225.00
beans/peas	155253	20.7 bu	3208943	60.48	194.08
oats	54388	30.7 bu	1671894	36.00	60.19
turnips	84486				
clover	104296				
animal products					
butter			8356137	13.5	112.82
veal			1081095	9.0	9.73
mutton			65317628	7.5	489.88
beef			36073092	7.5	270.55
pork			5228893	8.0	41.83
wool			18189510	12.0	218.27
animals					
horses	51577				
cows	64722				
calves	27418				
sucklers	11161				
sheeps	1719026				
lambs	678161				
fatting	124730				
foals	8165				
hogs	161198				
gross output (millions d.)					2070.69
seed and fodder					263.99
net output					1806.70
days worked (millions)					29.66

animal products were computed from the number of animals as follows:
butter-90% of cows giving 198 lbs each in the upland pasture

district and 86 lbs each elsewhere.
Veal-80% of the calves and all of the sucklers giving 32.6667 lbs. each.
Mutton-half of the sheep giving 40 lbs each in the heavy arable and 80 lbs elsewhere.
beef-256 pounds of net gain from each fatting animal and 640 lbs from 10% of the cows.
pork-45 lbs from each hogg.
wool-4 lbs from each sheep in the heavy arable district and 8 lbs elsewhere.

Table 2

Agriculture in the Yangtze, 1620

	Area (mu) Or number (Million)	Yield	Product (Million)	Price (1820 Cash)	Value of Gross output (Million 1820 cash)
primary land use					
paddy	42.4	1.7 shi	72.08	3494	251812
cotton	1.9	80 catty	152	80	12160
mulberry	0.7	6 catty	4.2	4110	17262
Total	45.0				
double cropping (at 40%)					
wheat	12.6	1.0 shi	12.6	2445	30813
beans	3.6	1.0 shi	3.6	2445	8804
rape	1.8	1.0 shi	1.8	4000	7200
animals					
sows	0.3				
pigs	0.9	90 catty	81	80.0	6480
chickens	6.3	9 catty	56.7	80.0	4536
draught	0.0				
gross output					339066
seed and fodder					6163
net output					332903
days worked (millions)					805.1137

Source: Li (1998, 2002).

Prices-Li reports many prices recorded in agricultural treatises. In some cases (e.g. rice, reported by Wang 1992, pp. 40-7) these can be compared to market prices, and Li's prices look approximately correct. I have used the market price for rice and estimated the price for the other crops according to the relative prices shown by Li and by Lillian Li (1992).

farms-3 million
Animal numbers and meat production from assumptions in Table 3 except that only 10% of farms were assumed to have a pig in 1620.
sows-one each on 10% of the farms
pigs-3 per sow

chickens-3 per farm on 70% of the farms

Table 3

Agriculture in the Yangtze, 1820

	Area (mu) Or number (Million)	Yield	Product (Million)	Price (1820 Cash)	Value of Gross output (Million 1820 cash)
primary land use					
paddy	40.4	2.3 shi	92.92	3494	324616
cotton	3.1	100 catty	310	80	24800
mulberry	1.5	6 catty	9	4110	36990
Total	45.0				
double cropping (at 70%)					
wheat	22.1	1.0 shi	22.1	2445	54044
beans	6.3	1.0 shi	6.3	2445	15406
rape	3.2	1.0 shi	3.2	4000	12800
animals					
sows	2.0				
pigs	6.0	90 catty	540	80.0	43200
chickens	10.5	9 catty	94.5	80.0	7560
draught	1.25				
gross output					519417
seed and fodder					146997
net output					472420
days worked (millions)					919.3104

Source: Li (1998, 2002).
farms-3 million

The animal numbers were conjectured on the basis of Buck (1937, Vol. 3, pp. 122, 124):
sows-one each on 40% of the farms
pigs-3 per sow, 100% annual slaughter rate
chickens-3 per farm on 70% of the farms, 100% annual slaughter rate.
draught-one each on 25% of the farms
Note: The implied annual production of pork is 15 kg per person in the Yangtze, which agrees with Buck's (1937, Vol. 3, p.77) budgets showing per capita meat consumption of 14.6 kg in the Yangtze Rice-Wheat region.

Table 4

PPP exchange rate: England and the Yangtze Delta

	Yangtze cash/kg	England pence/kg	Yangtze/ English	Yangtze share	English share	average share
rice	53.7	14.6	3.69	.62	0	.31
wheat	32.2	3.9	8.20	.10	.35	.23
beans	26.3	2.3	11.66	.06	.09	.07
pork	160	17.6	9.08	.09	.45	.27
fibre	480	26.4	18.16	.13	.11	.12

Price indices (copper cash per pence):
linear with Yangtze shares 6.98
linear with English shares 9.97
Fisher ideal 8.34
Törnqvist (Divisia) 7.42

Sources:
Rice:
China: the price taken to be 2.55 Taels per shi and 1370 copper cash per Tael. A shi was 100 litres is presumed to weight 65 kg (Li 1998, p. xvii).
England: Beveridge (1965, pp. 433)
Wheat:
China: The price was about 70% of the price per shi of rice according to Li (1998, 208n6, p. 212, notes 9 and 13).
England: Wheat cost 105.12 d per bushel. Each bushel weighed 60 lbs.
Beans:
China: Price per shi taken to be 70% of the price of wheat based on the Zhili prices graphed by Li (1992).
pork:
Yangtze: 80 cash per catty=160 cash per kilogram
England: 8 d. per pound = 17.64 d per kilogram
fibre--
Yangtze: ginned cotton cost 240 cash per jin (catty) or 480 cash per kilogram since 3 catties of unginned cotton made one catty of ginned cotton (Pomeranz 2000, p. 317).
England: raw wool cost 12 d. per pound or 26.46 d. per kilogram.

Price indices: see text.

Table 5

Agricultural Productivity Comparisons

	English Midlands C. 1806	Yangtze Delta C. 1620	Yangtze Delta C. 1820
output(£)/acre	3.30	24.45	27.35
days per acre	13.0	111.8	127.7
output (d)/day	60.9	52.5	51.4

Yangtze output values were all in c. 1820 cash prices and were converted to pence by dividing by the PPP exchange rate in Table 4.

Table 6

CPI exchange rate: England and the Yangtze Delta

	Yangtze cash/kg	England pence/kg	Yangtze/ English	Yangtze share	English share	average share
rice	53.7	14.6	3.69	.62	0	.31
wheat	32.2	3.9	8.20	.10	0	.05
bread	42.1	5.5	7.64	0	.35	.18
beans	26.3	2.3	11.66	.06	.09	.07
pork	160	17.6	9.08	.09	.45	.27
cloth	176	12.0	14.67	.13	.11	.12

Price indices (copper cash per pence):

linear with Yangtze shares	6.53
linear with English shares	9.40
Fisher ideal	7.83
Törnqvist (Divisia)	7.15

Sources:
Prices as in Table 4 except for:
bread:
China: estimated from bread equation in Allen (2001).
England: 10 d. for a four pound loaf in the 1820s (Mitchell and Deane 1971, p. 498).
cloth per square yard:
Yangtze: 1 bolt of cloth required 3 catties of unginned cotton or 240 cash. Domestic workers received 1 dou (.1 shi) of rice for spinning and weaving which came to 400 cash in the early nineteenth century. One bolt of cloth (3.63 sq yds) cost 640 cash or 176 per square yard.
England: one piece of Neild cloth was 29 yds by 28 inches (22.6 sq yds) and cost 22.6 shillings in 1812 or 12 d per square yard (Harley 1998, p. 18).

.

Table 7

Comparisons of Income per Day

	English Midlands Pence	Yangtze Delta Copper cash	Yangtze Delta Pence
man, per day worked	22 d	229 cash	30.5 d
man averaged over year	17 d	115 cash	15 d.
woman, per day worked	11-14 d	58 cash	8 d.
family, aver over year	20 d	140 cash	19 d.

Figure 1

Agricultural Labour Productivity:
Europe, 1300-1800

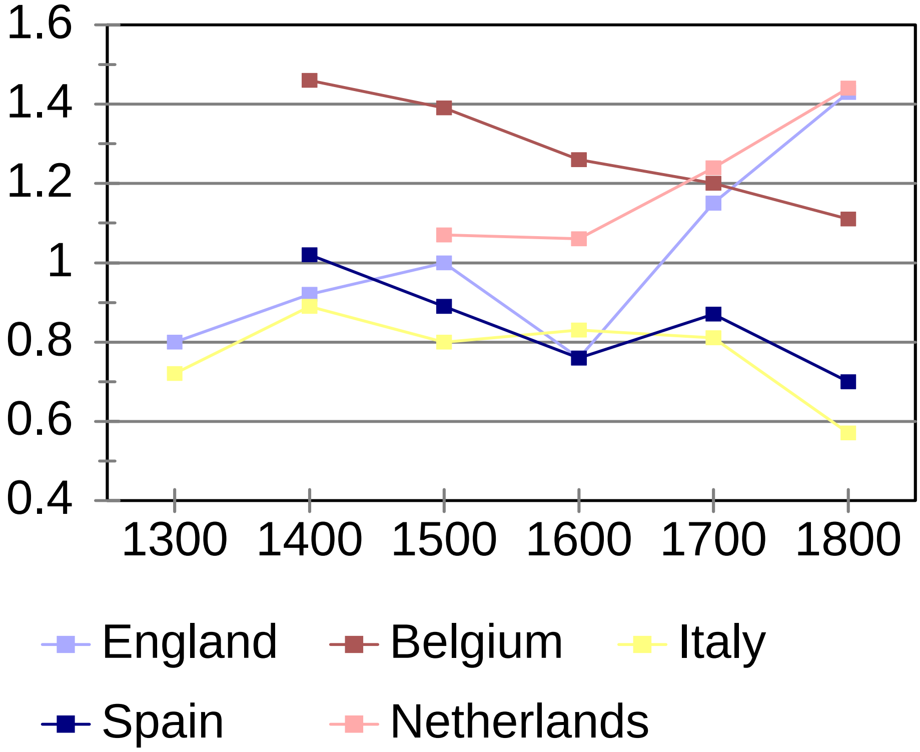
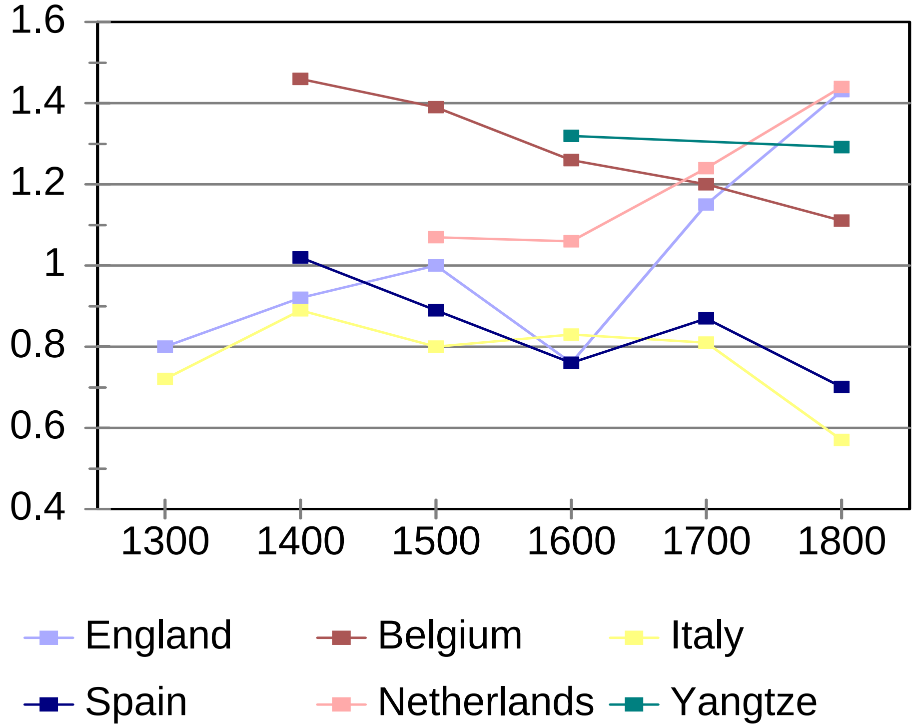


Figure 2

Agricultural Labour Productivity:
Europe and the Yangtze Delta, 1300-1800



References

Adas, Michael (1989). Machines as the Measure of Men, Ithaca, Cornell University Press.

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

Allen, Robert C. (1994). "Agriculture during the Industrial Revolution," in R. Floud and D.N. McCloskey, eds., The Economic History of Britain since 1700, Cambridge, Cambridge University Press, 2nd edition, Vol. I, pp.96-122.

Allen, Robert C. (2000). "Economic Structure and Agricultural Productivity in Europe, 1300-1800," European Review of Economic History, Vol. 3, pp. 1-25.

Allen, Robert C. (2001). "The Great Divergence in European Wages and Prices from the Middle Ages to the First World War," Explorations in Economic History, Vol. 38, pp 411-447.

Allen, Robert C. (2002). "Real Wages in Europe and Asia: A First Look at the Long-Term Patterns," (www.nuffield.oxford.ac.uk).

Batchelor, T. (1808). General View of the Agriculture of the county of Bedford, R. Phillips.

Beveridge, Lord (1965). Prices and Wages in England, Vol. I, London, Frank Cass & Co. Ltd., 2nd impression.

Blaut, J.M. (1993). The Colonizer's Model of the World, NewYork, The Guildford Press.

Bowden, Peter (1967). "Agricultural Prices, Farm Profits, and Rents," in Joan Thirsk, ed., The Agrarian History of England and Wales, 1500-1640, Vol. IV, Cambridge, Cambridge University Press, pp. 593-695.

Brenner, Robert and Isett, C. (2002). "England's Divergence from China's Yangzi Delta: Property Relations, Microeconomics and Patterns of Development," Journal of Asian Studies Vol. 61, pp. 609-22.

Broadberry, Stephen, and Bishnupriya Gupta (2003). "The Early Modern Great Divergence: Wages, Prices, and Economic Development in Europe and Asia, 1500-1800."

Buck, John L. (1937). Land Utilization in China, Nanking, Nanking University Press.

Diewert, W.E. (1976). 'Exact and Superlative Index Numbers', Journal of Econometrics, Vol. 4, pp. 115-145.

Elvin, Mark (1973). The Pattern of the Chinese Past, Stanford,

Stanford University Press.

Elvin, Mark (2004). Retreat of the Elephants : an Environmental History of China, New Haven, Yale University Press.

Frank, Andre Gunder (1998). ReOrient: Global Economy in the Asian Age, Berkeley, University of California Press.

Horrell, Sara (1996). "Home Demand and British Industrialization," Journal of Economic History, Vol. 56, pp. 561-604.

Horrell, Sara, and Humphries, Jane (1992). "Old Questions, New Data, and Alternative Perspectives: Families' Living Standards in the Industrial Revolution," Journal of Economic History, Vol. 52, pp. 849-880.

Huang, Philip C.C. (1990). The Peasant Family and Rural Development in the Yangzi Delta, 1350-1988, Stanford, Stanford University Press.

Huang, Philip C.C. (2002). "Development or Involution in Eighteenth-Century Britain and China? A Review of Kenneth Pomeranz's The Great Divergence: China, Europe, and the Making of the Modern world Economy," Journal of Asian Studies, Vol. 61, pp. 501-38.

Landes, David S. (1998). The Wealth and Poverty of Nations: Why Some are So Rich and Some So Poor, New York, W.W. Norton & Co.

Lee, James Z., and Wang, Feng (1999). One Quarter of Humanity: Malthusian Mythology and Chinese Realities, 1700-2000, Cambridge, MA, Harvard University Press.

Li, Bozhong (1998). Agricultural Development in Jiangnan, 1620-1850, New York, St. Martin's Press, Inc.

Li, Bozhong (2002). "Involution or Not: A Case Study of Farm Economy in Songjiang, 1823-34," Convergence and Divergence in Historical Perspective: The Origins of Wealth and Persistence of Poverty in the Modern World, All-U.C. Group in Economic History Conference, University of California, Irvine, November 8-10, 2002.

Maddison, Angus (1995). Monitoring the World Economy, 1820-1992, Paris, OECD.

Malthus, T.R. (1973) An Essay on the Principle of Population, introduction by T.H. Hollingsworth, London, J.M. Deant & Sons Ltd.

Marx, Karl (1853). 'The British Rule in India' and 'The Future Results of British Rule in India,' in The Portable Karl

Marx, ed. By Eugene Kamenka, New York, Penguin Books USA Inc, pp. 329-41.

McCulloch, J.R. (1857). A Descriptive and Statistical Account of the British Empire, 3rd edition, London, Longman, Brown, Green, and Longmans.

Mitchell, B.R. and Phyllis Deane (1971). Abstract of British Historical Statistics, Cambridge, Cambridge University Press.

O'Brien, Patrick, and Keyder, Caglar (1978). Economic Growth in Britain and France, 1780-1914: Two Paths to the Twentieth Century, London, George, Allen, and Unwin.

Parthasarathai, Prasanan (1998). 'Rethinking Wages and competitiveness in the Eighteenth Century: Britain and South India,' Past & Present, No. 158, pp. 79-109.

Perkins, Dwight H. (1969). Agricultural Development in China, 1368-1968, Edinburgh, Edinburgh University Press.

Pomeranz, Kenneth (2000). The Great Divergence: China, Europe, and the Making of the Modern World, Princeton, Princeton University Press.

Pomeranz, Kenneth (2002). "Beyond the East-West Binary: Resituating Development Paths in the Eighteenth-Century World," The Journal of Asian Studies, Vol. 61, pp. 539-590.

Prados de la Escosura, Leandro (2000). "International Comparisons of Real Product, 1820-1990: An Alternative Data Set," Explorations in Economic History, Vol. 37, pp. 1-41.

Priest, St. J. (1913). General View of the Agriculture of Buckingham, London.

Summers, R., and Heston, A. (1988). "A New Set of International Comparison of Real Product and Prices: Estimates for 130 Countries, 1950-1985," Review of Income and Wealth.

Summers, R., and Heston, A. (1991). "The Penn World Table (Mark 5): An Expanded Set of International Comparisons, 1950-1988," Quarterly Journal of Economics.

Smith, Adam (1776). An Inquiry into the Nature and Causes of the Wealth of Nations, ed. By Edwin Cannan, New York, The Modern Library, 1937.

United Nations, Food and Agricultural Organization (1984-6). Food Balance Sheets, Rome, Food and Agricultural Organization.

Wagner, Wilhelm (1926). Die chinesische landwirtschaft, Berlin, Verlag Paul Parey.

Wittfogel, Karl A. (1957). Oriental Despotism: A Comparative

Study of Total Power, New Haven, Yale University Press.

Wong, R. Bin (1997). China Transformed: Historical Change and the Limits of European Experience, Ithaca, Cornell University Press.

Young, Arthur (1768). A Six Weeks Tour through the Southern Counties of England and Wales, London, W. Nicoll.

Young, Arthur (1770). The Farmer's Guide in Hiring and Stocking Farms, London, W. Strahan.

Young, Arthur (1771a). A Six Month's Tour Through the North of England, 2nd edition, London, W. Strahan.

Young, Arthur (1771b). The Farmer's Tour Through the East of England, London, W. Strahan.

Xu, Dixin and Wu, Chengming, Chinese Capitalism, 1522-1840, Houndsmills, Basingstoke, MacMillan Press ltd.

Zhao Gang, Liu Yongcheng, Wu Hui et al. (1995) Qingdai liangshi muchanliang yanjiu (Research on grain yields in the Qing period). Beijing: Zhongguo nongye chubanshe.