APPENDIX FOR
BRITISH ECONOMIC GROWTH, 1270-1870: AN OUTPUT-BASED APPROACH

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1. DATA SOURCES

This section describes in more detail the three main databases. The Medieval Accounts Database assembled by Bruce Campbell (2000; 2007) relies heavily on manorial accounts, which were drawn up according to a common template by the reeve who managed the demesne under the close supervision of the lord's bailiff or steward (Campbell, 2000: 2). Amongst other things, these accounts provide detailed information on crops, animals and livestock products.

The number of manorial accounts which have survived varies over time, with numbers of sampled manors per year plotted as decadal averages in Figure A1.1. The fourteenth century is well represented, but the records are less abundant for the thirteenth and fifteenth centuries. Care must nevertheless be taken to ensure that all the main regions are covered, since there is a bias within the surviving records towards the south and east of the country. Care must also be taken in moving from data on the seigniorial sector to inferences about the development of English agriculture as a whole, since the non-seigniorial sector was always larger than the seigniorial sector and the relative sizes varied over time, as shown in Table A1.1. Even at its peak, the seigniorial sector accounted for no more than around a quarter of all agricultural land and output (Campbell, 2000: 26). Although the evidence on the non-seigniorial sector is more disparate, data do exist, which can be used to verify or qualify trends reconstructed from the manorial accounts (Dodds, 2004; 2007). Campbell (2007) shows that there is a close correlation between year-on-year fluctuations in crop yields derived from manorial accounts and annual changes in tithe receipts.

The Early Modern Probate Inventories Database is used as the main source for basic information on agriculture between the mid-sixteenth and the mid-eighteenth centuries (Overton, 1991; 2000; Overton, Whittle, Dean and Haan, 2004). The number of sampled farms per year is plotted in decadal average form in Figure A1.2, for comparison with the manorial accounts database. Perhaps surprisingly, the early modern period is less well served than the medieval period for surviving records on the agricultural sector. Again, care must be taken to ensure coverage of all the main regions, since the coverage of the

probate inventories sample is rather better in the south and east than in the rest of the country.

To derive grain yields from probate inventories, the starting point in Overton (1979) is the identity $v=py$, where v is the valuation per acre of growing grain recorded in probate inventories, p is the price per bushel after the harvest and y is the yield in bushels per acre. The yield is thus obtained from the valuation and the price as:

$$y = v/p \quad (1)$$

However, the calculations are more complex in practice because appraisers subtracted 10% of gross output for tithes, and care must also be taken to allow for the costs of reaping (r), threshing (t) and carting (c), which affected the value that the appraisers placed on a growing crop. Allen's (1988) valuation equation, accepted by Overton (1990) and Glennie (1991) thus becomes:

$$v = 0.9\,(py - ty - c) - r \quad (2)$$

Rearranging for comparison with equation (1), the yield becomes:

$$y = \frac{v + r + 0.9c}{0.9(p - t)} \quad (3)$$

A further complication concerns the months used for the crop valuations, since appraisers often valued crops in early months of the year by listing the costs incurred in bringing the crop to its current condition, thus resulting in spuriously low yields. Allen (1988) excludes these observations by setting a minimum yield of 5 bushels per acre, but this has the disadvantage of also excluding genuinely bad harvests. Here, attention has been restricted to valuations in the months of June to August, following Overton (1979: 369).

In contrast to the medieval period, there are no continuous runs of data on individual farms in the early modern period, but only one-off observations determined by the death of farmers. In estimating grain yields and stocking densities, this is dealt with by assuming comparable series in similar agricultural regions, hence introducing a time series aspect, as suggested by Clark (2004).

The Modern Farm Accounts Database of Turner, Beckett and Afton (2001) covers the period from the 1720s to the outbreak of World War I. The farm accounts in this sample are much less standardised than the medieval manorial accounts, but they do provide crucial data on the amount of land in use and crops sown and harvested, which allows the derivation of grain yields. Perhaps disappointingly, data on numbers of farm animals were not systematically collected, although there are some data on sales of animals.

As with the medieval and early modern samples, the modern sample of farm records is uneven in both temporal and spatial coverage. Figure A1.3 sets out the chronological distribution of the sampled farm records. Although the evidence is relatively thin for the first half of the eighteenth century, this period can be bolstered by the surviving probate inventories. The sample is stronger for the first half of the nineteenth century. The spatial distribution of farm records is more even than for the medieval and early modern periods, with the north and west of the country almost as well represented as the south and east (Turner, Beckett and Afton, 2001: 64). There is, of course, a danger that the surviving records are biased towards the better run farms, since there was no requirement to keep farm accounts. However, the farm accounts data are checked against the probate inventory data in the first half of the eighteenth century and against the official output data from the late nineteenth century to gauge yield levels.

2. ARABLE ACREAGE

This section provides more detail on the estimation of the total arable acreage in Table 1 of the main text, summarising Broadberry, Campbell and van Leeuwen (2011a). The key issue concerns the relationship between the arable acreage in the medieval period compared with the nineteenth century. County level data on the total land area and the arable acreage in the nineteenth century, are available from the Agricultural Returns for 1871 and the Tithe Files for 1836 (Parliamentary Papers, 1871; Kain, 1986). Table A2.1 indicates that when the area under agricultural land use was pushed close to its natural limits in the nineteenth century, 42.9 per cent of England's surface area was used for arable cultivation, amounting to 13.9 million acres. At that time, England's population was three-and-a-half times its level in 1290, the country was still heavily dependent on

domestic grain production, and arable and pastoral production were more closely integrated than ever before via the incorporation of fodder crops and sown grasses into rotations and near universal adoption of fodder-fed horses for farm work. It is therefore highly improbable that the amount of arable land in 1290 could have been greater than this.

But could it have been smaller? Table A2.2 provides estimates of the amount of arable land in 1290 by county, taking account of (1) the major changes in land use between 1290 and 1871 quantified on a regional basis and (2) the distribution of the population by county in 1290. The first part of the exercise draws on estimates by Grigg (1989: 29) of the amount of land drained and reclaimed, and quantification of the conversion from tillage to permanent grass via Beresford's (1989) analysis of the incidence of deserted medieval villages and Kussmaul's (1990) identification of changes in the seasonal patterns of marriage as parishes switched between a primarily arable pattern (autumn marriages) and a primarily pastoral pattern (spring marriages). Starting with a figure of 13.9 million acres of arable land in 1871 and allowing for the 1.4 million acres that came from drainage by methods that were not available in 1290, gives a figure of 12.5 million acres for 1290, as a lower bound. However, given the concentration of the deserted medieval villages and the shift from arable to pastoral marriage patterns in a narrow band of midland counties, together with the subsequent reversal of price incentives to switch from arable to pastoral production, it is difficult to see how this could have accounted for a permanent net conversion of more than half a million acres of arable land to pasture. The maximum arable acreage in 1290 is therefore unlikely to have been more than 13.0 million acres.

The second part of the exercise makes use of the maximum and minimum shares of land devoted to arable production in any county in 1836/1871, together with the distribution of population density in 1290, to arrive at an estimate of arable land use by county in 1290. The population density in 1290 matters because of the limited possibilities for trading grain between regions at the time: although markets existed, transport costs for grain were very high, so that regions with a high population density had to have a high

proportion of the county acreage in arable use and vice-versa. Table A2.2 sets out the estimated proportions and amounts of arable land by county, taking account of variations in population density, the location of the drainage schemes identified by Grigg (1989), the density of DMVs identified by Beresford (1989), and the effects of urbanisation, which particularly affected Middlesex and Surrey. The net effect of these calculations is an overall arable share in 1290 of 39.5 per cent, amounting to approximately 12.75 million acres (an area equivalent to over half of all farmland). These 12.75 million arable acres differed far more in distribution than in quantity from the 13.9 million arable acres in 1836/71. Proportionately, the arable acreage shrank most in metropolitan Middlesex, where pasture and grazing were in high demand from the capital and the massive horse-drawn traffic that it generated, whereas it grew most in Co. Durham, where cheap grain was needed to feed the growing army of miners who hewed the coal likewise demanded in ever greater quantities by London.

3. ARABLE OUTPUT

This section provides more detail on the derivation of English arable output net of seed and animal consumption in Table 2 of the main text. Gross arable output is obtained by multiplying the acreage for each crop by the yield per acre, and these gross outputs are converted to a net output basis by subtracting seed and fodder.

Aggregate trends in grain yields have been obtained from data on individual manors and farms using regression analysis. The basic specification for grain yields is as follows:

$$ln(YIELD_{it}) = \alpha + \sum_{i=1}^{I-1} \beta_i LOC_i + \sum_{j=1}^{J-1} \gamma_j REG_j + \sum_{t=1}^{T-1} \delta_t YEAR_t + \varepsilon_{it} \quad (4)$$

where $YIELD_{it}$ is the grain yield in manor or farm i in year t, α is a constant, LOC_i is a dummy for the location of each farm, REG_j is a dummy variable for the region in which each manor or farm is located, $YEAR_t$ is a dummy for the year and ε_{it} is the error term. The dependent variable is entered logarithmically so that the location and regional dummies have the same proportional effect on grain yields in all years.

The method produces an estimated national trend in index number form, and the absolute levels of the grain yields are obtained using the regional shares of the sown area in

1836/71 as weights for the modern and early modern periods and the 1290 shares for the medieval period. The regional shares of the arable acreage from Table A3.1 are interacted with the distribution of crops within each region, which can also be obtained from the databases, so that the regional shares in Table A3.2 are specific to each crop. Table A3.3 shows the estimated values for the regional dummies, together with standard errors and t-values. Yields tended to be high in all crops in East Anglia, the benchmark region, particularly during the early modern and modern periods. This is indicated by the preponderance of negative signs in parts B and C of Table A3.3. Nevertheless, wheat yields were higher in the midlands during the early modern period, as indicated by a statistically significant positive sign. During the medieval period, wheat yields were higher in the southern counties and the southeast, barley yields were higher in the southern counties and the midlands, oats yields were higher in the southeast and pulse yields were higher in eastern counties and the midlands.

Grain yields gross of seed as well as tithe are shown in Figure A3.1 for wheat, for illustrative purposes. From these gross yields it is necessary to subtract grain used as seed to derive the net yields shown in Table A3.4 for all the major crops. There are some differences between crops, but the different datasets appear to tell a consistent story, with yields declining during the late medieval period from around 1300, picking up again during the early modern period from the mid-sixteenth century, and growing more rapidly during the modern period from the early eighteenth century. The data exhibit a high degree of short run volatility, which has been smoothed out in Figure A3.1 with a 10-year moving average.

4. PASTORAL OUTPUT

This section provides more detail on the derivation of English pastoral farming output in Table 3 of the main text. Pastoral output is obtained by multiplying together the numbers of animals with the percentages of each animal producing and the yields per animal. Non-working animal numbers are derived from stocking densities for the medieval and early modern periods and from contemporary estimates for the modern period, as described in

the main text. The key assumptions are discussed fully in the main text, since this part of agricultural history has been less heavily researched than the arable sector.

As with the crop yields, aggregate trends in stocking densities have been obtained from data on individual farms and manors using regression analysis. The regression equation is essentially the same as equation (4), but with the logarithm of the stocking density (STOCKDENS) as the dependent variable rather than the logarithm of the grain yield.

The method produces an estimated trend in index number form, and the absolute levels of the stocking densities in benchmark years are obtained as weighted averages of the regional stocking densities, using the regional shares of pastoral farming shown in Table A4.1. These regional groupings are different from those in arable farming, reflecting the four main types of pastoral farming. Although by 1870 dairying had spread to counties where it had been scarce in 1300, the core activities of farms, especially in the northwestern counties, had shifted towards the fattening of cattle. Table A4.2 shows the estimated values for the regional dummies, together with standard errors and t-values. No particular region stands out as having had higher stocking densities across all livestock or across periods.

Table A4.3 sets out the key steps in the derivation of animal numbers for the medieval period, starting from detailed data on stocking densities for the demesne sector. The stocking densities on demesnes for the country as a whole in Part A are adjusted to stocking densities for the country as a whole in Part B on the basis of the share of the demesne sector in total acreage, which is set out in Table A1.1, combined with the four key assumptions concerning the relationship between the demesne and non-demesne sectors discussed in the main text.

The derivation of animal numbers from stocking densities is more straightforward in the early modern period. In Table A4.4, the stocking densities derived from the probate inventories in Part A can be applied to the country as a whole, since the demesne sector

had disappeared by 1500. Hence these stocking densities can be applied to the national sown acreage to derive the animal numbers in Part B.

Perhaps surprisingly, direct estimates of stocking densities are unavailable for the modern period. Instead, animal numbers from 1750 onwards are taken directly from contemporary estimates from John (1989), Mitchell (1988) and Turner (1998), and interpolated using data on annual sales at Smithfield and the Metropolitan Cattle Market from Mitchell (1988: 708) and Perren (1975: 388). Part A of Table A4.5 presents the animal numbers, which are then divided by the sown acreage to derive the stocking densities in Part B.

The animal numbers for the whole period 1270-1870 are plotted in Figure A4.1, using 10-year moving averages to smooth out short run volatility. Although there were substantial short run fluctuations, animal numbers remained stationary until the eighteenth century. Given the trends in arable agriculture, this meant that the pastoral sector increased its share of agricultural output substantially as population declined across the Black Death.

Table A4.6 sets out the percentages of animals producing milk, meat and wool. Again, the assumptions have been discussed fully in the main text. However, here it should be noted that, in contrast to the situation with animal numbers, there is broad consensus amongst researchers, and very radical changes would be needed to produce results which would significantly affect the overall trends of pastoral output.

Table A4.7 provides the data on yields of milk, meat and wool per animal, as discussed in the notes to the table and in the main text. For benchmark years in the fourteenth and nineteenth centuries, there is again consensus among researchers concerning the broad magnitudes, and the main contribution here concerns the interpolation for intervening years using the ratio of product to animal prices. The basic idea is that an increase in, say, the price of cattle relative to the price of beef signifies an increase in the yield of beef cattle. Price data are taken largely from Clark (2004; 2006), supplemented by Beveridge

(1939) and Thorold Rogers (1866-1902). The main result is that although there was some increase in yields during the late medieval period, the pace of change increased substantially from the mid-sixteenth century.

As noted in the main text, additional assumptions are needed to derive the output estimates for hay and hides. For hay, the starting point is the number of non-farm horses taken from Wrigley (2006: 450) for 1300 and from Allen (1994: 102) and Feinstein (1978: 70) for 1700, 1760, 1800 and 1850, with log-linear interpolation for years between. The number of non-farm horses rose from 50,000 in 1300 to 200,000 by 1750 before accelerating dramatically to 800,000 by 1850. The assumption of 2.4 tons of hay per horse is taken from Thompson (1983: 60).

For hides, it is necessary to calculate the numbers of working animals as well as the non-working animals given in Figure A4.1. For the early modern period, these working animal numbers can be derived directly from the stocking densities, which are assumed to apply to the whole agricultural sector. However, for the medieval period, the demesne stocking densities have been converted into the numbers of horses and oxen on all lands using Wrigley's (2006: 449) assumption that the stocking density of working animals on non-seigniorial holdings was three-quarters that on the demesnes. In making these estimates, allowance has been made for the declining share of demesne acreage. For the modern period, direct estimates of animal numbers are taken from Mitchell (1988), Turner (1998) and Allen (2005), since data on stocking densities are not provided in the Modern Farm Accounts Database. Figure A4.2 sets out the numbers of mature working animals in England. There was a steady process of substitution of horses for oxen as working animals, beginning in the early modern period. By the nineteenth century, the use of oxen had more or less died out.

The percentages of each animal producing hides are the same as the percentages producing meat in Table A4.6, with the addition of a figure of 13 per cent for horses and oxen from Clark (1991: 216). The yields per animal are taken from Clarkson (1991: 470).

5. TOTAL AGRICULTURAL PRODUCTION

This section provides more detail on the arable and pastoral shares of agricultural output in current prices shown in Table 5 of the main text as well as a fuller description of the methods used to estimate total agricultural production during the period between the end of the Medieval Accounts Database and the start of the Early Modern Probate Inventories Database.

Table A5.1 provides current price shares for individual products as well as the overall shares of arable and pastoral products, which are used as weights in the construction of the agricultural real output index. The most important developments within the arable sector were the decline of inferior grains, as bread was made increasingly from wheat rather than rye and oats became increasingly used only as animal fodder. The importance of sheep in the medieval economy is clear in the high shares of wool and mutton. Over time, as the share of wool declined, other types of meat and dairy produce became more important.

For the period 1492-1553, there is a gap in the quantity information used to construct the index of agricultural output. During this period of missing output data, however, abundant information exists on wages and prices, which can be used to fill in the gap. The approach taken here is to estimate a demand function for agricultural goods over the periods for which output, price and income information exist, 1300-1492 and 1553-1700, and then to use the estimated parameters of the demand function to derive output during the missing years 1493-1552.

Crafts (1985) calculated the path of agricultural output in Britain during the Industrial Revolution with income and price elasticities derived from the experience of later developing countries. The approach was developed further by Allen (2000) using consumer theory. Allen (2000: 13-14) starts with the identity:

$$Q^A = RCN \qquad (5)$$

where Q^A is real agricultural output, R is the ratio of production to consumption, C is consumption per head and N is population. Real agricultural consumption per head is

assumed to be a function of its own price in real terms (P^A/P), the price of non-agricultural goods and services in real terms (P^{NA}/P), and real income (Y). Assuming a log-linear specification:

$$\ln C = \alpha_0 + \alpha_1 \ln(P^A / P) + \alpha_2 \ln(P^{NA} / P) + \beta \ln Y \qquad (6)$$

where α_1 and α_2 are the own-price and cross-price elasticities of demand, β is the income elasticity of demand and α_0 is a constant. Consumer theory requires that the own-price, cross-price and income elasticities should sum to zero, which sets tight constraints on the plausible values, particularly given the accumulated evidence on elasticities in developing countries (Deaton and Muellbauer, 1980: 15-16, 60-82).

For early modern Europe, Allen (2000: 14) works with an own-price elasticity of -0.6 and a cross-price elasticity of 0.1, which constrains the income elasticity to be 0.5. Allen also assumes that agricultural consumption is equal to agricultural production. The assumption of balanced trade in agricultural goods before 1700 is retained, but the income and price elasticities are estimated from the data for England immediately before and after the "statistical dark age". It is important that the demand equation should be dynamic, so as to capture the volatility of the agricultural output series. The estimated demand function therefore takes the form:

$$\ln C_t = \gamma_0 + \gamma_1 \ln C_{t-1} + \gamma_2 \ln\left(P^A / P\right)_t + \gamma_3 \ln\left(P^A / P\right)_{t-1}$$
$$\gamma_4 \ln\left(P^{NA} / P\right)_t + \gamma_5 \ln\left(P^{NA} / P\right)_{t-1} + \gamma_6 \ln Y_t + \gamma_7 \ln Y_{t-1} + \varepsilon_t \qquad (7)$$

where t is a time subscript and ε is an error term. This specification allows the derivation of long run demand elasticities as follows: the long run own-price elasticity of demand is given by $(\gamma_2 + \gamma_3)/(1-\gamma_1)$, the long run cross-price elasticity of demand by $(\gamma_4 + \gamma_5)/(1-\gamma_1)$ and the long run income elasticity of demand by $(\gamma_6 + \gamma_7)/(1-\gamma_1)$.

Equation (7) is estimated by maximum likelihood and the results are shown in Table A5.2. Per capita agricultural output is regressed on current and one period lagged observations of the agricultural price index, the general price level and the real wage, over the period 1301-1493 and 1551-1700, with a gap from 1494 to 1550. Because of the one-year lag, there are 342 observations. The agricultural output, the real agricultural

price level and the real non-agricultural price level data are all taken from the dataset described in this appendix, while the real wage data are from Allen (2001).

The estimated long run income elasticity of demand is 0.62, which is close to the value of 0.5 assumed by Allen (2000). The price elasticities, however, are somewhat lower than those assumed by Allen. In particular, the estimated long-run own price elasticity of -0.34 is substantially lower than Allen's assumed value of -0.6, although the estimated cross price elasticity of 0 is not very different from Allen's assumed value of 0.1. The constraint that the three elasticities should sum to zero is not strictly met. Nevertheless, the results are encouraging enough to attempt to use the model to estimate the values of agricultural output per capita across the gap between 1494 and 1550.

Figure A5.1 plots the estimates of agricultural output per head covering the whole period 1302-1700. The series derived from the medieval manorial accounts data and the early modern probate inventories data is labelled "Agricultural output" and contains a gap between 1494 and 1550. The series labelled "prediction" is derived from the agricultural demand function in Table A5.2. The values of the real agricultural price index, the real non-agricultural price index and the real wage are used to derive the fitted values of agricultural output per capita. The prediction series tracks the original agricultural output per capita data reasonably well during the periods 1302-1493 and 1551-1700. In addition, the prediction series provides estimates for the period 1494-1550, when the data on crop proportions, grain yields, animal stocking densities, slaughter rates and animal yields, necessary for the direct estimation of agricultural output are unavailable. During these years, data on real agricultural prices, real non-agricultural prices and the real wage remain available, making it possible to estimate agricultural demand across the gap.

6. INDUSTRIAL PRODUCTION IN ENGLAND, 1270-1700

This section provides more detail on the industrial production index shown in Figure 2 of the main text, focusing on the period 1270-1700. Sources are described fully in the main text, while Figure A6.1 plots the main component series, grouped together into three

main sectors: metals and mining industries, textiles and leather industries and other industries.

Part A of Figure A6.1 plots on a logarithmic scale the metals and mining output index, which is based on the component series of tin, iron and coal. Although tin output grew more rapidly than industrial production as a whole, the coal and iron industries grew even more rapidly, particularly during the sixteenth century. Part B plots the textiles and leather output index, based on woollens and leather. Woollens grew more rapidly than the leather industry. Part C plots the "other industries" output index, which is based on food processing, construction and book production. Book production grew much more rapidly than food processing and construction, although the growth rate accelerated in construction with the growing urbanisation of the English economy after 1500.

Part D of Figure A6.1 plots the index of industrial production together with the three major sector sub-indices. Metals and mining was the most dynamic sector from the beginning of the sixteenth century, while textiles and leather exhibited the slowest growth over the period as a whole.

7. INDUSTRIAL OUTPUT IN GREAT BRITAIN, 1700-1870

This section provides more detail on the industrial production index shown in Figure 2 of the main text, focusing on the period 1700-1870. Sources are described fully in the main text, while Table A7.1 provides a full listing of the weights. Figure A7.1 plots the main component series.

Part A of Figure A7.1 provides a breakdown of industrial production into manufacturing, construction and mining. Both mining and construction grew more rapidly than total manufacturing over the period as a whole. Part B of Figure A7.1, however, shows that total manufacturing output included some very rapidly growing branches. The most rapid growth was in metals, driven by the iron industry. The next most rapid growth was in textiles, driven by the dramatically expanding cotton industry, but slowed down by the

relative decline of the more traditional textile industries. Food drink and tobacco and other manufacturing grew more slowly.

8. SERVICES IN ENGLAND, 1270-1700

This section provides more detail on the services output index shown in Figure 2 of the main text, focusing on the period 1270-1700. Sources are described fully in the main text, while Figure A8.1 plots the main component series, grouped together into three main sectors: commerce, domestic and housing, and government.

Part A of Figure A8.1 plots on a logarithmic scale the output of the total commerce sector, together with its component indices. The fastest growing part of commerce was domestic trade and transport, with two strong phases of growth. The first growth phase occurred with the rise of markets before the Black Death, while the second growth phase occurred with the spread of urbanisation after 1500. International trade and transport showed little trend growth before 1500, but then grew rapidly during the mercantilist period from the sixteenth century onwards. The financial sector declined with population after the Black Death and then showed relatively modest growth from the mid-fifteenth century, but with a serious setback during the Great Debasement of the mid-sixteenth century.

Part B of Figure A8.1 plots the total services output index together with its component parts. Total service sector output trended downwards during the medieval period, before picking up strongly from the mid-fifteenth century. The slowest growing sector was housing and domestic services, while the fastest growing sector was government, particularly before 1350. The state expanded its size rapidly during the wars of the late medieval period, and again with the rise of the mercantilist state during the seventeenth century. Commerce grew rapidly from the mid-sixteenth century.

9. SERVICES IN GREAT BRITAIN, 1700-1870

This section provides more detail on the services output index shown in Figure 2 of the main text, focusing on the period 1700-1870. Sources are described fully in the main text,

while Table A9.1 provides the weights, derived from Horrell, Humphries and Weale's (1994: 547) input-output table for 1841. Figure A9.1 plots the main component series.

Part A of Figure A9.1 provides information on commerce, government (public administration and defence), housing and domestic services, while Part B breaks down commerce into transport, distribution, finance and other commerce. In Part A, government grew most rapidly during the eighteenth century, albeit in a sharply cyclical fashion as a result of warfare. During the nineteenth century, commerce was clearly the fastest growing sector. Housing and domestic services grew more slowly but more steadily than government or commerce. The former two series coincide in the chart because domestic services were assumed to grow in line with population, whilst Feinstein's (1988) housing stock series happened to have a long run unit elasticity with respect to population during this period. In Part B, distribution and finance grew more rapidly than transport and other commerce, with finance particularly dynamic during the eighteenth century, but distribution more dynamic during the nineteenth century.

10. WEIGHTING SCHEME FOR GDP

This section describes in more detail the derivation of the weighting scheme for GDP in Table 9 of the main text. The real output series for agriculture, industry and services are reflated to nominal output using the sectoral price indices plotted in Figure 3 of the main text, with absolute levels of sectoral and total GDP in current prices established using Horrell, Humphries and Weale's (1994) input-output table for 1841.

The agricultural price data are taken largely from Clark (2004), as described in the main text. For industry, prices are taken from Clark (2006), Thorold Rogers (1866-1902) and Beveridge (1939). The full list of commodities included is as follows:

Textiles: linen cloth (Clark, 2006), wool cloth (Clark, 2006), work gloves (Clark, 2006), shirting (Thorold Rogers, Vol. 4: 583-588), stockings (Clark, 2006), cotton (Clark, 2006), cotton cloth (Clark, 2006), silk thread (Clark, 2006).

Metals: iron manufactures (Clark, 2006), nails (Clark, 2006), pewter (Clark, 2006), horse shoes (Thorold Rogers, Vol. 1: 554-559), lead (rolled, pig) (Thorold Rogers, Vol.4: 482-487).

Other manufactures: candles (Clark, 2006), charcoal (Clark, 2006), firewood (Clark, 2006), lamp oil (Clark, 2006), coal gas (Clark, 2006), parchment (Clark, 2006), hurdles (Thorold Rogers, Vol.1: 554-559), ligatures (Thorold Rogers, vol.1: 561-566), paper (Thorold Rogers, Vol. 4: 605-606), soap (Clark, 2006).

Construction: bricks (Clark, 2006), laths (Thorold Rogers, vol. 1: 515-520, Vol. 4: 468-472), plain tiles (Thorold Rogers, vol. 1: 515-520), wages of building labourers (Clark, 2006), crest tiles (Thorold Rogers, Vol. 4: 468-472), slates (Thorold Rogers, Vol. 4: 468-472), lime (Thorold Rogers, Vol. 4: 404-409), planks (Thorold Rogers, Vol. 5: 538-544), boards (Thorold Rogers, Vol. 5: 538-544).

Mining: coal (Clark, 2006).

Foodstuff: wheat (Clark, 2006), wheaten flour (Clark, 2006), bread (Clark, 2006), bacon (Clark, 2006), treacle (Clark, 2006), sugar (Clark, 2006), beer (Clark, 2006), malt (Beveridge, 1965; the average of Winchester, Eton, Westminster, Greenwich and Navy Victualling in London, Portsmouth, and Plymouth), spirits (Clark, 2006), tobacco (Clark, 2006), beer (Clark, 2006).

The price data for services are based largely on wage rates and housing rents from Clark (2004), although some information on transport prices from Thorold Rogers (1866-1902) has also been incorporated. For distribution, a weighted average of agricultural and industrial prices has been used, with the weights reflecting the relative size of the two sectors.

11. POPULATION

This section provides more information on the estimation of English population during the period before 1541, when the annual data of Wrigley and Schofield (1989) become available. Fuller details are available in Broadberry, Campbell and van Leeuwen (2011c). The basic approach is to use evidence of tenant numbers on individual manors to establish trends in population for the period between 1086 and 1541, ensuring a balance

between the relatively high density core of regions to the south and east of a line running roughly from the Wash to the Severn Estuary, and the lower density of peripheral regions to the north and west of this line, including southwest England as well as the western and northern regions. The approach was pioneered by Hallam (1988) for the period 1086-1315, and has been reworked for this period using additional material, and then extended to the period after 1315. The estimates for 1086-1315 are reported in index number form in Part A of Table A11.1. Compared with Hallam (1988), a slightly smaller population increase is found between 1086 and the late thirteenth century, but a similar pattern of faster growth in the twelfth than in the thirteenth century. The annual population growth rates presented in the table provide a check on the credibility of the estimates by demonstrating that successive benchmark estimates do not require implausible rates of change. Significantly, during the periods of population expansion, the annual growth rates do not exceed the firmly established rates seen over sustained periods between the mid-fifteenth and early eighteenth centuries, and are well below the rates observed from the second half of the eighteenth century (Wrigley and Schofield, 1989).

For the period after 1315, although the manorial sector was in decline, so that there are fewer manors with data than for the pre-1315 period, there is a clear improvement in another dimension, since use can now be made of estimates for particular manors which contain a time-series element taken from a single source, rather than comparing one-off estimates from different sources (Poos, 1991). To link up with the time series for the period 1086-1315 it is necessary to establish a benchmark for 1315. This exercise is started at 1300 so as to capture the growth of population to a peak in 1315 on the eve of the Great European Famine, which led to a substantial drop in the population. The estimates given in Part B of Table A11.1 confirm Russell's (1948) belief that the population bounced back strongly after 1325 and continued to rise until the first outbreak of plague in 1348-9. The Black Death, which was accompanied and reinforced by inclement weather and serious harvest failure, had a catastrophic effect, reducing the population by around 46 per cent within the space of just 3 years.

Part C of Table A11.1 tracks the path of population from 1377 to 1541. The manorial evidence suggests that after the bounce-back between 1351 and 1377, the downward trend from the 1348 peak resumed at a substantial rate between 1377 and 1400, and continued at a reduced rate to the middle of the fifteenth century. One way of understanding this trend would be if the later plague outbreaks disproportionately affected younger age groups, thus making it difficult for the population to rebound through increased fertility (Hatcher, 1977: 58-62). After 1450 the manorial data become too thin to provide the basis for a regionally balanced population estimate, so it is necessary to rely on other less direct sources to track the movement of population between 1450 and 1541.

Although Smith (2009) argues that population continued to decline during the second half of the fifteenth century, there are some serious problems with this line of argument. First, population needed to recover at some point to reach the firmly grounded level of 2.83 million by 1541 without requiring growth rates that strain credulity. If population continued to decline during the second half of the fifteenth century, then the rate of population growth required in the first half of the sixteenth century becomes implausibly high. Second, real wage rates turned down around 1450 after a long period of increase from the early fourteenth century and a rapid increase across the Black Death (Phelps Brown and Hopkins, 1956; Clark, 2005). Third, quinquennial population growth rates derived from replacement rates in the *inquisitiones post mortem* were persistently negative until the early 1430s and became persistently positive from the early1460s, with positive growth clearly outweighing negative growth during the 1440s and 1450s (Hollingsworth, 1969).

The next step is to pin down the absolute level of population during the medieval period, using the benchmark estimate for 1377 obtained from the poll tax returns and reported here in Table A11.2. The key assumptions made by Russell (1948: 146) to derive a population total for England are the proportion of children in the population and the rate of under-enumeration. Russell's assumptions and results are set out in the first column of

Table A11.2. Postan (1966: 562) suggested alternative assumptions, leading to the results set out in the second column of Table A11.2.

Whereas Russell assumed that children under the age of 15 accounted for 33.3 percent of the population, Postan suggested that the ratio may have been as high as 40 to 45 per cent. For the period after 1541, when reliable data become available, the percentage of under-15s in the population never rose above 40 percent, which surely represents the upper limit for 1377 (Wrigley and Schofield, 1989: Table A3.1). As Blanchard (1996) points out, such a high ratio tended to occur in periods of rapid population growth driven by high fertility. Since population was declining in the aftermath of the Black Death, a ratio as high as 40 to 45 per cent in the 1370s is improbable and a lower ratio more likely.

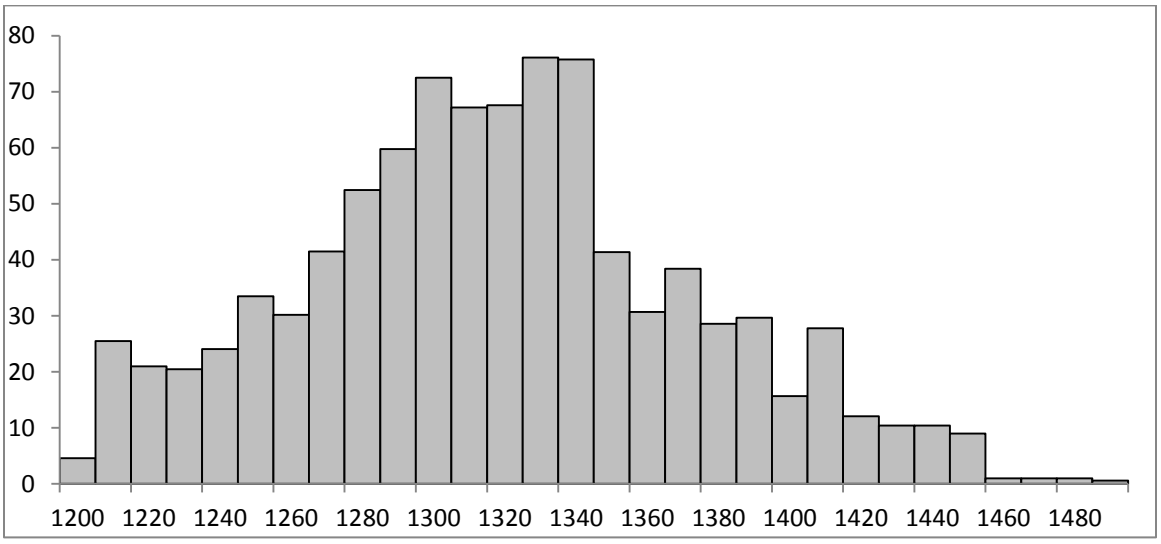
The second assumption of Russell that was challenged by Postan concerns the assumed rate of under-enumeration. Russell's figure of 5 per cent is based on an examination of the distribution of terminal numbers of local tax returns for evidence of excessive rounding, together with an allowance for "indigent and untaxed persons". Postan suggests a much higher rate of 25 per cent, which he justifies with reference to discrepancies between the poll tax returns and unspecified manorial sources. Poos (1991), however, supports Russell's ratio on the basis of a comparison of the poll tax returns and tithing evidence for a sample of Essex parishes. For a later period, Campbell (1981: 150) uses the discrepancy between the tax returns of 1524-1525 and the muster rolls of 1522 to infer an evasion rate of males varying from a minimum of 5 per cent to a maximum of 20 per cent, arguing for an average figure of the order of 10 per cent. The poll taxes, of course, taxed both adult males and females, and although the latter may have been less visible to the taxers than the former, Goldberg (1990: 200) concludes that "the underenumeration of women cannot have been a serious fault of the earlier [i.e. 1377] returns".

Russell's assumptions of a 33.3 per cent children's share and a 5 per cent under-enumeration rate result in a population total for 1377 of 2.23 million, while Postan's assumptions of a 45 per cent children's share and a 25 per cent under-enumeration rate

lead to an estimate of 3.22 million. The third column of Table A11.2 also presents a "best estimate" of 2.50 million, based on a children's share of 37.5 per cent and an under-enumeration rate of 10 per cent, more in line with Wrigley and Schofield's demographic evidence and Poos and Campbell's tax-evasion evidence.

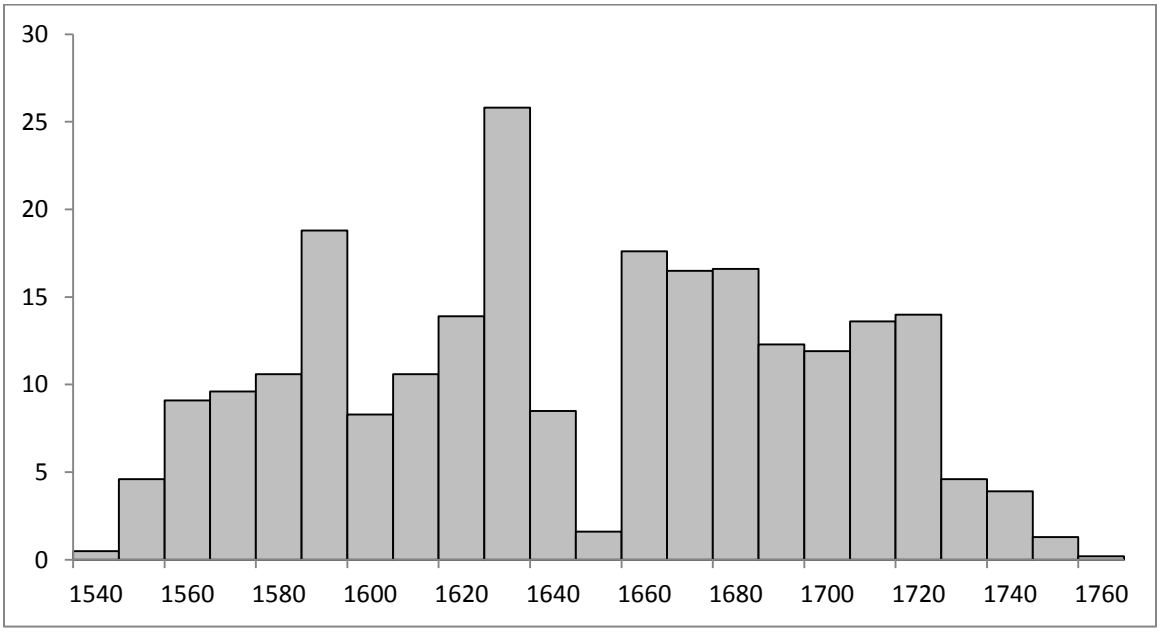
Putting together the trends from Table A11.1 with the benchmark "best estimate" of population in 1377 from Table A11.2 produces the levels of population charted in Table A11.3.

FIGURE A1.1: Number of sampled manors per year in the middle ages (decadal averages)



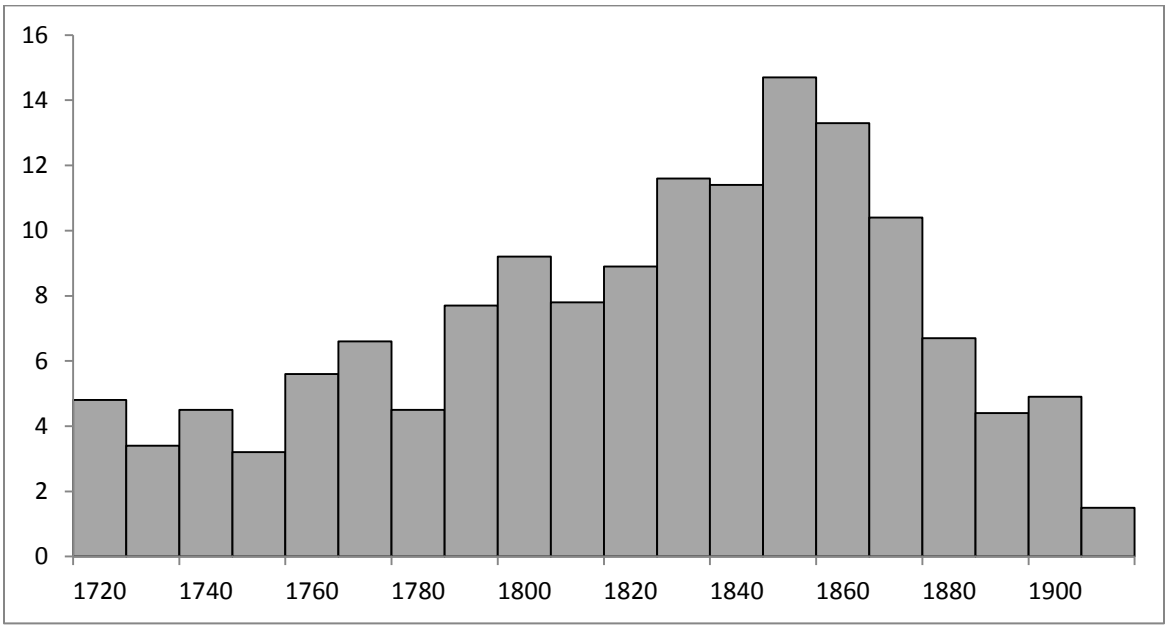
Source: Medieval Accounts Database.

FIGURE A1.2: Number of sampled farms per year in the early modern period (decadal averages)



Source: Early Modern Probate Inventories Database

FIGURE A1.3: Number of sampled farms per year in the modern period (decadal averages)



Source: Modern Farm Accounts Database

TABLE A1.1: Share of the demesne sector in sown acreage

	Demesne sector	Non-demesne sector	Total sown acreage	Share of demesne sector
		(m acres)		(%)
1250	1.79	5.32	7.11	25.2
1300	2.04	6.12	8.16	25.0
1380	1.12	4.63	5.75	19.5
1420	0.56	4.65	5.21	10.8
1450	0.32	4.70	5.03	6.4
1500	0.00	5.26	5.26	0.0

Sources and notes: Following Campbell (2000), the share of the demesne sector was set at 25% in 1300. Estimates for other years between 1270 and 1500 are obtained by extrapolation on the basis of trends in the cropped acreage on demesnes and tithe data in the non-demesne sector (Campbell, Bartley and Power, 1996; Dodds, 2004; Medieval Accounts Database). The demesne sector is assumed to disappear by 1500.

TABLE A2.1: County acreage and percentage arable, 1836/1871

	County acreage	% arable, 1836	% arable, 1871	Mean % arable 1836/71
Bedfordshire	303,360	60.1	61.5	60.8
Berkshire	481,920	58.5	57.3	57.9
Buckinghamshire	475,520	55.8	45.8	50.8
Cambridgeshire	558,080	70.1	75.6	72.8
Cheshire	613,120	25.5	27.6	26.6
Cornwall	889,600	23.8	43.0	33.4
Cumberland	979,200		27.5	27.5
Derbyshire	646,400	25.3	23.8	24.5
Devon	1,672,320	22.5	39.6	31.0
Dorset	661,760	21.5	37.8	29.6
Durham	635,520	54.9	35.2	45.0
Essex	983,680	72.4	60.4	66.4
Gloucestershire	800,640	32.0	43.8	37.9
Hampshire	1,030,400	64.3	50.2	57.2
Herefordshire	539,520	39.7	38.5	39.1
Hertfordshire	399,360	66.6	63.5	65.1
Huntingdonshire	236,800	49.8	65.8	57.8
Kent	1,000,320	48.5	52.3	50.4
Lancashire	1,234,560	27.1	20.6	23.8
Leicestershire	532,480		35.3	35.3
Lincolnshire	1,707,520	48.7	59.2	54.0
Middlesex	189,440		22.5	22.5
Norfolk	1,317,760	63.8	62.1	62.9
Northamptonshire	638,720		44.7	44.7
Northumberland	1,297,920	46.5	26.1	36.3
Nottinghamshire	532,480		54.8	54.8
Oxfordshire	473,600	55.8	58.1	57.0
Rutland	96,640	38.2	46.3	42.3
Shropshire	860,160	47.0	41.4	44.2
Somerset	1,044,480	24.4	28.3	26.4
Staffordshire	740,480	44.8	32.3	38.6
Suffolk	957,440	70.3	65.0	67.7
Surrey	485,120	48.8	39.9	44.3
Sussex	935,040	43.8	41.3	42.5
Warwickshire	620,800	47.5	43.7	45.6
Westmorland	506,240		12.2	12.2
Wiltshire	849,920	35.1	49.0	42.0
Worcestershire	451,200	42.7	45.1	43.9
Yorkshire, ER	755,200	65.6	64.7	65.2
Yorkshire, NR	1,378,560	32.2	31.3	31.8
Yorkshire, WR	1,815,040	30.0	28.3	29.2
ENGLAND	32,328,320			42.9

Sources: Parliamentary Papers (1871); Kain (1986).

TABLE A2.2: Population density and arable acreage by county in 1290

Region	County	Population per mile^2	% arable	Arable acreage
Eastern England:	Norfolk	200	60.0	790,656
	Huntingdonshire	155	62.5	148,000
	Suffolk	147	60.0	574,464
	Cambridgeshire	136	57.5	320,896
	Lincolnshire	134	57.5	981,824
NE midlands:	Rutland	146	62.5	60,400
	Northamptonshire	145	62.5	399,200
	Leicestershire	112	47.5	252,928
	Nottinghamshire	102	52.5	279,552
	Derbyshire	83	32.5	210,080
South-east:	Middlesex	331	60.0	113,664
	Bedfordshire	141	57.5	174,432
	Oxfordshire	125	62.5	296,000
	Hertfordshire	123	52.5	209,664
	Kent	118	47.5	475,152
	Buckinghamshire	117	47.5	225,872
	Essex	111	50.0	491,840
	Surrey	95	42.5	206,176
	Berkshire	93	50.0	240,960
	Sussex	85	37.5	350,640
	Hampshire	71	47.5	489,440
SW midlands:	Gloucestershire	123	47.5	380,304
	Wiltshire	119	47.5	403,712
	Somerset	105	42.5	443,904
	Dorset	104	42.5	281,248
West midlands:	Warwickshire	98	45.0	279,360
	Worcestershire	82	42.5	191,760
	Herefordshire	77	37.5	202,320
	Shropshire	77	37.5	322,560
North-east:	Yorkshire, ER	111	57.5	434,240
	Yorkshire, NR	70	25.0	344,640
	Co. Durham	62	25.0	158,880
	Yorkshire, WR	52	20.0	363,008
	Northumberland	51	25.0	324,480
South-west:	Devon	60	25.0	418,080
	Cornwall	55	25.0	222,400
North-west:	Staffordshire	58	30.0	222,144
	Cheshire	45	15.0	91,968
	Lancashire	37	15.0	185,184
	Westmorland	37	12.5	63,280
	Cumberland	34	15.0	146,880
ENGLAND		94	39.5	12,772,192

Source: See Appendix text.

TABLE A3.1: Regional shares of the national sown area in 1290 and 1836/71 (%)

Region	Counties	1290	1836/71
East Anglia	Norfolk and Suffolk	10.7	10.7
Eastern counties	Bedfordshire, Cambridgeshire, Essex, Hertfordshire, Huntingdonshire, & Lincolnshire	18.2	18.5
Southern counties	Berkshire Gloucestershire, Hampshire, Herefordshire, Wiltshire, & Worcestershire	14.9	14.0
Southwest	Cornwall, Devon, Dorset, & Somerset	10.7	7.4
Southeast	Kent, Middlesex, Surrey, & Sussex	9.0	8.4
Midlands	Buckinghamshire, Leicestershire, Northamptonshire, Oxfordshire, Rutland, & Warwickshire	11.9	9.4
North	Cheshire, Cumberland, Derbyshire, Durham, Lancashire, Northumberland, Nottinghamshire, Shropshire, Staffordshire, Westmorland, & Yorkshire	24.6	31.6

Source: Derived from Tables A2.1 and A2.2.

TABLE A3.2: Regional weights for the arable sector by year and crop (%)

A. 1290

	Wheat	Rye	Barley	Oats	Pulses
East Anglia	5.5	22.9	26.1	4.1	22.4
Eastern counties	25.2	4.2	2.3	23.0	8.7
Southern counties	14.9	11.2	20.7	13.7	10.8
Southwest	14.6	4.0	0.6	14.0	3.9
Southeast	5.3	30.7	6.5	11.3	4.6
Midlands	12.6	24.5	12.1	10.0	6.6
North	21.8	2.6	31.7	23.8	43.0
England	100.0	100.0	100.0	100.0	100.0

B. 1836/71

	Wheat	Rye	Barley	Oats	Pulses
East Anglia	10.8	19.0	15.9	3.4	8.0
Eastern counties	18.9	23.1	17.4	16.3	22.1
Southern counties	15.0	7.9	14.2	12.3	12.2
Southwest	7.0	0.6	8.4	10.3	3.2
Southeast	8.7	5.1	4.9	13.7	8.1
Midlands	9.8	3.9	5.6	15.4	9.1
North	29.8	40.5	33.5	28.6	37.2
England	100.0	100.0	100.0	100.0	100.0

Source: derived from shares of arable acreage in Table A3.1 and crop distributions within each region from the Medieval Accounts Database, the Early Modern Probate Inventories Database and the Modern Farm Accounts Database.

TABLE A3.3: Values of the regional effects in the arable yield regressions

A. Medieval period

	Wheat	Rye	Barley	Oats	Pulses
Constant	2.132	2.542	2.323	2.459	1.103
	(18.28)	(2.35)	(9.51)	(16.28)	(1.13)
Eastern counties	-0.007	omitted	omitted	-0.494	0.756
	(-0.13)			(-5.94)	(2.01)
Southern counties	0.382	0.507	0.721	-0.023	omitted
	(8.23)	(0.79)	(3.67)	(-.032)	
Southwest	omitted	omitted	0.072	omitted	omitted
			(0.25)		
Southeast	0.674	-0.253	-0.622	0.691	-0.532
	(10.17)	(-0.37)	(-1.71)	(11.52)	(-1.00)
Midlands	0.058	omitted	0.46	-0.234	1.213
	(1.28)		(2.06)	(-3.88)	(3.25)
North	omitted	omitted	omitted	omitted	omitted
R^2	0.577	0.604	0.542	0.538	0.428
N	4,955	1,292	4,630	4,999	2,130

B. Early modern period

	Wheat	Rye	Barley	Oats	Pulses
Constant	2.833	2.096	2.243	2.934	1.644
	(6.58)	(1.18)	(5.63)	(4.85)	(2.45)
Eastern counties	omitted	0.013	omitted	0.031	omitted
		(0.01)		(0.13)	
Southern counties	omitted	omitted	omitted	omitted	omitted
Southwest	omitted	omitted	-0.767	-0.539	omitted
			(-2.87)	(-2.25)	
Southeast	-0.096	omitted	-0.35	omitted	omitted
	(-2.33)		(-1.34)		
Midlands	0.375	NA	NA	NA	NA
	(3.34)				
North	omitted	NA	omitted	omitted	0.081
					(0.12)
R^2	0.677	0.774	0.524	0.687	0.548
N	799	198	922	445	483

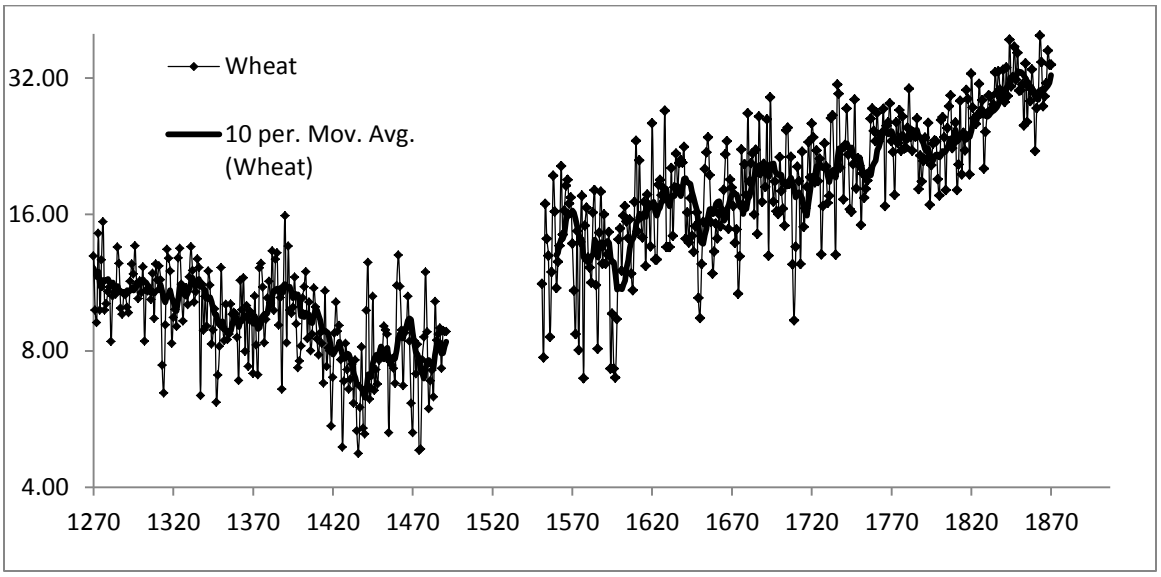
TABLE A3.3 (continued): Values of the regional effects in the arable yield regressions

C. Modern period

	Wheat	Rye	Barley	Oats	Pulses
Constant	2.78	2.967	3.632	4.105	3.316
	(17.75)	(6.63)	(7.80)	(12.71)	(3.43)
Eastern counties	-0.022	-0.051	-0.43	-0.34	0.075
	(-0.85)	(-0.10)	(-1.02)	(-1.49)	(0.08)
Southern counties	-0.132	-0.641	-0.199	-0.307	0.334
	(-5.02)	(-1.17)	(-0.46)	(-1.73)	(0.36)
Southwest	-0.173	NA	-0.595	-0.206	omitted
	(-3.27)		(-1.38)	(-0.43)	
Southeast	-0.235	NA	-0.33	omitted	0.179
	(-6.17)		(-0.79)		(0.19)
Midlands	-0.097	omitted	omitted	-0.429	0.015
	(-.246)			(-1.09)	(0.01)
North	NA	NA	NA	NA	NA
R^2	0.443	0.837	0.49	0.623	0.578
N	1,300	98	1,196	644	518

Notes: East Anglia is the benchmark region; t-statistics in parentheses; NA indicates that there are no observations available for a particular region; omitted indicates that a regional dummy was dropped because of collinearity.

FIGURE A3.1: English weighted national average wheat yields per acre, gross of tithe and seed (bushels, log scale)



Sources: Derived Medieval Accounts Database, the Early Modern Probate Inventories Database and the Modern Farm Accounts Database.

TABLE A3.4: English mean yields per acre gross of tithes, net of seeds in bushels (10-year averages)

	Wheat	Rye	Barley	Oats	Pulses	Potatoes
1270-1279	8.38	12.83	11.70	9.86	2.86	
1300-1309	7.80	9.19	11.73	8.69	6.36	
1350-1359	6.32	6.60	8.92	6.74	4.04	
1400-1409	6.36	5.77	10.74	6.76	4.35	
1450-1459	5.00	7.88	8.41	8.85	3.67	
1550-1559	9.99	6.35	9.02	10.56	5.74	
1600-1609	11.06	10.34	12.44	13.17	9.77	
1650-1659	13.46	9.83	17.87	12.10	9.35	
1700-1709	14.09	16.04	19.66	10.76	11.56	150.00
1750-1759	15.54	27.14	26.53	23.28	12.80	150.00
1800-1809	18.70	21.81	28.58	25.19	18.65	150.00
1850-1859	26.17	19.74	29.74	33.09	18.54	150.00
1861-1870	29.43	18.66	29.78	35.05	19.39	150.00

Sources and notes: Gross yield per acre taken from the Medieval Accounts Database, the Early Modern Probate Inventories Database and the Modern Farm Accounts Database. Seed sown per acre from the Medieval and Modern Databases. Pulses for the modern period and all seeds sown for the early modern period are taken from Overton and Campbell (1996), Allen (2005).

TABLE A4.1: Regional weights for the pastoral sector by type of farming and year

A. 1300

Type of Pastoral Farming	Counties	%
Region 1: Mixed enterprises with some dairying on grass / mixed husbandry	Essex & Herefordshire	7.2
Region 2: Fattening on arable, leys and grass/ mainly cattle based husbandry	Bedfordshire, Cambridgeshire, Huntingdonshire, Lincolnshire, Norfolk, Suffolk & Yorkshire (East Riding)	27.7
Region 3: Rearing with some fattening / extensive mixed husbandry	Cheshire, Cornwall, Cumberland, Derbyshire, Devon, Dorset, Durham, Hampshire, Gloucestershire, Lancashire, Leicestershire, Northumberland, Nottinghamshire, Shropshire, Somerset, Staffordshire, Westmoreland, Wiltshire & Yorkshire (North and West Riding)	42.1
Region 4: Primarily dairying / cattle husbandry	Berkshire, Buckinghamshire, Herefordshire, Kent, Middlesex, Northamptonshire, Oxfordshire, Rutland, Sussex, Surrey, Warwickshire & Worcestershire	23.0

B. 1870

Type of Pastoral Farming	Counties	%
Region 1: Mixed enterprises with some dairying on grass / mixed husbandry	Berkshire, Buckinghamshire, Hertfordshire, Kent, Northamptonshire & Oxfordshire	14.7
Region 2: Fattening on arable, leys and grass / mainly cattle based husbandry	Bedfordshire, Cambridgeshire, Essex, Huntingdonshire, Leicestershire, Lincolnshire, Norfolk, Northumberland, Nottinghamshire, Rutland, Suffolk, Sussex, Warwick & Yorkshire (East Riding)	41.6
Region 3: Rearing with some fattening / extensive mixed husbandry	Cornwall, Cumberland, Devon, Durham, Gloucestershire, Herefordshire, Shropshire, Westmoreland, Worcestershire & Yorkshire (North and West Riding)	25.0
Region 4: Primarily dairying / cattle husbandry	Cheshire, Derbyshire, Dorset, Hampshire, Lancashire, Middlesex, Somerset, Staffordshire, Surrey & Wiltshire	18.6

Sources: Campbell and Bartley (2006); Whetham and Orwin, (1971: 131); Medieval Accounts Database. These weights are based on the arable acreage in each county, derived from Tables A2.1 and A2.2. These shares are interacted with the distribution of stocking densities across animal types within each region to derive animal specific pastoral farming weights.

TABLE A4.2: Values of the regional effects in the stocking density regressions

A. Medieval period

	Cattle	Pigs	Sheep	Oxen	Horses
Constant	-0.551	-7.204	-2.421	-3.162	-4.425
	(-0.55)	(-3.94)	(-2.60)	(-6.95)	(-22.5)
Region 2	-3.472	omitted	omitted	1.192	-1.737
	(-4.99)			(1.72)	(-5.22)
Region 3	0.287	2.485	-5.093	1.924	0.091
	(0.59)	(2.74)	(-3.68)	(4.57)	(0.24)
Region 4	-0.715	omitted	0.302	1.486	-0.999
	(-1.40)		(0.18)	(3.43)	(-2.76)
R^2	0.682	0.729	0.608	0.743	0.617
N	6.861	2,302	7,984	6,797	6,838

B. Early modern period

	Cattle	Pigs	Sheep	Oxen	Horses
Constant	3.195	2.668	0.980	-10.052	3.134
	(0.75)	(0.48)	(0.13)	(-2.28)	(0.64)
Region 2	omitted	omitted	omitted	omitted	-0.059
					(-0.14)
Region 3	omitted	omitted	5.546	3.358	omitted
			(6.45)	(6.36)	
Region 4	NA	NA	NA	NA	NA
R^2	0.269	0.217	0.310	0.438	0.266
N	1,773	1,718	1,718	1,585	1,718

Notes: Definitions of regions listed in Table A4.1; Region 1 is the benchmark region; t-statistics in parentheses. Animal number are estimated directly for the modern period rather than indirectly from stocking densities, which were not collected systematically in the Modern Farm Accounts Database.

TABLE A4.3: Animal numbers, 1270-1459

A. Stocking densities on demesnes

Years	Animals per 100 sown acres		
	Cattle (mature + immature)	Sheep	Swine
1270-1279	8.03	22.90	3.38
1300-1309	10.25	10.00	3.69
1350-1359	9.85	28.86	3.04
1400-1409	8.67	25.64	2.00
1450-1459	8.01	27.86	2.18

B. Stocking densities adjusted for total agricultural sector

Years	Animals per 100 sown acres		
	Cattle (mature + immature)	Sheep	Swine
1270-1279	18.15	190.61	11.16
1300-1309	21.29	192.78	12.04
1350-1359	24.71	256.04	11.15
1400-1409	22.22	214.77	7.22
1450-1459	20.67	232.43	8.37

C. Animal numbers (millions)

	Milk cattle	Beef cattle	Calves	Sheep	Swine
1270-1279	0.47	0.42	0.47	14.22	0.83
1300-1309	0.60	0.54	0.60	15.72	0.98
1350-1359	0.51	0.46	0.51	15.26	0.67
1400-1409	0.40	0.36	0.40	11.29	0.38
1450-1459	0.36	0.32	0.36	11.73	0.42

Sources and notes: Derived from Medieval Accounts Database.

TABLE A4.4: Animal numbers, 1550-1759

A. Stocking densities from probate inventories

Years	Animals per 100 sown acres		
	Cattle (mature + immature)	Sheep	Swine
1550-1559	20.09	160.49	15.24
1600-1609	13.71	244.81	13.86
1650-1659	12.88	157.93	10.63
1700-1709	9.03	223.95	10.06
1750-1759	18.42	150.37	13.32

B. Animal numbers (millions)

	Milk cattle	Beef cattle	Calves	Sheep	Swine
1550-1559	0.41	0.37	0.41	9.55	0.91
1600-1609	0.32	0.29	0.32	16.75	0.95
1650-1659	0.35	0.31	0.35	12.29	0.83
1700-1709	2.41	0.22	0.24	17.36	0.78
1750-1759	0.57	0.52	0.57	13.58	1.20

Sources and notes: Derived from Probate Inventories Database.

TABLE A4.5: Animal numbers, 1750-1870

A. Animal numbers (millions)

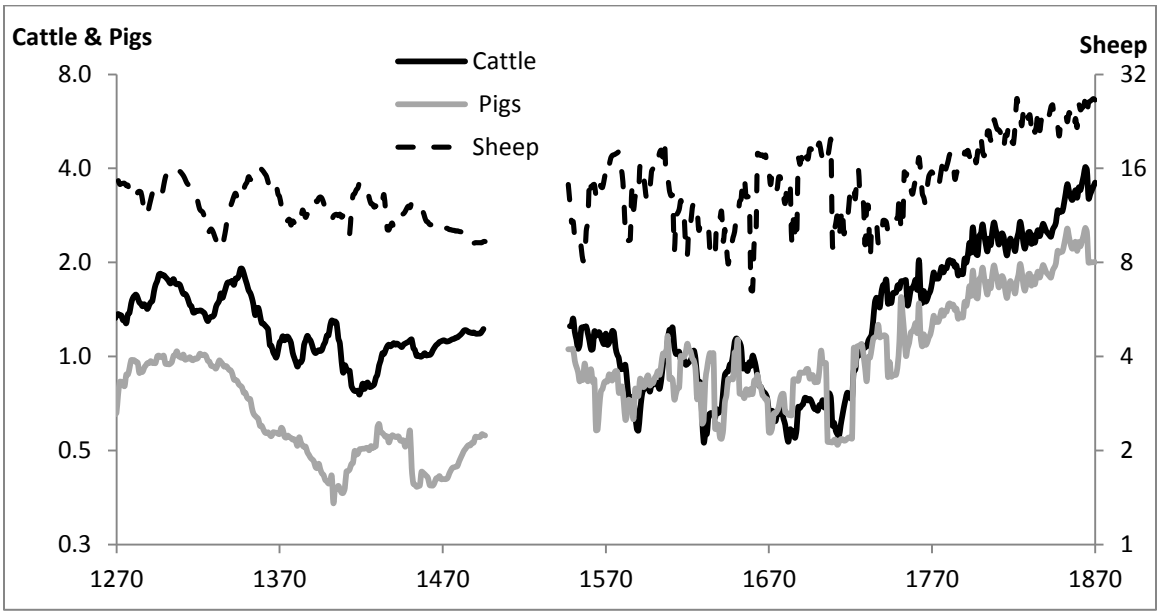
	Milk cattle	Beef cattle	Calves	Sheep	Swine
1750-1759	0.57	0.52	0.57	13.58	1.20
1800-1809	0.84	0.76	0.84	20.21	1.78
1850-1859	1.12	1.01	1.12	22.88	2.31
1861-1870	1.23	1.11	1.23	25.75	2.21

B. Implicit stocking densities

Years	Animals per 100 sown acres		
	Cattle (mature + immature)	Sheep	Swine
1750-1759	18.42	150.37	13.32
1800-1809	24.77	204.86	18.03
1850-1859	26.90	188.52	19.08
1861-1870	29.19	209.65	18.08

Sources and notes: Derived from Allen (2005); John (1989: Tables III.1 and III.2).

FIGURE A4.1: Non-working livestock in England in millions (10-year moving averages, log scale)



Sources: Derived from the Medieval Accounts Database; Early Modern Probate Inventories Database; Allen (2005); John (1989); Mitchell (1988); Turner (1998).

TABLE A4.6: Percentages of English animals producing specific products

	Milk	Beef	Veal	Mutton	Pork	Wool
1300	90	15	14.1	26	49	90
1700	90	25	21.1	26	49	90
1850	90	33	25.0	40	100	80

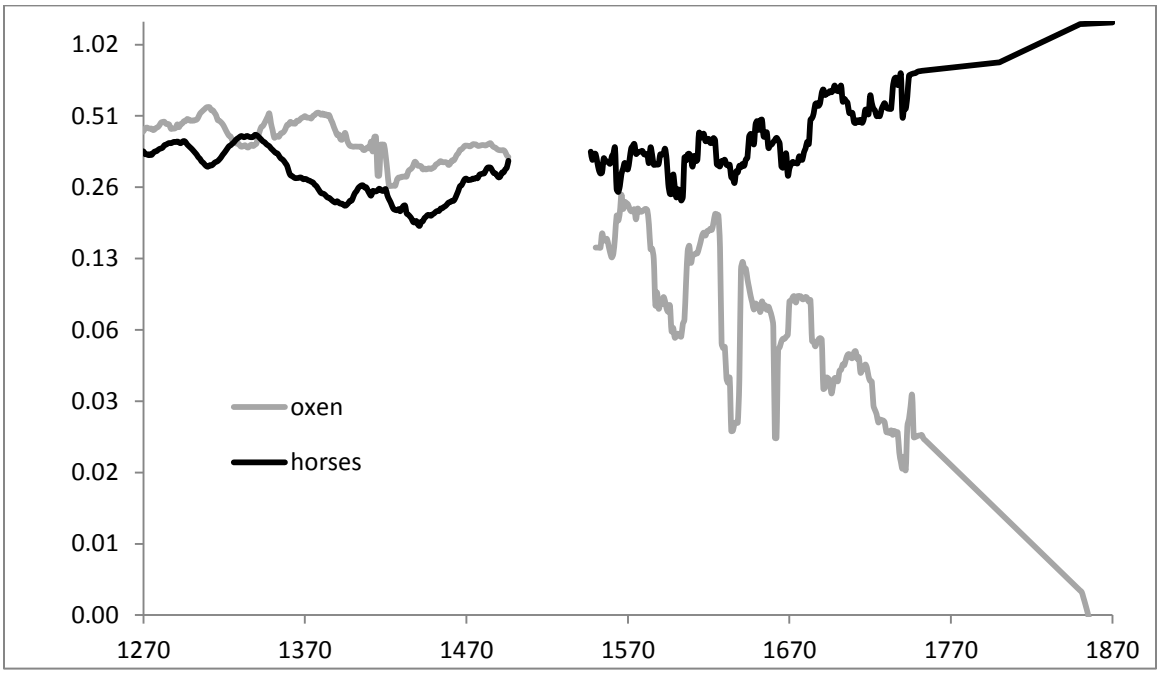
Sources: Holderness (1989: 147); Clark (1991: 216); Ecclestone (1996).

TABLE A4.7: English yields per animal (10-year averages)

Years	Milk (gallons)	Beef (lb)	Veal (lb)	Mutton (lb)	Pork (lb)	Wool (lb)
1270-1279	100.00	168.00	29.00	22.00	64.00	1.63
1300-1309	100.96	169.26	29.22	22.14	64.11	1.48
1350-1359	112.27	183.91	31.79	23.81	65.36	1.81
1400-1409	124.83	199.82	34.59	25.60	66.64	1.49
1450-1459	138.81	217.11	37.63	27.52	67.94	1.24
1550-1559	172.35	257.50	44.74	31.96	70.62	1.64
1600-1609	200.66	294.44	51.22	36.18	72.00	1.88
1650-1659	233.63	336.68	58.63	40.97	75.85	2.17
1700-1709	272.01	384.98	67.12	46.39	86.56	2.51
1750-1759	316.69	440.22	76.84	52.53	98.78	2.91
1800-1809	368.72	503.37	87.96	59.49	112.72	3.38
1850-1859	429.29	575.59	100.69	67.36	128.63	3.92
1861-1870	443.90	592.82	103.73	69.22	132.42	4.05

Sources and notes: Beef, pork, milk, and mutton are obtained from Clark (1991: 216), while veal is taken from Allen (2005: Table 6). Wool yield index from Stephenson (1988: Table 3), with the benchmark of 1.4 lb in 1300 from Britnell (2004: 416). The missing years were interpolated in line with the ratio of product to animal prices.

FIGURE A4.2: Working animals in England in millions (10-year moving averages, log scale)



Sources: Derived from the Medieval Accounts Database; the Early Modern Probate Inventories Database; Allen (1994); John (1989); Turner (1998).

TABLE A5.1: Output shares in English agriculture, 10-year averages (%)

A. Arable products in current prices

Year	Wheat	Rye	Barley	Oats	Pulses	Potatoes	Total arable products
1270-79	29.1	3.3	15.0	12.1	0.6		60.1
1300-09	25.7	3.2	12.0	8.9	1.3		51.2
1350-59	23.7	1.3	15.1	7.4	1.3		48.8
1400-09	20.7	1.3	17.1	5.7	1.4		46.3
1450-59	17.9	1.9	11.3	6.3	1.0		38.4
1550-59	33.1	3.8	12.2	7.1	2.0		58.1
1600-09	31.6	5.7	13.2	4.2	3.4		58.1
1650-59	32.8	3.6	20.0	2.8	5.3		64.5
1700-09	27.7	4.6	19.4	2.2	5.5	0.4	59.7
1750-59	25.6	0.8	16.5	4.7	4.5	5.6	57.8
1800-09	25.6	0.5	12.7	2.7	3.8	3.2	48.5
1850-59	22.6	0.2	11.3	2.1	2.1	6.5	44.8
1861-70	20.3	0.1	9.6	1.8	2.1	6.0	40.0

B. Pastoral products in current prices

Year	Milk	Beef	Pork	Mutton	Hay	Wool	Hides	Total pastoral products
1270-79	7.8	1.7	4.0	11.1	0.7	14.1	0.6	39.9
1300-09	11.7	2.3	5.0	13.4	1.1	14.6	0.7	48.8
1350-59	11.9	2.6	4.0	18.0	1.3	12.9	0.6	51.2
1400-09	14.2	3.2	3.1	17.6	1.6	13.0	1.1	53.7
1450-59	16.8	3.8	4.1	25.2	2.1	8.1	1.4	61.6
1550-59	18.4	2.4	3.6	7.0	3.0	5.6	2.0	41.9
1600-09	7.4	1.8	3.1	15.2	3.5	9.5	1.2	41.9
1650-59	10.7	2.1	2.1	11.5	4.0	4.2	0.9	35.5
1700-09	7.6	1.7	3.4	16.4	4.1	6.1	1.1	40.3
1750-59	13.1	3.7	4.8	11.5	5.0	2.9	1.2	42.2
1800-09	15.7	4.9	5.4	14.6	7.2	2.8	0.8	51.5
1850-59	16.7	5.9	7.4	14.7	6.6	3.2	0.8	55.2
1861-70	18.8	6.5	7.6	16.2	6.0	4.2	0.8	60.0

Sources: Derived from Medieval Accounts Database; Early Modern Probate Inventories Database; Modern Farm Accounts Database.

TABLE A5.2: Agricultural demand function, 1300-1700

A. Dynamic specification (dependent variable: *ln* C_t)

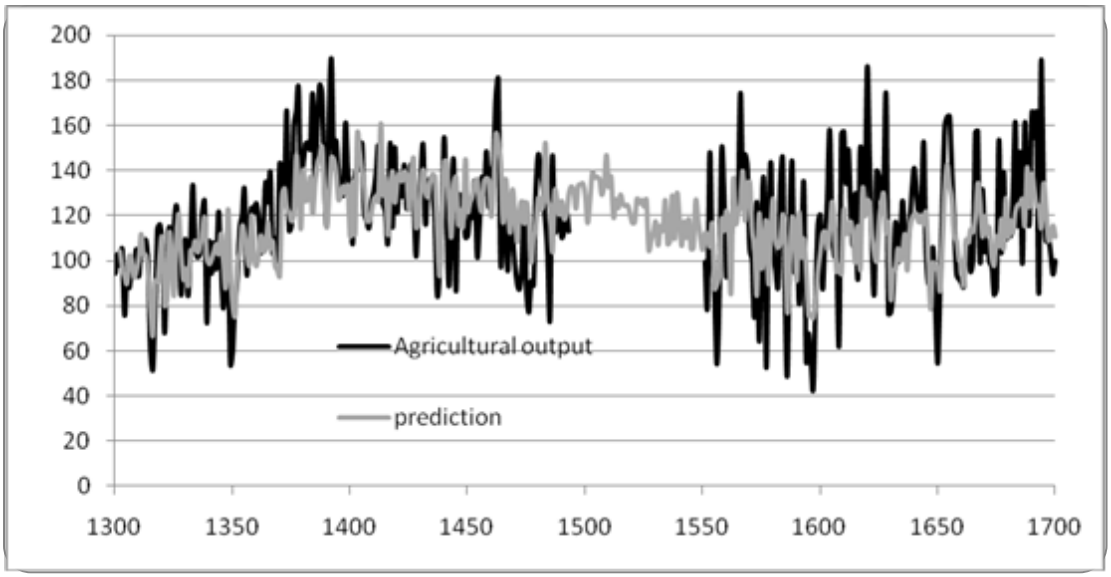
	Coefficient	Standard error
Constant	4.05	(1.04)
ln C_{t-1}	0.40	(0.06)
ln $\left(P^A / P\right)_t$	-0.07	(0.10)
ln $\left(P^A / P\right)_{t-1}$	-0.13	(0.13)
ln $\left(P^{NA} / P\right)_t$	0.58	(0.20)
ln $\left(P^{NA} / P\right)_{t-1}$	-0.58	(0.21)
ln Y_y	0.61	(0.12)
ln Y_{t-1}	-0.24	(0.12)
Log likelihood	63.27	
N	342	
DW	2.09	

B. Long run demand elasticities

Own price	-0.34
Cross price	0.00
Income	0.62

Source: See Appendix text.

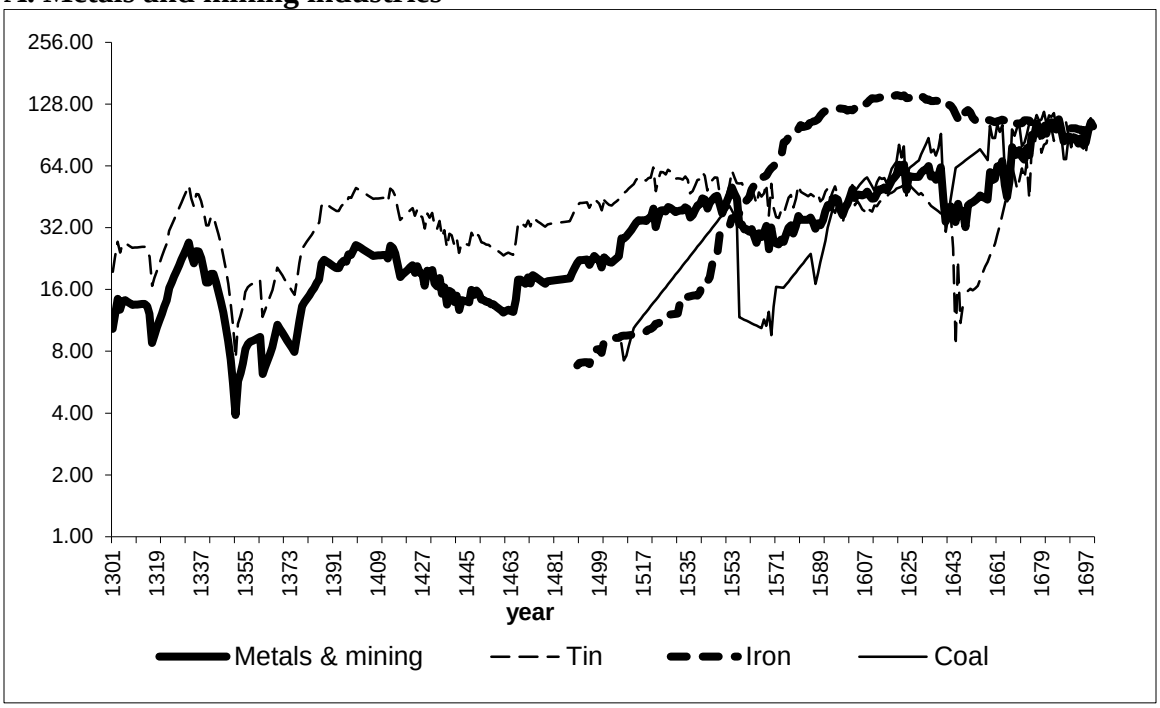
FIGURE A5.1: Agricultural output per capita, 1300-1700 (1300=100)



Source: See Appendix text.

FIGURE A6.1: English industrial production, 1270-1700 (1700=100, log scale)

A. Metals and mining industries



B. Textiles and leather industries

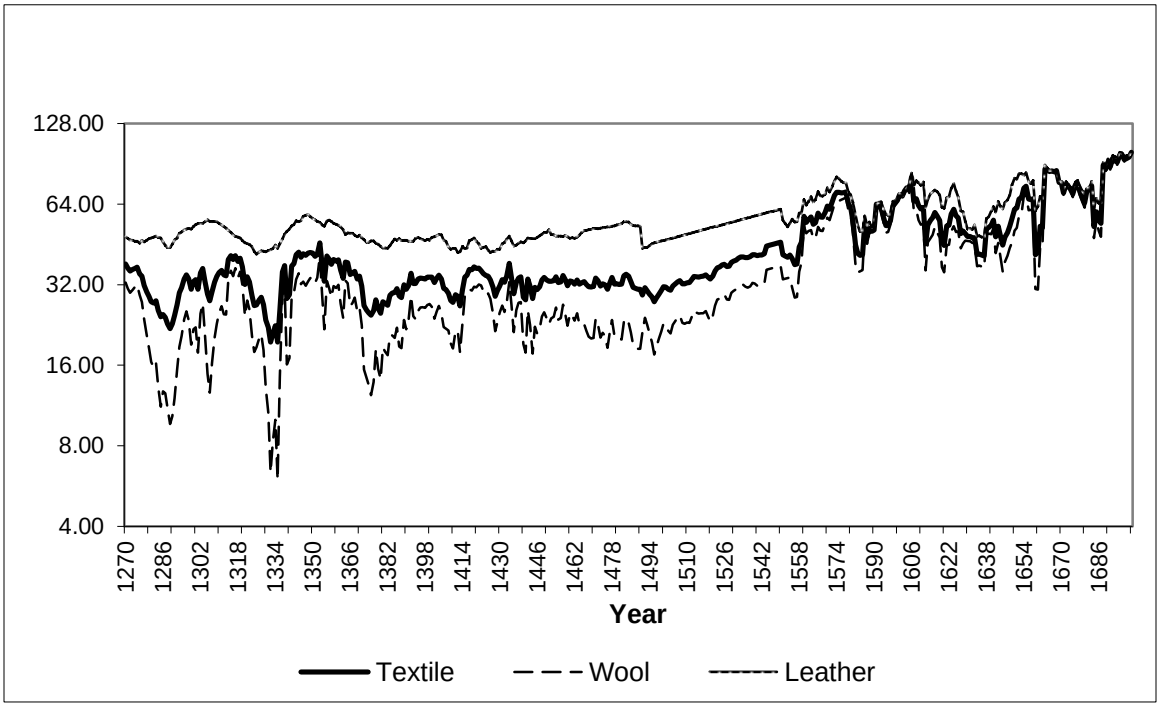
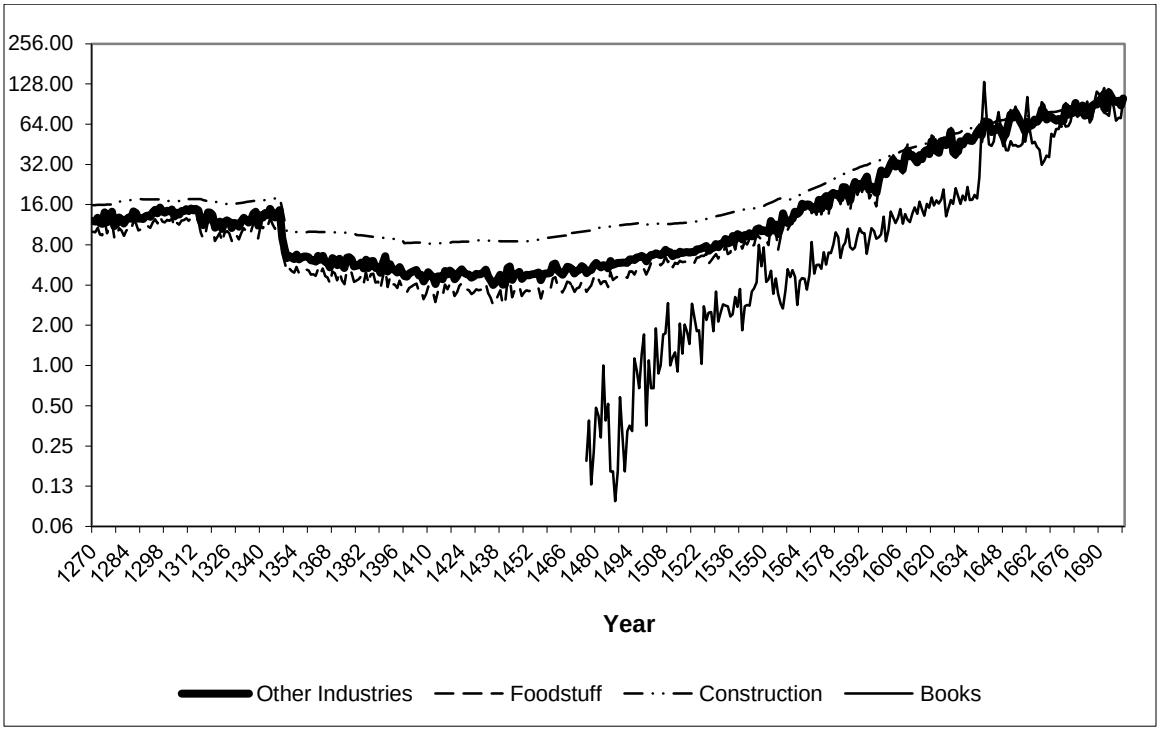
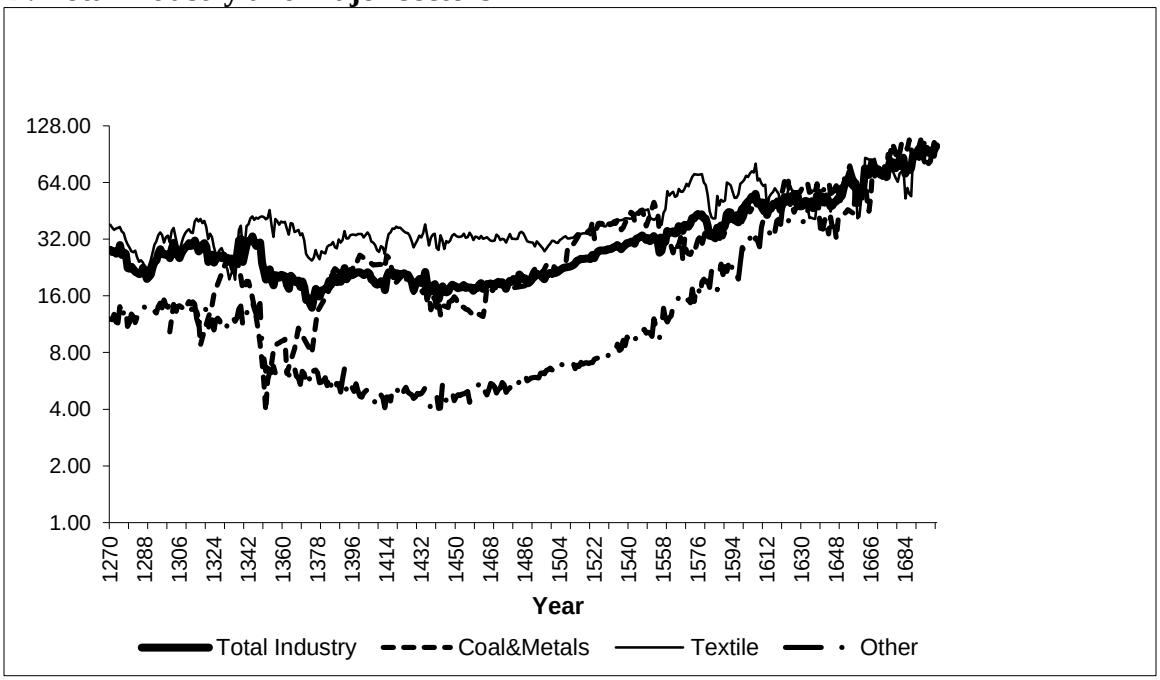


FIGURE A6.1 (continued): English industrial production, 1270-1700 (1700=100, log scale)

C. Other industries



D. Total industry and major sectors



Sources: See main text.

TABLE A7.1: British industrial output weights, 1700-1870 (%)

1700-1711	Coal, 11.4; Iron, steel and machine building, 11.8; Tin, 1.7; Cotton yarn and cloth, 8.8; Silk thread and goods, 11.4; Linen yarn and cloth, 21.2; Sugar, 0.8; Beer, 14.0; Malt, 4.4; Tobacco products, 2.1; Printed matter, 3.6; Building, 8.7
1711-1713	Coal, 10.7; Iron, steel and machine building, 11.8; Tin, 1.6; Cotton yarn and cloth, 8.2; Silk thread and goods, 10.7; Linen yarn and cloth, 19.7; Sugar, 0.7; Beer, 13.0; Malt, 4.1; Tobacco products, 2.0; Printed matter, 3.6; Candles, 5.2; Building, 8.7
1713-1722	Coal, 11.3; Iron, steel and machine building, 13.2; Tin, 1.4; Cotton yarn and cloth, 7.3; Silk thread and goods, 9.5; Linen yarn and cloth, 17.7; Sugar, 0.6; Beer, 11.7; Malt, 3.6; Tobacco products, 1.8; Paper, 0.8; Printed matter, 4.0; Soap, 2.6; Candles, 4.7; Building, 9.7
1722-1727	Coal, 5.9; Iron, steel and machine building, 8.2; Tin, 0.8; Cotton yarn and cloth, 4.6; Silk thread and goods, 5.9; Linen yarn and cloth, 10.8; Sugar, 0.3; Beer, 7.1; Malt, 2.2; Tobacco products, 1.0; Paper, 0.5; Printed matter, 4.1; Leather and leather goods, 34.1; Soap, 1.6; Candles, 2.9; Building, 9.9
1727-1739	Coal, 5.8; Copper ore, 0.5; Iron, steel and machine building, 8.1; Tin, 0.8; Cotton yarn, 4.5; Silk thread and goods, 5.8; Linen yarn and cloth, 10.7; Sugar, 0.3; Beer, 7.1; Malt, 2.2; Tobacco products, 1.0; Paper, 0.5; Printed matter, 4.1; Leather and leather goods, 33.9; Soap, 1.6; Candles, 2.9; Building, 9.9
1739-1761	Coal, 4.0; Copper ore, 0.4; Iron, steel and machine building, 5.6; Tin, 0.5; Cotton yarn and cloth, 2.4; Woollen and worsted yarn and cloth, 27.5; Silk thread and goods, 4.0; Linen yarn and cloth, 7.4; Sugar, 0.3; Beer, 5.0; Malt, 1.5; Tobacco products, 0.8; Paper, 0.3; Printed matter, 4.1; Leather and leather goods, 23.2; Soap, 1.1; Candles, 2.0; Building, 9.9
1761-1771	Coal, 3.9; Copper ore, 0.4; Iron, steel and machine building, 6.5; Tin, 0.5; Cotton yarn and cloth, 6.7; Woollen and worsted yarn and cloth, 27.1; Silk thread and goods, 3.9; Linen yarn and cloth, 7.3; Sugar, 0.3; Beer, 4.9; Malt, 1.5; Tobacco products, 0.8; Paper, 0.3; Printed matter, 3.4; Leather and leather goods, 19.7; Soap, 1.1; Candles, 2.0; Building, 9.8
1771-1780	Coal, 3.8; Copper ore, 0.3; Iron, steel and machine building, 6.5; Copper, 0.4; Tin, 0.5; Cotton yarn and cloth, 6.7; Woollen and worsted yarn and cloth, 27.0; Silk thread and goods, 3.9; Linen yarn and cloth, 7.2; Sugar, 0.3; Beer, 4.9; Malt, 1.5; Tobacco products, 0.8; Paper, 0.3; Printed matter, 3.4; Leather and leather goods, 19.6; Soap, 1.1; Candles, 1.9; Building, 9.8
1780-1787	Coal, 3.8; Copper ore, 0.3; Iron, steel and machine building, 6.5; Copper, 0.4; Tin, 0.5; Cotton yarn and cloth, 6.7; Woollen and worsted yarn, 12.2; Woollen and worsted cloth, 14.8; Silk thread and goods, 3.9; Linen yarn and cloth, 7.2; Sugar, 0.3; Beer, 4.9; Malt, 1.5; Tobacco products, 0.8; Paper, 0.3; Printed matter, 3.4; Leather and leather goods, 19.6; Soap, 1.1; Candles, 1.9; Building, 9.8

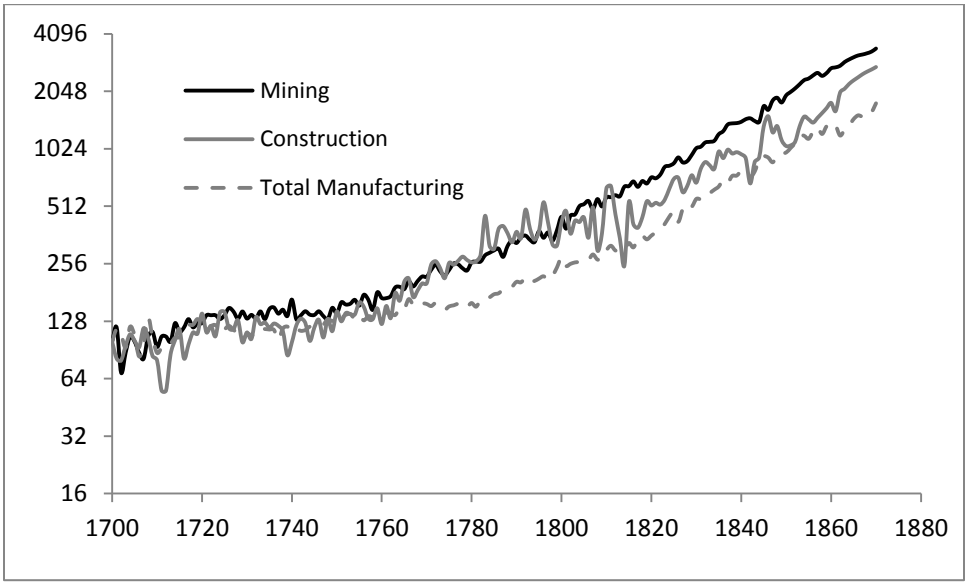
TABLE A7.1 (continued): British industrial output weights (%)

1787-1789	Coal, 3.8; Copper ore, 0.3; Iron, steel and machine building, 6.5; Copper, 0.4; Tin, 0.5; Cotton yarn and cloth, 6.7; Woollen and worsted yarn, 12.2; Woollen and worsted cloth, 14.7; Silk thread, 1.3; Silk goods, 3.0; Linen yarn and cloth, 7.2; Sugar, 0.3; Beer, 4.9; Malt, 1.5; Tobacco products, 0.8; Paper, 0.3; Printed matter, 3.4; Leather and leather goods, 19.5; Soap, 1.1; Candles, 1.9; Building, 9.7
1789-1801	Coal, 3.7; Copper ore, 0.3; Iron, steel and machine building, 6.5; Copper, 0.4; Tin, 0.5; Shipbuilding, 1.9; Cotton yarn and cloth, 6.7; Woollen and worsted yarn, 11.9; Woollen and worsted cloth, 14.4; Silk thread, 1.2; Silk goods, 2.5; Linen yarn and cloth, 7.0; Sugar, 0.3; Beer, 4.8; Malt, 1.4; Tobacco products, 0.8; Paper, 0.3; Printed matter, 3.4; Leather and leather goods, 19.1; Soap, 1.1; Candles, 1.9; Building, 9.8
1801-1831	Coal, 8.6; Copper ore, 1.0; Iron, steel and machine building, 11.5; Copper, 0.9; Copper products, 0.9; Tin, 0.4; Shipbuilding, 2.6; Cotton yarn, 5.1; Cotton cloth, 10.1; Woollen and worsted yarn, 6.9; Woollen and worsted cloth, 6.9; Silk thread, 0.6; Silk goods, 1.4; Linen yarn and cloth, 5.3; Wheaten flour, 1.4; Bread and cakes, 3.0; Sugar, 0.5; Beer, 0.9; Malt, 0.6; Spirits, 1.4; Tobacco products, 0.6; Paper, 1.9; Printed matter, 3.9; Leather, 1.3; Leather goods, 8.8; Soap and candles, 2.0; Building, 11.5
1831-1850	Coal, 10.7; Tin ore, 0.3; Copper ore, 0.8; Lead ore, 0.6; Iron, steel and machine building, 12.2; Copper, 0.6; Copper products, 1.0; Lead, 0.3; Tin, 0.1; Shipbuilding, 1.4; Furniture, 2.6; Timber products, 4.3; Cotton yarn, 11.3; Cotton cloth, 6.3; Woollen and worsted yarn, 3.8; Woollen and worsted cloth, 4.1; Silk thread, 1.0; Silk goods, 2.3; Linen yarn and cloth, 2.5; Hemp products, 0.1; Wheaten flour, 2.4; Bread and cakes, 1.6; Confectionary, 0.4; Sugar, 0.4; Beer, 2.3; Malt, 0.4; Spirits, 0.6; Tobacco products, 0.5; Paper, 1.5; Printed matter, 3.1; Leather, 1.1; Leather goods, 7.0; Soap and candles, 1.0; Vegetable oils, 0.1; Building, 11.4

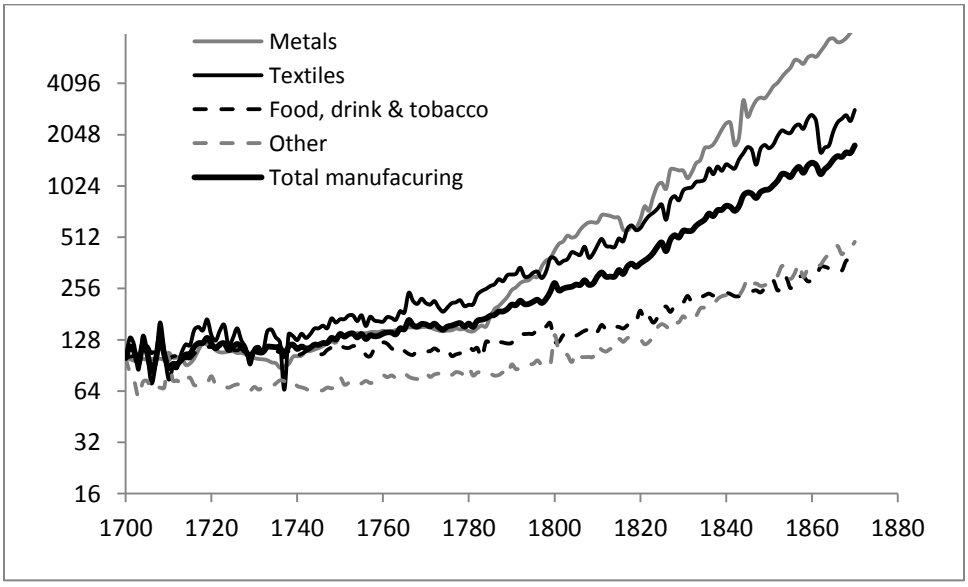
Source: derived from Hoffmann (1955: 18-19); Crafts and Harley (1992: 728).

FIGURE A7.1: Industrial output by sub-sector (1700=100, log scale)

A. Mining, construction and manufacturing



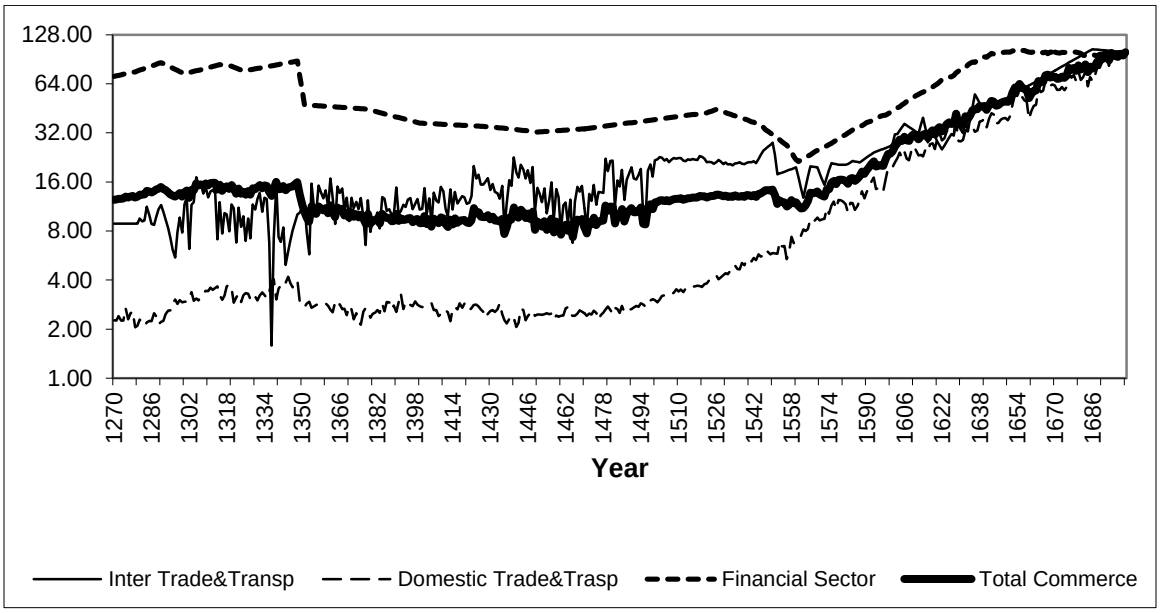
B. Metals, textiles, FDT, other manufacturing



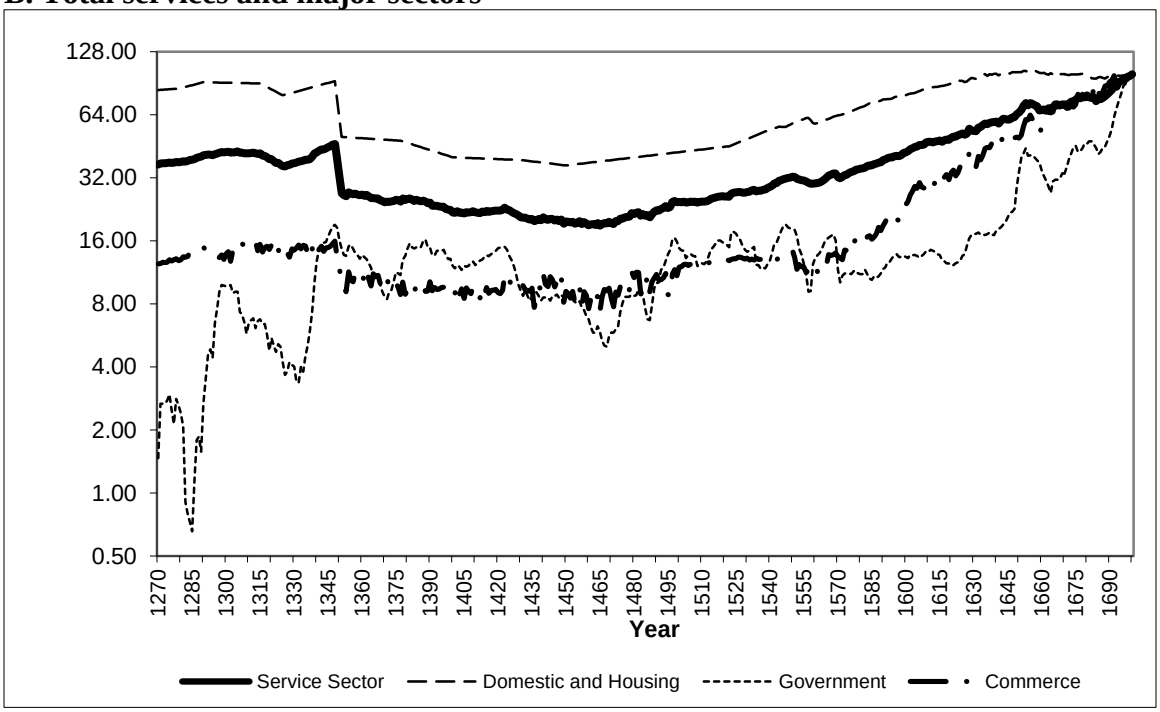
Source: See main text.

FIGURE A8.1: English service sector output, 1270-1700 (1700=100, log scale)

A. Commerce



B. Total services and major sectors



Sources: See main text.

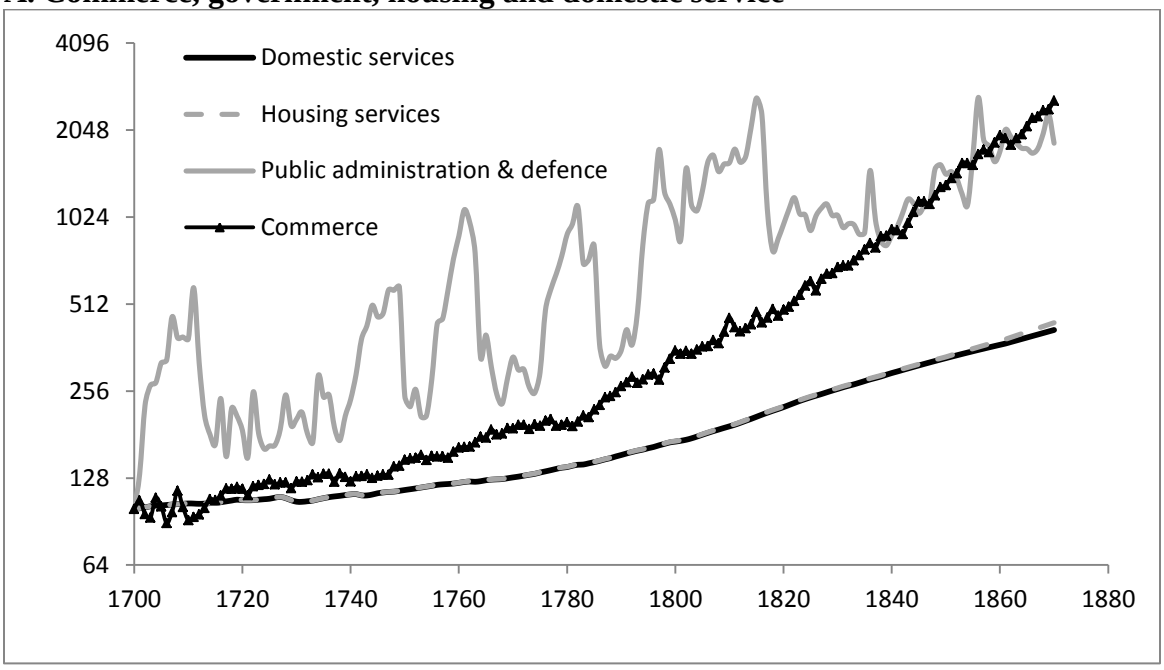
TABLE A9.1: British service sector output weights, 1841

	%
Commerce	62.3
Of which:	
Transport	10.3
Distribution	33.3
Finance	5.0
Other commerce	13.7
Domestic service	14.5
Housing	17.6
Public administration & defence	5.6

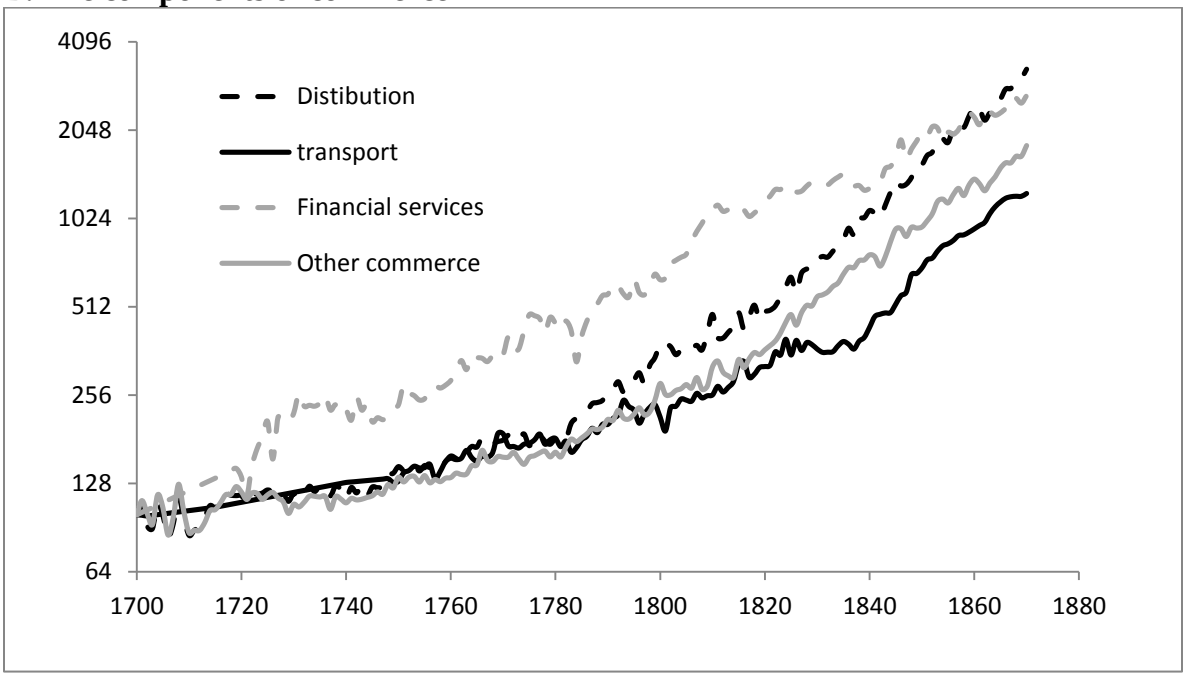
Source: derived from Horrell, Humphries and Weale (1994: 547).

FIGURE A9.1: Services output by sub-sector (1850=100, log scale)

A. Commerce, government, housing and domestic service



B. The components of commerce



Source: See main text.

TABLE A11.1: English population trends, 1086-1541

A. 1086-1315 (1086=100)	Year	Population level (1086=100)	Period	Annual growth rate (%)
	1086	100.0		
	1190	181.6	1086-1190	0.58
	1220	232.7	1190-1220	0.83
	1250	247.9	1220-1250	0.21
	1279	259.4	1250-1279	0.16
	1290	278.5	1279-1290	0.65
	1315	274.8	1290-1315	-0.05
B. 1300-1377 (1300=100)	Year	Population level (1300=100)	Period	Annual growth rate (%)
	1300	100.0		
	1315	108.1	1300-1315	0.52
	1325	94.9	1315-1325	-1.30
	1348	111.0	1325-1348	0.68
	1351	60.0	1348-1351	-18.53
	1377	57.5	1351-1377	-0.16
C. 1377-1541 (1377=100)	Year	Population level (1377=100)	Period	Annual growth rate (%)
	1377	100.0		
	1400	83.3	1377-1400	-0.79
	1430	80.8	1400-1430	-0.10
	1450	76.2	1430-1450	-0.29
	1522	94.0	1450-1522	0.29
	1541	112.8	1522-1541	1.02

Sources: Estimates derived from data on manorial trends as described in the text, apart from estimates for 1522 from Cornwall (1970: 39) and for 1541 from Wrigley, Davies, Oeppen and Schofield (1997).

TABLE A11.2: English population, 1377

	Russell	Postan	"Best estimate"
Laity	1,355,555	1,355,555	1,355,555
Clergy	30,641	30,641	30,641
Allowance for Cheshire, Durham & mendicant friars	31,994	31,994	31,994
Adult total	1,417,380	1,417,380	1,417,380
Share of population under-15	33.3%	45.0%	37.5%
Allowance for children	708,690	1,159,675	850,428
Total including children	2,126,070	2,577,055	2,267,808
Assumed rate of under-enumeration	5%	25%	10%
Allowance for under-enumeration	106,303	644,264	226,781
Total population	2,232,373	3,221,319	2,494,589

Sources: Russell (1948: 146); Postan (1966: 562).

TABLE A11.3: English population, 1086-1541 (millions)

Year:	Total population:	Year:	Total population:
1086	1.71	1348	4.81
1190	3.10	1351	2.60
1220	3.97	1377	2.50
1250	4.23	1400	2.08
1279	4.43	1430	2.02
1290	4.75	1450	1.90
1315	4.69	1522	2.35
1325	4.12	1541	2.83

Sources: benchmark years 1086-1450 from Table A11.1, with absolute level determined by the "best estimate" for 1377 from Table A11.2. Benchmarks for 1522 from Cornwall (1970: 39) and for 1541 from Wrigley, Davies, Oeppen and Schofield (1997).

ADDITIONAL REFERENCES

Allen, R.C. (1988), "Inferring Yields from Probate inventories", *Journal of Economic History*, 48, 117-125.

Allen, R.C. (1994) "Agriculture During the Industrial Revolution", in Floud, R. and McCloskey, D. (eds.), *The Economic History of Britain since 1700, Second Edition. Volume 1:1700-1860,* Cambridge: Cambridge University Press, 96-122.

Beresford, M. (1989), "A Review of Historical Research (to 1968)", in Beresford, M. and Hurst, J.G. (eds.), *Deserted Medieval Villages,* Gloucester: Alan Sutton.

Blanchard, I. S. W. (1996), *The Middle Ages: A Concept Too Many?* Avonbridge: Newlees Press.

Blanchard, I. S. W. (1996), *The Middle Ages: A Concept Too Many?* Avonbridge: Newlees Press.

Campbell, B. M. S. (1981), "The Population of Early Tudor England: A Re-evaluation of the 1522 Muster Returns and 1524 and 1525 Lay Subsidies", *Journal of Historical Geography*, 7, 145-154.

Campbell, B.M.S. and Bartley, K.C. (2006), *England on the Eve of the Black Death: An Atlas of Lay Lordship, Land and Wealth, 1300-49,* Manchester: Manchester University Press.

Cornwall, J. (1970), "English Population in the Early Sixteenth Century", *Economic History Review*, 23, 32-44.

Deaton, A. and Muellbauer, J. (1980), *Economics and Consumer Behaviour*, Cambridge; Cambridge University Press.

Feinstein, C.H. (1978), "Capital Formation in Great Britain", in Mathias, P. and Postan, M.M. (eds.), *The Cambridge Economic History of Europe, Volume VII, The Industrial Economies: Capital, Labour and Enterprise, Part I: Britain, France, Germany and Scandinavia,* Cambridge: Cambridge University Press, 28-96.

Goldberg, P. J. P. (1990), "Urban Identity and the Poll Taxes of 1377, 1379, and 1381", *Economic History Review*, 43, 194-216.

Grigg, D. (1989), *English Agriculture: An Historical Perspective*, Oxford: Blackwell.

Hatcher, J. (1977), *Plague, Population and the English Economy, 1348-1530,* London: Macmillan.

Hollingsworth, T. H. (1969), *Historical Demography*, London: Hodder and Stoughton.

Kain, R.J.P. (1986), *An Atlas and Index of the Tithe Files of Mid-nineteenth Century England and Wales*, Cambridge: Cambridge University Press.

Kussmaul, A. (1990), *A General View of the Rural Economy of England, 1538-1840*, Cambridge; Cambridge University Press.

Lee, C.H. (1986), *The British Economy since 1700: A Macroeconomic Perspective*, Cambridge: Cambridge University Press.

Lindert, P.H. and Williamson, J.G. (1982), "Revising England's Social Tables, 1688-1812", *Explorations in Economic History*, 19, 385-408.

Mayhew, N. (1995), "Modelling Medieval Monetisation", in Britnell, R. and Campbell, B.M.S. (eds.), *A Commercialising Economy: England 1086 to c. 1300*, Manchester, Manchester University Press, 55-77.

Overton, M. (1979), "Estimating Crop Yields from Probate Inventories: An Example from East Anglia, 1585-1735", *Journal of Economic History*, 39, 363-378.

Overton, M. (1990), "Re-estimating Crop Yields from Probate Inventories: A Comment", *Journal of Economic History*, 50, 931-935.

Overton, M. (1991), "The determinants of crop yields in early modern England", in Campbell, B.M.S. and Overton, M. (eds), *Land, Labour and Livestock: Historical Studies in European Agricultural Productivity*, Manchester: Manchester University Press, 284-322.

Overton, M. (2000), "Prices from Probate Inventories", in Arkell, T., Evans, N. and Goose, N. (eds), *When Death us do Part: Understanding and Interpreting the Probate Records of Early Modern England*, Oxford: Leopard's Head Press, 120-141.

Overton, M. and Campbell, B.M.S. (1992), "Norfolk Livestock Farming 1250-1740: A Comparative Study of Manorial Accounts and Probate Inventories", *Journal of Historical Geography*, 18, 377-396.

Parliamentary Papers (1871), *Agricultural Returns for Great Britain for 1871*, Parliamentary Papers, LXIX.

Poos, L. (1991), *A Rural Society After the Black Death: Essex, 1350-1525*, Cambridge: Cambridge University Press.

Russell, J. C. (1948), *British Medieval Population*, Albuquerque: University of New Mexico Press.

Smith, R. M. (2009), "Putting Benedictine Monks in Context: Mortality in England 1350-1540", unpublished paper, University of Cambridge.

Snooks, G.D. (1995), "The Dynamic Role of the Market in the Anglo-Norman Economy and beyond, 1086-1300", in Britnell, R. and Campbell, B.M.S. (eds.), *A Commercialising Economy: England 1086 to c. 1300*, Manchester, Manchester University Press, 27-54.

Turner, M.E. (1981), "Arable in England and Wales: estimates of the 1801 Crop Return", *Journal of Historical Geography*, 7, 291-302.

Whetham, E. H. and Orwin C. S, (1971) *History of British Agriculture, 1846-1914, (2nd edition),* Newton Abbot : David and Charles.