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An Historical Perspective on the Economic Consequences of Rapid Population Growth

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ABSTRACT.

The economic consequences of population growth constitute an important topic for historians and development economists alike. Quantitative historical studies have been mainly confined to time-series analyses of English data, showing very large negative responses of real wages to population growth. These results are shown to be not robust to alternative specifications, partly due to limitations of the data. This paper re-examines the question in two ways: by using single-country time-series of land rents instead of wages, and by estimating wage responses from a newly-constructed panel data set of the six largest European economies from 1500 to 1800. The new results show less dramatic negative consequences of population growth for real wages than did earlier studies, but the magnitude of the effect remains larger than expected from simple diminishing returns in a production function with reasonable factor substitution possibilities. The historical co-incidence of population growth, inflation, and income redistribution (away from labor) remains to be fully explained. The panel data results also confirm the superiority of English and Dutch economic performance in this period, as these countries were capable of absorbing more rapid population growth at constant real wages.

INTRODUCTION

Simon Kuznets defined modern economic growth as simultaneous growth in population and income per capita (Kuznets, 1966). This was for him the distinguishing characteristic of the modern world as distinct from the pre-modern Malthusian world in which population growth led to falling per capita incomes and eventually to a slowdown in population growth itself.

When Malthus wrote, modern economic growth seemed a utopian concept, divorced from the reality of historical experience. Most of us living today have experienced modern economic growth as a personal reality and not merely a theoretical possibility. And yet we remain concerned about the possibility of extending the process forward in time and outward to all the globe. We feel some discomfort at the cheery optimism of those who say rapid population growth can only spur the process on.

That discomfort arises because we have a less than perfect understanding of how modern economic growth works and why it is that population growth doesn't bring it to a halt. Economic historians have an important role to play in this discussion: to show us what changes in economic institutions and demographic behaviors allowed modern economic growth to appear first in Europe. Answering the questions of how and why requires first an answer to the question of when. When did Europe escape the Malthusian trap? Recent historiography has pushed back the starting point of the Industrial Revolution. This paper will explore the possibility that the structural break in the economic consequences of rapid population growth occurred earlier than is commonly believed.

Traditionally, Europe's history has been divided into two periods characterized by very different consequences of rapid population growth.

According to the consensus view, Europe before the Industrial Revolution was strongly Malthusian: living standards moved in inverse rhythm with the level of population. During Europe's nineteenth century development population growth was neutral or perhaps even beneficial to the rate of economic growth. As Keynes described it, the Malthusian devil had been chained.

This consensus is of recent origin and is not without its critics. In this paper I will pursue some doubts about the Malthusian consensus, especially for the early modern era (1500-1800). Industrialization after 1800 certainly altered economic and demographic life. But so, too, did the discovery of the New World, the invention of the printing press, and the Protestant Reformation, to name only a few of the momentous changes that separate the early modern period from medieval Europe. Economic change, never really absent in Europe's history, accelerated and accumulated in the three centuries before rapid industrialization, raising the possibility that the economic consequences of population growth might have changed as well. The best empirical tests of the economic consequences of population growth before 1800 raise doubts, too, because the consequences appear to have been too severe. There is ample motivation, then, for a reappraisal of the Malthusian consensus. We can begin by reviewing the evidence on which the consensus has been built.

Historical Overview

The evidence that the nineteenth century suits Kuznets's definition of modern economic growth is overwhelming, as indeed it should be since it was the basis for his generalization. The irrelevance of population growth rates for modern economic development can be seen in Figures 1 and 2, based on the work of Paul Bairoch. Figure 1 plots rates of growth of per capita income against rates of population growth in nine West European countries in two time periods, 1830-60 and 1860-1913. The absence of any relationship between the two is confirmed by a regression of per capita income growth on population growth. The coefficient is .44, with a standard error of .52. The R-squared was only 4%. The relationship is similarly absent when the time periods are examined separately or when country changes between periods are used.

Another way to view the matter is to compare specific country experiences. The most telling comparison is between England and France. Figure 2 shows the growth paths of Great Britain and France from 1700 to 1910, in both the population and per capita income dimensions. At the beginning of the eighteenth century France was three times the size of Britain. Over the next two centuries, Britain managed to maintain its lead in per capita income while expanding its population to overtake France. Per capita income grew .65% per year in Britain and .62% per year in France. Population grew .88% in Britain and only .31% per year in France. In a Malthusian world British economic welfare would have suffered for its exuberant demographic growth.

Europe from 1250 to 1800 has been described as precisely that sort of Malthusian world. Figures 3 and 4 show the course of population and real wage growth in England and France over that time period. Historians and economists have elaborated cyclical models to describe the six or seven centuries preceding the Industrial Revolution. Figures 3 and 4 serve as a useful reminder that the number of "cycles" is too few to prove such theories. What we have are a few periods of demographic expansion or decline, each separated by many decades of economic, social, and political change.

The first period is the demographic expansion from 1100 to 1348. We don't have much evidence on wages and prices from this period in which feudalism remained important, but what there is is consistent with diminishing returns.

In 1347-50 the Black Death, a pandemic of bubonic plague reduced Europe's population by about one third. Estimates for England suggest even worse (Hatcher, 1977). Repeated outbreaks held down population growth for most of the fifteenth century in England. The hypothesis of growth for France after 1400 is purely guesswork on the part of McEvedy and Jones (1978). By 1400 real wages had climbed appreciably above their pre-plague levels. In England they continued to climb slowly to 1450 and then held steady to 1500. The French data show wide movement in the fifteenth century because of the English occupation of northern France and the resulting disruption of agricultural production.

The third period is renewed demographic expansion from 1500 to about 1650. In France, the expansion may have halted by 1590. Population regained or surpassed its pre-plague levels, while real wages fell to what they had been in 1340. This was also the period of European exploration and conquest on other continents.

Demographic stagnation followed until the early eighteenth century. Real wages recovered somewhat, but never approached the heights of the fifteenth century. Renewed population growth then halted the rise in living standards.

In all, there were five periods: three expansions, one stagnation, and one decline. In using this historical record to test hypotheses about the economic-demographic system, it is important to recall the enormous potential for coincidence.

The Malthusian Orthodoxy and its Critics

Although Malthus advanced his theories early in the nineteenth century and attempted to illustrate them with historical evidence, Malthusian thinking did not come to dominate historical writing until a century or so after his death. A major pioneer of the Malthusian revival was Postan, a British medieval historian (cf. Postan, 1966). He challenged an earlier paradigm which gave primacy to commercialization, urbanism, and the money supply as the dynamic forces of European history. He pointed out that for the late medieval period (1200-1500) relative prices (especially real wages) changed in ways that were consistent with population movements but could not be explained by inflation alone.

The Malthusian model has subsequently been extended to all of European history before the Industrial Revolution by historians like LeRoy Ladurie who describes the movement of population, prices, and wages as the "respiration" of a giant social structure, and Habakkuk whose succinct Malthusian summary has been widely quoted. New population estimates for England by Wrigley and Schofield (1981) have strengthened the case. The model has been given more formal and explicit theoretical and empirical expression in the work of Ronald Lee. So strong is the consensus that one can now find chapter titles like "Economic Evidence of Population Change" (Hatcher, 1977) in which the course of population growth is inferred from the path of real wages.

Population has gone from being overlooked to being the single dynamic element in European history. Historians have therefore sought to explain many of the observed changes as consequences of population growth or decline. These include urbanization, income distribution, and inflation. Attempts to endogenize other features of the historical landscape besides real wages have not always been successful.

Malthus was reviled by Marx, and the strongest critique of the Malthusian historical paradigm has come from a Marxist historian, Robert Brenner. Just as Postan derailed the commercialization paradigm by pointing to a previously-ignored set of facts, Brenner challenges the Malthusians by pointing out the things they can't explain. He argues that technological stagnation, the foundation of diminishing returns, is itself a product of the structure of class relations. Moreover, changes in income distribution are, in his view, driven by class struggle and not by land-labor ratios. Postan shifted the emphasis from one set of measurable variables to another. Brenner offers no new strategies to solve the intractable problem of measuring class power independently of the outcomes of class struggle. Thus, the Marxist critique cannot itself be put to an empirical test except to the extent that the failure of specifiable alternatives raises its own credibility.

Another challenge might be seen as a resurrection of the earlier paradigm. Peter Lindert (1985) has argued that inflation's correlation with population growth and real wage declines suggests that some mechanism other than simple diminishing returns was at work. He suggests that inflation may have been endogenous to population growth. We can consider this challenge in more detail in the context of empirical specifications.

FORMAL APPLICATIONS OF THE MODEL: TIME-SERIES DATA.

The consensus view is neatly summarized in Ronald Lee's (1977, 1980, 1987) econometric model of long-run population and wage growth. In its typical form, the model consists of a regression of real wages on population and a time trend. Real wages and population are measured in natural logarithms, so the estimated coefficients are elasticities: the percent change in real wages due to a one percent change in population. The simplest interpretation of the model is that mortality and technological change are the two main exogenous forces. Technological change is assumed to occur smoothly and gradually and can therefore be captured by a time trend. The level of population at any time is treated as exogenous to the current standard of living, mainly because it reflects past values of exogenously-varying mortality. The regression model is thus a formal representation of Ladurie's description of European history as Malthusian equilibrium with "drift".

So simple a model can naturally be challenged on many grounds. We will pursue some objections in detail below. Some others will not be explored here, mainly for lack of data. The wage data generally come from construction work, while our models emphasize the much larger agricultural sector for which wage data are sparse. In using mason's wages as "the wage" we assume that the labor market was sufficiently competitive that wages in all sectors moved in parallel, even if there were persistent differentials. The level of population may not be truly exogenous in this equation, for two reasons. First, the full Malthusian model includes a feedback response in which higher real wages will raise the rate of population growth. This might create a bias against finding negative economic consequences of population growth. Lee has shown that the impact of the feedback response must have been too slow and too small to cause serious problems for a regression of current wages on the current <u>level</u> of population. A second problem is that the amount of labor supplied by a given population may depend on the level of the real wage. The direction of the bias will depend on the slope of the labor supply curve. If the population supplies more labor when wages are higher, the population elasticity will be biased toward zero. On the other hand, if income effects dominate the labor supply decision so that lower wages lead to more labor supplied per person in a given population, then the population elasticity will be too large.

The constant term in this regression has no particular meaning; its value is determined by the units of measurement of the variables in the model. The coefficient on time tells us how fast (in percent per year) real wages would rise (or fall) over time if population size remained constant. The coefficient on population size is the elasticity of real wages with respect to population size. This tells us how big a percentage change in real wages is produced by a given percentage change in population. Using the coefficients on time and population we can calculate a third measure of interest: the absorption rate. The absorption rate is the rate of population growth over time that would just offset the underlying economic growth trend and leave real wages constant, or, in other words, the rate of population growth that the economy can absorb.

The rate of growth of real wages over time will be equal to the time trend coefficient plus the rate of growth of population times the population coefficient. For it to be zero, the rate of population growth must be equal to minus the time coefficient divided by the population coefficient. In models that include higher-order polynomials of time the absorption rate is not a constant. Over long time periods, the absorption rate is essentially determined by the difference between the growth rate of real wages and the growth rate of population. Lee's model attempts to divide up the absorption rate between the effects of technological improvements and population growth by looking at the effects of deviations from trend in population growth on deviations from trend in real wages.

Table 1 reports estimates of this simple model for France and England in two time periods. We report versions with no time trend, a single (log-linear) time trend, and a quadratic in time. The English results are similar to those obtained by Lee (1977, 1980) using essentially the same data and a variety of alternative specifications. The population coefficient for the early period 1300-1500 is smaller than Lee found. This is due to the use of Hatcher's more recent estimates of population which make the magnitude of the plague declines greater than in the estimates used by Lee. Both countries show population elasticities greater than one for the period after 1500. In England the coefficients are between 2 and 3, depending on the detrending.

According to the linear time trend models, the absorption rate in France was .37% per year before 1500 and .07% per year after. For the same periods in England, the absorption rate was .49% and .33%. The declining absorption rate in France is attributed by the model mainly to a decline in the trend rate of economic growth, while the effects of population remained constant. By contrast, England's smaller decline in the absorption rate is attributed to a large increase in the negative consequences of population growth which offset an increase in the underlying trend economic growth rate.

More recently, Lee (1987) has extended the analysis to other European countries. In almost every case, the estimated elasticity of real wages with respect to population is below -1. This appears to be strong confirmation of the Malthusian point of view. The problem is that it may be too strong.

The Malthusian model is based on a simple production function with the principle of diminishing returns to labor in the context of fixed supplies of land. The size of the regression coefficient should correspond to the strength of diminishing returns in the production function. In the most commonly-used production function, the Cobb-Douglas function, the elasticity of labor's marginal product with respect to labor input is equal to the share of labor in total output minus one. If labor's share was around a half, then the coefficient should be minus one-half. It would be impossible for a Cobb-Douglas production function to produce an elasticity below minus one, and yet most of the regression estimates are well below that.

Lee (1980) is well-aware of this difficulty. He elaborates a two-sector general equilibrium model with a different type of production function for agriculture that could allow a wage-population elasticity as large as his estimates. The crucial characteristic of the production function is the degree of substitutability between land and labor (elasticity of substitution). A low degree of substitutability implies more sharply diminishing returns and more severe economic consequences of population growth. The Cobb-Douglas production function assumes rather high substitutability (the elasticity of substitution is fixed at unity). Other production functions allowing for much less substitutability could produce results like those estimated. Two facts suggest caution about this interpretation. The degree of substitutability implied by Lee's model is lower than that observed in direct studies of agricultural production. Moreover, Lee was unable to estimate the more complex specifications required by the alternative production functions because "the computer program encountered nearly singular matrices it could not invert" (Lee 1980, p. 529). In other words, population growth was too highly correlated with the time trend in early modern England to allow the estimation of more complex models.

There are other possible explanations that do not require such extreme assumptions about the production function. Three seem worthy of special notice. Labor markets might not work the way the model assumes. DeVries has found evidence for eighteenth-century Holland that there was institutional resistance to changing nominal wages, but that side payments to labor were adjusted when the cost of living changed. If this was a general feature of early modern labor markets, then the real wage-population elasticity exaggerates the economic consequences of population growth. If the supply curve for labor were backward-bending (i.e., adults worked more days or hours per year to make up for lower wages), then the real wage-population elasticity gives an exaggerated measure of diminishing returns in the production function and an exaggerated measure of the decline in consumption of goods. Finally, we have no direct knowledge of what happened to investment and the capital stock over the population cycle. With cheaper labor and more valuable output, the incentives for making improvements like drainage or fencing must have increased. On the other hand, if a larger, hungrier population diverted more of its annual output to consumption, then there may have been less capital in the form of seed, livestock, etc.

The most useful feature of Lee's general equilibrium model is that it generates predictions for quantities other than the real wage, like urbanization and land rents. We can therefore test its credibility outside of the real wage regressions. Before doing so, we need to consider a line of criticism that suggests that the real wage-population regression is so poorly specified as to produce sharply diminishing returns when there was in fact no Malthusian response at all.

INFLATION AND POPULATION GROWTH

General equilibrium models of the real economy generally ignore the price level. Lee's model is no exception. But one of the strongest facts about Europe's economic-demographic history is the close correlation between population growth and inflation. Peter Lindert (1985) notes this pattern, reestimates Lee's real wage regressions for England (1541-1800), including terms for lagged inflation rates, and finds that the coefficient on population falls to zero.

The statistical underpinnings of his results can be seen in Table 2, showing the correlations of prices, wages, and population. After detrending, population and prices were very weakly correlated in the late medieval period. After 1500, however, they became positively correlated and especially so in England where the correlation coefficient was .89.

This is an important and puzzling fact. England and France used specie money at this time. The quantity theory of money would predict that an increase in population would lead to a decline in prices, because of the larger volume of real output and transactions. Goldstone (1984), for example, has suggested mechanisms by which population growth might increase the velocity of circulation of money, but there is no evidence to confirm that changes in financial practices were sufficiently great to offset the inherent deflationary tendency. Lindert (1983) offers an alternative explanation: historical coincidence, or "impish Clio", to use his phrase. Perhaps it is just an historical accident that phases of population growth coincided with the importation of silver and gold into Europe from the New World. Lindert (1985) considers some alternative systematic sources of the correlation.

Although these questions about the origins of the correlation of population growth and inflation are interesting and worthy of future research, they are not crucial to the problem at hand. To put it simply, for the purposes of estimating the real wage consequences of population growth, the correlation of prices and population is not a problem in and of itself, but it does interact with other problems to make their effects worse. This is true whatever the source of the correlation of prices and population. The two potential problems that it might exacerbate are measurement error in the data on prices and wages, and what we might call "Keynesian" properties of labor markets, i.e., a tendency for nominal wages to be "sticky" and not adjust instantaneously to changes in the price level.

Lee (1985) discusses more fully the model of wage determination. In a neoclassical labor market, the nominal wage will be set equal to the marginal physical product of labor times the expected price level. In logarithms, the log of the nominal wage equals the log of marginal physical product plus the log of expected prices. The marginal physical product of labor is supposed to be determined by the time trend and population size terms.

One simple assumption to make is that observed prices are equal to expected prices. If so, then a regression of the log of nominal wages on the log of population, log prices, and a time trend should yield a coefficient of one on log prices, and the same coefficient on population as found in the real wage regressions. Table 3 shows that this is far from true. The coefficient on prices is far below one, and the coefficient on population drops to near zero.

Lee (1985:654) showed that Lindert's regression model was equivalent to the regressions in Table 3, so his discussion of Lindert's results applies equally well here. Both Lindert and I "expressed the log of nominal wages as a time trend, and found it insensitive to the price level or population." Lee went on to say that "it may be debatable whether population growth depresses real wages, but it seems unlikely that the money wage level should be completely independent of the level of prices, even when this level increased by a factor of ten; and equally unlikely that the money wage should have risen by a factor of six or seven over this period, apparently independently of any real or monetary influences."

I agree that these conclusions are unlikely in the extreme. I have tried various specifications for expected prices using lagged prices or prices in other countries, or other price series, but the results are generally similar. The statistical results of Tables 1 to 3 indicate that some of the assumptions underlying Lee's real wage model must be violated. Some possible violations are more serious than others. In all cases, they pose serious problems only because of the background positive correlation of prices and population.

One possibility that cannot be ruled out is that the nominal wage series is worthless for the purpose of estimating Malthusian effects. Even if money wages have the right trend, they will be of no use in a detrended model like the one we have been estimating unless they also move correctly over the cycle. Both the nature of the basic sources of wage data and the methods of construction of the published series make it likely that the timing of changes is poorly gauged. In the extreme, our real wage measure may simply subtract the log of prices from a series that is just noise around trend. Since prices were strongly positively correlated with population for reasons that remain mysterious, the estimated elasticity of real wages with respect to population growth may be nothing more than minus the regression coefficient of prices on population growth. Lindert (1985) thinks this the most likely alternative. It is a hard criterion, however, because it rests not merely on some element of measurement error but on the complete absence of any systematic component to the fluctuations of nominal wages around trend. In principle, any "signal" in the dependent variable should lead to unbiased parameter estimates, albeit with larger standard errors.

A second possibility is that nominal wages are reliably measured, but that observed prices measure expected prices with error. There are really two variants to this case. In the first variant, the error (difference between observed prices and expected prices) is uncorrelated with population. If so, then Lee's real wage model is appropriate for estimating population's effects. The nominal wage regression on prices and population will bias both coefficients toward zero when population is correlated with expected prices. The coefficient on observed prices will be less than one because of the measurement error in prices. The coefficient on population will then be influenced by its correlation with expected prices.

The second variant is what we might call cyclically "sticky" nominal wages. It may be that nominal wages do not respond fully to deviations in prices around their trend. One way to describe this is that the expected prices that are used to set nominal wages heavily discount deviations from trend, whatever their source. If so, then the difference between observed and expected prices could well be positively correlated with population. Lee's real wage model would exaggerate the negative consequences of population growth.

The time-series studies of real wages in England, which form the empirical basis for the Malthusian consensus, are evidently fraught with difficulties of interpretation. There is no definitive indication that population growth did not have negative consequences, but the evidence that it had very large effects is subject to dispute. Quite possibly the data are inadequate to support conclusive results. We therefore move now to a consideration of other approaches to the problem that rely on other data, other variables, and other dimensions of variation in population growth.

COUNTRY VARIATION

One way to avoid the identification problems of single-country time-series data is to use mixed cross-section time-series or "panel" data. In this section we use data drawn from six countries (England, Holland, France, Germany, Italy, and Spain), observed at fifty-year time intervals (1500, 1550,..1800). For each country at each point in time we have a population total (from DeVries, 1984) and an average real wage for the twenty-year period centered on the "census" year (constructed by me from published data on prices and wages). Because we are interested in explaining the effects of population growth on the movement of real wages, and not in the relationships between the absolute size of population in different countries and their different levels of real wages, we will work with percentage changes in variables between the half-century benchmarks. We construct the percentage change measures as the difference in logarithms of the original values.

Table 4 presents results of regression estimates. The basic model is in column 1. We regress the percentage change in real wages on a constant and the percentage change in population (the first difference of logarithms). The constant term in these regressions is like the time trend term in the time-series regressions. It tells us the percentage change that would occur in real wages over fifty years if there was no population growth. The most likely sources of a positive constant term are capital accumulation and technical progress. The coefficient on population growth is the elasticity of real wages with respect to population growth. Combining all the countries and time periods the estimate was -1.18. While this is not as dramatic as the -2 found for some of the English time-series results, it is larger than the -.5 we would expect from a simple Cobb-Douglas production function.

The absorption rate (the rate of population growth that can be sustained with constant real wages) can be calculated by dividing the constant term by the coefficient on population growth, and reversing the sign. Because the data are for fifty-year time periods, we must divide again by fifty to obtain the absorption rate as an annual rate of growth. From model 1 we would estimate the absorption rate to be .08% per year, considerably less than the .4% per year Lee estimated for England.

The basic model assumes that the absorption rate was constant in all countries and all time periods. If it was not, our estimate of the consequences of population growth could be biased. It would also be of interest to know about differences in the absorption rate over time and between countries. We can accomplish this by including dummy variables for countries (Model 2) or time periods (Model 3), or both (Model 4). These dummy variables allow the constant term to differ between countries or time periods. This allows for the absorption rate to differ because of different underlying rates of technical progress, but retains the assumption that the effect of population growth was the same.

Our estimate of the consequences of population growth does not change much when we add these controls for fixed effects of country or time period. This must be considered strong confirmation of the general conclusions of the time-series real-wage models. Population growth in early modern Europe evidently had not merely negative consequences for real wages, but consequences greater in magnitude than would be produced by simple changes in the land/labor ratio along a flexible production function.

The country effects reveal a sharp distinction between the "successful" countries of England and Holland and the other four. Note that when using dummy variables, one category must be left out. The constant term represents the effect of this excluded category. France was excluded in these regressions. The coefficients for the other countries therefore measure the extent to which they differed from France. The absorption rate calculated from the constant term of Model 2, corresponding to France, is nearly zero. The coefficients for Germany, Italy, and Spain are nearly zero, indicating that they had absorption rates nearly identical to that of France, so in all four countries the absorption rate was close to zero. The dummy variables for England and Holland had coefficients around .2. Adding these to the constant, we find absorption rates of about .3% per year. Thus, any positive population growth in most of Europe had negative consequences, while in England and Holland economic growth allowed for modest growth without declines in real wages.

The dummy variables for time periods are the most important for solving the problems of the simple time-series models. Because prices and population were highly collinear in England and France after 1500, and because both are measured with some error, we could not determine whether the estimated effect of population on real wages was a real consequence of population growth or an artifact of historical coincidence. By allowing for different underlying growth rates of real wages in each time period, we can eliminate the effects of any coincidence in the timing of European inflation and population growth. Model 3 estimates the consequences of population growth from the variation across countries only. The estimated effect is only slightly smaller than in the first two models, and still around -1. The excluded time category is 1650-1700. In that period the absorption rate was about .18% per year. The other periods after 1600 were not significantly different in a statistical sense, but the large coefficient for 1700-50 does imply an absorption rate of .42% per year. The negative coefficients in the sixteenth century imply that the absorption rate was lower than in the later years. Indeed, since they are greater in absolute value than the estimated constant, they imply that the absorption rate itself was negative. Population would have had to decline in absolute size in order to maintain real wages at a constant level during the years of the Price Revolution.

Model 4 includes both the country and time effects simultaneously. The results are not greatly changed from the separate models.

It is also possible to estimate different coefficients for population growth in different countries or different time periods by using interaction terms. The most appropriate hypothesis for the purposes of this paper is to test whether the impact of population growth declined in the eighteenth century. Model 5 therefore adds two new terms to the regression for the interaction of population growth with dummy variables for 1700-1750 and 1750-1800. The estimated coefficient on population growth corresponds to the years before 1700. For the two eighteenth-century periods the effect of population growth is the sum of the population coefficient and the interaction term. The coefficient on the 1700-1750 interaction is small with a very large standard error and has a negative sign; there was clearly no change in the basic Malthusian structure in those years. But for the last half of the eighteenth century the interaction term is positive and large enough to cancel out the baseline effect of population growth.

In other words, there appears to have been a transition to the "modern" pattern of very little cross-section correlation of population growth and economic growth in the second half of the eighteenth century. It is important to note, however, that when the interaction term is included, the fixed effect of the 1750-1800 time period becomes large and negative, indicating that there was downward pressure on real wages throughout Europe that was not related to population growth.

FURTHER IMPLICATIONS

The main virtue of Lee's general equilibrium model is that it generates predictions for quantities other than the real wage. Given his estimated wage-population elasticity, the magnitudes of other relationships can be predicted. The most important of these predictions bring us right back to our earlier theoretical discussion about the issues of urbanization, income distribution, and inflation.

Lee adopts a constant elasticity of substitution (CES) production function. A Cobb-Douglas production function is a special case of the CES with an elasticity of substitution between land and labor equal to one. Solving the equations of the general equilibrium model for a wage-population elasticity of -2.2, Lee finds that the elasticity of substitution would have to be .16. That implies very low substitutability between land and labor; lower than has been found in any direct study. Lee does not discuss this at any length, but by accepting the CES specification he is implicitly arguing that inflexible technology in agriculture is the root cause of all the other apparent consequences of rapid population growth.

Given the limited ability to absorb labor in agriculture, the model predicts that the agricultural labor force grows less quickly than total population. The predicted elasticity is .66. If the agricultural labor force was about 75% of the total, then only about half of population growth would be absorbed by agriculture. That implies that the rest must join the urban population, meaning that the elasticity of urban population with respect to total population would be around 2. In other words, urbanization would increase rapidly during periods of rapid population growth.

A second implication concerns the distribution of income. When wages fall at a faster rate than population grows, the total wage bill falls. Total output is rising, so the non-labor share of output is growing. Lee considers the ratio of rents to wages rather than rents alone. The point is that under a Cobb-Douglas Malthusian specification the elasticity of rents with respect to population would be less than one, while in Lee's CES model it must be greater than one.

URBANIZATION AND POPULATION GROWTH

Lee's two-sector neoclassical model suggests that agriculture had limited employment opportunities for "excess" population, so rapid population growth must lead to an even more rapid growth of urban population. Lee's model predicted an elasticity of .66 for rural population and perhaps 2 for urban population.

We can look at the urbanization-population relationship using the data base recently constructed by Jan de Vries (1984: 36-39). For sixteen territorial groupings, he has constructed estimates of total and urban population at fifty-year intervals from 1500 to 1800. In his own appraisal of the relationship of population growth and urbanization he concludes that rapid urban growth " was at least as much a phenomenon of demographic stagnation and decline as it was of demographic expansion." In other words, the rate of urbanization (growth of the percentage urban) was independent of the growth rate of population.

After some necessary consolidations, I retained thirteen regions and the six half-century time periods for a total of 78 observations. The dependent variable was change in the log of rural population, or change in the log of urban population. The independent variable was change in the log of total population. I also experimented with dummy variables for countries and time periods. The estimated elasticities are shown in Table 5.

It appears that rural population absorbed far more of population growth than suggested by Lee's model, and urban population less. The elasticity on rural population was never below .9.

It is of interest to compare these results with the work of Preston (1979) on the growth of cities in LDCs. His observations were cities, not urban populations of countries, and he included controls for income level, initial size, and other characteristics of the city and country. He found a coefficient of 1.002 relating national population growth to the growth of cities. It would appear that early modern Europe had a stronger pro-urbanization tendency for rapid population growth. On the other hand, urban growth in DeVries's data includes the addition of new cities as they cross the minimum 10,000 population threshold, which might exaggerate the estimate. In any case, it appears that population growth was and is not a significant factor in determining the urban percentage.

INCOME DISTRIBUTION AND POPULATION GROWTH

A useful complement to the study of population's effect on real wages is a study of its effect on land rents. If population growth was very bad for real wages, it ought to have been very good for real rents. If agriculture had as limited a capacity to absorb labor as posited by Lee, then the elasticity of real land rents with respect to population growth should be much greater than one.

A decadal series of land rents in England from 1500 was constructed using data in Kerridge (1953) and Allen (1988). An index for France was constructed from several local studies (Blouin, 1972; Deyon, 1967; Veyrasset-Herren and Ladurie, 1968; Zolla, 1893). In principle, the rent data represent the price of new leases on existing agricultural land of fixed quality. They should bear the same relation to the marginal product of land as the wage data bear to the marginal product of labor.

Regression results for France and England are presented in Table 6. Whereas the real wage results were broadly similar for the two countries, the real rent results are very different. Population growth in France had a large effect on rents: the elasticity was around one, although the large standard error means we can't reject the hypothesis that the true effect was zero (or two). In England the effect of population growth on real rents disappears once time trends are allowed for.

We can address the issue of income distribution in another way by using the ratio of rents to wages. This ratio has the advantage of not including output prices in its construction. In a Cobb-Douglas production function, the elasticity of the ratio of rents to wages with respect to labor input should be one. For production functions with less substitutability, it will be greater than one. Regression results for France and England are shown in Table 7. They look very similar for the two countries, with a population coefficient between 2.5 and 3.

The results reveal again the severity of data problems for England. The relative price of land and labor should not depend on the price level. In France it did not. Adding prices to the regression scarcely changed the estimates. In England, on the other hand, the price level completely determined the distribution of income, eliminating any influence of population or the time trend.

The English rent results do not lend any new confidence in the time-series real wage regressions discussed previously. They are completely consistent with the hypothesis that the English nominal wage data are meaningless after detrending while the rent data track price movements closely. They are not consistent with the other explanation advanced in the discussion of real wages, namely that prices might have been measured with error around their systematic correlation with population. That hypothesis would be consistent with the French results in which the addition of prices did not affect the regression of income distribution on population.

We are a long way from having a satisfactory knowledge of the movements of rents in the early modern period. Based on the results presented here, we can at least consider the hypothesis that population growth's strongly negative consequences for real wages were balanced by equally strong positive consequences for rents. A production function with inelastic substitution possibilities between land and labor could produce this pattern. Historians will no doubt want to consider other possibilities such as changes in the relative political power of landlords and laborers that may have magnified the effect of population growth on marginal products.

CONCLUSIONS

The Malthusian devil was chained in Europe sometime before the nineteenth century. The difficulty historians face is that there are too few long-run episodes and too many multicollinear movements over them to be confident of identifying the effects of population growth on the economy. These problems are especially severe in the available time series data for early modern England which has heretofore served as the main laboratory for testing the Malthusian model. Comparable data for France confirm the negative consequences of population growth, but may suffer from some of the same problems of coincidence in the historical timing of population growth and price changes.

Using a data set that combines cross-section and time-series evidence on the six leading economies of Western Europe, this paper found substantial negative consequences of population growth for real wages, at least up through 1750. Although the magnitude of the effect (around -1.2) was smaller than estimates found by Lee, it was larger than would have been expected from a simple Cobb-Douglas production function. In light of the very real possibility of measurement error in the cross-section population data, the true effect may have been even larger.

Changes in the rate of population growth had little effect on the rate of urbanization in early modern Europe. If weak substitutability in the agricultural production function were the source of the large wage effect, we would expect to see big increases in urbanization during rapid population growth. This result also goes against Goldstone's (1984) explanation of inflation as a consequence of rapid urbanization during rapid population growth. The true mechanism linking population growth and inflation remains obscure.

Real returns to land apparently rose rapidly when population grew. It is possible that total output rose, as classical production theory says it should. The question is whether the large swings in income distribution were produced by a market mechanism (factors paid their marginal products) or some other form of bargaining or persuasion.

Future studies will need to take a closer look at the operation of labor markets. Institutional arrangements that might violate the neoclassical assumption that labor is paid its marginal product in all sectors of the economy are the foundation of the labor surplus models of economic development (Lewis, 1954; Fei and Ranis, 1964). They are also the basis of historical concepts like the moral economy. Undoubtedly some variants of these models could explain the aggregate results without the same harsh implications about the consequences of population growth for the consumption levels of the laboring population. Perhaps indirect measures of changes in real incomes, like the patterns of demand for different types of goods, might help determine what really happened to consumption when population grew too quickly.

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TABLE 1. Population and Real Wages: Regression Results for France and England.

1300-1500

	FRANCE			ENGLAND		
Constant	23.408 (6.711)	12.288 (6.999)	-20.541 (87.777)	15.410 (0.760)	7.718 (2.420)	-21.621 (21.102)
Population (log)	-1.670 (0.691)	-1.134 (0.625)	-0.845 (1.001)	-1.037 (0.095)	-0.586 (0.158)	-0.402 (0.202)
Year		0.0042 (0.0015)	0.0470 (0.1140)		0.0029 (0.0009)	0.0419 (0.0279)
Year squared (divided by 1000)			-0.0152 (0.0405)			-0.0136 (0.0097)
R-squared	0.226	0.454	0.459	0.857	0.909	0.918

1500-1800

	FRANCE			ENGLAND		
Constant	12.702 (4.366)	18.867 (8.097)	58.199 (17.564)	10.840 (1.543)	15.724 (1.031)	74.936 (5.609)
Population (log)	-0.604 (0.436)	-1.365 (0.948)	-1.622 (0.873)	-0.487 (0.184)	-3.000 (0.326)	-1.920 (0.371)
Year		0.0009 (0.0010)	-0.0442 (0.0183)		0.0098 (0.0012)	-0.0695 (0.0196)
Year squared (divided by 1000)			0.0138 (0.0056)			0.0230 (0.0057)
R-squared	0.066	0.095	0.272	0.205	0.775	0.864

Notes: Standard errors are in parentheses. The dependent variable is the log of nominal wages minus the log of wheat prices. The unit of observation is a decade average.

TABLE 2. Correlations of Variables with Time, and Correlation Matrix of Detrended Variables in France and England in Two Time Periods.

1300 to 1500

	France				England			
	Population	Wheat Price	Money Wage	Real Wage	Population	Wheat Price	Money Wage	Real Wage
Time	-.30	-.01	.80	.60	-.87	-.31	.91	.92
Population	1.00	-.04	-.78	-.38	1.00	-.16	-.83	-.65
Wheat Price	-.04	1.00	.28	-.85	-.16	1.00	.37	-.49
Money Wage	-.78	.28	1.00	.27	-.83	.37	1.00	.63
Real Wage	-.38	-.85	.27	1.00	-.65	-.49	.63	1.00

1500 to 1790

	France				England			
	Population	Wheat Price	Money Wage	Real Wage	Population	Wheat Price	Money Wage	Real Wage
Time	.89	.87	.92	-.15	.95	.80	.97	-.20
Population	1.00	.20	.09	-.27	1.00	.89	.56	-.87
Wheat Price	.20	1.00	.88	-.73	.89	1.00	.69	-.96
Money Wage	.09	.88	1.00	-.31	.56	.69	1.00	-.48
Real Wage	-.27	-.73	-.31	1.00	-.87	-.96	-.48	1.00

Notes: The first row in each quadrant shows the correlation with time of the original variables (in logarithms). The square matrices show the correlations among the variables after a (log-linear) time trend (for each sub-period) has been removed. All variables are decade averages.

TABLE 3. Population, Prices, and Nominal Wages: Regression Results for France and England.

	1500-1800			
	FRANCE		ENGLAND	
Constant	11.132 (5.981)	-36.096 (23.871)	6.872 (1.261)	-17.797 (19.786)
Population (log)	-0.646 (0.692)	0.038 (0.734)	-0.308 (0.386)	-0.082 (0.423)
Prices (log)	0.644 (0.069)	0.444 (0.118)	0.274 (0.092)	0.102 (0.165)
Year	0.0031 (0.0008)	0.0534 (0.0248)	0.0050 (0.0009)	0.0341 (0.0233)
Year squared (divided by 1000)		-0.0150 (0.0074)		-0.0088 (0.0070)
R-squared	0.963	0.969	0.970	0.971

Notes: Dependent variable is the log of nominal wages. Standard errors in parentheses.

TABLE 4. The Effect of Population Growth on Real Wages, 1500-1800: A Mixed Cross-Section Time-Series Approach.

	1.	2.	3.	4.	5.
Constant	0.048 (0.057)	0.001 (0.111)	0.088 (0.087)	0.040 (0.112)	0.055 (0.107)
Pop. Growth	-1.184 (0.316)	-1.379 (0.340)	-0.990 (0.304)	-1.258 (0.328)	-1.463 (0.334)
Pop. Growth 1700-50					-0.140 (2.457)
Pop. Growth 1750-1800					1.842 (0.848)
England		0.202 (0.158)		0.186 (0.124)	0.153 (0.119)
Holland		0.198 (0.153)		0.193 (0.118)	0.206 (0.118)
Germany		0.040 (0.153)		0.036 (0.117)	-0.002 (0.113)
Italy		-0.021 (0.152)		-0.020 (0.117)	0.010 (0.112)
Spain		-0.001 (0.152)		0.000 (0.117)	0.015 (0.112)
1500-1550			-0.378 (0.122)	-0.355 (0.120)	-0.338 (0.114)
1550-1600			-0.208 (0.121)	-0.192 (0.119)	-0.179 (0.113)
1600-1650			0.077 (0.121)	0.057 (0.119)	0.042 (0.113)
1700-1750			0.121 (0.120)	0.136 (0.118)	0.164 (0.312)
1750-1800			0.012 (0.131)	0.061 (0.131)	-0.355 (0.228)
R-squared	.29	.38	.62	.70	.75

Notes: Standard errors are in parentheses. The sample consists of six countries observed over six fifty-year time intervals for a total of 36 observations. The dependent variable is the percentage change in real wages over a fifty-year time period (the log of real wages at the endpoint minus the log of real wages at the start).

Table 5. Urbanization and Population Growth in Europe, 1500-1800.

Estimated elasticities with respect to population growth:

Dependent variable:	Rural population		Urban population	
Additional controls				
None	.944	(.046)	1.30	(.222)
Country effects	.954	(.041)	.99	(.215)
Time period effects	.915	(.052)	1.54	(.243)
Time and country effects	.924	(.047)	1.18	(.242)

Notes: Standard errors in parentheses. The unit of observation is the change over a fifty-year period in one country or region (N=78). All variables have been measured in logs so the regression coefficient is an elasticity measure.

TABLE 6. Population and Real Rents: Regression Results for France and England.

	1500-1800					
		FRANCE			ENGLAND	
Constant	.446 (3.763)	-4.384 (6.999)	44.982 (7.526)	-14.247 (0.971)	-11.918 (0.935)	-31.448 (16.631)
Population (log)	0.634 (0.376)	1.231 (0.819)	0.908 (1.502)	1.255 (0.116)	0.056 (0.295)	-0.301 (0.422)
Year		-0.0007 (0.0008)	-0.0572 (0.0135)		0.0047 (0.0011)	0.0309 (0.0223)
Year squared (divided by 1000)			0.0136 (0.0097)			-0.0076 (0.0064)
R-squared	0.095	0.118	0.483	0.812	0.890	0.895

Notes: The dependent variable is the log of nominal rents minus the log of wheat prices. Standard errors in parentheses.

TABLE 7. Population and Income Distribution: Regression Results for France and England.

	1500-1800					
		FRANCE			ENGLAND	
Constant	-12.256 (3.486)	-23.251 (6.045)	-23.259 (6.374)	-25.088 (0.971)	-27.642 (0.935)	-17.789 (6.370)
Population (log)	1.238 (0.348)	2.596 (0.708)	2.597 (0.737)	1.742 (0.160)	3.057 (0.456)	0.060 (0.748)
Year		-0.0016 (0.0007)	-0.0016 (0.0009)		-0.0051 (0.0017)	0.0003 (0.0018)
Prices (log)			-0.0004 (0.0074)			0.8084 (0.1791)
R-squared	0.319	0.423	0.423	0.815	0.863	0.924

Notes: Standard errors in parentheses. The dependent variable is the log of the ratio of nominal rents to nominal wages. "Prices" are wheat prices.

Figure 1.

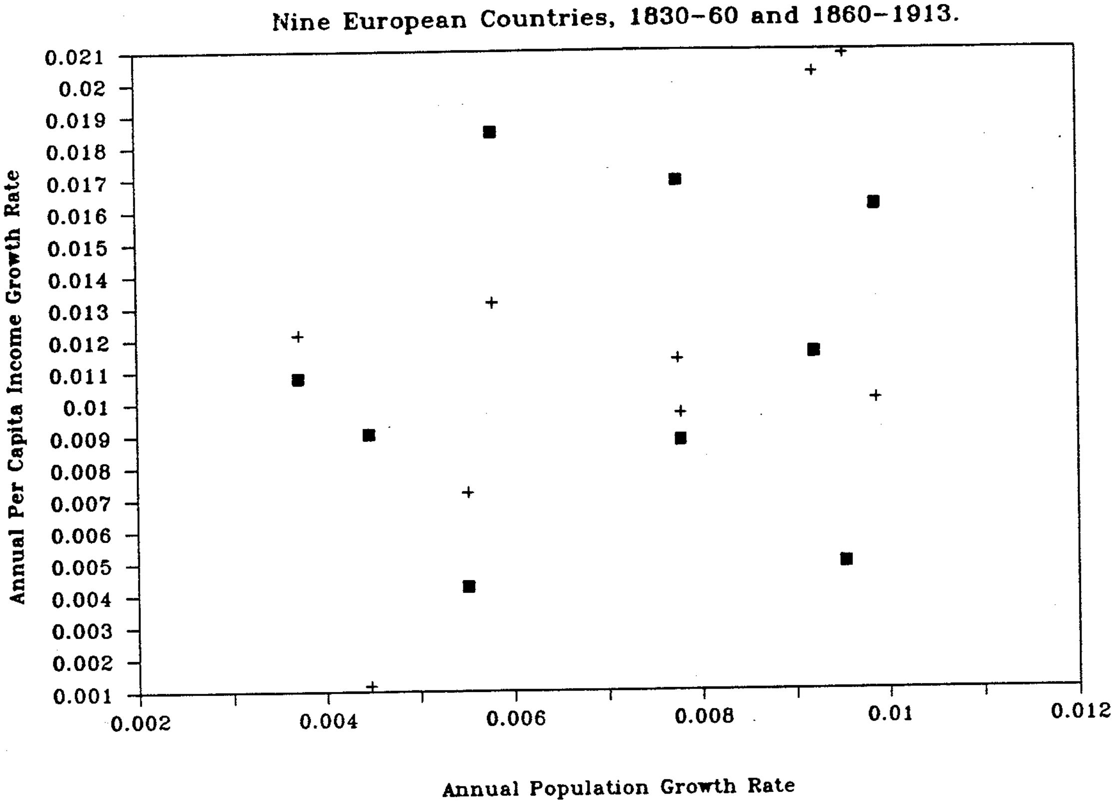


Figure 2.

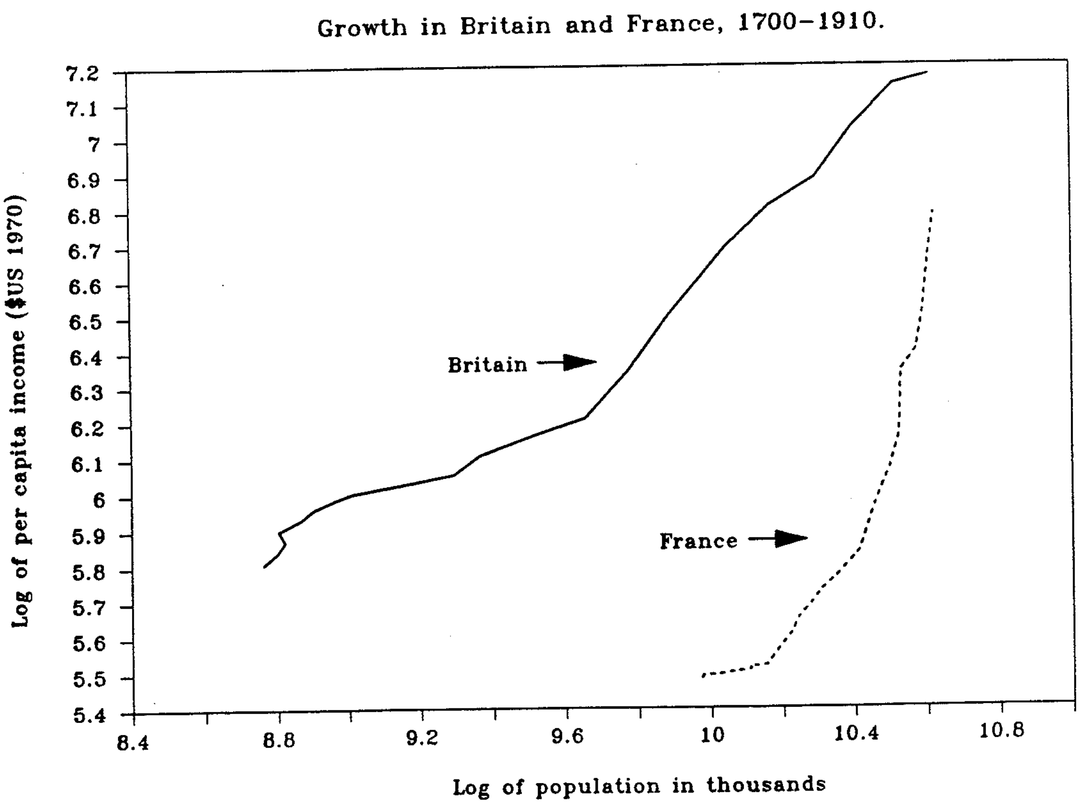


Figure 3.

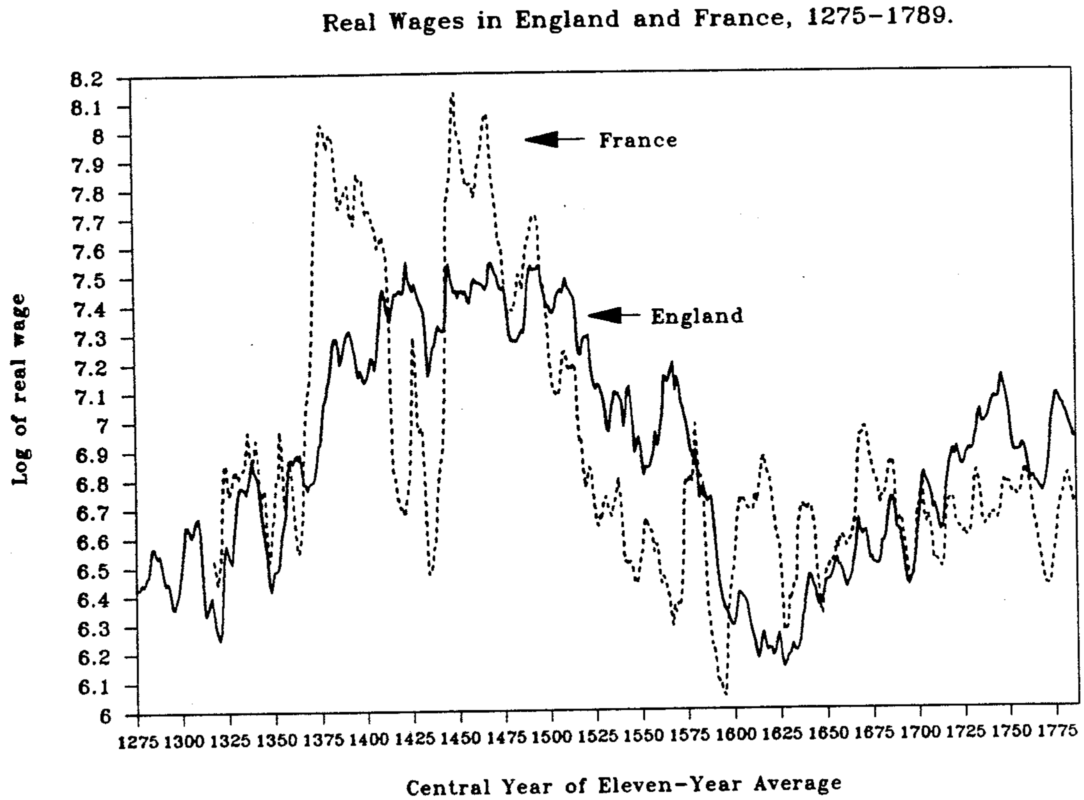
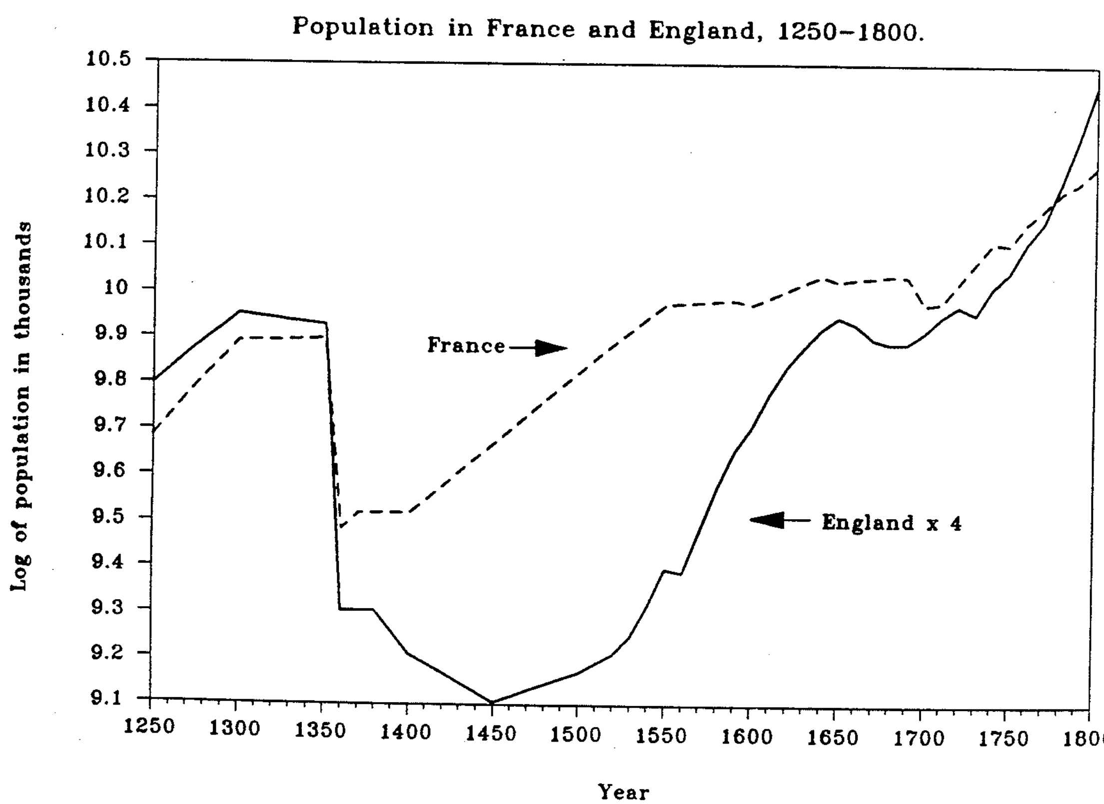


Figure 4.



APPENDIX: Sources and methods used in the construction of real wage data.

The real wage data emphasize consistency and comparability rather than breadth of coverage. For each country we have sought to construct long time series on the price of wheat and on the wages of construction labor for particular cities. These are the most reliably measured prices. Introducing other commodities or other types of labor would run the risk of introducing more error than information, and would be impossible to do in a consistent way for each country over the whole time period.

FRANCE

Wage and price data for the period before 1430 were garnered from many sources and subjected to numerous manipulations to yield consistent series. These are described in Weir (1986). After 1430, the data are for Paris based on Baulant (1968) for wheat prices; Baulant (1971) for wages 1400-1726, and Durand (1966) for wages 1726-89. Baulant and Durand used the same source for Paris wages, so their data require no adjustment for continuity.

Baulant, Micheline (1968). Le prix des grains à Paris de 1431 à 1788. Annales: ESC 23(3): 520-540.

Baulant, Micheline (1971). Le salaire des ouvriers du bâtiment à Paris de 1400 à 1726. Annales: ESC 26(3): 463-483.

Durand, Yves (1966). Recherches sur les salaires des maçons à Paris au XVIIIe siècle. Revue d'Histoire Economique et Sociale. 44(4): 468-480.

Weir, David (1986). Real wages in France and England, 1300-1789. Unpublished Paper, Yale University.

ENGLAND

The wage data are from Phelps-Brown and Hopkins (1955), covering construction workers in southeast England. I interpolated linearly over periods in which they indicated wages were rising from one level to another. Wheat price data come from three overlapping series: diverse localities from 1259 to 1702 (Rogers, 1866: v. I, pp. 223-234; v. 4, pp. 282-291; and v. 5, pp. 268-274); Oxford from 1583 to 1770 (Tooke, 1857, v. 6, pp. 427-436), and Winchester from 1646 to 1792 (Beveridge, 1939, pp. 81-84). Rogers and Beveridge report harvest year averages, which I have set against the later calendar year. The Oxford and Winchester series were adjusted to match the level of the Rogers series for years of overlap. The combined series is Rogers alone from 1260 to 1582, an average of Rogers and Oxford from 1583 to 1630, an average of all three from 1631-1703, an average of Oxford and Winchester from 1704-1770, and Winchester alone to 1792.

Beveridge, Sir William H. (1939). Prices and Wages in England from the Twelfth to the Nineteenth Century. London: Longman.

Phelps Brown, E.H., and Sheila Hopkins (1955). Seven Centuries of Building Wages. Economica (87), August.

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Tooke, Thomas (xxxx). A History of Prices.

ITALY

The Italian wage and price series are from Florence (1310-1620) and Milan (1600-1800). For the period of overlap, 1600-20, real wages (liters of wheat per day's work of a master mason) differed by about 15%. The splice was made by adjusting the nominal levels of Florence wages and prices (for 1310 to 1620) to the Milan level. The multiplier was .857 to reduce Florence prices to Milan level, which is the ratio of the silver content of the Milanese currency (Sella, 1968, p. 67) to the Florentine (Parenti, 1939, p. 59). Metrological information is from Vigo (1974, p. 394).

Tuscany (Florence):

Wheat prices: 1310-1566 (Goldthwaite, 1975, pp. 33-36) in soldi per staio (24.3629 liters) in Florence; 1508-1631 (Fanfani, 1940, p. 63) in soldi per staio of Sansepolcro (68 liters); 1520-1620 (Parenti, 1939, appendix p. 5), same units, in Florence. For the period of overlap (1508-1566) the correlation and levels of the Goldthwaite and Fanfani series were very close. Thus, the Sansepolcro series was used to extend the Florence series to 1631. The Parenti series verified the link. Occasional missing years in the Goldthwaite series (before 1490) were filled by interpolation on fitted trends.

Wages: 1310-1599 (Goldthwaite, 1980, pp. 436-439) in soldi per day, for masters and assistants; 1520-1620 (Parenti, 1939, appendix pp. 68-71) in soldi per day, for masters and assistants. The Goldthwaite series evidently derives from Parenti's, as the two are identical in coverage and values. Parenti's data was therefore used to extend the series to 1620. Missing years were filled by interpolation on fitted trends. The data for masters and assistants are of comparable quality.

Lombardy (Milan):

Wheat prices: 1398-1698 (Zanetti, 1964, pp. 155-158) in soldi per sacco in Pavia; 1605-1700 (Sella, 1968, pp. 138-140) soldi per libbra of bread (.76 kg.); 1701-1860 (de Maddalena, 1974a, p. 379) in soldi per moggio (146.2343 liters). Maddalena (1974b) also gives decennial index numbers (base 1701-10=100) of prices and wages for 1610 to 1800. Sella's prices are for bread (pane) and not wheat, while Zanetti's prices are for Pavia, not Milan. Sella's bread prices move closely with Pavia wheat prices, and are nearly as volatile.

A seventeenth-century price series was established by adjusting the level of Sella's bread price series to the price level of Maddalena's wheat prices. Maddalena's decennial index averaged 88.294 over 1621-1700; Sella's bread price averaged 367.8875 over the same period. Maddalena's (1974) wheat prices were 345.60976 soldi per hectoliter in 1701-10, the base of his index. Thus, the seventeenth-century prices for Milan are:

Sella's bread prices times (345.60976*.88294)/367.8875.

By this reckoning, the price level was higher in Milan than in Pavia.

Wages: 1600-1700 (Sella, 1968, pp. 84-111) for scalpellini, master masons, and unskilled labor in soldi per day; 1701-1860 (de Maddalena, 1974, pp. 419-420) for master masons and unskilled labor in lire per day. Sella's data are in the form of frequency distributions of days paid by wage rate per year. I constructed annual medians for each type of labor, indexed each series on an end-period base, averaged the three indexes, and then set the nominal level of the combined index for the level of master masons at the end of the century (35 soldi per day). That value is the same as Maddalena's wage for master masons in 1701 (1.75 lire = 35 soldi).

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Parenti, Giuseppe (1939). Prime Ricerche sulla Rivoluzione dei Prezzi in Firenze, Florence.

Sella, Domenico (1968). Salaria e Lavore nell' Edilizia Lombarda durante il Secolo XVII. Pavia.

Vigo, Giovanni. Real Wages of the Working Class in Italy: Building Workers' Wages (14th to 18th Century). Journal of European Economic History, 1974(3): 378-99.

Zanetti, Dante (1964). Problemi Alimentari di una Economia Preindustriale. Turin.

GERMANY

Augsburg:

Prices: Rye, 1460-1800 (Elsas, 1936, I, pp. 593-599) in den. per schaff. Missing years were interpolated on the series for gerste and fitted trends. Prices of wheat are available for 1670-1700 and after 1730. The ratio of wheat to rye increases substantially between those two periods.

Wages: Master masons 1500-1800 (Elsas, 1936, I, pp. 731-732 for maurergesellen). In periods of apparent stability, missing values were filled with the value given for adjacent years. Linear interpolation between 28 and 35 from 1538 to 1553, and between 70 and 84 in 1631 and 1645, and between available years from 1621 to 1631. Note that other wage series show either linear growth from 1620 to 1645 (e.g., recher p. 718) or big increases in 1620s and a smaller decline in the 1630s (e.g., drescher, p. 719).

Elsas, M. J., Umriss einer Geschichte der Preise und Lohne in Deutschland. Leiden, 1936., 3 vols.

FLANDERS

Antwerp:

Prices: Rye, 1366-1600 (van der Wee, 1963, I, pp. 173-178) in Brabant groats per viertel of Antwerp (79.627 liters); 1608-1816 (Verlinden, pp. 519-520) in stuivers per viertel (December price); rye in Brussels in December, 1501-1792 (Verlinden, pp. 501-503) in stuivers per sister. Gaps within and between van der Wee and Verlinden were filled using Brussels prices, adjusted for levels 1550-1650 (Antwerp=Brussels/.5438). All prices apparently refer to harvest years set against year of harvest.

Wages: 1400-1603 (van der Wee, 1963, I, pp. 333-343, 378-385) summer wages of master masons and mason's labourers in Brabant groats in Antwerp; 1570-1800 (Verlinden, pp. 1020-1024 for master masons and labourers, pp. 1029-1031 for carpenters). Both sources report frequency distributions, from which I extracted median values.

Verlinden, c., et. al., Dokumenten voor de geschiedenis van prijzen en lonen in Vlaanderen en Brabant. Bruges

van der Wee, Herman, The Growth of the Antwerp Market and the European Economy, 14th to 16th Centuries. Louvain, 1963.

SPAIN

Hamilton's three-volume study of prices and wages in Spain does not provide consistent long time-series of specific commodity prices or specific occupational wages within a single monetary area. The best partial series are for Valencia (wheat 1413-1650, wages 1392-1638) and New Castile (wheat 1501-1800, wages 1601-50; 1737-1800). Thus, from 1413 to 1638 it is possible to construct a nominal price of wheat and nominal wages of mason's helpers for Valencia. Hamilton's third volume did not publish the continuation of the Valencian series, giving detailed data only for New Castile. He did, however, publish quinquennial index numbers of real wages for Valencia from 1651 to 1800 (p. 215). The problem is to link the index series to the true price data before 1638.

The solution chosen was to establish real wages of building craftsmen in terms of wheat in New Castile in 1600/25 and 1750/90 and use the growth rate between those periods to link the two Valencian series. The New Castile wheat wage rose 10% between the two benchmarks. We therefore assign the Valencian real wage in 1750/90 to be 1.1 times the Valencian real wage measured for 1600/25 from direct data on wheat prices and nominal wages, and rescale the rest of Hamilton's real wage index accordingly.

Hamilton, Earl J., American Treasure and the Price Revolution in Spain, 1501-1650. Cambridge, Mass.: Harvard University Press, 1934.

Hamilton, Earl J., Money, Prices, and Wages in Valencia, Aragon, and Navarre, 1351-1500. Cambridge, Mass.: Harvard University Press, 1947.

Hamilton, Earl J., War and Prices in Spain, 1651-1800. Cambridge, Mass.: Harvard University Press, 1947.