The Population of England in the 14th and 15th Centuries

Robert E. Hall
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Scholars seem to be in substantial agreement that the population of England declined by about a third in the course of the 14th century and did not regain its previous level until after the beginning of the 16th century. Russell, for example, has prepared the following estimates of the population of England: (quoted in Slicher Van Bath, 6, p. 88)

1348	3,757,500
1350	3,127,500
1360-61	2,745,000
1369	2,452,500
1374	2,250,000
1377	2,223,373
1400	2,100,000
1430	2,100,000
1603	3,780,000

The question which interests me in this paper is: To what extent can this population cycle be explained by the working out of underlying economic or technological forces?

My approach to this question lies entirely within the confines of the hypothesis that the rate of change of population has a stable relation to the output per capita of the country. Although this hypothesis has had widespread intellectual popularity since its implications were first worked out by Malthus, I think that it would be a serious mistake to accept it unhesitatingly. I hope to show that it is inconsistent with the most modern interpretation of the population cycle under examination, but that on the other hand, it can underlie an explanation of some of the economic phenomena of the perios from 1300 to 1500.

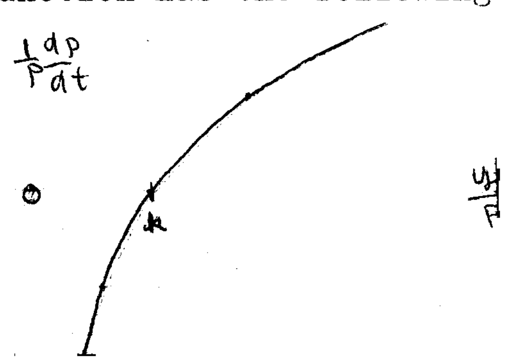
Stated more precisely, the fundamental hypothesis which underlies this work is that the proportional rate of change of population is a function of output per capita:

$$\frac{1}{p}\frac{dp}{dt} = m(\frac{y}{p})$$

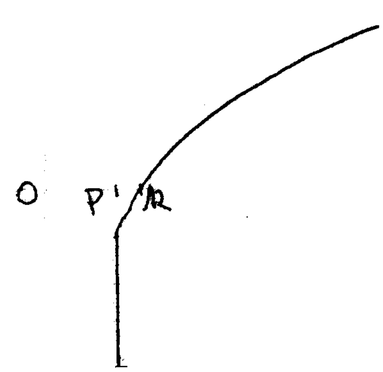
where p is population and y is aggregate output. The function m (for Malthus, or "misery and vice") has the properties m(O) = - ∞ and m(k) = 0, where k is the equilibrium pe capita output. I have assumed that

$$m(\frac{y}{p}) = \beta\log(\frac{y}{pk}) \quad .$$

A plot of this function has the following shape:



It is tempting to suppose that m falls off rapidly at a point somewhat below k; for example:



This might mean that if output per capita fell below the critical point p, the population would be devastated by diseases, particularly those related to protein and vitamin deficiencies. It is not my purpose to try to determine whether or not this is the case, because it turns out that my arguments depend only on the properties of m in the interval where $\frac{y}{p}$ is greater than k. Any reasonable choice of form for the function m can be approximated by a straight line or, as in this case, a logarithm function. I have chosen the log form because it leads to an easy solution to the differential equation involved.

The next step in the analysis is to estimate in a rough way the value of β, the coefficient of the reaction of population change to output per capita. Now the model depends in a critical way on the assumption that technology and behavior are unchanging through time. The only population data that I know of relating to such an economy are for Sweden in the second half of the 18th century (7). Heckshher states explicitly that he thinks that the population was in a Malthusian equilibrium during this period (3, p. 137).

An index of harvest success is also available for the period. My original intention was to generate a series of estimates of output per capita from the harvest index and then to estimate β by regression methods. A glance at the data shows that this would not yield very meaningful results. I am a little suspicious of the harvest index--it calls 1772 a year of not too serious famine and 1773 a year of normal harvests, while Hecksher and others identify these years as those of the worst famine in Sweden after 1750. Certainly the mortality figures support the latter view.

I was forced to fall back on more primitive means to estimate β. Suppose that in 1773 the consumption per capita dropped to half its equilibirum level, a reasonable assumption for a very serious famine. If

$$\frac{1}{p}\frac{dp}{dt} = \beta \log\left(\frac{y}{pk}\right) ,$$

$$-.027 = \beta \log\left(\frac{1}{2}\right) ,$$

or,

$$\beta = .040$$

Making the same assumption for 1772, I get

$$\beta = .012 .$$

Or, suppose that in 1760, a year of normal harvest following one of superabundant harvest, consumption per capita was half again its equilibrium level. Then

$$\beta = .024 .$$

On the other hand, it is possible to estimate β from a longer run point of view. The population of Sweden grew from 1,809,000 in 1752 to 2,352,000 in 1800, an annual rate of .00547 . This growth was fairly smooth except for yearly fluctuations. Hecksher estimates that a typical farm laborer consumed about 3000 calories per day during the 18th century, about one third more than during the 17th century (3, p. 148). Making the arbitrary assumption that the 17th century level of 2250 calories was the equilibrium level, I get the following estimate:

$$\beta = \frac{.00547}{\log(\frac{4}{3})} = .0191$$

None of these estimates has any firm basis on its own. However, I think that they provide some justification for believing that β lies between .01 and .04 . All that is necessary for the purposes of this paper is an estimate of the order of magnitude of β. The order of magnitude suggested by these calculations was something of a surprise to me because it implies an exceedingly slow process of equilibration after a change in population or in any of the factors determining equilibrium population. Suppose, for example, that the population is initially at the equilibrium level of 1 and one-third of the population suddenly disappears. If

$$y = p^{\alpha}T^{1-\alpha} \quad ,$$

where y is output in units of equilibrium consumption for unit population, and T is land taken to be constant at one unit, then

$$y = p^{\alpha} \quad ,$$

or,

$$\frac{y}{p} = p^{-(1-\alpha)} \quad .$$

Now,

$$\frac{1}{p}\frac{dp}{dt} = \beta\log(\frac{y}{p})$$

$$= -\beta(1-\alpha)\log p \quad ,$$

or

$$\frac{d}{dt}\log p = -\beta(1-\alpha)\log p \quad ,$$

which has the solution,

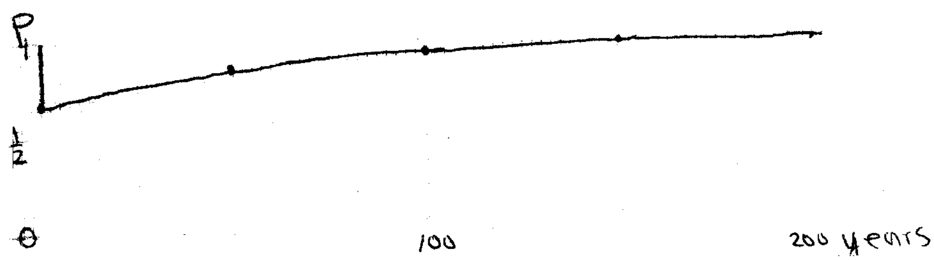
$$\log p = e^{-\beta(1-\alpha)(t-t_o)}\log p_o$$

or, $$p = \exp((\exp(-\beta(1-\alpha)(t-t_o))\log p_o) \quad .$$

Now taking $p_o = 2/3$, $\beta = .03$, $\alpha = 0.5$, and $t_o = 0$, I get

$$p = \exp(-.40497\exp(-.015t)) \quad .$$

Plotting this shows how slowly population responds:



The point at which half of the population loss has been recouped occurs when

$$\frac{5}{6} = \exp(-.40497\exp(-.015t)) \quad ,$$

or $$t = 50.8 \text{ years.}$$

This result calls into serious question some of the conclusions of the Malthusian theory. For example, even the slightest positive growth rate will rescue the population from a great deal of misery--in the Swedish case, a rate of growth of 0.5% per year (resulting most likely from a similar rate of growth in the amount of cultivated land) raised output per capita to a third greater than it would have been in equilibrium. In general, if the population really adjusts this slowly, than we should focus our attention on the states of Malthusian <u>dis</u>equilibrium. This conclusion is a trivial one for contemporary economies, but is less so for medieval economies, which the literature seems to treat as if they were in constant equilibrium.

I return now to the central question of this paper. In my sketchy survey of the literature on this question, I have found that the discussion has followed the zig-zag course taken by many historical controversies--there is a Classical, a Revisionist, a Neoclassical, and a Neorevisionist point of view. The Classical interpretation of the population cycle of the 14th and 15th centuries was simply that the Black Death wiped out a sizeable fraction of the population, which recovered very slowly in the subsequent 150 years. The Revisionist view held that the plague was much less important than the Classics thought, and that in fact it was only the symptom of an underlying decline caused basically by diminishing fertility of the land. The Revisionists were undone by the evidence, however; Lennard (4), Beveridge (2) and others produced manorial records which showed that if anything, output per acre increased very slightly over the period. As a result, the Neoclassical view returned the plague to an independent causal role with the added feature that the mortality from subsequent epidemics was just as improtant in determining the size of the population as was the pandemic of 1348-1350. But Postan (5) was unhappy with this intellectually untidy interpretation, particularly because he believed that the population decline began about 30 years before the plague. In the last paragraph of his paper he makes several proposals for the Neorevisionist thesis; one of the most interesting is that the large area of land put into cultivation in the 12th and 13th centuries diminished in fertility early in the 14th century, causing the population decline. Slicher Van Bath (6) has developed this idea more fully. He proposes that the declining fertility of the marginal land and the cultivation of what was once pasture led to chronic malnutrition early in the 14th century. The plague was then the natural mechanism of population adjustment: "The high mortality from the Black Death and the other 14th century epidemics can only be explained as the result of prolonged undernourishment" (p. 89).

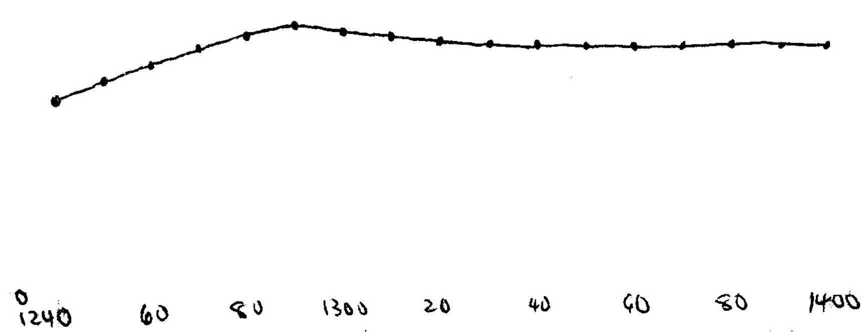
Although this Neorevisionist hypothesis is unquestionably attractive, I believe that it cannot really withstand careful scrutiny. I have worked out an example which is based on the assumptions about population and production used in my earlier example:

Evidence for the assumption of a decline in the fertility of new land under medieval conditions comes from the Rothamsted experiment, which showed that the fertility of new land decreased for the first thirty years or so and then remained roughly constant (1). I have assumed on this basis that a measure of effective land suitable for an aggregate production function is

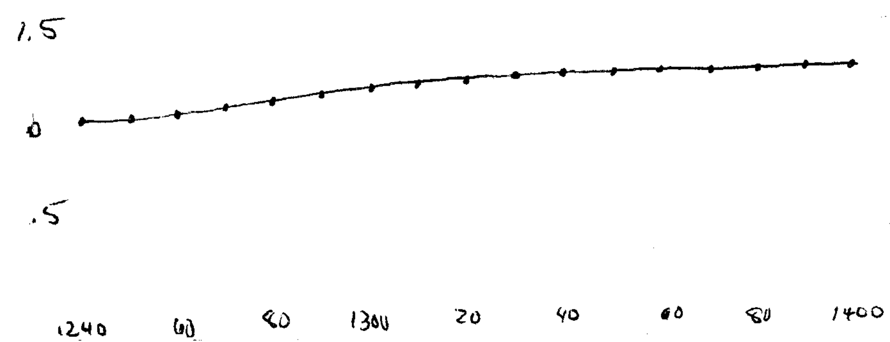
$$T(t) = (\frac{1}{2} + \frac{1}{2} e^{-.03(t-t_0)})T^N \quad ,$$

where T(t) is the effective amount of land at time t if T^N is the amount of land newly put into cultivation at time t_o. This amounts to assuming that at the outset new land is just as good as old but that one-half of its fertility declines to zero at a rate of 3% per year.

Finally, I have assumed that during the second half of the 13th century there was a 50% increase in land under cultivation which took place at a constant rate. Then to a fairly good approximation effective land is the amount shown in the following plot:



This illustrates the weakness of the mechanism underlying the Neorevisionist hypothesis--the declining portion of the effective land curve has only a very slightly negative slope, hardly enough to account for a major decline in population. In this example population never declines at all:



In fact, I have not been able to find any chronology of new land use which involves a declining population or an output per capita below the equilibrium. Unfortunately, I have not been able to prove any theorems about this because of the unwieldiness of the solution to the differential equations involved. In all the examples I have worked out, output per capita rose when new land was put into cultivation, but the resulting increase in population was never enough to require a decrease in population after the decline in the fertility of the new land. Thus the sluggish response of population to changes in output implies a second fundamental weakness of the Neorevisionist hypothesis.

Taken together, then, the small decline in effective land and the sluggish response of population make the marginal lands hypothesis thoroughly untenable as an explanation of the plague or of the population decline. Is there any hope for an explanation of the population decline which treats the Black Death as an integral part of the population mechanism? A second aspect of the Neorevisionist thesis proposes that the expansion of the 13th century caused a decline in the amount of land devoted to pasture and consequently caused a decrease in the amount of manure applied to the land. Whether or not this is a reasonable hypothesis depends on the importance of manure as an input in medieval agriculture, on the length of the lag between the decline in manuring and the decline in fertility, and so forth, matters which I have not been able to investigate. However, unless the lag involved is very long, this hypothesis imputes a high degree of irrationality to the producers, which reduces its theoretical attractiveness.

The greatest weakness of this and all other hypotheses which involve a mechanism of diminishing fertility of the land is that apparently it just wasn't so. For example, Beveridge (2) presents the following average yields in quarters per acre for the holdings of the Bishop of Winchester:

years	wheat	barley	oats
1200-1249	1.02	1.59	1.40
1250-1299	1.14	1.59	1.31
1300-1349	1.18	1.75	1.21
1350-1399	1.17	1.86	1.37
1400-1499	1.16	2.07	1.70

These are particularly striking figures because from 1300 real wages were rising spectacularly, leading us to expect a decrease in labor imput per acre and hence a decline in output per acre if fertility were constant.

Of course the only data which have been brought to bear against the notion of declining fertility come from the well-organized manors which kept careful accounts. Extension of this conclusion to all agriculture, particularly the marginal land newly brought into cultivation, is hardly justified. Still, there is no evidence that I know of which supports the notion of declining fertility.

I feel forced to conclude that the more hard-headed or modern ideas about the population decline of the 14th century are incorrect in spite of their manifest intellectual attractiveness. This was a surprising conclusion to me, just the opposite of what I set out to conclude. But, perhaps, despite what we would like to think, economics is not everything.

I think it is worthwhile to examine the view that the population decline was the result of the displacement of the population level from its equilibrium by the exogenous shock of the Black Death and the subsequent plagues. The prevailing medical interpretation seems to support this notion--it regards the plague as a disease entirely new to the population, one against which they had no immunological defense. The sudden appearance of new diseases is fairly common; polio, for example, was unknown before 1840 (8, p. 78). After the pandemic of 1348 to 1350, the plague settled in Europe and reappeared in a series of epidemics until the early 18th century. Widespread disagreement exists about the timing and mortality of these later epidemics. Nowhere in the medical literature that I read was there a suggestion that the economic state of the population was particularly important in the mechanism of the plague, except to note that often a famine preceded an epidemic by a few years. In fact, the climate and the great migratory movements of rats are considered the important factors and are treated at much greater length than is malnutrition.

What economic effects would we expect from a purely exogenous disturbance in the size of the population? Under the very simple assumptions I have proposed earlier, hypothetical population, output, and other economic variables would behave in the following way:

year	population	output	output per cap.	real wage	rent
1348	1.00	1.00	1.00	1.00	1.00
1350	.67	.82	1.24	1.24	.82
1360	.70	.84	1.21	1.21	.84
1370	.74	.86	1.16	1.16	.86
1400	.83	.92	1.09	1.09	.83
1450	.91	.96	1.04	1.04	.91
1550	.98	.99	1.01	1.01	.99

A series of downward shocks in population, such as recurrent epidemics, would generate a series of movements like this one superimposed on one another. Thus a serious epidemic every 20 or 30 years would keep the population chronically far below equilibrium.

Qualitatively, the following changes occur after the drop in population: output declines, output per capita increases, the real wage increases, and rent and the product per acre decline. As a result of the last effect, marginal land should go out of cultivation although since I have assumed that land is uniform, the model does not take this into account. Significantly, the evidence is exactly in accord with all of these predictions except the decline in product per acre. Postan (5) presents the following estimates of wages in units of wheat on the estates of the Bishop of Winchester:

1300-1319	1.00	1400-1419	2.10
1320-1329	1.40	1420-1439	2.00
1340-1359	1.48	1440-1459	2.36
1360-1379	1.54	1460-1479	2.20
1380-1399	2.35		

This evidence is too much of a good thing for my model, since this increase is several times greater than what I have predicted. However, Postan's series is probably not a very good measure of real wages throughout the economy, because it relates to the relatively small class of agricultural laborers. Furthermore, I suspect that part of the rise is accounted for by technical progress in agriculture--the failure of product per acre to drop during this period is also evidence pointing in this direction.

Evidence about the behavior of rents during this period is obscured by the institutional aggangements by which rents were paid. Postan gives some figures which indicate that rents were still falling in the course of the 15th century, but these are at best an inconclusive measure of economic rent.

Finally, the abandonment of marginal land which ocurred during this period is well documented.

Of all these results, the only one which is not suggested by the most elementary common sense is the increase in per capita output, and even that seems fairly obvious from the fact that land per person increases as population decreases. I am puzzled that Postan rejects the conclusion that per capita output might have increased, which he does on the basis of the observation that product per acre was constant. Instead he proposes what seems to me to be an economically inferior argument about the redistribution of income to account of the increase in real wages. In fact the whole literature connected with the 14th and 15th centuries seems to be permeated with the notion that the period was one of agricultural depression and impoverishment. It seems more likely that, on the contrary, it was a period of higher income and perhaps even one of technological progress in agriculture.

My conclusion, then, is that whatever its intellectual disrespectibility, the notion that the population decline of the 14th century was the result of the exogenous shocks of the Black Death and subsequent epidemics is the one that best fits the evidence. Under the Malthusian hypothesis of population change introduced at the beginning of this paper, there is no reason to believe that output per capita ever went below the equilibrium level during the 14th century and hence no support for the Neorevisionist view that the population decline was the result of malnutrition or other effects of low income. The alternative hypothesis which I have proposed is that the plague was an exogenous influence which kept the population of England well below its Malthusian equilibrium until 1500 or after. It is interesting to speculate upon the implications of this hypothesis relative to the subsequent economic development of England.

References

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