MALTHUS PERSISTS
THE ROLE OF MORTALITY AND INCOME IN THE FRENCH FERTILITY DECLINE OF THE LONG NINETEENTH CENTURY

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Abstract: *The onset of the French fertility decline, because it was the earliest in Europe and did not seem to follow the pattern other countries experienced, has motivated a considerable amount of literature. In this paper I contribute to that debate with some quantitative analysis of the long-tern dynamics of this process. I use time-series analysis to evaluate whether the Malthusian framework is still valid in this transition. In particular, I look at the long-run equilibrium between fertility, mortality and income, and the short-run dynamics that govern that same equilibrium. The results I obtain suggest that despite the fact that a long-run equilibrium seems to be maintained between variables, their short-run influence change radically over time.*

Keywords: economic history, demographic history (Europe pre-1913), France, demographic economics, fertility.

JEL classification: N33, J13.

[♣] This paper is part of the research I am carrying out for my doctoral thesis at the Department of Economics at Oxford University and was done while being a member of Nuffield College and a Student Research Associate of TARGET (University of British Columbia, Canada). It has benefited greatly from discussions with my supervisor, Bob Allen, and some colleagues at Nuffield College. Bent Nielsen provided also very useful suggestions. An earlier version of this article was presented at the Graduate Workshop on Economic and Social History (Oxford University), and I want to thank their participants for helpful comments. The responsibility for all remaining errors and omissions is, of course, entirely mine.

INTRODUCTION

Fertility in Europe reached, by the beginning of the twenty-first century, an historical minimum. Present below replacement birth rates create great worries in policy-makers that have to deal with pension systems heavily reliant upon future generations, curiosity in academics that wonder whether this will ever revert, and hope in many pessimists that fear the world will become irreversibly overpopulated sometime soon. This contrasts with what happened two hundred years ago, when the average household across the region had six or more children. Current rates are the product of a secular decline that began in Europe at some point in the late eighteenth or early nineteenth century. What sometimes comes as a surprise is that in this process France undoubtedly played the role of the first mover. The present perception is that low fertility can be associated with modern, industrial societies but France, in many ways, remained relatively traditional until quite late in the nineteenth century. There is an extensive literature in economics, history and demography evaluating this phenomenon, not only trying to figure out why was France the leader, but even questioning whether or not it is reasonable to talk about a demographic transition at all. Most arguments on different sides of the dispute are very much contested,[1] but the apparent success of Malthusian models to explain early modern population dynamics and the notable accomplishments of recent microeconomic models of family behaviour implicitly suggest –to some degree- that there might have been indeed a movement from one equilibrium to another one. Although many of these studies worked with a considerable amount of data, analyses remained mainly descriptive and conjectural at best. Only recently have there been some attempts to bring a more systematic quantitative approach to the subject [Weir, 1984a, 1995; Bonneuil, 1997]. By taking a closer look at the available data, and with the help of rigorous quantitative techniques, a part of France's particular story can be unveiled.

In this paper I will argue that although France was moving away from a traditional pre-industrial Malthusian equilibrium, that analytical framework remains useful to learn more things about the dynamics of this process in France. Further, I will try to contribute to the debate by assessing quantitatively part of these dynamics. For this purpose I put together a dataset containing yearly observations of selected vital statistics and real wages for France as a whole between 1740 and 1911. The aggregated time series help me to evaluate the relationship between vital rates and income within a Malthusian model –by far the most widespread approach taken to understand population dynamics in historical economics. Although the story I build is one where France is moving *away* from the Malthusian logic, the model can

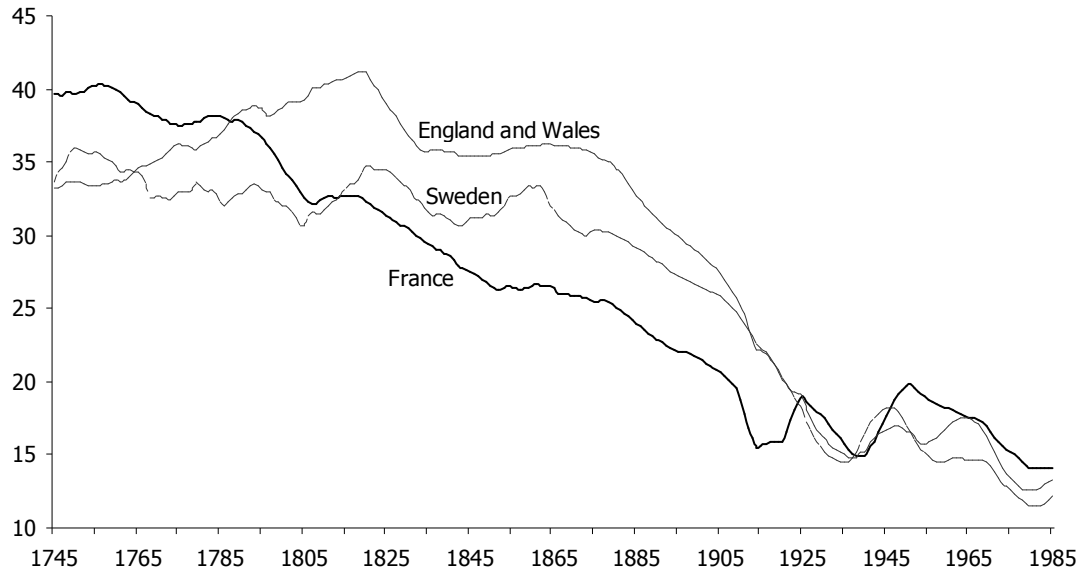
[1] A summary of the most important lines of arguments and authors can be found in van de Walle [1974: 6-11].

still be exploited to learn how that departure actually takes place. In particular, I look at the long-run equilibrium between fertility, mortality and income,[2] and the short-run dynamics that govern that same equilibrium,[3] using estimates of real wages –a novelty in studies of this sort that, due to the lack of alternative data, had traditionally relied upon primary products prices as a proxy for income. The results I obtain suggest that despite the fact that a long-run equilibrium seems to be maintained between variables, their short-run influence change radically over.

SOME STYLISED FACTS

Family reconstitution figures suggest that before 1750 all European regions behaved similarly in terms of fertility [Flinn, 1981: 30-31]. However, in the late eighteenth century those trajectories diverged. A sense of the different experiences taken since then can be grasped by looking at some carefully selected cases. Here I begin by looking at the crude birth rate.[4]

Figure 1. Crude birth rates in France, England and Wales, and Sweden, 1745-1985



Sources: For France, INED [1977: 332-333] and Chesnais [1992: 518-541, 555-578]; for England and Wales, Wrigley and Schofield [1981: 531-535] and Mitchell [1998: 93-116]; and, for Sweden, *Statistika Centralbyran* (Statistics Sweden, http://www.scb.se/indexeng.asp). Values are 11-year averages, centred in the year.

[2] Following, in spirit, studies like that of Bailey and Chambers [1993].

[3] As in Lee in Wrigley and Schofield [1981: 356-401], Weir [1984a], or Galloway [1988].

[4] This rate, because it overlooks many important factors such as age structure or pattern of marriage, is considered a coarse measure of fertility. Still, it remains as the most readily and widely available, and can be useful to illustrate the main differences among countries.

Figure 1 depicts (smoothed) series of crude birth rate for England and Wales, France and Sweden since the middle eighteenth till the late twentieth century. Without much loss of generality, the pattern followed by Sweden is, in some ways, representative of what goes on in other regions of Europe. There is some fluctuation around a mean and, at some point after the middle of the nineteenth century, a decline begins that goes all the way up to the interwar period. For Sweden that initial mean was about 33 births and the fall became evident after 1865. Other countries started at a higher rate like Finland (around 40) or at a lower rate like Denmark (around 31), and had different timings for their respective turning points, but their story is in essence the same. England and Wales could be included in that description, but its fertility rate had the particularity of having a clear *increasing* trend well into the nineteenth century. That trend reaches a peak around 1820, when a deep fall leads births to a level of 35.7, which is maintained in a 50 years plateau until the definitive (and steep) decline in the last quarter of the century.

This pattern contrasts especially with that of France, where the initial level is quite high (40 births), the fall comes early (around 1800), and the rest of Europe caught up with her only after the First World War. As Figure 2 shows, more sophisticated measures of fertility like the Ig index provide a similar story.[5] Marital fertility in the initial part of the period was around 0.8. This roughly means that married women were having as many children as 80% of what was biologically possible given the age and marriage structure. Such a level can indeed be considered high and suggests little or no control over fertility in the eighteenth century, especially if one bears in mind that cultural differences such as longer breast-feeding periods or biological disparities such as nutritional deficiencies prolonging post-partum amenorrhoea could explain by themselves the divergence from 'natural' rates.

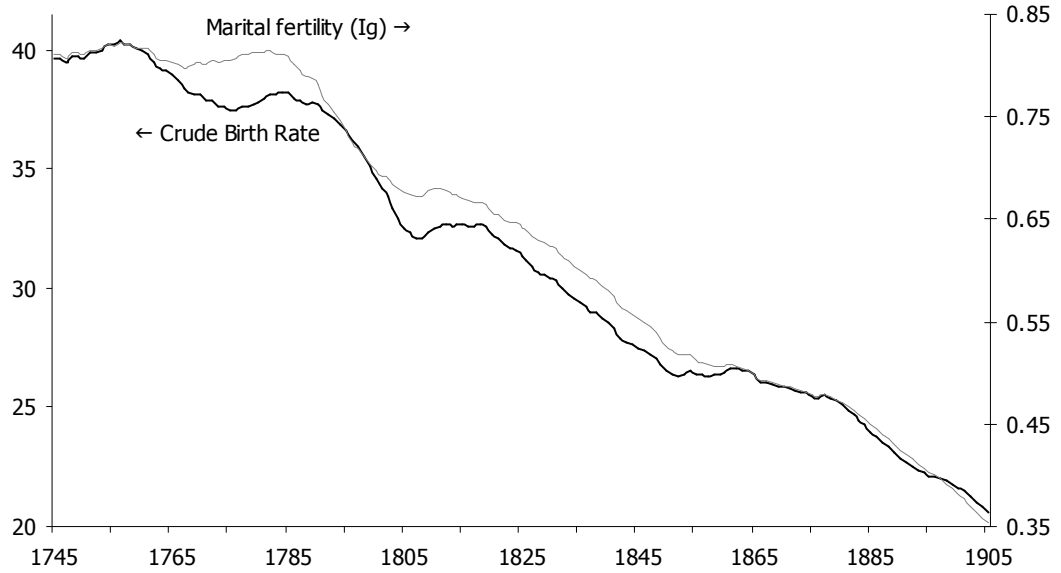
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[5] The Ig index was developed in the context of the European Fertility Project carried out at Princeton University from the 1960s [Coale and Watkins, 1986]. For the sake of evaluating divergences among countries a comparable measure was sought. The unit of reference chosen was the maximum fertility attainable. This index of marital fertility is then defined as:

$$I_g = \frac{B_t^m}{\sum_{a=15-19}^{45-49} N_{a,t} m_{a,t} h_a}$$

Where B_t^m is number of legitimate births in year *t*, $N_{a,t}$ is the number of women of age *a* in year *t*, $m_{a,t}$ is the proportion of women of age *a* actually married in year *t* and h_a is the rate of childbearing of married Hutterites at age *a*. The Hutterites are an Anabaptist sect that adheres scrupulously to precepts forbidding the practice of contraception or abortion, and their mothers do not nurse their infants more than a few months. They have the highest fertility rates recorded to date and are representative of the maximum biologically attainable. Hence, Ig represent the proportion of births with respect to the maximum attainable given the age structure of married women. Although its use remains questionable for some purposes (especially dealing with the early stages of the transition; see Guinnane et al. [1994]), it still represent a clear improvement from the crude birth rate.

Figure 2. Crude birth rate and marital fertility (Ig) in France, 1745-1906

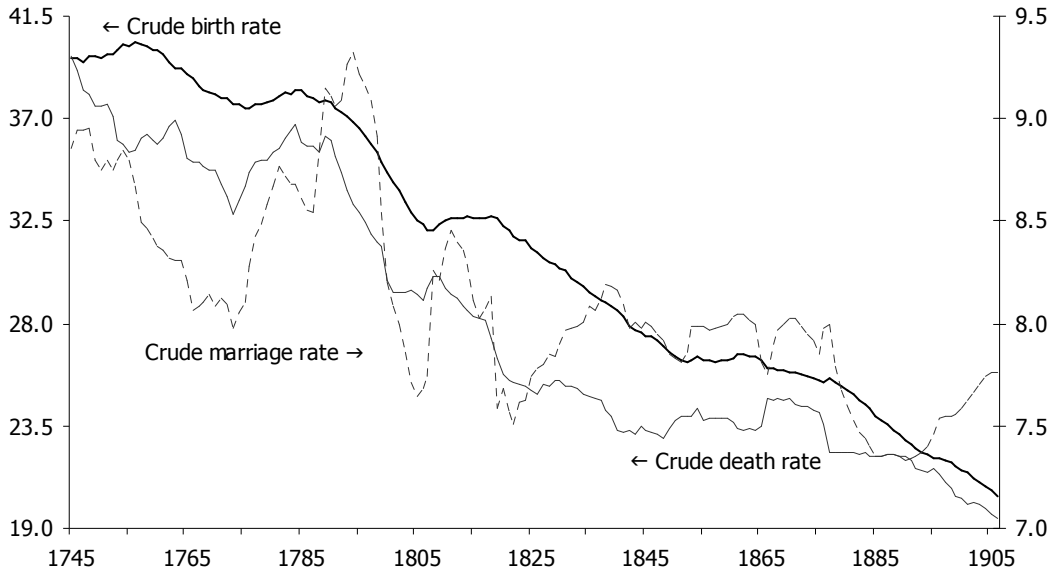


Sources: INED [1977: 332-333] and Chesnais [1992: 518-541, 555-578] for crude birth rate, and Weir [1994: 330-331] for the Ig index. Values are 11-year averages, centred in the year, and arrows indicate the axis of reference.

With respect to the crude birth rate, the picture is not substantially altered but some distinctions can be pointed out. Most notably, marital fertility does not immediately follow the crude birth rate in the fall after the middle of the eighteenth century and something similar happens in the first half of the nineteenth century. This phenomenon suggests that despite the fact that married women kept having the same proportion of children the actual number of births per population decreased. This can be explained by looking at the dynamics of other vital statistics. Figure 3 shows, together with the crude birth rate, the crude death and marriage rates.

Falls in the crude birth rate that are not reflected in the evolution of the Ig index seem to be associated principally with increases in population that followed the notable decreases in mortality. Also, sharp declines in nuptiality might have had their influence by reducing the population under risk of having children (assuming, of course, that the rate of illegitimate children remains constant).

Figure 3. Vital statistics in France, 1745-1906



Sources: See Appendix. Values are 11-year averages, centred in the year, and arrows indicate the axis of reference.

The story in Figure 3 could well fit as a textbook example of a demographic 'transition' from high to low fertility and mortality rates. Transition theory, a very popular approach to historic demography in the 1960s, suggested that modernisation was a very complex process that affected all societies in similar ways. Hence, the core of its argument relied upon the idea of finding regularities in this process and enumerating a sequence of natural stages in it. According to this theory, the two main factors affecting fertility were the supply and demand for children [Alter, 1992: 19]. If mortality was decreasing, fertility had to follow, so the timing of the process was relevant.

POPULATION DYNAMICS IN PRE-INDUSTRIAL SOCIETIES

The relationship between population dynamics and economy has been a major field of study at least since the late 18th century, when Reverend Thomas Malthus published his influential *Essay on the Principle of Population*.[6] In the modern interpretation of his view, a completely inelastic labour supply meets a labour demand that in the long-run is completely elastic with

[6] Malthus lived between 1766 and 1834, hence his life coincided with the British secular raise in birth rates described above. He was himself the sixth of the seven children and, after being appointed by Jesus College in Cambridge as a curate of a chapel in Wotton, he witnessed this evolution firsthand with the baptisms, marriages and burials performed by the parishioners [Niehans, 1990: 78].

respect to a 'natural' wage. Population dynamics are delineated in his *Essay* as relying upon the idea that:

> *"Population, when unchecked, increases in a geometrical ratio. Subsistence increases only in arithmetical ratio. […] By the that law of our nature which makes food necessary to the life of man, the effect of this two unequal powers must be kept equal […] This implies a strong and constantly operating check on population from the difficulty of subsistence. This difficulty must fall somewhere and must necessarily be severely felt by a large portion of mankind."* [Malthus, 1985 (1830): 71]

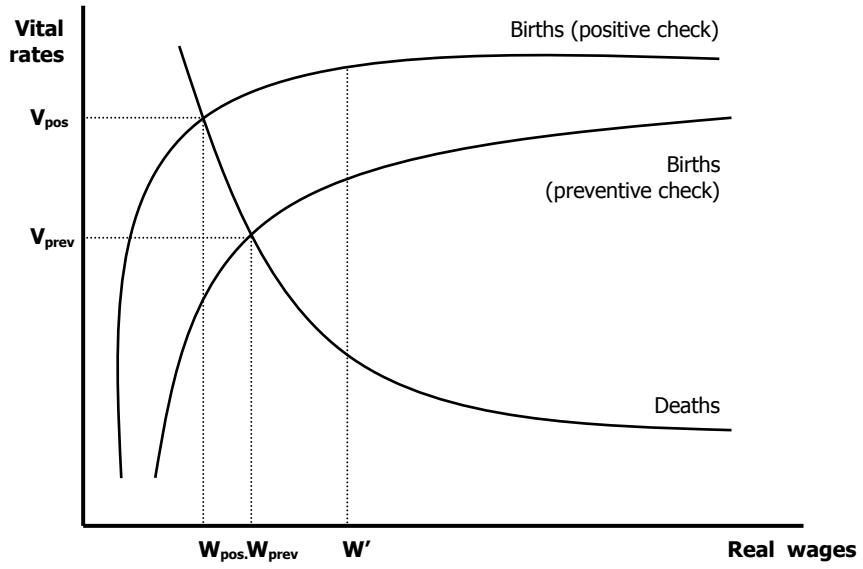
The idea of equilibrium is implicit in the above passage when referring to those unequal powers that "*must be kept equal.*" Diminishing returns to agriculture play the central role in putting a limit to the ever-increasing population. It is in the interaction of fertility and mortality that Malthus found the source of deviations from equilibrium (this theory abstracts from the influence of migration). He further suggested that the nature of the checks operating on mankind could come from two sources:

> *"…a foresight of the difficulties attending the rearing of the family acts as a preventive check, and the actual distresses of some of the lower classes, by which they are disabled from giving the proper food and attention to their children, act as a positive check to the natural increase of population."* [Malthus, 1985 (1830): 89]

Hence, preventive checks imply some explicit interaction between births and means of subsistence whereas the positive checks are associated with a non-responsiveness of fertility to income. Mortality, on the other hand, is strongly determined by income. Due to the law of diminishing returns, food would become eventually less abundant and war, famine and misery would condemn societies to a meagre subsistence standard of living. This concept of equilibrium then relies upon the interaction of two functions: one is relating deaths to income in a negative way, and other relating fertility to income in a positive (and eventually inelastic) way. The traditional graphical representation of this mechanism is depicted in Figure 4.

The interpretation of the death curve is straightforward. For very low real wages (in most of this paper I use the terms 'income' and 'real wages' interchangeably), survival is impossible and death rates are extremely high. As income increases, chances of survival also increase and population death rate falls. This fall, however, eventually reaches a biological limit. As Keynes rightly reminded use, people die in the long run. Hence, after some threshold death rates must become unrresponsive to further increases in wages. The actual position of this curve, on the other hand, is clearly dependent on external shocks (weather, natural disasters, etc.) and the technology to produce food or cure diseases. Hence, things like good or bad harvest, or earthquakes can generate short term movements of the curve, and the constant accumulation of medical knowledge is expected to drive it secularly towards the origin.

Figure 4. Malthusian equilibrium



Biological factors also play a big role in shaping the birth curves. For very low levels of income this can happen in two levels. One direct influence has to do with malnutrition, which is associated with increases in the age of first menstruation, reduction in the age of menopause, increases in the rate of spontaneous abortion, an-ovulation and amenorrhoea. An indirect influence is also present through lower reproduction chances due to increase in abstinence, decrease of libido, or decrease in coital frequency as a result of psychological stress or because one or both partners search for means to obtain food. For higher levels of income biology puts a ceiling to fertility since families cannot have infinite number of children. In this context, the distinction made by Malthus between positive and preventive checks is basically a cultural one. With the positive check, births behave as I just have described, purely in biological terms. With the preventive check, on the other hand, social norms can lower the rate at which births increase with income generating an equilibrium with lower fertility and mortality ($V_{pos} > V_{pre}$) and higher wages ($W_{pos} < W_{pre}$). Social norms here are to be understood basically as traditional marriage age [Lee, 1997: 1065], though they could be extended to incorporate customs in breast-feeding, abstinence in certain periods of the year, etc. In any case, the relevant thing about the interpretation of this preventive check is that it does not imply that families decide their size in an active sense: couples have just as many offspring as they can subject to social standards. The relationship that closes the circle and governs the dynamic of the model is an inelastic supply of labour in agriculture. If higher incomes (in the figure, depending on the case, $W_{pos} < W'$ or $W_{pre} < W'$) stimulate an increase in population (because, under W', births are higher than deaths) diminishing returns to labour in the agricultural sector will drive income back to the natural level.

This framework, as simple as it looks, has some predictions that seem to coincide with the data. In comparing different regions of the world, the dichotomy 'high wages'-'late marriage pattern' (in Western Europe), and 'low wages'–'early marriage pattern' (elsewhere) seems to correspond with the model [Hajnal, 1965]. Also, it provides an insightful interpretation of the curious pattern followed by England in the early stages of the period I am evaluating. Figure 1 showed a continuous increase of fertility in England and Wales in the second part of the eighteenth century. There is evidence that at least from the seventeenth century England experienced a secular increase in wages [Allen, 2001]. If, as suggested by Malthus, Britain was dominated by a preventive check, this increase in income represented a movement from $\mathbf{W}_{prev}$ to **W',** generating both an upward pressure of births and a downward pressure on death, both consistent with the data [Wrigley and Schofield, 1981: 531-535]. The story then breaks with the onset of the industrial revolution that puts a halt to the pressure of diminishing returns to agriculture and, hence, to a core assumption of the Malthusian logic.

As this last example shows, this equilibrium model depends on the characteristics of the labour market and, more specifically, depends on this labour market being dominated by the agricultural sector with land as a limiting factor. Its basic prediction is that technical and social progress cannot improve the human lot as long as population behaviour remains what it is. This approach where population plays such a significant role on many aspects of the economy has been quite successful to understand many pre-industrial society and has been applied extensively in the case of England, notably by Lee [1973], Wrigley and Schofield [1981], and more recently Bailey and Chambers [1993]. Indeed, one could accept that this simplified view of the problem describes with certain accuracy the dynamics of early rural economies.

More than two centuries after its formulation it seems that the industrialised world has escaped this fatalistic high fertility trap thanks to productivity-enhancing technological, institutional innovations, and a decline in fertility that have constantly deferred the operation of the Malthusian checks. I also already mentioned above the possible temporal evolution the death curve might have had. There are at least two arguments, involving each of the other relationships, which can explain why Malthusian dynamics can fail for modern societies. On the one hand, land is no longer the crucial factor of production. Now capital and technological change are key elements in production and generate a labour market more complex, where the substitution of workers with more diversified skills and educational levels is not perfect. On the other hand, a modern reader will certainly find uncomfortable this idea that wages have a positive influence on births and that couples are passive players in this dynamic

[Becker, 1991]. One is now prone to believe that families decide their size actively and that that decision involves a relationship much more complicated than that provided by the simple Malthusian logic. These two characteristics of modern societies, tough connected, are to some degree independent and one might expect to have a modern productive structure with families not deciding actively their size, or couples doing family planning in an eminently agricultural economy.

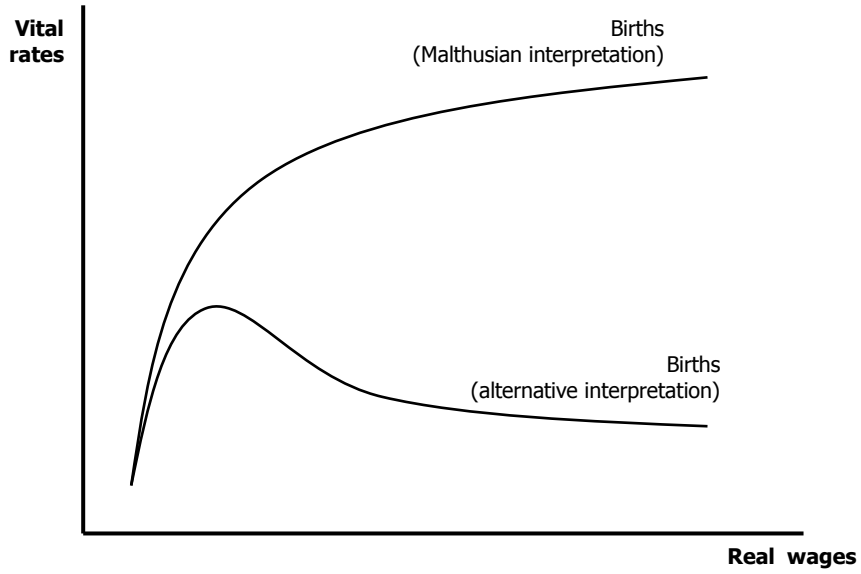
BEYOND MALTHUS

France in the period I am studying seems an ideal place to apply the Malthusian model. By 1850 three quarters of the country was still rural and even on the eve of the First World War the main source of income was the agricultural sector (see, for example, O'Brien [1996]). All through the nineteenth century agriculture dominated the economy, so the population feedback on wages could have played some role in maintaining an equilibrium between fertility and mortality rates. However, the decline in marital fertility was so abrupt and apparently unconnected with economic matters (see, for example, Coale and Watkins [1986]), that applying that framework without any qualifications seems careless. In this section I will argue that part of the Malthusian equilibrium model remains valid to analyse the case of France if we allow for the relationship between births and income to be more complex. Later in this study I make some suggestions on the reasons that might have triggered this process and driven its dynamics but, for the moment, I will try to show that a more intricate attitude towards family size (i.e., beyond biology and culture) within the Malthusian logic is consistent with the available data.

The obvious place to start is to ask why people have children. Malthus' answer was in the line of 'because they cannot help it'. A modern economist, on the other hand, would answer more in the line of 'well, that depends'. And that depends on income as well as on many other things (see, for example, Schultz [1997]). The main arguments suggest that, once the minimum biological requirements are met, increasing wages will induce people to have more children just as Malthus suggested. Ignorance and incapability to control sexual urges, children being considered as a source of labour or social security for the parents, or a Darwinist need to maximise the representation in the next generations are among the reasons for that. This same literature indicates that, beyond a certain threshold, further increases in income might induce families to have fewer children (see, for example, Becker et al. [1990]). Wealthier families not only have better access to education (hence having more information on family planning) and capital markets (hence not needing informal method to obtain income or

social security), but also higher wages that imply a higher opportunity cost of raising a child (hence, inducing fewer offspring). Also, within Darwinist logic, a less restrictive understanding of 'representation' can allow for a trade-off between having more children of 'low quality' (underfed, undereducated, etc.) or less children of 'higher quality'. What happens with further increases in income is even more speculative. Children might become again a normal good (since the increase in quantity does not lower the probabilities of producing a better educated individual and the cost of raising a child becomes marginally small), but it seems fair to assume that beyond certain point fertility becomes unresponsive to income and the curve 'flattens out'. These points have been made in the literature and Kremer [1993: 693-695] synthesized them to suggest a shape of the relationship between income and population growth. Given a death curve as the one mentioned above, and abstracting from migration (as Kremer does), the birth curve implied by this analysis must be something like that depicted in Figure 5.

Figure 5. Transition away from Malthusian checks



I am not claiming this particular functional form is the *actual* relationship between income and fertility, but I am confident to assume that shape is at least plausible and compatible with the general wisdom of modern economics regarding the choice of family size. Then, if a Malthusian logic dominated pre- and early-modern birth dynamics, and current family decisions are better described with this alternative logic, an explanation of the transition *must account for the movement from one to the other*. Many historical accounts relying upon scattered information and anecdotal evidence suggest that indeed France experienced a movement from a passive (Malthusian or, how I will refer to it later following the demographic literature, parity independent) attitude towards family planning to an active one (see, for example, Flandrin [1979: 174-242] or van de Walle in Wheaton and Hareven [1980: 135-178]). Of course, it is

very difficult to perceive this change in attitude quantitatively, but with the analysis below I hope to be able to show that actual data is consistent with this interpretation. If one believes this transition took place without any substantial change in the other assumptions of the Malthusian model (i.e., about restrictions imposed by the structure of the labour market and the shape of the death curve), the movement must have been *along* the deaths curve. And this is a prediction that can be evaluated.

Regarding that interpretation, however, another point should be made. I am suggesting that the birth curves are somewhat changing or moving but, how likely is it that the death curve moved during this period? As mentioned above, the function relating deaths and income depends basically on external shocks and technology. Besides some scattered famines in the second part of the eighteenth century, there is not much reason to believe any substantial external shock could have affected the relationship much. Other important events such as the French Revolution or the Napoleonic wars had only a marginal effect on mortality. Regarding changes in technology, the great breakthroughs in medical advances became widespread only at the end of the nineteenth century [Price, 1987: 49, 65], as the effectiveness of treatments against contagious diseases was limited until Pasteur's work in the 1860s and 1870s, which led to the use of antiseptics and sterilisation and to a new concern with contagion and disinfections. In general terms, then, I suspect that movements of this relationship were at best marginal.

LONG-RUN EQUILIBRIUM AND FERTILITY DECLINE

The classical Malthusian approach suggests that there must be a long-term equilibrium between income, mortality and fertility. And, if the transition took place in the way just described, that equilibrium must have certain characteristics. On the one hand, if fertility and mortality are moving together the relationship between them should positive close to unity. On the other hand, in the long-run income must have a negative effect on fertility, since the movement along the death curve imply an increase in income parallel to a decrease in both mortality and fertility. A way to evaluate that is to use time series to study the statistical relationship among those variables within a Malthusian model. Following the guidelines set up in Hendry and Juselius [2000], I will build an empirical time series model of the interaction between fertility, mortality and income. Other historical studies in this tradition (as, for example, Lee [1973] or Weir [1984a]) have relied upon crude birth and death rates to describe fertility and mortality, and grain prices as a proxy for income.

I gathered an alternative dataset that incorporates recent estimates of marital fertility (Ig) [Weir, 1994] and real wages of an unskilled labourer in Paris [Allen, 2001].[7] For mortality I still rely on crude death rates, but I make an adjustment to allow for infant mortality.[8] In all three cases I used the logarithms of the variables, which provides more homogeneous series without altering their basic characteristics. The standard approach to this problem is to think that fertility is a function of income and mortality (see Bailey and Chambers [1993: 346]) and for simplicity I assumed log-linear relationship among them.[9] The econometric model associated to this interpretation is the following:

$$\ln(\text{fertility})_t = \mu + \theta \ln(\text{income})_t + \lambda \ln(\text{mortality})_t + \varepsilon_t$$

Where ε_t is the error term and all other things are as written (in the way the model is constructed, the constant term does not have any direct interpretation). This formulation also facilitates the interpretation of the coefficients, which can be interpreted as the percentage change in fertility after a 1% change in the variable. Estimating that model with the time series collected generates the following results:

$$\ln(\text{fertility}) \underset{\text{t-values}}{=} \underset{(-0.17)}{-0.05} \underset{(-13.40)}{-0.50} \ln(\text{income}) + \underset{(8.76)}{0.47} \ln(\text{mortality})$$

$R^2 = 0.877$ sigma = 0.095 DW = 0.75

[7] I gathered these series from diverse sources. Real wages were obtained from Allen [2001]. I used index numbers (with 1890-99 = 100) for the daily income of a building labourer in Paris deflated by a price index. Since part of the price series for Paris was missing for the period after the French revolution, I built a proxy for those years applying the Strasbourg's rate of change in prices to the values available. The figures for marital fertility correspond to the Coale index Ig (see Coale and Watkins [1986: 153-162]), estimated for the whole period with yearly frequency by Weir [1994: 330-331]. For the period 1740-1839 crude birth, death and marriage rates were obtained from INED [1977: 332-333]. After 1840, birth and death rates are from Chesnais [1992: 518-541, 555-578] and marriage rates from Mitchell [1998: 93-119].

[8] For all my estimations, as suggested and also done by Weir [1984a: 37], I employed a death rate that adjusts mortality for the structural impact of birth rate variations through the infant mortality rate. The formula I used for this transformation was the following:

$$\text{adjusted CDR}_t = \text{CDR}_t - \text{IMR}_t \cdot \left[s \cdot \text{CBR}_t + (1-s) \cdot \text{CBR}_{t-1} \right]$$

Where CDR is the crude death rate, IMR the infant mortality rate (that I obtained from INED [1977: 332-333] for 1740-1839, and from Chesnais [1992: 580-597] for 1840-1911), and CBR the crude birth rate. The coefficient s is a separation factor for the proportion of all infant deaths that occur in the same calendar year as the infant's birth. Following Weir [1984a: 37], I assumed that for this sample that value is 0.74.

[9] It is clear that the potential nonlinearity of the relationship between income and birth mentioned before does not necessarily rule out the possibility of a linear relationship between them *and* mortality (that is, in the three-dimensional space).

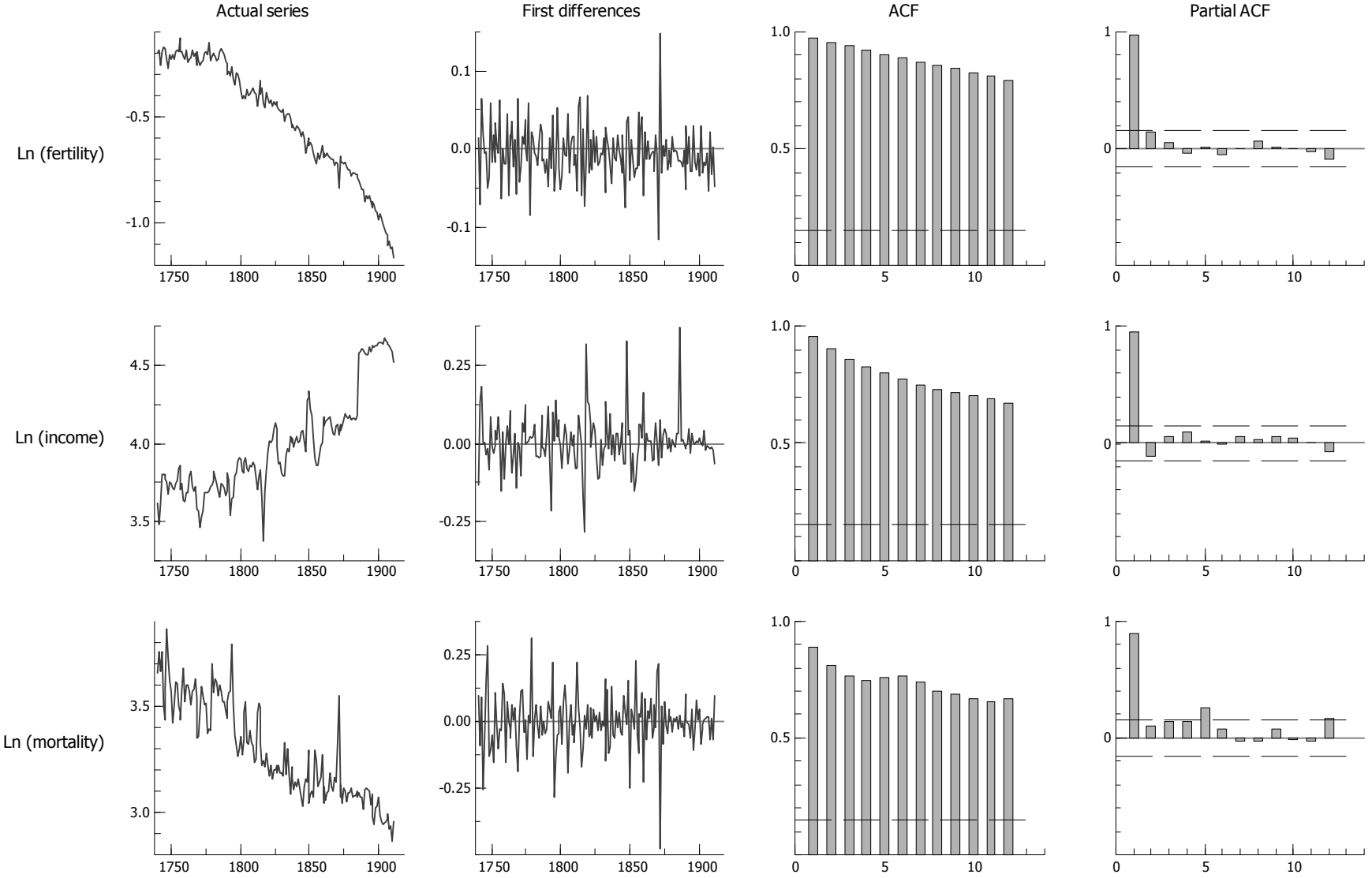
AR 1-2 test, F(2,164)	= 52.614	[0.0000]**
ARCH 1-1 test, F(1,164)	= 7.367	[0.0074]**
Normality test, χ^2 (2)	= 15.540	[0.0004]**
Heteroscedasticity test, F(4,161)	= 0.536	[0.7093]

Together with the estimated equation I also reported the R^2, the residual standard error (sigma), the Durbin-Watson test statistic (DW), and some specification tests.[10] Going now to the results, one can see that coefficients are significant and with the expected sign, though the coefficient for mortality is smaller than what the theory I described suggest. The low value of the DW test is the first to call attention about a possible problem in the model. The specification tests, in turn, suggest that no-autocorrelation, homoscedasticity and normality of the residuals are rejected, so the standard assumptions of time series analysis are clearly violated. Many of these problems could be associated with non- stationarity of the series. Most classical time series econometrics rely upon the assumption that data can be described by a stationary process, that is, a process whose means and variances are constant over time. Absence of stationarity generates underestimation of standard errors, hence increasing the chances of not rejecting a true hypothesis of coefficients equal to zero, and the R^2 cannot be interpreted as a measure of goodness-of-fit [Hendry and Juselius, 2000: 21]. Given the relevance of non-stationarity, I conducted an inspection of the statistical properties of the data to determine whether they have unit roots.

I begin by examining a graphical representation of the series, their first differences and their autocorrelation functions (ACF and partial ACF). These graphics can be found in Figure 6. A simple look at the trendy behaviour of the three variables suggests that they might not be stationary. Also, the strong persistence in the ACF indicates the possibility that the processes can be described by an AR model, while the single peak in the first lag of the partial ACF can be associated with a AR(1) process. The first differences, on the other hand, fluctuate around a fixed mean of zero suggesting stationarity.

[10] These estimations, as well as all the others in this paper, have been performed with PcGive 2.20. The AR 1-2 test evaluates the residual autocorrelation of order 2 (that is, assess the null hypothesis that the residuals are white noise against the alternative that they are generated by a second-order autoregressive process) and it is distributed F(2, T). The ARCH 1-1 is a test of autoregressive residual heteroscedasticity of order 1 (where the null hypothesis is that the disturbance is conditionally homoscedastic) , and PcGive reports its F-form. The normality test assesses the skewness and excess kurtosis of the residuals under a null of normality using a χ^2 (2). Lastly, the (White) heteroscedasticity test evaluates the null hypothesis of unconditional homoscedasticity against that the variance of the process that generate the errors depends on the variables of the model and their squares and it is distributed as a χ^2 , but here the F(2k, T-2k+1) equivalent is give, where k is the number of explanatory variables of the model.

Figure 6. Stationarity Analysis



Sources: See Appendix. Estimations performed using *PcGive 2.20*..

All these clues suggest that the variables could have a unit root, whereas the first-differences might be stationary. I tested those hypotheses using an Augmented Dickey-Fuller test (ADF) with two lags. According to those tests, for all three series the hypothesis of stationarity is rejected, whereas that hypothesis cannot be rejected for the first differences.[11] From this brief analysis I conclude that the series are integrated of degree 1 (I(1)).

Once the presence of non-stationarity is recognised, there are several ways to deal with it. One alternative is to use first differences or any other transformation of the data to generate a stationary series. This method, however, generally implies some loss of information. Alternatively, one could turn to a dynamic specification of the model which can produce good estimates without throwing away data. Hendry and Juselius [2000: 21] suggest that in presence of residual autocorrelation a re-specification of the model to have white-noise errors is a good step towards solving the problem.[12] So I built the above model in an autoregressive distributed lags form as follows:

$$\ln(\text{fertility})_t = \eta + \sum_{s=1}^{n} \rho_s \ln(\text{fertility})_{t-s} + \sum_{s=0}^{n} \theta_s \ln(\text{income})_{t-s} + \sum_{s=0}^{n} \lambda_s \ln(\text{mortality})_{t-s} + \upsilon_t$$

As a first step, I had to define the appropriate number of lags. Various procedures had been suggested for doing that. One standard way is to use the number of lags that minimise a penalised likelihood function. In this case, I evaluated the results of the three most widely used information criteria: Akaike, Hannan-Quinn, and Schwarz. Both Akaike and Hannan-Quinn were minimised at 3 lags, whereas for the Schwarz criterion the model with 2 lags slightly dominated. I decided then to model assuming n=3. I first run the model including all current values and three lags of the variables and then including only those terms that were significant. The first two columns in Table 1 show these estimates.

[11] For the initial series we have that ADF(fertility) = 1.90, ADF(real wage) = -1.24, ADF(mortality) = -1.93; whereas for the first differences ADF(fertility) = -9.26, ADF(real wage) = -11.13, ADF(mortality) = -8.52.

[12] More sophisticated specifications, like VAR models, could also help to solve this problem. Here I opted for a relatively simple formulation that provides good results, and those for a VAR could be explored in other works.

Table 1. Modelling ln(marital fertility) in France, sample 1743-1911

	Coefficient (t-value)			
	Dynamic model	Dynamic (restricted) model	Dynamic model with dummies	Dynamic (restricted) model with dummies
Constant	-0.087 (-0.80)	-0.079 (-0.78)	-0.096 (-0.95)	-0.114 (-1.35)
Fertility $_{t-1}$	0.408 (5.24)	0.408 (5.92)	0.371 (4.98)	0.406 (6.26)
Fertility $_{t-2}$	0.328 (4.25)	0.332 (4.57)	0.363 (4.99)	0.366 (5.36)
Fertility $_{t-3}$	0.200 (2.66)	0.200 (2.87)	0.210 (2.86)	0.177 (2.70)
Income $_{t}$	0.061 (2.09)	0.063 (3.14)	0.061 (2.24)	0.068 (3.64)
Income $_{t-1}$	0.002 (0.06)		0.010 (0.26)	
Income $_{t-2}$	-0.094 (-2.32)	-0.098 (-4.99)	-0.085 (-2.25)	-0.099 (-5.34)
Income $_{t-3}$	-0.007 (-0.21)		-0.023 (-0.83)	
Mortality $_{t}$	-0.048 (-1.94)	-0.037 (-1.82)	-0.020 (-0.83)	
Mortality $_{t-1}$	0.027 (0.96)		0.016 (0.64)	
Mortality $_{t-2}$	0.082 (3.00)	0.093 (4.62)	0.055 (2.09)	0.062 (3.42)
Mortality $_{t-3}$	-0.001 (-0.05)		0.011 (0.49)	
Dummy French Revolution			-0.025 (-3.39)	-0.024 (-3.31)
Dummy War Germany			-0.060 (-3.66)	-0.064 (-4.17)
sigma	0.027	0.027	0.025	0.025
R^2	0.991	0.990	0.992	0.992
DW	2.01	2.01	2.02	2.07
AR 1-2 test:	0.167 [0.8462]	0.128 [0.8801]	2.472 [0.0878]	2.869 [0.0597]
ARCH 1-1 test:	5.364 [0.0219]*	5.409 [0.0213]*	0.120 [0.7296]	0.217 [0.6422]
Normality test:	8.498 [0.0143]*	8.429 [0.0148]*	1.133 [0.5675]	0.512 [0.7740]
Heteroscedasticity test:	1.356 [0.1482]	1.683 [0.0649]	1.276 [0.1902]	1.389 [0.1600]

Sources: All variables are in logarithms. See footnote 7 for a sources. Estimations performed using *PcGive 2.20*. * denotes the 0.05 significance level and ** the 0.01 significant level.

Many of the problems pointed out above are solved, or at least reduced, in these dynamic models. The residual standard error decreased from 0.095 to 0.027, so the precision has been increased more than 3 times. The Durbin-Watson has improved and the residual correlation seems no longer a problem. Still, other tests suggest that there is heteroscedasticity and non-normality in the residuals. The coefficients of the autoregressive components are all positive and significant, showing a strong persistence in the level of fertility. Interestingly enough, income and mortality behave in similar way, but with opposite signs. The dominant significant coefficient is the one that corresponds to the second lag, suggesting this dominates the long-run effects and the other could play an short-term equilibrating role. From these estimations I can establish the long run solution of the model as in Hendry [1995: 212-214].[13] The estimation of the long-run solution for the first of the models is:

[13] The static or long-run solution of a dynamic, stochastic process denotes a hypothetical situation in which all change has ceased. Hence, for a variable x_t, $E(x_t)=E(x_{t-r})$ for all r and $E(x_t)=E(\nu_{t-r})$. In the model above:

$$\ln(\text{fertility}) = \underset{(-0.78)}{-1.37} \underset{(-2.84)}{-0.60}\ln(\text{income}) + \underset{(2.70)}{0.93}\ln(\text{mortality})$$

And for the restricted model:

$$\ln(\text{fertility}) = \underset{(-0.75)}{-1.33} \underset{(-2.88)}{-0.61}\ln(\text{income}) + \underset{(2.66)}{0.94}\ln(\text{mortality})$$

As was suggested earlier, standard errors have now increased, hence producing smaller but still significant t-values. Both estimations suggest that a 1% change in mortality induces a 0.93-0.94% change in fertility, confirming part of my suspicion that the relationship might be close to unity. Also, the long-run relationship between wages and fertility is negative: a 1% change in income would induce a 0.60% change in fertility.

Despite the satisfactory results of this model, it must be noted it still has some problems regarding the heteroscedasticity and normality of the residuals. In an attempt to solve these problems, I decided to bring some history in the model by constructing dummies that could capture the effect of some unusual events: the –extended- French Revolution (1789-1803) and the Franco-Prussian War (1870-1871). Both events generated great disruption in the country, and both are expected to have a negative impact on the level of fertility. The third and fourth columns of Table 1 report the results of including these dummies when all lags appear in the regression and when only the significant ones are kept. The coefficients of the dummies themselves are significant at the 1% level and with the expected sign. Their introduction does not greatly change the values of the coefficients of lagged fertility or income. Most of their impact seems to rely on mortality. They solve, however, the technical problems with the residuals: autoregressive residual heteroscedasticity and non-normality do not seem to be a problem any more. The new estimated long-term relationship does not alter substantially the previous result:

$$\ln(\text{fertility}) = \underset{(-0.90)}{-1.70} \underset{(-2.85)}{-0.66}\ln(\text{income}) + \underset{(2.67)}{1.11}\ln(\text{mortality}) - \underset{(-1.69)}{0.44}\,D_{FR} - \underset{(-1.70)}{1.06}\,D_{WG}$$

And, for the model with restrictions:

$$\left(1-\sum_{s=1}^{3}\rho_s\right)\ln(\text{fertility}) = \eta + \left(\sum_{s=0}^{3}\theta_s\right)\ln(\text{income}) + \left(\sum_{s=0}^{3}\lambda_s\right)\ln(\text{mortality})$$

Manipulating the coefficients one could get the expression wanted.

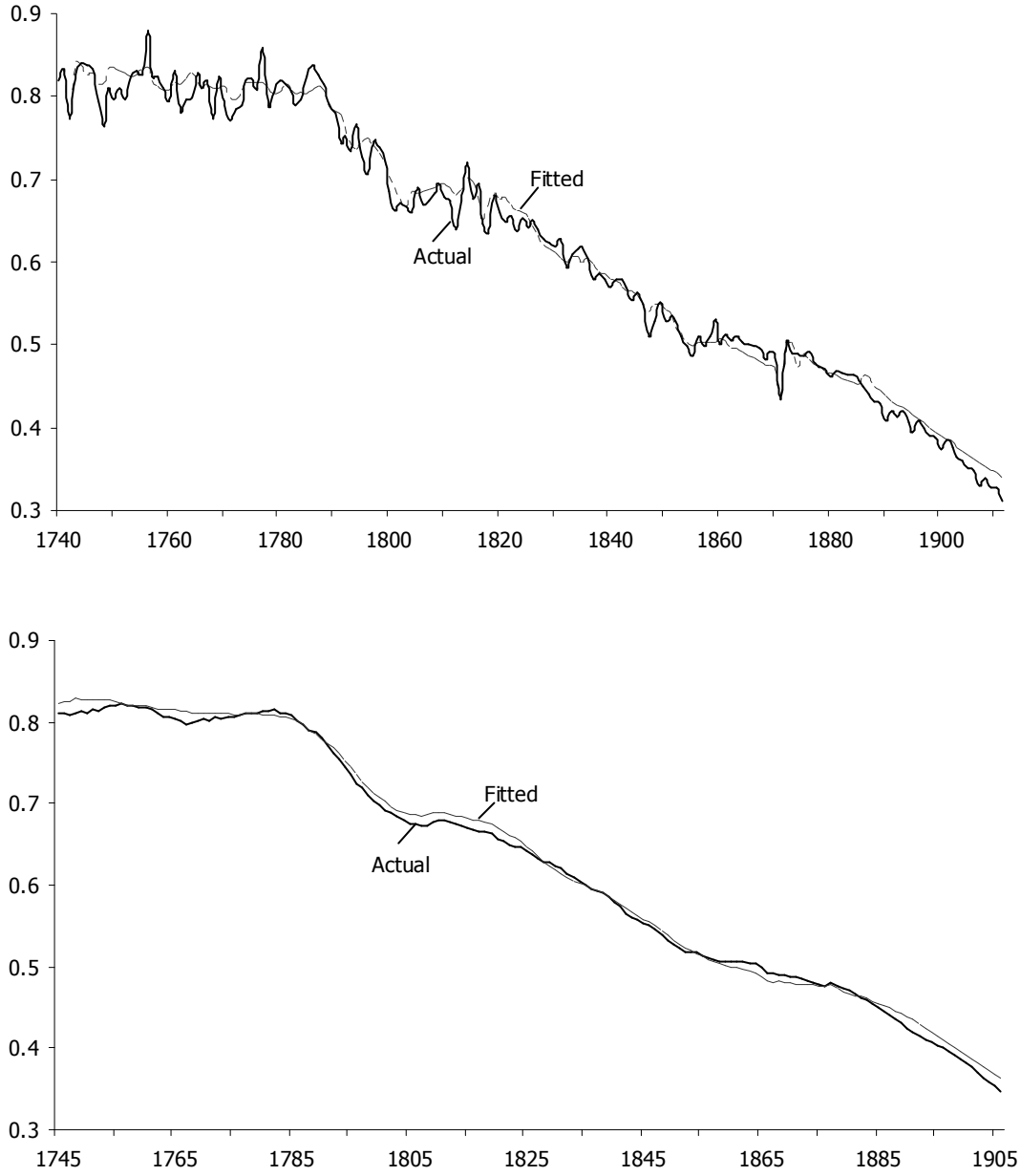
$$\ln(\text{fertility}) = \underset{(-1.10)}{-2.26} \underset{(-2.94)}{-0.62}\ln(\text{income}) + \underset{(2.51)}{1.23}\ln(\text{mortality}) - \underset{(-1.69)}{0.47}\,D_{FR} - \underset{(-1.70)}{1.27}\,D_{WG}$$

Which of these models is the appropriate to evaluate the hypothesis suggested? The models that incorporate the dummies seem to have a better general outlook, since they passed all specification tests at the standard significance levels. However, as can be appreciated if one looks at the AR 1-2 test, non-autocorrelation of the residuals is not rejected at 5%, but it is rejected at 10% significance, which is still high. Knowing that autocorrelation is probably the most serious of these problems, I am tempted to suggest that the models with no dummies are more accurate. Still, the main conclusions do not change much. Indeed, I find that the long-run relationship between fertility and mortality is close to unity, hence suggesting that the transition was experienced as a movement *along* the death curve.

Another way to exploit these econometric models is to use them to simulate the levels of fertility and evaluate alternative scenarios. By construction, these dynamic models could be interpreted as least-square approximation of the hypothetical function relating income and mortality with fertility. One could take any of the models in Table 1 and simulate the series of marital fertility using the true values of wage and mortality, and feeding back with the estimated values of fertility. Since the unrestricted dynamic model with dummies is the one that bring together the largest amount of information from the series, I decided to use it to simulate the fertility series in the way just described. The outcome is depicted in Figure 7.

The fit of the estimated model looks quite good. The largest divergence from the true value is of no more than 8% (at the end of the period) and on average it does not surpass 2.3%. Hence, the smoothed series almost overlaps with the true values. Using this model I evaluated some counterfactual experiments in an attempt to isolate the relative importance of wage and mortality in the fertility dynamics.

Figure 7. Actual and smoothed estimated marital fertility (Ig) using dynamic model with dummies, 1743-1911

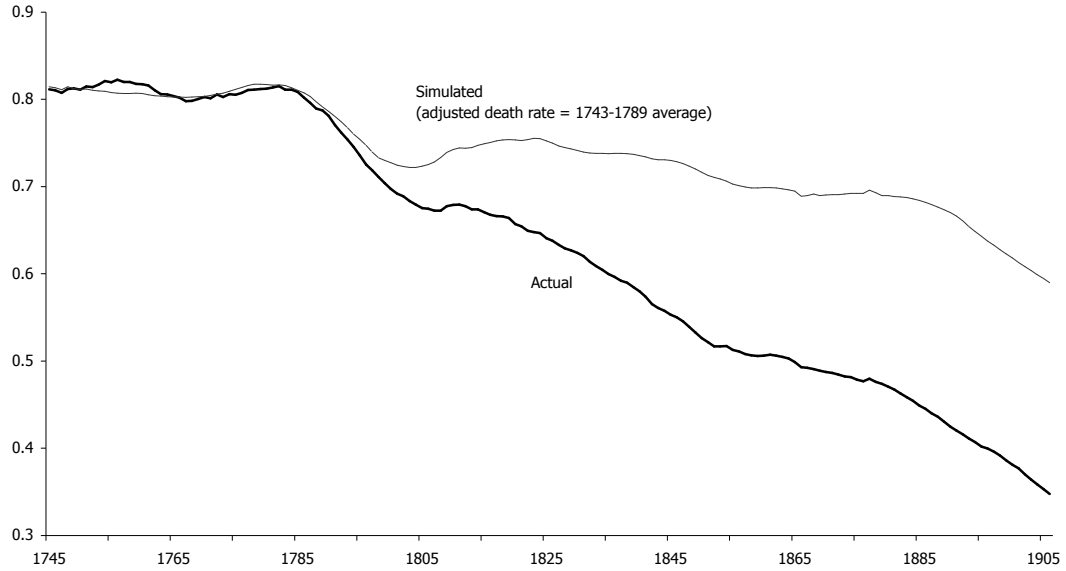


Sources: Weir [1994: 330-331] for actual values and my estimations for fitted. Smoothed series are 11-year averages centred on the year.

If the story I suggest holds, one would expect that different but constant death rates could have produced relatively constant fertility rates. Figure 8 shows this is the case if one substitutes actual values for constant high alternative death rates. In this exercise I took as reference the values corresponding to the average of the earliest period up to the French Revolution (with an adjusted crude death rate of 35). As can be seen in the graph, simulated values were affected by the dummy that perceives the effect of the French Revolution but, beyond that,

fertility remains roughly constant when death rates are kept in the low level and converges quickly to the later values when the final values are introduced.

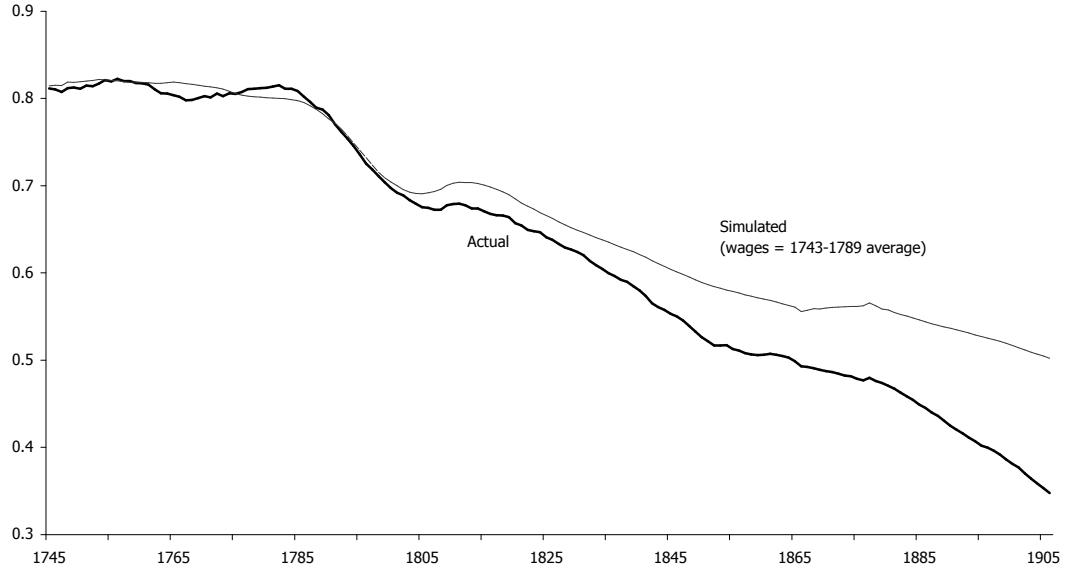
Figure 8. Smoothed simulated marital fertility (Ig) keeping mortality constant at its initial value, 1745-1906



Sources: Weir [1994: 330-331] for actual values and my estimations for fitted. Series are 11-year averages centred on the year.

A similar exercise is done with real wages in Figure 9.

Figure 9. Smoothed simulated marital fertility (Ig) keeping income constant at its initial value, 1745-1906

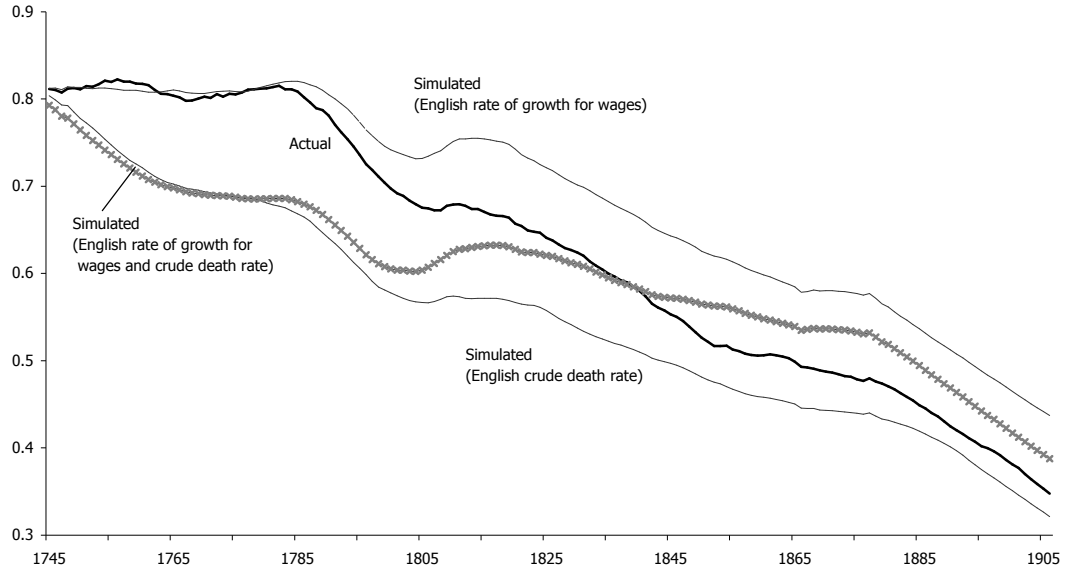


Sources: Weir [1994: 330-331] for actual values and my estimations for fitted. Series are 11-year averages centred on the year.

In this case, maintaining wages constant at their late eighteenth century level do not seem to affect radically the decreasing path of fertility. And this is to be expected if the dynamics of this process are those I suggested earlier: a movement along the death curve. A corollary of this model is that fertility is in fact more affected by mortality than by income. Far from suggesting economics did not play a role, this apparent passive role of income in determining the fertility level can be understood in terms of economic equilibrium between demographic variables and income.[14]

Before ending this section I perform one last exercise. In European historiography there is always this constant reference to the different trajectories of France and Britain, so I thought of using this model to ask: what if France was Britain? In Figure 10 I play with that idea in different ways.

Figure 10. Smoothed simulated marital fertility (Ig) using income or mortality from England and Wales, 1745-1906



Sources: Weir [1994: 330-331] for actual values and my estimations for fitted. English real wage series were obtained from Allen [2001] and correspond to daily wage of a labourer in London deflated by a consumer price index. English crude death rates are from Wrigley and Schofield [1989: 531-535] (up to 1870) and Mitchell [1998: 93-119] (between 1870 and 1911). Series are 11-year averages centred on the year.

As expected, the very low level of mortality England had in the late eighteenth century would have brought an even earlier transition in France. Since real wages in Britain were already quite high, they grew slower than in France and this milder rate of change in income would

[14] Interestingly enough, similar results for the characteristics of the transition has been obtained for Sweden by Eckstein et al. [1999], who used a least-square approximation to a life-cycle model to simulate fertility.

have delayed somewhat the decline. Putting both things together generates an earlier but then smoother decline in fertility.

In this section I tried to make the point that the fertility transition can be understood within the general Malthusian framework assuming that what changed was the shape of the fertility curve and equilibrium shifted from high mortality/fertility and low income, to one of low mortality/fertility and high income. Beyond the basic scheme I mention in accordance with Kremer's [1993] analysis up to this point I have not made any suggestions on how that shape might have changed. Since the model I just used relied upon the long-term relationship among variables, it does not provide a particularly useful framework to assess this question. Hence, in the next section I move to use short-run analysis to provide some answers on this respect.

SHORT-RUN ANALYSIS AND RESPONSIVENESS TO INCOME

The movement from a classical Malthusian equilibrium to one where actual parental choice dominates suggests a series of hypotheses regarding the short term effects of income on vital rates. Under a preventive-check equilibrium one expect a significant and positive response of marriage, a not necessarily significant but positive (if any) response of fertility (because it is supposed to operate through marriage, which implies some lag), and a negative response of deaths. Under the alternative equilibrium many things could happen, but one can expect a higher responsiveness (positive or negative) of fertility, and a lower or non-responsiveness of marriages and deaths. There are several ways to test these hypotheses, but probably the most standard in this Malthusian framework is short-run analysis. Short-run analysis has become quite a popular technique to evaluate historical population dynamics using time series data [Lee, 1997; 1079-1086] and has been used, for example, by Lee (in Wrigley and Schofield [1981: 356-401]) to study the case of England, by Weir [1984a] for France and by Galloway [1988] for various countries in Europe.

This approach involves studying short-run fluctuations of detrended variables to infer the slopes of the Malthusian relationships. Its main appeal relies upon the possibility of treating wages as exogenous (because the long term effects have been removed) and, hence, eliminating the identification problem. The typical transformation of the series to remove the longer term variation is accomplish by dividing each term in the series by a 11-year moving average centred in that term. This transformation also removes the influence of population size and age structure for demographic variables and of secular inflation and real income change in

prices [Lee in Wrigley and Schofield, 1981: 357]. Further, the nature of this detrending also allows us to treat coefficients as elasticities [Galloway, 1988: 283]. Alternative ways of transforming the data to remove non-stationarity (such as first-differencing), and other methods of estimation (such as two-stage least squares, vector autoregressive models or regression of pooled data) could be used for this, but they do not seem to provide any substantive improvement in the results [Galloway, 1988: 282].

In his study of French population dynamics, Weir [1984a] used short-run variation to estimate the effect of price shocks on current and future birth, marriage and death rates. He began by constructing autoregressive distributed lag models of those variables and grain prices. That is, regressing the detrended birth, marriage and death rates against their own lagged values and lagged values of detrended wheat prices. For the birth and marriage equations he also included lagged values of death rates, something that is quite standard in the literature, and that it is used to net out the effect of death rates. To generate the effect of a price shock he simulates the impact of a 1% increase in prices in a single year through the estimated system of coefficients. The numbers obtained are the cumulative elasticities and represent the area between the path followed by the variable after the shock and the trend it would have had if that shock never happened, so they measure to some degree the responsiveness of the variable to the price shock. Weir performed these calculations for France and England in three different periods he refers to as pre-transitional (1740-1789), transitional (1790-1829), and post-transitional (1830-1870). The most robust result he obtained is the strong responsiveness of marriage to price movements in the pre-transitional period. With this finding he claimed that France was experiencing a preventive check and not a positive check, as suggest by other authors [Wrigley and Schofield, 1981: 479]. Regarding the sensitivity of fertility he could not find any meaningful difference between England and France and interpreted the weakening of the relationship between marital fertility and prices after the French revolution as an indication of failure of the neo-Malthusian approach. The estimated responses of deaths were more unstable and no clear conclusion is drawn from them apart from evaluating the probable sources of noise that generated these ambiguous results [Weir, 1984a: 39-40].

I think Weir approach, with some amendments, can be useful in evaluating some of the hypotheses posed before, so I decided to extend some of his results. In what follows I tried to improve on his calculations in two different ways. On the one hand, Weir (as well as most researchers performing historical short-run analysis) relied upon grain prices as a proxy for the standard of living. Short-run analysis depends on the variation of series. Since Weir's interest was focused on a historic period where the available data on real wages lacked any substantial variation he did not have many alternatives but to rely on commodities prices.

Recent estimations of real wages indices [Allen, 2001] allowed me to calculate the responses to a more appropriate measure of income and to assess the accuracy of his estimations. On the other hand, I already noted that Weir elaborated on three distinct periods ending in 1870. For reasons that will become apparent later, I tend to believe the transition was still going on in the late nineteenth century, so I extended the period of analysis to include a fourth phase that could shed some light on the overall dynamics of the transition.

The short-run analysis I perform simply replicates Weir's [1984a] which, in turn, follows closely Lee [in Wrigley and Schofield, 1981: 356-401]. The regressions used to construct the simulations are those in Tables 3, 4 and 5. Later I will draw my attention to these, but for the moment my results –together with those of Weir- are reported in Table 2. To make assessment and comparison easier, I reported the inverse of Weir results (that is, the effect of a *decrease* instead of an *increase* in prices) which is comparable with that of an increase in wages.

Table 2. Impact of income shocks on current and future vital rates in France, 1747-1906

Elapsed years	Decrease in prices (Weir)			Increase in wages			
	1747-1789	1790-1829	1830-1865	1747-1789	1790-1829	1830-1865	1866-1906
	Fertility (crude birth rate)						
0	0.085*	0.047*	0.021**	0.179	0.035	0.027*	-0.006**
1	0.172*	0.116*	0.122**	0.141	0.180	0.170*	-0.052**
2	0.094*	0.060*	0.031**	0.164	0.086	0.127*	-0.118**
3	0.185*	0.082*	0.054**	0.209	0.090	0.013*	-0.156**
4	0.172*	0.077*	0.053**	0.217	0.082	0.024*	-0.139**
	Nuptiality (marriage rate)						
0	0.485*	0.476	0.126**	0.753*	0.431	0.162*	0.012**
1	0.471*	0.059	0.079**	0.404*	-0.188	0.141*	-0.187**
2	0.378*	0.435	0.074**	0.779*	0.725	0.083*	-0.194**
3	0.532*	0.411	0.098**	0.920*	0.382	0.105*	-0.118**
4	0.608*	0.306	0.092**	0.893*	0.173	0.105*	-0.122**
	Mortality (adjusted crude death rate)						
0	0.180**	-0.148**	-0.141	0.267*	0.202*	-0.107*	-0.342
1	0.056**	-0.164**	0.052	0.302*	-0.090*	0.190*	-0.120
2	-0.234**	-0.501**	-0.260	-0.201*	-0.094*	-0.399*	-0.101
3	0.208**	-0.498**	-0.238	0.030*	0.090*	-0.377*	-0.354
4	0.452**	-0.424**	-0.190	0.304*	0.210*	-0.185*	-0.411

Sources: Effects after the decrease in prices are the negative of those reported by Weir [1984a; 38-40]. The effects of an increase in wages are from my calculations, based on the techniques suggested in that same paper, and the sources are described in footnote 7. Stars indicate whether the F-test for the regression used to construct the estimate is significant to the 1% (**) or 5% (*). Estimations were carried out using *PcGive 2.20*.

Again, the coefficients that appear in the table are the result of simulating the impact of a 1% increase in prices in a single year and represent the area between the path followed by the variable after the shock and the trend it would have had if that shock never happened. They measure, then, the responsiveness of the variable to the income shock. Looking at the first two periods, one thing that comes out of the comparison is that my estimates for the response of fertility in the early periods are relatively similar to those of Weir. I obtain only slightly

higher values, but the story told is basically the same and suggests that the influence of income on fertility was positive (hence, showing evidence of a positive shock) but decreasing through time. Regarding nuptiality, my estimates for the pre-transitional period are substantially higher implying that a doubling in the wages would create an expansion of marriages over the ensuing five years equal to 89% of the number of marriage in an average year, instead of the 61% obtained by Weir. This reinforces the preventive check argument. The least satisfactory results are those showing the effect of income on mortality. My estimates are equally or more disappointing that those obtained by Weir in terms of their instability, and could be due to the influence of late eighteenth century famines and the revolution. As a general (and, by the way, expected) result, the period that covers the French revolution and the Napoleonic empire manifest either weak or unstable results.

The two last periods show some interesting results. After 1830 the preventive check affecting fertility is only slightly positive, the sensitivity of marriage to income decreases considerably and that of death rates begins behaving as expected. But in the last interval two remarkable things happen. Firstly, the influence of income on fertility becomes negative. Secondly, the responsiveness of death rates, though it remains negative, losses significance. All these results point to support the hypotheses I suggested before. Death rates reaction (which instability, I agree, warns us to be cautious), seems to fade away all through the nineteenth century. Fertility, on the other hand, becomes increasingly sensitive to short-run changes in wages, but its response turns from being slightly positive to be strongly negative. And nuptiality, which in the early stages played a crucial role, looses relevance to eventually become affected in a different way (which, in this particular case could be influenced by the strong fall in marriage that occurs during the Franco Prussian War). The transition changed the situation in the sense that couples could get married and not have a family (that is, having children) immediately. This could have generated a period of relative independence between marriage and wealth.

Having said that, I want now to cast some doubts on this analysis. All these estimation rely upon a number of autoregressive distributed lag regressions that I have not described yet. I will show that those regressions have in general a bad fit and the values in Table 2 should be taken with a lot of caution. The reason why I still reported them is that they remain comparable to Weir results (which, by the way, do not rely upon substantially better regressions) and are still illustrative of what the data (weakly) suggests. But, interestingly enough, these relatively unsuccessful estimations tell a story that goes in the lines of what I have claimed earlier about the characteristics of the transition. I will begin by looking at the fertility equa-

tions. In Table 3 I reported the regressions for crude death rate, that I used to construct the elasticities above, and for marital fertility (Ig).

Table 3. Modelling fertility (short-run analysis) in France, sample 1748-1906

	Coefficient (t-value)			
	1748-1789	**1790-1829**	**1830-1865**	**1866-1906**
	Crude birth rate			
Constant	0.5884 (1.99)	0.3639 (1.29)	1.2288 (3.43)	1.7382 (5.38)
crude birth rate $_{t-1}$	0.1392 (0.70)	0.2791 (1.47)	-0.0427 (-0.22)	-0.0530 (-0.29)
crude birth rate $_{t-2}$	0.0934 (0.49)	0.1025 (0.52)	-0.1416 (-0.77)	-0.2312 (-1.22)
adjusted death rate	-0.0044 (-0.06)	0.0966 (1.55)	-0.0508 (-0.77)	-0.2484 (-8.72)
adjusted death rate $_{t-1}$	-0.0537 (-0.93)	-0.0136 (-0.21)	-0.0489 (-0.72)	0.0339 (0.67)
adjusted death rate $_{t-2}$	0.0645 (1.11)	0.0657 (1.07)	0.0192 (0.31	-0.0482 (-0.94)
adjusted death rate $_{t-3}$	0.0008 (0.01)	0.0579 (1.07)	-0.0080 (-0.13)	-0.0162 (-0.64)
real wage (unskilled)	0.1790 (2.08)	0.0352 (0.56)	0.0266 (0.46)	-0.0057 (-0.14)
real wage (unskilled) $_{t-1}$	-0.0631 (-0.61)	0.1354 (1.67)	0.1450 (1.95)	-0.0466 (-1.01)
real wage (unskilled) $_{t-2}$	0.0123 (0.12)	-0.1386 (-1.59)	-0.0334 (-0.41)	-0.0695 (-1.52)
real wage (unskilled) $_{t-3}$	0.0445 (0.55)	0.0158 (0.22)	-0.0953 (-1.35)	-0.0522 (-1.14)
sigma	0.025	0.026	0.021	0.013
R^2	0.286	0.384	0.477	0.789
F (10,T) =	1.242 [0.305]	1.807 [0.104]	2.284 [0.046]*	11.19 [0.000]**
DW	2.01	2.12	2.00	2.14
	Marital fertility (Ig)			
Constant	0.5688 (2.01)	0.7286 (2.47)	1.2866 (3.57)	1.8201 (5.63)
marital fertility (Ig) $_{t-1}$	0.1577 (0.81)	0.1172 (0.61)	-0.0621 (-0.32)	-0.1203 (-0.66)
marital fertility (Ig) $_{t-2}$	0.1177 (0.63)	-0.0842 (-0.43)	-0.1841 (-1.00)	-0.2695 (-1.45)
adjusted death rate	0.0045 (0.07)	0.0469 (0.79)	-0.0528 (-0.83)	-0.2324 (-8.57)
adjusted death rate $_{t-1}$	-0.0686 (-1.22)	-0.0256 (-0.41)	-0.0555 (-0.84)	0.0274 (0.57)
adjusted death rate $_{t-2}$	0.0649 (1.12)	0.0659 (1.13)	0.0172 (0.28)	-0.0470 (-0.97)
adjusted death rate $_{t-3}$	-0.0015 (-0.03)	0.0557 (1.08)	-0.0027 (-0.04)	-0.0138 (-0.55)
real wage (unskilled)	0.1930 (2.28)	0.0495 (0.82)	0.0227 (0.40)	0.0067 (0.16)
real wage (unskilled) $_{t-1}$	-0.0533 (-0.52)	0.1226 (1.58)	0.1418 (1.96)	-0.0474 (-1.05)
real wage (unskilled) $_{t-2}$	0.0082 (0.08)	-0.1091 (-1.29)	-0.0280 (-0.36)	-0.0760 (-1.71)
real wage (unskilled) $_{t-3}$	0.0102 (0.13)	0.0312 (0.46)	-0.0840 (-1.23)	-0.0462 (-1.04)
sigma	0.025	0.025	0.020	0.012
R^2	0.334	0.333	0.473	0.786
F (10,T) =	1.555 [0.167]	1.447 [0.210]	2.245 [0.049]*	11.05 [0.000]**
DW	2.01	2.10	1.99	2.17

Sources: See footnote 7 for a sources. Variables are percentage deviations from 11-year moving averages. Estimations performed using *PcGive 2.20*. * denotes the 0.05 significance level and ** the 0.01 significant level.

Estimation for both variables are similar and can be interpreted as a robustness check of my results. Significant coefficients are not different from one specification or the other, so evaluating either of them will provide basically the same outcome. As I mentioned before, the fit of these regressions is disappointing. In the first period, only changes in current wage seems to explain changes in fertility (and their influence is positive, arguing in favour of the preventive check). For the second and third periods results are even weaker: only the first lag of wages are somewhat significant (at 15% or 10% level, depending on the variable), but the relationship is still positive. In the fourth period, however, this relationship reverts. Coefficients are not really different from zero under the standard significance levels, but if one considers as relevant values at 15% level, it is interesting to note that the second lag of the wages turn to have negative coefficients as well as the (less significant) first and third lags. All re-

sults from this table are weak, but they could suggest some transition towards a different relationship between income and fertility. This can be complemented with the results on nuptiality in Table 4.

Table 4. Modelling nuptiality (short-run analysis) in France, sample 1748-1906

	Coefficient (t-value)			
	1748-1789	**1790-1829**	**1830-1865**	**1866-1906**
Constant	-0.2239 (-0.58)	-0.0331 (-0.05)	0.7156 (1.73)	0.7127 (1.53)
crude marriage rate $_{t-1}$	0.4687 (2.57)	-0.2175 (-1.26)	-0.1306 (-0.68)	-0.0305 (-0.13)
crude marriage rate $_{t-2}$	-0.2451 (-1.43)	-0.3110 (-1.78)	-0.0491 (-0.27)	0.1525 (0.71)
adjusted death rate	0.1507 (0.88)	0.3252 (1.07)	-0.0518 (-0.55)	-0.3849 (-3.65)
adjusted death rate $_{t-1}$	0.1349 (0.94)	0.6243 (1.79)	0.0803 (0.81)	0.3763 (3.15)
adjusted death rate $_{t-2}$	-0.1345 (-0.91)	-0.2430 (-0.74)	0.1551 (1.63)	0.2516 (1.86)
adjusted death rate $_{t-3}$	0.1946 (1.31)	0.3710 (1.30)	0.1600 (1.67)	0.0158 (0.15)
real wage (unskilled)	0.7532 (3.36)	0.4306 (1.25)	0.1616 (1.82)	0.0117 (0.09)
real wage (unskilled) $_{t-1}$	-0.7023 (-2.50)	-0.5251 (-1.16)	0.0007 (0.01)	-0.1981 (-1.39)
real wage (unskilled) $_{t-2}$	0.7240 (2.64)	0.9125 (1.96)	-0.0532 (-0.43)	-0.0150 (-0.10)
real wage (unskilled) $_{t-3}$	-0.1217 (-0.54)	-0.3364 (-0.92)	0.0136 (0.13)	0.1057 (0.79)
sigma	0.066	0.143	0.031	0.040
R^2	0.470	0.308	0.486	0.678
F (10,T) =	2.745 [0.015]*	1.29 [0.281]	2.359 [0.040]*	6.319 [0.000]**
DW	2.14	2.10	1.80	2.06

Sources: See footnote 7 for a sources. Variables are percentage deviations from 11-year moving averages. Estimations performed using *PcGive 2.20*. * denotes the 0.05 significance level and ** the 0.01 significant level.

In this case, the results are very suggestive. The first period regression is actually reasonably good and shows a strong relationship between income and marriage rate. This evidence points toward a classic Malthusian period of preventive checks acting through nuptiality and could explain the little reaction of fertility: all the action is happening in marriages. What the successive periods show is simply a fading of this relationship which, again, is supportive of my story. The negative elasticities reported in Table 2 for the last period are sustained only by the second lag of the real wage, which is only marginally significant. The account that provides these two tables is one of a transition away from a preventive check.

Table 5. Modelling mortality (short-run analysis) in France, sample 1748-1906

	Coefficient (t-value)			
	1748-1789	**1790-1829**	**1830-1865**	**1866-1906**
Constant	0.7071 (2.28)	0.5269 (1.53)	1.8106 (5.17)	1.3278 (3.23)
adjusted death rate $_{t-1}$	0.4199 (3.33)	0.6447 (3.94)	-0.1208 (-0.64)	0.2128 (1.28)
adjusted death rate $_{t-2}$	-0.3503 (-2.62)	-0.2968 (-1.80)	-0.3318 (-1.86)	-0.1858 (-1.12)
real wage (unskilled)	0.2672 (1.16)	0.2020 (0.99)	-0.1065 (-0.62)	-0.3420 (-1.26)
real wage (unskilled) $_{t-1}$	-0.0776 (-0.32)	-0.4221 (-1.64)	0.2835 (1.35)	0.2949 (0.95)
real wage (unskilled) $_{t-2}$	-0.4240 (-1.75)	0.2444 (0.90)	-0.5885 (-2.89)	-0.0922 (-0.30)
real wage (unskilled) $_{t-3}$	0.4549 (2.15)	0.0998 (0.46)	0.0490 (0.29)	-0.2156 (-0.80)
sigma	0.073	0.088	0.065	0.088
R^2	0.359	0.380	0.336	0.115
F(6,T) =	3.274 [0.012]*	3.37 [0.011]*	2.445 [0.049]*	0.7359 [0.624]
DW	2.22	2.14	2.10	2.00

Sources: See footnote 7 for a sources. Variables are percentage deviations from 11-year moving averages. Estimations performed using *PcGive 2.20*. * denotes the 0.05 significance level and ** the 0.01 significant level.

Table 5 shows the regressions for mortality. Here the results are again somewhat weak. In this case the autoregressive component plays some role in every period, but real wages have some unstable influence on mortality. In the first period the second and third lags are significant, but have opposite signs and they almost cancel out. It could well be that the instability in these result come from the different periods of famines and war France experienced in the eighteenth and nineteenth century, but in the two later periods, the only coefficients that are significant to some degree (the third in the third period and the current value in the fourth equation) show a negative sign, confirming the idea of a negative relationship between income and mortality.

CONCLUSIONS

This exploration of the French case reveals nice dynamic story within the Malthusian framework. In particular, it raised the possibility of an alternative type of 'preventive' shock. Similarly to what Lee and Wang [2000] suggested for Imperial China, the preventive mechanisms went beyond marriage and implied, in one way or another, an *active* attitude towards family size. Active in the sense that couples have a saying and act according to an idea of family planning. Fertility transition in France was not a response to Malthusian population pressure in the traditional sense. Instead, while remaining relatively backward with respect to other regions in Europe in economic terms, it experienced a proto-modern transformation. The fact that this behavioural change occurred in a eminently rural environment –where diminishing returns to agriculture still play a large role- allow us to still talk about a Malthusian dynamic, but France was in part moving away from the traditional world.

Now, what could have induced this departure from the traditional dynamics? The analysis performed up to this point does not suggest any particular answer on that respect. Although quite useful to understand many features about the dynamics governing the interaction of demographic variables and income, aggregated time series data hide the local diversities. I expect that a study based on disaggregated data could help to understand the source of change, and I try to do that elsewhere (Murphy [2005]).

I believe one of the key elements to understand the story I built in this essay is the idea that two distinct logics governed fertility dynamics in France at different moments in time. And I think that is important because it establishes the extent to which economics can provide an answer to why the fertility decline began (supposedly) in the wrong place. Malthusian mod-

els have been quite successful in explaining pre-industrial population dynamics, whereas modern fertility choice models have provided useful insights in understanding the factors that drive the modern demand for children. What it is sometimes overlooked is the fact that choice, an essential assumption in the microeconomic approach to family, is normally absent in the Malthusian world. If both models are to be considered valid to explain a single society in two different moments of time, a successful story of the transition must be able to build a link between them. In particular, it must be able to introduce choice at some point in the story. In this paper I attempted to do precisely that. I suggested that early modern France was dominated by a Malthusian dynamic and that that dynamic gave way –gradually- to a new one where choice on the size of family predominated.

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