The Western European Marriage Pattern and Economic Development

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Abstract

For several centuries before the First World War women's age at first marriage in the west of Europe was higher than in the east (and in the rest of the world). In their low mortality regimes Western Europeans chose lower fertility in part through a higher female age at marriage. This allowed women to increase their human capital both formally and informally in the years before child bearing so that more informed mothers brought up better educated offspring. The demographic pattern influenced the stock of human capital and directly contributed to Western Europe's development advantage. The predicted relations of this economic model of the household are tested with two datasets, one at the county level for England for the second half of the nineteenth century and the other at the national level for Europe 1870-1910.

Key Words- Human Capital- Household Production- Economic Development- 19th Century Europe

JEL Classification - N13, N33, O15, J12, J24

The Western European Marriage Pattern and Economic Development

A distinctive feature of the Western European family in the three or four centuries before the First World War was the late age at first marriage of women (Hajnal 1965). Even more apparent by the nineteenth century was Western Europe's economic pre-eminence (Landes 1998, Broadberry and Gupta 2006). The present paper explores the relationship between these two European characteristics.

Physical capital in the pre-industrial world consisted largely of buildings. Not until the railway age of 1840s did physical capital impact substantially upon an economy (Feinstein and Pollard 1988). Instead early sustained economic growth is usually attributed to technological ingenuity (Von Tunzelman 2000 130). Ingenuity suggests human capital was a source of innovation, and, in the absence of widespread schooling, there was also a key role for the family in informal as well as formal education.

The family, or more precisely family formation, also contributed to pre-industrial economic-demographic equilibrium. Balancing the size of the population against the productive potential of the economy was a vital means of maintaining living standards in pre-industrial economies (Wrigley and Schofield 1989 ch 11). T.R.Malthus (1830) observed that the 'prudential restraint on marriage' achieved such an equilibrium with a fixed agricultural area in the 'Old World', and was unnecessary amid the abundant land of the 'New World'. The customary justification for 'restraint', later average female age at marriage and a higher proportion remaining unmarried, in western Europe was the need to accumulate or acquire sufficient resources to create a separate household for a married couple.

In their recent 'survey and speculation' De Moor and van Zanden (2010) identify the defining traits of Hajnal's 'European Marriage Pattern' as a greater than usual power balance between marriage partners, weak parental authority, and separate households. These characteristics led to emphasis on consensus and narrow spousal age gaps– what Stone (1977) called the 'companionate marriage'- driving up the average age at marriage and creating high female celibacy. Individual search for a partner required attaining an age of 18-20 at least, whereas arranged marriages could be set up for younger persons. De Moor and Zanden note that north west European parents invested heavily in their children and achieved high literacy rates. Like Voigtlander and Voth (2009) they stress the critical role of the Black Death, not conceding Hallam's (1985) contention, based on the Lincolnshire fenland, that marriage ages were high already before 1348-9. But they differ in their emphasis on the plague's boost to surviving women's labour market position. The European Marriage Pattern, De Moor and Zanden observe, was initially limited to the north west. In southern Europe, exemplified by Italy, it did not emerge so strongly; women in Florence still married in their late teens during the 15th century.

The end of the European marriage pattern diverged as much between countries as the onset. The Revolution of 1789 set France on a different demographic course from the rest of Europe (McPhee 2006, Spagnoli 1997). But the fundamental behaviour underpinning the demographics was still plainly operating in most countries around 1900, as the East-West European comparison shows. Birth rates in the late-marrying East European Czech and Baltic provinces were just as low as those in the late-marrying West European countries – it was the early marrying Balkans that differed (Sklar 1974). Hajnal (1965) observes that the First World War reinforced a shortage of marriageable men already established by emigration, thereby temporarily increasing female celibacy and age at marriage. Unsurprisingly the turbulent half century after 1914 that saw such enormous social, economic and ideological changes in Europe, also eventually eliminated the 'European Marriage Pattern'.

Why the marriage custom emerged and what consequences flowed from it is illuminated by an economic theory of the family or household, particularly as concerns the production of human capital. Human capital is often judged critical to economic growth and development (Mankiw, Romer and Weil 1992, Rebelo 1991, Sianesi and Van Reenen 2003). In a historical context a recent hypothesis has been that economic growth was triggered when technical progress changed so as to boost the returns to education at the beginning of the industrial revolution (Galor and Weil 2000). In the 1840s private returns to investment in male literacy were higher than those on alternative investments in Britain (Mitch 1984), consistent with such a shift in technical progress, or with a persistent market failure. An alternative hypothesis is that technical progress widened the gap between child and parental wages, encouraging more investment in children's education and less child labour (Hazan and Berdugo 2002).

Both hypotheses appeal to an exogenous technical change in the nineteenth century triggering investment in human capital. However there is evidence that European sustained and relatively heavy investment in education began earlier than the nineteenth century and was not exclusively commercially motivated (Reis 2005). Since the 'great divergence' between Western Europe and the rest of the world (Broadberry and Gupta 2006) also began earlier, the contribution of the household warrants consideration.

One human capital hypothesis from household production theory is that economic development historically was triggered by increases in the relative 'price of children'. This encouraged substitution by the family towards 'child quality', greater investment in human capital (Becker 1993)[1]. In the pre-industrial context, such a shift in household demand would also require a re-allocation of household time so as to increase household production of education and training broadly defined. More human capital accumulation then boosted economic growth.

This paper contends instead that the evidence for later nineteenth century Europe at least- and probably for Western Europe from the fifteenth and sixteenth centuries - is that lower mortality required lower birth rates. These were achieved in part by later marriage. Later marriage raised the level of female education in a general sense, by providing time not entirely committed to child rearing. The lower time cost and general price of investing in 'child quality' of better informed mothers, stimulated sustained investment in human capital, which in turn eventually raised outputs and incomes.

Section 1 summarises the elements of the pertinent household production theory, pointing out the critical role of mortality to the 'price of children' and to the 'price of child quality'. Section 2 discusses measurement and data issues. Sections 3, 4 and 5 consider in turn empirical estimates of the three fundamental equations of the proposed explanation – birth rate, age at marriage and 'child quality'. Section 3 demonstrates that later nineteenth century European and English county-level fertility depended closely on death rates. Section 4 shows that at the beginning of the twentieth century age at marriage and proportion of women married in their twenties across European economies and English counties were highly correlated with fertility. Section 5 shows that lower human capital was strongly associated with earlier higher percentages of women married or female age at marriage, even when schooling is

[1] 'Even a modest tax on births can have a large negative effect on the number of children and a large positive effect on the amount spent on each child .' (Becker 1993 p22). Becker Tamura and Murphy (1990) present another model that explains an inverse relationship between family size and human capital arising from increasing returns to human capital. The static formulation of the present paper does not require this increasing returns assumption.

controlled. Section 6 estimates an aggregate production function from a European cross-country panel and shows that human capital, as measured by literacy, was a substantial contributor to incomes in the later nineteenth and early twentieth centuries.

1. Economic-demographic Equilibrium and Investment in Human Capital

The western European marriage pattern (WEMP), which emerged by the 16th century and persisted until at least the First World War, exhibited three principal features; an unusually late age of first marriage for females (around 25), a low rate of illegitimate births (two percent or less) and a high proportion of females never marrying (more than 10 percent) (Hajnal 1965). Marriage typically was associated with establishing a separate household- the formation of a new nuclear family.

A Malthusian view of the economic function of the age at marriage is represented in figure 1. There is an equilibrium population N* when total births are balanced by total deaths at (average) age of marriage A*. A good harvest or technical progress increases the demand for labour, bidding up wages. Births increase (to B_1) with the rise in wages, because higher wages allow earlier marriage (from A* to A_1) as well as encouraging more births from established couples. Along with lower death rates (M_1), higher wages therefore disrupt the economic-demographic balance and population begins growing (from N*). In due course the greater population becomes a larger work force that drives down the wage to the initial equilibrium, and the age at marriage rises accordingly. Contrary to this model, recent evidence on the long term working of the pre-industrial English economic demographic system (from the sixteenth to the long nineteenth centuries) indicates that the 'positive check' of mortality was minimal and the self-stabilising properties of the system were extremely weak (Lee and Anderson 2002; Nicolini 2007; Crafts and Mills 2009).

FIGURE 1 ABOUT HERE

A more plausible view of fertility than embedded in the Malthusian model is that the timing of family formation, the age at first marriage of females, was related to the lifetime goals and constraints of the marriage partners. For present purposes the historical function of the family was to choose- subject to constraints-

- numbers of children (n), (partly by age at marriage – alternatives included infanticide and abortion),

- investment in them (education and health, drilling and skill acquisition) (q), even when the state begins substitute provision,
- goods and services, such as food and clothes (by domestic production and by earning to purchase in markets) (z)

The economics of the family or household postulates that individuals or couples trade off these three objectives against each other according to their perceived time and money costs and returns. Whereas the Malthusian model is usually presented in aggregated or macro form, household economics focuses on the representative decision takers for analysis, before aggregating, and also allows the possibility that higher wages do not increase fertility.

In Becker's (1981,1986) neoclassical model of the utility maximising family the net unit cost or 'full price' of child rearing (π_n) includes the value of goods consumed, time absorbed and earnings generated. The time budget is total time available (t) to the family or the family decision-makers. This time is distributed between producing children ($n.t_n$), improving their 'quality' ($n.q.t_q$), working for wages (t_w) and consuming and producing other goods and services ($z.t_z$). Subscripts here indicate unit time allocations; t_n is time absorbed per child in rearing, and t_q is time spent per child in achieving a given 'quality'.

$$t = n.t_n + z.t_z + t_w + n.q.t_q$$

The general family budget constraint (s) includes the price of goods consumed net of earnings by a child (p_n), the price of each child's 'quality' investment outlays (p_q) (school and doctors' fees for instance) and the price of other goods (p_z). It also includes the time absorbed in each of these activities valued at the opportunity cost, the wage rates (w) of those involved. On the other side of the constraint, in addition to total possible wage earnings w.t, there is non-wage income v, such as from Poor Relief or property.

$$s = (p_n+w.t_n).n + (p_z + w.t_z)Z + (p_q+w.t_q)q.n. = w.t + v$$

Primarily concerned with the later twentieth century western family, Becker's model did not recognise that child 'price' and child 'quality' (or household investment in human capital) would be affected by the chances that a child might die before adulthood, but this was an important consideration in the three centuries or so before the First World War[2]. Adam Smith (1961 76) assumed that four births were necessary for a completed family size of two children in the later eighteenth century, or that m = 0.5, where m is the chance of a child dying before adulthood. Smith's judgement is consistent with reconstitutions on survival to age 15 in pre-1750 France and Switzerland (Flinn 1981 Table 6.10). The greater the likelihood of child deaths, the more time and money must be spent to achieve a target family size and child quality. Total family births then for target n are $b = n/(1- m) \equiv nd$.

Births were limited by later age at marriage; b=b(a); the 'prudential restraint' mechanism. Given target births, in the absence of other controls age at marriage was determined, a=a(b). Consequently, a target family size, coupled with the perceived chances of children dying before becoming adults, established the age at marriage[3].

Malthus' model of figure 1 therefore must be modified to take into account the dependence of births on deaths in the longer term and target family size[4]. In addition, in figure 2 the Malthusian 'positive check', whereby death rates depended on wage rates, is eliminated. Aggregating the neoclassical model across households, a fall in the likelihood of child deaths, or an improvement in mortality (or, comparing one region with low mortality to a region with a high death rate), for a given target family size, would lead to lower birth rates. The age at marriage would eventually be higher to bring this about.

In figure 2, exogenous mortality decline leaves equilibrium population unchanged at N* and equilibrium wage is also unaffected. Birth rates depend upon mortality as well, because families are interested in surviving children, and age at marriage depends upon birth rates. So in the long run a fall in mortality is exactly matched in this special case (discussed further below) by a leftward shift in the wage-fertility relation and by a higher average marriage age (from A_1 to A_2). However if customary behaviour about marriage does not change quickly, there will be a population expansion during the adjustment period, which may be very long. This is

[2] Mortality itself could depend on w and/or p_z.as in the 'positive check' of the Malthusian model. At low standards of living harvest failures reduces the real wage so that the mortality rises of the more vulnerable members of society. Indeed the association of grain prices and mortality has been used to infer living standards where they cannot be directly measured (Bengtsson and Dribe 2005). Child mortality might also depend on birth rate, with a lower death rate when birth spacing was wider. Child mortality to, say, age 15, at issue here, is greater than mortality for parents, the concern of Stark and Wang (2005), but they are strongly correlated over time and across countries.

3 A temporary rise in 'd' may allow a subsequent temporary fall in 'a' also by opening up a niche in a static agricultural economy for another household.

[4] Also the gradient of the births-wage function could change; births may decline, rather than increase, as wages rise because of the higher opportunity cost of children.

an example of the 'demographic transition', about which there is an enormous literature[5].

FIGURE 2 ABOUT HERE

Also unlike the Malthusian formulation, the household model allows for investment in children. Child 'quality' (investment in children's education and health, q) may be interpreted in different ways. It might enter the parental preference function as the present value of a child's life-time expected earnings, themselves depending on the investment in the child's education and health. Or the product of numbers of children and their utility or consumption may be discounted by the (unobservable) rate of parental altruism, determined by the number of children (Becker, Murphy and Tamura 1990). The present model adopts the simplest specification of treating all children in a family equally[6].

Historically the European family then is assumed to have maximised preferences (u) for children, their 'quality' and other goods, subject to fertility (b) and general budget constraints (s). They recognised in their constraints that they wanted to achieve a number of surviving children. This number was related to (costly) births as n=b/d.

Max u = u(n,q,z) s.t. b=n.d=b(a) and S, where S is derived as follows;

$p_n.\ n\ .d\ +p_z.\ z\ +p_q.q\ .n.d = w.t_w + v$ …..cash budget …(1)

$n.d.t_n + z.t_z + t_w + n.d.q.t_q = t$ …time budget[7]….(2)

The companionate nature of the European Marriage system implies that the decision would be made jointly by the prospective partners before marriage, and their choices would determine female marriage age. Consequently in practice there may have been two wage rates – for male and female- in the general budget constraint (3).

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[5] For a sample, see the original statement by Thompson (1929), an analysis of British experience informed by the idea (Teitelbaum 1984) and a 250 year study of 67 countries (Chesnais 1992). Teitelbaum undertakes regression analysis of nineteenth century English county data in order to find the determinants of the year in which 'fertility transitions' took place. Some historical demographers expressed scepticism about use of the concept in the series of studies (of which Teitelbaum's is one) planned by the Office of Population Research at Princeton (for example Laslett 1985). Brown and Guinnane (2002) demonstrate how some misconceptions of the project could have become established.

[6] In some societies there may well be gender differences in investment because money spent on male education (p_q) could boost lifetime income, whereas the payoff to such spending may be less obvious for females.

[7] Constant returns to household production are assumed implicitly. In principle, if there were economies of scale in family size then $t_n=t(n)$, $t'>0, t''<0$, and conversely for diseconomies of scale. Wages are measured in time units, unlike q, z and n, and therefore total time spent in wage work can be included in the time budget. By contrast time allocated to the other components depend on the level of the activities.

$S = (p_n+w.t_n)(n.d) +(p_z +w.t_z)Z + (p_q+w.t_q)q.(n.d) = w.t + v$ ….general budget…(3)

Or where π_i are generalised or full prices, including the effects of child mortality risk,

$\pi_n .n + \pi_{z.} Z + \pi_q.q.n =S$

The constraint; when q=0, gives

$n = (S -\pi_z. Z)/ \pi_n$

and when $n\rightarrow 0$, $q \rightarrow \infty$.

Child Quality-Quantity Substitution

Figure 3 shows the limiting 'no substitution' case. Lower risk of death increases child quality as well as child target numbers, by cutting the general 'price' of children (π_n) and boosting real income (raising household utility from U_1 to U_2). The curvature of the constraint, combined with sufficient substitutability in the preference function, explains some properties of this model. In response to a 'child price' fall, 'quality' possibly may fall while child numbers increase and age at marriage declines. More children, other things being equal, could mean fewer resources for investment in each.

FIGURE 3 ABOUT HERE

With a unit elasticity of substitution between child 'quality' and 'numbers', child mortality risk exercises no influence on investment in human capital; the impact of raising the full price of 'child quality' is exactly offset by the higher full price of numbers of children (see Appendix)[8]. Rentier or Poor Law incomes (v) also do not affect investment (the rich are not better educated). However these particular results depend critically on an assumed unit elasticity of substitution. With a smaller elasticity the income effect of lower child mortality risk (particularly at high levels) dominates substitution away from quality, so that quality goes up as well as target family size.

Mortality, Fertility and Family Size

A fall in risk of death cuts the family cost of a surviving child and therefore boosts target family size (n). But the lower likelihood of death itself may require fewer births

[8] This suggests that Chakraborty (2004) conclusions, considering only the quality impact of mortality, might be altered with endogenous fertility.

in total, despite an increased n (the elasticity of births to mortality risk is positive, $e_{bm} > 0$). Families may reduce 'hoarding' of children in the face of greater certainty of their survival[9]. Where $e_{nm} < 0$ is the elasticity of target family size with respect to the mortality risk [10],

$e_{bm} = e_{nm} + m/(1-m)$ …(4)

An aggregate version of equation (4) illuminates the demographic difference between western and eastern Europe. Western Europe before 1914 consisted of 'low pressure' societies, with relatively low birth rates and low death rates. 'High pressure' societies by contrast were to be found in Eastern Europe in the same period, with high birth rates and high death rates[11]. Assuming broadly similar e_{nm}, equation (4) indicates that the mortality risk (m) determined by how much higher in the East were births (b). Since e_{nm} must be negative, the observed difference between high and low pressure societies requires that $m/(1-m) > |e_{nm}|$. For example if $e_{nm} = -0.2$ and $m=0.4$, $e_{bm} = 0.47$; that is a greater mortality risk is matched by a higher births of almost half as much. One way to generate the special case of Figure 2 has $e_{nm} = m/(1-m)$; for instance $m=0.2$ and $e_{nm} = -0.25$. (Another is the unit elasticity of substitution case of the Appendix).

Age at marriage is therefore likely to be lower in the 'high pressure' society to provide these births. When there are more births and each imposes costs on the household, the resources available for spending on child quality must fall. Here then is a plausible *prima facie* link between high European age at marriage and Western European economic development; lower mortality requires fewer births, higher age at marriage and permits greater child quality, which in due course raises productivity and innovation.

Another link is established when household investment in human capital is reinforced by the experience and education of the mother (De Tray 1973). This might be expected to determine her children's education and health in a society where the

[9] Other more complex models can explain observed fertility-mortality relations- for example Sah (1991) and Cigno (1996). The present formulation has the merit of simplicity.

[10] Since $b=n/(1-m)$,
$\partial b/\partial m = (\partial n/\partial m)(1-m)^{-1} + n.(1-m)^{-2}$.
Multiplying through by m/b and substituting for b yields (4) .

[11] The difference between these types is explained by an elasticity of substitution well below unity. This conclusion is reinforced when total mortality risk assumed to vary with child mortality risk, for the decline in household time is an income effect that supports the price effects on child numbers and quality. On high pressure and low pressure regimes see Wrigley and Schofield (1989 eg p473).

family is the provider of these services (cf. Marshall 1961 469)[12]. The understanding brought to these tasks by a women of 25 or 30 on average must be greater than by one of 15. Later age at marriage, after first leaving the parental home to work as a servant in early modern Europe, offered greater general experience that counted as a form of education (Cleland and Wilson 1987 p15). In 1851 one quarter of British women, mainly young and unmarried, held jobs outside their homes, principally in domestic service, garment making or the textile industry, an occupational distribution similar to the rest of western Europe (Tilly and Scott 1975). Assuming such work widened their horizons, the more educated mother would have a lower time costs (t_q) of investment in her child's human capital; $t_q = t(a)$[13].

Lower time costs of achieving a given child quality reduce the full price of quality (π_q). From the general budget constraint,

$$\partial n/\partial q = -\pi_q.n/(\pi_n + \pi_q.q)$$

So a lower full price of quality reduces the gradient of the constraint. A given reduction in target family size secures a greater increase in quality, while the intercept is unchanged (figure 4). At the same time greater female education also permits a higher market wage, and other opportunities. These will raise child full costs π_n over a lifetime, shifting the intercept downwards in figure 4, and reducing the target number of children.

FIGURE 4 ABOUT HERE

The Aggregate Model

Aggregating over couples, the basic family economics model linking the Western European marriage pattern and economic development consists of three endogenous variables (denoted by upper case versions of the representative couple's choice variables) and three equations. The individual choices of number of births are established by variables such as the components of 'full prices' and give rise to an aggregate fertility equation. When births are normalised by population, this becomes a

[12] Children admitted to the Orphan House in Charleston, South Carolina, from the 1790s to 1840 were more likely to be literate if their mothers were literate (Murray 2004). David Mitch (1992 chapter 4) finds parental literacy a major cause of adult literacy in Victorian Britain.

[13] There is much present day evidence for the relationship between later marriage age and greater education.. Behrman et al (1999) substantiate the higher productivity of more educated women and Gaiha and Kulkarni (2005) find an impact of mothers' age at marriage and education on a measure of child quality in India. Nordblom (2004) assumes 'child quality' is a function of 'within the family education' and parental education, as well as state schooling.

crude birth rate equation[14]. Marriage opportunities depend upon the gender balance of the population, which could be distorted by migration or war for instance raising the ratio of females to males. Higher ratios reduce female marriage chances and therefore births. So a variable G reflecting this balance also influences aggregate births. Where B is now the crude birth rate;

$B = B(M, V, p_n, p_q, p_z, w, t_n, t_q, G)$ …(5)

The second equation links average age at marriage and birth rate,

$A = A(B, G),$ …(6)

Births cause age at marriage in the sense that couples wanting 'low' births must choose 'high' female ages at first marriage in the Western Europe. Those factors that explain births and target family size also determine age at marriage.[15] In addition, as with getting married at all age at marriage will have depended upon opportunity, measured by G.

The third relationship is the average child quality or human capital equation

$Q = Q(M, V, p_n, p_q, p_z, w, t_n, t_q)$ ….(7)

The 'mother's experience' equation joins average age at marriage with human capital investment;

$t_q = f(A)$ … (7a)

By substitution of (7a), (7) becomes a quasi-reduced form and includes age at marriage as an explanatory variable.

To link the marriage pattern to European economic development the final relationship necessary is one that joins human capital - or 'child quality' when the child enters the labour force - to the output or growth of the economy as a whole. A modern commonplace is that human capital drives economic growth (for example Mankiw Romer and Weil (MRW) 1992 and Galor and Moav 2006). O'Rourke. and Williamson (1997) calculated the impact of literacy and school enrolment on European real wage convergence or divergence on Britain and the US in this period for individual

[14] Normalising instead by married women of child bearing age would yield a marital fertility equation since by assumption marriage is necessary for births. But since the concern is with economic-demographic interaction, the effects of births on population growth, the crude birth rate is judged more appropriate

[15] The concern here is with long term relationships. Cycles in economic activity also generate temporary changes in nuptiality, affecting the age at marriage. These short run changes, reflecting shifts in timing rather than in fundamentals, were sufficiently marked that marriage rates have been employed as an index of industrial fluctuations (e.g. Lewis 1978 p.255).

countries. But eastern Europe was not considered and so quantification of the present model requires estimating another equation.

One of the simplest ways for the family model to impact on the economy is through an aggregate production function with human capital as an argument. Mankiw, Romer and Weil (1992) for the modern period showed that their reduced form model estimate implied a three factor (capital, labour and human capital) structural Cobb-Douglas function with coefficients of one third on each input. Such a production function is the basis of the approach adopted in the empirical exercise below, though the precise specification is adjusted to take into account differences in technological epochs.

The full model developed here provides an explanation for the coincidence of the marriage pattern and European economic development, with a lower 'm', mortality risk, in western Europe reducing 'b', births, and directly raising 'q', child quality for the representative couple. The lower crude birth rate, B, requires a higher average age at marriage, A. Greater child quality, more investment in human capital, raises output.

A second connection is created when the longer term consequence of a higher marriage age is a fall in t_q., an improvement in the efficiency of household investment in child quality. This increases investment in children. When they grow up and begin work, their productivity and the output of the economy is higher than if mortality had never fallen and the position of women never changed with the higher marriage age. The next step is to establish whether the evidence supports this account.

2. Measurement and Data

Mortality risk for children up to, say, age 15 at the aggregate level might be approximately measured by death rates, but series on death rates sufficiently long to cover the onset of the European marriage pattern, though desirable, are unattainable. The available evidence nonetheless does suggest that life was short in the late medieval period, which culminated in famine and a series of devastating fourteenth century plagues. Two studies of late medieval monasteries provide indications of sustained high mortality rates in England ((Hatcher 1986; Bailey 1996). In the Durham area, tenant numbers imply that population fell to 45 percent of pre-Black Deaths by the end of fourteenth century, and tithe evidence indicates a similar collapse of output (Dodds 2004).

Because of the favourable population-resource balance, survivors in the fifteenth century experienced high wages and living standards. In many countries the immediate post-Black Death level of real wages was not attained for another three or four centuries (Allen 2001, Van Zanden 1999). Pamuk (2007) notes that, among other changes induced by the Black Death, appear to have been a higher female age at first marriage and reduced fertility. Subsequent lower real wages stemmed from population and labour force growth exceeding expansion in the demand for labour. So this demographic response was insufficient to stabilise populations at early fifteenth century levels, if mortality did not return to the high late medieval levels.

The likelihood then is that population growth was triggered by mortality decline in Western Europe over the 15th and 16th centuries compared with earlier years, probably largely brought about by quarantine regulations (Slack 1981). Venice's quarantine measures reduced plague frequency by the 16th century and eliminated plague after 1630 completely (De Seguy Dupeyron 1834 12). Since the marriage pattern becomes apparent by the sixteenth century, the readily available statistics confirm that mortality first fell and then the late age at marriage emerged when population recovery was threatening high living standards - consistent with the proposed model.

Also consistent is the observation that the 'European Marriage Pattern' was first centered in the Netherlands and Britain (De Moor and Zanden 2010). By the seventeenth century, economic vitality in Europe was focussed in the extreme North Western corner of the continent, before the Atlantic trade could have made a substantial contribution (Israel 1989 p5). Technical superiority of Dutch craftsmen, and of Dutch shipbuilding techniques and ship owning, can plausibly be related to Dutch human capital. Wages, also reflecting skill and productivity, were moderately dynamic in Antwerp, Amsterdam and London from the sixteenth century. But in most other major cities of Europe real wages collapsed between 1500 and 1750 (Allen 2001).

Many elements combine to explain the fortunes of individual economies. It is most unlikely that a single source of human capital accumulation was sufficient to explain the pattern of European economic development over three or more centuries. In any case the data over this period is not available to evaluate any link across the whole of Europe. Instead the proposition to be tested and quantified here is that, when a wide range of data becomes available in the nineteenth century, a causal connection existed between the European marriage age and the level of European incomes.

The model is tested on two data sets (Appendix B). One is county level data for nineteenth century England. The other is an unbalanced panel of European countries, including Russia, at decadal intervals for 1870-1910. It is important to include (data-scarce) eastern Europe in the data set both for comparison with Western Europe and to avoid sample selection bias. A cost is that some measures are only available or can be constructed for selected years[16].

Demographic and economic variation across Europe was much greater than within England, providing some offset to the different levels of aggregation. Brown and Guinnane (2007) have pointed out that the larger and more aggregated the unit of observation (countries compared with counties, for instance), the more difficult will it be to find statistically significant relations between units, even when there are such relations for individuals in those observation units – assuming the same range of variation. This also means that in what follows the tests of rejecting the null hypothesis of no association are much more stringent than they would be if individual level, or more finely disaggregated, observations were available.

3. Fertility and Death Rates.

Across Europe and within England in the later nineteenth century, lower death rates were associated with lower fertility, when controlling for other influences and allowing for possible feedbacks. This is consistent with Western European low birth rates being triggered by the ending of an earlier high mortality regime.

Estimation of birth rate equation (5) establishes that the neoclassical household model can account for the fertility impact of declining mortality risk. The theoretically appropriate death rate would measure the risk perhaps over the years 0-15, but for the following exercises only approximations to this ideal variable are available. In the regression models of Table 1, for English counties in 1861, the approximation is infant mortality (ranging from 121 to 174 per 1000 live births). Assuming that wages (w) reflect human capital, male and female illiteracy are

[16] The use of decadal intervals over forty years largely averages out the possibility that economies in the sample may have been at different stages in their business cycle in the observation years. The data set is restricted to Europe because New World countries were not subject to the same land scarcity as Europe- or in some respects the same traditions- and Asian series on comparable bases are usually unavailable (and marriage concepts may differ.)

employed as a proxy for male and female wages, or wage opportunities. The gender balance (G), determining the likelihood of a female finding a marriage partner and therefore being able to choose the number and quality of children, is measured by the ratio of females to males. Wealth (V) is measured by savings deposits. Other variables that may capture elements of 'child full price' are availability of manufacturing employment and proportion of girls in the county not attending school ten years earlier. It turns out that none of these last three variables were statistically significant and so they are not reported in Table 1.

TABLE 1 ABOUT HERE

In all specifications of table 1 mortality (M) is a positive and significant determinant of fertility. The OLS coefficient of equation 1, Table 1 implies that a fall of 50 reduced the birth rate per 1000 persons by just over two, and by just under two with the mortality coefficient of equation (2). A DHW test indicates the null of exogeneity cannot be rejected at the 5 percent level in both cases. Gender differences in wages (proxied by literacy at marriage) are very significant. Male earning power and a positive male wage elasticity of births are reflected in the negative coefficient on male illiteracy (to this extent consistent with the Malthusian doctrine). The bigger effect though is from female earning power or human capital that especially measures the time cost of children ($w.t_n$); the 36 percent variation in female illiteracy (from 18 to 54 percent) accounts for 7 births per 1000 according to (1) and 6.6 births according to (2). The negative coefficient on the gender balance indicates that counties with greater ratios of women to men achieved lower crude birth rates, because of their lower marriage chances. In short, infant mortality significantly determined birth rates and the opportunity cost of female time was critical to fertility, a notion missing from Malthus' theory.

Across Europe the range of fertility and mortality variation was considerably greater than within England; Russian crude death rates were double those of Denmark and Norway, though all fell over the period analysed. The 1870-1910 panel therefore provides more information than a single cross-section[17]. As with the county data, death rate is a significant determinant of births (Table 2). Larger coefficients ('death')

[17] General mortality is used as a proxy for mortality in the 0-15 age group. The crude death rate is used in the European data

are estimated in equations (5 and 6) assuming death rate is endogenous but Hausman testing these against their OLS equivalents suggests the null of exogeneity may not be rejected. The death rate coefficient of 0.48 (equation 2 Table 2) indicates that a one standard deviation cut in the death rate (5.4) reduces the birth rate by 2.6, or about 8 percent. At the sample mean, the implied elasticity is 0.33. The average crude death rate for the sample is 23, for which the Coale/Demeny model South yields 67 percent surviving to age 15 [18]. For a completed family size of two, three births were necessary on average. Recall equation (4) that e_{bm}= (m/(1-m))+ e_{nm}. Then at the mean of the sample e_{nm} = 0.33- (0.33/0.67) = -0.16. Target family size rises by one sixth of a fall in the mortality rate.

The negative GNP per capita elasticity ('gnppc') of births combines the effects of both unearned income (V) and earnings of males and females (w) from (5). Since the V elasticity must be positive, the implied wage elasticity must be strongly negative to outweigh the unearned income (V) effect, contrary to Malthus's assumption of a positive wage elasticity. On average then, across Europe in the years 1870-1910 the time cost of children generated a substitution effect greater than the pure income effect, consistent with the female illiteracy finding for the English county regressions. According to the GNP coefficient ('gnppc') of equation (2) Table 2, one standard deviation of GNP per head (573) lowers birth rate by (573*.0042=) 2.4.

TABLE 2 ABOUT HERE

The standard deviation of the female proportion of the population was three times greater between countries than within them. Consequently it is difficult to separate the impact of this variable from fixed country-specific effects. Certainly the random effects estimates (Table 2, equations 4 and 6) are higher and more significant than fixed effects, though both panel types have the theoretically predicted sign. As a proxy for the time costs of children, greater illiteracy is associated with higher fertility, controlling for GNP per head (equation 1 Table 2). Lower mortality risk then reduced fertility as predicted by the first stage of the model, and in line with the English county data.

4. *European Age at Marriage and Fertility*

The model's postulated relationship, between average age at marriage and birth rates, A=A(B) (equation 6), still apparently held around 1900 despite alternative

[18] And infant mortality of 0.17 with a population increase of 1.04%. Model North yields 1- m=0.69. http://www.census.gov/ipc/www/pas.html.

methods of fertility control (Crafts 1989) (Table 3 and figure 5). West of a line from Trieste to the Eastern Baltic the great majority of women aged 20-24 were single whereas to the east, most were married. Only 11 percent of Bulgarian women aged 20-29 were unmarried or widowed, compared with 45 percent in Britain half a century earlier (Hajnal 1965 136 119). The mean age at first marriage of Serbian women between 1896 and 1900 was 19.8 compared with 26.7 in Sweden (Webb 1911 395). In nineteenth century western Europe the percentage of those married among women aged 15 and over was below 55 and usually less than 50. For Serbia and Bulgaria, the 1900 censuses recorded 69 percent, and for Romania, 65. These nuptiality differences continued to be associated with marked fertility variations.

In figure 5 Eastern Europe's high birth rate is very apparent in the left cluster. The country above the line and to the left, Russia, probably owes its position to the quarter century lag in measuring proportion of women single. The true proportion in 1900 was very likely lower, closer to the Serbian percentage, which would improve the fit of the regression. France is an outlier below the regression line in figure 5, thanks to changes during the Revolution[19] (McPhee 2006; Spagnoli 1997). When France is excluded, extrapolation of the west European marriage age-fertility relationship predicts that of Eastern Europe[20].

FIGURE 5 ABOUT HERE

TABLE 3 ABOUT HERE

Within England a pattern similar to that across Europe, though less varied, can be found. In English counties age at first marriage of women born between 1826 and

[19] The Revolution brought new inheritance laws, the ending of clerical authority, removal of tithes, and fiscal equity. Despite the Restoration, the impact of many of these changes was permanent. Inheritance legislation encouraged the desire to keep small family properties intact and in turn prompted lower birth rates.

[20] The two regimes of figure 5 are on the one hand France, which had undergone a transition to low fertility and on the other all the other countries. Excluding France and Eastern Europe from the sample the proportion single regression line gives the following predictions for Eastern Europe;

	Birthrate predicted by regression excluding France and E Europe	Actual Birthrate
Bulgaria	41.3	42.3
Romania	40.9	38.8
Russia	43.2	49.3
Serbia	43.8	42.4

.

1841, and married between 1841 and 1861, ranged from 25.8 to 23.0 (Crafts 1978)[21]. As the model predicts, the (target) birth rate is highly correlated with age at marriage; two thirds or more of the variance of mean marriage age in 1861 is explained simply by the 1861 crude birth rate ('varying between 30.2 and 40.3 per 1000 population) and by the gender ratio. The more women there were to men in a county the greater the time a women was obliged to spend in search for a marriage partner. Age at marriage is established by difficulty of finding a suitable partner, child quality, target family size and the mortality rate that determines the number of births necessary to achieve this target; the birth rate covers family size, quality and mortality, as well as those variables that explain target family size, such as wages. Equations 1 and 2 Table 4 indicates that a fall in the crude birth rate by 10 per thousand would have brought about an increase in the age of marriage of 1.9 years.

Instrumental variable estimation allows for the possibility that birth rate responded to age at marriage as well as age at marriage being chosen with target births in mind, but does not greatly change the fertility coefficient. The DHW endogeneity test does not permit the rejection of the null of exogeneity.

TABLE 4 ABOUT HERE

5. Child Quality and Age at Marriage

The key relationship to be tested is that age at marriage is linked to the 'full price' of child quality. Evidence on this third fundamental equation (7), with (7a) substituted in, is provided by taking later literacy as a measure of child quality. A higher marriage age in this context means the possibility of more, and more effective, investment in child quality. Mortality also may affect the full price of quality. Finally households may, or may be obliged to, choose to buy schooling which will have an effect on child quality.

All poor, European periphery countries were highly illiterate in 1900, with rates around 70 percent (Flora 1972). In Western Europe the index was usually well under 20. Young Serbian or Bulgarian women could very rarely read and write in the 1890s. Only 65 and 123 respectively in every thousand who married could do so (Webb 1911 304), less than the proportion in East Anglia of the mid-seventeenth

[21] The estimates are derived from the proportions of women ever married in various age ranges. Crafts finds weak negative correlations between age at marriage on the one hand and urbanization and infant mortality on the other.

century (Cressy 1977). In England and Wales of the 1890s, 940 per 1000 were able to write, and even the figure for primarily agricultural Ireland was 824.

Within southern European countries there was a similar, if less extreme, pattern to that of Europe as a whole. In Spain, the highest ages at marriage for females in 1887 and male literacy rates in 1910 were found in Madrid and Asturias, only exceeded by Old Castile. Conversely, Andalusia and Levante (Valencia and Murcia) showed the lowest regional age at marriage and literacy (the correlation coefficient over 12 regions is +0.73) (Nunez 1990; Rowland 1988).

The range of variation in Italy was greater than in Spain. In 1861 the lowest age of female marriage was in Catania, Sicily, at 20.4 years and the highest was 26.3 in Teramo, Abruzzo (Rettarolli 1992). Sicily's illiteracy was among the highest Italian regional rates at 81.18 % in 1881 for those over 6 years of age, compared with 32.27% in Piedmont (Censimento 1883).

In addition to investing their time, households could spend money on 'child quality' and those that did not may have taken advantage of state provision of education in the later nineteenth century[22]. Also the efficiency of household production would affect willingness to allow children to attend formal education outside the home, as well as the permitted duration of schooling- which could be short. As late as 1906 children in some Italian communes ceased formal education at 9 years old, after only three years (Webb 1911 220).

TABLE 5 ABOUT HERE

The continuing importance of informal education for human capital investment is suggested by failure of schooling 20 years earlier to be a unique guide to literacy ranking around the beginning of the twentieth century in Europe (Table 5). France schooled more intensively than Britain but experienced higher illiteracy. Similarly for Austria-Hungary compared with Belgium. Finland is an extreme case,

[22] In north western Europe the widespread ability to read was clearly related to religion. From 1686 every adult citizen in Sweden was required to be able to read the central texts of the Lutheran Catechism. From 1726 by law households were regularly examined and the results noted in a register. The male head of household was responsible for performance (Petterson 1999). But beliefs can only be observed indirectly, by their effects. French Catholicism differed sufficiently from the Catholicism of southern or eastern Europe to render questionable placing them in the same religious category for purposes of explaining and predicting behaviour. Hungary did not show the European marriage pattern in the later eighteenth century but (in 1949) the majority of the population were Roman Catholic, as in many countries that did. As far as primary schooling, which might be linked to literacy, is concerned. Peter Lindert (2004 p103) concludes ''history is ambivalent about the role of religion in the overall supply of primary schooling``.

partly because the Flora illiteracy index of 1.1% refers to the ability to read only. Among those over 14 only 55.3% could both read and write in 1910 (Hjerpe, Miettinen and Vesalainen 1999). Even with this adjustment Finland appears more literate than Greece or Portugal, both of which enrolled much higher proportions of their populations in primary school.

60 percent of European inter-country variation in illiteracy in 1910 is explained by the proportion of women single aged 25-29, when the Finnish datum is adjusted. Adding in the proportion of the primary age school population attending school twenty years earlier raises the explained variance to 87 percent for the adjusted data, and both coefficients are statistically significant (equation (1) Table 6).

Although the dates of the presumed explanatory variables of Table 6 precede those of the dependent, illiteracy, variable, possibly persistence in the data might lead to a correlation even if true causation runs from illiteracy to proportion married or age at marriage. Instrumental variables estimation for the proportion married was therefore also tried (equation (2) Table 6). Controlling for possible two-way causation and for schooling, proportion of women aged 25-29 single (and therefore age at marriage) is a statistically significant influence upon cross-national variations in literacy. The coefficient of 'proportion of women single' in the IV equation (2) implies that a change of one standard deviation of this proportion (16) changes illiteracy by considerably more than does one standard deviation (5) of schooling. .

TABLE 6 ABOUT HERE

The 'within country' data set offers another opportunity to test and quantify the human capital equation (7). For the child quality investment, illiteracy in 1885 is estimated as a function of earlier school attendance, mortality and age at marriage (Table 7).

TABLE 7 ABOUT HERE

Table 7 shows that counties with a higher age at marriage in 1861 are less illiterate in 1885, controlling for school attendance 30 years earlier (a proxy for the price of 'quality' p_q). Marriage age here reflects the 'full price' of quality, female efficiency in home education, t_q=f(a). A one year higher age at marriage cuts illiteracy in 1885, with a mean of 11.8 percent, by a substantial 3.09 percent (equation iii). Infant mortality (as a contributor to the 'full price' of 'quality') has the expected sign but in the IV estimation (equation 3 Table 7) is not significant at the 10 percent level.

School attendance apparently mattered more for boys than for girls; the impact on illiteracy 34 years later of the percentage not attending school in 1851 is always higher for boys. Differential mean non-attendance at 55.9 percent for girls and 51.4 percent for boys does not seem sufficient to warrant an exclusive explanation in terms of diminishing returns to school attendance.

From both the English county and the European national data the evidence is that age at marriage as an influence on children's home background, as well as schooling, is necessary to explain literacy (the best approximation available for wider child quality and human capital in this period).

6. The Contribution of Human Capital

The final component of the present interpretation requires a link to European economic development. In the MRW (1992) neoclassical economic growth model the long run boost to output per worker from a higher proportion of income devoted to human capital formation is $\theta/(1-\eta-\theta)$, where θ is the elasticity of output with respect to human capital and η is the physical capital elasticity. For their period and sample MRW contend that this expression is close to unity because each of the input elasticities is about one third. The Western European marriage pattern (WEMP) meant that a larger proportion of time was devoted to human capital formation more effectively than elsewhere. In the MRW model this means that if a WEMP country devoted double the share of income to human capital formation compared with a non-WEMP economy, the first would have achieved double the long run output per worker.

Human capital accumulation was therefore likely to have mattered a great deal for economic growth but the procedure followed in the present paper to establish the link with later marriage requires that literacy be a good proxy or measure of human capital. As indicated in section 1, the simplest test is to estimate for the period a generalised Cobb-Douglas aggregate production function that includes this measure of human capital, duly adjusted to take into account the distinctive features of the period. If literacy is a significant determinant of output per head in the later nineteenth century then a significant long run impact on output of the WEMP through this channel seems likely.

Economic development typically was more sedate in the nineteenth century than after 1950. The dynamic sectors were manufacturing, mining and infrastructure, largely powered by coal-based steam technology. Traditional agriculture was often protected against foreign competition to slow migration into rapidly growing towns and industries. The pace at which resources switched out of agriculture was therefore both a measure of technical progress in those industries and in the economy as a whole. A directly estimated historical production function will shift at a rate dependent on urbanization (for instance Allen 2003), or on the closely related migration of labour out of agriculture (Williamson 1991).

Imposing a constant returns to scale restriction (as do MRW 1992), the aggregate production function of the present model is:

$Y/L = \varphi E^{-\lambda} (K/L)^{\eta} (H/L)^{\theta}$ …(8)

where Y is aggregate output, K is physical capital, L is labour, H is human capital, E is agricultural employment share and φ is a constant

Assuming the labour force is proportional to the population, N (because of data deficiencies), (8) may be divided through by population to create the equation below, estimated in Table 8.

$\text{Ln}(Y/N) = \varphi + \eta \ln(K/N) + \theta \ln(H/N) + \lambda \ln(\mu N/E)$

where μ is the labour force participation rate and μ N/E is the reciprocal of the labour force employed in agriculture.

To measure physical capital across European economies the empirical model focuses upon infrastructure because it was so capital-intensive. In particular railways transformed the capital requirements of European economies in the second half of the nineteenth century and therefore railway length is employed as the capital proxy. Human capital is measured by the literacy rate. In contrast to the commonly used schooling variable, literacy has the merit of being a direct measure of human capital rather than an input to human capital production (Hanushek and Kimko 2000). Nonetheless it must be only a partial measure, as is the case for the physical capital proxy. The likelihood is then that both estimated output elasticities will understate the true full factor coefficients.

In the production function of table 8, the human capital coefficient is large and significant ($\theta \approx 0.12$ in equation 1) compared with physical capital ($\eta \approx 0.09$ in 1). Both equations were (Hausman) tested against their fixed effect equivalent. Differences in the coefficients were not systematic and therefore the more efficient random effect models were preferred.

Instrumental variables are needed to test whether the coefficient on literacy or human capital reflected a demand for the factors of production rather than the effect on output some instrumental variables. The requirement that they were exogenous to the European economy, but influenced the factors of production, is highly problematical. By default the following three instruments were chosen; a policy variable that might affect capital accumulation, the level of average tariff, the death rate which could determine child quality and which other tests in this paper suggest was exogenous and a time trend, perhaps measuring a component of technical progress. The estimate of the human capital coefficient becomes much larger, and remains significant in the RE model, while the physical capital coefficient becomes statistically insignificant. This experiment at a minimum then suggests that the human capital coefficients of equations 1 and 2 Table 8 are not upward biased.

If the IV estimate of Table 8 is accepted then the static effect alone of human capital was very large. From the cross-European relation and the coefficient of equation (3) table 6, the divergence between Great Britain and Russia in women aged 25-9 unmarried of (42-9=) 33 percentage points created a difference of (1.35*33=) 44 percent points in illiteracy - about two thirds of the total gap in 1900. Immediately raising literacy by this much would have boosted Russian GNP per head by 45 percent (from equation (3) Table 8)[23]. But in any case the long run impact of the greater investment in human capital undertaken by WEMP regimes would be much larger than the static effect. Over the several hundred years that major literacy differences persisted between the two countries such a differential could be expected to exercise a large cumulative effect stemming from greater savings and investment in human capital.

TABLE 8 ABOUT HERE

Without placing too much weight on their precise values, the parameter estimates of Table 8 then imply that human capital as measured by literacy played a substantial role in European economic development 1870-1910, at a time when the gap between western and eastern Europe was widening. Coupled with other evidence presented, they also indicate that the unusual marriage pattern of western Europe contributed significantly to this growth.

[23] [Ln(75.2)-Ln(31.2]*0.51

7. Conclusion

In a longer term perspective, the likelihood is that declines in mortality in western Europe from the 15^{th} and 16^{th} centuries required measures to control births, if living standards were not to fall precipitously. The late female age at first marriage was one response, and the consequent smaller number of births created more opportunity for investment in child quality. To the extent that later marriage created greater scope for women beyond child bearing and rearing, this investment effect was reinforced. As women were the principal eventual socialisers of the next generation, their wider experience was likely to be transmitted in more efficient and greater learning, broadly interpreted. In some historical epochs literacy would be a proxy for such education.

Although a lower death risk reduced the 'full price' of a child, the increase in target completed family size was small compared with the reduction in births necessary to achieve it. This was ensured by the high levels of mortality in medieval Europe and in Eastern Europe through to the early twentieth century.

Three equations of human capital supply by the family provide the core of the explanatory model. The first is that deaths determine target births, but other variables also matter, such as earnings, efficiency and opportunity costs. Target births then determine age at marriage in the second equation. Human capital or child quality is explained in the third equation. The critical variable in this last relationship is age at marriage, here an index of family efficiency, independent of schooling. Finally human capital as measured by literacy is utilised in the production relationship, and impacts upon output.

Nineteenth century Europe showed striking demographic and economic associations. Lower female age at first marriage was linked with higher fertility and lower literacy. At the same time literacy was positively associated with productivity and output. These relations analysed in the present paper suggest that Eastern Europe was poorer than Western Europe because of lower human capital. In turn inferior human capital endowments were rooted in choices whereby women married younger and were uneducated in the widest sense.

Systematic evidence for relationships lasting four centuries is less easy to accumulate than for later nineteenth century European economic development. So it is reassuring to find that on the eastern side of the marriage age divide during the later nineteenth century, in Asia Minor, some had reached similar conclusions about the means and the consequences of long-run transmission and accumulation of human capital as proposed in this paper. A British traveller reported the following discussion;

‘Hundreds of years ago our women knew quite as much as Frank[24] women’ observed my host.

‘Yes’ replied his companion ’And then we could hold our own against the Franks. But the Frank women have been educated since those times….’ (Burnaby 1877).

[24] The term ‘Frank’ for many centuries referred to Western Europeans.

References

Allen R C (2001) The Great Divergence in European Wages and Prices from the Middle Ages to the First World War, *Explorations in Economic History* 38, 411–447

Allen R C (2003) Progress and Poverty in Early Modern Europe, *Economic History Review,* LVI, 3 pp. 403–443

Allen R C, Bengtsson T and Dribe M (2005) *Living Standards in the Past: New Perspectives on Well-Being in Asia and Europe,* Oxford University Press

Bailey M (1996) 'Demographic Decline in Late Medieval England: Some Thoughts on Recent Research' *Economic History Review* 49, iss. 1, pp. 1-19

Becker G S (1981) *A Treatise on the Family*, Cambridge MA Harvard University Press

Becker G S (1986) *An Economic Analysis of the Family, 17th Geary Lecture*, ISRI Dublin

Becker G S (1993) *Human Capital: A Theoretical and Empirical Analysis with Special Reference to Education* 3rd edition University of Chicago Press

Becker G S Murphy KM and Tamura R (1990) Human Capital, Fertility and Economic Growth, *Journal of Political Economy* 98 5 S12-S37

Behrman J R , Foster A D, Rosenzweig M R and Vashishtha P (1999) Women's Schooling, Home Teaching and Economic Growth' *Journal of Political Economy* 107 682-714

Bengtsson T and Dribe M (2005) 'New Evidence on Living Standard of Living in Sweden During the Eighteenth and Nineteenth Centuries: Long-Term Development of the Demographic Response to Short-Term Economic Response', in Allen R C, Bengtsson T and Dribe M eds *Living Standards in the Past: New Perspectives on Well-Being in Asia and Europe,* Oxford University Press

Broadberry S and Gupta B (2006) The Early Modern Great Divergence: Wages, Prices and Economic Development in Europe and Asia, 1500-1800, *Economic History Review*, 59 (2006): 2-31,

Brown, J. C. and Guinnane, T. W. (2002) 'Fertility transition in a rural, Catholic population: Bavaria, 1880-1910', *Population Studies*, 56: 1, 35 — 49

Brown, J. C. and Guinnane, T. W. (2007).'Regions and time in the European fertility transition: problems in the Princeton Project's statistical methodology', *Economic History Review,* . 60(3), 574-595

Burnaby F (1877 *On Horseback Through Asia Minor*

Censimento della Popolazione (1883) *Proporzione degli Analfabeti classificati per eta,* Bol 7, Roma

Chakraborty, S (2004) 'Endogenous Lifetime and Economic Growth' *Journal of* Economic *Theory,* May, v. 116, iss. 1, pp. 119-37

Chesnais, J-C (1992) *The Demographic Transition: Stages, Patterns and Economic Implications; A Longitudinal Study of Sixty-Seven Countries Covering the Period 1720-1984,* Oxford

Cleland, J. and Wilson, C. (1987). 'Demand Theories of Fertility Transition: An Iconoclastic View.' *Population Studies* 41:5-30. p15

Cigno A (1998) 'Fertility Decisions When Infant Survival is Endogenous' *Journal of Population Economics* 11 21-28

Crafts N F R (1978) 'Average Age at First Marriage for Women in Mid-Nineteenth Century England and Wales: A Cross-Section Study' *Population Studies* 32 1 21-25

Crafts N F R (1989) Duration of Marriage, Fertility and Women's Employment Opportunities in England and Wales in 1911 *Population Studies* 43 2 325-335
Crafts N F R and Mills T C (2009) From Malthus to Solow: How Did the Malthusian Economy Really Evolve? *Journal of Macroeconomics* 31 68–93
Cressy D (1977) 'Levels of Illiteracy in England 1530-1730' *Historical Journal* 20 1-23
De Segur Dupeyron M (1834) *Rapport Adresse a Son Exc le Ministre du Commerce*, Paris
DeTray D N (1973) Child Quality and the Demand for Children *Journal of Political Economy*, 81, 2,. S70-95
Dodds B (2004) Estimating arable output using Durham Priory tithe receipts, 1341-1450 *Economic History Review*, LVII, 2 (2004), pp. 245_285
Feinstein C H and Pollard S (1988) *Studies in Capital Formation in the United Kingdom, 1750-1920* Clarendon Press
Flinn M (1981) *The European Demographic System 1500-1820* Harvester
Flora P (1972) *Historical Processes of Social Mobilization, Urbanization and Literacy, 1850-1965*
Foreman-Peck J S and Lains P (2000) 'European Economic Development: The Core and the Southern Periphery, 1870-1910' in J G Williamson and S Pamuk eds *Long Run Economic Change in the Mediterranean Basin*, Routledge
Gaiha, R and Kulkarni, V (2005) 'Anthropometric Failure and Persistence of Poverty in Rural India' *International Review of Applied Economics*, April v. 19, iss. 2, pp. 179-97
Galor O and Moav O, (2006) 'Das Human-Kapital: A Theory of the Demise of the Class Structure' *Review of Economic Studies*, 73, 1, 85-117
Galor, O and Weil, D N (2000) 'Population, Technology, and Growth: From Malthusian Stagnation to the Demographic Transition and Beyond', *American Economic Review*, September, v. 90, iss. 4, pp. 806-28
Hajnal J (1965) 'European Marriage Patterns in Perspective' in D V Glass and D E C Eversley eds *Population in History: Essays in Historical Demography*, Edward Arnold
Hallam, H. E. (1985) 'Age at First Marriage and Age at Death in the Lincolnshire Fenland 1252-1478' *Population Studies* 39 1 55-69
Hanushek, E A. and Kimko, D D. (2000) 'Schooling, Labor-Force Quality, and the Growth of Nations' *American Economic Review*, December. 90,. 5, 1184-1208
Hatcher J (1986) 'Mortality in the Fifteenth Century: Some New Evidence' *Economic History Review* 39, iss. 1, pp. 19-38
Hazan, M and Berdugo, B (2002) 'Child Labour, Fertility, and Economic Growth', *Economic Journal*, 112, iss. 482, pp. 810-28
Hjerppe R, Miettinen U and Vesailen T (1999) 'Levels of Education in Finland in the 20th Century: A Methodological Report of Assessment of Human Capital' *Proceedings of the Third Conference of the European Historical Economics Society,* Lisbon
Israel J (1989) *Dutch Primacy in World Trade 1585-1740*, Clarendon
Landes D S (1998) *The Wealth and Poverty of Nations: Why Some Are So Rich and Some So Poor,* Norton
Laslett, P. (1985) 'Review' *Population and Development Review*, 11, 3 , 534-537
Lee C H (1991) 'Regional Inequalities in Infant Mortality in Britain 1861-1971: Patterns and Hypotheses' *Population Studies* 45 1 55-65

Lee, R. and Anderson, M., (2002). Malthus in State Space: Macro Economic–Demographic Relations in English History, 1540–1870. *Journal of Population Economics* 15, 195–220.
Lewis WA (1978) *Growth and Fluctuations 1870-1913* Allen and Unwin
Lindert P H (2004) *Growing Public: Social Spending and Economic Growth Since the Eighteenth Century*, Cambridge University Press
Malthus T R (1830) *A Summary View of the Principle of Population*, London John Murray
Mankiw, N. G. D., Romer, D. and Weil, N.,(1992) "A Contribution to the Empirics of Economic Growth", *Quarterly Journal of Economics*, 108, pp. 407-37.
Marshall A (1961) *Principles of Economics* Macmillan
McPhee, P. (2006) 'Daily Life in the French Revolution' in P. McPhee, *Living the French Revolution 1789-1799* London,. Macmillan.
Mitch, D F (1984) 'Underinvestment in Literacy? The Potential Contribution of Government Involvement in Elementary Education to Economic Growth in Nineteenth-Century England' *Journal of Economic History* 44, iss. 2, pp. 557-66
Mitch, D F (1992) *The Rise of Popular Literacy in Victorian England : the Influence of Private Choice and Public Policy,* Philadelphia : University of Pennsylvania Press
Mitchell B R (1975) *European Historical Statistics*, Macmillan London
De Moor T and Van Vanden J L (2010) 'Girl Power: the European Marriage Pattern and Labour Markets in the North Sea Region in the Late Medieval and Early Modern Period', *Economic History Review*, 63, 1, 1-33
Murray J E (2004) 'Family Literacy and Skill Training in the Antebellum South: Historical-Longitudinal Evidence from Charleston', *Journal of Economic History* 63 3 September 773-
Nicolini, E.A., (2007). Was Malthus Right?: A VAR Analysis of Economic and Demographic Interactions in Preindustrial England. *European Review of Economic History* 11, 99–121.
Nordblom, K (2003) 'Is Increased Public Schooling Really a Policy for Equality? The Role of Within-the-Family Education' *Journal of Public Economics,* September v. 87, iss. 9-10, pp. 1943-65
Nunez C (1990) 'Literacy and Economic Growth in Spain 1860-1977'in G Tortella ed *Education and economic development since the Industrial Revolution* Valencia
O'Rourke K. and Williamson J. G., (1997) 'Around the European Periphery, 1870-1913: Globalization, Schooling and Growth', *European Review of Economic History*, 1, pp. 153-90.
Pamuk, S. (2007). The Black Death and the Origins of the 'Great Divergence' across Europe, 1300-1600. *European Review of Economic History 11*(3), 289–317.
Petterson L (1999) 'State Subsidies to Primary Education – Why and When?' *Third Conference of European Historical Economics Society* , Lisbon
Rebelo, S., 1991, 'Long-run policy analysis and long run growth', *Journal of Political Economy*, 99, (June), 500-521.
Reis J (2005) 'Economic Growth, Human Capital Formation and Consumption in Western Europe before 1800' in R C Allen, T Bengtsson and M Dribe eds *Living Standards in the Past: New Perspectives on Well-Being in Asia and Europe,* Oxford University Press
Rettarolli R (1992) 'L'eta al matrimonio' in *Storia della famiglia Italiana 1750-1950,* eds M Barbiglia and D I Kertzer, Il Mulino, Bologna

Rowland R (1988), "Sistemas matrimoniales en la Península Ibérica (Siglos XVI-XIX). Una perspectiva regional", in Vicente Pérez Moreda and David-Sven Reher, eds. *Demografía histórica en España*. Madrid: Ediciones El Arquero, pp. 72-137.
Sah R (1991) The Effect of Child Mortality Changes on Fertility Choice and Parental Welfare' *Journal of Political Economy* 99 582-606
Scott, J. W. and Tilly, L. A. (1975) 'Women's Work and the Family in Nineteenth-Century Europe', *Comparative Studies in Society and History*, 17, 1, pp. 36-64
Sianesi B. and van Reenen, J., 2003, 'The returns to education: macro-economics', *Journal of Economic Surveys*, 17(2), 157-200.
Sklar J L (1974) 'The Role of Marriage Behaviour in the Demographic Transition: The Case of Eastern Europe Around 1900' *Population Studies*, 28,. 2. 231-247
Slack P (1981) 'The Disappearance of the Plague: An Alternative View' *Economic History Review* 34 3 469-476
Smith A (1961) *The Wealth of Nations* Methuen
Spagnoli, P.(1997) 'The Unique Decline of Mortality in Revolutionary France,' *Journal of Family History* 22, 425-61
Stark, O and Wang, Y (2005) 'The Intergenerational Overlap and Human Capital Formation' *Review of International Economics*, February v. 13, 1, pp. 45-58
Stephens W B (1987) *Education, Literacy and Society,1830-70*, Manchester University Press
Stone L. (1979) *Family, Sex and Marriage in England 1500-1800,* Penguin
Teitelbaum, M. S. (1984). *The British Fertility Decline: Demographic Transition in the Crucible of the Industrial Revolution*. Princeton, NJ
Thompson, Warren S. (1929). 'Population'. *American Journal of Sociology* 34(6): 959-975
Van Zanden J L (1999), 'Wages and the Standard of Living in Europe, 1500-1800' *European Review of Economic History*, August . 3, . 2, pp. 175-97
Voigtländer, N. and Voth, H-J. (2009) 'Malthusian Dynamism and the Rise of Europe: Make War, Not Love' *American Economic Review*, 99, 2, 248-254.
Von Tunzelman G N (2000) 'Technology Generation, Technology Use and Economic Growth' *European Review of Economic History* 4 2 121-146
Webb A D (1911) *The New Dictionary of Statistics*, Routledge London
Williamson J G (1991) 'Did English Factor Markets Fail During the Industrial Revolution?' in N F R Crafts, N H Dimsdale and S Engerman eds. *Quantitative Economic History*, Oxford Clarendon Press
Wrigley W A and Schofield R S (1989) *The Population History of England 1541-1871: A Reconstruction,* Cambridge

Appendix A . Household human capital model

The effect on quality-quantity substitution of unit elasticities of substitution on the preference function in the household model can be shown as follows.

Suppose $U=n^{\alpha} q^{\beta} z^{\gamma}$

then the demand for children is

$$n = ((\alpha-\beta)/(\alpha+\gamma)) \ [v+wt] / [(p_n + wt_n).d] \quad \ldots(1)$$

If $\beta>\alpha$, the utility elasticity of child quality is greater than that for numbers of children, therefore there are no children demanded and no marriage is necessary. Hereafter assume $\alpha>\beta$. Lower child mortality (reducing d) raises target family size (by cutting the 'price' of a surviving child) with unit elasticity. Lower child earnings - from say legislation requiring school attendance - raises p_n and therefore reduces target family size.

. The 'child quality' equation, with the above unit substitution elasticity preference function, is:

$$q=\{\beta/(\alpha-\beta)\](\pi_n/\pi_q) = [\beta /(\alpha-\beta)](p_n + wt_n)/ (p_q + wt_q) \ \ldots(2)$$

q is fixed solely by relative prices and income effects are irrelevant. Therefore when p_n rises, n falls and a (age at marriage) increases, q must go up.

Substituting b (=n/d) for n in (1) shows that, with the unit substitution elasticity, there is no relation between fertility and child mortality.

$$b = [(\alpha-\beta)/(\alpha+\gamma)] \ (v + wt))/ (p_n + w \ t_n) \quad \ldots.(3)$$

The effect on births of the increase in the target n exactly counter-balances the impact of the lower mortality and so total births or fertility- and therefore age at marriage- remain unchanged (the elasticity of births with respect to mortality, $e_{bm} = 0$).

A smaller elasticity of substitution changes the response so that $e_{bm} > 0$.

Appendix B: DATA SOURCES, DEFINITIONS AND DESCRIPTIVE STATISTICS

English County Data

Percentage of brides and grooms illiterate 1885 (ILLIT188), Percentage Boys not at school 1851, (BOYSNOTA), Percentage girls not at school 1851 (GIRLSNOT), Boys aged 5-9 occupied 1851 (BOYSOCCU), Boys aged 10-14 occupied 1851 (BOYSOCC1), number of domestic staff per 1000 of population 1841 (DOMESTIC), Males aged twenty and over engaged in manufacturing 1851 (%) (MANUF), Percentages of illiterate grooms 1860 (M1860), Percentages of illiterate brides 1860 (F1860), Deposits in savings banks 1844 percentage above or below average (DEPOSITS); Stephens (1987)

Infant mortality 1860 (INFANTMO) Lee (1991)

Mean age at first marriage for women 1861 (AGEMARRI) Crafts (1978)

Crude birth rate 1861 (BIRTH61) Hechter, M., *U.K. County Data, 1851-1966* [computer file]. Colchester, Essex: UK Data Archive [distributor], 1976. SN: 430.

Female ratio to males 1861 Calculated from UK *Census of Population* 1861.

Variable	Obs	Mean	Std. Dev.	Min	Max
illit1885t	42	11.78571	4.033613	4	22
boysnotats~s	42	51.38095	6.040321	36	66
girlsnotat~s	42	55.95238	7.811662	30	70
pop1861	42	450.7381	522.6229	22	2500
depositsin~s	42	-2.78571	38.24857	-71	86
marriag~1861	42	24.65238	0.654902	23	25.8
manuf	42	8.192857	9.349381	0.7	36.6
infantm~1861	42	139.1905	17.07121	114	174
m1860	42	28.07143	7.412556	15	44
f1860	42	32.80952	8.980298	18	54
birth61	42	33.52381	2.448973	30.2	40.3
femaleratio	42	1.0324	0.045654	0.9482	1.1217

Europe Panel

Primarily from Foreman-Peck and Lains (2000) and Mitchell (1975). Riitta Hjerpe kindly provided the sources for Finnish reading and writing literacy. Greek GNP per capita for 1880 and 1900 by splicing with Dertilis' estimates in 1914 prices, for which thanks are due to Ioanna Pepelassis (Dertilis G (1993), *Atelesforoi i Telesforoi? Foroi kai Exousia sto Neoelliniko Kratos, [Taxes and Power in the Modern Greek State*], Athens.). GNP per capita in constant prices- 1980 international dollars (GNPPC), Population in 000 (POP), Tariff revenue/import value (AVTARIF), Illiteracy (ILLIT) (LH=log(100-ILLIT), Crude birth rate per 1000 (BIRTHR), Crude death rate per 1000 (DEATHR), Length of railway line (RAILKM) (LK=log(RAILKM/POP), % of labour force employed in agriculture (AGRILAB), Metallic standard adherence (DUMSTAN).

The following countries are included for at least some years: Austria-Hungary, Belgium, Bulgaria, Denmark, Finland, France, Germany, Greece, Italy, Netherlands, Norway, Portugal, Romania, Russia, Serbia, Spain, Sweden, Switzerland, United Kingdom

Variable		**Mean**	**Std. Dev.**	**Min**	**Max**	**Observations**
birthr	overall	33.40778	6.340865	19.6	50.3	N = 90
	between		5.886642	22.64	48.72	n = 19
	within		2.422271	27.76778	39.44111	T-bar = 4.73684
deathr	overall	22.88333	5.825617	12.9	36.7	N = 90
	between		4.796521	15.94	34.08	n = 19
	within		3.291313	15.86333	30.90333	T-bar = 4.73684
illit	overall	38.08621	30.66072	1.5	91	N = 87
	between		30.03828	3.92	78.02	n = 19
	within		10.35203	7.846208	94.30621	T-bar = 4.57895
gnppc	overall	1339.405	575.7192	565	2991	N = 84
	between		535.6182	685	2575.6	n = 19
	within		249.2839	740.9048	1978.405	T-bar = 4.42105
female~p	overall	0.219487	0.014896	0.157487	0.245097	N = 83
	between		0.018526	0.157487	0.230121	n = 19
	within		0.006327	0.203379	0.234621	T-bar = 4.36842
pop	overall	20160.61	29342.19	1300	160700	N=94
	between		29074.94	2054.8	118720	n =19
	within		6774.69	-14059.4	62140.61	T-bar = 4.9474

avtarif	overall	0.109955	0.077293	0.004	0.341	N = 89
	between		0.070791	0.0056	0.2812	n =19
	within		0.031202	-0.01264	0.213155	T-bar = 4.6842
agrilab	overall	0.532683	0.191416	0.087	0.85	N = 82
	between		0.190287	0.114	0.8375	n = 19
	within		0.049438	0.375483	0.690483	T-bar = 4.3158
railkm	overall	10676.63	14592.35	0	66581	N = 95
	between		13297.45	400.6	41694	n = 19
	within		6605.966	-15393.8	40456.23	T = 5