CARDIFF BUSINESS SCHOOL
WORKING PAPER SERIES

Cardiff Economics Working Papers

James Foreman-Peck

The Western European Marriage Pattern and Economic Development

E2009/15

Cardiff Business School
Cardiff University
Colum Drive
Cardiff CF10 3EU
United Kingdom
t: +44 (0)29 2087 4000
f: +44 (0)29 2087 4419
www.cardiff.ac.uk/carbs

ISSN 1749-6101
September 2009

The Western European Marriage Pattern and Economic Development

James Foreman-Peck

August 2009

Abstract

For several centuries, women's age at first marriage in Western Europe was higher than in the east (and in the rest of the world). Over the same period Western Europe began slow but sustained economic development relative to elsewhere. A model based on the economics of the household explains this association in two related ways. Both connect mortality, and the exercise of fertility restraint through higher marriage age, with greater human capital accumulation. The first explanation is simply an association but the second proposes a causal link where higher age of motherhood reduced the cost of investment in children. Evidence is provided that the causal process was operative in later nineteenth century Europe

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

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

Cardiff Business School
Cardiff University
Colum Drive, Cardiff CF10 3EU

Foreman-peckj@cf.ac.uk

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 a possible role for human capital as a source of innovation, and, in the absence of widespread schooling, there was 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.

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

* Over the unusually long gestation of this paper I have been helped by many people, some of whom I have now forgotten. But I do remember gratefully comments of participants in seminars or conferences at Nuffield College Oxford, Carlos III Madrid, Lund , Hebrew University Jerusalem, Cardiff, Strasbourg and Humboldt University Berlin and also those at the AEA meeting in New Orleans and a CEPR meeting in Krakow. Assistance from Giovanni Federico, Leandro Prados de la Escosura, Peter Lindert and Roger Clarke has been much appreciated, with the usual disclaimer.

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, this shift in household demand would also require a reallocation 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.

[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.

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

1. Economic-demographic Equilibrium and Investment in Human Capital

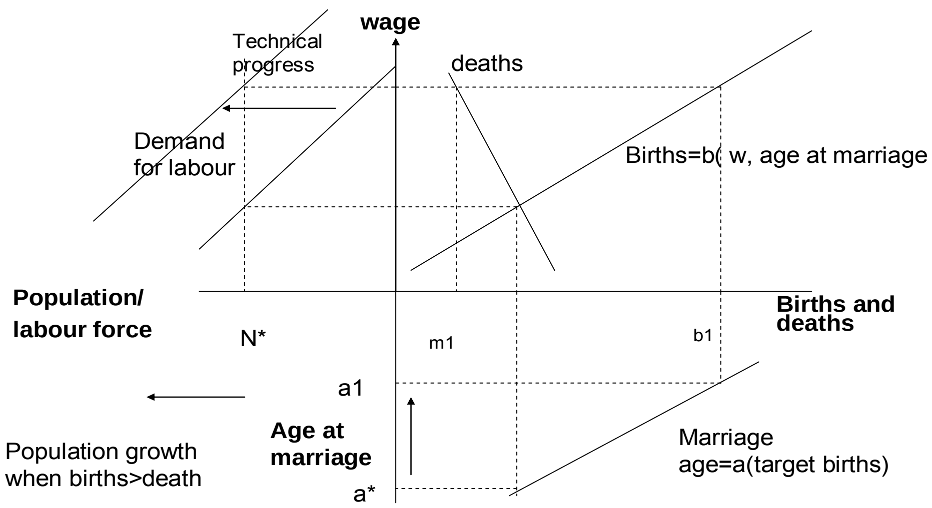
The western European marriage pattern, which emerged by the 16^{th} century and persisted until at least the First World War, exhibited three principal features; an unusually late age of first marriage for females (around 25) , a low rate of illegitimate births (two percent or less) and a high proportion 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 function of the age at marriage is represented in figure 1. There is an equilibrium population N* when births are balanced by deaths at age of marriage a*. A good harvest or technical progress increased the demand for labour, bidding up wages. Births increased (to b1) with the rise in wages because higher wages allowed earlier marriage (from a* to a1), as well as encouraging more births from established couples. Along with lower death rates (m1), higher wages therefore disrupted the economic-demographic balance and population began growing (from N*). In due course the greater population became a larger work force that drove down the wage to the initial equilibrium, and the age at marriage rose accordingly.

Recent evidence on the long term working of the pre-industrial English economic demographic system (from the sixteenth to the 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). 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

Figure 1 A Malthusian Model of Age at Marriage



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.

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.

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

Child 'price' and child 'quality' (or household investment in human capital) are affected by m, the child mortality rate[2]. Adam Smith (1961 76) assumed that on average m = 0.5 in the eighteenth century, so that four births were necessary for a completed family size of two children, and this is consistent with reconstitutions on survival to age 15 in pre-1750 France and Switzerland (Flinn 1981 Table 6.10). The higher the death rate the more time and money must be spent to achieve a target family size and child quality. Total family births 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 a mortality rate, 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. If conditions affecting mortality improved (or, comparing one

---

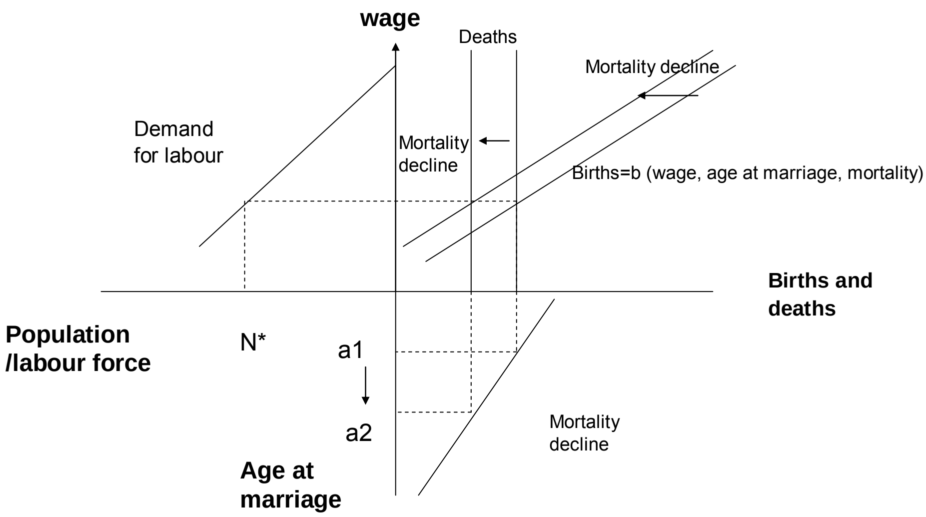
[2] Mortality itself could depend on w and/or p_Z.as in the 'positive check' of the Malthusian model. At low standards of living harvest failures reduces the real wage so that the mortality rises of the more vulnerable members of society. Indeed the association of grain prices and mortality has been 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 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.

region with a low mortality to a region with a high death rate), for a given target family size, birth rates would be lower in due course and the age at marriage would eventually be higher. 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 leftwards shift in the wage-fertility relation and by a higher marriage age (from a1 to a2). 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.

Figure 2 A Household Economics Model: post-medieval mortality decline, or West versus East Europe, or even Europe versus India



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[5].

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[6]....(2)

Depending on how household decisions are made, the optimisation could be undertaken by an individual or collectively by both spouses.

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

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

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

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 mortality 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 U1 to U2).

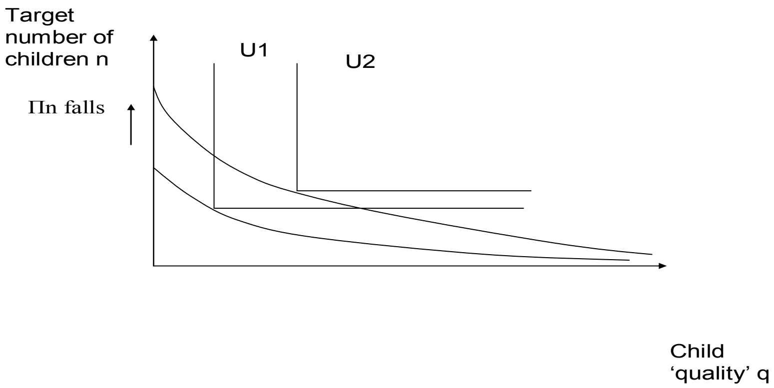
The curvature of the constraint, combined with sufficient substitutability in the preference function, explains some properties of this model. In response to a 'child price' fall, 'quality' possibly may fall while child numbers increase and age at marriage declines. More children, other things being equal, could mean fewer resources for investment in each.

---

[5] 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.

[6] 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.

Figure 3. Household investment in human capital: child 'quality' versus numbers- a fall in, or lower, mortality



With a unit elasticity of substitution between child 'quality' and 'numbers', child mortality rate 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)[7]. 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 (particularly at high mortality rates) dominates substitution away from quality, so that quality goes up as well as target family size.

Mortality, Fertility and Family Size

A fall in child mortality cuts the family cost of a surviving child and therefore boosts target family size (n). But the lower death rate itself may require fewer births in total, despite an increased n (the elasticity of births to mortality is positive, $e_{bm} > 0$). Families may reduce 'hoarding' of children in the face of greater certainty of their survival[8].

Where e_{nm} is the elasticity of target family size with respect to the mortality rate[9],

$e_{bm} = e_{nm} + m/(1-m)$ …(4)

---

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

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

[9] 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) .

Western Europe before 1914 may be described demographically as consisting of 'low pressure' societies, with 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[10]. Assuming broadly similar e_{nm}, equation (4) indicates that the mortality rate (m) determined by how much higher in the East were birth rates (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 rate is matched by a higher birth rate 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* (non-causal) 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.

A causal 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 family is the provider of these services (cf. Marshall 1961 469)[11]. 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, may have offered greater general experience that counted as a form of education. By the nineteenth century relatively well paid unmarried female factory employment was a possibility in some regions. At the same time women educated to a higher level tend to marry latter. A more educated mother

[10] The difference between these types is explained by an elasticity of substitution well below unity. This conclusion is reinforced when total mortality is assumed to vary with child mortality, 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).

[11] 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.

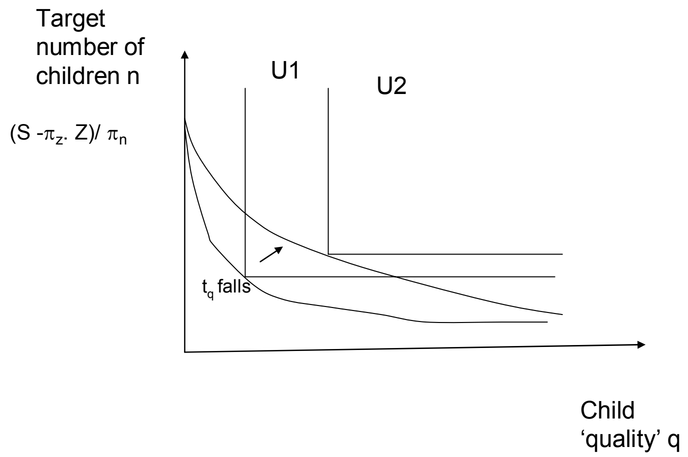
would have a lower time costs (t_q) of investment in her child's human capital; $t_q = t(a)$[12].

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.

Fig. 4 Age at marriage and household investment in children: a fall in the time costs of child quality



To summarise, the basic family economics model of a non-causal link between Western European marriage pattern and economic development consists of three

[12] There is much present day evidence for both relationships. Manda and Meyer (2005) show the association between later marriage age and greater education in Malawi. 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.

endogenous variables and three equations. The choice of number of births is established by fundamental variables, such as full prices. The fertility equation is then

$b=b(m, V, p_n, p_q, p_z, w, t_n, t_q)$ …(5)

The second equation links age at marriage and birth rate,

$a=a(b)$, …(6)

Births cause age at marriage in the sense that a family wanting 'low' births must choose a 'high' female age at first marriage in the Western Europe. Since 'a' is one means by which 'b' and 'n' are chosen, those factors that explain 'b' and 'n' also determine 'a'.[13]

The third relationship is the child quality or human capital equation

$q= q(m, V, p_n, p_q, p_z, w, t_n, t_q)$ ….(7)

The causal link equation joins 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 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 countries. But eastern Europe was not considered and convergence on the leaders is not the same as growth; 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) Cobb-Douglas function with coefficients of one third on each factor. The appropriate specification may depend upon the epoch under consideration.

---

[13] 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, perhaps 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).

. The full model developed here provides an explanation for the coincidence of the marriage pattern and European economic development, with a lower ‘m’, mortality, in western Europe reducing ‘b’, birth rates, and directly raising ‘q’, child quality. The lower birth rate requires a higher age at marriage, ‘a’. Greater child quality, more investment in human capital, raises output, without being causally linked to the higher marriage age.

A causal connection is created when a 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

Series on death rates sufficiently long to cover the onset of the European marriage pattern would be desirable but are unattainable. The available evidence nonetheless does suggest that life was short in the late medieval period, which culminated in 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. Apparently in many countries this level of real wages was not attained for another three or four centuries (Allen 2001, Van Zanden 1999). Lower real wages stemmed from population and labour force growth exceeding expansion in the demand for labour.

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.

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.

With increasing pervasiveness of the state in the nineteenth century, public provision began to substitute for that of the family; the marriage pattern started to fade both for this reason and because of diffusion of other means of family limitation. Were richer data sets available for earlier periods, later family evolution suggests that relations of the model might be even more apparent then.

As it is the model is tested on two data sets; one cross-national and the other within one country, nineteenth century England. An unbalanced panel of countries for Europe, including Russia, at decadal intervals for 1870-1910[14] is employed. Because forty years is a short time to allow variation in the phenomenon of interest, even when there is some panel data, a single cross-section is analysed first. 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[15].

[14] Constructed from Mitchell (1975) and data in Foreman-Peck and Lains (2000). This last focussed especially on economies of South East Europe, of particular concern for comparison with North West Europe in the present study.

[15] 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

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 (but not essential for) Western European low birth rates being triggered by the ending of an earlier high mortality regime.

In the birth rate equation (5) estimated in Table 1, for English counties in 1861 infant mortality ('inf. m.', ranging from 121 to 174 per 1000 live births) is a positive and significant determinant of fertility. The OLS coefficients of equations 2 and 3 of Table 1 imply that a fall of 50 reduced the birth rate per 1000 persons by just under 2.

Table 1 Crude Birth Rate 1861 English Counties

	(1)	(2)	(3)	(4)	(5)
inf.m.	0.59	0.040	0.040	0.217	0.187
	(3.01)**	(3.10)**	(3.10)**	(2.51)*	(6.08)**
f1860		-0.193	0.260	-0.016	
		(0.79)	(4.61)**	(0.13)	
Deps	-0.0125		-0.012		
	(1.42)		(1.42)		
manuf	0.125		0.025		
	(3.61)**		(0.61)		
m1860		-0.116	-0.105	-0.087	
		(3.28)**	(2.11)*	(1.24)	
Const	24.27	26.298	27.24	6.438	7.635
	(9.46)	(14.62)**	(12.70)**	(0.75)	(1.85)
girls		-0.063	-0.055		
		(2.17)*	(1.82)		
Obs	39	39	39	39	39
R-sq	0.63	0.76	0.78	(0.04)	(0.21)
Est	OLS	OLS	OLS	IV	IV

Notes: Robust t statistics in parentheses: * significant at 5%; ** significant at 1%
Eq. 4.Instrumented: infantmortality1861.Instruments:f1860 m1860 manuf marriageage1861.Firststage F-stat= 10.40
Eq. 5.Instrumented: infantmortality1861.Instruments:manuf marriageage1861 f1860.First stage F-stat =14.25
Excluding Yorkshire and London Including Monmouth. Variable key in Appendix

Allowing for the possibility that mortality is endogenous increases the impact by a factor of five (the birth rate ranged from 30 to 40). The wealth measure, savings deposits ('deps'), is negative related to births but is not significant at the 10 percent

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.)

level. Gender differences in human capital effects (as measured by literacy) are very significant in the OLS equations. Male earning power and a positive male wage elasticity of births are reflected in the negative coefficient on male illiteracy ('m1860' Table 1). The biggest effect is from female human capital, that measuring the time cost of children ($w.t_n$), female illiteracy ('f1860', ranging from 18 to 54 percent), where the 36 percent variation accounts for 7 births per 1000. Availability of manufacturing employment ('manuf') ceases to be a significant influence on births once the human capital variables are included in the model. Proportion of girls not attending school ten years earlier negatively impacts on fertility – perhaps because school attendance reflects lack of employment opportunities.

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[16].

As with the county data, death rate is a significant determinant of births (Table 2), with larger coefficients ('death') estimated in equations (5 and 6) assuming death rate is endogenous. The death rate coefficient of 0.54 (equation 2 Table 2) indicates that a one standard deviation cut in the death rate (5.4) reduces the birth rate by almost 3, or about 10 percent. At the sample mean, the implied elasticity is 0.39. The average crude death rate for the sample is 23, for which the Coale/Demeny model South yields 67 percent surviving to age 15 [17]. 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 $e_{nm} = 0.39- (0.33/0.67) = -0.1$. Target family size rises by one tenth 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 (w) from (3). Since the V elasticity must be positive, the implied wage elasticity must be strongly negative to outweigh the unearned income (V) effect. This implies that on average across Europe 1870-1910 the time cost of children generated a substitution effect greater than the pure income effect. According to the GNP coefficient ('gnppc') of equation (1) Table 2, one standard deviation of GNP per head (573) lowers birth rate by (573*.0084=) 4.8.

---

[16] 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

[17] 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.

Table 2 Crude Birth Rate in Europe 1870-1914: Panel Regressions

	(1)	(2)	(3)	(4)	(5)	(6)
death	0.399	0.537	0.464	0.436	0.681	0.581
	(3.52)**	(5.50)**	(4.37)**	(3.43)**	(8.88)**	(2.69)**
gnppc	-0.0084			-0.003		-0.005
	(3.55)**			(1.81)		(2.07)*
illit	0.103	0.056	-0.002	-0.037		
	(1.76)	(2.04)*	(0.03)	(0.78)		
year	1.475	0.163	-0.262			0.836
	(2.77)**	(0.68)	(0.74)			(2.22)*
agrilab				3.246		
				(0.55)		
Const	26.88	18.372	23.095	26.677	17.251	24.24
	(6.29)**	(6.42)**	(5.68)**	(4.17)**	(10.12)*	(3.19)**
$R^2$with	0.679	0.5254	0.5361	0.6381	0.5977	0.6522
Betwn	0.4662	0.5607	0.4459	0.4765	0.5092	0.5625
Overl	0.4162	0.5234	0.4383	0.4233	0.4900	0.5112
Obs	78	83	83	74	78	78
Estim	FE	RE	FE	FE	IV FE	IV FE

Notes: Absolute value of z statistics in parentheses; * significant at 5%; ** significant at 1%.
Eqn. 5 Instrumented: deathr; Instruments: year illitfin gnppc standard area pop. First stage F-stat=24.95. Eqn. 6 Instrumented: deathr; Instruments: year standard area pop illitfin kl density. First stage F-stat= 23.05

Population growth was shifting a higher proportion into the reproductive age group. The trend rise in crude birth rates ('year' equation 1 Table 2) of 1.47 every decade, took place around a sample average of 32 . Equation (4) Table 2 shows that a lower proportion of the labour force employed in agriculture ('agrilab') is associated with a lower birth rate but not significantly so.

4. *European Age at Marriage and Fertility*

As late as 1900, to the west of an invisible boundary from Trieste to the 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.

The model's postulated relationship, a=a(b) (equation 6), still apparently held despite alternative methods of fertility control (Crafts 1989) (Table 3 and figure 5). France is an outlier below the regression line in figure 3, thanks to the redistribution of property during the Revolution that encouraged lower birth rates. Eastern Europe's high birth rate is very apparent in the left cluster. In particular the outlier 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.

Fig. 5 European fertility and age at marriage c 1900

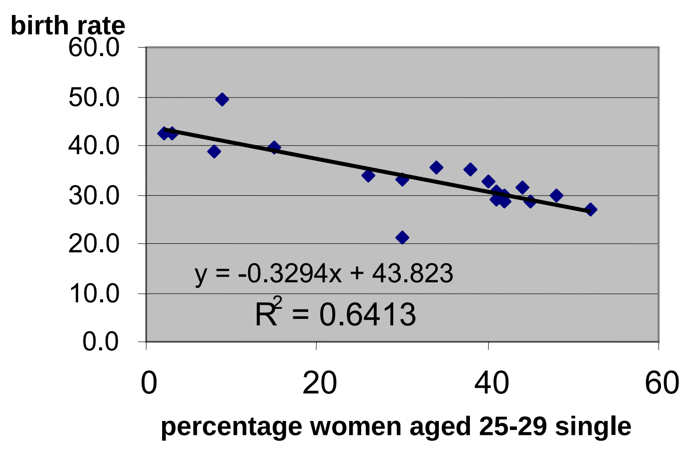


Table 3 European Fertility and Proportion of Women Single c 1900

	Birth rate	Percentage women aged 20-24 single	Percentage women age 25-29 single
Austria	35.0	66	38
Hungary	39.4	36	15
Belgium	28.9	71	41
Bulgaria	42.3	24	3
Denmark	29.7	75	42
Finland	32.6	68	40
France	21.3	58	30
Germany	35.6	71	34
Italy	33.0	60	30
Netherlands	31.6	79	44
Norway	29.7	77	48
Portugal	30.5	69	41
Romania	38.8	20	8
Russia	49.3	*28	*9
Serbia	42.4	16	2
Spain	33.9	55	26
Sweden	27.0	80	52
Switzerland	28.6	78	45
Great Britain	28.7	73	42

Source: Hajnal 1965; Mitchell 1975

Notes * USSR 1926

Within countries 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 1841, and married between 1841 and 1861, ranged from 25.8 to 23.0 (Crafts 1978)[18]. As the model predicts, the (target) birth rate is highly correlated with age at marriage; half the variance of mean marriage age in 1861 is explained simply by the 1861 crude birth rate ('birth61x' varying between 30.2 and 40.3 per 1000 population, equation 4 Table 4). Equation 1 table 4 has a coefficient on birth rates similar to that in the bivariate cross-European relationship (figure 5). Instrumental variable estimation allows for the possibility that birth rate or literacy respond to age at marriage as well as age at marriage being chosen with target births in mind.

Table 4. Mean Age at First Marriage for Women 1861; English County Regressions

	(1)	(2)	(3)	(4)
birth61x	-0.340	-0.416	-0.152	-0.188
	(8.02)**	(2.71)**	(2.05)*	(4.90)**
Inf.mort.			-0.004	-0.0002
			(0.41)	(0.03)
m1860	-0.042	-0.051		
	(3.00)**	(2.51)*		
f1860	0.069	0.086		
	(3.76)**	(2.59)*		
depos	0.002	0.002		
	(1.26)	(0.56)		
manuf	-0.003	0.0005		
	(0.29)	(0.04)		
Obs	39	39	39	39
R-squared	0.70	0.67	0.50	0.51
	OLS	IV	IV	OLS

Notes: Robust t statistics in parentheses; significant at 5%; ** significant at 1%

Eqn 2 Instrumented: birth61x, Instruments: m1860 f1860 manuf depositsinsavingsbanks infantmortality1861 first stage F stat 22.4
Eq 3 Instrumented: birth61x , Instruments: infantmortality1861 depositsinsavingsbanks manuf first stage F stat=20.2

Once birth rate is included in the model, infant mortality ('inf. mort.') ceases to contribute, in accordance with the theory of equation (6) (Table 4 equations 3 and 4). Age at marriage is established by target family size and the mortality rate that determine the number of births necessary to achieve the objective; the birth rate covers both. Equation 4 Table 4 implies that a fall in the crude birth rate by 10 per

[18] 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.

thousand required an increase in the age of marriage of 1.9 years. Male and female illiteracy ('m1860','f1860') are statistically significant influences on county marriage age (Equation 1 Table 4). But manufacturing employment ('manuf') (in 1851) is not significant at the 5 percent level.

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 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[19]. 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 European Marriage, Schooling and Illiteracy 1890-10

	% of women aged 25-29 single around 1900	Primary school children c.1890 % of pop	% Illiteracy 1910 (Flora)
Austria-Hungary	27	12.6	17
Belgium	41	10.1	13.4
Bulgaria	3	5.9	62.2
Denmark	42	15.4	3.0
Finland	40	2.3	1.1 [45]**
France	30	14.7	11.9
Germany	34	15.9	3.0
Greece	13	7.8	59.7
Italy	30	8.1	39.3
Netherl'ds	44	14.2	7.5
Norway	48	14.3	3.0
Portugal	41	4.7	68.9
Romania	8	3.2	65.0
Russia	9	2	55.0
Serbia	2	3.0	77.5
Spain	26	10.5	52.2
Sweden	52	15.1	1.5
Switzerl'd	45	16.0	1.5
Great Britain	42	13.0	7.5

Source Hajnal 1965 Tables 2 and 3: Mitchell 1975; Flora 1975. Notes: Single women in Austria and Hungary are aggregated. * per 1000 of under 15 age group. ** see discussion in text.

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,

[19] 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. Illiteracy regressions Europe 1910

	(1)	(2)	(3)
propnsingle	-0.556	-1.425	-1.347
	(2.08)*	(3.60)**	(7.94)**
schooling	-3.730	-2.110	
	(4.07)**	(1.64)	
Constant	85.165	96.129	72.128
	(14.37)**	(7.59)**	(18.00)**
Observations	19	18	19
R-squared	0.87	0.71	0.60
	OLS	IV	OLS

Notes Robust t statistics in parentheses; significant at 5%; ** significant at 1%
Eqn (2) Instrumented: propnsingle, Instruments: schooling agrilab first stage F-stat=9.34

The 'within country' data set offers another opportunity to test and quantify the human capital equation. 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 Illiteracy in English Counties 1885

	Age at Marriage 1861	Boys not at school 1851	Girls not at School 1851	Mortality	R^2	N	Estimation method
(i)	-1.78	0.30	0.17	-	0.67	42	OLS
	[3.09]	[3.03]	[2.24]				
(ii)	-3.14	0..29	0.17	-0.001	0.62	42	IVs deposits, manuf, girlsnot, boynotat,infantmo . First stage F=10.49
	[-3.41	[3.38]	[2.64]	[0.04]	(pseudo)		
(iii)	-3.09	-0.30	-0.17	-	0.62	42	IVs deposits, girlsnot, boysnot Birth rate ,infantmo . First stage F=12.26
	[-5..34]	[-3.26]	[2.55]		(pseudo)		

Notes: London excluded. Monmouth and extra metropolitan Kent, Surrey and Middlesex included. t ratios in parentheses.

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. 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 has the expected sign but in the IV estimation is not significant at the 10 percent level.

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 (a proxy for wider child quality and human capital).

6. The Contribution of Human Capital

The final component of the present interpretation is that human capital played a vital role in European economic development over the period 1870-1910. 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).

The constant returns to scale, aggregate production function of the present model is:

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

where Y is aggregate output, K is physical capital, L is labour, H is human capital and A is agricultural employment share. Assuming the labour force is proportional to the population, P (because of data deficiencies), (8) may be divided through by population to create the equation below, estimated in Table 8.

$Ln(Y/P)=B +\eta \ln(K/P) +\theta \ln(H/P) +\lambda \ln (\mu P/A)$

where μ is the labour force participation rate and $\mu P/A$ 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).

In the instrumental variables estimates of the production function of table 8, equation (ii), the human capital coefficient is large and significant ($\theta\approx0.4$ in equation ii) compared with physical capital ($\eta\approx0.2$ in ii), (which implies that the coefficient on 'raw' labour is 0.4). 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.

What effect does this relationship imply for later marriage? From the cross-European relation and the coefficient of equation (3) table 6, the difference 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. Raising literacy by this much would have boosted

Russian GNP per head by 36 percent, to about the level achieved by Austria-Hungary a decade earlier[20].

Table 8 Production Function Random Effects Panel Regressions: Europe 1870-1910

Dependent variable log GNP per head

	Log Human capital (% literacy)	Log Capital (rail km per head)	Resources in agriculture	R^2 within between overall	N	Estimation
(i)	0.208 [2.85]	0.073 [2.51]	-1.403 [-7.19]	0.615 0.924 0.871	75	Panel Random Effects
(ii)	0.397 [2.36]	0.193 [2.30]	-0.772 [-2.10]	0.542 0.859 0.775	71	Panel IV Random, human capital and capital endogenous, agrilab, average tariff, year, deathrate, log population. First stage F-stat 16.3 and 15.8 for human and physical capital respectively (FE)

Note: t ratios in parentheses

Within England a higher level of economic development meant that the impact of marriage age and literacy, as well as the dispersion of these variables, was lower than across Europe. The difference between the maximum and minimum ages was only 2.8 years. Had a gap in marriage age by county as great as five years been observed, the regression model of equation 3 Table 7 implies that this would have been associated with more than a (3.09*5≈)15 percentage point difference in illiteracy. Literacy ranged from 78 to 96 percent. Adding the 15 percentage points on to the least literate county would have raised output by 7 percent, according to the cross-European production function.[21].

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.

7. Conclusion

In a longer term perspective, the likelihood is that declines in mortality in western Europe from the 15th and 16th centuries required measures to control births, if living

[20][Ln(74)-Ln(30)]*0.4

[21] Using the same equation of table 8, (ln(93)-ln(78))*0.4=0.07.

standards were not to fall precipitously. The late female age at first marriage was one response. Fortuitously, a smaller number of births created more opportunity for investment in child quality. Up to this point the association of the marriage pattern and higher living standards is explained – at least qualitatively- without a direct causal connection.

To the extent that later marriage created more opportunities for women outside child bearing and rearing, a causal link can appear. 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. At some stages in history literacy would be a proxy for such education.

Although a lower death rate 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. It turns out to do so more substantially in Eastern than in Western Europe.

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 customs 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[22] 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).

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,

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

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

[22] The term 'Frank' for many centuries referred to Western Europeans.

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
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
Lee C H (1991) 'Regional Inequalities in Infant Mortality in Britain 1861-1971: Patterns and Hypotheses' *Population Studies* 45 1 55-65
Lee, R., 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
Manda, S and Meyer, R (2005) 'Age at First Marriage in Malawi: A Bayesian Multilevel Analysis Using a Discrete Time-to-Event Model' *Journal of the Royal Statistical Society:* Series A (Statistics in Society), v. 168, iss. 2, pp. 439-55
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
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
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.
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
Sianesi B. and van Reenen, J., 2003, 'The returns to education: macro-economics', *Journal of Economic Surveys*, 17(2), 157-200.
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
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
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
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**.**

Appendix B: DATA SOURCES AND DEFINITIONS

English County Data

Percentage of brides and grooms illiterate 1885 (ILLIT188), Percentage Boys not at school 1951, (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 agriculture 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 1860 (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.

Europe Panel

From Foreman-Peck and Lains (2000) and Mitchell (1975).

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).