Health and the Revolution in Household Behavior 1880-1940: Fertility, Education and Married Female Labor Supply

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Abstract

Between the latter nineteenth century and the 1930s there was a dramatic revolution in American families. Family size continued its long-term decline, the schooling of older children expanded dramatically and the proportion of married females' adulthood devoted to market-oriented activities increased. Over this same period there were significant reductions in mortality, especially among the young, and impressive reductions in morbidity. This paper considers all these trends jointly, modeling the changes in fertility, child schooling and lifetime married female labor supply as a consequence of exogenous changes in health. These interactions are then quantified using calibration techniques. The simulations suggest that reductions in child mortality alone cannot explain the transformation of the American family. Indeed, in our preferred calibration, reductions in child mortality lead to a modest decline in human capital and increase in fertility, with little effect on married female labor force involvement. In sharp contrast, reductions in morbidity are found to lower fertility and increase education. The time savings from lower fertility more than offset the increased time mothers invest in their childrens' quality, freeing some time for market work. However, lower fertility alone cannot account for the increase in market work of married women. In our framework, the majority of the increase is a consequence of a narrowing of the gender wage gap. More generally, viewing the implications of health improvements deepens our understanding of the American family transformation, complementing explanations based on skill biased technical change and improvements in household durable goods.

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1 Introduction

Between the latter nineteenth century and the 1930s there was a dramatic revolution in American families. Family size continued its long-term decline. The schooling of older children expanded tremendously, as epitomized by the 'high school movement.' Additionally, the proportion of married females' adulthood devoted to market-oriented activities increased, even as market-oriented activity performed at home declined. Over this same period there were significant reductions in mortality, especially among the young, and impressive reductions in morbidity. Interrelations among these changes in the family and changes in health have seldom been examined simultaneously despite their coincident timing and several obvious ways they may interact. As one example, if fewer young children die, fertility may fall, freeing mother to devote more years to market labor.

This paper considers all these trends jointly, modeling the changes in fertility, child schooling and lifetime married female labor supply as a consequence of exogenous changes in health. These interactions are then quantified using calibration techniques. The simulations suggest that reductions in child mortality alone cannot explain the transformation in the American family. Indeed, in our preferred calibration, reductions in child mortality lead to a modest decline in human capital and increase in fertility, with little effect on married female labor force involvement. In sharp contrast, reductions in morbidity are found to lower fertility and increase education. The time savings from lower fertility more than offset the increased time mothers invest in child quality, freeing some time for market work. Nevertheless, to quantitatively account for the full increase in mother's time spent at work, it proves necessary to generate further reductions in mother's household production time. In our framework this is driven by a narrowing of the gender wage gap.

Viewing the implications of health improvements deepens our understanding of the American family transformation, complementing explanations based on narrowing of the gender wage gap, skill biased technical change and changes in household technology. This argument is laid out as follows: in section II we further discuss the trends to be explained. The third section provides a review of literature and motivates the model. Section IV develops the framework. The model's calibrations are discussed in Section V. The sixth section discusses calibration results. A final section summarizes.

2 Trends in fertility, schooling, and married female labor supply

2.1 Married female labor force participation

White wives seldom worked outside the home in the late 19th century. However a significant proportion of new brides in the 1920s devoted many years of adulthood to market labor. Below we estimate these trends from a cohort perspective. The Census Bureau reports that the Married Female Labor Force Participation Rate (MFLFPR) among white married women increased from 2.5% in 1890 to 9.8% in 1930, and to 20.7 in 1950. However, for at least three reasons these cross-section snapshots are of limited value for analysis of change across several cohorts. First, those cross-section estimates are based on Census questions that, especially in the nineteenth century, differed appreciably from the modern participation concept, first used in 1940. Beginning in 1940 the Census tabulates as 'in the labor force' respondents indicating they either worked for pay in the past week, were temporarily away from work (on vacation, for example), or had engaged in job search over that period. Prior to 1940, the concept was that of gainful occupation (though the question varied a bit from Census to Census). Goldin (1990) notes that in the nineteenth century many women who worked on their husband's farm or kept boarders viewed themselves as principally housewives; and this is the 'occupation' they reported to the Census takers. She constructs a labor force measure for 1890 consistent with the 'modern' notion, finding that the Census measure needed to be revised upwards by almost 10 percentage points (roughly increasing the white MFLFPR for 1890 by a factor of 5 compared to the Census). Sobek (1997) replicates Goldin's methodology using data for Census years 1880, 1900, 1910 and 1920 from IPUMS.[1] He finds that adjusted MFLFPRs were relatively stable over this entire period, followed by a rapid acceleration post-1940.

A second shortcoming of the census figures is that our framework is based on decisions of lifetime labor supply made as young adults. This suggests a lifetime measure of market work, which requires cohort data. However, even with cohort data which correctly measures work in each year, there remains the question whether young adult females accurately foresaw their mid-life participation rates. Indeed, Goldin (1990, pages 154-157) examines survey data from young women regarding their expected future MFLFPRs and finds that when rates have increased rapidly young women have underestimated their future participation. Less clear is whether their parents-who in our model control the human capital investments in children- may have better anticipated their daughters' life cycle work.

Another limitation of labor force *participation* data is that the number of *hours worked* varies tremendously across those within the labor force at a point in time, as well as across time. This creates an additional complication since our framework addresses the allocation of time to an activity, rather than participation in that activity.

To address these shortcomings, we construct a measure termed Life Cycle Participation Rate (LCPR) which reflects both the available cohort information as well as the cross-section adjustments to MFLFPRs, to provide a lifetime measure of married female market work across several birth cohorts.

[1] Integrated Public Use Microsamples of the US census (cf. www.ipums.umn.edu)

First, cohort participation profiles for white married females attaining adulthood between 1880 and 1940 are taken from Roberts' (2007, Fig. 1.9). For those born 1931-1940, achieving adulthood in 1960, data from the Historical Statistics of the U.S. (2006, 1-702)) is used. This component is based on actual behavior at different ages and is consistent with perfect foresight on the part of young adults. Second, the adjustments to the Census cross-section MFLFPRs for a given year from Sobek (Table 2.5) are added to the Census averages from step 1; this is a static expectations component, based on the cross-section in the year the young female commences adulthood (about age 20). Finally, this sum is multiplied by .75 in each year to produce the reported LCPR, which assumes that the average married woman in the labor force devotes three-quarters of her time endowment within a year to market work and that this ratio is constant across time.[2] These calculations are shown in Table 1.

These cohort measures are appreciably greater for a birth cohort than is the Census cross-section number for the same year. Also, notice that the cohort attaining adulthood (age 20) in 1930 has roughly twice the lifetime participation of the young female adult of 1880 (18.1 compared to 9.2). The reconciliation of these findings with the relatively trendless cross-section adjusted MFLFPRs reported by Sobek is that young wives especially after 1920, began to re-enter the labor force in greater numbers once their children matured.

2.2 Schooling

Murphy, Simon and Tamura (2008) construct estimates of the years of schooling completed by children born in census years 1850-2000 using enrollment data from IPUMS. They find that the cohort of children born in 1880 would ultimately complete 5.02 years of school. This rate had more than doubled to 10.5 years by 1930. Another perspective on the growth of formal education is afforded by the explosive increase in the high school graduation rate. This rate had been but 2% in 1870, rising modestly to 8.8% in 1911-1912. Then the 'high school movement' rapidly raised graduation rates, which had reached 45.6 percent only 25 years later in 1936-1937 (Goldin and Katz, 2008, p. 27).

[Insert Table 1 here]

2.3 Fertility

Fertility declined in the United States from at least the early nineteenth century until the 1930s. Jones and Tertilt (2007) have recently analyzed historical cohort fertility in the United States based on self

[2] Through the 1940s there was less part-time work available than in later years (Goldin, 1990). This is one reason many women performing market-oriented labor worked from home into the twentieth century. And, women working from home did work part time. Further, labor legislation reduced the number of hours which constituted full time employment over this period. Both the .75 scaling factor, and its assumed constancy, abstract from these complications.

reports of retrospective fertility of ever-married women contained in the 1900 and 1940 U.S. Census. For the cohort of females born 1856-1960, who would attain adulthood around 1880, children ever born was 4.9. Fertility fell rapidly so that women reaching adulthood in 1900 (born 1876-1880) had but 3.25 children. Cohort fertility reached a nadir in their survey results for those born 1906-1910 (reaching adulthood about 1930); the following cohorts were the leading edge of the baby boom.

3 Literature review

There is an immense literature on the topics of the high school movement, fertility decline, and the rise in the MFLFPRs. The following examples are only suggestive of the breadth and depth of research in these areas. Existing research on American fertility, schooling, and labor force participation in the period from late nineteenth century through the 1930s does not address the high school movement, fertility, and MFLFPRs simultaneously. Claudia Goldin's research (1990, 2006 and Golden and Katz, 2008) has detailed the record of schooling and female labor market work over long periods including the interval we examine. Her preferred theoretical mechanisms are principally that: the rising importance of clerical work and of sophisticated machinery increased the returns to skill, encouraging the high school movement; the decline in the gender wage gap combined with respectable white collar jobs for women reduced the stigma of working wives, contributing to the rise in married female labor force participation; the ability of high school graduates with clerical skills to return to respectable office jobs after children became older accounts for much of the accelerated rise in cross-sectional MFLFPRs in the 1940s and 1950s. The Depression and consequent strengthening of marriage bars retarded this increase in the 1930s.

A variation on Goldin's view is that of Adeshade (2009) and Rotella (1980, 1981) who envision that an exogenous increase in high school attendance induced skill-biased technical change in office machines. Innovators foresaw that a large pool of educated females willing to work at wages below males would complement skill-biased office equipment. They responded to these incentives by designing and manufacturing office machinery, which increased the demand for female clerical workers, pulling them from the home sector. Galor and Weil (1996) suppose that capital deepening accompanying the second industrial revolution decreased the return to strength, narrowing the gender wage gap, reducing fertility and increasing MFLFPRs.

Other theories of the rise in MFLFPRs appeal to technological change in household production. According to Greenwood, Seshadri and Yorukoglu (2005) the rise of labor-saving capital goods in the household (clothes washers, dryers, vacuum cleaners, dishwashers, etc.), in combination with diminishing marginal utility of non-tradeable goods produced in the household, reduced the marginal value of females' time in the household sector. In their model, increases in the quantity and quality of durable household appliances (which they model as declines in their price) reduce the reservation wages of females, increasing MFLFPRs in the middle of the 20th century. They conduct a theoretical calibration exercise and find that half of the increase in MFLFPRs was due to labor-saving technology in the home. Albanesi and Olivetti (2007) argue that technological improvements related to the bearing and nursing of children were instrumental to the rise in the labor force participation of mothers. Finally, Fernández, Fogli and Olivetti (2004) propose a role for culture in the rise of MFLFPRs, arguing that men whose own mothers had worked are more likely to prefer a spouse who works.

3.1 Implications of mortality and morbidity decline

There were significant reductions in mortality and morbidity in the United States beginning near the end of the nineteenth century. After a few general remarks about these transitions, we consider recent theory about the implications of improvements in health for fertility, human capital investments, and mother's market work. Mortality was high and variable in the United States until the last decades of the nineteenth century. High baseline mortality was spiked by periodic epidemics of cholera, typhoid, yellow fever, influenza and other infectious diseases. However, in the 1870s or 1880s mortality began a rapid descent to much lower levels. Haines (2000, Table 3.4) reports that life expectancy at birth among the white population in 1880 was 39.6 years, rose to 49.6 in 1900, 57.4 by 1920, and reached 69.1 in 1950. Much of the mortality decline in the first decades of transition was concentrated among infants and children (so that increases in life expectancy at age 10 were less spectacular). The white infant mortality rate, i.e., deaths in the first year of life per thousand live births–which was a horrific 214.8 in 1880–had declined to 120.1 in 1900 and to 26.8 by 1950 (Haines, 2000, Table 4.3). However, infants were not the only children to die at high rates in the nineteenth century. For example, while the probability of surviving to age 1 in 1880 was .829, the probability of living to age 15 in 1880 was .707. So, of 100 children born in 1880, an additional 12 died between the ages of 1 and 15 (Murphy, Simon Tamura, 2008, Tables 14 and 15).

Preston and Haines (1991) describe how the mortality transition was facilitated by massive public investments in clean drinking water and hygienic waste removal as well as advances in scientific understanding. Once the germ theory of disease gained acceptance, practices such as washing hands before eating, quarantining those who are ill, boiling water, pasteurizing milk, and keeping living areas clean boosted health and reduced mortality. Many vaccines were introduced beginning in the latter nineteenth century, including cholera and typhoid, and for diphtheria, whooping cough, and tuberculosis early in the twentieth century. The discoveries of sulfa drugs in the 1930s , then mass production of penicillin in the 1940s, helped further reduce mortality and perhaps morbidity(Preston and Haines, 1991).

Mokyr (2000) argues that new understandings of the role of hygiene in preventing sickness and death led mothers to devote more time to housework. Mothers, he argues, now believed that through their efforts they could directly lower the probability of child death. Further, with the mechanisms of disease still poorly understood, housewives made sure that any error in their effort would be on the side of too much, rather than too little, cleanliness. Whereas God's Will had previously been the sole determinant of which children lived and died, now cleanliness had risen next to Godliness. Mothers' obsession with cleanliness, he argues, delayed the onset of female market work.

In the context of economic development, Soares and Falcao (2008) consider linkages among increases in adult longevity and MFLFP. They show that increases in adult life expectancy are the major driver of the rise in human capital, the decline in fertility and the movement of married women from the home to the market sector. They assume that increases in own adult longevity increase the period over which investments in own market-oriented human capital can be recouped. This increases human capital investments by females in their early adulthood, inducing them to substitute away from fertility and increase market work. They also consider implications for investments in the human capital of children. To the extent that the production of child quality utilizes mother's time (and no goods), adult longevity has an ambiguous effect on child quality: greater adult longevity for children increases the returns to their market human capital, but mother's higher human capital increases the opportunity cost of investing in children.

Hazan (2009) points out that, empirically, increases in adult longevity are typically associated with *reductions* in the total amount of hours worked over the life cycle. This was true in the U.S. from the end of the 19th century through the middle of the 20th century: the work week became shorter and the age upon retirement declined (Costa, 2000). Consequently, modeling increased adult longevity as causing longer labor market attachment is problematic.

Hazan and Zobai (2006) examine effects on parental human capital investments in children of perfectly foreseen increased longevity of children in adulthood. They point out that when parents receive utility from the aggregate earnings of children in adulthood, increases in longevity increase the returns to both quantity and quality. Consequently, increased longevity need not lead to fertility decline and increased education.

Soares and Falcao briefly consider implications of child mortality. In their framework parents receive utility from surviving children and as child mortality declines, so does fertility. They note that lower child mortality increases the returns to parental investments in quality, so that investments per child increase. In their framework the increase in parental investments per child more than offsets the decline in fertility, so that total time investments in children increase. Thus, lower child mortality reduces MFLFP, as in Mokyr, whereas greater adult longevity increases it: lower child mortality increases mother's investments in children (reducing labor supply), whereas increased adult longevity increases adult human capital, and the incentives for labor market attachment.

Of course, not all children exposed to infectious diseases died from them. There is, however, evidence that those subjected to harsh physiological insults at one point suffer increased morbidity at later ages (Costa, 2009). That is, survivors of serious disease(s) and/or harsh working conditions may be physically compromised in ways that depress future capacity at work and/or school. If morbidity operates similar to a reduction in 'ability,' it may depress human capital investments. Consequently, morbidity decline may increase the capacity to produce human capital. Bleakley (2007, 2009) provides convincing examples of how reductions in morbidity stimulated human capital. Debilitating hookworm disease had been prevalent in the American South through the early 20th century. In response, J.D. Rockefeller funded a highly effective campaign to eradicate hookworm. Bleakley finds that the curtailment of hookworm was associated with significant increases in schooling and sizeable reductions in fertility among the affected populations. His findings are similar for the curtailment of malaria in the America South circa 1920, with an income boost of about 15% in the next generation within those states experiencing the greatest reductions (compared to baseline states).

Our paper builds on the recent theoretical work of, especially, Hazan and Zobai, and Soares and Falcao, and the empirical findings of Bleakley, Costa, and Hazan. When addressing implications for human capital accumulation in the late nineteenth and early twentieth century U.S., it is appropriate to focus on parental investments in child human capital, as do Hazan and Zobai. In light of the dramatic implications for human capital, earnings and adult morbidity associated with the curtailment of infectious diseases, as stressed by Bleakley and Costa, we attempt to quantify implications of morbidity improvements. Following Soares and Falcao we are interested in explaining MFLFPRs, fertility, and human capital investments in children in terms of health factors. However, we treat seriously the findings of Hazan that work lives have shortened as adult longevity has increased. Furthermore, in the framework of Soares and Falcao all costs of children are related to child quality. However, Becker (1981) argues there are also costs of children which are increasing in the quantity of children, and largely unrelated to child quality. Important examples include the reductions in female productivity during and after pregnancy, the costs of basic clothing, perhaps extra living space, and the costs of 'picking up' after children and feeding them (whether these activities are implicit costs associated with mother's foregone labor earnings, or direct costs if the services of a nursemaid and domestic help are purchased). Including such costs may alter the conclusions of Soares and Falcao that reductions in child mortality unambiguously increase total, or even per child, investments in child quality. In particular, the insight of Hazan and Zobai-that increased adult longevity increases the returns to both quantity and quality-will be shown to operate with respect to reductions in infant/child mortality. Finally, mother's market work is conditioned by decisions in household production beyond child care. Our formulation allows mother's time in such activities to vary with her market wage.

4 Modeling the household

4.1 Preferences

Parents care about the number of their surviving children, the earnings in adulthood of those children, and the consumption of household produced goods. Their utility is written:

$$U = \ln H_t + \psi \ln\left(\frac{1+\gamma}{2} w_{t+1}\pi_{t+1}\hat{h}_{t+1}n_{t+1}\right) + \sigma \ln\left(\frac{1+\gamma}{2} w_{t+1}\pi_{t+1}h_0\right) \tag{4.1.1}$$

Here, H_t is the consumption of household production goods, n_{t+1} is the number of children surviving to adulthood. w_{t+1} is the wage per unit of human capital earned by adult males at time $t+1$, γw_{t+1} is the wage per unit of human capital earned by adult females at time $t+1$, and $1-\gamma$ is the gender gap in labor market wages. ψ and σ are preference parameters. $\hat{h}_{t+1}$ is the human capital bequest made by parents to each adult child (boys and girls are equal in number and receive equal human capital bequests).[3] π_{t+1} is the productive time endowment of adult children (as discussed below, this variable combines the length of the productive adult years with the average degree of health over those years). Thus the second term of (4.1.1) is the utility parents derive from their own contribution to the child's earnings. That is, parents get a 'warm glow' from being 'good parents' (Andreoni, 1990).[4] In the third term h_0 is the stock of 'unimproved' human capital associated with nature's endowment, learning by doing/observation and any minimum legal requirements of parents regarding food, attention and training of their children. Thus, it is the 'no-schooling' stock of human capital.[5] Human capital in adulthood $h_{t+1} = h_0 + \hat{h}_{t+1}$. Therefore, the third term is that portion of child earnings in adulthood bequeathed by 'nature' and culture. With logarithmic preferences, the utility function is strictly quasi-concave and monotonically

[3] The expression $(1+\gamma)/2$ takes into account that the average child earns the average of the male and female wage.

[4] A common alternative is to assume that the portion of earnings deriving from optional parental investments ($w_{t+1}\hat{h}_{t+1}$, for males) and the 'exogenous' portion $w_{t+1}h_0$ are perfect substitutes. In addition to overstating the substitutability between them, that formulation precludes closed-form solutions in our setup. Our approach allows the transparency of explicit solutions; however, we also discuss below how thedegree of substituability affects the quantitative findings.

[5] Or if a few years of schooling is culturally-if not legally- demanded by 1880, the human capital acquired from that schooling could be also included in h_0. Connolly (2004), among others, stresses that informally acquired human capital was a significant share of total human capital into the first decades of the twentieth century.

increasing in each argument. Parental choices are made over H_t, n_{t+1} and $\hat{h}_{t+1}$, and are constrained in various ways, which we now explain.

4.2 Constraints

All adults marry for life upon reaching adulthood and make all decisions for the household's remaining life at the beginning of adulthood. Fathers work full-time. Mothers allocate time π_t among household production, market work, and children. The market earnings of fathers, mothers, and older children are spent on family consumption and developmental inputs for young and older children. By accounting for these uses of time and goods we develop below an overall budget constraint for the family.

4.2.1 The life cycle and time use

Period structure Childhood is spent under the direction and care of parents. Childhood is two periods long; 'early' and 'later' childhood. Upon reaching adulthood, adults live an additional π periods. The proportion d_t of a mother's ever-born children die in the first period of dependency. All children surviving the first period also survive the second period of dependency and the π_{t+1} periods of adulthood. During the second period of childhood surviving children may work or attend school.

Mother's time allocation Mother's devote time to household production, raising children and the labor market. Of the considerable time mothers devote to the rearing of children, some portion is 'chores,' with the rest used to advance her children's human capital development. In the first period of motherhood, mothers devote $\bar{\rho}_t$ units of time on children to activities largely unrelated to the child's quality. These include many time-costs of pregnancy, 'picking up' after children, laundry, dishwashing, etc. She spends an additional ρ_t units of time performing chores induced by each older (i.e., surviving) child. These time requirements related to the quantity of children are exogenously determined in our model by the state of household technology. Further, since most such chores require little skill, we assume that the time required is independent of the stock of mother's human capital ($h_t = \hat{h}_t + h_0$). Mothers devote e_t units of time to the development of human capital in each young child. This 'quality' time includes activities such as reading and talking to, and educational play with, the young child. It also can reflect, as in Mokyr (2000), time spent learning about and preparing safe and nutritious foods, household cleaning directed at reducing the population of bacteria and viruses in the household, or monitoring activities designed to protect the child from accidents. We suppose that the productivity of mother's time devoted to human capital increases linearly in her human capital. z_t units of time are allotted to household production in which market goods c_t are combined with mother's time to produce household consumption goods H_t. These goods are consumed by parents throughout their adult lives;

H_t also includes any household public goods which are enjoyed by children and parents.[6] Mothers may also devote time to the labor market (such time is not determined by where it is performed – home/factory/office/store – but by its pecuniary motivation). In combination, these uses of time are constrained by the π_t units of time at mother's disposal. Thus, mother's time use must satisfy

$$n_{t+1}e_t/(1-d_t) + m_t + (\rho_t + \bar{\rho}_t/(1-d_t))n_{t+1} + z_t = \pi_t \tag{4.2.1}$$

Children's time budget Although there are two periods of dependency, each surviving child has $T < 2$ units of productive time, since very young children cannot work at all and older children lack the stamina and strength and concentration to work full time (Lord and Rangazas, 2006). In early childhood all children are 'schooled' for some minimum fraction $\bar{s}$ of T. This schooling is exogenous and has no opportunity cost due to the young child's lack of strength, concentration, understanding, or learning by doing character. In the second half of childhood parents decide how much time $\hat{l}_t$ the child should contribute to the household budget through market work and how much time $\hat{s}_t$ he should prepare for adulthood through schooling. Hence, the time constraint faced by each child is given by

$$\hat{s}_t + \bar{s} + \hat{l}_t = T.$$

Sources and uses of money income In addition to goods used in household production there are goods outlays on the quantity and quality of children. Parents spend $(\tau_t + \bar{\tau}_t/(1-d_t))\pi_{t+1}(1+\alpha\gamma_t)w_th_t$ on each surviving child on clothes, housing, and other child consumption items that tend to mechanically increase with a family's standard of living, yet have little effect on child quality (such goods are the numeraire). Although we believe such expenditures to be common, they are little-treated in the literature. τ_t reflects consumption goods per older (i.e., surviving) child per dollar of potential adult earnings while $\bar{\tau}_t$ reflects consumption goods for each young child. In the 19th century such purchases of market goods were probably predominantly based on father's earnings, alone, while in contemporary times the earnings base is that of both parents. For this reason we posit that a fraction α of mother's potential earnings is included with father's earnings in determining such consumption.

Parents also spend money for children's developmental inputs. In early adulthood parents choose goods inputs $\bar{x}_t$, each unit costing $\bar{p}_t$. Since the public financing of primary schooling is independent of usage, the cost $\bar{p}_t$ of all goods inputs (including books, educational toys and broadening vacations, etc.) is less than one. For older children developmental inputs are denoted by $\widehat{x}_t$, with a cost of $\hat{p}_t$. The calibrations take into account that the high school movement dramatically lowered $\hat{p}_t$. Total goods

[6] With logarithmic preferences **mother's** time allocation proves independent of whether household productivity benefits from skilled labor; of course H_t and utility are higher when skills matter.

expenditures across all children are therefore

$$n_{t+1}(\hat{p}_t\widehat{x}_t + \bar{p}_t x_t/\left(1-d_t\right) + w_t h_t\left(\tau_t + \bar{\tau}_t/(1-d_t)\right)\pi_t(1+\alpha\gamma_t)).$$

Market earnings for a husband beginning adulthood in t are $w_t h_t \pi_t$. The potential earnings of the wife (i.e., if she devoted all time to market labor) are $\gamma_t w_t h_t \pi_t$, remembering that $1-\gamma$ is the gender wage gap. Potential household labor income also includes potential earnings of older children, given by $\mu w_t n_{t+1} h_0(T-\bar{s})$, where $\mu \in (0,1)$ reflects the wage gap per unit of human capital between adult males and children, and h_0 is childhood human capital. In a modest concession to tractability, this expression reflects the assumption that the schooling of children does not affect their earnings until adulthood. Thus the model understates parents' incentives to school young children[7], but captures qualitatively how schooling responds to changes in prices and technologies. Actual earnings of children are below potential earnings to the extent that older children spend time $\hat{s}_t$ in school. Altogether the sources of potential household money income are

$$\left(1+\gamma_t\right) w_t h_t \pi_t + \mu w_t n_{t+1} h_0(T-\bar{s})$$

Money constraint The families overall budget constraint is expressed as

$$\begin{aligned}
\left(1+\gamma_t\right) w_t h_t \pi_t + \mu w_t n_{t+1} h_0(T-\bar{s}) \quad = \quad & \mu w_t n_{t+1} h_0 \hat{s}_t + n_{t+1}\gamma_t w_t h_t \left(\rho_t + \frac{(\bar{p}_t + e_t)}{1-d_t}\right) \\
& + n_{t+1}\left(\hat{p}_t\widehat{x}_t + \frac{\bar{p}_t x_t}{1-d_t}\right) + \gamma_t z_t w_t h_t + c_t \\
& + n_{t+1} w_t h_t \pi_t \left(\left(\tau_t + \frac{\bar{\tau}_t}{1-d_t}\right)(1+\alpha\gamma_t)\right). \qquad (4.2.2)
\end{aligned}$$

The household's potential labor income is given on the left-hand side. The right-hand side gives the total spending on, respectively, the implicit costs of schooling older children, the implicit cost of mother's time devoted to quality and quantity of children, the money outlays for kids education, the implicit costs of mother's time devoted to household production, the goods used in household production.

4.3 The production of human capital

As noted when deriving the budget constraint, the production of children's human capital $\hat{h}_{t+1}$ utilizes market goods while children are young and older ($\bar{x}_t$ and $\widehat{x}_t$), mother's effective time $e_t h_t$ when children are young, and the kid's time $\hat{s}_t$ when children are older. Children's human capital for use in their adulthood h_{t+1} is given by

$$h_{t+1} = h_0 + \hat{h}_{t+1}, \qquad (4.3.1)$$

[7] The impact of early schooling on the earnings of older children is emphasized in Lord and Rangazas (2006).

where $\hat{h}_{t+1}$ is specified as:

$$\hat{h}_{t+1} = \left(b\hat{s}_t\widehat{x}_t\right)^{\theta_1}\left(bh_t\bar{s}\bar{x}_t e_t\right)^{\theta_2}.$$

The parameter b is an efficiency scalar, and $\theta_1,\ \theta_2 \in (0,1)$ are production function parameters (elasticities). Thus, all inputs are productive and subject to diminishing marginal returns.

4.4 Household production

We assume that household production is governed by the equation

$$H_t = c_t^{v_1}\left(h_t z_t\right)^{1-v_1}. \tag{4.4.1}$$

We have noted that fathers work full time in market-oriented labor and that older children work when not in school. Of course, especially in the nineteenth century, fathers and children were also engaged in household production. To the extent they work 'at home', their labor efforts are priced at their market wage and included in c_t. Intuitively, this assumes they have the same productivity in the market as in household production, and places a valuation on their household production time equal to their foregone market earnings. Consequently, the model does not require us to distinguish where the work of children and fathers is performed or whether work performed at home is for family consumption or sale to the market. Similarly, domestic servants are hired inputs and are included in c_t. As men and children leave the home, and as domestic servants are released, intermediate market goods (for example, store-bought flour and clothes, and washing machines) become more important.

4.4.1 Optimization

Parents of generation t choose the quality and quantity of children, $(\bar{x}_t,\ e_t,\ \widehat{x}_t,\ \hat{s}_t, n_{t+1})$ and their own consumption 'utilizing z_t and c_t' so as to maximize their utility function given by equation (4.1.1), subject to constraints (4.2.1) and (4.2.2). The lagrangean L is written,

$$\begin{aligned} L \;=\;& \ln H_t + \psi \ln\left(\frac{(1+\gamma_t)}{2} w_{t+1}\pi_{t+1}\left(b\hat{s}_t\widehat{x}_t\right)^{\theta_1}\left(bh_t\bar{s}\bar{x}_t e_t\right)^{\theta_2} n_{t+1}\right) + \sigma \ln\left(\frac{(1+\gamma_t)}{2} w_{t+1}\pi_{t+1} h_0\right) \\ & +\lambda \left[\begin{array}{c} \left(\mu w_t n_{t+1} h_0\left(T-\bar{s}-\hat{s}_t\right) - \gamma_t z_t w_t h_t - n_{t+1}\left(\rho_t + \left(\bar{\rho}_t + e_t\right)/(1-d_t)\right)\gamma_t w_t h_t - c_t\right) \\ +\left(w_t h_t \pi_t\left(1+\gamma_t\right) - n_{t+1}\left(\hat{p}_t\widehat{x}_t + \bar{p}_t\bar{x}_t/(1-d_t) + w_t h_t \pi_t\left(\tau_t + \bar{\tau}_t/(1-d_t)\right)\left(1+\alpha\gamma_t\right)\right)\right) \end{array}\right] \end{aligned}$$

The first order conditions (FOCs) for the optimal choices of $c_t,\ z_t,\ \bar{x}_t,\ e_t,\ \widehat{x}_t,\ \hat{s}_t,\ \&\ n_{t+1}$ are

$$\begin{aligned}
v_1/c_t &= \lambda, && (4.4.2)\\
(1-v_1)/z_t &= \lambda\gamma_t w_t h_t, && (4.4.3)\\
\theta_2\psi/\bar{x}_t &= \lambda\bar{p}_t n_{t+1}/(1-d_t), && (4.4.4)\\
\theta_2\psi/e_t &= \lambda\gamma_t w_t h_t n_{t+1}/(1-d_t), && (4.4.5)\\
\theta_1\psi/\hat{s}_t &= \lambda\mu n_{t+1} h_0, && (4.4.6)\\
\theta_1\psi/\widehat{x}_t &= \lambda\hat{p}_t n_{t+1}, && (4.4.7)\\
\psi/n_{t+1} &= \lambda\left(\left(\rho_t+(\bar{\rho}_t+e_t)/(1-d_t)\right)\gamma_t w_t h_t-\mu w_t h_0\left(T-\bar{s}-\hat{s}_t\right)\right)\\
&\quad+\lambda\left(\hat{p}_t\widehat{x}_t+\bar{p}_t\bar{x}_t/(1-d_t)+w_t h_t\pi_t\left(\tau_t+\bar{\tau}_t/(1-d_t)\right)(1+\alpha\gamma_t)\right). && (4.4.8)
\end{aligned}$$

These FOCs are interpreted in a standard fashion. To provide a few examples: Equations (4.4.4–4.4.7) govern the demand for human capital inputs. They all balance the left-hand-side marginal utility of raising human capital (and therefore child earnings in adulthood) against the utility cost of doing so. Notice that in each equation this **cost** is increasing in fertility $n_{t+1}/(1-d_t)$, so that as stressed by Becker (1981) the price of children quality is increasing in the quantity of children. Further, in (4.4.4) and (4.4.5) which govern the inputs for young perishable children, this price of quality per surviving child is increasing in $1/(1-d_t)$, since the higher is child mortality, the more children must be born in order to produce a surviving one. The cost of mother's and older child's time inputs are increasing in their respective wages. Similarly the goods input prices enter into their FOCs for goods. Equation (4.4.8) governs the choice of number of surviving children. Notice that all human capital inputs enter into the price side of this expression. So, in Becker's symmetry, the price of child quantity is increasing in its quality. Additionally, this price of quantity also increases in the various fixed costs associated with each surviving child (both goods and time, for both young and older children). Solving the system of optimality conditions above yields the explicit demand functions discussed below.

Number of surviving children The number of surviving children is driven by the equation:

$$n_{t+1}=\frac{\psi\pi_t\left(1+\gamma_t\right)\left(1-2\theta_1-2\theta_2\right)}{(\psi+1)\left[\left(\pi_t\left(\tau_t+\frac{\bar{\tau}_t}{1-d_t}\right)(1+\alpha\gamma_t)+\gamma_t\left(\rho_t+\frac{\bar{\rho}_t}{1-d_t}\right)\right)-\mu\left(T-\bar{s}\right)\frac{h_0}{h_t}\right]} \qquad (4.4.9)$$

One easily 'signed' result is $\partial n_{t+1}/\partial d_t < 0$. A decline in child mortality reduces the time and goods costs of producing a surviving child, increasing the number of surviving children (this result is also found in Becker and Barro, 1988). Thus, an effect overlooked by Soares and Falcao is that reductions in child mortality also increase the returns to *quantity* of children. As seen below, this weakens the prospects that reductions in child mortality will increase investments in child quality. The effect on fertility, $\partial\left(n_{t+1}/(1-d_t)\right)/\partial d_t$ proves ambiguous: a reduction in fertility occurs only if the fixed costs of older children exceed their potential labor income in the second period of dependency. Increased 'adult longevity' π_t also has an ambiguous effect: there is a wealth effect seen in the numerator which would serve to increase fertility. However, the price of a child also increases with π_t since a constant proportion of potential household income is spent on each child's consumption. Thus, there is a conflicting substitution effect, making the overall result in need of further assessment. Notice that parent's stock of human capital h_t is inversely related to fertility; all else the same, when human capital of parents increases the quantity of surviving children will decrease. Lord and Rangazas (2006) explain this result in terms of a declining opportunity cost of schooling children (utility loss from forgone consumption) as parental earnings rise relative to potential child earnings. Similarly the cost of quantity rises as the potential relative earnings of children fall as parent's earnings rise with parental human capital. Jones and Tertilt (2008) show that, empirically, fertility and income have varied inversely since at least the middle of the nineteenth century in the United States. Since human capital has risen over this time, and human capital increases income, this finding is supportive of the model. The calibrations reveal that parameter changes having an initial impact on human capital can become magnified for the subsequent generations.

Early investment in childhood Mothers' time and market goods invested in the human capital of younger children are given by

$$e_t = \frac{\theta_2\left(1-d_t\right)\left[h_t\left(\pi_t\left(\tau_t+\frac{\bar{\tau}_t}{1-d_t}\right)\left(1+\alpha\gamma_t\right)+\gamma_t\left(\rho_t+\frac{\bar{\rho}_t}{1-d_t}\right)\right)-\mu h_0\left(T-\bar{s}\right)\right]}{\gamma_t h_t\left(1-2\theta_1-2\theta_2\right)} \tag{4.4.10}$$

$$\bar{x}_t = \frac{\theta_2 w_t(1-d_t)\left[h_t\left(\pi_t\left(\tau_t+\frac{\bar{\tau}_t}{1-d_t}\right)\left(1+\alpha\gamma_t\right)+\gamma_t\left(\rho_t+\frac{\bar{\rho}_t}{1-d_t}\right)\right)-\mu h_0\left(T-\bar{s}\right)\right]}{\bar{p}_t\left(1-2\theta_1-2\theta_2\right)}. \tag{4.4.11}$$

Note that $\partial e_t/\partial d_t$ and $\partial\bar{x}_t/\partial d_t$ cannot be signed in the presence of fixed goods and time costs and $\bar{\tau}_t$ and $\bar{\rho}_t$. Intuitively, lowering d_t reduces the fixed costs required to produce a surviving child, inducing a substitution effect away from e_t and $\bar{x}_t$. This effect can potentially overturn the positive effects on e_t and $\bar{x}_t$ of the lower price of child quality a smaller d_t entails. Both human capital inputs rise when the productive adult life π_t increases; with consumption costs per child (unrelated to quality) increasing with π_t, there is a substitution effect away from quantity of children toward child quality. Notice that if these fixed costs were eliminated from the model, the human capital inputs would be independent of π_t. This effect, not found in Soares and Falcao, identifies a new route by which human capital increases with π_t.

Investment in older children Investment in older childhood is represented by the following relations:

$$\widehat{x}_t = \frac{\theta_1 w_t \left[h_t \left(\pi_t \left(\tau_t + \frac{\bar{\tau}_t}{1-d_t} \right) (1+\alpha\gamma_t) + \gamma_t \left(\rho_t + \frac{\bar{\rho}_t}{1-d_t} \right) \right) - \mu h_0 (T - \bar{s}) \right]}{\hat{p}_t (1 - 2\theta_1 - 2\theta_2)} \tag{4.4.12}$$

$$\hat{s}_t = \frac{\theta_1 \left[h_t \left(\pi_t \left(\tau_t + \frac{\bar{\tau}_t}{1-d_t} \right) (1+\alpha\gamma_t) + \gamma_t \left(\rho_t + \frac{\bar{\rho}_t}{1-d_t} \right) \right) - \mu h_0 (T - \bar{s}) \right]}{\mu h_0 (1 - 2\theta_1 - 2\theta_2)} \tag{4.4.13}$$

In the presence of the fixed time and goods costs of quantity, $\bar{\rho}_t$ and $\bar{\tau}_t$, the human capital inputs for older children unambiguously decline when child mortality declines, $\partial \hat{s}_t / \partial d_t > 0$. Significantly, this implies that even if e_t and $\bar{x}_t$ were to rise when d_t falls, the overall effect for the human capital bequest h_{t+1} is ambiguous; this issue is addressed through calibration. Note that π_t has the same human capital inducing effects on inputs into older children's human capital as discussed above for younger children.

Notice that increases in parent's human capital h_t, by increasing the goods purchased for children, create a substitution effect away from n_{t+1} and toward all human capital inputs, unambiguously increasing $\bar{x}_t$, $\widehat{x}_t$, and $\hat{s}_t$. However, the cost of mother's time input, e_t, also increases with her human capital. On balance, e_t still rises with h_t but to a lesser extent than the other inputs. This is consistent with the observation that the time input of children in the production of their own human capital (e.g., the high school movement) has increased by more than that of mother.

Mother's time in household production: Mothers' time in household production is given by the equation

$$z_t = \frac{(1 - v_1)}{(1 + \psi)} \frac{1}{\gamma_t} (1 + \gamma_t) \pi_t \tag{4.4.14}$$

Note that z_t is independent of d_t while the wealth effect from increasing π_t serves to increase household production. Significantly, z_t is decreasing in γ_t: The higher is γ_t, the more expensive is mother's time input, which causes z_t to fall. This is only partially offset by an endowment effect; potential family resources increase with mother's wage.

Market goods in household production: Goods inputs in household production are given by the equation

$$c_t = \frac{v_1}{(1 + \psi)} (1 + \gamma_t) w_t h_t \pi_t \tag{4.4.15}$$

This expression reveals that an increase in the relative wage of females has a positive endowment or wealth effect, which serves to increase the use of market goods in household production.

Taking the ratio of (4.4.14) to (4.4.15) shows that narrowing the gender wage gap has the intuitively appealing effect of raising the relative goods intensiveness of household production. As the relative market wages of mothers increase, store-bought goods are substituted for mother's time. This mechanism proves to be an important reason for the decline in mother's household production time, and rise in her market work time.

More generally, any increase in the household's endowment causes c_t to increase. Through time, both w_t and h_t have risen causing c_t (but not z_t) to increase. Thus the good's intensiveness of household production increases even if there is no change in γ_t. Since there was a gradual reduction over time in the time devoted to household production by children and domestics (whose time inputs are implicitly valued at the opportunity cost of children or wage of domestics), the rise in store-bought goods characterizing the second industrial revolution is well-reflected by this depiction.

Female labor market work The mother's time constraint was given in (4.2.1). That equation shows that mother's labor market time increases with endogenous reductions in her household production and child investment time, and in the number of surviving children. Calibration exercises reveal that a given parameter change (or combination of changes) can have opposing effects on these components of mother's time use.

5 The calibration

This section examines the evidence used to specify the parameter values chosen to calibrate the initial baseline. In some instances the time path of the parameters and of the calibration targets is also discussed; in other instances this is undertaken in the results section.

5.1 The calibrated value of d_t

The expression $1/(1-d_t)$ is the ratio of live births to those surviving young childhood. In the model, the goods cost per surviving young children $\bar{\tau}_t$ per dollar of potential parental earnings would then be multiplied by that ratio to generate the goods costs of quantity, given mortality rates, of producing a surviving young child. In the data, it is fairly straightforward to determine the age 10 mortality rate. However, calculating the d_t to be used in the calibration process is a bit more complicated. To see why, suppose there is some constant goods cost c, say, per year associated with a child surviving to age 10[8]. The estimate $10c/(1-d_t)$ exaggerates the cost of producing a child surviving to age 10, because those dying as infants, for example, impose no tangible costs in subsequent years. Annual death rates by age are provided beginning in 1900 for those age 0, 1-4, 5-9, 10-14, etc. in Historical Statistics of the United States (Vol. 1, Ab989, p. 473). These data permit the following estimate of the fixed goods costs of

[8] To our knowledge, there are no compelling age-consumption goods profiles for child consumption for the late 19th or early 20th centuries.

producing a child surviving to age 10:

$$\frac{c\,(1+S_{1t}4+S_{2t}5)}{1-d_t},$$

where d_t is the proportion of live births failing to reach their $10th$ birthday. $S_{1t}(S_{2t})$ are the probabilities of surviving into years 1-4 (5-9). For 1905, the fraction dying in the first year is .14. Using the preceding historical statistics, S_1 is calculated as the average of the proportion surviving the first year, .86, and that of those surviving the fourth year .80, or .83. S_2 is the average of .80 and .78, or .79. Using the expression above, the cost of a surviving child is then:

$$\frac{c\,(1+.83(4)+.79(5))}{.78}=0.827(\frac{10c}{1-d_t})=1.06(10c).$$

Thus in our calibration model $1/(1-d_{1900})=1.06$, so that d_{1900} is .057 (whereas if based on survivorship through 10 years, or .78 of births, d_t would have been the much higher .22). Since the 'age 0' rates may be a bit high, we round down to set $d_{1900}=.05$.[9] The same calculations for 1930 produce $c\,(1+.94(4)+.92(5))\,/\,(.92)=1.029(10c)$, so that the calibration = .02 (with rounding). The calculation for 1880 is made more complex by the absence of the sort of detailed data available for 1900 and 1930. However, Preston and Haines (1991, p. 54) report an infant mortality rate for 1880 of about 21%, with about 29% dying before their $5th$ birthday. In the absence of data, we assume that 36% have died prior to their $10th$ birthday. The calculations for 1880 are then: $c\,(1+.75(4)+.70(5))\,/(.64)=1.17(10c)$, so that $d_{1880}=.15$.

5.2 Mother's time allocation to child quantity

Similarly, $\bar{\rho}_t$ (the fixed time required of mother per young child unrelated to child quality) is multiplied by $1/(1-d_t)$ to find the fixed time costs per surviving child. The calibration of $\bar{\rho}_t$ involves several steps. Ramey (2008) exploits time use surveys conducted in the 1920s to estimate how housewives' time spent in home production varied with the number and ages of children in the first half of the twentieth century. She finds that a woman with no children and at least some high school spent 44 hours per week in home production, the presence of children increased mother's time in housework. The additional time required by a child decreased as the child matured: a child under one year of age added 17 hours to the housewives' work week. Indeed, Albanesi and Olivetti (2007) estimate that breast feeding alone requires about 14 to 17 hours per week during the first year. If the youngest child was between one and five years, Ramey finds housewives spent almost seven extra hours per week and if the child was between six and 15 years of age, the housewife spent an extra 2 hours per week.

[9] The documentation for 1905 and 1930 in series Ab989 does not make clear whether the 'age 0' deaths include fetal deaths (stillborns). Table Ab920 provides infant mortality rates for selected years, which fall somewhat short of the 'age 0' numbers. The differences are not so significant as to affect any interpretations.

Albanesi and Olivetti (2007) estimate that early in the twentieth century episodes of incapacitation of mother during pregnancy and/or following childbirth were more prevalent than today, with each pregnancy, on average, associated with 4.5 unproductive months. All of the pre-pregnancy time loss and some portion of the post-pregnancy time costs should be added to the Ramey figures. We assume incapacitation costs added an average of 8 weeks per pregnancy. Taking a full-time work week to be 70 hours, 8 weeks represent 560 hours, which divided by 52 weeks implies over 10 hours per week should be added to the first year. Hence over 10 years of young childhood, the total time spent is about $(17 + 10) + 5(7) + 4(2) = 70$; divided by 10 years gives 7 hours per week on an average child surviving through the first 10 years. Based on a 70 hour work week, this is about 10% of mother's time endowment per week.

A final question concerns the disposition of these time costs between activities promoting child quality and those concerning quantity. Initially we suppose they are approximately equal. During later childhood, the time spent between 10 and 20 years of age is around 2 hours per week, requiring 2.9% of the total weekly time of a housewife.

5.3 Relative female wage, γ_t

Goldin concludes that the "ratio of female to male earnings in the economy as a whole rose from 0.46 to 0.56 during the period 1890-1930....(1990, p. 63)." We assume this trend was evident in 1880 so that $\gamma_{1880} = .43$, $\gamma_{1905} = .50$ and $\gamma_{1930} = .56$.

5.4 Returns to scale

As seen in the human capital investment equations (4.4.10) to (4.4.13), the higher are the returns to scale, the higher are the human capital inputs for a given value of the net fixed costs of child quantity, $w_t h_t \left(\pi_t \left(\tau_t + \frac{\bar{\tau}_t}{1-d_t} \right) (1 + \alpha\gamma_t) + \gamma_t \left(\rho_t + \frac{\bar{\rho}_t}{1-d_t} \right) \right) - \mu h_0 (T - \bar{s})$. Thus the returns to scale are not chosen independently. In the baseline simulation the best model fit is where $\theta_1 = \theta_2 = .15$. Thus, if there were 10%, say, increases in all of the human capital inputs that change from period to period (h_t, e_t, $\hat{s}_t$, $\bar{x}_t$, and $\widehat{x}_t$), human capital production h_{t+1} would increase by 7.5%, so total returns to scale would be .75. Similarly, the total returns from doubling all goods inputs $\bar{x}_t + \widehat{x}_t$ (or all student time inputs $\widehat{s}_t + \bar{s}$) are $\theta_1 + \theta_2 = .30$. These returns to scale fall in the mid-range of values used in the literature (Lord and Rangazas,1993 and Browning, Hansen, and Heckman, 1999). Increasing the returns to scale from a given baseline would induce parents to increase their human capital bequests, which increases positively all choice variables related to adult human capital in the subsequent period.

5.5 Time available for teenagers to work

The optimal value of each human capital choice variable is decreasing in $\mu h_0 (T - \bar{s})$, while the number of surviving children is increasing in that term. These implications are immediately understandable as $\mu h_0 (T - \bar{s})$ is the earnings a child could contribute toward the family budget were there no schooling beyond that nearly universally provided to all children by 1880, $\bar{s}$. The higher are these potential earnings the less expensive are children of a given quality, increasing the attractiveness of additional children and increasing the relative price of child quality. These potential earnings may be foregone when time is devoted to school, explicitly realized when children are employed outside the home in wage labor, or foregone when children are engaged in the household production of H_t. When they do work at home their time is valued at the market wage and this expense is reflected in the goods cost of the household production good.

The direct monetary contributions of children were significant in the late $19th$ century, but had become insignificant by the middle of the twentieth century. Their contributions declined to a large degree because of choices endogenous to our framework; the high school movement increased the time older children devoted to human capital accumulation $\hat{s}_t$, reducing the time available to work. Exogenous to the framework are compulsory schooling and child labor legislation (Puerta, 2009) as well as changes in the cultural norms affecting the expectations of parents regarding the extent and purpose of work among teenagers (Zelizer, 1994). These latter changes all reduce the time available $(T - \bar{s})$ for those impacted by the policy. However, children directly impacted by such policy–those working more and attending school less–were concentrated at lower levels of parental earnings (Goldin and Parsons, 1989). Consequently, the median household we address may not have been much affected by work restrictions or compulsory schooling laws.[10] For this reason, we hold $h_0 (T - \bar{s})$ constant over this interval.

The ratio of a child's wage per unit of human capital to that of an adult male is assumed to be constant at $\mu = .3$. This estimate is derived from Goldin and Parsons, dividing the earnings per child of different ages from 10-19 and gender by their probabilities of working, and then averaging. Someone who undertakes no learning subject to opportunity cost (that is, just learning by doing or very early

[10] Zelizer (1994) argues that as the economic contribution of children declined, there was a shift in the perception of parents toward children; they became 'emotionally priceless," even if there were no longer economically significant benefits (and, of course, large costs). In her view, child labor as a source of household income became reprehensible. Children could still have small jobs and chores, but only insofar as these help develop character and good work habits. Any earnings would be retained by the children in order to develop the ability to manage money. As children worked less in and out of the home, organized leisure increased. Boy and cub scouts, girl scouts and brownies, boys and girls clubs of America, Demolay, Pop Warner (later pee wee) football, and American Legion baseball are significant examples of youth organization which had their origins in the first decades of the twentieth century.

In the limit as $(T - \bar{s})$ approaches 0, the positive effect of parental human capital h_t on mother's time investments in early child education e_{th} and the negative effect of h_t on fertility vanish. Additionally, the effect of any reduction in child mortality d_t or fixed time costs per child ρ_t or $\bar{\rho}_t$ on all human capital choice variables is either less negative or more positive the smaller is $\mu h_0 (T - \bar{s})$.

education) is normalized to $h_0 = 1$.

5.6 Other parameters

Reflecting the public school movement of the mid-nineteenth century, we set $\bar{p}_t = .5$, as there remained some rate bills at higher ages, outlays for books and other home inputs, and transportation costs. This price is unchanged over the calibration. The price of schooling inputs to older children for 1880 is $\hat{p}_t = 0.85$. This price is set below one since some free or subsidized public high schools were available in 1880. As the high school movement proceeds, $\hat{p}_t$ falls as described in the next section.

Other parameters are 'free' and used to pin down the initial baseline. In particular, the exponent on mother's time $1 - v_1$ in household production is set at .26 for 1880 in order to allow the time mothers devote to market to match the figure from Table 1. We discuss later whether $1-v_1$ may change through time. Initially, parents and their children each have four periods of adulthood so that $\pi_t = \pi_{t+1} = 4$. There is little direct evidence on the portion of parental income devoted to the private consumption goods of young and older children. Modern estimates of the non-human capital outlays on children in 2006 for middle-income families give an estimate of around 6%.[11] Supposing private consumption expenditures on children were a superior good in the twentieth century, we set $\tau_t = .02$ and $\bar{\tau}_t = .025$, or 2% and 2.5% per child (so if income is distributed evenly across the four periods of adulthood, 8% of first-period income would be spent on each young child's private consumption). The efficiency parameter b in the production of human capital is chosen to have h_{t+1} be reasonable in relation to h_0. The taste parameter ψ is used to pin down fertility. The full set of parameter values is shown in Table 2.

[Insert Table 2 here]

6 Calibration results

6.1 Initial baseline

The calibration of the initial baseline for 1880 is quite good as seen in the first column of Table 3. Fertility $n_{t+1}/(1 - d_t)$ is 4.84 or right at the 4.9 for the cohort of young mothers in 1880 (see earlier discussion). Mothers devote 3.8% of their time endowment to furthering the human capital of each young child (compared to the target of 4.5%). Mothers devote $e_t = 9.5\%$ of their adult time endowment to market-oriented activities, very close to the 9.2% estimate reported in Table 1. Mothers

[11] This estimate by the United States Department of Agriculture is in undiscounted dollars and subtracted from total outlays costs of healthcare, education and child care, and 2/3 of food. See http://www.cnpp.usda.gov/Publications/CRC/crc2006.pdf

spend one-third of their time on the direct care of young children in the first period of adulthood, $n_{t+1}(e_t + \bar{\rho}_t)/(1 - d_t) = .32$. They spend almost 10% of their time on child-related activities for older children, $\rho_t n_{t+1} = .094$. Most time over the adult female life cycle (3.21/4) is devoted to household production of private and public goods (100% of time is spent in household production in the third and fourth, or 'empty nest', periods of adulthood). Older children devote 8% of their time to schooling, so that $\bar{s} + \hat{s}_t = .17 + .08 = .25$, which corresponds to the 5 years of schooling achieved for the cohort born in 1880. The total human capital bequeathed to children of the 1880 parents is $h_{t+1} = 1.25$. Since the base (or unimproved human capital) is normalized to $h_0 = 1$, this implies that the return to each of the five years of formal schooling received by the average student in 1880 was not quite 5% (Golden and Katz, 2008 Table 2.5 p. 78-79).

6.2 Simulating the young adults of 1905 and 1930

The calibrations enable an initial quantification of many factors influencing the demographic transition and the shift from home to market among married females. We first see how well health-related stories alone can explain the trends in schooling, fertility, and female market work. Next, we return to the initial baseline to consider quantitative implications of several mechanisms discussed in the literature. Then, we combine the health and other explanations. Finally, we consider a couple of additional mechanisms which enable a better fitting of the facts.

6.2.1 Reductions in child mortality

We first consider the decline in child mortality, all else constant. As noted above, the 'effective' d_t falls from .15 in 1880 to .05 in 1905 and to .02 by 1930. The results of this are shown in Table 3. Due to considerations of space and focus we discuss only implications for time allocation (the patterns for market goods are parallel except when noted). Of greatest significance is the finding that the decline in child mortality impedes rather than stimulates the quantity/quality tradeoff: maternal investments e_t, schooling investments by older children $\hat{s}_t$, and the human capital bequeathed to each child h_{t+1} all decline, while the number of surviving children increases, as does fertility (for fertility, the year-specific survival rates are used to convert the number of surviving children to fertility). Recall that lower d_t unambiguously reduces investments in older children since it lowers the price of quantity (increasing the relative price of quality). However, declines in d_t increase the benefits of quality investments in younger children and lower the price of quantity. Our simulations show that the latter effect dominates so that maternal investments per child fall about one-third. Only for appreciably lower values of $\bar{\tau}_t$ and $\bar{\rho}_t$ would lower child mortality increase human capital.

That reductions in child mortality, ceteris paribus, impede the demographic transition is novel. However, as noted below, the same factors contributing to reductions in mortality typically also reduce morbidity, so that the ceteris paribus assumption is unwarranted. The number of surviving children rises by 2.5 children per woman. If reductions in child mortality do not explain the rise in quality (fall in quantity), might other aspects of the health revolution be capable of doing so?

6.2.2 Improvements in morbidity

Bleakley's evidence regarding the decline in morbidity among young southerners following the eradication of hookworm may not be an isolated example. Declines in malnutrition, sequale from tuberculosis, malaria, smallpox, cholera, typhoid, other diarrheal episodes, exposure to animal waste products, industrial and other work related accidents all contribute to morbidity. Fogel (2004) and Abdus and Rangazas (2010) stress changes in adult height or body mass as indicators of changes in overall net nutrition and health. The heights of adult men entering Amherst College increased from 169.9cm in 1870 to 178.1cm in 1935.[12] This suggests that even upper middle class households were susceptible to significant physiological insults in the nineteenth century, and that the extent of such insults declined through time. In modern Brazil a 1% increase in height has been found to increase earnings by 7.7% (Strauss and Thomas, 1998). However, only much smaller wage gains are associated with extra height in contemporary developed economies (Case et al. 2009).[13]

Bleakley (2009), though, offers compelling evidence that reductions in morbidity can have significant positive effect on wages. He concludes that the combined effects of the eradication of hookworm and malaria in the America South of the early 20th century increased income by 25% compared to states not experiencing reductions in malaria and hookworm. Also of importance, Costa (2009) finds that between 1910 and the 1990s functional disabilities declined by 0.6% per year among men age 60-74; she also reports "that the average decline in chronic respiratory problems, valvular heart disease, arteriosclerosis, and joint and back problems was about 66% from the 1900s to the 1970s and 1980s, a decline of 0.7% per year (Costa, 2009, p. 2)." According to Costa, the reductions in joint and back problems were a consequence, in part, of changes in the occupational structure from farm, craft, and common laborer jobs to professional and proprietor employments. Of course, musculoskeletal problems and arteriosclerosis, in particular, often do not impact health greatly before age 40.[14] We envision that

[12] Historical Statistics of the United States, Vol. 2, P. 582, Series BD661.

[13] Further, net nutrition may have been greater in 1900 America than in modern Brazil.

[14] Ashraf, Lester and Weil (2009) find only small gains in income from health improvements in a general equilibrium simulation of contemporary developing economies. Immigration was a significant source of labor supply in the United States at the end of the 19th century and the first decades of the 20th century. This makes the applicability of their results to the United States of the 19th century unclear. Their framework also stresses the role of increased longevity which we have chosen to ignore (since in the U.S. increased longevity was associated with shorter, not longer, work lives). Bleakley

morbidity reductions induced changes in earnings from a combination of: 1) increased productivity of human capital inputs; and 2) the ability to use given human capital for a greater portion of the productive adult years.

Morbidity among children may reduce the ability to concentrate and endure, compromising not only the ability to do physical labor for long periods, but also the ability to absorb extended and/or high-level academic lessons. In this way, a reduction in morbidity extends the capacity to focus and increases the productivity of the student's time input. Using our framework, this can be calibrated in two ways. One approach would is to increase the efficiency parameter b in the human capital production function, thereby increasing the human capital derived from any human capital investment. Although plausible, this approach has the drawback of not affecting the human capital inputs in the period where b increases; with logarithmic preferences optimal input choices are independent of b. Consequently, an increase in b at the end of the nineteenth century would not induce any rise in high school attendance until the parents of 1930 make their human capital bequest. Thus, neither the national high-school movement nor the rise in schooling in the South following eradication of hookworm could be explained by this mechanism.[15] That said, the increase in human capital induced by a higher b leads to greater investments in the following period, since inputs rise with h_t. Thus, this mechanism may help explain the rise in human capital over longer periods.

A second avenue is to increase the returns to scale in the production of human capital; this is the approach followed in the simulations. Intuitively, returns to scale increase with the ability to maintain focus for longer periods of study, which increased physical endurance enables. To capture this change we increase θ_1 and θ_2 each from .15 in 1880 to .16 in 1905 and to .17 in 1930; this increases the total returns to scale among reproducible inputs from .60 in 1880 to .64 in 1905 and .68 in 1930. The implications are shown in Table 3 in the θ columns (d_t is reset to its baseline value). Increasing the returns to scale does produce a directionally-correct quantity/quality trade-off; fertility falls and human capital increases. Indeed, a fertility of 2.36 is quite close to that achieved by brides of 1930. Human capital – and therefore male earnings – rise by 20% (from 1.25 to 1.50). However, the implied increase in human capital time investments is too small. Recall that total schooling investments are $\bar{s} + \hat{s}_t$. This

(2009) attemps to reconciles the microeconomic evidence (such as we employ) with their macroeconomic findings.

[15] Notice that our framework easily incorporates skill-biased technical change (SBTC) so long as the median household is constrained in the sense of Becker and Tomes (1986). In their framework, constrained parents are those who bequeathe less than the fully efficient human capital bequest. With a return to high school almost 10 percent in 1880, yet few students attending, most parents appeared to have been constrained. An episode of SBTC would increase the wage per unit of human capital of children in their adulthood w_{t+1}. For constrained households an increase in w_{t+1} has an ambiguous effect on human capital bequest. It entails a substitution effect serving to increase investments in child quality but an income effect inducing parents to increase own consumption at the expense of human capital investments. In our framework, the income and substitution effects just offset, so that fully anticipated increases in the child wages from SBTC do not affect the parents investments (of course, the earnings and utility of the children are increasing in w_{t+1}).

increases from .17 + .08 = .25 in 1880 to .17 + .144 = .31 in 1930. Years of schooling attained by the children of households formed in 1880 was about 5 (Murphy, Simon, Tamura, 2008, Table 8, p. 274) and rose to about 10.5 for households formed in 1930. This implies total schooling time should rise to about .52 (so $\hat{s}_t$ should rise to about .35) to fully account for the high school movement. However, this experiment increased schooling by only $1/5th$ the required amount. The mother's time devoted to quality per child e_t rises about 70% (Mokyr provides no guidance for the appropriate increase).

[Insert Table 3 here]

The fraction of adult life devoted to market work by married females – the top numbers in the m_t row – rose from .095 or 9.5% of the adult time endowment to 11.2% (.36 and .49 units of time on the 4 period basis – the bottom numbers in the m_t row). Recall from Table 1 the estimated portion of adult life devoted to market work by married females attaining adulthood in 1930 was 18.1%, so the calibrated reductions in fertility combined with increased maternal investments per surviving child does not release enough additional time for market work.

Morbidity reductions, as noted, can also manifest as an increased capacity to use given skills in adulthood. Assume Costa's 0.7 percent average annual reduction in chronic respiratory problems, valvular heart disease, arteriosclerosis, and joint and back problems is also applicable to the period 1880-1930. Then, such debilitating adulthood conditions would be almost 30 percent lower in 1930 than 1880. We suppose this increases the proportion of the adult years available for productive work by somewhat less than half that 30 percent decline. Thus, we quantify the implications of these health improvements in adulthood by an increase in the quantity of effective adult life π_t from the initial baseline of 6.2%, or from 4 to 4.25 by 1905 and another 6.2% to 4.52 by 1930. This reflects some combination of increased days worked and increased vitality and productivity on days worked.

Restoring d_t, θ_1 and θ_2 to their initial values, the increase in π_t increases human capital investments in children, reduces fertility and increases mother's life cycle market work. Indeed the results are muted versions of the effects of increasing returns to scale (if the shares of the total increase in earnings between the two sources–returns to scale and effective adult time endowment–had been roughly equal, the quantitative implications would have been quite similar also). What drives the result here is non-standard, though. The increase in π_t increases life resources, which has positive wealth effects on goods used in household production and fertility, but not on child quality in adulthood (human capital per adult child). Thus, fertility is normal, but the impact of the income elasticity for quality is zero. Intuitively, the marginal price of quality is rising with investments because of the decreasing returns to scale, but the price of quantity of children (for given quality) is constant. Thus, after the relative prices pin down quality, all additional resources go to quantity. However, these relative prices do change as π_t rises. Since the standard of living of children rises with resources (via τ_t and $\bar{\tau}_t$) the price of an additional child rises when π_t increases. This induces substitution away from quantity toward quality. Overall, quality rises and the substitution effect dominates on quantity, decreasing the number of surviving children. One might notice that the expression for mom's time in household production (eq. 4.4.14) is increasing in π_t, yet is constant in the Table 3. This is because the table is reporting actual (not effective) time. Since the effects of increasing π_t and θ are similar, we might view the π_t changes alone as capturing the lower bound effects of improved morbidity.

As a final 'health' experiment we combine all of the parameter changes from above, for d_t, θ_1, θ_2 and π_t. In Table 3 these results are under the 'All Health' columns. This experiment hits some targets directly. For example, fertility is 2.28 children in 1930. Human capital has increased from 1.25 in the baseline to 1.58, a cumulative of 26.4%. This increase reflects both the impact effects of the parameter changes on children's human capital, as well as the effects on children's human capital in subsequent generations induced by the resulting higher parental human capital. However, the rise in the time inputs of older students remains too low as does mother's market work time. We therefore consider other potentially important mechanisms to see if they can improve the model's overall fit.

6.2.3 Other explanations

Starting from the baseline, Table 4 (the γ_t columns) shows the implications of increasing the ratio of adult female to adult male wages from .43 in 1880 to .56 in 1930 (extrapolating from Goldin 1990). This narrowing of the gender wage gap has a slightly positive effect on human capital and a moderately negative effect on the number of surviving children. Thus as a stand-alone explanation of the evolution of child quality or quantity it contributes little. However, rising γ_t induces mother's to curtail the now-more-expensive time they devote to household production and this frees time for increased market work. Indeed, by 1930 time devoted to market work by mom has risen to 24% of her adult time endowment, exceeding the 18.2% from Table 1. (Of course, absent the depression-era strengthening of marriage bars actual time worked by the 1930 cohort would have been larger). With our functional forms the own relative price elasticity of demand for the household production input z_t is one, so that the large rise in mothers' relative wage induces a significant drop in their time input. This substitution effect is in part offset by a positive wealth or endowment effect as seen in the numerator of equation 4.4.14. Additionally, the same rise in γ_t directly increases the use of goods inputs in household production, see (4.4.15). Thus, rising relative wages for women increase the ratio of goods inputs to mother's time in household production. This explanation for the rise of women's market work differs from that suggested by Greenwood and Sheshardi in their oft-cited 'Engines of Liberation.' In their story, household work falls as household capital goods become less expensive; this increases purchases of labor-saving appliances, 'pushing' mom into the labor force. In our framework, it is the rise in mother's relative wage which pulls her into the labor market, with her displaced home production time imperfectly offset by rising market goods (which could be conceived to be household capital goods, since we do not distinguish between durables and non-durables). Goldin (1990) argues that the office revolution increased the returns to education for females and increased their schooling. This led to a narrowing of the gender wage gap. Adeshade (2009), however, argues that the office machinery central to the office revolution was the result of induced technological change. In her view, an 'exogenous' increase in female schooling provided the impetus to invent, manufacture and install skill-biased office machinery. Suppose Adeshade is correct, but the high school movement is instead due to improved health. Then the narrowing of the gender wage gap itself may also be related to health improvements.

The economic environment was changing in other important fashions over this period. To capture some of these changes we extend the non-health explanations to simultaneously include a rising wage per unit of human capital w_t (perhaps a consequence of physial capital deepening). We also now incorporate falling fixed time costs in child rearing ρ_t and $\bar{\rho}_t$, and falling prices for educational inputs used by older children $\hat{p}_t$. Thus, the γ_t changes are kept, the wage per unit of human capital grows by 25% of the base value by 1905 and another 25% by 1930. Fixed time costs per young child fall from 4.5% of mom's time while the child is young in 1880 to 3.7% in 1930. The reduction for older children is from 2.9 to 2.5%. Finally, $\hat{p}_t$ falls from .85 in 1880 to .25 in 1930, reflecting the public financing of the high school movement. Table 4 reveals these combined stories (but exluding health) do not stimulate human capital nearly enough, and entail fertility that is far too high. Mom's labor supply is also too high. If we allowed a greater reduction in the fixed time costs of children (reflecting Greenwood and Sheshardi type of changes) fertility would then be higher yet and it would be unclear whether human capital would rise or fall.

[Insert Table 4 here]

We now consider simultaneously all of the parameter changes in all of the 'health' and 'non-health' stories. These results are shown in Table 3 in the 'All' columns. The results are, for many variables, quite satisfactory. Fertility for 1930 is close to the mark at 2.17. Also, human capital increases 50% from 1.25 to 1.88 which, when combined with the increases in the wage per unit of human capital and increase in effective time, allows real earnings per adult male to more than double. Modest problems remain. In particular, whereas in the simulation $\hat{s}_t$ rises from .08 to .20, it needed to rise to .35 to reflect the actual increase in time spent in school. Also, at 26.7% the portion of the productive years devoted to market work by married females is about 50% too high. We now consider modifications which improve the overall fit.

First, we have modeled the public provision of high school as a reduction in the price of goods inputs (i.e., school buildings and teachers). This did not induce the 'high school movement' in terms of increased schooling time by older students: with our functional forms the human capital production function entails a zero cross-price elasticity, so the reduction in $\hat{p}_t$ increases the goods inputs, but not the time input. Suppose instead that the school buildings and teachers raise human capital only if used in conjunction with student time. In particular, suppose $\widehat{x}_t$ and $\hat{s}_t$ are perfect complements. The human capital production function becomes:

$$h_{t+1} = \left(b \min\left(\hat{s}_t, a\widehat{x}_t\right)\right)^{\theta_1} \left(b h_t e_t \left(\bar{s}\bar{x}_t\right)\right)^{\theta_2} \tag{6.2.1}$$

Since $\hat{s}_t = a\widehat{x}_t$ upon optimization, the above equation becomes:

$$h_{t+1} = \left(ba\widehat{x}_t\right)^{\theta_1} \left(b h_t e_t \left(\bar{s}\bar{x}_t\right)\right)^{\theta_2}. \tag{6.2.2}$$

The optimal value for $\hat{s}_t$ is now

$$\hat{s}_t = \frac{a^2\theta_1 w_t \left(h_t\left(\pi_t\tau_t(1+\alpha\gamma_t) + \gamma_t\left(\rho_t + \frac{\bar{\rho}_t}{1-d_t}\right)\right) - \mu h_0\left(T - \bar{s}\right)\right)}{\left(\hat{p}_t + a\mu w_t h_0\right)\left(1 - a\theta_1 - 2\theta_2\right)}, \tag{6.2.3}$$

which shows that the reduction in $\hat{p}_t$ from public provision of high school now has a positive effect on $\hat{s}_t$. Most other results are little affected. Consider the number of surviving children:

$$n_{t+1} = \frac{\psi\pi_t(1+\gamma_t)\left(1 - a\theta_1 - 2\theta_2\right)}{(\psi+1)\left(\left(\pi_t\tau_t(1+\gamma_t) + \gamma_t\left(\rho_t + \frac{\bar{\rho}_t}{1-d_t}\right)\right) - \frac{\mu h_0(T-\bar{s})}{h_t}\right)}, \tag{6.2.4}$$

which is the same as before if $a = 2$.

In general, by setting $a = 2$ and adjusting the efficiency parameter b we can replicate the initial baseline with a small difference in $\hat{s}_t$ and $\widehat{x}_t$. In the new baseline $\hat{s}_t = .065$ (as opposed to .08 in the original model). This makes the baseline total time $\hat{s}_t + \bar{s} = .235$ and changes the target for 1930 to .493 (again as moving from 5 to 10.5 years of schooling). Now, though, reductions in $\hat{p}_t$ have positive effects on $\hat{s}_t$(and smaller effects on $\widehat{x}_t$). With this specification, employing the full set of parameter changes we find that for 1930 $\hat{s}_t = .32$, exactly what is needed to meet the target.

There are several ways to address the issue that mother's market work is too large. One is simply to argue that marriage bars reduced the actual market work of married females compared to their plans as given by the model. Another is to re-visit the Mokyr and Greenwood /Sheshardi arguments. The last two rows of Table 4 reveal that there is a reduction in time devoted to younger and older children totaling

.137. Even though mothers spend an extra .03 on each child's quality (as suggested by Mokyr), this is more than offset by reductions in fertility and reductions in the fixed time costs per child. However, since the increase in m_t is .69 (or 17% of the time endowment), the main increase in female market work comes from a reduction in household production time z_t. This reduction is, as noted above, induced by the increase in γ_t, which increases goods inputs c_t and reduces mother's time input. Recall, that the c_t consisted of market goods (including any explicitly purchased domestic servants or laundresses and the imputed value of any time devoted to household production by family members other than mother). Suppose that between those households formed in 1880 and 1905, increases in canned goods, store-bought clothes and bread, as examples, were just offset in cost terms by reductions in the time of domestics and other family members. Indeed the use of domestics fell rapidly in the early decades of the twentieth century and daughters who were 'at home' among the households formed in 1905 had left the home to go to school for the households formed in 1930 (Goldin, 1990). For the households forming in 1930, a mother was pretty much the household labor force for the median household. And, compared to mothers of 1905 the extra driving, shopping, and cleaning she had to do may have more than offset the time savings from electricity, vacuum cleaners and store-bought substitutes for her home production output. That is, there was 'More Work for Mothers' among households of 1930. To capture this possibility in the framework, suppose the exponent on z_t $(1 - v_1)$ increases by .03, from .26 to .29. That is, the share of market goods (including implicit and explicit outlays for household laborers, as well as durable household capital) falls from .74 to .71 for the household of 1930. Inspection of the demand functions above reveal that this change has no effect on the demands for human capital inputs or surviving children. However, it will reduce z_t to .76 , very close to the .73 –or 18.2 percent of total time- indicated in Table 1.

7 Summary

There was a revolution in the American family between the latter part of the nineteenth century and the first half of the twentieth century (which has continued unabated since). Births and deaths fell, investments in children rose, and mothers began their long-term migration to the market from the home. We developed a calibration model to examine the extent to which the health revolution, characterized here by declining child mortality and declining morbidity throughout life, could explain these facts. Especially when coupled with more traditional explanations, the model can fit the stylized facts of the period well.

Our formulation suggests that decreases in child mortality were not, by themselves, likely to have been significant drivers of the decline in fertility, rise in human capital, or rise of married women's market work. Although lower mortality increases the returns to maternal investments in young children, it also lowers the cost of surviving children (of given quality). This latter effect proves dominant in our calibration. On the other hand, reductions in morbidity raise the return to–and investments in–human capital, as well as increase the extent to which human capital can be applied. Both of these effects stimulate the demographic transition, lowering fertility and increasing human capital investments. However, increased maternal time investments in children and reduced fertility have opposite effects on mother's non-market time commitments and therefore morbidity decline cannot, alone, explain the rise in adult female market orientation. In this model the closing of the gender wage gap contributes in an important way to the rise of female market orientation. A higher relative wage causes households to shift away from reliance on mother's time in household production, and toward market goods. Thus, higher relative wages pull females into the labor force. In contrast, the Greenwood, et. al story regarding household production is that household consumer durables reduce the value of mother's time in the home sector, 'pushing' them into the labor market. The model is capable of explaining the high school movement following free provision of schools in a special case where student time and educational goods inputs (schools and buildings) are perfect complements.

Significantly, the model can explain the relevant stylized facts without invoking skill-biased technical change. While we do not question the importance of skill biased change, it is intruging that Margo (2000) and Goldin and Katz (2008) both report skill premiums for the antebellum period quite similar to those observed at the onset of the high school movement. This makes it interesting that one need not invoke SBTC (skills biased technical change) to 'set off' the high school movement and the rise in women's market orientation. That said, the reductions in morbidity increase the returns to education-as does SBTC- so the mechanisms are complementary rather than exclusive. Future work should attempt to tease out the relative contributions.[16] An additional avenue of research would incorporate the features of this paper's model into a unified growth framework (cf. Galor, 2005; Galor and Weil, 2000; Ashraf, Lester, and Weil, 2008, Doepke, Hazan and Moaz, 2007). Such an extension would prove daunting: the resulting framework must then not only explain the phenomena disscussed in this paper but also prove capable of encompassing the subsequent baby boom, and then bust, as well as the continued increases in human capital and female market work.

[16]SBTC is not necessary to explain these movements. However, the changes in technology that produced the office revolution, or rise of the service sector, may nonetheless have played an important role not captured by our analysis or in conventional models of SBTC. Goldin (cf 1990) has spoken to this by noting that female clerical (or 'pink collar') employment increased a young female's prospects for interacting with and marrying a high-earning, well-respected white-collar or other professional male. Clerical jobs-which in general required some high school or business school training- also were more pleasant in terms of cleanliness, noise, and safety. Thus, although the conventionally measured skill premium may have been high for some decades, the non-pecuniary benefits may have risen during this period.

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