Revolution in Fertility, Schooling and Women's Work, 1875-1940: Assessing Proposed Explanations

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Abstract

The era between the Civil War and WWII was one of revolutionary change within the American family. Family size continued its long-term decline and by the 1930s fertility was not much above contemporary levels (later rising during the baby boom). 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. Horrific rates of infant and child mortality declined dramatically (with more gradual gains since). Thus, this interval contained the emergence of many important features of contempoary families. This paper considers these trends jointly through calibration of successive generations of representative husband and wife households who choose the quantity and quality of children, household production, and the extent of mother's involvement in market-oriented production. One important contribution is that standard explanations such as rising wages, declining mortality, skill-biased technological change, curriculum improvements during the high school movement, reductions in morbidity, and reduced time costs of children cannot in combination reduce fertility to observed levels or increase stocks of human capital to levels seen to be necessary by the calibrations. Instead, a rising relative preference for child quality over quantity is also required, leading to an increased share of potential family income devoted to child education, child consumption and an increase in time mother's investments in child quality. A second significant contribution is the gathering of information and strategies employed to present reasonable quantitative depictions of the behavior of cohorts over an interval in which significant data limitations are pervasive.

Keywords: American Family, Quantity-Quality Trade-Off, Convergence, High School Movement, Married Female Labor Force Participation Rate.

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1 Introduction

The era between the Civil War and WWII included many revolutionary changes in the American family, as it obtained many of it's contemporary features. Family size continued its long-term decline and by the 1930s fertility was not much above current levels (later rising during the baby boom). The schooling of older children expanded tremendously, as epitomized by the 'high school movement.' Although the trend toward increased schooling expanded to encompass college for many in subsequent generations, this earlier period firmly established the centrality of education to good employment. Additionally, the proportion of married females' adulthood devoted to market-oriented activities increased, even as market-oriented activity performed at home declined. Although those marrying in the mid-1920s still typically quit work outside the home with a first birth, many returned in the 1940s after their children had matured so that life-cycle rates of participation increased significantly. Even though the work-family balance continued to shift powerfully toward work in subsequent decades, the earlier period established that market work by married females was a serious and acceptable option. The Progressive Era included the extension of the franchise to all female adults and, relatedly, the introduction of many public health initiatives. Finally, horrific rates of infant and child mortality declined dramatically. Although such mortality at the end of the period under consideration remained above current levels, there was much higher confidence that a child born would not die during dependency.

This paper considers these trends jointly through calibration of successive generations of representative husband and wife households who choose the quantity and quality of their children, household production, and the extent of mother's involvement in market-oriented production. Exogenous rates of infant and child mortality, returns to labor market experience, skill premiums, various costs of children, and cohort income levels are model inputs used to generate time paths for schooling inputs, fertility, mother's market work, and wages, including the gender wage ratio. These outputs enable us to determine the fit of the model and assess proposed explanations of family change. One important contribution is the finding that standard explanations such as rising wages, declining mortality, skill-biased technological change, curriculum improvements during the high school movement, and reduced time costs of children cannot in combination reduce fertility to observed levels or increase stocks of human capital to levels seen to be necessary by the calibrations. Slower acquisition of human capital via work experience over the period is (only) one reason the pace of the quantity-quality trade-off found in the calibrations is below what is observed empirically.

For the calibrations to replicate observed behavior an increased 'taste' for child well-being is required. This is modeled as a rising relative preference for child quality over quantity, an increased share of potential family income devoted to child consumption, and an increase in time mothers invest in each child's quality. When calibrated under these assumptions the model fits the observed changes in the family quite well. This increased taste for child well-being is consistent with increased bargaining power for wives within marriage and a stronger relative preference for child quality among mothers than fathers. A second significant contribution is the gathering of information and strategies employed to present reasonable quantitative depictions of the behavior of cohorts over an interval in which significant data limitations are pervasive.

The paper is organized as follows. Section II presents a brief description of the historical period, the stylized facts to be explained, and those factors deemed to explain them. This is followed in section III by a selective review of literature. Section IV presents the model. Section V explains the calibration strategy. This is followed by a presentation of calibration results in section VI. A final section summarizes and concludes.

2 The Historical Setting

The 'second' industrial revolution of the Post-Civil War decades involved the spread of large-scale unskilled labor-saving capital equipment powered by, first steam, then electricity. These new machines often substituted for human muscles (cf Galor and Weil (1996)), opening the door for more women to be employed in manufacturing. The new machines also increased the demand for skilled blue-collar workers to design and service machines. Large-batch and continuous process technologies led to increases in the number of employees per firm, adding layers of bureaucracy which greatly increased the need for clerical workers (cf. Goldin (1990)). Clerical employees needed more than rudimentary reading, writing, and arithmetic skills; business skills such as an understanding of basic book keeping and the ability to type were also increasingly necessary.

Acquisition of these skills required additional training, either on the job, in high school, or in business schools. In the early transition this increase in demand was met by on–the-job training of high-skill blue collar workers among men and learning-by-doing in manufacturing among females. Productivity would be lower initially as employees had not yet learned how to perform the tasks required for job mastery. Also, since the human capital acquired was firm or industry specific, workers presumably paid for at least some portion of their training costs through lower wages. As they mastered their tasks, less output was lost to learning and productivity was higher because of the additional experience-based skill. For this reason, the returns to experience were quite high in the late nineteenth and early twentieth century. Conversely, many jobs around 1900 required little schooling. Literacy was valued, but productivity in handicrafts and manufacturing depended more on work experience than general school knowledge. A few jobs required significant schooling (such as book keeper, clergy and school teacher), but for most jobs literacy was sufficient.

As skill-biased technical change proceeded, many of the prerequisites to performing advanced design and mechanical engineering jobs could just as easily-and perhaps less expensively- be taught in school. With no comparative advantage in the provision of this basic knowledge, firms began to require such training before a man seeking a profession was hired. Similarly, with the expansion of clerical jobs, females learned typing, stenography, and basics of book keeping in the classroom. The returns to experience fell as draftsmen and machinists came to acquire their knowledge at school in 'shop' courses, while the return to education beyond literacy was increasing (the premium to 'advanced,' or high school training, remained high). Returns to experience have, however, recovered in the past few decades (Olivetti (2006)).

Advances in transportation equipment and farm machinery increasingly allowed machines to substitute for human muscles, reducing the premium paid to strong males. Thus, over the first few decades of the twentieth century, muscle power and work experience came to be less important determinants of pay, while the contribution of schooling to earnings increased. These factors contributed to a narrowing of the wage gap between men and women. The declining premium for muscles depressed men's earnings relative to women's. Also, men in general had much more experience than women in the late nineteenth century, so as the premium to experience fell, the impact was greater for men. Indeed, in 1890 the vast majority of females ceased work upon marriage, so that the number of years of experience for most females would be few. However, women born in the twentieth century devoted a larger portion of their lives to market work, narrowing the experience gap. Indeed, Goldin (1986, 1990) and Goldin and Polachek (1987) argue that higher average premiums for experience for females relative to males accounts for close to 30 percent of the narrowing of the gender wage gap over the longer period from 1890 to 1970.

As the labor market adjusted to a higher demand for skilled workers, the premium paid to high school graduates remained high or even increased. Before the high school movement, most high schools were private and attended only by children of the affluent. High schools were then most often preparatory for college and learned professions, such as the clergy. Indeed, of those few high school graduates the proportion who continued on to college in the late nineteenth century was perhaps 50%, a figure which declined with the onset of the high school movement and would not be exceeded until the 1960s (even as the proportion of successive birth cohorts attending college increased steadily (Goldin and Katz (2008)). With the onset of the high school movement, a larger proportion of those students attending high school viewed a diploma as a terminal degree. Schools responded to the different preparatory needs of their students by dropping Latin from the curriculum and adding 'shop' and typing courses.

An equally important change in the curriculum was the decline of the one-room schoolhouse which was gradually supplanted by graded schools.

Through the first decade of the twentieth century high school attendance and graduation rates were low and increasing only slowly. Low attendance meant the general populace was unwilling to publicly support secondary schools. In turn, private tuition and room and board kept attendance from rising high enough to encourage public support. Further, in the latter decades of the nineteenth century, a family's secondary earners were more often older children rather than wives. Especially in poor families, children could not have been spared for higher education even if tuition was heavily subsidized.

After 1910, though, as incomes rose and population densities increased, public secondary education began to spread widely. During the peak years of the 'high school movement', between 1910 and 1940, the high school graduation rate among youth rose from 9 percent to 50% (Goldin and Katz(2008, 195)). Not only was the quantity of education received increasing, but so also was its quality as measured by schooling expenditures. Real expenditures per youth aged 5-19 more than tripled between 1910 and 1950.

Goldin and Katz (2008) view the wage premium to skill as the outcome of a 'race' between skill-biased-technical change, which increases the demand for skilled labor, and increases in the supply of skilled workers such as high school graduates. In the latter 19th century and into the 1910s the skill premium remained high as increases in the supply and demand for skills were moderate and roughly offsetting. The explosion in skilled workers with the high school movement, though, led to an appreciable reduction in the premium to skills. Indeed, Goldin and Katz (2008, p. 316) find that "from 1910 to 1930 the skill premium fell by 1.28 percent per year on average."

The shift in total labor demand toward office workers reduced the proportion of the workforce for which large muscles were a big advantage, reducing the relative productivity and pay of males (cf. Goldin and Polachek (1987)). Female clerical workers were more likely to return to work as their children matured, so that the life cycle labor participation of married females increased as the proportion of females working in clerical occupations soared. This helped produce the rise in the married female labor force participation rate from 4.6 in 1890 to 21.6 in 1950 (Goldin (1990, p. 17, Table 2.1)). The rise in schooling, lower premium to male strength, and increase in female market experience all contributed to a narrowing of the gender wage gap. Goldin(1990) reports that between 1890 and the 1930s the gender wage gap in the economy as a whole closed from .46 to .56, narrowing only slightly more to .60 by 1970.

Families were also becoming smaller as wives gave birth to fewer children . This trend was not new, as fertility had been declining in the United States from at least the early nineteenth century. Jones and

Tertilt (2007) and Murphy, Simon and Tamura (2008) analyze historical cohort fertility in the United States based on self reports of retrospective fertility of ever-married women coded in various Census years. Women born in the 1850s who eventually married attained adulthood circa 1880 and would bear about 5 children. Females born only a half century later, with fertility centered about 1930, end up bearing only about 2.5 children, or roughly half that of their grandmothers.

There was a smaller decline in the number of children who would survive to adulthood than in fertility, as deaths during infancy and childhood declined from horrific levels. 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. The white infant mortality rate, i.e., deaths in the first year of life per thousand live births–which was staggering 214.8 in 1880–had declined to 120.1 in 1900 and to 26.8 by 1950 (Haines, 2000, Table 4.3); these rates were appreciably higher for black children. Children who survived infancy were at lower, but still significant, risk of death. 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.

More generally, this period was one of rising female power. The right of women to vote was formalized by the 19th amendment to the United States Constitution in 1920. As described above, more women were working for pay, and those who did earned an appreciably larger proportion of men's earnings than had been the case a generation before. Further, women spent less time debilitated in pregnancy and were empowered to reduce the rate at which their children succumbed to illness.

3 Literature review

There is an immense literature on the topics of the high school movement, fertility decline, gender wage gap, mortality decline, and role of women-including the rise in market work among married females, for the United States. The following discussion is, of necessity, highly selective.

The scope, causes and implications of the high school movement are examined in depth by Goldin and Katz (2008). They blend statistics on school enrollments and characteristics, and trends in wage skill premiums, with deep appreciation of the interactions among technological change, institutions, and returns to education. Skill-biased technological change increased the demand for skilled, well-educated workers, while community characteristics (such as size of manufacturing base and homogeneity of citizenry) help explain the timing, nationally and regionally, of the increases in education.

Since parents incur most costs of education, such as tuition and foregone earnings and housework of children, while their children in adulthood reap the higher salaries education provides, most formulations of schooling decisions assume parents are altruistic toward children (cf. Becker (1981)). That high school attendance was low in the late nineteenth century, even though the increase in earnings from high school was high, suggests some form of credit market imperfection (cf. Becker and Tomes (1986), Galor and Ziera (2004)). Becker and Tomes point out that parents cannot legally assign debt to children. This means that parental finance of children's education reduces parental consumption. Consequently, altruistic parents of limited means- relative to the cost of the fully efficient level of child education- are forced to make difficult trade-offs between own consumption and investments in child quality. When this results in investments in children that are inefficiently low, parents are said to be 'transfer-constrained' (Lord (2002, Ch. 6). Among such parents, all intergenerational transfers motivated by altruism will take the form of human capital bequests; financial transfers will be zero. Rangazas (2000) reports simulations indicating that a macro growth model based on such transfer constraints performs much better relative to observed growth characteristics of the U.S. than does a framework in which parents always make the fully efficient investments in their children. In the framework developed below we follow the lead of this literature and limit transfers to children to human capital bequests.

Lord and Rangazas (2006) develop a model of the demographic transition and rise of schooling investments since 1800. Their framework also assumes altruistic parents, while emphasizing the role of declining wealth from family enterprise in reducing fertility. An important mechanism raising schooling investments over time is that parental human capital is increasing relative to that of their still-dependent children. This reduces the potential foregone earnings of children from school attendance relative to family earnings. In this way the utility opportunity cost of schooling children declines. The framework we develop highlights a similar mechanism.

Goldin and Katz (2008) argue that the returns to a year of education have varied not only over time but also across education or skill levels at a point in time. They view these patterns as resulting from interactions among the demand for and supply of skill, and institutions. Skill-biased technological change (SBTC), which increases the demand for skilled or educated labor, accelerated in the latter nineteenth century and then preceded at a fairly steady rate throughout the twentieth century. They note that during the early acceleration, high school enrollments were low and the premium to skill was bid up. As high school graduation rates soared after 1915 the premium to skill was bid down.

Goldin (1990) presents extensive evidence on the earnings of women relative to men, and why they changed over time, across sectors and occupations. She finds that from 1890 to the 1930s there was a significant narrowing of the gender wage gap. In Goldin and Polachek (1987) this narrowing is quantitatively partitioned into roles for changing amounts and returns to experience, increases in the level and returns to education[1], discrimination, and changing rewards to other gender characteristics (male strength in particular). Increases in education are found to be most important, perhaps accounting for more than 40 percent. Increases in the work experience of women relative to men are only somewhat less important. Goldin (1990) and Goldin and Katz (2008) argue that changes in work responsibilities along with a shift in training away from on-the-job and into schools reduced the returns to experience; with a greater portion of work skills developed via high school attendance, there was less scope for productivity advance from experience. For this reason, from 1890 to WWII the increase in total human capital, obtained either on the job or at work, rises less rapidly than trends in the level and returns to schooling alone (controlling for experience) would suggest.

Goldin (1990) chronicles the rise in female labor force participation, stressing important roles for changes in the economy's occupational distribution (especially the rise of the clerical sector), and for institutions (marriage bars slowed the increase). Adeshade (2009) and Rotella (1980, 1981) 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

[1]More generally, Goldin and Katz (2008) show the return to a year's education varies both over time and across levels of education. This is discussed further in the calibration section.

second industrial revolution decreased the return to strength, narrowing the gender wage gap, reducing fertility and increasing married female labor force participation rates (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. In a theoretical calibration exercise they find that half of the increase in MFLFPRs was due to labor-saving technology in the home. Bailey and Collins (2010) confront the claims of Greenwood et al. with spatial data regarding the spread of electricity and trends in fertility. They find little evidence to support the claims of Greenwood et al. 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. Fernández, Fogli and Olivetti (2004) propose a role for culture in the rise of MFLFPRs. They find that males whose own mothers had worked are more likely to prefer a spouse who works. Mokyr (2000) argues that new understandings of the role of hygiene in preventing sickness and death led late nineteenth and early twentieth century 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. Mothers' obsession with cleanliness, he argues, delayed the expansion of female market work. [2]

Fertility in the U.S. fell through the 19th century until sometime in the 1930s, then rose during the baby boom years, before falling to roughly replacement levels in recent decades. Jones and Tertilt (2007) present time-series evidence on U.S. fertility and some of its correlates. They find a strong negative

[2]In the context of economic development, Soares and Falcao (2008) consider linkages among adult longevity and MFLFP. In their framwork 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 point out that increases in own adult longevity lengthen 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 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. However, Hazan (2009) shows that increased adult longevity in the United States over the period we consider was associated with lower, rather than higher, life cycle market work among men. His finding limits the relevance of the Soares and Falcao mechanisms for the current study.

relationship between the occupational income of fathers and household fertility. A similarly strong negative relationship is found between the education of the husband and/or wife and fertility. If there is positive assortative spousal mating on education, all of these findings are consistent with Becker's (1981) observation that children require significant time, and that as the value of time (especially mother's wages) increases, children become more expensive. So long as children are treated symmetrically and parents care about both the quantity and quality (i.e., earnings in adulthood) of children, higher wages would reduces fertility and simultaneously induce a substitution toward child quality . Lord and Rangazas (2006) simulate changes in the quantity and quality of children in the U.S. for the past two centuries. They argue that an important determinant of the quantity-quality trade-off is the decline in wealth from family businesses, which serves to reduce fertility.

Doepke (2005) examines implications of reductions in child mortality using several variants of the Barro-Becker (1988) model of intergenerational altruism and endogenous fertility. He finds that in each variant the number of children ever born declines, while the number of surviving children increases. His results suggest that declining infant and child mortality cannot by themselves explain the large decline in net reproduction rates observed in the United States (and other industrialized countries) over the last century. Our results below are consistent with those models' predictions and we seek to identify which other factors may explain declining fertility. Soares and Falcao (2008) briefly consider implications of child mortality. 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.

Miller (2008) and Doepke and Tertilt (2011) review the rather conclusive evidence that women place relatively more weight than men on child expenditures and welfare-what might be termed 'child quality.' Shifts in income from husbands to wives tend to reduce expenditures on alcohol, tobacco, and men's clothing while increasing expenditures on children's' food and clothing. Evolutionary arguments likewise suggest that men are relatively less concerned with quality of children than are women (cf. Diamond (1997)). Miller (2008) points to the early twentieth century as a period in which female power is rising, most spectacularly with passage of the 19th Amendment, ratified in 1920, granting women the vote. Miller presents evidence that as individual states, and then the nation, ceded the franchise to women, this engendered passage of legislation increasing local public health spending which, in turn, contributed to the decline in infant and child mortality. Doepke and Tertilt (2009) suggest that greater power for females can lead to more resources for schooling. They develop a framework in which men granted the franchise to women in response to rising rates of return to human capital. These higher returns meant that ceding power to females would increase the bargaining power of their daughters and the education of their grandchildren. Cvereck (2007) argues that increased employment among single females in the last decades of the nineteenth century increased their bargaining power within marriage. The resulting increase in the share of marital output would rise as the gender wage gap narrows. Doepke and Tertilit (2011) illustrate a noncooperative bargaining model in which a narrowing of the gender wage gap can alter the mix of household public goods produced via household production functions. In their framework, higher wages for wives make her time input more expensive and can reduce the household supply of time-intensive public goods such as children even in the absence of a change in preferences. Chiappori (1992) considers a cooperative marriage bargaining model. In his framework, husbands and wives have different preferences for household public goods (such as quantity and quality of children). As wive's bargaining power increases, there is increased weight given to her preferences. Collectively, this literature points to an increase in the relative power of females circa 1900 which led to increased investment in the quality and well-being of children. Since greater investments per child imply children who are more expensive, fertility may be expected to fall.

Our research builds on the foregoing research in a variety of ways. Below we present a model of two-parent households in which fertility, child labor and human capital, and degree of married female labor force participation are endogenous. This framework is calibrated to the United States between the Civil War and WWII using a wide range of information, including changes in the gender wage gap, returns to schooling, levels of human capital inputs, and infant and child mortality. The model's flexibility and careful calibration allow us to assess many of the explanations for family change considered above.

4 Modeling the household

4.1 Determinants of Human Capital

For each generation of adults there are four determinants of adult human capital; schooling, experience, unskilled labor, and gender. The human capital of an adult male in period t is $[h_{0mt} + \widehat{h}_t]E_{mt}$ while that of a female is $[h_{0ft} + \widehat{h}_t]E_{ft}$. Here, $\hat{h}_t$ is the number of units of schooling human capital bequeathed by the parents of $t-1$ to their children and is assumed to be equal across males and females. $h_{0ft}(h_{0mt})$ is the stock of 'unimproved' human capital associated with nature's endowment, learning by doing/observation prior to market work, and any minimum legal or cultural requirements of parents regarding food, attention and training of their children. Thus, it is the 'no-schooling' stock of human capital. In general, the greater physical strength of males means that $h_{0mt} > h_{0ft}$, although as argued by Galor and Weil (1996) the market premium to this strength differential has declined over time.[3] $E_{mt}(E_{ft})$ indicates how schooling and unskilled human capital are augmented by work experience.

The potential earnings of males and females are determined by the market valuation of their stocks of human capital. The market values units of unskilled human capital and units of skilled human capital equally whether provided by males or females. That is, gender earnings differences depend upon differences in the stocks of human capital by gender and differences in time worked in the market rather than discrimination. It is standard to view each efficiency unit of human capital as being valued at some constant rate per unit, say w_t. However, market conditions may lead to circumstances in which higher and lower levels of human capital are valued differently. Goldin and Katz (2008) regard this as an interaction between changes in the supply of skill by households and the demand for skill by firms. To accommodate this possibility, units of unskilled human capital are paid at rate w_t while units of skilled or schooling human capital are rewarded at rate $\widehat{w}_t$. In particular, when skill-biased technical change (and thus firm demand for skill) proceeds more rapidly than skill supply, $\widehat{w}_t$ is increasing in the stock of schooling capital. This is captured by

$$\widehat{w_t} = w_t \widehat{h}_t^{\epsilon}.$$

Thus the potential earnings of a male are

$$w_t h_{0mt} E_{mt} + \left(w_t \widehat{h}_t^{\epsilon}\right) \widehat{h}_t E_{mt} = w_t \left[h_{0mt} + \widehat{h}_t^{1+\varepsilon}\right] E_{mt} = w_t h_{mt}, \tag{4.1.1}$$

where h_{mt} has scaled the schooling human capital by its market premium over unskilled human capital so as to enable valuation of each unit by w_t. Similarly, the potential adult female earnings are

$$w_t \left[h_{0ft} + \widehat{h}_t^{1+\varepsilon}\right] E_{ft} = w_t h_{ft}. \tag{4.1.2}$$

Combining (4.1.1) and (4.1.2) yields the potential household earnings

$$w_t(h_{ft} + h_{mt}) = w_t h_t.$$

If the 'race' between skill and technology just offset one the other, $\varepsilon = 0$ and h_{mt} and h_{ft} are simply the (unscaled) human capital of males and females (while h_t is the sum of adult human capital in the household). The ratio of an adult female's earnings working full-time to those of an adult male working full-time is

$$\gamma_t = \frac{w_t h_{ft}}{w_t h_{mt}} = \frac{h_{ft}}{h_{mt}},$$

Hence, the gender wage gap is

$$1 - \gamma_t. \tag{4.1.3}$$

[3] This could be modeled either as a reduction in the price of male unskilled human capital, or as done here, a reduction in the units viewed by the market.

4.2 Production of Schooling Human Capital

Schooling human capital is acquired during dependency and deployed during adulthood. Parents of generation $t-1$ choose the quality of education, the goods inputs such as teachers and books, x_t, the quantity of their children's education-fraction of youth devoted to schooling s_t. They also choose the time spent on human-capital enhancing activities by mother e_t, the effectiveness of which depends on the mother's human capital h_{ft}. Thus, the schooling human capital produced, and which children can deploy as adults in $t+1$ is given by

$$\hat{h}_{t+1} = b_t^p s_t^{\theta_s^p} x_t^{\theta_x^p} \left(h_{ft} e_t\right)^{\theta_{he}^p}, \tag{4.2.1}$$

where b_t^p is an efficiency scalar, and $\theta_s^p,\ \theta_x^p,\ \theta_{he}^p \in (0,1)$ are production function parameters (elasticities).

4.2.1 Preferences

Parents are assumed to care about the number of children surviving to adulthood n_{t+1} (half of whom are boys), the earnings in adulthood of those children, and the consumption of household produced goods. These sentiments are embodied in the utility function U_t for parents beginning adulthood in t

(4.2.2)

$$U_t = \ln G_t + \psi_t \ln w_{t+1} \hat{h}_{t+1}^{1+\varepsilon} (E_{mt+1} + E_{ft+1}) \frac{n_{t+1}}{2} + \sigma_t \ln w_{t+1} (h_{0ft+1} + h_{0mt+1})(E_{mt+1} + E_{ft+1}) \frac{n_{t+1}}{2},$$

where G_t is the consumption of household production goods.

Potential earnings of children in adulthood derive from two sources. The third term is the earnings across all surviving children derived from unschooled (or unskilled) human capital. Parent's relative taste for these 'unimproved' earnings is σ_t; such earnings may be increased by choosing to have a larger number of surviving children n_{t+1}. The aggregate earnings of adult children associated with schooling human capital is given by the second term. The relative preference for such earnings is captured by ψ_t , and these earnings may be increased by having more surviving children n_{t+1} and by investing more in their education (which increases $\hat{h}_{t+1}^{1+\varepsilon}$). In the description of the budget set below, it is seen that all surviving children impose costs, and that such costs are not a matter of choice. All surviving children also confer 'nature's bounty' of the unimproved human capital. Bequeathing schooling human capital to children imposes additional costs, and these costs are only voluntarily undertaken.[4] In general, parents may place unequal valuations on earnings potential by source.[5] Andreoni (1990) in an influential paper argues that altruists get a 'warm glow' from their own contributions to a recipient,

[4] The costs of unimproved earnings may include some expenditures on mandatory schooling; the key feature is that these costs are not subject to choice.

[5] As noted in the literature review, there is evidence that men and women have different preferences over fertility and quality; this specification allows us to analyze implications of those differences.

and therefore place a different valuations on own contributions than to other sources (here unimproved earnings from 'nature') of a recipient's well-being. Both ψ_t and σ_t embody a taste for quantity of children. However, only ψ_t reflects a taste for improving the quality (i.e., schooling) of individual children. For this reason an increase in ψ_t/σ_t is viewed as an increased relative preference for quality of children over quantity of children.

The second, or schooling, term assumes parents have some assumption about the outcome of the 'supply-demand' of skills race as reflected in the term $(1+\varepsilon)$. $\hat{h}_{t+1}^{1+\varepsilon}$ may be expanded to

$$\hat{h}_{t+1}^{1+\varepsilon} = b_t s_t^{\theta_s} x_t^{\theta_x} \left(h_{ft} e_t\right)^{\theta_{he}}, \tag{4.2.3}$$

where

$$b_t = b_t^{p(1+\varepsilon)},\ \theta_s = \theta_s^p(1+\varepsilon),\ \theta_x = \theta_x^p(1+\varepsilon),\ \theta_{he} = \theta_{he}(1+\epsilon).$$

With logarithmic preferences, the utility function is strictly quasi-concave and monotonically increasing in each argument. Parental choices are made over $G_t,\ n_{t+1}$ and $\hat{h}_{t+1}^{1+\varepsilon}$, and are constrained in various ways, which we now explain.

4.3 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 in their adulthood 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.

4.3.1 The life cycle and time use

Period and Mortality Structure Childhood is spent under the direction and care of parents. Childhood lasts one period and parents die as children reach adulthood. Not all live births result in a child who survives to adulthood. The number of live births required to produce 1 child surviving to adulthood equals d_1. d_1 exceeds one for two reasons. First, some children die within the first year of life (infant mortality). Indeed, a significant portion of all infant mortality is neonatal, occurring in the first weeks of life. (Some other conceptions are carried nearly to term and naturally aborted late, or perhaps still-born). Second, some children who survive infancy also die before reaching adulthood. d_1 reflects both types of mortality, so that as either declines so will d_1. d_2 is the number of children reaching age 1 that is required to produce 1 child reaching adulthood; d_2 reflects only youth mortality.

Mother's time allocation Mother's devote time to household production, raising children and the labor market. Each live birth demands $\bar{\rho}_t$ units of mother's time on children to activities largely unrelated to the child's quality, whether the child survives infancy or not. Even deaths occurring within the first year of life impose large costs for mother in terms of lost productivity during pregnancy, recovery following delivery, time to nurse and tend while the infant survives, and grieving costs upon the infant's demise. Each child surviving infancy imposes additional time costs of ρ_t on mother during its dependency largely unrelated to child quality. These include 'picking up' after children, laundry, dishwashing, etc. Since most such chores require little skill, we assume that the time required is independent of the stock of mother's human capital.

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 G_t. These goods are consumed by parents throughout their adult lives; G_t also includes any household public goods which are enjoyed by children as well as parents.[6] Mothers may also devote time to the labor market, m_t (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 1 unit of time at mother's disposal. Thus, mother's time use must satisfy

$$n_{t+1}\left[d_2(\rho_t + e_t) + d_1\bar{\rho}_t\right] h_{ft} w_t + m_t + z_t = 1 \tag{4.3.1}$$

Children's time budget Dependency lasts one period. Each of the $d_2 n_{t+1}$ children surviving infancy has $T < 1$ 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 (cf. Lord and Rangazas, 2006). Total time devoted to schooling s_t includes both some unproductive time of young children, as well as that of older children. In early childhood all children are 'schooled' for some minimum fraction $\bar{s}_t$ 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. Parents decide how much time l_t older, potentially wage-earning, children should contribute to the household budget through market work and

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

how much time $\widehat{s}_t$ to spend in schooling. Hence, the time constraint faced by each child is given by

$$\widehat{s}_t + l_t = T. \tag{4.3.2}$$

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 $d_2\tau_t w_t h_t$ for 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.

Parents also spend money for children's schooling or developmental inputs x_t, each unit costing P_t. Since the public financing of primary schooling was independent of usage even in the late 19th century, the cost of all goods inputs (including books, educational toys and broadening vacations, etc.) is less than one. For older children attending high school, developmental inputs were less subsidized. Total goods expenditures across all children are therefore

$$n_{t+1}d_2(P_t x_t + w_t h_t \tau_t). \tag{4.3.3}$$

Market earnings for a husband beginning adulthood in t are $w_t h_{mt}$. The potential earnings of the wife (i.e., should she devote all time to market labor) are $w_t h_{ft}$. Older children can work, but are assumed to offer only their unskilled human capital to the market while dependents. Due to less strength and concentration as compared to adults, children earn only μw_t per unit of unskilled human capital, with $\mu \in (0,1)$. These potential earnings are therefore $d_2\mu w_t n_{t+1} h_{0t} T$, where h_{0t} is average unskilled human capital across males and females $(h_{0mt} + h_{0ft})/2$.[7] Actual earnings of children are below potential earnings to the extent that older children spend time $\widehat{s}_t$ in school. Altogether potential household money income is

$$w_t h_t + d_2\mu w_t n_{t+1} h_{0t} T. \tag{4.3.4}$$

Combining the results from (4.3.1), (4.3.2), (4.3.3), and (4.3.4), the family's overall budget constraint is expressed as

$$\begin{aligned} w_t h_t + d_2\mu w_t h_{0t} T n_{t+1} &= d_2\mu w h_{0t}\widehat{s}_t n_{t+1} + n_{t+1}\left[d_2(\rho_t + e_t) + d_1\bar{\rho}_t\right] h_{ft} w_t \\ &\quad + n_{t+1}d_2(P_t x_t + w_t h_t \tau_t) + z_t w_t h_{ft} + g_t \end{aligned} \tag{4.3.5}$$

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

[7] Thus, young males earn h_{0mt}/h_{0ft} times the earnings of young females. The impact of early schooling on the earnings of older children is emphasized in Lord and Rangazas (2006).

mother's time devoted to quality and quantity of children, the money outlays for kids education and consumption, the implicit costs of mother's time devoted to household production, the goods used in household production.

4.4 Household production

We assume that household production is governed by the equation

$$G_t = g_t^{\nu} \left(h_{ft} z_t\right)^{1-\nu}. \tag{4.4.1}$$

As specified, the productivity of the wife's time in household production is increasing in her human capital. This is certainly plausible, but below we see that mother's optimal choice of household production time z_t is independent of h_{ft}. 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 implicitly priced at their market wage with the cost included in g_t. 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 g_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, $(x_t,\ \widehat{s}_t,\ e_t,\ n_{t+1})$ and their own consumption 'utilizing z_t and g_t' so as to maximize their utility function given by equation (4.2.2), subject to constraints (4.3.1) and (4.3.5). Recalling that $s_t = \overline{s}_t + \widehat{s}$, the Lagrangian L is written,

$$\begin{aligned} L \;=\; & \ln G_t + \psi \ln w_{t+1} b_t (\widehat{s}_t + \overline{s}_t)^{\theta_s} x_t^{\theta_x} \left(h_{ft} e_t\right)^{\theta_{he}} \left(E_{mt} + E_{mf}\right) \frac{n_{t+1}}{2} + \sigma \ln w_{t+1} h_{0t} (E_{mt} + E_{mf}) \frac{n_{t+1}}{2} \\ & + \lambda \left[\begin{array}{c} (d_2 \mu w_t n_{t+1} h_{0t} \left(T - s_t\right) - z_t w_t h_{ft} - n_{t+1} \left[d_2(\rho_t + e_t) + d_1 \bar{\rho}_t\right] h_{ft} w_t - g_t) \\ + w_t h_t - n_{t+1} d_2 (p_t x_t + w_t h_t \tau_t) \end{array} \right] \end{aligned}$$

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

$$v_1/g_t = \lambda, \tag{4.4.2}$$

$$(1-v_1)/z_t = \lambda\gamma_t w_t h_{ft}, \tag{4.4.3}$$

$$\theta_x\psi/x_t = \lambda d_2 p_t n_{t+1}, \tag{4.4.4}$$

$$\theta_{he}\psi/e_t = \lambda d_2 w_t h_t n_{t+1}, \tag{4.4.5}$$

$$\theta_s\psi/\widehat{s}_t = \lambda d_2 \mu n_{t+1} h_{0t}, \tag{4.4.6}$$

$$\begin{aligned}(\psi+\sigma)/n_{t+1} &= \lambda\left(\left[d_2(\rho_t+e_t)+d_1\bar{\rho}_t\right]h_{ft}w_t - d_2\mu w_t h_0\left(T-s_t\right)\right)\\ &\quad +\lambda d_2(p_t x_t + w_t h_t \tau_t).\end{aligned} \tag{4.4.7}$$

These FOCs reveal standard intuitions. Equations (4.4.4–4.4.6) govern the demand for human capital inputs. They all balance the left-hand-side marginal utility of accumulating human capital (and therefore child earnings in adulthood) against the utility cost from foregone parental consumption of doing so. Notice that in each equation this cost is increasing in fertility $n_{t+1}d_2$, 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 developmental inputs for perishable children, this price of quality per surviving child is increasing in d_2 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 children's time inputs are increasing in their respective wages. Similarly the goods input prices enter into their FOCs for goods. Equation (4.4.7) 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.

The quality and quantity of children Parental investments in child quality are given by youth schooling inputs x_t and $\widehat{s}_t$ and mother's time devoted to children's human capital production e_t. The quantity of surviving children is n_{t+1} so that fertility (i.e., children ever born) is $d_1 n_{t+1}$. These investments are given by

$$x_t = \frac{\theta_x\psi w_t\left[d_2 h_t\tau_t + h_{ft}\left(d_2\rho_t + d_1\bar{\rho}_t\right) - d_2 h_{0t}\mu T\right]}{d_2 p_t\left[\psi\left(1-\sum_i\theta_i\right)+\sigma\right]} \quad i = s, x, he \tag{4.4.8}$$

$$\widehat{s}_t = \frac{\theta_s\psi\left[d_2 h_t\tau_t + h_{ft}\left(d_2\rho_t + d_1\bar{\rho}_t\right) - d_2 h_{0t}\mu T\right]}{d_2\mu h_{0t}\left[\psi\left(1-\sum_i\theta_i\right)+\sigma\right]} - \bar{s} \quad i = s, x, he \tag{4.4.9}$$

$$e_t = \frac{\theta_{he}\psi\left[d_2 h_t \tau_t + h_{ft}\left(d_2\rho_t + d_1\bar{\rho}_t\right) - d_2 h_{0t}\mu T\right]}{d_2 h_{ft}\left[\psi\left(1 - \sum_i \theta_i\right) + \sigma\right]} \quad i = s, x, he \tag{4.4.10}$$

$$n_{t+1} = \frac{h_t\left[\psi\left(1 - \sum_i \theta_i\right) + \sigma\right]}{(1 + \psi + \sigma)\left[d_2 h_t \tau_t + h_{ft}\left(d_2\rho_t + d_1\bar{\rho}_t\right) - d_2 h_{0t}\mu T\right]} \quad i = s, x, he \tag{4.4.11}$$

Notice first that the structure of these expressions is quite similar. Consider first the quality variables x_t, $\widehat{s}_t$, and e_t. The numerators differ in that each contains the exponent for that input, while for the denominators each contains the price for that input. The common term inside the braces in the numerator for each expression is the cost, net of potential benefits, of an additional child surviving to adulthood independent of quality (fixed costs of child consumption and mother's time inputs for quantity minus potential child earnings). The common term inside the rounded brackets in the denominator reflects the cost of increasing quality (which is lower the higher are the returns to scale in human capital production). Thus, an increase in the numerator relative to the denominator is associated with a higher relative price per surviving child, and leads to an increase in the child quality variables. Notice, also, that these common terms are 'flipped' in the expression for surviving children, so that a higher relative price per surviving child leads to a reduction in n_{t+1}. These considerations are central to the 'quantity-quality' trade-off (cf. Becker (1981)).

More particularly, notice that if the human capital of the male h_{mt} and female h_{ft} increases by the same percentage while unskilled human capital of children h_{0t} is unchanged, there is an increase in the net costs of quantity of children and an increase in the relative price of child quantity. Consequently, there is a substitution away from quantity toward quality ($x_t, \widehat{s}_t, e_t$ all increase and n_{t+1} falls). n_{t+1} falls as the net cost of children increases by a larger percentage than the family's earnings endowment. Lord and Rangazas (2006) obtain a similar result in terms of a declining opportunity cost of schooling children (utility loss from forgone parental consumption) as parental earnings rise relative to potential child earnings. Jones and Tertilt (2007) 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.

As noted, if h_{mt} and h_{ft} rise in one period (with children's unskilled human capital h_{0t} unchanged), there will be greater investments in children through $x_t, \widehat{s}_t$, and e_t. Ceteris paribus, then, h_{mt+1} and h_{ft+1}will also increase, increasing x_{t+1}, $\widehat{s}_{t+1}$, and $e_{t+1}$and so on. Thus, as Lord and Rangazas (2006) note, there is an important supply-side element associated with any initial rise in human capital which carries forward into future generations. This effect becomes weaker through time, though, as h_{mt+1} and h_{ft+1} rise relative to h_{0t+1}.

The choices over quantity and quality are also affected by expectations of infant and child mortality. A reduction in infant mortality reduces d_1 with no effect on d_2. Since this reduces the number of births entailing a cost of $\overline{\rho}_t$ required to produce a surviving child, the cost of a surviving child falls. Consequently, quantity of children is substituted for quality so that x_t, $\widehat{s}_t$, and e_t fall while n_{t+1} rises. (cf. Doepke (2005) and Becker and Barro (1988)). The number of children ever born to a cohort, or just fertility, is $d_1 n_{t+1}$. Inspection of (4.4.11) reveals that there is an ambiguous effect of reduced infant mortality on fertility. That is, even though the number of surviving children demanded has fallen, the fact that fewer births are required to produce a surviving child makes the effect on births unclear.

A ceteris paribus reduction in d_2 also reduces d_1, but by a lower percentage. This would have an ambiguous effect on the quality and quantity variables (although n_{t+1}falls and x_t, $\widehat{s}_t$, e_t rise unless the infant mortality rate is quite high-as it was through the mid-late nineteenth century). Now suppose some percentage decline in youth mortality d_2 is accompanied by a reduction in infant mortality such that d_1 falls by the same percentage. This would have no effect on any of the quality variables or on the number of children surviving infancy $d_2 n_{t+1}$. The quality variables are unchanged because their prices per unit per surviving child are proportional to d_2 (recall their $F.0.C.'s$), so that the increase in the net cost of quantity is just offset by an increase in the net cost of quality. That is, there would be no change in the relative prices of quantity and quality. However, there is a decline in n_{t+1} equal to 1 divided by the percentage decline in d_1 and d_2, but no change in fertility $d_1 n_{t+1}$. In the current framework, child quality variables are unlikely to rise as mortality falls. This differs from Soares and Falcao (2008) who suggest child quality is likely to rise as mortality falls, as they put less emphasis on the fact that falling mortality reduces the costs of quantity (as well as quality).

Notice that goods inputs x_t increase with the wage per unit of human capital w_t, whereas the other quality variables $\widehat{s_t}$ and e_t do not. All components of the 'mechanical' costs of quantity are all related to human capital variables and so increase with w_t. However, the price of the time inputs of mothers in $e_t$and of children in $\widehat{s_t}$ is proportional to w_t; thus, w_t drops out of their solutions. However, the cost per unit of x_t is P_t. Consequently, w_t remains and x_t increases with w_t/P_t.

Finally, notice that the solutions for the quality variables are increasing in $\theta_x, \theta_s,$ and θ_{he}. These coefficients, in turn, are increasing in the market premium to skill (i.e., ε) which is expected by parents to be operative during children's adulthood. In the calibration section it is stressed that such expectations are not necessarily accurate.

4.4.2 Mother's time in household production:

Mothers' time in household production is given by

$$z_t = \frac{(1-v)\,(h_{ft}+h_{mt})}{(1+\psi+\sigma)\,h_{ft}}. \tag{4.4.12}$$

Notice that if human capital of females h_{ft} increases by a larger percentage than that of males, then the time mothers spend in household production z_t falls. That is, a reduction in the gender wage gap induces mothers to reduce time in household production, and increase time devoted to market work. Intuitively, in the denominator, the more expensive is mother's time input, the less of it is used in household production. This is only partially offset by a wealth effect (present in the numerator). Note, though, that if h_{mt} were to increase with no change in female human capital, the derived demand for z_t would increase (as in De Vries (2008)). Note that z_t is independent of infant and youth mortality.

Market goods in household production: Goods inputs in household production are

$$g_t = \frac{vw_t(h_{mt}+h_{ft})}{(1+\psi+\sigma)} \tag{4.4.13}$$

This expression reveals that an increase in the household's potential wage earnings, arising from any combination of higher wages, or higher human capital for males or females, serves to increase the use of market goods in household production.

Taking the ratio of (4.4.12) to (4.4.13) shows that an increase in the wife's human capital reduces the ratio of her time input to goods inputs, so that household production becomes more goods intensive over time. The good's intensiveness of household production also increases with increases in the wage per unit of human capital, even if h_{ft} is constant. Recall that the time inputs of children and domestics are valued at their wages and included in g_t. We can infer that the increased expenditures on store-bought goods inputs characterizing the second industrial revolution exceeded in magnitude the reduced expenditures on child and domestic inputs.

The mother's time constraint was given in (4.3.1). That equation shows that mother's labor market time increases with endogenous reductions in household production, child investment time, and the number of surviving children; it also increases if the exogenous time costs of child quantity (ρ_t and $\overline{\rho}_t$) fall over time. Calibration exercises reveal the relative importance of these different sources of change in market orientation.

5 Baseline 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. Some aspects of the calibration are complicated by a paucity of data, and in such instances we explain our attempts to overcome-if imperfectly-the data limitations.

Human Capital

Stocks and flows of human capital are not directly observed, but may be inferred from information on earnings, schooling investments and work experience. Given the data available, our approach to calibrating human capital is, first, to utilize information on the gender wage gap and then, schooling inputs.

Recall that the gender wage ratio is modeled as

$$\gamma_t = w_t h_{ft} / w_t h_{mt} = h_{ft} / h_{mt},$$

or equivalently,

$$\gamma_t = \frac{w_t \left[h_{0ft} + \widehat{h}_t^{1+\varepsilon} \right] E_{ft}}{w_t \left[h_{0mt} + \widehat{h}_t^{1+\varepsilon} \right] E_{mt}}, \tag{5.0.14}$$

where $\hat{h}_t^{1+\varepsilon}$ allowed for the possibility that the wage per unit of schooling human capital was increasing in the level of schooling human capital. The production function for human capital was given by

$$\hat{h}_{t+1} = b_t^p s_t^{\theta_s^p} x_t^{\theta_x^p} \left(h_{ft} e_t \right)^{\theta_{he}^p}. \tag{5.0.15}$$

As discussed below, these specifications for human capital along with available data enable us to pin down some parameters, and to establish calibration targets for schooling human capital.

Narrowing of Gender Wage Gap Due to Changes in Experience

Goldin and Polachek (1987) find that the female to male ratio of earnings among full-time employees across 6 occupations closed from .463 in 1890 to .556 in 1930, further narrowing to .603 by 1970. Most of the narrowing occurred by the 1930s and Goldin (1990, p.62) notes this ratio in the economy as a whole “was virtually stable from 1950 to around 1980.”[8] Supposing a cohort’s average wage ratio in adulthood is the ratio when the cohort members are about age 40, the cohort born in 1850, becoming parents in 1875, experienced the wage ratio $\gamma_{1890} = .46$, while the cohort born in 1925, who would become parents in 1950, experienced $\gamma_{1970} = .60$. The cohort born in 1900, becoming parents in 1925, might confront $\gamma_{1940} = .57$ (given the slow increase between 1930 and 1970). We average γ_{1890} and γ_{1940} and set $\gamma_{1915} = .52$ for the birth cohort of 1875 (who became parents in 1900).

[8]However, if the ratio is instead based on hourly earnings among full-time workers there is a further increase to .662 by 1970 as full-time men come to work longer hours than full-time women, especially after 1940.

The reasons for this significant closing of the gap, and their relative importance, have been examined by Goldin (1986, 1990) and Goldin and Polachek (1987). They determine that changes in the occupational distribution can explain only a modest portion of the narrowing; rather, most was due to rising wages for females within occupational groupings, especially among clerical and professional employments.[9] The limited importance of changes in the occupational distribution leads them to examine the roles of changes in the quantities of education and experience, as well as the returns to education and experience. The portion of the gap not explained by these characteristics is often viewed as discrimination, although since measured as a residual, it may instead reflect omitted factors or mis-measurement of included factors. Goldin (1986, 1990) and Goldin and Polachek (1987) note that especially in the early portion of this interval, much of the unexplained portion may be fairly attributed to gender differentials in strength in an era when muscles had a high marginal product. Our approach is to allow the narrowing of the gap to be a consequence of changes in work experience, education, and returns to strength.[10]

Goldin and Polochek (1987, p. 147) find the role of education (including both changes in the rate of return to education and level of education) in narrowing the gap is 50% more important than that of experience, while speculating that a reduction in the premium to strength was at least as important as that of experience. Supposing equal roles for experience and changes in the reward to strength, this suggests they each explain 28-29% of the narrowing, with education then explaining about 43%.

Goldin and Polachek (1987) propose exact figures for the effect of work experience on human capital separately for males and females in both 1890 and 1970. These are, for males $E_{m1890} = 2.53$ and $E_{m1970} = 2.01$, and for females $E_{f1890} = 1.62$ and $E_{f1970} = 1.41$. The slight reduction for females occurred even as the average experience among working women increased significantly. This downward trend for males and females is consistent with the discussion in section 2 which noted that over this period there was a substitution away from employer and industry specific on-the-job-training toward the acquisition of general human capital in schools. Thus, overall increases in human capital for this period occurred only because schooling human capital rose by more than returns to experience fell. The ratio E_{ft}/E_{mt} rose from .64 to .70, or by 9.37 percent between 1890 and 1970. Ceteris paribus, this increases the gender wage ratio to $.463(1.0937) = .506$, or by .043. Of the total increase in the gender wage ratio, $.603 - .463 = .14$, this relative increase in returns to experience explains about 30%.

Schooling Human Capital and the Premium to Male Strength

[9] Goldin and Polachek (1987, Table 1) report that holding wages constant at their 1890 level but applying them to the 1930 occupational distribution only narrows the gap by 2.6 of the almost 10 point increase between 1890 and 1930.

[10] They find that the unexplained portion of the gap remained roughly constant between the 1930s and 1970. Goldin (1990) argues that discrimination seems to emerge after 1940, especially in the clerical sector. Consequently, as the gender gap has narrowed over time, the relative importance of discrimination has increased.

Considering the expression for the wage ratio (5.0.14), we set unskilled human capital for males forming households in 1875 (born in 1850), $h_{0m1875} = 10$, without loss of generality. Given E_{m1890}, E_{f1890} and γ_{1890} we have

$$\left[\frac{h_{0f}+\hat{h}_{1875}^{1+\varepsilon}}{10+\hat{h}_{1875}^{1+\varepsilon}}\right](1.62/2.53) = .463.$$

This then identifies a locus of values for unskilled female human capital and effective schooling human capital given by

$$h_{0f1875} = 7.23 - .277\hat{h}_{1875}^{1+\varepsilon}.$$

Information on the level of schooling and returns to schooling help establish a range of values for $\hat{h}_{1875}^{1+\varepsilon}$. Murphy, Simon and Tamura (2008) report that, nationally, the average years of schooling for the birth cohort of 1850 was 3.35 years. This suggests a value for

$$\hat{h}_{1875}^{1+\varepsilon} = (1 + r_h)^{3.35},$$

where r_h is the rate of return to a year of schooling.

Since the U.S. Census did not begin collecting information on educational attainment until 1940, there is no direct national evidence on the rate of return to education for the 1850 birth cohort. However, Goldin and Katz (2008, Table 2.5, 78-9) present microeconomic evidence on the returns to schooling among males 18-65 based on a 1915 Iowa state census. The returns to those younger than 35 are also reported separately, enabling us to infer the returns to those age 35 and older. Slightly more than half of the males in that sample are older than 35. The returns for this 35-65 group help establish a range of plausible returns for the 1850 birth cohort -the mid-point of ages 35 and 65 is 50, and someone aged 50 in 1915 would have been born in 1865. This approach yields an estimate of 3.73% for each year of common school and of 6.23% for each year of high school; few men in this age grouping would have had many years of high school. Interestingly, the returns for this period were increasing with educational attainment. (The returns for those 18-34 were 4.83% for common school and 12.0% for high school). It seems unlikely that returns would have been much higher for the median southern household, even though the skill premium was somewhat higher in the South (cf Wright (1986)). The foregoing suggests an estimate for r_h of perhaps 4%.

Other considerations suggest a somewhat higher rate may be warranted. In Iowa, almost all healthy men were literate by this date, so attainment of basic literacy must not have much differed by years of education, even though average years were low. Further, there was a significant premium to literacy. Indeed, at the turn of the century Goldin (1900, p. 100) finds in a sample of manufacturing women that, holding education constant, the return to literacy was 14%. If men with but two years of education, say, were literate, an estimate for r_h exceeding 4% may be warranted. Also, state-level estimates of the rate of return to an additional year of education (not based on micro data) for this period are higher, about 10% (Murphy, Simon, and Tamura (2008)). We decided to also consider a second baseline, associated with $r_h = 7\%$. Consequently, there are two initial values for

$$\hat{h}_{1875}^{1+\varepsilon} = (1 + r_h)^{3.35},$$

namely: 1.14 and 1.26.

The two resulting values for females unskilled human capital $h_{0f1875} = 7.23 - .277\hat{h}_{1875}^{1+\varepsilon}$ are 6.52 and 6.84 (as compared to $h_{0m1875} = 10$). These figures imply a premium to strength for males for the initial period of about 50%, which seems reasonable. For example, Goldin and Polachek (187, 147) note that "data on piece-rate earnings in 1895 indicate that males earned on average 30 percent more than did females (i.e., the wage ratio was .77), when the piece rate was identical for both, and when both worked at the same job, in the same factory." They point out that this constitutes a lower-bound on the reward to greater male strength since it was only in those occupations where physical differences were less important that men and women worked together. And, in 1875 the premium was presumably greater than in 1895.

Changes in Schooling human Capital and Premium to Strength

In each of the two baselines, increases in education are targeted to contribute roughly 43% of the narrowing of the gender wage gap from .463 to .603 by 1970. Thus, schooling human capital alone must raise the wage ratio to $.463 + (.43)(.603 - .463) = .523$. The required value for the cohort born in 1925 (forming households in 1950) is $\hat{h}_{1950}^{1+\varepsilon}$; it is obtained from

$$\left[\frac{h_{0f1875} + \hat{h}_{1950}^{1+\varepsilon}}{10 + \hat{h}_{1950}^{1+\varepsilon}}\right] 1.62/2.53 = .523.$$

Thus, in the low returns case, where $r_h = .04$, $\hat{h}_{1875}^{1+\varepsilon} = 1.4$, and $h_{0f1875} = 6.84$, $\hat{h}_{1950}^{1+\varepsilon} = 7.27$. This makes the (effective) schooling human capital of the 1925 birth cohort, compared to the 1850 birth cohort, equal to $\hat{h}_{1950}^{1+\varepsilon}/\hat{h}_{1875}^{1+\varepsilon} = 7.27/1.4 = 5.2$; that is, (effective) schooling human capital must increase a little more than 5-fold in this case to generate the postulated narrowing of the gender gap associated with education. In the high returns case the increase is from 2.6 to 9.0, so that schooling human capital rises by a multiple of 3.46.

Finally, the premium to men's strength was declining, enough to raise the wage ratio by 28% of the narrowing from .463 to .603, or to $.463 + (.28)(.603 - .463) = .502$. This then enables us to solve for h_{0m1950} from

$$\left[\frac{6.84 + 1.4}{h_{0m1950} + 1.4}\right] 1.62/2.53 = .502.$$

Thus, $h_{0m1950} = 9.11$ in the low returns case (and 9.0 in the high returns case). That is, we find that for the 1925 birth cohort there remains a premium to male strength of about 35%. That a significant premium to strength remained at this time is confirmed by Rendall (2010), who finds that 83% of the more recent narrowing of the wage ratio from 1980 to 2005 (from about .60 to .77) is explained by a declining premium to male strength.

Human Capital Productivity Parameters, Inputs, and Role of Curriculum

I. Returns to scale in human capital production

We next ask whether the observed increases in schooling inputs might be consistent with the increases in $\widehat{h}^{1+\varepsilon}$ suggested above. To address this requires *i*) measures of the schooling inputs for the 1850 and 1925 birth cohorts, and *ii*) values for the exponents in the human capital production function (5.0.15).

The exponent on an input in the human capital production function is its elasticity of human capital with respect to the input. All empirical evidence indicates that the time (or quantity of school) margin s_t is appreciably more productive than are schooling inputs such as teachers or books, the x_t, which reflect school quality.(cf. Lord and Rangazas (1993) and Browning, Hansen, and Heckman, (1999)). A consensus estimate for goods is $\theta_x^p = .10$; perhaps somewhat lower in recent times and possibly somewhat higher in earlier periods. This value has also been employed for the effect of mother's time input $h_{ft}e_t$ and we set $\theta_{he}^p = .10$ as well. A broader range of values has been estimated for θ_s^p with most falling between .5 and .7. We employ a compromise value of $\theta_s^p = .6$ (see Lord (1989) and Browning, Hansen, and Heckman (1999) for additional discussion). $\theta_s^p + \theta_x^p + \theta_{he}^p = .8$ are therefore the returns to scale in human capital production.

II. Schooling Inputs: Expenditures

This section presents evidence on school expenditures and on school attendance over the period. These are then used to assess the increase in human capital, given the elasticities of human capital with respect to inputs discussed above while holding constant the efficiency of human capital inputs. Next, any shortfall in schooling human capital derived from observed inputs- relative to the targets determined in the calibration above- is allocated to increases in the efficiency scalar b in human capital production (i.e., multifactor productivity in human capital production).

Table A1 depicts the time path of schooling expenditures. Column (1) indicates the year of the expenditures. Column (2) provides the expenditures per pupil enrolled in public primary and secondary schools in 1982-1984 constant dollars.[11] Column (3) is the school enrollment rate (public and private)

[11] Table Bc909-925 Public elementary and secondary school expenditures from Historical Statistics of the United States, Millennial Edition. New York: Cambridge University Press. Volume 2, contributed by Claudia Goldin.

of those aged 5-19, including post-secondary.[12] The product of columns (2) and (3) yields column (4), expenditures per population member aged 5-19.[13] Column (5) is the ratio of expenditures per pupil enrolled in some year compared to that in 1870; column (6) is the ratio of expenditures per 5-19 population member in some year to those in 1865. Rangazas (2002, Table 1, p. 935) reports that the share of GDP devoted to primary and secondary education rises from 1.0 percent in 1880 to 2.4% in 1940. In the initial baseline it is envisioned that the ratio of schooling expenditures to father's life earnings is about .7. Since our figures include college expenditures for 1940, the targeted share is 2.6% for that year.

III. Time in School

Table A2 provides information about time spent in school by children aged 5-19 in various years. Column (1) indicates the school year. Column (2) is the average days attended per enrolled public school student. Column (3) is the percent of the 5-19 year old population enrolled in school (public and private, includes college enrollment). The product of columns (2) and (3) yields column (4) the days attended per member of 5-19 population (assuming days attended are equal for private and public students). The fraction of days in a year attended are then provided in column (5). The time spent in school per member of the 5-19 population triples between the 1870 and 1940 school years. Suppose we envision that schooling time of a member of a given birth cohort may be proxied by the column (5) fraction corresponding to when birth cohort members are aged 15. Then, for example, members of the birth cohort of 1925 (viewed in 1940) devote 30.9% of their time endowment to school. For the 1900 birth cohort we average the figures from 1910 and 1920 to get 20.2%; the figure for the 1875 birth cohort is then 12.9%. This approach would require an unavailable 1865 figure for the 1850 birth cohort. Unfortunately, simply linearly (or geometrically) interpolating patchwork using the 1870 and 1880 figures may be problematic due to the disruption in schooling among whites during the Civil War and the illegality of schooling for black slaves prior to emancipation. The following motivates our choice of values for that birth cohort.

Murphy, Simon and Tamura (2008, Table 8) provide years of education completed by birth cohort.

[12] Table CG.A.15 School enrollment of 5- to 19-year-olds per 100 persons, by sex and race: 1850 to 1994; Goldin (1999) "A Brief History of Education in the United States". Percentage includes attendance at public and private schools and also home schooling (so long as deemed comparable to regular schooling and led to a degree).

[13] This requires the reasonable assumption that expenditures per public and private student are roughly equal. For 1940, college expenditures among those 18 and 19 are added to the total to make comparable to the student attendance data discussed below. This adds about 10% to the 1940 total: Current expenditures per public elementary and secondary school pupil in average daily attendance in 1941 was $675 in 1982-1984 dollars. Call this expenditures per enrolled student. See HSUS Bc924.p 2-482. The comparable figure is $2503 for 1941 in 1982-1984 dollars for enrolled undergraduate students-educational and geneneral expenditures per student (HSUS table Bc966). Thus, the ratio of college to elementary and secondary students is 3.71. About 20% of the 1925 birth cohort ever enrolled in college, whereas about 8% graduated. We assume the enrollment rate averages about 15% for 18-19 year olds. Two years of college are added onto that from K-12. So, (2/15)(2503)(.16)= 53.4; this increases expenditures for 1940 to 463+53=516.

For the 1850 birth cohort this is 3.35 years; for the 1875 birth cohort this has risen to 4.75 years. As discussed above, there is evidence that the rate of return to schooling at moderate levels of education was low but increasing over this period. Assume the rate of return to education was 5% for the earlier period and 5.5 percent for the later period. This then implies that the average worker in the 1850 cohort would earn $(1.05)^{3.35} = 1.18$ times that of someone with no education, whereas a member of the 1875 birth cohort would earn some $(1.055)^{4.75} = 1.29$ times that of someone with no education. This implies an increase in the stock of human capital of about 1.29/1.18 or 9.3 percent among those with no experience. Among males this would imply an increase in (effective) schooling capital of .29/.18 or a little more than 50%. Thus, the efficiency parameter b_{1875} in the human capital production function for children of the 1850 birth cohort (born in 1875 with human capital based on 1890 schooling inputs) is set to produce a value for $\widehat{h}_{1875}^{1+\varepsilon}$ 50% or so above the $\widehat{h}_{1850}^{1+\varepsilon}$ level.

Empirical increase in $\widehat{h}$ with implications for increase in b

Below we assess the increase in schooling human capital associated with the time path of goods and time inputs in Tables A.1 and A.2 shown in the appendix, and the production function parameters previously discussed.[14] It remains to pin down the goods and time inputs for the 1850 birth cohort (i.e., those input values in 1865) which are necessary to that calculation. To find them, we first considered the increase in average schooling between the birth cohort of 1850 and that of 1875. Then rates of return to education from Goldin and Katz (2008) were applied to that increase in schooling to obtain the increase in total human capital (assuming unchanged returns to experience), which enables us to infer the increase in schooling human capital. Once found, we allowed for a 10% improvement in schooling productivity (the b efficiency scalar) over that period. We found then that to achieve the human capital of the 1875 birth cohort, the human capital inputs for 1870 needed to be reduced by about 13% to yield the appropriate 1865 value. The share of time devoted to school increases from 8.5% for the 1850 birth cohort to 30.8 percent for the 1925 birth cohort. These figures are comparable to those produced by Rangazas (2002, Table 2, p. 936).

Using the inputs from the tables discussed above (including the 1865 adjustments to 1870 values); the assumed human capital production elasticities for inputs; and an assumed 50% increase in mom's human capital between those born in 1850 and 1925, we find schooling human capital for the birth cohort of 1925 which is 3.1 times that of the 1850 birth cohort. Recall, though, the increase in schooling human capital necessary to account for 43% of the narrowing of the gender wage ratio was by a factor of 5.2 in the $r_h = 4\%$ case, and of 3.46 in the $r_h = 7\%$ case. The gap between the increase in schooling

[14]This calculation will also assume that 1) mother's human capital rises 50% between 1875 and 1925 (similar to what our preferred calibrations produce). It is also assumed that there is no change in mother's time input in terms of quality per child as mother's input is assumed constant in the first sets of experiments.

human capital based on observed inputs and that required to appropriately narrow the gender wage ratio in our framework then is associated with an increase in the efficiency parameter in human capital production b^p. In the '4%' case the required increase in efficiency is 67.7% $(i.e., (3.1)(1.67) = 5.2)$ and of 11.6% in the high case.

Cohort Income Change and the Wage Per Unit of Human Capital

In our framework, the human capital of husbands and wives is known when the household is formed (since it depends on the choices of *their* parents and the exogenous returns to experience). Further, mother's market time does not depend upon her wage (see the model). Consequently, knowledge of the wage earnings of a household in a period $w_t h_t$ enables one to solve for the wage per unit of human capital w_t. However, the U.S. Census did not include a question on earnings until 1940. Thus, household income must be estimated indirectly.

Our approach to estimating the life earnings of a male beginning parenthood in year t begins with several years of the national average income per worker covering the working years of adult employment for that male. These are augmented with exogenous information on the gender wage gap, and the proportion female within the workforce. In particular, the life cycle or permanent wage earnings of a male beginning adulthood in t are:

$$y_{m,t} = \sum y_{w,i}/(L_{m,i} + \gamma_i(1 - L_{m,i}),$$

where $y_{w,i}$ is output or income per worker in year i, $L_{m,i}$ is the share of males in the labor force in i, and γ_i is the gender wage gap confronted by the wives of those males. The $y_{w,i}$ are for those years when the male would be age 30, 40 and 50 (or 25, 35, 45, and 55 if adulthood begins in a non-Census year, see Table 1 below).[15]

[15] Household income would be given by

$$y_t = w_t[h_{0f} e_{f,t} m_t + h_{0m,t} e_{m,t}] + w_t \widehat{h}_t^{\epsilon_{t+1}} \left[e_{f,t} m_t + e_{m,t}\right],$$

where m_t is the portion of time the wife devotes to market-oriented work.

Table1: Calculation of Life Cycle Permanent Income Per Full-time Male

Birth yr.	y_w *	$L_{m,i}$ **	γ	$(L_{m,i} + \gamma_i(1 - L_{m,i})$	$y_{m,t+1}$	$y_{m,t+1}/y_{m,1890}$
1850	7.56$^{(1)}$	.832$^{(4)}$	.463	.91	8.33	1.00
1875	9.66$^{(2)}$	.794$^{(5)}$	.52	.107	10 .71	1.29
1900	13.79$^{(3)}$	.754	.58	.143	15.33	1.84

*Real output per worker in thousands of year 2000 dollars is from Murphy, Simon, and Tamura (2008), Table1. All figures are adjusted by labor's share of GDP, assumed constant at 70% throughout the period. **The male share of the labor force is from Historical Statistics of the United States: Table Ba417-424 - Labor force participation, by sex and race: 1850-1990.

(1) average of 1880, 1890, and 1900; (2) average of 1900, 1910, 1920, and 1930; (3) average of 1930, 1940 and 1950; (4) average of 1880 and 1900; (5) average of 1910 and 1920.

This income per adult male $y_{m,t}$ can be expressed in terms of the wage per unit of (unskilled) human capital w_t and his human capital using

$$y_{m,t} = w_t h_{0m,t} E_{m,t} + \widehat{w}_t \widehat{h}_t E_{m,t} = w_t \left[h_{0m,t} + \widehat{h}_t^{1+\varepsilon} \right] E_{m,t},$$

recalling that $\widehat{w}_t = w_t \widehat{h}_{t+1}^{\varepsilon}$, with $\varepsilon > 0$ in periods when the wage per unit of human capital is increasing in the level of schooling human capital. Once w_t is known, the choice variables of t may be solved for. Knowledge of the choice variables x_t and s_t allows calculation of $\widehat{h}_{t+1}$, and the procedure is repeated for the next cohort. The only remaining barrier to determining w_t is to pin down the ε for each period t.

Gold and Katz (2008) emphasize that so long as different skill levels are imperfectly substitutable, the relationship between 'units of human capital' and earnings among full-time workers is not in general linear, but instead depends upon supply and demand conditions within the skill class. The demand for skilled labor reflects the pace of skill-biased technical change (SBTC), while school enrollment patterns dominate the supply. In this framework, the wage premium to skill (and therefore earnings inequality) are determined by a 'race' between the demand for and supply of skill.

For the calibration we first determine which periods were affected by increasing wage per unit of human capital (i.e., $\varepsilon > 0$), and then consider the magnitude of ε. We must further consider whether parents would have expected $\varepsilon > 0$ for their children and whether, in children's adulthood, the expected skill premium materialized. *Expectations* of skill premia, $\varepsilon_e > 0$, influence the parents' choice of human capital inputs, whereas the *actual* premia, ε_a,if any, influence the value for w_t for those children in adulthood. Goldin and Katz conclude, "(w)e do not know precisely when in the nineteenth century the premium to schooling increased and whether it was as high even in 1850, but we do know that by 1900 a year of high school or college was a very good investment (2008 , p. 288)." It seems the premium to skill was rising in the latter portion of the nineteenth century, and we assume the parents of 1875 expected their offspring would benefit from a greater wage premium and that, in fact, those assumptions were ex post correct. It also seems reasonable to expect that parents of 1900 would have expected $\varepsilon > 0$. However, "(t)he returns to a year of schooling plummeted from 1915 to the early 1950s. But the returns to schooling were so high prior to the narrowing that even after the decline in the wage premium education remained a very good investment (Goldin and Katz (2008), p. 289)." Unfortunately, the expectations of an exceptional wage premium were not realized by their children, whose working years were centered in the 1920s-1950s. Those becoming parents in 1925 are assumed not to have expected $\varepsilon > 0$ and their children are assumed not to have experienced $\varepsilon > 0$.

What is the magnitude of ε expected by the parents of 1875 and 1900 (and experienced by the children born circa 1875)? Goldin and Katz provide evidence of the decline in the skill premium following the onset of the high school movement around 1915. For example, among females (males) in 1895 the ratio of earnings of clerical workers compared to production workers was 1.94(1.69); by 1919 this ratio had declined to 1.52(1.20). Assume that the 1919 premium is that arising when the wage per unit of human capital is linear in human capital (i.e., $\varepsilon = 0$). This implies that $\widehat{w}_{1900} = w\widehat{h}_{1900}^{1+\varepsilon_e}$ must allow for a ratio of skilled to unskilled workers at the turn of the century which is roughly a third more than that just a generation later. Supposing that skilled workers received 3-4 times as many schooling inputs as unskilled workers, a value of $\varepsilon = .20$ for 1895 (and $\varepsilon = 0$ for 1919) plausibly produces the premium.[16]

Market-Oriented Work of Wives

White wives seldom worked outside the home in the late 19th century. However, by the 1920s a significant proportion of new brides would-with interruptions-devote many years of adulthood to market labor. Life cycle participation rates for white married females of different birth cohorts attaining adulthood between 1880 and 1940 are derived from Roberts' (2007, Fig. 1.9); the participation rates for each age bracket are added, with the total then divided by the number of age brackets (see also Goldin (1990, Ch. 2)). These figures are derived from Census data and are presented in Table 2 below as the LCPR.

[16] Consider a female in the $r_h = 7\%$ case, with unskilled labor of 6.5 and schooling human capital of 2.6. Imagine a composite input with returns to scale of .8. If unskilled workers receive 30% of the schooling inputs that a skilled worker does, then the ratio of skilled to unskilled is about 1.5 (similar to 1919). If, instead, $\varepsilon = .2$ so that the composite input has an effective exponent of (1.2)(.8) =.96, the ratio of skilled to unskilled is about 1.8, similar to that in 1895.

Table 2: **Life Cycle Labor Force Participation Among White Married**

1 **Birth Cohort**	2 **Attain Adulthood**	3 **LCPR**	4 **Adjustment**	5 **ALCPR**	6 **AVG**
1855-64	1880	2.5	9.8	9.2	5.85
1865-74	1890	3.5	9.9	10.2	6.85
1875-84	1900	4.4	8.7	9.8	7.1
1885-94	1910	6.8	6.4	9.9	8.35
1895-04	1920	11.8	6.4	13.6	12.7
1905-14	1930	21.0	3.2*	18.1	19.55
1911-21	1940	28.7	0.0	21.2	24.95
1921-31	1950	36.1	0.0	27.0	31.55
1931-40	1960	41.3	0.0	31.0	36.15

* There is no adjustment measure for 1930, the last census year before the modern concept. We assume one-half of the adjustment for 1920 applies to 1930. (Hist. Stat. U.S. for 1940 on, I-702, extrapolated for 60-69 for 1960 adulthood cohort). Averages are computed across age groups of 20-29,..., 60-69. Column 5 is (.75) times the sum of columns 3 and 4. (Also, see text for more details). Column 6 is the average between columns 3 and 5.

A potential difficulty is that, before 1940, Census questions differed appreciably from the modern participation concept.[17] In particular, prior to 1940, the question was that of one's 'gainful occupation' (though the question varied a bit from Census to Census). Goldin (1990) notes that many women in the nineteenth century engaged in market-oriented work on their husband's farm or kept boarders; under the modern conception of labor force participation they would be counted as in the labor force. However, many viewed themselves as principally housewives, and reported this 'occupation' to Census takers. Goldin examines the extent of the underestimate for 1890, finding 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, Table 2.5) replicates Goldin's methodology to extend the findings for 1880, 1900, 1910 and 1920.[18] He finds that adjusted MFLFPRs were relatively stable over this entire period, followed by a rapid acceleration post-1940. These cross-section adjustments are in Column 4. They are added to the LCPRs, then multiplied by .75 to produce the adjusted life cycle participation rates ALCPR in Table 2. The scaling down by .75 reflects Goldin's contention that wives working from home worked only part-time, whereas most women working outside the home worked full-time through about 1940. Another possibility is to consider the simple average of the LCPR and the ALCPR; this is provided in column 6 as AVG. The LCPR increases 8 fold between the 1855-64 and 1905-14 birth cohorts. In contrast, participation doubles for those cohorts using the ALCPR and somewhat more than triples using the AVG concept. All measures are increasing over time because young wives entering the labor force in the 1920s, began to re-enter the labor force in greater numbers once their children matured.

[17] 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.

[18] He uses data from IPUMS-the Integrated Public Use Microsamples of the US census (cf. www.ipums.umn.edu)

Regardless of which series one prefers, it may be inappropriate to suggest the calibrations could reproduce them. On one hand, our model assumes plans made at the beginning of adulthood are implemented. However, Goldin emphasizes that during the Great Depression marriage bars were extended to numerous sectors of the economy, reducing the employment of married women (Goldin (1990, Ch. 6). And, since work interruptions reduce the value of prior work experience upon re-entering the workforce, participation may have remained lower even after marriage bars were eliminated in the 1940s.([19])([20]) In fact, the calibrated values fall well within the broad range of participation rates from Table 2.[21]

Mortality

In 1900 the infant mortality rate was 16.24%, while the mortality rate for those ages 1-19 was 3.23%. With about 19.5% of children ever born dying during dependency, about $d_{1,1900} = 1.24$ live births were required to produce a child surviving dependency, while $d_{2,1900} = 1.035$. [22]. By 1925 the infant mortality rate had fallen to 7.54%, while the mortality rate for those aged $1 - 19$ was 1.03%. Consequently, $d_{1,1925} = 1.098$ and $d_{2,1900} = 1.014$. Murphy, Simon and Tamura (2008, Tables 13-15) report that infant mortality was 17.1% in 1880, with an additional 12% of births dying between ages 1-15. These figures are used to produce $d_{1,1875} = 1.47$ and $d_{2,1875} = 1.14$.

Fertility Targets

The U.S. Census irregularly collected data on fertility in the first half of the 20th century. Jones and Tertilt (2007) use these Census responses to estimate children ever born for earlier periods. For

[19] Conversely, Goldin (1990, pages 154-157) examines survey data from young women born between 1944 and 1954 regarding their expected future participation rates and finds that when rates have increased rapidly young women have underestimated their future participation. Less clear is 1) whether such underestimation occurred for the earlier cohorts we consider and, 2) whether their parents-who in our model control the human capital investments in children- may have better anticipated their daughters' life cycle work.

[20] Another potential limitation of labor force *participation* data is that *hours worked* can vary appreciably 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. Goldin (1990), however, argues that most workers outside the home worked full time until about 1940.

[21] Goldin (1990) stresses that there was considerable heterogenity among women regarding their labor market behavior. While few (especially white) married women worked outside the home in the late nineteenth and early twenetieth centuries, those currently employed tended to have significant persistence in the labor force, and those not working currently tended to have not accumulated much work experience since marriage. Similarly, those without children worked more than those with children. This heterogenity has declined over time. Although a model with multiple types of agents may be preferred, there is insufficient data for such a calibration since education was not gathered in the Census until 1940. Thus, although we could determine the education of someone born in 1880-age 60 in 1940-and ascertain whether they worked in 1940, we would not know their participation in earlier years. Goldin notes clerical workers were more likely to return to work at older ages, and most working women were employed in factories or as domestics through 1900. Thus, using 1940 employment to discern the link between education and employment in 1910, say, would suggested a much stronger positive relationship between work and education than had been true. Although there was significant heterogeneity, it should not be overstated. For example, in a Women's Bureau Survey from 1940, Goldin calculates that those between the ages of 40-49 in 1939 (and thus born between 1880 and 1889) had 15.5 years of work experience if currently working, and 7.6 if not currently employed (Table 2.5, p. 31). Or, viewing fertility, among white married females aged 23-27 in 1900 who had not given birth to a child, the labor force participation rate was 4.1 percent; if she had given birth to 1 child the rate was 2.1 percent (or 1.7 percent if she had given birth to 2 children at the time of the Census).

[22] Information on mortality by age since 1900 is available in the HSUS table Ab988-1047.

the cohort born between 1851-1855, children ever born is 5.3 (based on responses in the 1900 Census). For the birth cohorts of 1876-1880 (chosen to reflect children born to parents setting up households in 1875), children ever born was 3.25 (based on responses in the 1940 census). For the birth cohort of 1901-1905, estimated from responses in the 1950 Census, fertility had fallen to 2.59.

Mother's time allocation to child quantity

The calibration of mother's time required per infant and per (older) child unrelated to child quality, $\overline{\rho}_t$ and ρ_t involves several steps. Ramey (2009) 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. Thus, in 5 of the 19 years (ages 1-19), 7 hours per week are devoted per child; from ages 6-19, that is in 14 of the 19 years of dependency beyond infancy, 2 hours per week are devoted to children. Assuming this is all for quantity of children, $\rho = (5/19)(7/70) + (14/19)(2/70) = .048$.

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 7 weeks per pregnancy. Taking a full-time work week to be 70 hours, 7 weeks represent 490 hours, which divided by 52 weeks implies a little over 9 hours per week should be added to the first year. Consequently, $\overline{\rho} = (1/20)(26/70) = .018$

In the baseline human capital calibration, these values are employed in each period. They are allowed to fall moderately over time in the second and third experiments as described below.

Time available for teenagers to work

The optimal value of each human capital choice variable is decreasing in $\mu h_{0t} T$, while the number of surviving children is increasing in that term. These implications are immediately understandable as $\mu h_0 T$ is the earnings a child could contribute toward the family budget were there no schooling of children old enough to work. 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 G_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 19*th* century, but had become insignificant by the middle of the twentieth century. Their earnings contributions declined to a large degree because the high school movement increased the time older children devoted to human capital accumulation $\hat{s}_t$. Exogenous to the framework are compulsory schooling and child labor legislation (cf Goldin and Katz (2008), Puerta (2009), Doepke and Zilibotti (2005), Moehling (1999)) which may affect the time available 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.[23]

The ratio of a child's wage per unit of human capital to that of an adult male is assumed to be constant at $\mu = .4$. This estimate is consistent with the evidence of Goldin and Parsons (1989) upon dividing the earnings per child of different ages from 10-19 and gender by their probabilities of working, and then averaging. In the calibrations, it is the change in the human capital of parents relative to that of children (along with other parametric changes) which drives changes in schooling.

Other parameters

Parental expenditures on the goods inputs x_t are independent of the price P_t. From equation (4.4.8) if P_t is 10% lower, x_t is 10% higher. Because of the expansion of public education, and in particular the high school movement for the period in question, the price to parents of schooling inputs fell through time. The precise rate at which it fell and the total extent of the fall are not known. As an initial guess, we set $P_{1890} = .8$, as there remained some rate bills at higher ages, outlays for books and other home inputs, and transportation costs. As the high school movement proceeds, P_t falls. It is initially assumed that by 1940 $P_t = .2$, a reduction of 75%. Given that taste parameters are used to pin down

[23] Zelizer (1985) 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.

As potential parental earnings relative to potential child earnings become large, the positive effect of parental human capital h_t on mother's time investments in early child education e_t and the negative effect of h_t on fertility diminishes. Additionally, the effect of any reduction in child mortality 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 $\mu h_0 T$.

the initial x_t, the results would be essentially unchanged if the 75% reduction had instead occurred from an initial price of .9 or .6. Further, in the calibration section we note implications of a smaller (or larger) percentage change in this price over time.

Other parameters are 'free' and used to pin down the initial baseline. In particular, the exponent on mother's time $1-v$ in household production is set at .26 for 1875 in order to allow the time mothers devote to market to match the 5.8% figure suggested for the first period.[24] 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 per child in 2006 for middle-income families are around 6%.[25] Supposing private consumption expenditures on children were a superior good in the twentieth century, we set $\tau_{1875} = .04$ per child for the parents of 1875. The taste parameters ψ and σ are used to pin down initial schooling inputs and fertility.

6 Calibration results

The objective of the paper is to identify the mechanisms which best explain the facts of family transition between the Civil War and WWII. Prior sections presented a model capable of addressing several central mechanisms in the literature and established model parameters and calibration targets. The analysis next considers implications for the time path of the model's choice variables of changes in the model's parameters. The presentation proceeds in a series of nested experiments. Some parameters are common to both the $r_h = 4\%$ and $r_h = 7\%$ cases for every experiment; these are displayed in Table 3. Other parameters differ only in their initial baseline value across experiments (such as the human capital efficiency parameter b^p and the taste parameters ψ and σ); still other parameters have different time profiles across experiments. Table 4 lists these parameters by case and experiment. The first experiment assesses how well a 'pure human capital' version of the model can match the observed time path of fertility, human capital inputs, mother's market-oriented time, and gender wage ratio, and the targeted time part for human capital production. In this Human Capital Baseline Experiment, the time-varying exogenous parameters are limited to those for experience for males E_{mt} and females E_{ft}, the price per unit of the schooling goods input P_t, and income per adult male $y_{m,t}$. The results of this experiment are found in Tables 5 and 6.

►Insert Tables 3, 4, 5, and 6 about here◄

In this specification, the mortality parameters d_{1t}, and d_{2t} are set to 1; that is, every child born

[24] To maintain the desired intial market time for mother, this value is adjusted trivially across the different experiments.

[25] 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

survives to adulthood. Also, the time path of mother's time cost of child quantity per child $(\overline{\rho}_t + \rho_t)$ is held constant across periods, as is the share of potential parental earnings devoted to child consumption per child τ_t.The preference parameters regarding child quality ψ_t and child quantity σ_t are also time invariant. Finally, this experiment abstracts from a role for mother's time in affecting the human capital production so that $\hat{h}_{t+1} = b_t^p s_t^{\theta_s^p} x_t^{\theta_x^p} h_{ft}^{\theta_{he}^p}$.[26]

Initial baseline

In both cases for this experiment, and for the subsequent experiments, the desired initial baseline is closely matched. The parents of 1875 choose about 5.3 births, fraction of children time devoted to school about 12%, mom's time devoted to the labor market around 5.8% and about 1.4% of fathers' lifetime earnings allotted to expenditures on the schooling goods input. Also, reflecting the discussion above, the effective schooling capital of the children of those becoming parents in 1875, $h_{1900}^{1+\epsilon}$, is set about 50% above that for the parents. For parents in the $r_h = 4\%$ case, $h_{1875}^{1+\epsilon} = 1.4$, so target $h_{1900}^{1+\epsilon}$ to be a bit above 2. In the $r_h = 7\%$ case, $h_{1875}^{1+\epsilon} = 2.6$ so target $h_{1900}^{1+\epsilon}$ to be about 4.

Human Capital Baseline Experiment

Schooling human capital does rise across the periods, fertility does fall, and the gender wage ratio does increase. However, the changes in these variables are far less than necessary by the end of the study. Consider the case where initial schooling capital is low $\widehat{h}^{1+\varepsilon} = 1.4$ (i.e., when $r_h = 4\%$). With the initial schooling human capital low, a large percentage increase was required to raise the gender wage ratio sufficiently for the birth cohort of 1925; recall from the calibration discussion that the required $\widehat{h}^{1+\varepsilon} = 7.27$, or 5.2 times that of the 1850 birth cohort. In fact, in this case and experiment $\widehat{h}^{1+\varepsilon}$ increases by only 157% (to 3.6), far below the targeted amount. Given that the model setup emphasizes a quantity-quality trade-off, it is perhaps unsurprising that the reduction in children ever born, from 5.3 to 5.1, is too small as well (the target for parents beginning adulthood in 1925 is 2.6). Children's time devoted to school only increased about 13% as correspond to the actual increase of about 200%. x_t increases by a factor of 12, below the target of 16.5. Mother's time devoted to market roughly doubles. Table 6 shows the results are no better for the $r_h = 7\%$ case.

The role of changes in the skill premium ε proves to be modest. Consider the $r_h = 7\%$ case. Each parent of 1900 had schooling human capital of $\widehat{h}_{1900} = 3.1$, but with $\varepsilon = .2$ had a market valuation equal to that from $\widehat{h}_{1900}^{1+\varepsilon} = 3.89$ units, were each unit of human capital paid the same wage. However, given the household income, higher $\widehat{h}_{1900}^{1+\varepsilon}$ leads to a somewhat lower wage $w_{1900.}$ This lower wage reduces human capital goods inputs x_{1900}. Also, it is $\widehat{h}_{1900}$ rather than $\widehat{h}_{1900}^{1+\varepsilon}$ that enters into the human capital production function, so there is no boost to quality associated with the chosen inputs. $\widehat{h}_{1900}^{1+\varepsilon}$ does,

[26] The possibility of mother's altering their time devoted to child quality is deferred to the third experiment (Increased Taste for Child Quality) for two reasons, where the motivation for its inclusion is stronger.

however, increase the h_{f1900} and h_{m1900} and in that way increases the quality variables x_{1900} and s_{1900}.

Why are the increases in schooling capital and the reductions in fertility each too small? [27] What is 'wrong' with the 'Human Capital' calibration? Inspection of the schooling input demand equations reveals that they are increasing in the parental stocks of human capital. But, in the human capital calibration, male human capital is actually falling over time. Female human capital does rise, but not enough to increase the parental stock. One problem in the human capital story is that the reduction in returns to experience more than offsets the early increase in schooling human capital. Thus, the 'supply-side' driver of human capital identified by Lord and Rangazas (2006) is not operative. The remaining forces increasing schooling human capital are insufficiently powerful (even were the returns to experience held constant). The rising wage per unit of human capital w_t, and a falling price of schooling goods inputs P_t both serve to increase the goods input x_t. However, neither of these increases the time input of students s_t. Another contributor to rising schooling human capital is the rise in general schooling productivity over time (the efficiency scalar b^p increases 65% in the $r_h = 4\%$ case, a much smaller 17% in the $r_h = 7\%$ case). Considering the $r_h = 4\%$ case, even if schooling inputs (and mom's human capital) were unchanged, $\widehat{h}^{1+\varepsilon}$ would still rise by 65% (of the large total increase of 500% this case requires).

Adding in Mortality and Reduced Time for Mother in Child Quantity

The second experiment adds in the actual time path for infant and child mortality. It took the parents of 1875's 1.47 live births to produce a surviving child in 1875, falling to 1.098 for the parents of 1925 ($d_{1,1875} = 1.47$, $d_{1,1925} = 1.098$). The number of children reaching age 1 required to produce a child surviving to adulthood, d_2, fell from 1.14 to 1.018. Significantly, since d_1 falls by a larger percentage than d_2, these mortality reductions will, ceteris paribus, cause the quality variables x_t and s_t to decline.

►Insert Tables 7 and 8 about here◄

Additionally, we allow for the possibility of technological improvements in child care-better home appliances, for example- which reduce ρ_t over time (as in Greenwood, Sheshardi, and Yorukoglu (2005)) and reductions in the morbidity accompanying childbirth (as in Albanesi and Olivetti (2007)) which reduce $\overline{\rho}_t$. In particular, in both cases, mother's time required per child surviving from age 1 to adulthood, falls from $\rho_{1875} = .048$ for the parents of 1875 to .040 for the parents of 1925. Also, the time costs to moms of pregnancy and the child's first year of life are allowed to fall from $\overline{\rho}_{1875} = .018$ to

[27] Remember that schooling inputs fall in price from .8 to .2. With unitary own-price elasticity of demand this alone increases the goods inputs by a factor of 4. Further, in this case (and in most other cases in other experiments), the rise in the wage per unit of human capital is about 100% (99% in this case). Inspection of the equation governing the goods input reveals the demand for these inputs is proportional to the wage. Thus, if nothing else was changing these price changes would increase the goods input by a factor of 8.

$\overline{\rho}_{1925} = .014$. These reductions lower the price of child quantity relative to quality, further hampering any increase in schooling human capital and reductions in fertility. The results of this experiment are contained in Tables 7 and 8.

Overall, the results for fertility are about the same as in the human capital experiment. Fertility $d_{1,1925}n_{1925} = 5.1$ (4.88) in the $r_h = 4\%$ ($r_h = 7\%$) case-compard to the target of about 2.6. In the $r_h = 4\%$ case, the increase in schooling human capital is 131% (as opposed to the 157% in the human capital calibration and the 500% target).

Increased 'Taste' for Human Capital

The third experiment introduces several changes in parameters consistent with an increased 'taste' on the part of households for child quality and child well-being relative to child quantity. The results are as shown in Tables 9 and 10. As discussed in the literature review, in a household utility function, decision rules might reflect the outcome of household bargaining between husband and wife. As wives' labor force participation and earnings increased relative to husband's and women obtained the franchise, the bargaining power of wives increased.

►Insert Tables 9 and 10 about here◄

Also, Zelizer (1985) argues that early in the twentieth century children became emotionally priceless even as their instrumental value was declining. Economists might rephrase this argument as parents having moved from an exchange to an altruistic regime in their interactions with children. Regardless of the exact cause, in the calibrations this is operationalized by increasing the taste parameter emphasizing investments in child quality ψ_t and decreasing the taste parameter σ_t that is related to child quantity but does not influence the desirability of quality investments. Mokyr (2000) and Miller (2008) note that Progressive Era mothers were taught to clean spaces carefully to eliminate germs, boil water and milk, make sure children washed hands, and engaged in other activities designed to reduce the chances of illness and death. Mokyr argues that these activities increased mother's time commitment to household activities. Since these activities would increase child health, an important aspect of human capital, mother's time devoted to household production e_t is now also included as a choice variable, so that $\widehat{h}_{t+1} = b_t^p x_t^{\theta_x^p} s_t^{\theta_s^p} (h_{ft} e_t)^{\theta_{he}^p}$. Finally, we envision that children's consumption or well-being even as a dependent is a superior good. Consequently, as income rose through time so did the share of potential parental earnings devoted to child consumption per child τ_t. Thus, while for the parents of 1875 $\tau_{1875} = .04$, the calibration increases it to $\tau_{1925} = .06$ for the parents of 1925. The parametric assumptions are summarized in Table 4.

Given the inclusion of e_t and the specified changes in τ_t, the taste parameters ψ_t and σ_t were altered to achieve, if possible, targets for choice variables, including fertility and schooling inputs for human capital. These adjustments improve the fit dramatically for the following reasons. Viewing the child quality equations, it is seen that x_t, $\widehat{s}_t$ and e_t are positively related to ψ_t and negatively related to σ_t. This makes sense as ψ_t is the preference parameter for that portion of aggregate wealth of adult children associated with schooling human capital, while σ_t is that associated with the exogenous unskilled human capital which is increasing in the quantity of surviving children. However, these equations also reveal that as ψ/σ increases, the positive effect of ψ on child quality diminishes. The effect of σ_t on the quantity of surviving children n_{t+1} (and therefore fertility) is theoretically ambiguous.[28]

We supplement this mechanism with an increasing share of potential parental wealth devoted to per child consumption τ_t over time. In particular, we allow τ_t to rise from $\tau_{1875} = .04$ to $\tau_{1900} = .05$ to $\tau_{1925} = .06$. This has a powerful effect of increasing the cost of an additional child of given quality, inducing a substitution toward child quality, away from quantity of children (again see the equations for schooling inputs and surviving children). Notice that if τ_t were not increasing over time, there would be significant downward pressures on the share of potential family earnings spent on all children, given the large decline in fertility. Even the postulated per child increase results in a much lower aggregate share of potential family earnings devoted to child consumption over time.[29]

Allowing mother's time devoted to child quality to change also improves the fit: e_t enters directly into the production function for schooling human capital so that $\widehat{h}_{t+1}$ increases with τ and ψ, while falling in σ. In both the r_h cases, the increase is from 0.5 percent per child to 0.9 percent per child. This 80% increase by itself leads to an 6.1% increase in the endogenously produced human capital (recalling that the exponent on $e_t = 0.10$).

The outputs of this calibration experiment hit most target variables directly (Tables 9 and 10). Consider first the case where $r_h = 7\%$. Children ever born among the parents of 1925 is now 2.69 (where the target was 2.6); the gender wage ratio is .60 (the target .603); the ratio of schooling human capital to the initial level is 3.53 (the target was 3.46). The fraction of women's lives devoted to market work increases from 5% to 28%. This 360% increase is comfortably within the plausible range identified in Table 2. The fraction of time devoted to schooling $s_t = \widehat{s}_t + \overline{s}_t$ increases from 0.085 to 0.327 while the target is 0.31. The 1940 value of the goods input is 23.8 times the 1865 value. This exceeds the target of 16.5-fold increase. In this case P_t fell from 0.8 to 0.3; if the decline in P_t was a bit smaller, this target could be hit as well.

[28]In the range of values relevant to the calibration this effect is positive and, further, the effect of σ_t can be seen to dominate that of ψ_t (unless ψ_t is several times larger than σ_t). Thus, as we continue to increase ψ_t relative to σ_t, the effects on schooling inputs and fertility decline.

[29]This is private consumption; recall, children also benefit from the household production of communal goods G_t. Private consumption includes square feet of bedroom, quality and quantity of clothes, spending money for food and entertainment, etc.

The fit for high case $r_h = 4\%$ is just as good (see Table 9). Fertility declines to 2.63 (with the target of 2.6). $\gamma_{1970} = 0.603$ as targeted. Schooling human capital rose to 6.46, compared to the target of 7.2. As in the $r_h = 7\%$ case, the student time input is very close while the goods input again rises too much. Mother's market time is again within the range from Table 2. Thus, the increased 'taste' for child quality experiment is quite successful at reproducing the revolution in family behavior between 1875 and 1940.

7 Discussion and Summary

This paper developed a microeconomic model of household fertility, human capital accumulation, and married female labor force participation in which successive generations are linked through parental human capital. That framework is sufficiently general to allow simultaneous examination of several mechanisms proposed as explanations of the great changes in family behavior in the generations following the Civil War. An initial baseline for the model was calibrated and then theoretical simulations were performed to assess the relative importance of those mechanisms. It was found that a 'human capital' story, based on falling prices for educational goods inputs, rising parental incomes, SBTC, and falling returns to market work experience was incapable of producing the targeted increase in schooling human capital, or the observed increase in time devoted by students to school, and actual decline in fertility; the quantity-quality trade-off contained in the model was too weak when confronted with this pattern of parameter changes over time.

A second experiment altered the 'human capital' calibration by incorporating empirical rates of infant and child mortality, and allowing maternal time costs per child (unrelated to child quality) to fall across generations. This experiment not only did not improve the fit of the model to the targets, it made it somewhat worse. The features added to yield this experiment reduce the price of surviving children. Despite features from the 'human capital' experiment which boost schooling capital- most importantly productivity advance in human capital production- the overall result is that the fertility of parents beginning adulthood in 1925 was only marginally below that of parents beginning adulthood in 1875 (falling from 5.2 to 5.1, whereas the empirical decline is to 2.6). The human capital in adulthood of females barely rises over the period, while that of males actually falls. As in the human capital calibration, the force of declining returns to experience largely offset the force of a 3-4 times increase in schooling human capital. Intuitively, the declines in return to experience were also-perhaps especially-felt in unskilled occupations and, in the latter 19th century unskilled human capital was the majority of total human capital. Significantly, though, in otherwise identical calibrations except that the returns to experience are kept constant (not reported), the rise in human capital and the decline in fertility remain far too small. Additional forces are required to sufficiently spur schooling investments and curb fertility.

This leads to the third experiment, which highlights mechanisms stressed in prominent recent work in this area. Miller (2008) and Doepke and Tertilt (2009) point to the extension of the franchise to women and increases in women's relative wages as factors increasing the influence of women in the economy and at home. Increases in women's power have been seen to result in increased spending on the education, health, food and clothing of children. This is captured in our calibrations by several parametric assumptions. First, there is an increase in the relative preference ψ_t for child quality produced by parents (from schooling human capital) compared to σ_t, which reflects the taste for exogenous wealth per child (deriving from unskilled human capital). Both ψ_t and σ_t reflect a taste for surviving children; an increase in ψ_t/σ_t increases the household preference of quality of children relative to quantity of children. A second, and related, change is that the share of potential adult earnings devoted to the consumption of dependent children is allowed to increase over time, reflecting increased concern with the relative well-being of each dependent child. This increases the cost of child quantity relative to child quality. Finally, mothers were allowed to increase the time they spent on each child's human capital development. Collectively, these forces produced in the calibrations the same powerful quantity-quality trade-off observed empirically for this period.

The important parametric changes underlying the 'human capital' and 'mortality' experiments, changes in mortality rates and returns to experience, have been carefully examined in the literature. This increases confidence in the finding that neither the pure human capital story, nor that augmented with mortality considerations, are capable of reproducing observed movements in fertility and human capital investments. Certainly there is less direct evidence about changes in the weight given to household member's taste parameters, as summarized by changing weights in a unitary household utility function. Similarly, although it would be surprising were consumption per child not a superior good over this period, empirical validation, let alone quantification, is lacking. Suppose these mechanisms are not responsible for the dramatic changes in family behavior during the latter portion of the nineteenth century and first few decades of the twentieth century. It then seems likely that other, less immediately apparent, mechanisms must be operating. At a minimum, the current study suggests fruitful directions for empirical work.

Appendix 1

Table A1: Expenditures on Students

1 Beginning School year	2 $ per pupil enrolled	3 % enrolled[3]	4 Expenditures per pop 5-19	5 1870 $per pupil enrolled	6 Product/ 1865 product
1865[1]			31.1		1.00
1870	74	0.484	35.82	1.00	1.15
1875	84			1.14	
1880	78	0.578	45.08	1.05	1.45
1885	106			1.43	
1890	121	0.543	65.70	1.64	2.11
1895	155			2.09	
1900	165	0.505	83.33	2.23	2.68
1905	200			2.70	
1910	264	0.592	156.29	3.57	5.03
1915	284			3.84	
1920	323	0.643	207.68	4.36	6.68
1925	463			6.26	
1930	573	0.699	400.53	7.74	12.87
1935	540			7.30	
1940	620	0.748	463.76 (516)[2]	8.38	14.9 (16.6)

[1]Estimated (See Text)
[2]Includes expenditures of those 18-19 in college in 1941, see footnote 13
[3]Numbers in column 3 are displayed as proportions

Table A2: Children's Time in School

1 School Year beginning	2 product/365	3 percentage enrolled[2]	4 days attended	5 product
1865[1]				0.085
1870	79.4	0.484	38.43	0.105
1875	79.4			
1880	80.0	0.578	46.24	0.12
1885	84.1			
1890	86.6	0.543	47.02	0.129
1895	94.8			
1900	98.0	0.505	49.49	0.136
1905	106.0			
1910	111.8	0.592	66.19	0.181
1915	120.9			
1920	125.9	0.643	80.95	0.222
1925	135.9			
1930	144.0	0.699	100.62	0.276
1935	146.3			
1940	150.7	0.748	112.69	0.309

[1]Estimated (see Text)
[2]Numbers in this column are displayed as proportions
Source: 1.Goldin(1999), TableCG.A.6.

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