Explaining the Revolution in U.S. Fertility, Schooling and Women's Work Among Households Formed in 1875, 1900 and 1925

Matthias CINYABUGUMA, William LORD, and Christelle VIAUROUX*

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Abstract

Research paper: human capital, fertility, MFLFPR, history, calibration

Structured Abstract

-This paper addresses revolutionary changes in the education, fertility and market work of U.S. families formed in the 1870s-1920s: Fertility fell from 5.3 to 2.6; the graduation rate of their children increased from 7 to 50 percent; and the fraction of adulthood wives devoted to market-oriented work increased from 7 to 23 percent (by one measure).

-These trends are addressed within a unified framework to examine the ability of several proposed mechanisms to quantitatively replicate these changes. Based on careful calibration, the choices of successive generations of representative husband-and-wife households over the quantity and quality of their children, household production, and the extent of mother's involvement in market-oriented production are simulated.

-Rising wages, declining mortality, a declining gender wage gap, and increased efficiency and public provision of schooling cannot, individually or in combination, reduce fertility or increase stocks of human capital to levels seen in the data. The best fit of the model to the data also involves: 1) a decreased tendency among parents to view potential earnings of children as the property of parents and, 2) rising consumption shares per dependent child.

-Greater attention should be given the determinants of parental control of the work and earnings of children for this period.

-One contribution is the gathering of information and strategies necessary to establish an initial baseline, and the time paths for parameters and targets for this period beset with data limitations. A second contribution is identifying the contributions of various mechanisms toward reaching those calibration targets.

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

JEL classification numbers: I21, J13, J22, N31, and N32.

*Matthias Cinyabuguma and Christelle Viauroux are Assistant Professors of Economics at UMBC, and William Lord is Professor of Economics at UMBC. We are grateful to Marie Steele for wonderful-and cheerful-research assistance. We also thank Peter Rangazas, Marianne Wanamaker, and seminar participants at the Western Economic Association meetings, Meetings of the Cliometric Society, and the Public Policy Seminar at UMBC for useful comments.

1 Introduction

The American family has never been a static institution. That said, the latter decades of the nineteenth century and first decades of the twentieth century were ones of exceptional change. Over this period households came to choose much smaller families, to forego child labor, to view extensive formal education among dependent children as essential preparation for adulthood, and to allocate a significant portion of the adulthood of wives to market labor. Indeed, comparing households formed in the 1870s and those formed in the 1920s, fertility fell by half (from about 5.3 to 2.6 children); the proportion of their children who graduated high school increased from about 7 to 50 percent; employment rates among male youth ages 10-15 fell from about 30 to 6 percent; and, the fraction of adulthood devoted to market-oriented work by wives increased several fold (from 7 to 23 percent by one measure).

Based on a calibration of family decisions across three generations, we conclude that changes in the net cost of children offer the best explanation of the decline in fertility and rise in schooling over this period. Further, an important element of this increase in net costs seems to derive from evolving norms which reduce the perceived appropriateness of sending children to work. The narrowing of the gender wage gap is fully capable of accounting for the rise in married women's market work (indeed, marriage bars during the Great Depression make our calibrated increase greater than that which occurred). The remainder of this Introduction further describes our approach and contribution.

Labor economists have developed sophisticated models of household labor supply, fertility, and human capital investments, including applications to the period under consideration. Macro economists have also examined these issues, as well as longer-term determinants of growth. Fewer of these macro formulations have narrowly focused on this period. Traditional economic historians have emphasized data collection and the importance of institutions and norms as well as markets.

A first contribution of this paper is to synthesize these literatures, creating a useful bridge to each subfield. From labor economics, a model of household optimization which includes a broad range of household decisions is developed. Three successive generations of parents and their children are linked via careful calibration, emphasizing the dynamics and tools favored by macro economists. The necessary microeconomic and macroeconomic historical data is assimilated to calibrate the framework. The results are interpreted in light of all three literatures, with the institutions and norms studied by economic historians assuming a prominent role.

A second contribution is the identification of those mechanisms best able to explain the family dynamics within the calibration, as well as those seen to have little explanatory power. At the household level, parents maximize utility over the quantity and quality of children, the work of wives and children, and the production of household public goods. Explicit (and commonly employed) functional forms are assumed for household utility, household production and human capital production. An important consideration was a choice of functional forms which yield closed-form solutions for all choice variables. This allows clear, and hopefully intuitive, price-theoretic interpretations of all results. Successive generations are linked as the human capital bequest by one generation of parents proves important to the decisions made by their children once they become adults. A wide range of data is assimilated to restrict the feasible parameterization of the model for households formed in 1875, 1900 and 1925. (This requires some discussion of adjacent cohorts: The initial baseline for 1875-parents requires knowledge of the human capital investments in them, as children, by the parents of 1850, while the earnings of households forming in 1950 are greatly influenced by their human capital-bequeathed by the parents of 1925.) Nested versions of the model are simulated to assess the contributions of various mechanisms, individually and in combination, toward fitting the time paths of the target variables. Finally, the results and their significance are viewed in light of the broader literature and other plausible mechanisms.

The calibrations indicate that rising wages, declining mortality, a declining gender wage gap, and increased efficiency and public provision of schooling cannot, individually or in combination, reduce fertility or increase stocks of human capital to levels seen in the data. Calibrations hit the targets only when additional mechanisms are addressed. In particular, the best fit of the model to the data also involves: 1) a decreased tendency among parents to view potential earnings of children as the property of parents and, 2) rising consumption shares per dependent child. These results suggest that for standard 'quantity-quality' models to provide a good quantitative fit, they need to incorporate parental utility from child consumption and welfare during dependency. Several potential explanations are discussed as to why child consumption shares increased and the willingness to work children decreased. Additional research is required to assess their relative contributions.

A final contribution is establishing the consistency of a calibration based on microeconomic determinants of the gender wage gap with results from the growth accounting literature. This increases confidence in the separate results and provides an important example where methods and data from one subfield are usefully employed to address an important issue in another.

Of course, not every potentially important mechanism can be included in a given model. Further, the quantitative responses to parametric change may prove sensitive to how the various mechanisms which are considered are modeled. Thus, the paper also informally discusses mechanisms not addressed within the model included; implications of differing degrees of responsiveness to those mechanism which are addressed are also considered.

The paper is organized as follows. Section 2 presents a brief description of the historical period, the stylized facts to be explained, those factors deemed to explain them, and a selective review of literature. Section 3 presents the model. Section 4 explains the calibration strategy. This is followed by a presentation of calibration results in sections 5 and 6. A final section summarizes and concludes.

2 The Historical Setting and Literature Review

The literature on the high school movement, fertility decline, gender wage gap, mortality decline, and rise in market work and earnings among married females for the United States is immense. The following survey is, of necessity, highly selective.

Stagnant, then Growing Demand for Educated Workers. The 'second' industrial revolution of the Post-Civil War decades involved the innovation and spread of large-scale unskilled-labor-saving capital equipment powered by, first steam, then electricity. New machines substituting for human muscles raised the relative productivity of women in manufacturing (see Galor and Weil, 1996). Simultaneously, the demand rose for skilled blue-collar males to design new machines and service existing ones. Through 1900 high-skill blue collar workers were trained primarily 'on–the-job.'[1] For this reason, the returns to experience were high in the late nineteenth and early twentieth century (see Goldin and Polachek, 1987). Conversely, most jobs through 1900 required only the basic literacy and numeracy acquired in common or grammar school. Nineteenth century returns to a year of education were low, in parts depressed by the shortness of the school year, a curriculum which was only loosely linked to market skills, meager expenditures on books, buildings, and teachers, and an occupational structure with relatively few positions requiring 'advanced' education. In this light, Connolly (2004) emphasizes the quantitative significance of unskilled human capital within the late nineteenth century economy, especially in the South. Those few jobs requiring additional schooling (such as bookkeeper, clergy or school teacher) were often filled by the children of upscale households who might attend the odd public high school, a private boarding school, or college. .

Nevertheless, at century's end (and perhaps much earlier) there was a significant premium to skill (Goldin and Katz, 2008). New large-batch and continuous processing technologies meant larger firms with layers of bureaucracy to record sales and expenses, issue payrolls, market goods, manage financial assets, provide legal services, etc. This greatly increased demand for clerical and other white collar workers with business skills, such as basic bookkeeping and typing (Goldin and Katz, 2008). With no comparative advantage in the provision of this basic knowledge, firms began to require appropriate schooling of those seeking skilled positions. With growing demand for educated workers, more parents desired public high schools and this increase in potential class sizes lowered the prospective cost of

[1] To the extent such human capital was general, rather than firm- or industry-specific, and since risks of separation were significant, workers presumably paid for some portion of their training costs through lower wages (Becker, 1975).

public provision. Both provision and enrollment soared.

As draftsmen and machinists came to acquire more human capital in 'shop' courses at school before commencing work, on-the-job training and the return to experience on shop floors fell. Similarly, females learned business skills in the classroom instead of at work. Thus, over the first few decades of the twentieth century, work experience became a less important determinant of pay while education became more important (Goldin and Polachek, 1987 and Goldin, 1990). For this reason, from 1890 to WWII the increase in total human capital, obtained either on the job or at work, would have risen less rapidly than trends in the level of and returns to schooling (controlling for experience) would suggest.

Goldin and Katz (2008) view the wage premium to skill and education as the outcome of a 'race' between skill-biased technological change (SBTC), which increases the demand for skilled labor, and increases in the supply of skilled workers which, for this period, meant high school graduates. They conclude SBTC accelerated in the latter nineteenth century and then proceeded at a fairly steady rate throughout the twentieth century. During the early acceleration, high school enrollments remained low and the skill premium was bid up. Into the 1910s that premium remained high as increases in the demand for, and supply of, skills were roughly offseting. However, high school graduation rates soared after 1910 and Goldin and Katz (2008, p. 316) find that "from 1910 to 1930 the skill premium fell by 1.28 percent per year on average." Doepke and Zilibotti (2005) and Doepke and Tertilt (2009) argue SBTC affected the political process, resulting in child labor laws, reduced fertility, increased public spending on health (and therefore lower child mortality) in the late 19^{th} and early 20^{th}centuries.[2]

The Growth in Education. 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, parents would not forego child earnings for 'advanced' education even if tuition was heavily subsidized. Consequently, the demand for public high schools remained weak. High schools were, if public, urban, or if private, attended by children of the affluent. After about 1910, though, as incomes rose, population densities increased, the roles of children were redefined, and the wage premium to high school completion remained high, public secondary education spread widely among boys and girls. The high school graduation

[2] Doepke and Zilibotti note that men find child labor harmful in the aggregate, as it substitutes for their own labor and depresses the wages of adult men. As SBTC proceeds, it increases the return to education and families respond by having fewer children, each of whom they educate more. With fewer children, the foregone child earnings in their *own* family from child labor restrictions are reduced, which makes parents more willing to support legislative restrictions. They provide informal evidence that patterns of fertility, education and child labor legislation are consistent with their theory. Doepke and Tertilt argue that SBTC encouraged men to surrender economic and political power to women. Intuitively, husbands prefer to maintain bargaining power over their own wives. Working in the opposite direction, men want their daughters and grandchildren to have good education and want their son-in-laws to be well-educated. Additionally, female voters put more weight on child quality than do men. As SBTC raises the return to education, these benefits to offspring and grandchildren come to outweigh the loss of reduced bargaining power in their own home and men vote to increase women's rights. They present suggestive stylized facts supporting these hypotheses.

rate rose from 9% to 50% during the 'high school movement' between 1910 and 1940 (Goldin and Katz, 2008, p. 195). The quality of education was also rising as real expenditures per youth aged 5-19 more than tripled between 1910 and 1950 (see Table A.2.1).

Since parents incur most costs of educating dependent children, such as tuition, foregone earnings and housework of children, while their children in adulthood reap the higher salaries education provides, most formulations of schooling through the teenage years assume parents are altruistic toward children (Becker, 1981). That high school attendance was low in the late nineteenth century, despite a sizeable wage premium to graduates, suggests some form of credit market imperfection (Becker and Tomes, 1986, Galor and Zeira, 1993). Becker and Tomes note that since parents cannot legally assign debt to children, 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 constrained households, all altruistically motivated intergenerational transfers are human capital bequests (no financial bequests). Rangazas (2000) simulates a model of U.S. economic growth based on altruistically motivated human and physical capital transfers. He finds that calibrations reflecting transfer constraints better match U.S. growth characteristics than do calibrations in which parents always make the fully efficient investments in their children. Consequently, in the framework developed below, transfers are in human capital form, only.[3]

Lord and Rangazas (2006) model the demographic transition and rise of schooling investments since 1800. Their framework assumes altruistic parents and emphasizes the role of declining wealth from family enterprise in reducing fertility. They note that as education has risen, so has the earnings gap between mature adults and their teenage children. For this reason, the potential earnings forgone by schooling children have fallen relative to adult potential earnings. With diminishing marginal utility of consumption, the opportunity cost of schooling children -the utility loss from lower parental consumption- declines. The framework developed below includes a similar mechanism.

An important aim of growth accounting is to attribute observed growth in output per worker or per hour worked to underlying derterminants. The role of improvements in the quality of the labor force via increased education has been estimated in a variety of ways. Abramovitz and David (2000) find only a small role for human capital in late nineteenth century U.S. growth. Goldin and Katz (2008) find that education contributes more than 14 percent toward the growth in output per labor hour between 1915 and 1940. Turner, Tamura, and Mulholland (2011, 2013) have recently estimated a much larger

[3] Many small estates are an 'accidental' consequence of unannuitized life cycle savings; to incorporate them would require modeling transfers under conditions of uncertainty.

role for human capital. In section 4 we use novel methods and data and find an estimate close to that of Goldin and Katz.

The Gender Wage Gap. Polachek (1975) presents an early analysis of the division of labor by gender within the family. He shows that an initial comparative advantage which induces gender specialization leads to reinforcing follow-up investments. These increase productivity differentials over time and cement early time allocation patterns. Suppose, as assumed in the model below, physical strength confers a greater bump to productivity in market work than child care. Then males would have greater labor market experience and women would assume all child care responsibilities. Goldin and Polachek (1987) and Goldin (1990) examine the earnings of women relative to men and why they changed over time. They report that from 1890 to the 1930s there was a significant narrowing of the gender wage gap from .46 to .56, and to .60 by 1970. In Goldin and Polachek (1987) this narrowing is quantitatively partitioned into roles for changing amounts and returns to experience, increases in the level of and returns to education, 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.

Women born in the twentieth century devoted a larger portion of their lives to market work, reducing the differential in the *quantity* of experience. Goldin (1986, 1990) and Goldin and Polachek (1987) argue that relatively more experience for females coupled with relatively lower returns to experience for males, accounts for about 30 percent of the decline in the gap. The spread of steam, and then later electric, power replaced human muscles on the farm and in the factory. The shift in total labor demand toward office workers further reduced the proportion of jobs for which large muscles were a big advantage. The falling premium to strength lowered the relative productivity and pay of males by a smaller amount than changes in experience (Goldin and Polachek, 1987). The findings of Goldin and Polachek (1987) and of Goldin (1986) play a key role in the calibration of the model in section 4.

The Increased Market Work of Wives. Goldin (1990) stresses the rise of the clerical sector for increasing female labor force participation (marriage bars during the Great Depression slowed the increase). Female clerical workers were more likely than female manufacturing workers to return to work as their children matured. Consequently, the life cycle labor force participation of married females increased as the proportion of females working in clerical occupations soared. Indeed, the married female labor force participation rate (MFLFPR) rose from 4.6 in 1890 to 21.6 in 1950 (Goldin, 1990, p. 17, Table 2.1).[4]

Albanesi and Olivetti (2007) argue that technological improvements related to the bearing and

[4] Anectol (2011) analyzes more recent trends in female employment. Light and Omori (2012) discuss the decline in life-long marriage in recent decades, with implications for female employment.

nursing of children were instrumental to the rise in the labor force participation of mothers. Conversely, Mokyr (2000) argues that new understandings of the role of hygiene in preventing sickness and death led turn-of-the-century mothers to devote more time to housework, delaying the acceleration of mother's market work. Galor and Weil (1996) suppose that the capital deepening accompanying the second industrial revolution decreased the return to strength, narrowing the gender wage gap, reducing fertility and increasing married female labor force participation rates (MFLFPRs). 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 value of mother's time in the household. These appliances reduce the reservation wages of females and increased MFLFPRs in the middle of the 20th century.[5] [6]

Mortality. High baseline mortality before the last decades of the nineteenth century was spiked by periodic epidemics of cholera, typhoid, yellow fever, influenza and other infectious diseases. However, beginning around 1880 mortality commenced a rapid descent. The white infant mortality rate, which was a staggering 214.8 in 1880, had declined to 120.1 in 1900 and to 26.8 by 1950 (Haines, 2000, Table 4.3); rates among black children were even higher. 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 and Tamura, 2008, Tables 14 and 15). This mortality transition was facilitated by massive public investments in clean drinking water and hygienic waste removal as well as advances in scientific understanding (Preston and Haines, 1991).[7]

Fertility. Fertility was declining in the United States from at least the early nineteenth century. Jones and Tertilt (2008) and Murphy, Simon and Tamura (2008) analyze 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 bore about 5.3 children. Females born only a half century

[5] The mechanisms Greenwood et al. suggest only become operative at the end of the period addressed in this paper. Adeshade (2009) and Rotella (1980, 1981) envision that an exogenous increase in high school attendance induced skill-biased technical change in office machines. 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.

[6] Soares and Falcao (2008) consider linkages among adult longevity and MFLFP. Increased longevity lengthens the period over which investments in human capital can be recouped. This increases human capital investments by females, inducing them to substitute away from fertility and increase market work. However, Hazan (2009) shows that increased adult longevity in the United States was associated with lower, rather than higher, life cycle market work among men.

[7] Once the germ theory of disease gained acceptance, a concerted effort was undertaken by governmental and charitable institutions to inform mothers of the risks of germs and of those steps mothers could take to protect the health of their children. 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. Vaccines against cholera and typhoid arrived late in the nineteenth century, while vaccines against diphtheria, whooping cough, and tuberculosis became available 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). Morbidity is considered further in section 5.3.1.

later, with fertility centered about 1930, ended up bearing only about 2.6 children-just half that of their grandmothers. Children surviving into adulthood fell by a smaller percentage as deaths during infancy and childhood declined from horrific levels.

Jones and Tertilt (2008) find a strong negative 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. Then, so long as each child is treated the same, and parents care about both the quantity and quality (i.e., earnings in adulthood) of children, higher wages would reduce fertility and simultaneously induce a substitution toward child quality.

In Soares and Falcao (2008) parents receive utility from surviving children and, as child mortality declines, so does fertility.[8] Doepke (2005) examines reductions in child mortality for fertility using several variants of the Barro-Becker (1989) model of inter-generational altruism. In each variant fertility does fall, but the number of surviving children *increases*. Our calibrations support the findings of Doepke; other factors prove responsible for the decline in net reproduction rates.

Lord and Rangazas (2006) conduct a quantitative assessment of a theory of long-run growth in the United States-from 1800-2000 which is able to re-produce central features of the quantity-quality trade-off. Their macroeconomic transition model includes fertility, student time in human capital production, and multi-generational family business. Family business generates a wealth effect which increases fertility. The decline in family business accounts for about 40% of the decline in the nineteenth century. Our results are contrasted with their findings.

Female Empowerment and Increased Concern for Children. 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. Most states in the preceding decades had passed laws enabling women to keep monies earned while married and to enter into contracts-the principle of coverture was in rapid retreat. More women were working for pay, earning higher wages relative to men than had their mothers. Further, mothers spent less time debilitated in pregnancy and were taught how to reduce the rate at which their children succumbed to illness.

Miller (2008) and Doepke and Tertilt (2011) review convincing evidence that women place relatively more weight than men on child expenditures and welfare. Shifts in income from husbands to wives

[8] 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 reduced the married female labor force participation (MFLFP).

tend to reduce expenditures on alcohol, tobacco, and men's clothing while increasing expenditures on children's food and clothing. Therefore, the increase in the relative power of females circa 1900 may have increased investments in the quality and well-being of children. Greater investments per child make children more expensive, lowering fertility. This mechanism is reinforced if the share of parental resources devoted to each child's consumption during dependency is increased.

Declining Economic Role of Children. Massachusetts introduced the first state compulsory schooling law in 1852 but by 1910 41 states had such laws, while 40 had passed child labor legislation (Goldin and Katz, 2008, p.191). Puerta (2009) finds compulsory schooling laws increased school enrollment in affected areas 7 percent (and reduced fertility by 15% among women of reproductive age). Other researchers have found somewhat smaller effects (Goldin and Katz, 2008).

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.' In her view, child labor as a source of household income became reprehensible.[9] Moehling (2005) finds that even by the first decades of the twentieth century children's private consumption was increasing in their earnings. 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 football, and American Legion baseball are among the youth organizations which had their origins in the first decades of the twentieth century.

Our research builds on the foregoing literature in a variety of ways. Below we present a model of two-parent households in which fertility, child labor and human capital, household production and MFLFP are all endogenous. This framework is calibrated to the households formed circa 1875, 1900 and 1925 including information on 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.

3 Modeling the household

3.1 Determinants of Human Capital

For each generation of adults there are four determinants of adult human capital; schooling, labor market experience, unskilled labor, and gender. The human capital of an adult male in period t is $[h_{0m} + \widehat{h}_t]E_{mt}$ while that of a female is $[h_{0ft} + \widehat{h}_t]E_{ft}$. Here, $\hat{h}_t$ is units of schooling human capital bequeathed by the parents of $t-1$ to their children. $\hat{h}_t$ is assumed to be equal across males and

[9] 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.

females. h_{0ft} (respectively h_{0m}) is the stock of 'unimproved' human capital available for use while a dependent youth in $t-1$ and as an adult in t. It is associated with nature's endowment, learning-by-doing or observation prior to market work for female and male respectively. As explained in Section 4, h_{0m} is assumed constant through time, while h_{0ft} increases as the premium to strength declines (yet $h_{0m} > h_{0ft}$ for all t). Such unskilled human capital includes any minimum legal or cultural requirements of parents to provide food and attention to their children. Thus, it is the 'no-schooling' stock of human capital. E_{ft} (respectively E_{mt}) indicates how schooling and unskilled human capital are augmented by work experience for females and males respectively.

The potential earnings of males and females are determined by the market valuation of their stocks of human capital. The market places the same value w_t on units of unskilled and skilled human capital, whether provided by males or females. Thus the potential earnings of a male beginning adulthood in t are

$$w_t h_{0m} E_{mt} + w_t \widehat{h}_t E_{mt} = w_t \left[h_{0m} + \widehat{h}_t \right] E_{mt} = w_t h_{mt}, \tag{3.1.1}$$

where $h_{mt} = \left[h_{0m} + \widehat{h}_t \right] E_{mt}$ is the male's stock of human capital in adulthood. Similarly, the potential adult female earnings are

$$w_t \left[h_{0ft} + \widehat{h}_t \right] E_{ft} = w_t h_{ft}. \tag{3.1.2}$$

Combining (3.1.1) and (3.1.2) yields the potential household earnings

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

The ratio of the earnings of an adult female working full-time with average experience to those of an adult male working full-time is

$$\gamma_t = \frac{w_t h_{ft}}{w_t h_{mt}} = \frac{h_{ft}}{h_{mt}}, \tag{3.1.3}$$

Hence, the gender wage gap is[10]

$$1 - \gamma_t. \tag{3.1.4}$$

3.2 Production of Schooling Human Capital

Schooling human capital is acquired during dependency and deployed during adulthood. Parents forming households at t choose the quality and quantity of their children's education. The quality, x_t, is

[10] Changes in the gender wage gap over time are more important than the initial level of the gap. This paper assumes that changes in the gender wage gap arise from changes in schooling, experience, and the premium to strength (as in Goldin and Polachek,1987).

determined by goods inputs such as teachers and books, while the quantity, s_t, is the fraction of a child's youth devoted to schooling. Parents also choose the time spent on human-capital enhancing activities by mother e_t, the effectiveness of which depends on her human capital h_{ft}. Thus, the schooling human capital produced in accordance with parental choices in t, and which children can deploy as adults in $t+1$ is given by

$$\hat{h}_{t+1} = b_t s_t^{\theta_s} x_t^{\theta_x} \left(h_{ft} e_t\right)^{\theta_{he}}, \tag{3.2.1}$$

where b_t is an efficiency scalar, and $\theta_s,\ \theta_x,\ \theta_{he} \in (0,1)$ are production function parameters (elasticities). Multiplicative human capital production functions have been a workhorse in labor economics for decades (Ben-Porath, 1967, Heckman, 1976, Lord, 1989). This specification implies own-price elasticities of 1, and cross-price elasticities of 0. Other implications are discussed in Sections 4 and 5.

3.3 Preferences

Parents care about the number of children surviving to adulthood n_t (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

$$U_t = \ln G_t + \psi \ln w_{t+1} \hat{h}_{t+1} (E_{mt+1} + E_{ft+1}) \frac{n_t}{2} + \sigma \ln w_{t+1} (h_{0ft+1} E_{ft+1} + h_{0m} E_{mt+1}) \frac{n_t}{2}, \tag{3.3.1}$$

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 (i.e., unskilled) human capital. Parent's relative taste for these 'unimproved' earnings is σ; such earnings may be increased by choosing to have a larger number of surviving children n_t. The aggregate earnings of adult children associated with schooling human capital is given by the second term. The intensity of preference for such earnings is captured by ψ, and these earnings may be increased by having more surviving children n_t and/or by investing more in their education (which increases $\hat{h}_{t+1}$). Andreoni (1990) argues that altruists get a 'warm glow' from their own contributions to a recipient, and therefore place a higher valuation on the marginal dollar of own contributions to a recipient's well-being than to those from other sources. His findings suggest that there is no reason to expect σ and ψ to be equal. Both ψ and σ embody a taste for quantity of children. However, only ψ reflects a taste for improving the quality (i.e., schooling) of individual children. For this reason an increase in ψ/σ is viewed as an increased relative preference for quality of children over quantity of children.

If the preferences of parents were purely altruistic toward their children, parental utility would depend upon the utility of children (cf. Becker, 1981) rather than the potential earnings in adulthood of children However, since the utility of children is likewise increasing in the their potential earnings (and thus consumption) these preferences and those of children are closely aligned. Furthermore, the formulation above facilitates discussion of alternative mechanisms in the results section, while avoiding the nearly insuperable data demands of infinitely lived economic agents. 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 and $\hat{h}_{t+1}$, and are constrained in various ways, which we now explain.

3.4 Constraints

All adults marry for life upon reaching adulthood and immediately make all decisions for the new household's remaining life. 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.

3.4.1 The life cycle and time use

Period and Mortality Structure Childhood is spent under the direction and care of parents. Childhood and adulthood each last one period, but adulthood is imagined to last twice as long as childhood.[11] Not all live births result in a child who survives to adulthood. The number of live births to a mother at time t required to produce 1 child surviving to adulthood in $t+1$ equals d_{1t}. d_{1t} 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 die before reaching adulthood. d_{1t} reflects both types of mortality, so that as either declines so will d_{1t}. d_{2t} is the number of children surviving infancy necessary to produce 1 child reaching adulthood; d_{2t} reflects only youth mortality.

Mother's time allocation Mothers devote time to household production, raising children and the labor market. Each live birth demands requires significant mother's time 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 time costs of $\overline{\rho}$ for mother in terms of lost productivity during pregnancy,

[11] Some early versions of the paper allowed for multiple periods in childhood and adulthood. For the issues addressed the insights gained were dominated by the costs of increased complexity. Were the framework extended to a general equilibrium growth model, for example, it would be necessary to include a consumption-savings margin. The fact adulthood is twice as long as dependency is addressed in the calibration section.

recovery following delivery, time to nurse and tend while the infant survives, and time grieving an infant's demise. Each child surviving infancy imposes additional time costs of ρ on mother during its dependency largely unrelated to child quality. These include 'picking up' after children, laundry, dish washing, 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 surviving infancy. 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 such human capital development increases linearly in her human capital.

z_t units of mother's time are allotted to household production. z_t is combined with market goods c_t 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.[12] 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

$$n_t \left[d_{2t}(\rho + e_t) + d_{1t}\bar{\rho}\right] + m_t + z_t = 1 \tag{3.4.1}$$

Children's time budget Dependency lasts one period. Each of the $d_{2t}n_t$ children surviving infancy has $T_t < 1$ 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 (Lord and Rangazas, 2006). Parents decide how much time, l_t, older, potentially wage-earning, children should contribute to the household budget through market-oriented work (performed in the market or at home) and how much time s_t to spend in schooling. Hence, the time constraint faced by each child is given by

$$s_t + l_t = T_t. \tag{3.4.2}$$

3.4.2 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 $d_{2t}\tau_t w_t h_t$ for each surviving child on clothes, housing, and other child

[12] With logarithmic preferences mother's time allocation proves independent of whether household productivity is increasing in her skill level; of course G_t and utility are higher when her skills matter.

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; they also prove important to the calibration .

Parents also spend money for children's schooling or developmental inputs x_t, with each unit costing P_t. Public financing of *primary* schooling made a given family's cost independent of usage by the late 19th century, (unless one desired to supplement the short school year of the time). For older children attending high school, tuition was less subsidized. Overall, .the cost across all goods inputs (including books, educational toys and broadening vacations, etc.) is less than one, and was falling over time with the further expansion of public schooling. Total goods expenditures across all children are given by

$$n_t d_{2t}(P_t x_t + w_t h_t \tau_t). \tag{3.4.3}$$

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 in t, but if they do, offer only unskilled human capital to the market while dependents; for females, h_{ft+1}. Due to less strength and concentration as compared to adults, children earn only $\mu_t w_t$ per unit of unskilled human capital, with $\mu_t \in (0,1)$. These potential earnings *in period* t are therefore $d_{2t}\mu_t w_t n_t h_{0t+1} T_t$, where h_{0t+1} is average unskilled human capital across males and females $(h_{0m} + h_{0ft+1})/2$. Actual earnings of children are below potential earnings to the extent children spend time s_t in school. Altogether potential household money income is

$$w_t h_t + d_{2t}\mu_t w_t n_t h_{0t+1} T_t. \tag{3.4.4}$$

Combining the results from (3.4.1), (3.4.2), (3.4.3), and (3.4.4), the family's overall budget constraint is expressed as[13]

$$\begin{aligned} w_t h_t + d_{2t}\mu_t w_t h_{0t+1} T_t n_t &= d_{2t}\mu_t w h_{0t+1} s_t n_t + n_t \left[d_{2t}(\rho + e_t) + d_{1t}\bar{\rho}\right] h_{ft} w_t \\ &\quad + n_t d_{2t}(P_t x_t + w_t h_t \tau_t) + z_t w_t h_{ft} + g_t \end{aligned} \tag{3.4.5}$$

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 mother's time devoted to quality and quantity of children, the money outlays for kids education and

[13] The price per unit of the human capital goods input is less than 1 because much schooling is publicly provided. Often the taxes to pay for public education come from levies on real property. The budget constraint abstracts from those and other taxes since the burden of additional notation swamps any insight gained. The schooling taxes would range from about .3 percent of life wealth in the intial period to about 1.5 percent in the last period (see calibration discussion). One approach is to envision taxes are levied on wage earnings and to then simply view the wage per unit of human capital as being net of tax.

consumption, the implicit costs of mother's time devoted to household production, the goods used in household production.

3.5 Household production

We assume that household production is governed by the equation

$$G_t = g_t^{\nu} \left(h_{ft} z_t\right)^{1-\nu} . \tag{3.5.1}$$

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 likewise included in g_t. As men and children work more outside the home, and as domestic servants are released, intermediate market goods (for example, store-bought flour and clothes, and washing machines) become more important. The multiplicative production function implies own-price elasticities of 1 and cross-price elasticities of 0.

3.6 Optimization

Parents of generation t choose the quality of children $\hat{h}_{t+1}$ based on input choices $x_t,\ s_t$, and e_t; quantity of surviving children n_t; and public goods consumption G_t based on input choices z_t and g_t, so as to maximize their utility function given by equation (3.3.1), subject to constraints (3.4.1) and (3.4.5). The Lagrangian L_t is written,

$$\begin{aligned} L_t \;=\;& \ln g_t^{\nu} \left(h_{ft} z_t\right)^{1-\nu} + \psi \ln w_{t+1} b_t {s_t}^{\theta_s} x_t^{\theta_x} \left(h_{ft} e_t\right)^{\theta_{he}} \left(E_{mt+1} + E_{ft+1}\right) \frac{n_t}{2} \\ & + \sigma \ln w_{t+1} h_{0t+1} (E_{mt+1} + E_{ft+1}) \frac{n_t}{2} \\ & + \lambda \left[\begin{array}{c} \left(d_{2t} \mu_t w_t n_t h_{0t+1} \left(T_t - s_t\right) - z_t w_t h_{ft} - n_t \left[d_{2t}(\rho + e_t) + d_{1t}\bar{\rho}\right] h_{ft} w_t - g_t\right) \\ + w_t h_t - n_t d_{2t} (P_t x_t + w_t h_t \tau_t) \end{array} \right] \end{aligned} \tag{3.6.1}$$

The first order conditions (FOCs) for the optimal choices of $g_t,\ z_t,\ x_t,\ e_t,\ s_t$, and n_t are

$$v/g_t = \lambda, \tag{3.6.2}$$

$$(1-v)/z_t = \lambda w_t h_{ft}, \tag{3.6.3}$$

$$\theta_x \psi / x_t = \lambda n_t d_{2t} P_t, \tag{3.6.4}$$

$$\theta_{he} \psi / e_t = \lambda n_t d_{2t} w_t h_{ft}, \tag{3.6.5}$$

$$\theta_s \psi / s_t = \lambda n_t d_{2t} \mu_t w_t h_{0t+1}, \tag{3.6.6}$$

$$\begin{aligned}(\psi+\sigma)/n_t &= \lambda\left(\left[d_{2t}(\rho+e_t)+d_{1t}\bar{\rho}\right] h_{ft} w_t - d_{2t}\mu_t w_t h_{0t+1}\left(T_t - s_t\right)\right) \\ &\quad + \lambda d_{2t}(P_t x_t + w_t h_t \tau_t).\end{aligned} \tag{3.6.7}$$

These FOCs reveal standard intuitions. Equations (3.6.4–3.6.6) 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 $n_t d_{2t}$, so that as stressed by Becker (1981) the price of child quality is increasing in the quantity of children. Further, in (3.6.4) and (3.6.5) which govern the developmental inputs for perishable children, this price of quality per surviving child is increasing in d_{2t} 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 (3.6.7) 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 child 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.

3.6.1 The quality and quantity of children

Proposition 1 *Parental investments in child quality are given by youth schooling inputs x_t and s_t and mother's time devoted to children's human capital production e_t. The quantity of surviving children is n_t (so that fertility is $d_{1t} n_t$). These investments are given by*

$$x_t = \frac{\theta_x \psi w_t \left[d_{2t} h_t \tau_t + h_{ft}\left(d_{2t}\rho + d_{1t}\bar{\rho}\right) - d_{2t} h_{0t+1} \mu_t T_t\right]}{d_{2t} P_t \left[\psi\left(1 - \sum_i \theta_i\right) + \sigma\right]} \qquad i = s, x, he \tag{3.6.8}$$

$$s_t = \frac{\theta_s \psi \left[d_{2t} h_t \tau_t + h_{ft}\left(d_{2t}\rho + d_{1t}\bar{\rho}\right) - d_{2t} h_{0t+1} \mu_t T_t\right]}{d_{2t} \mu_t h_{0t+1} \left[\psi\left(1 - \sum_i \theta_i\right) + \sigma\right]} \qquad i = s, x, he \tag{3.6.9}$$

(3.6.10) $$e_t = \frac{\theta_{he}\psi\left[d_{2t}h_t\tau_t + h_{ft}\left(d_{2t}\rho + d_{1t}\bar{\rho}\right) - d_{2t}h_{0t+1}\mu_t T_t\right]}{d_{2t}h_{ft}\left[\psi\left(1-\sum_i \theta_i\right)+\sigma\right]} \quad i = s, x, he$$

(3.6.11) $$n_t = \frac{h_t\left[\psi\left(1-\sum_i \theta_i\right)+\sigma\right]}{(1+\psi+\sigma)\left[d_{2t}h_t\tau_t + h_{ft}\left(d_{2t}\rho + d_{1t}\bar{\rho}\right) - d_{2t}h_{0t+1}\mu_t T_t\right]} \quad i = s, x, he$$

Proof. See Appendix 1 ■

Discussion. Notice that all of these optimal solutions share a similar structure. Consider first the human capital input, or 'quality,' variables x_t, s_t, and e_t. The numerators differ only in that each contains the exponent in human capital production for that input; each denominator includes the 'own' input price, but is otherwise the same. 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. These considerations are central to the 'quantity-quality' trade-off in both the family-level and economic growth literatures (Becker, 1981 and Galor, 2005).

Selected Comparative Statics. Suppose that schooling human capital rises across generations but that unskilled human capital remains constant. Then the human capital of adult males h_{mt} and females h_{ft} increase (relative to $t-1$) while unskilled human capital of children is unchanged. Higher parental human capital increases the fixed costs of child consumption and of mother's time inputs related to quantity; potential child earnings-which depend on the quantity of unskilled labor- are constant. Thus, the net costs of child quantity increase, inducing a substitution away from quantity toward quality (x_t, s_t, e_t all increase and n_t falls). Viewed differently, n_t falls as the net cost of children increases by a larger percentage than potential parental earnings. Ceteris paribus, then, h_{mt+1} and h_{ft+1}will also increase, increasing x_{t+1}, s_{t+1}, and e_{t+1} and so on. This effect becomes weaker through time, though, as parental human capital rises relative to that of their dependent children.

Thus, as Lord and Rangazas (2006) note, there is a supply-side element associated with any initial rise in human capital which carries forward into future generations. In their framework, as parental earnings rise relative to potential child earnings, there is a declining opportunity cost of schooling children (the utility loss from forgone parental consumption is lower at higher levels of consumption). 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 paper's model is consistent with that pattern. As in Lord and Rangazas (2006), Becker and Barro (1988) and Barro and Becker (1989), as examples, increases in wages have no effect on fertility, due to offsetting income and substitution effects.

Infant Mortality. Parent's choices over quantity and quality are affected by their expectations of infant and child mortality. A reduction in infant mortality reduces d_{1t} with no effect on d_{2t}. Since lower infant mortality means fewer times mother must expend $\overline{\rho}$ units of time in order to produce a surviving child, the cost of a surviving child falls with d_{1t}. Since schooling and other human capital investments do not occur during infancy, those costs are unaffected by changes in infant mortality. Overall, though, the *relative* price of human capital inputs rise, so that quantity of children is substituted for quality: x_t, s_t, and e_t fall while n_t rises. This result is also obtained in Doepke (2005) and Barro and Becker (1989). The number of children ever born to a cohort, or just fertility, is $d_{1t}n_t$. Inspection of (3.6.11) reveals that there is an ambiguous effect of reduced infant mortality on fertility. That is, even though the number of surviving children demanded has risen, the fact that fewer births are required to produce a surviving child makes the effect on births unclear.

Youth Mortality. Suppose now that youth mortality declines, while infant mortality is unchanged. This reduction in d_{2t} also reduces the number of children born required to produce a surviving child d_{1t}; indeed, d_{2t} and d_{1t} would fall by the same percentage.[14] This would not affect any of the quality variables as the numerator and denominator would each fall the same percentage. The relative prices per child surviving to adulthood of quantity and quality are unchanged. Notice that there is also no change in the number of births $d_{1t}n_t$ or the number surviving to childhood $d_{2t}n_t$. However, the number of surviving children clearly falls (in percentage terms the decline is 1 divided by the percentage decline in d_{2t} and d_{1t}. In the current framework, child quality variables are unlikely to rise as mortality falls. This differs from Soares and Falcao (2008) who 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 time inputs s_t and e_t do not. All components of the 'mechanical' costs of quantity include 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 s_t is proportional to w_t. With the numerator and denominator increasing by the same percentage, w_t drops out of their solutions. However, the cost per unit of x_t is P_t. Consequently, w_t remains and

[14] Suppose the youth mortality rate is m_y. Then $d_{2t} = 1/(1-m_y)$. If the infant mortality rate is m_i, then $d_{1t} = d_{2t}/(1-m_i) = 1/[(1-m_y)(1-m_i)]$ so that changes in youth mortality change d_{2t} and d_{1t} by the same percentage.

x_t increases with w_t/P_t. Finally, notice that the solutions for the quality variables are increasing in θ_x, θ_s and θ_{he}.

Costs of Children. A child is more expensive the greater is the share of potential parental earnings spent on each child, τ_t. An increase in that share also reduces the relative price of child quality. Thus, the quality variables x_t, s_t and e_t are all increasing in τ_t, while the number of surviving children n_t declines. The potential economic benefit of children is increasing both in the total time children are available for work, T_t, and in their wage per unit of human capital as compared to parents, μ_t. When these are lower, the net costs of children of given quality (fixed costs minus potential benefits) are higher. Thus, lower values for these parameters induce substitution toward the quality variables and away from fertility.

3.6.2 Goods inputs and mother's time in household production

Proposition 2 *Goods inputs in household production are*

$$g_t = \frac{vw_t(h_{mt} + h_{ft})}{(1 + \psi + \sigma)} \tag{3.6.12}$$

Optimal mothers' time in household production is given by

$$z_t = \frac{(1 - v)\,(h_{ft} + h_{mt})}{(1 + \psi + \sigma)\,h_{ft}}. \tag{3.6.13}$$

Proof. See Appendix 1 ■

The proof is available upon request from the authors. Equation (3.6.12) 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. Notice that if human capital of females h_{ft} increases by a larger percentage than that of males, 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, the more expensive is mother's time input, the less of it is used in household production (as shown in the denominator). 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). That is, households with high-earning husbands demand lots of household public goods and so demand lots of mother's time input. Note that z_t is independent of infant and youth mortality.

Taking the ratio of (3.6.13) to (3.6.12) 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 goods' 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. Consequently, 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 (3.4.1) shows that her 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 and $\overline{\rho}$) fall over time. Calibration exercises reveal the relative importance of these different sources of change in market orientation.

4 Assignment of Parameter and Target Values, and Calibration of the Initial Baseline

The model above was calibrated to examine the quantitative significance of several proposed determinants of the revolution in households formed between 1875 and 1925. A meaningful calibration requires that the model's parameters be 'pinned down' to capture a fact or otherwise be reasonably restricted. Otherwise, if numerous parameters are 'left free,' sensitivity analysis may produce such a large range of possible impacts that few meaningful conclusions are possible. This section also produces estimates of the changes in schooling human capital- endogenous targets which are not directly observed.

Table 1 helps link the household decisions and notation within the model to the life cycles of the various cohorts. Consider for example the birth cohort of 1850, which forms households in 1875. Column (2) reviews the composition of the human capital used in adulthood by that cohort. Assuming the adult work life is 40 years, males work full-time in the labor market between ages 25 and 65, or the years 1875-1915. Column (3) notes that over those same ages and years, households choose the household production inputs (the wife's time and market goods) and the wife's time in the labor market. Column (4) suggests the interpretation that children are born to that household when parents are between the ages of 25 and 30-and thus over the years 1875-1880. Finally, in Column (5) children commence school at age 6, with the first starting when parents are age 31 in 1881. The potential schooling period is ages 6-19, so the last child would be finished by 1900.[15] Parents implement their human capital investment plans over those same years period.

[Insert Table 1]

Some values for parameters and targets are easier to assign than others. For example, published infant and youth mortality rates in different years-the basis for d_{1t} and d_{2t}- can reasonably be assumed

[15]Less realistically, but in strict conformity with the model, could imagine all children are born in 1875, commence school at age 6 in 1881 and complete schooling in 1895.

to be fairly accurate. Some, such as the gender wage gap in different years (which determines γ_t) have been carefully estimated and are used with confidence. Similarly, targets for the goods and time inputs in human capital production x_t and s_t can be inferred from government publications and the prior literature. The taste parameters are difficult to estimate directly, but are chosen so as to achieve specific values for the quality and quantity of children in the initial baseline.

Among the more difficult items to determine are the time paths for the efficiency parameter in human capital production b_t; unskilled human capital among females; schooling human capital $\widehat{h}_t$; and the wage per unit of human capital w_t. Fortunately, careful estimates by Goldin and Polachek (1987) of the gender gap through time and of the determinants of the narrowing of that gap allow inference of b_t, h_{0ft}, and $\widehat{h}_t$. Then, with $\widehat{h}_t$ in hand, estimates of the growth in income across cohorts are developed and then used to determine w_t. The method of calculating b_t, h_{0ft}, $\widehat{h}_t$ and w_t.are fully described in the text below. For many parameters and targets, only the main results are presented in the body of the text, with additional details found in Appendix 2 or footnotes. For easy reference, Table 2 lists all parameters and targets, including a few words on how they are determined.

[Insert Table 2]

4.1 Gender Wage Ratio γ_t and Experience Impacts E_{mt} and E_{ft}

Goldin and Polachek (1987) and Goldin (1990) calculate the time path of γ_t and also estimate the roles played by changes in unskilled human capital, schooling human capital, and experience to the narrowing of that gap over time. Their study thus provides an excellent, consistent framework for the determination of various parameters and targets that would otherwise be difficult to ascertain. 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."[16]

For purposes of calibration, the gender wage ratio confronting adults forming households in t, γ_t, is based on the economy-wide figure for $t+15$ -when that birth cohort is age 40, and roughly in mid-career. Then $\gamma_{1875} = .463$, the economy-wide gender wage ratio in 1890 as measured by Goldin and Polachek. Averaging their estimates for 1890 and 1930, for parents of 1900 (birth cohort of 1875) γ_{1900} is set equal to .52. The cohort born in 1900, becoming parents in 1925, might confront $\gamma_{1925} = .57$ (given the slow increase between 1930 and 1970). For the cohort born in 1925, $\gamma_{1950} = .603$, the economy-wide value

[16] 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.

for 1970; the decisions of this cohort are not targeted, but the gender wage gap it confronts reflects the human capital investments of the parents of 1925).

The average impact of experience on human capital among households formed in 1875 (more generally in period t) is likewise based on that in the entire labor market in 1890 (in year $t+15$). As calculated by Goldin and Polachek (1987) this is $E_{m1875} = 2.53$ for males and $E_{f1875} = 1.62$ for females.[17] For the successive cohorts of parents their results suggest that for males $E_{m1900} = 2.36$, $E_{m1925} = 2.19$ and $E_{m1950} = 2.01$. For females these impacts are $E_{f1900} = 1.55$, $E_{f1925} = 1.48$, and $E_{f1950} = 1.41$. The slight reduction among females occurred even as the average experience among working women was increasing significantly. The downward trend among males and females is consistent with the discussion of 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, human capital among males was rising over this period only because the increases in schooling human capital were (appreciably) greater than the decline in experience human capital. Among females, the decline in experience human capital was offset by increases in both schooling and in the productivity of their unskilled human capital.

4.2 Determination of $\widehat{h}_{1875}$ and h_{0f1875}

Information on the years and rate of return to schooling are used to establish an estimate for $\hat{h}_{1875}$. The U.S. Census did not begin collecting information on educational attainment or income until 1940. The average years of schooling for the birth cohort of 1850 was perhaps 6 years. Smith (1986, Table 1) reports figures for pre-1865 birth cohorts by race. Upon weighting by population, this implies schooling of about 6.3 years. His data relies on replies from the 1940 census on education completed. Consequently, this figure is possibly inflated upwards both by survivor bias and (over)reporting bias. Bleakley, Costa and Lleras-Muney (2013, Fig. 4) plot educational attainment among a sample of white Union Army soldiers from 1863 (the Gould Sample) with educational attainment a bit less than 6 years for those born in the mid-1840s [18]

Making inferences primarily from microeconomic evidence in Goldin and Katz (2008) it is assumed that the rate of return to a year of schooling was 3.1% for the cohort born in 1850. [19] The low returns

[17] The experience numbers have been converted from the log form in which Goldin and Polachek presented them.

[18] This estimate of 6 years for the birth cohort of 1850 appears consistent with the time series attainments reported in Goldin and Katz (2008, Fig. 1.4), which is a bit over 7 years for the Native-Born birth cohort of 1876.

[19] Goldin and Katz (2008, Table 2.5, pp. 78-9) present returns to schooling among males 18-65 based on a 1915 Iowa state census. The returns to those younger than 35 are 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 of males is 3.73% for each year of common school (very few attended high school at that time). The mid-range male in that subsample would be age 50, and so born in 1865. From at least 1865 through the first decades of the twentieth century the returns to primary school were increasing (see Goldin and Katz, 2008 and Card and Krueger, 1992). For example, in

to education at that time reflect some combination of the short school year and low expenditures per student (both discussed below). Labor demand considerations presumably played a role as well.

With a return of 3.1%, a person born in 1850 with the average of 6 years of education earns 20% more than a fellow cohort member with no education, $(1+.031)^6 = 1.2$. If attainment was a bit lower than 6 years, the return would be a bit above 3.1%. Such a comparison in contemporary society would be nonsensical, as individuals with no education are in no way otherwise the same as those with average education. However, in the middle of the 19th century those without formal education need not have been 'defective' (President Abraham Lincoln had about 1 year of formal education and his successor, Andrew Johnson, had no years of formal education).

The unskilled human capital of a male parent h_{0m} is set to 10, which simply establishes the scale for human capital. The 20% premium to an educated male worker thus implies that $\widehat{h}_{1875} = 2$. As discussed in a subsequent section, results are little affected if we instead used higher (lower) values for $\widehat{h}_{1875}$, such as $\widehat{h}_{1875} = 2.8$ (1.2), so long as other parameters are calibrated to be consistent with those values. There is now enough information to determine the unskilled human capital of females in 1875, h_{0f1875}. To see this, recall the expression for the gender wage ratio (3.1.3) and apply it to parents of 1875. Then substitute in the values established above for γ_{1875}, $\widehat{h}_{1875}$, E_{m1875}, E_{f1875} and h_{0m} to yield

$$\gamma_{1875} = \frac{\left[h_{0f1875} + \widehat{h}_{1875}\right] E_{f1875}}{\left[h_{0m1875} + \widehat{h}_{1875}\right] E_{m1877}}. = \left[\frac{h_{0f1875} + 2}{10 + 2}\right] \frac{1.62}{2.53} = .463$$

which indicates that $h_{0f1875} = 6.68$. This value implies a premium to strength for males for the initial period of almost 50% which is both huge and plausible (cf. Goldin and Polachek, 1987, p.147).[20]

the Goldin and Katz (2008) Iowa sample, the returns for those 18-34 had risen to 4.83% for common school. This suggests a rate of return for males born in 1850 below the 3.73% figure. Also, the market rate of return for females would surely have been below that for males, as would the return to all schooled in the South (see Wright, 1986). Altogether, a return of about 3 percent for each year of common school seems appropriate for those1850; a value of 3.1% fits the baseline calibration nicely. Bleakley, Costa and Lleras-Muney (2013, p. 5) report a rate of return to formal schooling of only about 1% for the mid-19th century. This return would apply principally to education obtained by cohorts born in the 1830s and earlier. This is consistent with the Goldin and Katz evidence that the rate of return to schooling was low but rising.

[20] Goldin and Polachek (1987) 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, the premium to strength for teenagers in the 1860s was presumably greater than in 1895. Alternatively, Goldin (1990) argues that there may have been a modest amount of discrimination within manufacturing in the 19th century. Thus, if such discrimination for unskilled attributes was 15%, say, then the productivity of unskilled females in the typical job would have been well above 6.68. This type discrimination could be captured in the model by deflating a 'true' female unskilled productivity by a discrimination factor. However, since the approach developed below is based on changes in the gender wage ratio unrelated to discrimination, abstracting from discrimination is not important to the issues examined. Interestingly, Goldin argues that in the first few decades of the twentieth century discrimination rose significantly, as firms began to rely on internal labor markets. In these clerical jobs, she argues, all women were passed over for training opportunities, since most women were expected to quit upon pregnancy, if not marriage. Thus, those married women who did continue to work received less on-the-job-training and fewer promotions, and this was reflected in their earnings.

4.3 Narrowing of Gender Wage Gap Due to Changes in Experience

The reasons for the significant closing of the gender wage gap, and their relative importance, have been examined by Goldin and Polachek (1987) and Goldin (1986, 1990). Goldin and Polachek (1987) emphasize the changing roles for experience, unskilled human capital (i.e., strength) and schooling for this period.[21] They estimate that the role of education (reflecting both changes in the rate of return to, and level of, education) in narrowing the gap is 50% more important than that of experience. They also conclude that a reduction in the premium to male strength was at least as important as that of experience. Supposing equal roles for experience and changes in the reward to strength, each explains about 29% of the total narrowing, with education then explaining about 43%. Recall Goldin and Polachek (1987) found $E_{m1875} = 2.53$ and $E_{m1950} = 2.01$, and for females $E_{f1875} = 1.62$ and $E_{f1950} = 1.41$. The ratio $\frac{E_{ft}}{E_{mt}}$ rose from .64 to .70, or by 9.37 percent between parents of 1875 and 1950. Ceteris paribus, this increases the gender wage ratio to .463(1.0937) = .506, or by .043, or about 30% of the total increase in γ_t, .043/(.603 − .463).

4.4 Schooling Target $\widehat{h}_{1950}$, As implied by micro evidence on the gender wage gap

As noted, increases in schooling human capital are targeted to contribute roughly 43% of the narrowing of the gender wage gap from .463 to .603. Thus, increases in $\widehat{h}_t$ alone must raise the wage ratio to $.463 + (.43)(.603 - .463) = .523$. The required value bequeathed by households formed in 1925 (and used by their adult children beginning in 1950), $\hat{h}_{1950}$, is then obtained from

$$\left[\frac{6.68 + \hat{h}_{1950}}{10 + \hat{h}_{1950}}\right] \frac{1.62}{2.53} = .523.$$

This produces a level of schooling capital for our last birth cohort, 1925, of $\widehat{h}_{1950} = 8.2$. This makes the schooling human capital of the 1925 birth cohort, compared to the 1850 birth cohort, equal to $\frac{\hat{h}_{1950}}{\hat{h}_{1875}} = \frac{8.2}{2} = 4.1$; that is, schooling human capital must increase a little more than 4-fold to generate the postulated narrowing of the gender gap associated with education. [22]

4.5 Unskilled Human Capital h_{0f1950}

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 $.463 + (.28)(.603 - .463) = .502$. Assuming this was associated with

[21] Goldin and Polachek find that narrowing of the gap was primarily due to rising wages for females within occupational groupings- especially clerical and professional - rather than changes in the occupational distribution (the latter explaining only about 2.6 of the 10 rise in the ratio between 1890 and 1930). Goldin (1990) argues that discrimination seems to emerge only after 1940, especially in the clerical sector. Polachek (1975) also addresses the role of discrimination.

[22] The years of schooling together with the rate of return to scholing determine $\widehat{h}_{1875}$. In general, the smaller is $\widehat{h}_{1875}$ the larger is the multiple of increase in $\widehat{h}_{1875}$ required to have schooling explain 43% of the narrowing of the gender wage gap, and the greater is the resulting role for educational efficiency b_t.

rising valuations for unskilled female labor, we can solve for h_{0f1950} from

$$\left[\frac{h_{0f1950}+2}{12}\right]\frac{1.62}{2.53} = .502.$$

Thus, by the birth cohort of 1925 the valuation of female unskilled human capital has risen to almost three-quarters that of men, $h_{0f1950} = 7.41$. Rendall (2010) confirms that a significant premium to strength existed into the 1980s. Notice that the restrictions on levels of male and female human capital from the gender wage ratio expression do not rule increases in human capital from factors that change h_{0m}, $h_{0ft,}$ and $\widehat{h}_{t+1}$ equiproportionally, as may occur with a general improvement in health (decline in morbidity). This point is pursued further in a later section.

4.6 Targeted schooling human capital and role of education in growth accounting

This section demonstrates this targeted increase in schooling human capital- from $\widehat{h}_{1875} = 2$ to $\widehat{h}_{1950} = 8.2$ (i.e., the schooling bequest of parents starting families in 1925)- is consistent with the contribution of education found in the growth accounting literature. Comparison is made with several prominent recent findings. First, Turner, Tamura, and Mulholland (2011, 2013) create original long-run data series for the United States, including output per worker and human capital. They use this data to engage in growth and development accounting exercises by states, regions and time periods. Over the course of the twentieth century, they find that, nationally, education contributed 30.1 percent of total growth in *output per worker* (2013, Table 6), assuming a labor share of two-thirds. For the subperiods $1880-1920$ and $1920-1960$ the contributions are estimated to be 42.4 and 27.7 percent (2011, Table 6). That large contribution over the first sub-period is especially surprising in light of the extensive capital deepening and reorganization of production typically associated with the second industrial revolution. They abstract from unskilled human capital, making for a faster rate of growth in human capital from schooling than when-as in our approach-unskilled human capital is quantitatively important. They also assume a 10 percent rate of return to a year's schooling, which is about double the rate of return to a year of common school (grades 1-8) found for 1915 by Goldin and Katz (2008, Table 2.5). [23] In our paper, the contribution of education to growth is the growth in human capital due to schooling relative to income growth across cohorts born in 1850, 1875, 1900, and 1925 (and their educational inputs at age 15, or years 1865, 1890, 1915, and 1940). This produces a contribution of education to growth over the period of 20.9 percent.[24] Although this is lower than the contribution as estimated by Turner et

[23] They point to estimates that a one-year increase in the average education within a state increases output per worker by 10%. However, the factors producing an increase in a state's average level of education-improved infrastructure, commericial growth, etc.-may overstate the effect on an individual of increasing own education by a year with given state infrastructure (Topel, 1999).

[24] Among men, holding experience and unskilled human capital constant, formal schooling increases total human capital from $[10 + 2](2.53) = 30.36$ to $[10 + 8.2](2.53) = 46.04$, or about 52%. Recalling that unskilled human capital among

al., it is somewhat above other well-known estimates based on labor productivity growth, or output per man-hour.

Since hours worked declined dramatically from the late nineteenth century into the middle of the twentieth century, output per man-hour increased much more rapidly than did output per worker. For this reason, a given role for education is lower when expressed in light of labor productivity growth than in terms of output per worker. In order to compare our results with those based on output per man-hour, the rise in cohort output per worker is adjusted to reflect the decline in hours worked over this period. Sundstrum (HSUS, 2, Ba-O, Ba-P, p. 47-48) reports that hours worked per week declined from about 62 in 1890 to 38 in 1960. This implies output per man-hour increased about 63% more than output per worker over this period. Expressed in terms of growth of output per man-hour, the schooling human capital target in our paper contributes about 15.7 percent of growth. This percentage is quite similar to Goldin and Katz (2008, Table 1.3) who find education explains about 14.3% of the rise in output per man-hour between 1915-1940. They use the previously discussed Iowa sample, weighting income differences at each level of education by the educational shares in the labor force. Their methodology is unaffected by the quantitative significance of unskilled labor. Abramovitz and David (2000, Table 1.5) conduct growth accounting over several intervals, including 1890-1927 and 1929-1966. Their figures imply that over the entire period 1890-1966, the contribution of education is about 10.3%. Unlike Turner et al., they find the contribution of education was especially low in the earlier period, which includes much of the second industrial revolution but only the first few years of the high school movement. Overall, despite significant differences in methodology, the targeted increase in schooling human capital from our parameterization fits easily within the range of recent prominent estimates. In the results section, growth accounting is revisited when results of this paper are compared with other quantitative assessments.

4.7 Human Capital Productivity Parameters, Inputs, and Role of Curriculum

The production function for schooling human capital was given by

$$\widehat{h}_{t+1} = b_t s_t^{\theta_s} x_t^{\theta_x} \left(h_{ft} e_t\right)^{\theta_{he}} \tag{4.7.1}$$

Values for the θs from the literature along with constructed estimates of the inputs enable us to infer the rise over time in the efficiency parameter b_t.

females begins at 6.68, the percentage increase in human capital from schooling alone is 71%. Using an estimated average of male and female labor for shares between 1890 and 1965 (about .73 for males), the increase in schooling human capital across these cohorts would be about 57%. Over a 75 year period, this corresponds to an average annual growth rate of human capital from educational deepening of about .6 percent. If labor's share of income is .7, this implies an average annual contribution to output per worker of (.6)(.7) = .42 per cent. Since growth in output per worker across these cohorts averaged 2.01 percent (discussed below), the relative contribution from educational deepening is .42/2.01 = .209, or 20.9 percent.

4.7.1 Returns to scale in human capital production

Using schooling inputs is superior to using years of schooling, as the time spent in school and the educational inputs per year have increased dramatically over time. Are observed increases in schooling inputs consistent with the four-fold increase in $\widehat{h}_t$ calculated 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 (4.7.1).

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 (Lord and Rangazas, 1993 and Browning, Hansen, and Heckman, 1999). A consensus estimate for goods is $\theta_x = .10$; perhaps a little lower in recent times and possibly a little higher in earlier periods. A value of .10 has also been employed for mother's time input $h_{ft}e_t$, $\theta_{he} = .10$ (Rangazas, 2002). A broader range of values has been estimated for θ_s with most falling between .5 and .7. We employ an intermediate value of $\theta_s = .6$ (see Lord, 1989 and Browning, Hansen, and Heckman, 1999 for additional discussion). $\theta_s + \theta_x + \theta_{he} = .8$ are therefore the returns to scale in human capital production.[25]

4.7.2 Schooling Inputs: Expenditures and Time

Table 3 shows the targets for goods and time inputs chosen by parents for their children's human capital. x_t/x_{1850} is the (constant dollars) ratio of the schooling expenditures for the children aged 5-19 of generation t relative to those of 1850.[26] The input choices of 1850-parents are exogenous parameters which help determine the human capital of their children, the parents of 1875; the calibration chooses the 1875, 1900 and 1925 values for x_t and s_t. Schooling expenditures and school attendance for those aged 5-19 are measured when the children are age 15. Thus, for parents forming households in 1875 their schooling input choices are measured when their first child would be age 15, in 1890, and given the notations x_{1875} and $s_{1875.}$

[Insert Table 3]

Table 3 shows both goods and time inputs increase dramatically. x_{1925}/x_{1850} is 14.9 (or 16.6 if we include college expenditures for those 18 and 19 years old in the last cohort). Rangazas (2002, Table

[25] If the returns to scale were lower, the percentage increase in $\widehat{h}_t$ from the historical increase in goods and time inputs would be smaller. Consequently, to achieve the targeted $\widehat{h}_{1950}$ the percentage rise in b_t would need to be larger. Education has long been considered a low productivity growth sector. Lowering θ_s somewhat and increasing b_t a bit had little effect on any interpretations in the experiments considered below.

[26] The data underlying Table 3 is presented in Appendix 3, Tables A2.1 and A2.2.

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 x_{1875} is chosen so that the ratio of schooling expenditures to father's life earnings should is a bit above 1.0 percent (since women and children also contributed to earnings). Since our figures include college expenditures for the last cohort of parents, the targeted share for x_{1925} is 2.6 percent. Time in school triples between the 1870 and 1940 school years, with the fraction of days in a year attended in 1940 exceeding 30 percent; thus $s_{1925} = .309$. These figures are comparable to those produced by Rangazas (2002, Table 2, p. 936). (Since youth is only half of adulthood, the targets for the calibration are the s_t values divided by 2.) [27]

4.7.3 Increase in $\widehat{h}_t$ between 1850 and 1875 birth cohorts

Recall, the schooling human capital bequeathed by parents of 1850 was (exogenously) determined to be $\widehat{h}_{1875}$=2.0. In the calibration, the parents of 1875 choose the schooling capital their children take into adulthood, $\widehat{h}_{1900}$. As noted, the schooling inputs for a birth cohort are measured when cohort members are age 15. In Table 3, the schooling input per population member aged 5-19 increased 43% and the goods input 111% between 1865 and 1890. Given the elasticity of human capital with respect to time inputs is .6, and for goods inputs .1, all else the same schooling capital would rise by 37% between those cohorts. However, there was also some multifactor productivity growth in human capital production over this period as graded schools, curriculum reforms, and openness in the schooling of blacks began to occur. It is assumed that b increased 10% over this period, a bit less than .4% per year (.00388) (far below the average rate of multi-productivity growth in the entire economy for this period). Altogether, this implies an increase in schooling capital of a bit more than 50% between these cohorts, from $\widehat{h}_{1875} = 2.0$ to $\widehat{h}_{1900} = 3.0$. The efficiency parameter b_{1875} (based on 1890 schooling inputs) is then set to produce a value for $\widehat{h}_{1900}$ of about 3.0. In the model developed above, an increase in the schooling human capital of children from one generation to the next, increases the schooling inputs those children choose in adulthood for *their* children. Consequently, the stipulated increase in schooling human capital between the birth cohort of 1850 and that of 1875 impacts the subsequent time-path of the endogenous variables. The larger is that stipulated increase, the greater is the simulated increase in $\widehat{h}_t$ for the next two generations. Thus, if one believes the increase in $\widehat{h}_t$ between the 1850 and 1875 birth cohorts is appreciably above (below) 50%, other factors would have to contribute less (more) to an explanation of

[27] The following motivates our choice of values for that birth cohort. For 1860 and 1870 census data indicates the proportion age 5-14 enrolled were 69.4 and 75.1. Since it is hard to imagine enrollments were rising much during the Civil War, the 1860 figure is used for 1865. This provides a rise in enrollments of $\frac{75.1}{69.4}$ or 8.2% between 1865 and 1870. Suppose there was also a modest increase of 5 days attended per enrolled student per year in the several years following the Civil War. Then, the 1865 school-year student (born in 1850), is assumed to have spent 9% of his time endowment in school. It is similarly assumed that there is a 15 percent increase in expenditures on goods inputs between 1865 and 1870. Differences of a few percentage points in these schooling input estimates for the 1850 birth cohort would have little impact on any results.

the rise in human capital across all generations studied (moderate-sized changes in the estimate of the 1865 inputs have only a small impact on the entire change between 1865 and 1890). This sensitivity is discussed in the results section.

4.7.4 Empirical increase in $\widehat{h}_t$ with implications for increase in b_t

How much of the total projected increase in $\widehat{h}_t$, from 2 to 8.2, is due to increases in inputs, and how much to multi-factor productivity change in the schooling sector? The portion due to increases in inputs is calculated using the time paths for goods and time inputs discussed above (see Tables A2.1 and A2.2) along with the production function elasticities (the θs). This increase derives from increases in schooling inputs and/or their quality. 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 doubling in mom's effective human capital input [28], we calculate schooling human capital for the birth cohort of 1925 which is 3.0 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 4.1 (i.e., 8.2/2). The gap between the 3-fold increase in schooling 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_t. Consequently, the required increase in efficiency is 37% (i.e., 3.0(1.367) = 4.1). There is little quantitative guidance as to the rate of total factor productivity advance in the production of schooling human capital over this long interval. However, there are several reasons to believe it was non-trivial. First, this period witnessed the transformation from one-room school houses to graded schools across the country. Second, changes in curriculum dramatically increased the correspondence between the knowledge imparted in schools and the knowledge useful in the marketplace. For example, typing and business courses proliferated at the expense of Latin and dancing classes (Goldin and Katz, 2008). The baseline simulation increases b_t by 10% across each generation; over the 75 year period, this corresponds to multifactor productivity growth in schooling of almost .4% per year. Although measures of economy-wide multifactor productivity growth for this period vary widely, this implied growth rate in b_t is appreciably below such estimates. This is appropriate as education is typically -certainly later in the twentieth century- envisioned to be a relatively low productivity growth sector. [29]

[28] Mother's effective time input is her human capital times her time input. This effective time input approximately doubles between 1875 and 1925 in our preferred calibrations, with some probable increase between 1850 and 1875. Since the exponent $\theta_{he} = .1$, even a several percentage points difference in the growth of this effective time input from that postualted would have very small effects.

[29] Recall that the increases in inputs from the birth cohort of 1850 to that of 1875 are imputed to calibrate the model. If one only focuses on the increase in $\widehat{h}_t$ between those chosen by parents of 1875 and of 1925 the implied growth in b_t is essentially unchanged.

4.8 Cohort Income Change and the Wage Per Unit of Human Capital

The growth accounting exercise discussed above relied on estimates of income across cohorts. The calibration also requires values for the wage per unit of human capital confronting a household formed at time t, w_t. Values for w_t may be determined endogenously, even though the framework is partial equilibrium. The key to tractability is that the human capital of husbands and wives is known when the household is formed (since schooling is already completed and the returns to experience are exogenous). The few steps required to determine w_t are explained below.

First, in Table 4, column 2, an estimate of the average income per worker over the working years- or permanent income- is shown for workers forming households in t, y_{pt}. This permanent income per worker is a weighted average of the earnings of males and females of t,

$$y_{pt} = w_t[L_{m,t}h_{m,t} + (1 - L_{m,t})h_{ft} = w_t[L_{m,t}h_{m,t} + (1 - L_{m,t})\gamma_t h_{mt}]$$

where $L_{m,t}$ is the proportion of the labor force that is male and where the second equality uses the fact that $h_{m,t} = \gamma_t h_{f,t}$.[30] Table 4 indicates the values for $L_{m,t}$ and shows the estimates of the male earnings for each cohort; values for γ_t were given in section 4.1.

Notice that w_t is not uniquely determined for cohorts beyond the 1875-households, but rather depends upon how the simulations affect human capital. However, 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.

4.9 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. Table 5, column 3, reports life cycle participation rates (LCPR) for white married females of different birth cohorts. Figures are derived from Roberts' (2007, Fig. 1.9); for each birth cohort he sums Census participation rates for several age brackets during its member's adult years, then divides by the number of brackets (see also Goldin, 1990, Ch. 2). LCPRs increased dramatically, from 2.5 percent among white females born 1855-64 (attaining adulthood about 1880), to 21 percent among for those attaining adulthood about 1930.

[Insert Table 5 here]

[30] This expression also assumes that labor force participants work full-time. Goldin (1990) argues that female employees typically worked full-time through 1940.

However, as stressed by Goldin (1990), Census figures prior to 1940 understate the market-oriented labor of wives working from home in family businesses.[31] She estimates the undercount for 1890 and Sobek (1997) performs similar corrections for 1880, 1900, 1910 and 1920. Their cross-section participation adjustments are shown in column 4; these fall steadily after 1890. Column 5 presents an adjusted LCPR, termed ALCPR. It consists of the sum of the LCPR and (.75) times the adjustment in column 4. Scaling by .75 is done to account for Goldin's finding that those working from home typically only worked part-time; in contrast, before around 1940 she finds that most of those working outside the home did so full-time. These adjusted participation rates more than double between the birth cohorts of 1855-64 and 1905-14, rising from 9.9 to 23.4 percent. Those agnostic about such adjustments may prefer the simple average of the LCPR and ALCPR, or AVG. These are provided in column 6, and rise from 6.2 to 22.2 percent for those attaining adulthood in 1880 and 1930, respectively. [32]

Institutional responses to the Great Depression are not accounted for within the model. In particular, 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.[33] Absent those marriage bars, life cycle participation rates for the new brides of 1925 would be higher. Consequently, since our model does not factor in marriage bars, it would not be surprising if the simulations overshoot empirical participation.

Conversely, Goldin (1990, pp. 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

[31] Before 1940, Census participation questions differed appreciably from the modern participation concept. Prior to 1940, the question was that of one's 'gainful occupation' (though the wording 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.

[32] Goldin (1990) notes considerable heterogenity among women's labor market participation. Those employed in any year tended to have significant participation persistence.Similarly, those without children worked more than those with children. This heterogenity has declined over time and the initial extent 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).

[33] 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 and the initial extent 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).

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.

4.10 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 $d_{2,1900} = 1.03$.[34] 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 $d_{2,1875} = 1.14$.

4.11 Fertility Targets

The U.S. Census irregularly collected data on fertility in the first half of the 20th century. Jones and Tertilt (2008) use these Census responses to estimate the children ever born in earlier periods. For the cohort born between 1851-1855, attaining adulthood in the 1870s, 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 1900), 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.

4.12 Mother's time allocation to child quantity

Recall that each infant requires A proportion $\overline{\rho}$ of mother's time for activities unrelated to child quality, while each older child imposes a time cost of ρ. Consider first the time costs beyond infancy, ρ. 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. 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, with older children requiring less time: 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 6 and 15 years of age, the housewife spent an extra 2 hours per week. Thus, in 5 of the 19 years (ages 1-5), 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. Assume all of this time is spent

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

on activities related to the quantity of children (rather than their quality). Given the 70-hour work week, mothers spend $(\frac{5}{19})(\frac{7}{70})+(\frac{14}{19})(\frac{2}{70}) = .048$, or 4.8% of her time during the each child's dependency from age 1 through age 19. Since the length of dependency is only half that of adulthood, $\rho =$ .024.

What about the time required per infant $\overline{\rho}$? Ramey found each child under age 1 added 17 hours to the housewives' work week. Indeed, Albanesi and Olivetti (2007) estimate breast feeding alone required about 14 to 17 hours per week the first year. They also find that episodes of incapacitation of mother during pregnancy and/or following childbirth early in the twentieth century were more prevalent than today. They find the average pregnancy was associated with 4.5 unproductive months. Assuming productivity is reduced by 60% during the incapacity, this increases the time cost by an average of about 7 weeks per pregnancy. All of the pre-pregnancy time loss and some portion of the post-pregnancy time costs should be added to the Ramey figures. Seven weeks represent 490 hours, which divided by 52 weeks implies that incapacity adds a little over 9 hours per week to the 17 from Ramey, for a total of 26. Consequently, $\overline{\rho} = (.5)[(\frac{1}{20})(\frac{26}{70})] = .009$. The average infant absorbs about 1% of mother's adult time endowment.

4.13 Relative wage of dependent children

Recall that $\mu_t h_{0t+1} T_t$ are the potential earnings contribution of a dependent child toward the family budget. Potential earnings are reduced when children are sent to school, and explicitly realized when children are employed in wage labor. When children are engaged in the household production of G_t their time is valued at the market wage and this expense is reflected in the goods cost of the household production good. The direct monetary contributions of children were significant in the late 19th century, but had become insignificant by the middle of the twentieth century. Their earnings contributions declined mainly because the high school movement increased the time older children devoted to human capital accumulation.

The ratio of a child's wage per unit of human capital to that of an adult male in 1875 is assumed to be $\mu_{1875} = .4$. This estimate is consistent with the evidence of Parsons and Goldin (1989) upon dividing the earnings per child of different ages from 10-19 and gender by their probabilities of working, and then averaging. As motivated above, μ_t is assumed to decline from $\mu_{1875} = .4$ to $\mu_{1925} = .3$.

4.14 Other parameters

Parental expenditures $P_t x_t$ on the goods inputs per child x_t are independent of the price; from equation (3.6.8) 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 is uncertain. As an initial assignment $P_{1875} = .5$, as most high schools were still private at that time, outlays for some books and other home inputs were not subsidized, and transportation costs were not trivial. As the high school movement proceeds, P_t falls. It is assumed that by 1940 $P_t = .2$, a reduction of 60%.[35] Unsurprisingly, it is the percentage reduction rather than the initial value that is important to results. $P_{1925} = .2$ yields simulated goods inputs close to those in the data for x_{1925}. The choice of P_{1925} is re-considered in the discussion of the 'best fit' calibration.

The 1875 value for the time potentially available for dependent children to work is set to $T_{1875} = .2$. Notice that since dependency is only one half the length of the one period of adulthood, T_{1875} could not exceed .5. Further, if children in the first 6 years of life cannot work and children age 19 have left the home, the available maximum falls below one third. Finally, children between ages 6-12, say, lack the stamina to work full-time and/or attentively, suggesting a value of approximately .2; and, within the narrow range of feasible values, .2 produces the best fit for the initial baseline.

Other parameters are more difficult to measure and are chosen to produce the desired initial baseline. The exponent $1 - v$ on mother's time in household production in 1875, z_{1875}, is set to .26 which yields the previously estimated figure for time mothers devoted to market work $m_{1875} = 5.8\%$.[36] There is little direct evidence on the portion of lifetime parental income devoted to the private consumption goods of dependent children. Modern estimates of the non-human capital outlays per child in 2006 for middle-income families are around 6% (USDA, 2006). The shares of household income devoted to housing and transportation have increased dramatically from early in the 19th century, while the shares of income devoted to food at home and clothing have declined.[37] Some portion of those increases in housing have gone to reducing the number of children per bedroom (child privacy may be a superior good). Similarly, a portion of the higher income share devoted to transportation involves help financing cars and car insurance for teenage children, or transporting younger children to 'play dates.' Although information on expenditures on toys and child entertainment is scarce, it seems probable that expenditure shares have increased for them as well. Supposing that 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. Since contemporary fertility is lower, $\tau_{1875} = .04$ leaves the share of household income devoted to child consumption across all children roughly constant. The unobserved taste parameters ψ and σ are chosen so as to pin down initial schooling inputs (especially ψ) and fertility (especially σ).

[35] Given that taste parameters are also used to pin down the initial x_t, see below, the results would be essentially unchanged if the 60% reduction had instead occurred from an initial price of .6 or .4. In each case goods inputs would increase 150% from their initial level, ignoring any indirect effects of rise in inputs in one period for those purchased in later periods.

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

[37] http://www.bls.gov/opub/mlr/2001/05/art3full.pdf.

5 Missing the Targets: Income and Schooling Costs; Mortality Decline

This paper examines quantitative implications of several proposed explanations of changes in the behavior of married households formed between 1875 and 1925. The calibration proceeds as a series of nested exercises, often adding features not considered in the preceding one. This results section begins with a description of the initial baseline.

5.1 Experiment 1: Growth of Public Schooling, and Changing Returns to Experience

5.1.1 The Initial Baseline

For this and subsequent experiments the choices made by the parents of 1875 are as targeted for the baseline: Parameters are set such that $\widehat{h}_{1900,}$ the schooling human capital chosen for children by the parents of 1875 is, 3.04, about 51% above the $\widehat{h}_{1875} = 2$ embodied by those parents. Those parents choose about 5.3 births, send children to school about 13% of student's time endowment, while wives's devote 7.4% of their adult time endowment to the labor market, and about $e_{1875} = .026\%$ of their time endowment raising the human capital of each child. Aggregate schooling goods inputs are close to 1% of GDP.[38] The parameter values common to all experiments is given in Table 6. [39]

[Insert Table 6]

5.1.2 Experiment 1 Results:

Experiment 1 examines implications of changes in parental resources and the direct costs and efficiency of educational investments. First, it incorporates the exogenous rise in life cycle parental earnings (or 'permanent income') across generations. A second feature is the inclusion of the empirical experience profiles of men and women E_{mt} and E_{ft}. Third, the per-unit price P_t of goods inputs in human capital production x_t is allowed to fall over time reflecting the end of school rate bills and the rise of public sector provision of high school. Finally, the efficiency parameter b_t in human capital production rises over time as described in Section 4.

This simulation misses most targets by wide margins as shown in Table 7. Fertility declines only from 5.3 to 5.1, as opposed to the target of 2.6. The time input of students s_t barely increases, rising to only 103% of the its 1875 value, whereas the increase is 233% in the data (from .129 to .309). Goods

[38] Husbands in 1875 had normalized lifetime earnings of 1000. Adding the earnings of wives increases income somewhat, say to 1100. If young adults with dependent children and old adults each have the same income, goods inputs across all children divided by parental income provide the GDP share. Each child surviving infancy uses $x_{1875} = 2.3$, and about 4 children survive infancy.

[39] The taste parameters are $\psi = .55$ and $\sigma = .23$ in Experiment 1. To maintain other features of the initial baselene once mortality decline is included in Experiment 2 and thereafter, $\psi = .40$ and $\sigma = .174$.

inputs x_t perform somewhat better rising to 500% of the initial baseline value compared to the target of 700%.

x_t increases for two main reasons. First, the posited decline in P_t from .5 confronting the parents of 1875 to .2 for 1925 parents by itself increases x_t by 150%. Second is the large increase in the wage per unit of human capital: The exogenous increase in male earnings across generations arises from some combination of higher w_t and more human capital. With only a small increase in total parental human capital, the rise in w_t from that confronting the parents of 1875 to those of 1925 is 87%, roughly equal to the rise in earnings across the generations. Ceteris paribus, this increases x_t by 87%. In combination those two price changes account for 92% of the increase in x_t. Parents of 1875 bequeath $\widehat{h}_{1900} = 3.04$ to their children, whereas parents of 1925 bequeath $\widehat{h}_{1950} = 4.46$ units of schooling human capital; the target though is $\widehat{h}_{1950} = 8.2$.

[Insert Table 7]

To appreciate why the fit of the model is so poor, consider again the solutions for x_t (3.6.8), s_t (3.6.9), n_t (3.6.11), and z_t (3.6.13). The moderate increase in $\widehat{h}_{t+1}$ (3.2.1) which does occur is primarily due to three factors. First, is the aforementioned increase in x_t.[40] Second, the postulated 21% rise in multifactor productivity in the schooling sector increases $\widehat{h}_{t+1}$ by 21%. Larger increases in s_{1925} would also go a long way toward increasing schooling human capital since the output elasticity for s_t ($\theta_s = .6$) is so much greater than that for goods inputs ($\theta_x = .1$).

Neither P_t nor w_t appear in the expression for the student's time input s_t or fertility. (Actually, w_t enters in both the numerator of s_t via parental income and the denominator through the opportunity cost of student's time, and so cancels out). If there were a smaller degree of substitutability between x_t and s_t, reductions in P_t would increase s_t. Cinyabuguma, Lord, and Viauroux (2009) consider the implications of a human capital production function in which x_t and s_t are perfect complements. In that case, although s_t then increases when P_t falls, the increase in x_t is smaller and the implications

[40] Card and Krueger (1996) examine the link between earnings in adulthood and schooling expenditures per student within a year in the early decades of the American South. They find increases in earnings in adulthood of somewhat greater than 1% for every 10% increase in expenditures per student on instruction. Their findings are at the upper-end of estimates for the U.S. over this period. Even so, part of the higher earnings effect occur because increases in school quality increased the years of schooling children choose to receive. Thus, a 10% increase in expenditures per student per year translates to a larger percentage increase over a student's entire school tenure. Once this effect is taken into account their results are even consistent with the elasticity $\theta_x = .1$ assumed in the calibration. Nevertheless, 'the baseline' experiment was repeated using a value of $\theta_x = .15$ to examine the sensitivity of the results to changes in this parameter. This only very modestly improved the fit of the model, as s_t and n_t were little affected. Given the modest effects of the higher value and the sentiment that for lifetime resources $\theta_x = .1$ is the 'best guess,' subsequent experiments are based exclusively on that value.

for $\widehat{h}_{t+1}$ are essentially the same.

The effect of higher parental human capital (which increases the costs of children but not their potential benefits) is weak in Experiment 1. Despite the small simulated increase in schooling human capital, the stocks of human capital in adulthood h_{mt} and h_{ft} fall because the (exogenous) returns to experience declined. When the schooling targets are met in Experiment 3, the increase in schooling human capital is more than twice as large as the negative impact of experience among males, and about three times as large among females. Finally, mother's labor market participation rises from 7.4% to 15.1% of the life cycle endowment, compared to a target of 23.3%. The rise in mother's market time is driven by the narrowing of the gender wage gap which reduces time devoted to household production, z_t. Since increasing schooling human capital narrows the gender gap, the fit for mother's target will improve in experiments more closely approaching the $\widehat{h}_{1950}$ target. Further discussion of mother's market work is postponed until Experiment 3. In summary, Experiment 1 reveals that additional factors must be examined if the simulated model is to fit the targets.

As in the current study, Galor (2005) finds limited evidence that increases in per capita income to some threshold level contributes much to the demographic transition. "The simultaneity of the demographic transition across Western European countries that differed significantly in their income per capita suggests that the high level of income that was reached by those countries...had a limited role in the demographic transition (Galor, 2005, p.228)." Similarly, Bleakley and Ferrie (2013) find that 19th-century random wealth shocks to families in Georgia had little effect on the education of those families' sons or grandchildren. Also, Doepke (2004) points out that subsidies to education (here a reduction in P_t) need not cause a decline in fertility. "Since a subsidy lowers the cost of children, an education subsidy increases fertility among parents who would have sent their children to school even without the subsidy (Doepke, p.361)." The findings of this paper thus echo similar findings for different times and places.

Conversely, Lord and Rangazas (2006) conduct a quantitative assessment of a theory of long-run growth in the United States-from 1800-2000 which *does* reproduce central features of the quantity-quality trade-off.[41] The discrepancy between their rapid increase in schooling from higher income and education subsidies in the first decades of the twentieth century and our much smaller response is largely a consequence of in the specification of the human capital production function. Their framework contains two periods of schooling for dependent children. Significantly, the schooling of younger children is exogenous. Consequently, increases in human capital result only from increases in the schooling of

[41] As in this paper, there is exogenous income growth and decline in the price of schooling. Unlike this paper, their framework includes multigenerational family business and life cycle savings. Family business creates an additional source of wealth which made for high fertility in 1800.

older children.

On one hand, they assume a lower elasticity associated with schooling time than we do. On the other hand, the *percentage* increases in schooling are much larger in their framework, as they are defined relative to the endogenous schooling (i.e. that among older students) only. In particular, suppose younger children spend .085 of their time endowment in school and total schooling time increases in the late nineteenth century from .105 to .12. Then, in their human capital production function, the schooling input has risen from .105-.085 = .02 to .12 -.085 =.035; an increase of 75%. In our framework the percentage increase would only be 26.3 percent, from .095 to .12.[42] Also, whereas skilled human capital is only about 16% of the total human among 1875-parents in our calibration, it is about 70% in theirs. To quantify the impact of these two differences, we use the targeted time inputs over our period in their human capital production function. Then, assuming the same growth rate of per capita income as in our calibration, education's share of total income growth is about 30% for that period under their formulation, or almost 50% higher than ours. This is problematic as, aside from the outlier estimates of Turner, et al., 30% appears 'too large.' Since that framework and the one in this paper vary in other ways, we simply note that it is unclear whether their results would persist if the role of schooling capital in growth was lower. [43]

5.2 Experiment 2: Reduced Child Mortality

Experiment 2 augments the parameter changes in Experiment 1 by incorporating the significant reductions over time in infant and child mortality (and thus in d_{1t} and d_{2t}). As discussed in the literature review and model development sections, declining mortality may increase the number of *surviving* children n_t, as the significant costs of pregnancy must be incurred less frequently to procure a child surviving into adulthood. Nevertheless, children ever born $d_{1t}n_t$ are likely to fall given the decline in d_{1t}.

Inspection of the expressions for the child quality variables x_t, s_t, and e_t suggests the impact effect of mortality decline depends upon the relative percentage changes in d_{1t} and d_{2t}. Empirically, the percentage decline in d_{1t} exceeds that in d_{2t}. The number of children ever born required to produce a child surviving to adulthood d_{1t} fell from $d_{1,1875} = 1.47$ to $d_{1,1925} = 1.098$, a decline of 25.8%; this exceeds the decline of 10.7% in the number of children surviving infancy required to produce a child who reaches adulthood d_{2t} ($d_{2,1875} = 1.14$ while $d_{2,1925} = 1.018$). Thus, there is a greater percentage decline in the fixed costs of producing a surviving child $d_{2t}h_t\tau_t + h_{ft}\left(d_{2t}\rho + d_{1t}\bar{\rho}\right)$ than in the potential benefits

[42] They offset this overly large increase somewhat by adding a small constant to schooling time.

[43] In their preferred calibration, declining family business income accounts for about 40% of the fertility decline in the nineteenth century, but has little effect in the twentieth century. These reductions in family business income have no effect on the schooling of children in their model. Fertility decline and schooling increases continue into the twentieth century.

$d_{2t}h_{0t+1}\mu_t T_t$. This induces a substitution away from quality toward quantity. Thus, the prospects for improving the fit of the simulation through this channel appears limited.

Indeed, incorporating declining mortality decline produces results broadly consistent with Experiment 1. Results are displayed in Table 8. As anticipated, the percentage increases in x_t and s_t from 1875 to 1925 are a bit smaller than the small increases found in Experiment 1. The simulation reveals that compared to the trivial reductions in fertility in Experiment 1, the reductions in mortality induce a larger fertility $d_{1t}n_t$ decline, from 5.3 to 4.4 for those parents of 1925. Fertility remains far above the target of 2.6 and the decline in fertility which does occur is entirely a consequence of the decline in infant mortality, as reflected in the lower d_{1t}. Indeed, as anticipated, there is a modest *increase* in the number of *surviving* children n_t (from 3.6 to 4).

[Insert Table 8 here]

The finding that falling infant mortality cannot account for the decline in net fertility rates is not new. Doepke (2005) shows analytically in a series of models that infant mortality decline may be expected to increase the number of surviving children (i.e., net fertility) while typically reducing total fertility. Doepke (2004) assesses the quantitative significance of those models via a calibration of fertility in England as infant mortality declines from 1860. His calibrations support the hypothesized inability of infant mortality decline to explain the decline of net fertility. Doepke also presents an extensive review of empirical studies across a broad range of countries. The empirical results are more mixed than his theoretical findings, or the quantitative findings for England. Nevertheless, he concludes that overall the empirical evidence supports the inability of infant mortality decline to explain the demographic transition. Our calibration for the United States over this period may be seen as complementing both Doepke's theoretical findings (2005) and his quantitative findings for England (2004). More generally, Galor (2005, p.225-227) in his influential review of unified growth models and empirical evidence concurs that infant mortality decline was not the underlying cause of the demographic transitions across Western Europe.

6 Reaching the Targets: Increasing Disregard for the Potential Earnings of Dependent Children, and Greater Child Consumption

6.1 Quantity and Quality of Children

The inability of the experiments conducted so far to reproduce stylized facts concerning education and fertility raises the question of what mechanisms may be capable of explaining those facts. Viewing the optimal solutions for the quality variables (x_t, s_t, and e_t), and for quantity n_t, reveals several candidates for strengthening the simulated quantity-quality trade-off. First, recall that lowering P_t increases x_t. However, while reductions in P_t in Experiments 1 and 2 have a powerful effect on x_t, impacts on $\widehat{h}_{t+1}$ and n_t are modest. Second, increases in mother's time per child unrelated to child quality ρ or $\overline{\rho}$ would lower n_t and increase investments in child quality. However, Olivetti (2006) and Greenwood, Sheshardi and Yorukoglu (2005) present evidence that from near the end of the interval considered here ρ and $\overline{\rho}$ were trending *downward.* Third, the taste parameters ψ and σ could be changed to improve the fit of the model to the targets. Economists, though, have an appropriate aversion to invoking a change in tastes with no motivation beyond producing desired results. In that spirit our calibrations will not adjust preferences, while the discussion acknowledges mechanisms capable of altering preferences over this long period.

Yet to be considered are several parameters affecting the net cost of children's potential earnings: Potentially, the quantity-quality targets might be achieved by some appropriate combination of a lower wage per unit of human capital of children relative to adults μ_t, lower time children are available for work T_t, and/or an increase in each child's private consumption share τ_t. Below it is shown that such a combination exists and, we argue, is quite plausible.

Parents, recall, view each dollar of potential earnings of children $d_{2t}\mu_t w_t n_t h_{0t+1} T_t$ as a one dollar expansion of the household's potential income. This assumption was warranted for middle-class households in the decades following the Civil War when the second earners in families tended to be children rather than mothers (Parsons and Goldin, 1989). Conversely, in recent decades there is little presumption that middle class parents have the right to compel children to work and then remit earnings to the parents (Zelizer, 1985). Consequently, over this transitional period norms apparently changed in such a way as to frown upon child labor undertaken for the benefit of the family. Indeed, Moehling (2005) finds that by the second decade of the twentieth century even daughters who turned over their paychecks to parents nevertheless enjoyed higher private consumption. Further, Zelizer (1985) argues that by the middle of the twentieth century the jobs and earnings of child workers were viewed by parents as appropriate only as human-capital-enhancing experiences (learning the value of money, working and saving toward a goal, fulfilling obligations, etc.) rather than as contributions to the family coffers. Below we consider how the rise of such norms might be reflected within the model.

6.1.1 Child Labor Restrictions and Compulsory Schooling Laws Reduce T_t

Evidence of changing norms is the proliferation of legislation affecting children's' schooling and work. Massachusetts introduced the first state compulsory schooling law in 1852 and, by 1910, 41 states had such laws, while 40 had legislated restrictions on child labor (Goldin and Katz, 2008, p. 191). Assuming some groups would need to change behavior to comply, and that compliance was enforced, the impact on work and schooling could be modeled as a reduction in T_t.[44] Puerta (2009) examines implications in the US between 1850 and 1920. He finds compulsory schooling laws increased school enrollment in affected areas 7% relative to otherwise similar areas which did not pass such legislation. These impacts would be concentrated among the working and lower classes, among whom the effects may have been far above 7%. Further, such legislation may reflect new, more restrictive middle-class norms regarding child labor. Such norms also effectively lower T_t and may have preceded and been quantitatively more significant than the actual legislation.

Prominent quantitative assessments by Doepke (2004) and Lord and Rangazas (2006) conclude that legislation affecting child labor and schooling was central to the decline in fertility during England's demographic transition after 1840. The Forster Act of 1870 had made primary education the duty of the public sector. That Act significantly increased the public subsidization of education. In 1874, the Factory Acts were amended, raising the minimum age at which children could work and extending that provision to all industries. Doepke notes child labor restrictions "unambiguously increase the cost of children, and therefore lead to lower fertility (362)" and that fertility decline in England accelerated shortly after these changes. He conducts simulations of policies and demographic transitions in South Korea, Brazil and England, contrasting the effects of policies that subsidize education and restrict child labor. Unlike child labor restrictions, he shows subsidization policies can actually increase fertility by reducing the cost of children who would have been attending school without the subsidies. His results suggest child labor restrictions are an important aspect of English fertility decline.

Lord and Rangazas attempt to reproduce through calibration the relatively unique longer-term pattern of English fertility- increasing fertility during the late eighteenth century through the first decades of the nineteenth century, and then its long decline. They are largely successful in explaining the rise in fertility into the early nineteenth century. However, the 'Doepke effect' mentioned above, whereby fertility is encouraged by increased public subsidization of children already in school, helps keep fertility relatively constant after 1840. Only by invoking compulsory schooling legislation is fertility pushed down, setting off the demographic transition.

Rather than a change in norms, Doepke and Zilibotti (2005) provide an explicit economic self interest rationale for child labor restrictions. They point out that nineteenth-century working class families had conflicting economic interests regarding child labor restrictions. On one hand, the labor earnings of own children led parents to oppose such restrictions. This effect increases with family size.

[44] Schooling and work legislation removes low-wage younger children from the labor force; the average μ_t among older children not covered by the legislation is (all else the same) *increasing.* Consequently, modest reductions in T_t produce a full effect on potential child earnings less than proportional to the reduction in T_t.

On the other hand, since child labor is a substitute for unskilled adult labor, restrictive child labor legislation would confer higher wages to working-class fathers. This trade-off, they argue, was altered by SBTC, which raised the return to, and demand for, childrens' education. But higher quality per child increases the cost of child quantity, so fertility falls. With smaller families, the child earnings foregone by restricting child labor are reduced. Consequently, the effect on father's earnings comes to dominate and the working class votes in favor of child labor restrictions. Thus, in response to SBTC, child labor restrictions are voted in by families already planning smaller families.

Most researchers, including Goldin and Katz (2008) and Puerta (2009), have found only a modest role for Compulsory Schooling and Child Labor legislation. In the analysis below, reductions in T_t reflect some unspecified combination of new norms among the middle-class and/or binding restrictions affecting the potential work of of lower-class children.

6.1.2 Falling μ_t, Markets and Norms

The potential earnings of children would also be lowered by a reduction in their wage per unit of human capital relative to adult males, μ_t.[45] Lower μ_t reduces the opportunity cost to parents of schooling children and powerfully increases s_t; it also lowers n_t by reducing potential earnings of children. The simulations above have yielded values for s_{1925} well below, and for n_t well above, the target. Lower μ_t could help reach those targets.

μ_t falls if the relative wage within the market falls, or if parents allow working children to keep an increasing share of their earnings. It could be that each of these was important at some point. According to Zelizer (1985), technical change was reducing the demand for unskilled youth from the late nineteenth century. The affected employments she discussed -cash boys and girls in grocery and department stores, for example- mainly affected children below high school age. By this argument, μ_t was falling among younger children in the late nineteenth century. This coincides with a sharp decline in their labor force participation rates: participation among boys aged 10-15 fell from 32.5% in 1880 to 6.4% in 1930 (among girls the decline was from 12.2% to 2.9%) (Whaples, 2010). Further, during the Great Depression employment opportunities dried up, reducing μ_t even among older teens. This likely helps explain the further expansion of -especially male- high school enrollments during the 1930s. Thus, it is possible that market forces alone were driving down μ_t and that this could explain some portion of the rise in schooling and the decline in fertility.

However, Zelizer's evidence of decreasing demand for child labor is quite limited and it is, overall, unclear how technological change was affecting μ_t among young workers before the Depression.

[45] Recall that a reduction in the relative hourly wage differs from a reduction in μ_t. The relative hourly wage $\mu_t h_{0t}/h_t$ can also fall if the human capital of adults is increasing (holding μ_t constant).

Another possibility-indeed, Zelizer's principal thesis- is that parental norms were changing as children transformed from being 'economically valuable to emotionally priceless.' "While in the nineteenth century, the market value of children was culturally acceptable, later the new normative ideal of the child as an exclusively emotional and affective asset precluded instrumental or fiscal considerations (Zelizer, p.11)." The new norm prohibited child labor undertaken for the benefit of the family. This lower propensity to view potential child earnings as parental property constitutes a reduction the rate parents 'tax' the earnings of children. In the model, this is a lower 'effective' value for μ_t; over time, an increasing share of market earnings becomes property of the child.

Increasing disregard of childrens' earnings may have been an evolution of the separate spheres ideology. An aspect of separate spheres household organization in the nineteenth century-women at home, men working away from home -was the notion that the home was sacred and the market profane. Thus, according to Degler (1980, p. 73-74), "(e)xalting the child went hand in hand with exalting the domestic role of women; each reinforced the other." Exhortations for a family wage-a salary that could support a male wage earner and his dependents would extend the firewall between the gentle home and harsh market- were also rising over this period. In Zelizer's words, "the expulsion of children from the "cash nexus" ... although shaped by profound changes in the economic, occupational and family structures, was also part of a cultural process of "sacralization of children's lives (Zelizer, 11)."

These considerations are now combined to produce Experiment 3. First, suppose that $\mu_{1875} = .40$, as in Experiments 1 and 2, falls to $\mu_{1900} = .35$, and then to $\mu_{1925} = .30$. (Thus, a son born to parents forming households in 1925 who earned \$100 per month would be able to retain \$25 for use on private consumption whereas a son of 1875 parents would remit everything to parents.) Second, suppose the time potentially available for children to work on parents account falls 75% from the 1875 level, from $T_{1875} = .20$ to $T_{1900} = .10$ and then $T_{1925} = .05$. The 1925 value is consistent with parents continuing to view two teenage years as suitable for labor on behalf of the family. Third, as discussed in the data section, we allow the share of parental income devoted to private consumption per child τ_t to rise over time (such expenditures include clothes, toys, spending money for entertainment, and separate bedrooms). [46] Here, $\tau_{1875} = .04$ as in prior experiments but then rises to $\tau_{1900} = .045$ and $\tau_{1925} = .052$. Thus the value for households forming in 1925 remains below the contemporary estimate of .06 motivated in the data description.[47]

[46] This is private consumption; recall, children also benefit from the household production of communal goods included in G_t.

[47] Zelizer (1985, 153) reports on a 1930 study indicating that the cost of raisng a child to age 18 was \$7,425, while income was approximately \$2500. The ratio is 2.97. Haveman and Wolfe (1995, Table 1, 1830) find annual costs of children to parents in 1991 are \$7,579 whereas mean income of a household in the middle quintle is \$30,148. Multiplying the annual cost by 18 produces a ratio of costs to income of 4.56.

Experiment 3 uses these time profiles for T_t, μ_t and τ_t, along with the other Experiment 2 parameters. Results are reported in Table 9. Fertility at 2.63 and the .324 share of childhood devoted to schooling are extremely close to the targets of 2.6 and .301; likewise $\widehat{h}_{1925} = 8.19$ as compared to the target of 8.2. Given the calibration strategy, it is perhaps unsurpising that the gender wage ratio is exactly met at .603. Setting the undetermined $P_{1925} = .23$ produces $x_{1925} = 16.7$ (the target is 16.6). The parameter values necessary to achieve the targets are not precisely pinned down. In particular, the targets can also be met by offsetting higher values for τ_t with higher values for T_t. As one example, nearly the same results are achieved when $\tau_{1900} = .05$ and $\tau_{1925} = .055$, if then $T_{1925} = T_{1900} = .12$ (with $T_{1875} = .20$).

Although not immediately obvious, an increase in τ_t also contributed to the decline in U.S. fertility in Lord and Rangazas (2006). They calibrated per child consumption as a share of adult's life cycle earnings, as we do, and they kept that share constant across generations. However, in their framework total household life wealth included unearned family business income. As the relative importance of family business declines in the development process, the share of child consumption in total family resources increases, as in the simulations above.

[Insert Table 9]

6.1.3 Mother's Time devoted to Household Production

In Experiment 3, the proportion of wives' adult life cycle devoted to market work rises from $m_{1875} = .074$ to $m_{1925} = .327$. This latter figure exceeds the target of 23.4 percent (Table 5, columns 5). This section accounts for the increase within the simulation and then addresses the overshooting of target participation. Within the model, m_t changes for two types of reasons: 1) a changing mix of the quantity and quality of children; and 2) the rise in the relative wage of women.

Recall that each conception requires $\overline{\rho}$ =.009 units of mother's life-cycle time endowment through infancy, and an additional $\rho = .024$ of time per child unrelated to child quality through dependency. The 2.7 fewer conceptions and 1.2 fewer children surviving infancy free up 5.3% of mother's time for market. But, starting from $m_{1875} = .074$ in 1875 this only increases m_{1925} to .127 or 12.7%. Additionally, time devoted to child quality per older child e_t increases over 60%, from $e_{1875} = .0025$ to $e_{1925} = .0038$, but the low levels combined with the decline in net fertility results in little change in m_{1925} from this channel. Most important to the increase in m_{1925} is the decline in the gender wage gap. This reduces the time wives devote to household production (3.6.13) and accounts for the majority of the increase in m_{1925}.

As discussed in section 4.9, it is unsurprising that the calibration would overshoot the empirical target for m_{1925}. As noted there, many employers (very openly) implemented marriage bars during the Great Depression of the 1930s; many employed married women were 'let go' and other married women potentially interested in working were not considered by employers. This effort to increase employment opportunities for male heads of households directly reduced the participation of married women. Given some degree of persistence in market work, it is probable that subsequent participation was reduced as well. Viewed in this light, the model's overshoot of participation is unsurprising.[48]

6.2 Discussion

6.2.1 Extensions yielding similar implications

Greater Power of Wives

Doepke and Tertilt (2011) review convincing empirical evidence indicating greater relative control of family resources by wives increases expenditures on children. These expenditures are for private consumption goods such as clothing and for other goods, such as food, that have human capital dimensions.[49] These results suggest consumption of dependent children increases with the bargaining power of wives, rather than simply the pooled potential household wealth. In a household bargaining model, suppose mother's preferred τ_t and the 'taste for quality' parameter ψ are larger than father's. Then the household's bargaining solution in response to a declining gender wage gap may yield higher values for τ_t and ψ. However, Doepke and Tertilt make clear there are numerous reasonable ways to model household bargaining and the implications of bargaining can prove sensitive to reasonable alternative assumptions. Nevertheless, such an approach may offer a complementary explanation of the 'family revolution.'

Similarly, government policies may more nearly reflect the preferences of females once they gain the franchise. Miller (2008) presents convincing evidence that the enfranchisement of women in the United States contributed to legislation and expenditures designed to improve the welfare and reduce

[48] Allowing for an exogenous Progressive Era increase in e_t as mothers perceive their productivity in the production of child health has risen -as claimed by Mokyr (2000)- would lower the calibrated m_{1925}. This would reduce the gap between the calibrated and empirical m_{1925}. The calibrated rise of m_{1925} would also be smaller if the elasticity of substitution between goods and time in household production was less than that implied by the functional form for household production, which is 1.

[49] Evolutionary arguments also suggest that men are less concerned with the quality of children than women (Diamond, 1997). In Doepke and Tertilt (2009) men grant the franchise to women in response to rising rates of return to human capital. More power for wives leads to increases in the bargaining power of their daughters and in the education of their grandchildren, which grandparents like. Cvereck (2007) argues that increased employment among single females in the last decades of the nineteenth century increased their bargaining power and share of marital output. Doepke and Tertilit (2011) illustrate a noncooperative bargaining model in which a narrowing gender wage gap alters the mix of household public goods produced via household production functions. In their framework, higher wages for wives make their 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. In Chiappori's (1992) cooperative marriage bargaining model, husbands and wives have different preferences for household public goods (such as quantity and quality of children). As a wife's bargaining power increases, there is increased weight given to her preferences.

the mortality of children. For example, programs which disseminated knowledge of the germ theory of disease empowered mothers to protect their children from often-fatal illnesses (Mokyr, 2000).

6.2.2 Greater love of children?

Another possible factor altering sentiments was the decline in infant and child mortality. The early-modern English family historian Lawrence Stone suggests that when infant and child mortality rates are high, it is "folly to invest too much emotional capital in such ephemeral beings (Stone, 1977, p. 105)." As infant and child mortality rates plummeted after 1880 parents may have felt it safer to form early and strong attachments to their children.

Becker and Barro (1988) assume utility per child is higher when the number of children is lower, corresponding to higher altruism per child when families are smaller. If parents also care about the consumption of dependent children, smaller families would be associated with larger private consumption shares per child. This makes each child more expensive and reduces the relative price of quality. In our framework, these mechanisms could be approximated by an increase in τ_t.

Now combine several of the points from above: Greater political for females may have contributed to the decline in infant mortality. This, in turn, might reduce the emotional distancing of parents from highly perishable infants in the high-mortality regime (as described by Stone, 1977). As a final link, more intense emotional bonding may result in greater altruism per child (as in Becker and Barro, 1988). Translated into the parameters of our framework, greater female power could produce some combination of changes in τ_t, μ_t, T_t and ψ capable of inducing the family transformation.

Social historians agree that over time parents perceived that their efforts contributed more to childrens' survival and success. Into the nineteenth century, many believed that God had pre-ordained who would be saved, leaving little role for parents in childrens' salvation (Calvinism). However, the early nineteenth century rise of Romanticism and Arminianism (salvation through faith) provided more scope for parents to mold the character and fate of their children. Further, Darwin's writings reduced the average belief in an active God, while the Germ Theory of Disease made parents aware their children's survival depended importantly upon parental efforts.[50] If the death of a child was not solely God's Will, then perhaps the conception of a child might also be in the domain of parental choice.

Parents began to consciously control fertility and perceive the survival and development of a child was their province. Andreoni (1990) develops a model of 'impure' altruism. In his framework, an altruist gains more utility when personally responsible for an increase in the income of someone about

[50] Dye and Smith (1986, 347) report that in 1915 "[s]ocial reformer Florence Kelley articulated the new consciousness: "So long as did not know that children need not die...[W]e strove for resignation, not intelligence. A generation ago we could only vainly mourn. Today we know that every dying child accuses the community. For knowledge is available for keeping alive and well so nearly all, that we might justly be said to sin in the light of the new day when we let any die."

whom the altruist cares than if the higher income arises from another source. Similarly, as parents perceive more responsibility for the life and welfare of their children, they may value improvements in their life and welfare more than before. This view is also consistent with reductions in T_t and μ_t and increases in τ_t and ψ.

6.3 Other Possibilities

6.3.1 Morbidity

Morbidity, like mortality, also fell significantly from the late 19th century.[51] Reductions in morbidity increase effective human capital, by raising the productivity of time, and/or the amount of time (as with an increase in the number of years in adulthood one is capable of working). Given the various uses of time in the model there are many ways morbidity change could influence parental choices. Some morbidity reductions principally affect youth, as the reductions in hookworm in the American South described by Bleakley (2007). Others, such as fewer musculoskeletal problems and increased remaining life beyond dependency principally affect adults. Elimination of the sorts of childhood afflictions that lead to lifetime scarring, as evidenced by rising final height in adulthood and IQs, may affect the productivity of time both when young and when old.

There are reasons to suspect the effects of lower morbidity on the quantity and quality of children were modest over this period. To see this, suppose reduced morbidity increases the effective unskilled and skilled human capital of adults, and the unskilled human capital of dependent children all by same factor $D > 1$. Inspection of the optimal solutions for s_t, e_t and n_t reveal that there is no impact effect from scaling all human capital terms by some constant D.

Nevertheless, even this type of age-neutral morbidity decline has some behavioral implications. In particular, reductions in morbidity increase x_t to Dx_t. However, as seen in Experiment 1, with θ_x small, this has little effect on $\widehat{h}_{t+1}$. Also, eradication of hookworm among the young, for example, would increase student's effective time at school, as well as work. Similarly, mother's effective time input in offspring's human capital production would rise. Thus, $\widehat{h}_{t+1}$ would increase, with knock-on

[51] Bleakley (2009) concludes that the combined efforts of the eradication of hookworm and malaria in early 20th century southern states increased income by 25% compared to unaffected states. Costa (2009) finds that between 1910 and the 1990s functional disabilities declined by 0.6% per year among men age 60-74, while over a similar period "the average decline in chronic respiratory problems, valvular heart disease, arteriosclerosis, and joint and back problems was about...0.7% per year (2009, p. 2)." Declines in malnutrition, sequelae from polio, tuberculosis, malaria, smallpox, cholera, typhoid, other diarrheal episodes, exposure to animal waste products, industrial and other work related accidents further contributed to morbidity decline. The decline in these physiological insults was reflected in the increasing heights of adult men entering Amherst College which rose from 169.9 cm in 1870 to 178.1 cm in 1935. (Historical Statistics of the United States, Vol. 2, P. 582, Series BD661). This suggests that even upper middle class households benefited from reduced physiological insults in the nineteenth century. At the intersection of mortality and morbidity, remaining years of life expected by a 20-year-old male in 1870 were 41, rising to 45 in 1919-1921, and to about 49 in 1949-1951, potentially increasing the life cycle supply of human capital (Hazan and Zobai, 2006).

effects for choice variables in the subsequent period. Unreported calibration results show the full impact is small when morbidity decline increases D_t by a total of 18% over three generations. If morbidity decline affects different components of human capital asymmetrically, the impacts could be larger (moving closer toward *or* further away from the targets). For example, with limited empirical support, Cinyabuguma, Lord and Viauroux (2009) report simulations in which morbidity decline increases the effective human capital of adults much more than that of dependent children. In that event, a significant increase in child quality and decrease in child quantity can arise. Robust progress relating to morbidity decline awaits improved empirical understanding of how various components of human capital have been affected over time.

6.3.2 Skill Premiums and Skill-Biased Technological Change

Another potential explanation of the rapid rise in schooling that began shortly before 1920 is that SBTC increased the wage premium to skill and thereby encouraged public high school provision and attendance. This paper's model was loosely adapted to allow for changing skill premiums and calibrated to assess the role of those changes. In particular, the wage per unit of schooling capital was made to be increasing, but concave, in schooling human capital. The rate at which this wage increased with schooling was calibrated in accordance with the empirical skill premiums during the early adulthood of the children.[52] The results suggest an acceleration of the skill premium played little role in increasing education or, via the quantity-quality trade-off, reducing fertility.

The reason is straightforward: The skill premium was declining at a rapid rate nationally throughout the central years of the high school movement. Indeed, Goldin and Katz (2008, p. 316) report that the skill premium declined 1.28 percent per year between 1910 and 1930. Relatedly, Katz and Margo (2013) detail significant skill premiums and SBTC even from the antebellum period.[53] If neither SBTC nor high skill premiums were a new phenomenon, it is unclear why they should have stimulated attendance just as the high school movement began. The issue does not disappear if the focus is on rates of return to schooling rather than skill premiums. Of course, the rate of return depends on costs as well

[52] Units of unskilled human capital were paid w_t while units of skilled or schooling human capital received $\widehat{w}_t$. With a skill premium associated with SBTC, $\widehat{w}_t$ is increasing in the stock of schooling capital as captured by

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

with $\varepsilon > 0$. Thus the potential earnings of a male become

$$w_t h_{0m} E_{mt} + \left(w_t \widehat{h}_t^{\epsilon} \right) \widehat{h}_t E_{mt} = w_t \left[h_{0m} + \widehat{h}_t^{1+\varepsilon} \right] E_{mt} = w_t h_{mt}, \tag{6.3.1}$$

[53] Their research reveals that while early manufacturing was (famously) de-skilling, other sectors paid significant skills premiums. Overall, they characterize the aggregate economy as experiencing SBTC even during the antebellum period..

as benefits. And, public provision of high school lowered tuition while child labor restrictions and new norms stigmatizing the work of children lowered the cost of schooling children. Thus, it is possible that the rate of return to schooling was rising even as the wage premium was falling. Even if that is true, these cost reductions were already incorporated in Experiment 3 via lower P_t, μ_t and T_t; that experiment reached the targets without invoking rising skill premiums.

Despite the foregoing, we believe it likely that SBTC was important to the family revolution. For one thing, SBTC reduced the premium to muscles, which reduced the gender wage gap. As stressed in this paper, this reduction in the gender wage gap pulled married women into the labor force. More generally, Katz and Margo (2013, Tables 4 and 6) present time- series evidence on the economy's occupational distribution from the nineteenth century. They demonstrate that there was an acceleration in the share of employments characterized as 'white collar' after 1910, as the high school movement was unfolding. Our model is poorly suited to address this general skill upgrading within occupations associated with SBTC.

As one example, Goldin (1990) emphasizes SBTC contributed to an expansion of clean, interesting, and respectable office jobs for females in the early decades of the twentieth century. She notes that before such jobs were available, the work of a wife in a factory or domestic service was evidence that the husband had failed as provider. These 'higher-status' female clerical jobs, however, were perhaps intrinsically meaningful to wives, and caring husbands would 'allow' their wives to work if they desired. Clerical work, though, required additional education. As applied to our theory, increased human capital among married females increases the cost of time required to raise each child, contributing to the decline in fertility. As a second example, Goldin and Katz (1999) argue that the significant regional differences in the timing of the high school movement were a product of regional differences in the stocks of social capital. Many parents nationally desired advanced schooling for their children that they might obtain the opportunities afforded by SBTC. However, public provision required the imposition of property taxes, and only relatively homogenous communities were willing to take on that burden.

In summary, an adaptation of our model to allow for skill premiums did little to explain the family revolution. However, compelling changes in the occupational structure lead us to believe that SBTC played an important role in the increase in schooling.[54] It is also possible SBTC played some role in fertility decline.

[54] At least one previous calibration exercise of the United States has invoked SBTC. Greenwood and Seshadri (2002) devise a highly stylized two-sector model to produce the demographic transition and structural transformation. A central building block is their assumption that skilled labor is not useful in the agricultural sector, but is productive elsewhere in the economy. Then SBTC increases education and income of those in the 'manufacturing' sector, inducing structural transformation and fertility decline. However, for the period of interest to the current paper, the return to education was at least as high among farm owners and operators as among blue-collar or white collar workers (Goldin and Katz, 2008, Table 2.5). Their assumption may be more appropriate for more recent times.

7 Summary and Conclusion

This paper analyzed the great reduction in fertility, rise in schooling, and acceleration of the movement of married women into the paid labor force that occurred between the latter portion of the 19th century into the first decades of the 20th century. First, a model of household decisions over fertility, schooling of children, household production and married female labor supply was developed. In that model, transfer-constrained parents make all transfers to children via human capital bequests and the quantitative significance of unskilled human capital in the nineteenth century is made explicit. An initial baseline for the model was calibrated based on historical data. Then a series of careful simulations assessed the quantitative importance to family change of several mechanisms proposed in the literature.

Experiment 1 invoked falling prices for educational goods inputs (i.e., increased public provision of education), rising parental incomes, changing returns to work experience, and rising multifactor productivity in the production of schooling. In combination, these induced a significant increase in the goods input. However, there was little effect on schooling time, schooling human capital, or fertility. These results reinforce findings in the literature of weak effects on fertility of income (Galor, 2005) or subsidies to education (Doepke, 2004).

Experiment 2 extends the first by incorporating the empirical decline in infant and child mortality. This does little to improve the fit of the model. Intuitively, falling infant and child mortality reduce the price of surviving children and this effectively offsets the decline in the price of quality (via schooling) for surviving children. Although fertility declines, net (of mortality) fertility is largely unchanged. This limited effect on net fertility of declining infant and child mortality finding is consistent with theoretical and empirical evidence presented in Doepke (2005) and Galor (2005).

Experiment 3 examined factors which increase the net cost of children. Specifically, it incorporated lower values of the opportunity cost to parents of schooling children (lower μ_t), a smaller window of time parents were willing to work children (lower T_t), and a higher budget share for private consumption per child (τ_t). These mechanisms prove capable of achieving the model's targets for fertility and human capital. The reduction in μ_t had a powerful effect on increasing s_t, while achieving the targeted reduction in fertility required higher τ_t in addition to lower T_t and μ_t. Our preferred explanation of the declines in μ_t and T_t and increase in τ_t includes a change in parental norms so as to make child labor less acceptable and/or increase parental altruism toward children. Additionally, there is evidence that child labor and compulsory schooling legislation had modest direct effects on schooling and indirect effects on fertility. Such legislation may itself be a response to changing norms. Alternatively, Doepke and Zilibotti (2005) suggest SBTC led narrowly self-interested adult males to favor restrictions on child labor.

We acknowledge the that the quantity-quality trade-off quite possibly involved additional influences. However, limited current understanding of how morbidity decline affects the productivity of time at different ages and in different uses precludes a definitive assessment of its impact. This paper does clarify why an age-neutral reduction in morbidity may have only negligible effects on schooling and fertility. Also, we noted that SBTC as reflected in skill premiums would not have much explanatory power in our framework since premiums were falling during much of the high school movement. Although not captured by our framework, the growing proportion of occupations combining high skill and social status suggests that SBTC played some role in the high school movement.

Finally, this paper assumes unitary household preferences. Empirically, it appears wives (as compared to their husbands) have a stronger relative preference for child welfare. Household bargaining models in the presence of a decline in the gender wage gap often predict an increase in spending on children, as proposed in this paper. An analysis employing several different bargaining assumptions would prove a valuable complement to the current contribution.

Market work among wives increases significantly in each experiment. The principal mechanism is the decline in the gender wage gap which induces substitution away from household production toward market work. The time savings from reduced fertility also contributed (especially in Experiment 3). The calibrated increase in married women's market work exceeds the empirical rise. This, though, is not surprising: During the Great Depression many employers imposed marriage bars, which directly reduced current employment among married women-and quite possibly reduced their employment in later years once the bars were lifted.

The results of this paper suggest fruitful directions for our future research. In the current framework, an increase in the exogenous private consumption share of dependent children was necessary for a calibration to meet all targets. An analysis which makes that share endogenous would increase confidence in the quantitative significance of that mechanism. Second, alternative hypotheses generating the reduced interest among parents in appropriating child earnings will be modeled and evaluated. Third, the existing framework will be extended to analyze the regional convergence of southern to northern incomes, schooling, and fertility which characterized this period.

Appendix 1: Proofs of Propositions 1 and 2.

Condition (3.6.7) gives:

$$\begin{aligned}\frac{1}{\lambda n_t} &= \frac{1}{(\psi+\sigma)}\left[d_{2t}\rho + d_{1t}\bar{\rho}\right] h_{ft}w_t - d_{2t}\mu_t w_t h_{0t+1}T_t + d_{2t}w_t h_t \tau_t) \\ &\quad + \frac{1}{(\psi+\sigma)}\left(h_{ft}w_t d_{2t}e_t + d_{2t}\mu_t w_t h_{0t+1}s_t + d_{2t}P_t x_t\right)\end{aligned}$$

Conditions (3.6.4), (3.6.5) and (3.6.6) can be re-written:

$$\frac{1}{\lambda n_t}\frac{\theta_x\psi}{d_{2t}P_t} = x_t, \tag{7.0.2}$$

$$\frac{1}{\lambda n_t}\frac{\theta_{he}\psi}{d_{2t}w_t h_{ft}} = e_t, \tag{7.0.3}$$

$$\frac{1}{\lambda n_t}\frac{\theta_s\psi}{d_{2t}\mu_t w_t h_{0t+1}} = s_t. \tag{7.0.4}$$

When introducing the expressions of (7.0.2), (7.0.3), (7.0.4) above and simplifying gives

$$\frac{1}{\lambda n_t} = w_t \frac{[d_{2t}\rho + d_{1t}\bar{\rho}]\, h_{ft} - d_{2t}\mu_t h_{0t+1}T_t + d_{2t}h_t\tau_t)}{[\sigma + \psi\,(1 - \Sigma\theta)]} \equiv w_t A_t \tag{7.0.5}$$

where

$$A_t \equiv \frac{[d_{2t}\rho + d_{1t}\bar{\rho}]\, h_{ft} - d_{2t}\mu_t h_{0t+1}T_t + d_{2t}h_t\tau_t)}{[\sigma + \psi\,(1 - \Sigma\theta)]} \tag{7.0.6}$$

The expressions of (7.0.2), (7.0.3) and (7.0.4) can be rewritten:

$$x_t = \frac{\theta_x\psi w_t}{d_{2t}P_t}A_t;\ e_t = \frac{\theta_{he}\psi}{d_{2t}h_{ft}}A_t;\ s_t = \frac{\theta_s\psi}{d_{2t}\mu_t h_{0t+1}}A_t \tag{7.0.7}$$

which, when substituting for A_t gives (3.6.8), (3.6.10) and . From (3.6.2) and (3.6.3), we get that

$$\frac{(1-v)}{z_t w_t h_{ft}} = \frac{v}{g_t} = \lambda, \tag{7.0.8}$$

or

$$g_t = \frac{v w_t h_{ft}}{(1-v)} z_t \tag{7.0.9}$$

Furthermore, using (7.0.8) in (7.0.5), we get

$$\frac{g_t}{v n_t} = w_t A_t$$

$$n_t = \frac{g_t}{v w_t A_t} = \frac{h_{ft}}{(1-v)\,A_t} z_t, \tag{7.0.10}$$

where the third equality uses the expression of (7.0.9). Now plugging the expressions of (7.0.7) in (3.4.5) and solving for h_t gives

$$\begin{aligned} h_t &= \frac{h_{ft}}{(1-v)\,A_t} z_t \left[(\theta_s + \theta_{he} + \theta_x)\,A_t\psi + d_{2t}\,(\rho h_{ft} + h_t\tau_t - \mu_t h_{0t+1}T_t) + d_{1t}\bar{\rho}_t h_{ft}\right] \\ &\quad + z_t\left(h_{ft} + \frac{\nu h_{ft}}{(1-v)}\right) \end{aligned}$$

where we use (7.0.10). Finally,

$$z_t = \frac{h_t\,(1-v)}{h_{ft}\left[\left[(\theta_s + \theta_{he} + \theta_x)\,\psi + \frac{d_{2t}\left(\rho h_{ft} + h_t\tau_t - \mu_t h_{0t+1}T_t\right) + d_{1t}\bar{\rho}_t h_{ft}}{A_t}\right] + 1\right]}$$

which, using the expression of (7.0.6) and simplifying gives (3.6.13). Finally, using (7.0.10) and (7.0.9) and substituting for A_t gives (3.6.11) and (3.6.12).

Appendix 2: Goods and Time Inputs

Table A2.1 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. Column (3) is the school enrollment rate (public and private) of those aged 5-19, including post-secondary. The product of columns (2) and (3) yields column (4), expenditures per population member aged 5-19. 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 student attendance data discussed below. This adds about 10% to the 1940 total.[55] 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 should be a bit above 1.0 percent (since women and children also contributed to earnings). Since our figures include college expenditures for 1940, the targeted share is 2.6% for that year.

[55] 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 (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.

Table A2.1:Expenditures on Students

1 Beginning School year	2 $ per pupil enrolled[2]	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)[4]	8.38	14.9 (16.6)

[1] Estimated (See Text)
[2] 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.
[3] Numbers are displayed as proportions. 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).
[4] Educational and general expenditures per undergraduate in 1941 (HSUS table Bc966)

Table A2.2 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 attended in a year are then provided in column (5). School time triples from the 1870 to the 1940 school year. Schooling time of a member of a given birth cohort is 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%. These figures are comparable to those produced by Rangazas (2002,

Table 2, p. 936).

Table A2.2: Children's Time in School

1 School Year beginning	2 product/365	3 percentage enrolled[2]	4 days attended	5 product
1865[1]				0.09
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), Table CG.A.6.

Table 1: Choice Variables and HC entering adulthood

Cohort born	Married male working full-time, utilize HC [1] (ages 25-65)	Choose household production inputs and mother's labor supply (ages 25-65)	Have children (ages 26-30)	Choose HC inputs, Schooling HC (ages 31-45)
1850	1875-1915	1875-1915	1876-1880	1881-1895
	$h_{m1875} = \left(h_{0m} + \widehat{h}_{1875}\right) E_{m1875}$	z_{1875}, g_{1875}	$d_{11875} n_{1875}$	x_{1875}, s_{1875}
	$h_{f1875} = \left(h_{0f1875} + \widehat{h}_{1875}\right) E_{f1875}$	m_{1875}		$e_{1875}, \widehat{h}_{1900}$
1875	1900-1940	1900-1940	1901-1905	1906-1920
	$h_{m1900} = \left(h_{0m} + \widehat{h}_{1900}\right) E_{m1900}$	z_{1900}, g_{1900}	$d_{11900} n_{1900}$	x_{1900}, s_{1900}
	$h_{f1900} = \left(h_{0f1900} + \widehat{h}_{1900}\right) E_{f1900}$	m_{1900}		$e_{1900}, \widehat{h}_{1925}$
1900	1925-1955	1925-1955	1926-1930	1931-1945
	$h_{m1925} = \left(h_{0m1900} + \widehat{h}_{1925}\right) E_{m1925}$	z_{1925}, g_{1925}	$d_{11925} n_{1925}$	x_{1925}, s_{1925}
	$h_{f1925} = \left(h_{0f1900} + \widehat{h}_{1925}\right) E_{f1925}$	m_{1925}		$e_{1925}, \widehat{h}_{1950}$

[1] HC: Human Capital

Table 2: Parameters and Variables description

Variables	Targets
$\widehat{h}_t$	Units of schooling HC [1] bequeathed by the parents of t-1 to their children
x_t	HC goods input per child; inferred from published estimates (4.7.2)
s_t	Student HC time input per child; inferred from published estimates (4.7.2)
l_t	Child's time working during dependency; $T_t - s_t$
$d_{1t}{*}n_t$	Number of live births to a mother at time t; published estimates (4.11)
n_t	Number of children surviving to adulthood; published estimates (4.10 and 4.11)
m_t	Fraction of time mothers devote to the labor market; inferred from published estimates (4.9)
z_t	Mother's time input in household production; restricted by values of $m_t, \rho_t, \overline{\rho}_t$ (4.9, 4.12, 4.14)
γ_t	Hourly wage of adult female relative to that of adult male; inferred from published estimates (4.1)
Variables	Other
g_t	Goods input in household production; optimal solution, equation 3.6.12
e_t	Mother's HC time input per child; optimal solution, equation 3.6.10
Parameters	Human capital
θ_s	Elasticity of HC with respect to s_t, commonly employed value from literature (4.7.1)
θ_x	Elasticity of HC with respect to x_t, commonly employed value from literature (4.7.1)
θ_{he}	Elasticity of HC with respect to mother's time input $(h_{ft}e_t)$, (4.7.1)
b_t	Efficiency parameter in HC production, inferred from $\widehat{h}_{t+1}$ target (4.4.5)
E_{mt}	Impact of work experience on life earnings of adult males; published estimates (4.1)
E_{ft}	Impact of work experience on potential life earnings of adult females; published estimates (4.1)
P_t	Cost per unit of x_t, inferred (see sections 4.14, 6.1.2)
w_t	Wage per unit of HC; inferred subject to constraint (4.8)
μ_t	Hourly wage of child relative to that of adult male; inferred from published estimates (4.13)
h_{0m}	stock of unskilled HC for males; assumed, determines scale (4.2)
h_{0ft}	stock of unskilled HC for females; inferred under constraint (4.5)
T_t	Potential work time of children in t; inferred under constraint (4.14 and 6.1.2)
τ_t	Per child private consumption share of potential adults earnings; inferred from contemporary values (4.14)
ν_t	goods inputs in household production; set to meet baseline m_t (4.14)
Parameters	Mortality
d_{1t}	Number of births to a mother required to produce 1 surviving child; derived from published estimates (4.10)
d_{2t}	Number of children surviving infancy to produce 1 surviving child ; derived from published estimates (4.10)
Parameter	Taste
ψ	Determines relative taste for skilled earnings of children; 'pins down' $\widehat{h}_{t+1}$ (4.14)
σ	Determines relative taste for earnings derived from unskilled HC; 'pins down' n_t (4.14)
Parameters	Other
ρ	Mother's non-HC time cost per child surviving infancy; inferred from time use surveys (4.4.10)
$\overline{\rho}$	Mother's non-HC time cost per birth; inferred from time use surveys (4.4.10)

[1] HC: Human Capital

Table 3: Goods and time schooling inputs

Households formed in year t	1850	1875	1900	1925
Year HC[1] input observed (children age 15), $t+15$	1865	1890	1915	1940
$\frac{x_t}{x_{1850}}$	1	2.11	5.88[2]	14.9 (16.6)[3]
s_t	0.09	0.129	0.201	0.309

[1] HC: Human Capital

[2] Average of values for 1910 and 1920

[3] The value in parenthesis includes college expenditures among 18 and 19 years olds.

Table 4: Calculation of Life Cycle Permanent Income Per Full-time Male, $w_t h_{m,t}$

1	2	3	4	5	6
Age 25 in t	y^*_{pt}	$L_{m,t}$ **	γ_t	$[w_t h_{m,t}]^{***}_E$	$\left[\frac{w_t h_{m,t}}{w_{1875} h_{m,1875}}\right]^{***}_E$
1875	$7.56^{(1)}$	$.832^{(5)}$	.463	8.30	1.00
1900	$9.66^{(2)}$	$.794^{(6)}$	.52	10.71	1.29
1925	$13.79^{(3)}$	.754	.58	15.37	1.84
1950	$33.8^{(4)}$	.627	.603	39.67	4.78

*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.
*** $[w_t h_{m,t}]_E$ is the empirical estimate for male life cycle earnings in t; i.e. a parameter.
(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 1950, 1960, 1970 and 1980;
(5) average of 1880 and 1900; (6) average of 1910 and 1920.

Table 5: Life Cycle Labor Force Participation of White Married Females

1	2	3[1]	4[2]	5[3]	6
Birth Cohort	Attain Adulthood	LCPR	Adjustment	ALCPR	AVG
1855-64	1880	2.5	9.8	9.9	6.2
1865-74	1890	3.5	9.9	10.9	7.2
1875-84	1900	4.4	8.7	10.9	7.6
1885-94	1910	6.8	6.4	11.6	9.2
1895-04	1920	11.8	6.4	16.6	14.2
1905-14	1930	21.0	3.2*	23.4	22.2

1. Figures from Roberts (2007, Fig. 1.9). Averages are computed across age groups of 20-29,..., 60-69.
2. Goldin (1990, Ch. 2), Sobek (1997, Table 2.5)
3. Column 5 is sum of column 3 plus 0.75 times column 4 (see text)
* There is no adjustment measure for 1930, the last census year before modern concept.Figures from Roberts (2007, Fig. 1.

Table 6: Input table for parameters that are common to all runs

Parameters	Year 1875	Year 1900	Year 1925
Y_t	1000	1286	1840
θ_s	.6	.6	.6
θ_x	0.10	0.10	0.10
θ_{he}	0.10	0.10	0.10
b_t	1.23	1.40	1.54
P_t	0.50	0.35	0.20[1]
T	0.20	0.20	0.20
E_{mt}	2.53	2.36	2.19
E_{ft}	1.62	1.55	1.48
ρ	0.024	0.024	0.024
$\overline{\rho}$	.009	.009	.009
h_{0m}	10.0	10.0	10.0 (10.0)[3]
h_{0ft}	6.67	6.93	7.19 (7.45)[3]

[1]An alternative value for P_{1925} is discussed in section 6.1.2, and Table 9

[2] T is permitted to change across periods in section 6.1.1

[3]Values in adulthood for children of 1925-parents

Table 7: Experiment 1; Income, Public Schooling, Experience [1]

(a) Parental Characteristics Variables

Variables	Year 1875	Year 1900	Year 1925
$\widehat{h}_t$	2.0	3.04	3.71
$\frac{w_t}{w_{1875}}$	1.0	1.27	1.86
γ_t	0.463	0.502	0.537

(b) Parental Choice Variables

Variables	Year 1875	Year 1900	Year 1925
x_t	2.36	4.58	11.8 (16.5) [2]
s_t	.128	.136	.134 (.309) [2]
e_t	.0026	.0025	.0024
n_t	5.29	5.15	5.12
$d_{1t} * n_t$	5.29	5.15	5.12 (2.60) [2]
g_t	796	1052	1540
z_t	.738	.698	.668
m_t	.074	.119	.151(.233) [2]
$\widehat{h}_{t+1}$	3.04	3.71	4.46 (8.2) [2]
γ_{t+1}	.502	0.537	0.58 (.603) [2]

[1] This experiment allows for rising exogenous income, falling price of schooling inputs P_t, and changing profile of premium to experience $E_{m,t}$ and E_{ft} as in Table 6. Also, $d_{1t} = d_{2t} = 1$ since mortality is not considered in this experiment.

[2] The figures in parentheses are targets for the variable in 1925. For x_{1925} the target is 7 times the 1875 value; for s_t see Table A.2.2; fertility target in text; for m_t see Table 5; targets for $\widehat{h}_{1950}$ and γ_{1950} are given in the text.

Table 8: Experiment 2, Mortality [1]

(a) Parental Characteristics Variables

Variables	Year 1875	Year 1900	Year 1925
$\widehat{h}_t$	2.0	3.00	3.63
$\frac{w_t}{w_{1875}}$	1.0	1.27	1.87
γ_t	0.463	0.502	0.536

(b) Parental Choice Variables

Variables	Year 1875	Year 1900	Year 1925
x_t	2.34	4.48	11.4 (16.5) [2]
s_t	.128	.133	.129 (.309) [2]
e_t	.0025	.0024	.0023
n_t	3.63	3.93	4.00
$d_{1t} * n_t$	5.33	4.87	4.40
g_t	849	1121	1641
z_t	.768	.727	.700
m_t	.074	.122	.157(.233) [2]
$\widehat{h}_{t+1}$	3.00	3.63	4.32 (8.2) [2]
γ_{t+1}	.502	0.536	0.577 (.603) [2]

[1] In addition to those parameter changes of Experiment 1, the mortality exercise incorporates the time profiles of infant and child mortality as reflected in $d_{1,1875}$, $d_{1,1900}$, and $d_{1,1925}$; and $d_{1,1875}$; and $d_{2,1875}$, $d_{2,1900}$, and $d_{2,1925}$.

[2] The figures in parentheses are targets for the variable in 1925. For x_{1925} the target is 7 times the 1875 value; for s_t see Table A.2.2; fertility target in text; for m_t see Table 5; targets for $\widehat{h}_{1950}$ and γ_{1950} are given in the text.

Table 9: Experiment 3; Reaching the Targets[1]

(a) Parental Characteristics Variables

Variables	Year 1875	Year 1900	Year 1925
$\widehat{h}_t$	2.0	2.99	5.01
$\frac{w_t}{w_{1875}}$	1.0	1.27	1.70
γ_t	0.463	0.502	0.549

(b) Parental Choice Variables

Variables	Year 1875	Year 1900	Year 1925
x_t	2.33	6.08	16.7 (16.6) [2]
s_t	.128	0.206	.320(.309) [2]
e_t	.0025	.0033	.0038
n_t	3.63	2.89	2.40
$d_{1t} * n_t$	5.33	3.59	2.63 (2.60)[2]
g_t	849	1121	1761
z_t	.768	.727	.580
m_t	.074	.159	.327 (.233)[2]
$\widehat{h}_{t+1}$	3.00	5.01	8.19 (8.2) [2]
γ_{t+1}	.502	0.549	0.603 (.603) [2]

[1] In addition to those parameter changes of the Mortality Experiment 2, this exercise incorporates a time profile for dependent's wage per unit of human capital retained by parents, $\mu_{1875} = .40$, $\mu_{1900} = .35$, and $\mu_{1925} = .30$; for the time available for dependent children to work as perceived by parents $T_{1875} = .20$, $T_{1900} = .10$ and $T_{1925} = .05$; and for the share of potential parental earnings devoted to private consumption per child $\tau_{1875} = .04, \tau_{1900} = .045$, and $\tau_{1925} = .052$; finally, $P_{1925} = .23$.

[2] The figures in parentheses are targets for the variable in 1925. For x_{1925} the target is 7 times the 1875 value; for s_t see Table A.2.2; fertility target in text; for m_t see Table 5; targets for $\widehat{h}_{1950}$ and γ_{1950} are given in the text.

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