August 2005

Supply Factors and the Mid-Century Fall in the Skill Premium

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ABSTRACT

Supply factors affecting the costs of obtaining schooling explain much the U-shaped trend in the skill premium in the U. S. across the twentieth century. Specifically, the direct costs fell dramatically in the early part of the century as a result of increased public funding and falling fertility rates during the high school movement. The foregone earning costs of schooling were also low for mid-century workers because of high youth unemployment during the Great Depression.This paper develops a model and uses historical data to incorporate these factors and examine their quantitative importance. The baseline model is able to explain about 40 percent of the mid-century decline – and alternative calibrations explain up to 71 percent – without any mid-century decline in the demand for skill.

JEL Classifications: I2, J31, N32
Keywords: return to schooling, high school movement, skill-biased technical change

[1]I am grateful for helpful comments received from Paul Evans, Belton Fleisher, Trevon Logan and Rick Steckel.

1. Introduction

Understanding the dynamics of growth and inequality are two of the central problems in economics, and the skill premium is important to both topics. Growth explained by the accumulation of skill in the workforce, through schooling increases for example, is governed by the wage premium to schooling (e.g., Denison, 1962 and 1967, Jorgensen, 1995). A recent growth literature has applied this idea to analyzing levels of development in a cross-country context (e.g. Bils and Klenow, 2000, Klenow and Rodriguez-Claire, 1997, Krueger and Lindahl, 2001, and Hall and Jones, 1999). Similarly, the skill premium is an important determinant of wage inequality. The recent growth in the wage returns to schooling in the United States has had an important impact on overall wage inequality and it has also been argued that increases in skill premia for less easily observable skills has driven much of the observable increase to wage inequality (Juhn, Murphy, and Pierce, 1993, Katz and Murphy, 1992). This recent rise in the premium to skill has generated interest in the long run determinants of the wage premia to skill.

Goldin and Katz (1999a) document that the long run trend of most measures of the skill premium is U-shaped over the course of the twentieth century[2]. For example, Figure 1 presents the available Mincerian return data[3] for young (age 18-34) and all (age 18-65) full-time non-farm workers, along with the average years of schooling of young workers.[4] Schooling levels increase steadily over the century, but the Mincerian returns to schooling show a mid-century dip, with a slightly larger fall for young workers. The figure shows short run fluctuations such as the "Great Compression" of the 1940s, the fall in college premium in the 1970s, or the post-1980 acceleration of the return to schooling that have been well examined (e.g., Goldin and Margo, 1992, Katz and Murphy, 1992). This study complements that literature by addressing the long run trend in the skill premium. It builds on the argument of Goldin and Katz (2001) by quantifying the role that supply factors in the curious mid-century reversal.

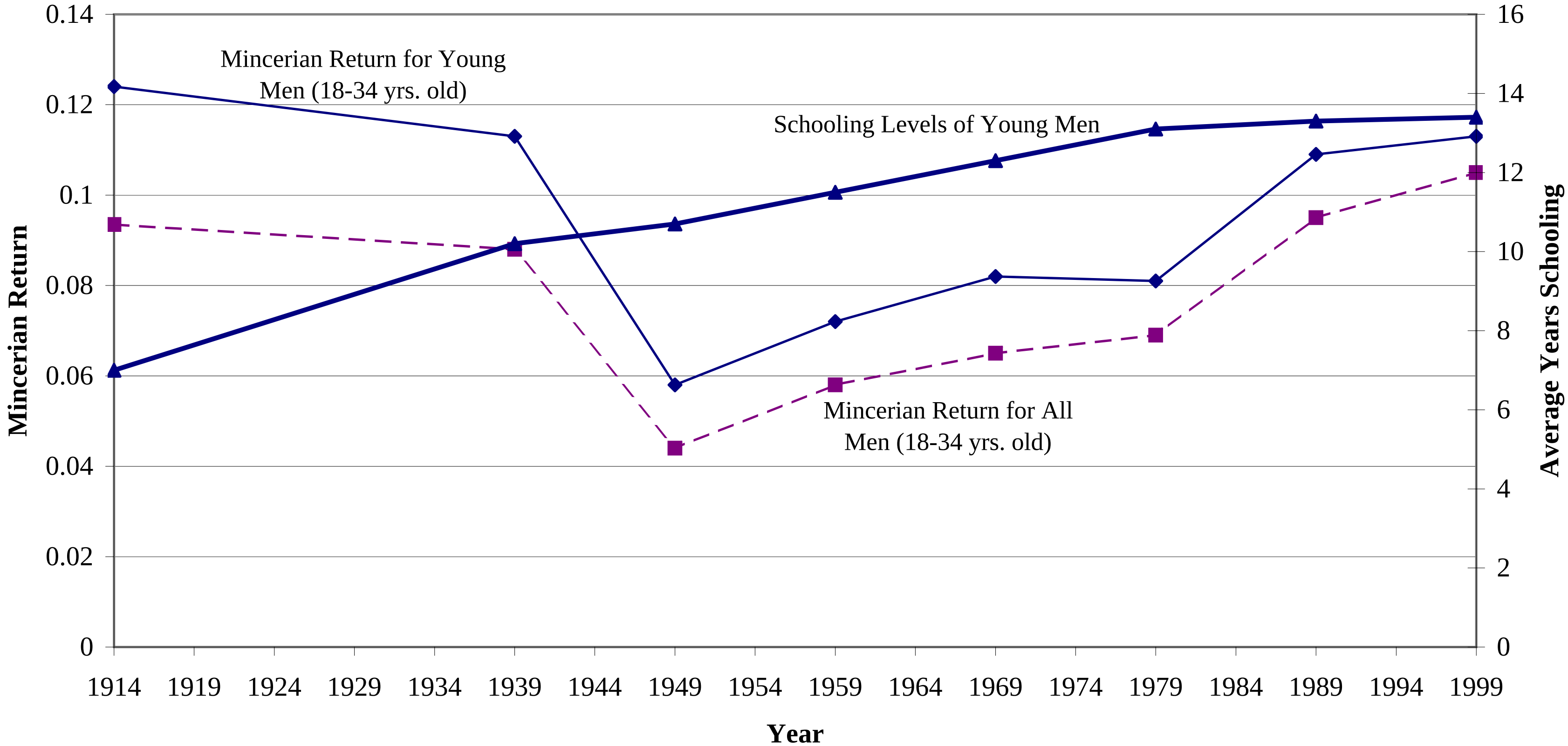
An existing theory, quantified by Mitchell (2005), argues that this reversal is the result of

[2] Juhn, Murphy, and Pearce (1993) provide detailed evidence of the rising inequality in the later part of the century, while Goldin and Katz (1999a, 1995) and Keat (1960) show a narrowing of various types of skill premia in the early part of the century.

[3] The coefficient on years of schooling from a regression of log wages on years of schooling, potential experience, squared potential experience and perhaps other controls, ala Mincer (1974). Although there is much debate on its interpretation as a rate of return (see Heckman, Lochner, and Todd, 2003, for example). I use the Mincerian coefficient as a measure of relative wages of individuals with different schooling levels, but continue with the convention of referring to it as the "return" to schooling.

[4] The earliest data point, 1914, is based on Iowa census data from Goldin and Katz (1999a), while the later evidence is from on U.S. census (IPUMS, 2004) data. The numbers have been adjusted for comparability following the same methodology as Goldin and Katz (1999c).

Figure 1: Schooling and Mincerian Returns of Non-Farm Male Workers



Sources: 1914 Mincerian return based on Goldin and Katz (1999a) data. Schooling level based on Goldin and Katz data and Bureau of Education (1905) data. 1939-1999 data is based on IPUMS census data.

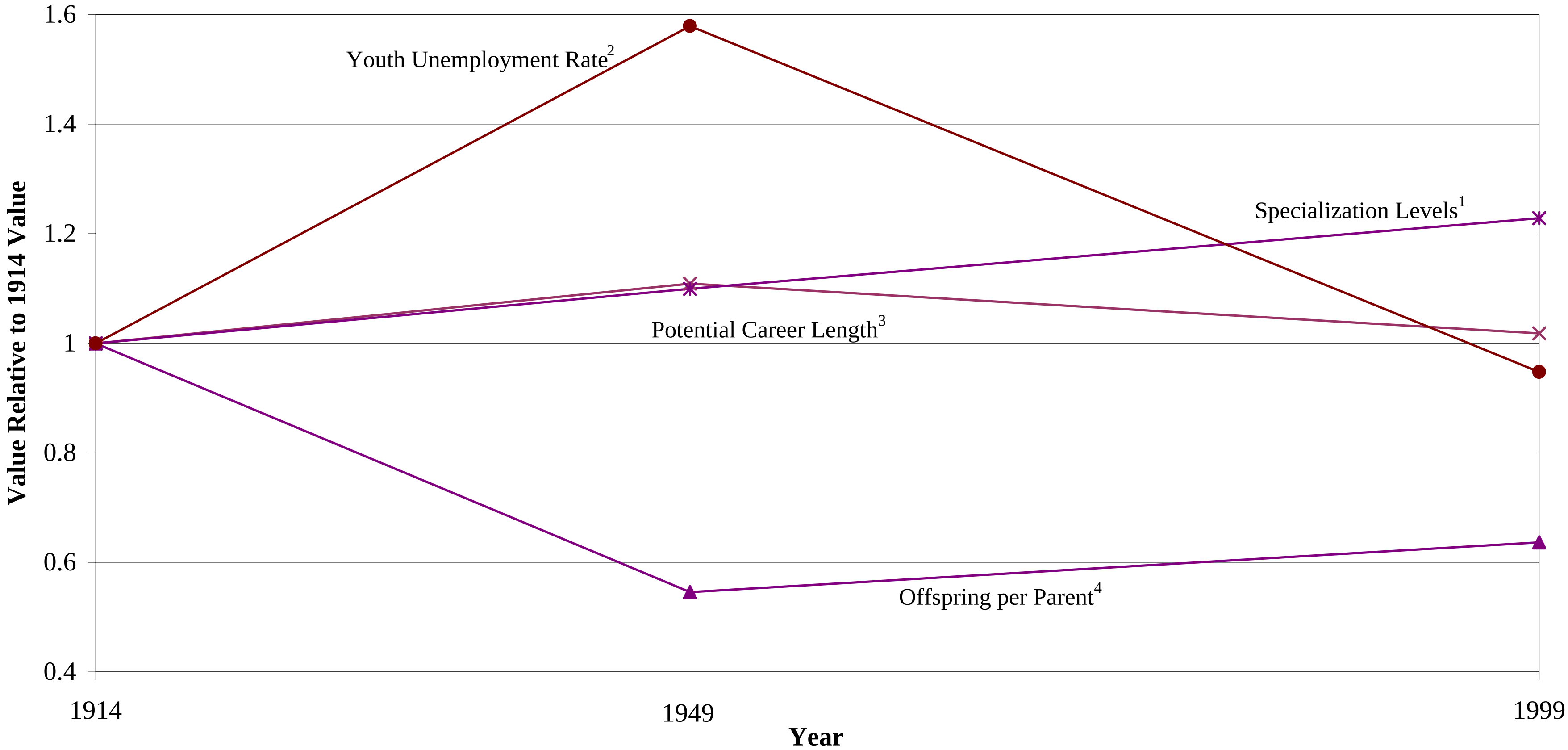
in the early part of the century with the advent of the assembly line and the spread of large-scale production, but skill-biased in the latter part of the century with the introduction of automation and computers. Mitchell's demand-driven model argues that specialization is deskilling, and the level of specialization increases with plant size. He therefore uses the inverted-U trend in average plant-size to calibrate the demand for skill over the twentieth century.

In contrast, this paper demonstrates that even with increasing demand for skill across the century, much of this reversal can be quantitatively explained by changes in the willingness to acquire schooling (i.e., the supply schedule for education). Furthermore, this trend in the willingness to acquire schooling is based on the costs of schooling, which are more readily observable than the demand for skill.

Essentially, both marginal direct and indirect (i.e., foregone earning) costs of schooling were lower for workers at mid-century. The lower direct costs were a result of increased access to secondary schools accompanying the high school movement in the early part of the century. Much of these changes in the direct costs of schooling can be explained by levels of government funding for education (as a fraction of GDP) and also fertility, which determines the size of student-aged cohort relative to the working (parent) generation. Namely, the large decrease in fertility and large increase in government funding in the early part of the century dramatically lowered the predicted direct costs that students faced. In the latter part of the century, the rising levels of education forced many students to face the higher direct costs of college on the margin. The lower indirect costs at mid-century were due to the high unemployment of school-age workers in the Great Depression. In later decades, when unemployment rates were lower, the indirect costs of schooling rose again. Finally, potential career lengths (which help determine the lifetime return to education) also contributed to this trend.

In addressing the long run role of supply factors, I simplify by focusing on the schooling decisions of three separate cohorts of young workers: the high return cohort in 1914, the low return cohort in 1949, and the high return cohort in 1999. Figure 2 presents the argument heuristically by plotting four important variables for the relevant cohorts in the early part, middle, and end of the twentieth century: (1) the extent of specialization; (2) youth unemployment rate; (3) potential career (i.e., education plus working life), and (4) offspring per parent. Each series is normalized by its 1914 level. Specialization (a potential measure of the demand for skill) rises steadily over the century. In contrast, youth unemployment rates, potential career length and fertility rates (i.e., factors affecting the supply schedule for education) show a mid-century reversal. The argument

Figure 2: Schooling Factors Over Time



Notes:

[1] The log of the number of industry-occupation cells with workers in the census. The 1914 is the average across the 1910 and 1920 censuses.

[2] Youth unemployment is aged 16-19. The data is the relevant years for the workforce, aged 18-34: an average of annual data from 4-20 years prior.

[3] Potential career length is min(life expectancy, retirement age)-6, where life expectancy is conditional on reaching age 10.

[4] Offspring per "parent" is for the parent generation of young workers, aged 18-34: half of average of the completed fertility of women aged 38-69 at the time.

is that the shifting supply schedule for education outpaced demand in the first half of the century (causing increases in schooling levels and falling returns), but slowed in the second half of the century and was in turn outpaced by demand (again causing increases in schooling levels but rising returns).

The argument is quantified using a model similar to Kaboski (2004a), which was able to explain 40 percent of the *cross-country* variation in returns to schooling using calibration techniques. I perform two types of exercises to calibrate direct costs. The first exercise calibrates the direct costs exogenously using enrollment rates in public and private schooling, with reference to historical state laws relevant to direct schooling costs (i.e., laws mandating free tuition, transportation, and books at the high school level) in alternative calibrations. The baseline calibration explains 42 percent of the actual decrease from 1914 to 1949 and 16 percent of the actual increase from 1949 to 1999. Alternative exogenous calibrations explain up to 71 percent of the decrease and 53 percent of the increase. The second exercise endogenizes the direct costs to schooling decisions, given the trends in fertility and government educational expenditures. The baseline endogenous calibration explains 41 percent of the decrease before 1949 and also 16 percent of the later increase. Alternative endogenous calibrations explain up to 59 percent of the decrease and 38 percent of the increase.

The conclusion is that factors affecting the supply of schooling are quantitatively important in explaining the mid-century reversal. This idea contrasts with the demand-side theory for this reversal that posits a change in direction of skill-bias in technological progress.

This demand-only explanation is problematic for several reasons:

- First, if demand for educated labor were decreasing in the first half of the century and increasing in the second half with no reversal in the direction of supply changes over the period, one would at the very least expect a smaller growth in level of education supplied in the early half of the century. The data in Figure 1 do not support this, nor is it consistent with the historical evidence on the importance of the high school movement in the first half of the twentieth century.
- Second, the link between plant size and specialization is tenuous at best, and the interpretation of specialization as deskilling is also problematic. Even if there are higher levels of specialization within larger plants, plant size would say nothing about the amount of specialization between plants. Indeed, as shown in Figure 2, more direct measures of specialization (i.e., the variety of occupations and industries) grew steadily even before 1950. Mitchell's model would interpret this as a persistent fall in the demand for skill, so calibrating his model with this more direct measure of specialization would produce a persistent fall in the skill premium

and no mid-century reversal. The model here produces the reversal from supply changes, and interprets the trend in specialization as causing a persistent increase in the demand for skill from the introduction of new skill-intensive sectors. This interpretation is consistent with evidence in Kaboski (2001) and (2003b) that new industries and occupations have higher average levels of education.

- Third, there is more direct evidence that technical change was skill-biased earlier in the century (e.g., Goldin and Katz, 1998).
- Finally, there is historical evidence for the government initiatives in high school expansion and the measurable demographic changes in fertility and life expectancy, all of which one would associate with shifts in the supply schedule of schooling.[5]

The rest of the paper is organized as follows. Section 1 develops the model. Section 2 gives a brief historical summary of the high school movement, which is relevant to the calibration decisions presented in Section 3. Section 4 examines the results and Section 5 concludes.

2. Model

A static model is viewed as sufficient, since dynamic labor market linkages over time are not likely to be important in comparing labor markets sufficiently separated in time. The static model presented is quite similar to Kaboski (2004a). The model yields a competitive equilibrium of a representative firm hiring a continuum of agents who differ in their education and skill. Agents maximize lifetime income by choosing their levels of schooling and the sector in which they work, taking the costs (direct and indirect) of schooling, wage schedules, and the range of available sectors as given. Since new sectors have high skill requirements, the larger the range of sectors (or occupations), the greater specialization and the higher the demand for skill. Again, this is motivated by evidence (see Kaboski, 2001, and Kaboski, 2004b) that workers in new industries and occupations have higher average education levels.

[5] Another potential supply effect would be the closing of immigration in the 1920s. This is not considered because it was difficult to introduce into the model.

A. Production

A representative firm produces final output from the intermediate outputs $x(i)$ of a continuum of imperfectly substitutable sectors indexed by their level of complexity i.

$$Y \equiv \left(\int_0^I x(i)^{1-\mu} di \right)^{\frac{1}{1-\mu}}$$

Sector outputs are produced by a continuum of workers indexed by their skill level h[6]:

$$(1) \quad x(i) = \int_{-\infty}^{\infty} a(i,h) l(i,h) dh \text{ where } a(i,h) \equiv \tilde{a}(i,h)^{\alpha}$$

Here $l(i,h)$ indicates the amount of labor of human capital (or skill) level h at work in sector i. The labor productivity $a(i,h)$ is specific to both task and skill level, and I is the maximum complexity level of any existing sector. The output $x(i)$ of a given sector is the sum of the outputs of agents of different skill levels h who work in the sector.

The parametric form of $a(i,h)$ is:

$$a(i,h) = \exp\left(\frac{i^{1+\phi} h^{1-\phi}}{(1+\phi)(1-\phi)} \right)$$

In theory, ϕ can take any value and determines both 1) the relative weight of sector and skill in labor productivity and 2) the extent of diminishing returns to skill within a given sector. This parameterization satisfies three important conditions that ensure labor markets have certain desirable properties.

$$Condition\ 1 : \frac{\partial a(i,h)}{\partial h} \geq 0$$

Condition 1 says that workers with higher levels of skills have an *absolute advantage* over less skilled workers, and ensures that wages will be increasing in skill.

$$Condition\ 2 : \frac{\partial^2 \log a(i,h)}{\partial i \partial h} > 0$$

Condition 2 is a statement that workers with higher levels of skill have a *comparative advantage* in

[6] Introducing heterogeneous capital into sector production in a Cobb-Douglas fashion is relatively straightforward, as shown in Kaboski (2004b), but would not affect the analysis. With this in mind, $a(i,h)$ can be thought of as determined by not only human capital productivities, but also the relative productivities and prices of complementary physical capitals.

more complex sectors. Given Condition 2, more skilled laborers work in more complex tasks.

$$\textit{Condition } 3 : \frac{\partial^2 \log a(i,h)}{\partial h^2} < 0$$

Condition 3 is an assumption of *log diminishing returns*, which will allow the log wage returns to skill to fall as the skill levels of the workforce increase.

The firm maximizes profits taking the wage profile as given. Its first-order condition:

$$(2) \quad w(i,h) = \alpha L^{\mu} [x(i)]^{-\mu} a(i,h)$$

shows that wages can be thought of as a price $\alpha L^{\mu} [x(i)]^{-\mu}$ on output in sector i times the worker's productivity $a(i,h)$ in that sector.

B. Households

There is a measure one of agents who differ in θ, their ability[7]. The density function $g(\theta)$ is everywhere positive and finite along a bounded interval $\left[\overline{\theta}, \underline{\theta}\right]$. An agent's level of skill h is simply the sum[8] of years of schooling s and ability θ. Taking wages and schooling costs as given, agent θ's objective is to choose a level of schooling and a sector to maximize lifetime income net of direct schooling costs. The agents' problem is therefore:

$$\max_{\substack{i\in[1,I]\\ s\in[0,\bar{s}]}} \tau(s;T,u,u_y)w(i,h) - \int_0^s \eta(z)w(i,h)dz$$

$$(3) \qquad \text{s.t. } h \;=\; \theta + s$$

where $\tau(s;T,u,u_y)$, the effective time spent in the labor force, is a function of schooling, given the years of "potential career" that can be allocated toward schooling or work, T, the long-horizon ("career") unemployment rate, u, and the short-horizon ("youth") unemployment rate on the margin of entering the workforce, u_y. The direct cost of schooling (i.e., tuition, transportation, books, etc.) is proportional to the indirect cost of schooling (i.e., foregone wages). It is a function of the level of

[7] This parameter θ could represent inherent ability, family background characteristics, or any other heterogenous quality that is a complementary to education in increasing skill or wages.

[8] Schooling and ability are perfect substitutes in producing skill, where log wages are proportional to skill. Defining $\tilde{h} = e^h = e^{s+\theta}$ yields something more analogous to a standard formulation of human capital, where wages are proportional to $\tilde{h}$. It is clear that schooling and ability are complementary in producing wages and human capital as measured by $\tilde{h}$.

schooling and is captured by $\eta(.)$.

The relevant first-order conditions can be simplified and written in logs as:

$$(4) \qquad \frac{\partial \log w(i,h)}{\partial i} = 0$$

$$(5) \qquad \frac{\partial \log w(i,h)}{\partial s} = \frac{-\tau'(s;T,u,u_y)w(i,h) + \eta(s)w(i,h)}{\tau(s;T,u,u_y)w(i,h) - \int_0^s \eta(z)w(i,h)dz}$$

Equation (4) says that workers choose the occupation that pays them the highest wage. Equation (5) shows that the marginal wage return to schooling is the ratio of marginal (indirect, $-\tau'$ and direct, η) costs, over lifetime income net of direct costs. Clearly, this marginal log wage return is strongly related to the Mincerian return.

C. Equilibrium

Solving for equilibrium involves applying the market clearing conditions for labor inputs (of different skill level h and in different tasks i) and is quite similar to Kaboski (2001). Assumptions 1 and 2 produce increasing mappings of tasks to abilities $\theta(i)$ and and tasks to skill levels $h(i)$.

Labor market clearing simplifies[9] to:

$$(6) \qquad l(i,h) = \begin{cases} \tau[s(i);T,u,u_y]g(\theta(i))\theta'(i) & \text{for } h = \theta(i) + s(i) \\ 0 & \text{otherwise} \end{cases}$$

The amount of task i produced is therefore[10]:

$$(7) \qquad x(i) = a[i,h(i)]\tau[h(i) - \theta(i);T,u,u_y]g(\theta(i))\theta'(i)$$

Combining equation (2), the expression for wages that comes from firm optimization, with equation (4), the household optimality condition for the choice of i, yields the constant elasticity of

[9] In words, the demand for labor of type h working in task i must equal the supply. For task-skill combinations that satisfy $h = h(i)$, the supply is the effective time workers spend in the labor force, given their optimal level of schooling, times the density of workers of the type θ that choose task i. The $\theta'(i)$ term is the Jacobian term from transforming the density in terms of θ to a density in terms of i. For task-skill combinations that are not optimal, the supply is zero.

[10] Equation (1) assumed that the mass of tasks was distributed across a two-dimensional (h,i) plane. This density would need to be integrated across h in order to reduce the dimensionality to one (the i dimension). The existence of the function $h(i)$ shows that the problem was already one-dimensional, and the mass is distributed along the line $h(i)$. Hence no integration is needed.

substitution expression:

$$(8) \qquad \frac{a_1(i,h)}{a(i,h)} = \mu \frac{x'(i)}{x(i)}$$

where the subscript on a indicates a partial derivative with respect to the first argument. Taking logs and differentiating (7) and combining with (8) produces a second-order differential equation in the matching function $\theta(i)$. Omitting functional dependencies, this equation is:

$$(9) \qquad \frac{\theta''}{\theta'} + \left(\frac{g'}{g} - \frac{\tau'}{\tau}\right)\theta' + \left(\frac{a_2}{a} + \frac{\tau'}{\tau}\right)h' + \left(\frac{\mu - 1}{\mu}\right)\frac{a_1}{a} = 0$$

This differential equation[11] yields the optimal choice of i given θ. The corresponding optimal choice of h (and therefore s) can be easily found by applying (5). Equilibrium schooling decisions are non-decreasing in θ and so wages are increasing in s.

3. Historical Background of the High School Movement

The surge in secondary education enrollment in the United States during the early half of the twentieth century has been well studied by economic and education historians (e.g. Goldin 1998, 1999, Goldin and Katz, 1999b, and Krug, 1964, 1972). Here I briefly summarize aspects of this movement relevant to the argument and calibrated simulations.

In the nineteenth century, the public high school had not yet emerged as a dominant institution. Secondary education was a wide mesh of public and private preparatory schools, Latin schools, normal schools, and high schools. While public primary schools, so-called common schools, were nearly universally accessible and relatively well-attended, public secondary schools were scarce and less available. Indeed the number of public secondary students first surpasses the number of private secondary students in 1887. Still, only six percent of youths graduated from high school in 1900, and curricula tended to be college preparatory. Many rural areas lacked public high schools.

Education levels in 1914 were correspondingly quite low. Based on enrollment data, young people entering the workforce in 1905 averaged an estimated 5.3 years of schooling (Bureau of Education, 1905). Iowa census data, the best available data, showed higher levels of education of 8.9 years for young men aged 18-34 in 1914, but these were certainly much higher than the national average which didn't reach these levels until 1940 (Goldin and Katz, 1999c). By 1950, these U.S.

[11] In the quantitative simulations, η is a discontinous function of s. Hence, the mapping $i(\theta)$ and $h(\theta)$ are only piece-wise differentiable, and a series of differential equations satisfying (9) define $i(\theta)$ and $h(\theta)$.

census levels had risen to 10.7 years.

The surge in enrollment generally regarded as the takeoff of the high school movement began in the 1910s. Only nine percent of youth were graduating from high school in 1910, but by 1940 this number had risen to fifty percent (Goldin and Katz, 1997). Among the many reasons, several institutional developments on the supply side were important. First, in 1917 the Smith-Hughes Act set up federal funds for states incorporating vocational curricula into their public high schools. Thus, high schools began giving instruction in subjects that were deemed useful to the masses. Second, and related, the high school format, together with the introduction of the junior high school, became the dominant paradigm for secondary education. Third, on a state-by-state basis, laws were enacted to expand access and lower financial and other barriers to secondary education.[12] For example, tuition-free legislation had been passed in almost all states outside of the South by 1924. More important, the overwhelming majority (44 of 48) of states made provisions for transfers of students in rural areas without a high school to study at nearby schools. The home school district was generally required to pay tuition fees and in some cases transportation costs (Hood, 1924). In addition, state laws promoted government funding of other non-tuition costs, such as books and instructional materials. By 1944, only ten states (generally Southern) did not have some form of public provision of secondary school textbooks (Proffitt, 1944).

An additional supply factor pushing young people out of the labor force and into high school during was the high youth unemployment in the Great Depression. Indeed, the National Industrial Recovery Act forbid the hiring of youths in manufacturing (Goldin, 1999).

The increase in government expenditures on non-higher education was dramatic over this period, increasing from 1.3 percent of GDP in 1910 to 2.5 percent in 1940. This increase was necessary not only because of the surge in public enrollment, but also because secondary education,especially the new vocational training, was much more expensive than primary education. Expenditures per pupil for secondary education were about twice those at the primary level.

4. Calibration

I calibrate points in time for which reasonably complete data are available: 1914, 1949, and 1999. The labor market in 1914 includes people who entered the labor market just prior to the high school movement. The mid-century low-point for returns to schooling is 1949 (1950 census).

[12]The Bureau of Education published periodic comparative studies and compilations of these laws in 1915, 1918, 1920, 1922, and 1924. See Hood (1924).

The simulations focus on young people (aged 18-34), so calibration decisions are based on these ages. Given the years and age range of interest, timing decisions must be made to adequately calibrate the values. Most details of these decisions, as well as data sources, are left to the appendix.

Calibration involves technology parameters and the two factors effecting the supply of schooling – the direct costs of schooling captured by $\eta(z)$ and the effective working time captured by $\tau(s; T, u, u_y)$. Given the total direct costs of schooling, $\eta(z)$ is calibrated using two methods to calibrate the fraction of direct costs born by agents. For τ and η, several alternative calibrations are presented to check the robustness of results to reasonable variation in calibrated values.

A. Direct Costs of Schooling

The function $\eta(z)$ measures the direct costs of schooling relative to the wage (or indirect cost of schooling) born by students in year z of schooling. The direct cost born by students is the fraction f of the total direct costs of schooling $\tilde{\eta}(z)$ not paid by the government (i.e., $\eta(z) = f(z)\tilde{\eta}(z)$)

Both $f(z)$ and $\eta(z)$ are step functions, where f_j and $\tilde{\eta}_j$ are distinguished by primary ($j = 1$), secondary ($j = 2$), or tertiary ($j = 3$) levels.[13] The $\tilde{\eta}_j$ were estimated in Kaboski (2004a) using government expenditures data from a cross-section of countries that fully fund education at each of these respective levels [14] These values of $\tilde{\eta}_1$=0.13, $\tilde{\eta}_2$=0.30, and $\tilde{\eta}_3$=0.42 are consistent with evidence that spending per pupil is about twice as high for secondary education as for primary, and substantially higher for tertiary education.

Again, two alternative approaches are used to calibrate the fraction of total costs born by students at each level (i.e., f_1, f_2 and f_3). The first takes the f_j as exogenous and calibrates them directly. The second takes the relative cohort size and the fraction of GDP spent on schooling at each level as exogenous, but endogenizes f_j to schooling decisions. The higher the levels of schooling attained and the larger the cohort size, the higher the fraction that the government cannot fund. The larger the fraction of GDP spent on government funding, the lower the fraction. I discuss each approach in turn.

Exogenous Direct Costs

The fraction of schooling not funded by the government f_j is calibrated directly using the fraction of students at a given level enrolled in private schools. For primary education, this fraction

[13] Primary is the first six year, secondary is the next six years, and teratiary is up to four more years of schooling.

[14] The estimation was the average value of $\tilde{\eta}_j$ using equation (10) and the fact that $f_j = 1$ for countries that fully fund public education at level j. See Kaboski (2004a) for details.

is relatively stable over the period. The values for f_1 are 0.09, 0.11 and 0.12 for 1914, 1949, and 1999, respectively. Hence, the implied direct costs students face at the primary level η_1 are quite small: 0.012, 0.014 and 0.016, respectively.

For secondary education, the numbers are somewhat higher; f_2 is 0.20 for 1914, 0.07 for 1949 and 0.09 for 1999.

Unfortunately, these values do not fully capture the costs of schooling students facing the earliest students for two reasons discussed in Section 3. First, public schools were not available in many rural areas and so rural students often faced prohibitive costs. Second, public schools were not always free, often charging students for books, fees, and even tuition, especially for students outside the district. By mid-century, these barriers had been overwhelmingly removed. Hence, Alternative A assumes that even public school students faced 40 percent of true direct costs, which increases the calibrated value of f_2 to 0.52 for 1914.

For tertiary schooling, the exogenous values are 0.48 and 0.22 for 1949 and 1999. No value is calibrated for 1914, since data is not available and any positive costs would yield the simulation's prediction that no one attends tertiary school, which is quite close to the reality.

For higher education, however, out-of-pocket costs are sizable even at public schools, and public subsidies to private tertiary institutions are also substantial. Therefore, I calibrate Alternative B, which assumes that public school students pay one-third of the true costs, while private school students pay two-thirds. In this case, the tertiary values for 1949 and 1999 are 0.49 and 0.41, respectively.

Endogenous Direct Costs

Here f_j is solved endogenously as:

$$\begin{aligned} f_j &= 1 - \frac{\text{government expenditures at level } j}{\text{total direct schooling costs at level } j} \\ &= 1 - \frac{e_j Y_w}{F \int s_j(\theta)\tilde{\eta}_j w(\theta) g(\theta) d\theta} \end{aligned} \tag{10}$$

where e_j is the fraction of income that the government uses to fund education at level j (=1, 2, or 3), Y_w is income per worker[15] (i.e., adult), F is is the number of children per adult, $s_j(\theta)$ is the

[15] In the data (the source of e_j) educational expenditures are paid across cohorts and over time, income should not be discounted since educational expenditures are not. So I multiply discounted earnings by the ratio of average real time to average discounted time $(T - s_{avg})/\tau(s_{avg})$. That is,

$$Y_w = (T - s_{avg})/\tau(s_{avg})Y$$

years of schooling at level j (=1, 2, or 3) of agent θ. That is, agents take f_j as given and choose schooling levels s. It is straightforward to show that the integral in (10) is decreasing in f_j and that a solution to the equation exists.[16]

Solving (10) requires appropriate values for e_j and F_j. The values for e_j are calculated directly using data on government expenditures and national income. Unfortunately, I do not have e_1 and e_2 independently for the earlier years, only the sum of the two. Hence, for all years I assume (as was generally the case historically at the local level) that funding is first directed toward primary schooling until f_1 equals zero, and any remaining funding was then used for secondary schooling. The values for $e_{12} = e_1 + e_2$ are 0.012 for 1915, 0.022 for 1949, and 0.038 for 1999. The values for e_3 are 0.000 for 1914, 0.002 for 1949, and 0.006 for 1999.[17]

Values of F are calculated as one-half the completed fertility (i.e., children ever born) of the relevant generation of mothers. Based on mothers' prime fertility period of age 20-35, the mothers of children 18-34 were assumed to be 38-69 years old. The values for F are 2.2 for 1914, 1.2 for 1949, and 1.4 for 1999. The lower mid-century numbers reflect the fall in fertility in the early part of the century and especially the Great Depression. The later years include some mothers of baby-boomers. Unfortunately, in 1999 younger mother's had not yet completed their fertility in 1989 (the year of most recent IPUMS data for children ever born), so women aged 28-44 in 1989 were excluded in the number for 1999. Alternative C calibration includes these women with incomplete fertility and yields a lower value of 1.1 for 1999.

A summary of the calibration values for the direct schooling costs is presented in Table 1. The endogenous simulations yield much higher costs of schooling, with the "high school" movement showing up as a fall in both secondary *and* primary costs. Despite dramatic increases in government expenditures at the tertiary level, tertiary costs of education actually rise from 1949-1999 because of the dramatic growth in college attendance.

This same approach was used to estimate $\tilde{\eta}_j$ in Kaboski (2004a).

[16] The solution is unique for all but f_3 in 1914. In the 1914 simulation no one attends tertiary education, which is quite similar to the data in 1914. Since I calibrate no government funding for tertiary education in 1914, any positive value of f_3 prevents tertiary attendance and therefore satisfies (10).

[17] Total expenditures were divided by two since data suggests that only half of university expenditures are student-related. Other expenditures (e.g., research, hospital services and independent operations, auxiliary services, and public services) are not instructional costs. The identical approach was used in estimate $\tilde{\eta}_3$. See Kaboski (2004a) for further details. The earliest available data is 1920 and amounted to less than 1/20th of one percent. Hence, I calibrate a value of zero for 1914.

Table 1: Calibration of Direct Costs

Parameter	Calibration Source	Baseline Values			Alternative A*			Alternative B**			Alternative C***		
		1914	1949	1999	1914	1949	1999	1914	1949	1999	1914	1949	1999
Total direct costs relative to wages:	Estimated from countries that fully fund education, Kaboski (2004a)												
Primary schooling, $\tilde{\eta}_1$		0.13	0.13	0.13	--	--	--	--	--	--	--	--	--
Secondary schooling, $\tilde{\eta}_2$		0.30	0.30	0.30	--	--	--	--	--	--	--	--	--
Tertiary schooling, $\tilde{\eta}_3$		0.42	0.42	0.42	--	--	--	--	--	--	--	--	--
		Exogenous Calibration:											
Fraction of direct costs faced by students:	Private school fraction of enrollment at each level of schooling												
Primary schooling, f_1		0.09	0.11	0.12	--	--	--	--	--	--	--	--	--
Secondary schooling, f_2		0.20	0.07	0.09	0.42	0.07	0.09	--	--	--	--	--	--
Tertiary schooling, f_3		†	0.48	0.22	--	--	--	†	0.49	0.41	--	--	--
		Endogenous Calibration:											
Children per Adult, F	1/2*Women's completed fertility	2.2	1.2	1.4	--	--	--	--	--	--	2.2	1.2	1.1
Public funding as a fraction of GDP:	Government expenditure data												
primary and secondary level, e_1+e_2		0.012	0.022	0.038	--	--	--	--	--	--	--	--	--
tertiary level, e_3		0.000	0.002	0.006	--	--	--	--	--	--	--	--	--
Resulting fraction of direct costs faced by students:	Endogenously determined per equation (10)												
Primary schooling, f_1		0.49	0.00	0.00	--	--	--	--	--	--	0.49	0.00	0.00
Secondary schooling, f_2		1.00	0.67	0.42	--	--	--	--	--	--	1.00	0.67	0.15
Tertiary schooling, f_3		††	0.65	0.75	--	--	--	--	--	--	††	0.65	0.70

-- Indicates value is identical to baseline value.
* Alternative A assumes that even public secondary school students faced 40 percent of direct costs in 1914.
** Alternative B calibrates that public tertiary school students face one-third of direct costs and private tertiary school students face two-thirds of direct costs.
*** Alternative C calibrates a lower women per children for 1999 because it includes young women aged (28-44) with incomplete fertility in the 1989 data.
† This number could not be calibrated, but any positive value would produce the simulations result that no one obtains tertiary schooling
†† There is no unique value of f_3 satisfying (10), since tertiary funding is zero and any positive number would produce the result that no one obtains tertiary schooling in 1914.

Effective Working Time

Effective working time is increasing in potential career length T, decreasing in s, and incorporates discounting (the income from) future years of work. Youth unemployment, u_y, is modeled as an instantaneous unemployment rate on the margin of schooling, where as overall unemployment, u, affects the probability of working throughout the rest of the career. That is, u_y, is the unemployment rate at a point in time for students who are indifferent between continuing with schooling or entering the labor market. It will effect the marginal costs of additional schooling, τ_1, without changing potential career length on average. This is a nice analytical simplification which captures two necessary elements of realism. One, unemployment rates are higher for youths. Two, cyclical unemployment rates have large effects on marginal decisions while having much smaller effects on lifetime income.

Consider the following representation of discounted lifecycle labor income (using the time the person with average schooling, s_{avg}, enters the market as a point of reference):

$$\int_s^T e^{-\tilde{r}(t-s_{avg})}(1-u_y\chi_{t=s})(1-u\chi_{t\neq s})w(s+\theta)e^{\gamma(t-s)}e^{x(t-s)}dt$$

where γ captures growth in wages over time, x captures a linear[18] return to experience, and earnings are discounted at a rate $\tilde{r}$ back to the time when the person with average schooling enters the labor market.

Factoring out $w(s+\theta)$ and comparing with labor income in (3), it is clear that the remaining integral is the expression for discounted career length. Linearizing this expression around $s = s_{avg}$ yields:

$$\begin{aligned}
\tau(s;T,u) &\equiv c_1 + c_2 s \\
c_1 &\equiv \frac{(1-u)\left[e^{-r(T-s_{avg})}-1\right]}{-r} + (1-u_y)s_{avg} \\
c_2 &\equiv -(1-u_y) \\
r &\equiv \tilde{r} - \gamma - x
\end{aligned}$$

Two observations on these expressions should be made. First, the composite discount rate r incorporates discounting, the time trend growth in wages, and the growth in experience. Second,

[18] My omission of a quadratic return to experience departs from the Mincerian model, but allows a closed form expression for τ. Given discounting, the negative returns to experience observed at the end of careers are not quantitatively important.

given our choice of s_{avg} as the point of reference for discounting, c_2 shows that the foregone time cost of schooling is the probability that a youth is employed at that time, $(1 - u_y)$.

What remains is to calibrate values for T, s_{avg}, u, u_y and r. .

Potential career is the sum of time spent in school and in the labor market. Children enter school at age six and leave the labor market at either death or retirement. I therefore use the formula:

$T =$ min(life expectancy, retirement age)-6

Life expectancy is conditional[19] on reaching age 10, which eliminates variation coming from infant and early childhood mortality that is irrelevant to schooling decisions. Using a retirement age of 65 across the century, the T values are 55, 59, and 59 for 1914, 1949, and 1999, respectively. Alternative A, a calibration more favorable to the theory that supply factors matter, uses the median retirement ages in the data (see Gendell and Siegel, 1992) of 67 (T=61) in 1949 and 62 (T=56) in 1999.

Using IPUMS census data the average schooling levels are 10.7 years in 1949 (1950 census) and 13.4 years in 1999 (2000 census). For 1914, the Iowa census average of 8.9 years is known to be substantially higher than the national average, but school life expectancy[20] values (5.4 years in 1905 when the target populations would have been aged 9-25) are typically at least a year lower than average years of schooling in later censuses. Hence, the intermediate value of 7 years is used for calibration.

The overall unemployment rate averaged over long (career length) periods varies relatively little from 1890 to 2000. The values calibrated for u are 6 percent for 1914, 8 percent for 1949 and 6 percent for 1999. The youth unemployment rate, calibrated for 16-19 year olds and averaged over shorter (15-year) periods, are significantly higher than the career unemployment rates and show greater variation. Age-specific unemployment rates are first available in 1948, but fortunately youth rates are strongly related to overall unemployment rates[21] and therefore can be imputed for earlier

[19] This was used as the earliest age when children are at the margin of entering the workforce. It makes almost no difference whether life expectancy is calculated based on the conditional life expectancy at age 10 or age 15.

[20] School life expectancy is analogous to life expectancy where enrollment rates at different levels of schooling are used to calculate a distribution of drop out levels.

[21] An OLS regression of youth (16-19 year old) unemployment u_y on overall unemployment u_o for the years 1948-2003 produces the following regression equation:

$u_y = 4.27 + 1.99u_o \quad R^2 = 0.84$

years. The baseline u_y values for 1914, 1949 and 1999 are 19, 30 and 18 percent, respectively. Again, the higher values in 1949 are the result of much of the 18-34 year old workforce having made their marginal education decisions during the Great Depression.

The value of r is chosen to match the 1914 Mincerian return of 12.4 in the data. Because the costs of schooling are higher in the endogenous schooling costs model, two separate values are needed: 0.092 for the exogenous model and 0.071 for the endogenous model. Given secular wage growth of 2 percent and a linear return to experience of 1.5 percent, these discount rates would imply interest rates of 12.7 and 10.6 percent respectively. It is well known that the levels of Mincerian returns imply high discount rates, which is often taken as evidence for credit constraints in educational decisions. Lacking other data, we keep this discount rate constant over time[22]

Table 2 summarizes the calibration decisions for effective career length. Along with the baseline values, alternatives D and E are presented. Alternative D presents plausible calibrated values for potential career and youth unemployment that are more favorable than the baseline to the theory that supply factors matter, while alternative E chooses calibration values that are stacked against the theory.

B. Technology Parameters

The remaining parameters are the technology parameters I, μ, ϕ and the distribution of ability θ. Recall that I governs both the level of specialization and the demand for skill. In each simulation, a different I value is set to match the average schooling level in the data at each point in time. The calibrations of μ, ϕ and $g(\theta)$ follow Kaboski (2004a), which presents more details. The inverse elasticity of substitution between tasks μ is set to 0.7 based on estimates of the elasticity of substitution of workers with different skill levels. The parameter ϕ governs the diminishing returns to skill and was estimated in Kaboski (2004a) from the cross-country distribution of output. These two parameters play very minor roles in the Mincerian return predictions – notice they do not appear in equation (5) for the marginal wage return, but ϕ does have important effects on the predicted values of I. Finally, the distribution of θ is calibrated as a uniform distribution over the interval $\left[\underline{\theta}, \bar{\theta}\right]$, where $\underline{\theta} = 0.01$ and $\bar{\theta} = 6.01$. This calibration effects the unobserved ability bias in measured

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A regression restricting the constant term to be zero yields:

$$u_y = 2.70 u_o \quad R^2 = 0.72$$

[22] This constant r would be consistent with constant growth and interest rates along a balanced growth path, assuming a constant return to experience.

Table 2: Calibration of Effective Career Time

Parameter	Calibration Source		Baseline Values			Alternative D*			Alternative E**		
			1914	1949	1999	1914	1949	1999	1914	1949	1999
Potential Career Length, T	min(life expectancy, retirement) - 6		55	59	59	55	61	56	--	--	--
Average Schooling, s_{avg}	Average years schooling of men age 18-34		7.0	10.7	13.4	--	--	--	--	--	--
Overall unemployment rate, u	Average overall unemployment rate over 40 year career		0.06	0.08	0.06	--	--	--	--	--	--
Youth unemployment rate, u_y	Average unemployment rate for 18-34 year olds at age 16		0.19	0.30	0.18	0.18	0.39	0.16	0.23	0.27	0.20
Discount rate, r	1914 Mincerian return in baseline models:	Exogenous f	0.092	0.092	0.092	--	--	--	--	--	--
		Endogenous f	0.071	0.071	0.071	--	--	--	--	--	--

-- Indicates value is identical to baseline value.

* Alternative D calibrates a larger plausible variation in youth unemployment and a changing retirement age.

** Alternative E assumes a conservatively small variation in youth unemployment.

Mincerian returns and is based on evidence on the returns to ability in micro-data in the U.S. and and also aggregate returns in the cross-section of countries. A summary of these calibrated values are presented in Table 3.

5. Results

The calibrated simulations match the relevant labor market facts fairly well. For example, although only average years of schooling is calibrated, the model produces reasonable numbers for the distribution of schooling. Primary schooling is completed by nearly all, ranging from an average of 5.2 years (out of 6) in 1914 to 5.8 years in 1999. The high school movement occurs predominantly between 1914 and 1949, with average years of secondary education increasing from just 1.8 years in 1914 to 4.6 years in 1949, and then to 5.4 years in 1999. The increase in tertiary education occurs in the second half of the century increasing from an average of just 0.6 years in 1949 to 2.2 years in 1999. Also, the log wage vs. schooling relationship is essentially linear, curving slightly up at the very highest levels of schooling due to an increase in the ability bias.

We focus on the simulation results for the Mincerian returns and levels of specialization, which are presented in Table 4. The rows show the levels of Mincerian returns for 1914, 1949 and 1999, the changes in Mincerian returns between these years, the fraction of these changes explained by the model, and the implied levels of skill-bias/specialization in the economy. The first set of columns give the results for the baseline model with exogenous direct costs of schooling and various alternative calibrations, while the second set show the results for simulations with endogenous direct costs.

Recall that the discount rate was calibrated for the baseline model to match the Mincerian return in the data of 12.4 in 1914. None of the alternative calibrations deviates greatly from this value. Each of the simulations yields an early century decline in the returns to schooling followed by an increase in the second half of the century. I examine the specifics of these predictions more closely:

- **1914-1949 decline in returns:** The simulations explain a substantial fraction of the decline of 6.6 (i.e., 12.4 minus 5.8) percentage points observed in the data from 1914 to 1949. The drop in the baseline simulation with exogenous costs from 12.4 to 9.6 represents 42 percent of this observed decline. The decrease from 12.7 to 9.4 in the baseline simulation with endogenous costs likewise represents 41 percent of the fall in the data. The most favorable calibrations show even larger declines. The A+B+D exogenous cost calibration (i.e., the

Table 3: Calibration of Technology Parameters

Parameter	Calibration Source	Value
Level of specialization, I	Match average years of schooling in simulation	various (see Table 4)
Inverse elasticity of substitution of tasks, μ	Estimates of elasticity of substitution of workers (Kaboski, 2004a)	0.7
Diminishing returns to skill parameter, ϕ	Estimated from cross-country distribution of output per worker (Kaboski, 2004a)	0.76
Distribution of talent, $g(\theta)$	Return to ability quartile in the U.S. and 75/25 interquartile range of years of schooling range (Kaboski, 2004a)	uniform on [0.01, 6.01]

Table 4: Simulation Results

Calibration Source	Year	Actual Data	Exogenous Simulations						Endogenous Simulations			
			Baseline	Alternative Calibrations					Baseline	Alternative Calibrations		
				A	B	D	E	A+B+D		C	D	E
Mincerian Return: Levels	1914	12.4	12.4	13.2	12.4	12.5	11.8	13.3	12.4	12.4	12.6	11.9
	1949	5.8	9.6	9.6	9.6	8.6	9.9	8.6	9.7	9.7	8.7	10.0
	1999	11.3	10.5	10.5	11.3	10.8	10.3	11.5	10.6	9.8	11.1	10.4
Mincerian Return: Changes and Percent of Actual	1914-1949	-6.6	-2.8	-3.6	-2.8	-3.9	-1.9	-4.7	-2.7	-2.7	-3.9	-1.9
			42%	55%	42%	59%	29%	71%	41%	41%	59%	29%
	1949-1999	+5.5	+0.9	+0.9	+1.7	+2.2	+0.4	+2.9	+0.9	+0.9	+2.1	1.6
			16%	16%	31%	40%	7%	53%	16%	16%	38%	29%
Specialization/Skill-Bias Level	1914		1.34	1.38	1.34	1.35	1.11	1.39	1.37	1.37	1.37	1.35
	1949		1.45	1.45	1.45	1.39	1.26	1.39	1.44	1.44	1.37	1.45
	1999		1.59	1.59	1.65	1.60	1.34	1.66	1.61	1.57	1.65	1.60

Explanation of alternative calibrations:

"A" calibrates higher costs to secondary schooling in 1914.

"B" calibrates that higher (one-third) costs to public tertiary students and relatively lower (two-thirds) costs to private tertiary students.

"C" calibrates lower children per women for 1999 by including young women with incomplete fertility.

"D" calibrates falling retirement rates after 1950 and larger changes in youth unemployment.

"E" calibrates smaller changes in youth unemployment.

"A+B+D" calibrates "A" (i.e., higher secondary schooling costs in 1914), "B" (i.e., higher tertiary costs to public students and lower tertiary costs to private students) and "D" (i.e., falling retirement after 1950 and larger changes in youth unemployment) together.

calibration using alternatives A, B and D together) produces a decline from 13.3 to 8.6 (or 71 percent of the observed fall), while the D endogenous cost calibration produces a decline from 12.6 to 8.7 (59 percent). Even calibration E, which is stacked against the theory, produces sizable declines in both the exogenous and endogenous simulations.

- **1949-1999 increase in returns:** The simulations explain a smaller fraction of the observed increase of 5.5 percentage points 1949 to 1999, though the increases are still generally sizable. The baseline increases from 9.6 to 10.5 for the exogenous costs and 9.7 to 10.6 for the endogenous costs, representing 16 percent of the observed increase in both cases. The most favorable calibrations yield increases from 8.6 to 11.5 (exogenous alternatives A+B+D) and 8.7 to 11.1 (endogenous alternative D). These increases amount to 53 and 38 percent, respectively, of the actual increase. The least favorable simulations E (exogenous costs) and C (endogenous costs) produce very small, though positive increases.
- **Trend in skill-bias/specialization:** Recall that skill-bias and specialization are measured by the same parameter, I, which is calibrated to match average levels of education. Each of the simulations shows an increase in skill-bias/specialization over the century. Moreover, the levels of skill-bias and specialization do not decline sharply between 1914 and 1949. Indeed, in most of the simulations these levels increase, albeit at smaller rates than in the 1949-1999 period. This slow yet positive trend is consistent with the data on specialization (recall Figure 1) and other research (e.g., Goldin and Katz, 1998, and Kaboski, 2001) on the direction of skill-bias in the early part of the century. In the exceptions, exogenous calibration A+B+D and endogenous calibration D, the levels of specialization stay constant. Thus, in none of the simulations do we see a dramatic decrease in skill-bias before 1949 or a decrease in specialization after 1949 as argued by Mitchell.[23]

In summary, the baseline model is able to explain about 40 percent of the mid-century decline in the returns to schooling and 16 percent of the post-1949 increase. The reversal in this trend comes from supply factors, i.e., factors affecting the costs of schooling as the demand for schooling increases over time. More favorable calibrations can explain as much as 59-71 percent of the early century fall, and 38-53 percent of the late century rise in the Mincerian returns to schooling.

Furthermore, since I am interested in the long run trend, the use of the 1949 Mincerian

[23] Of course, these are also the two simulations that show the largest drop in Mincerian returns. One could argue that a model that matched the entire drop of 6.6 percentage points might require falling demand for skill. Indeed, the dramatic fall in returns during the 1940s has been interpreted as the result of falling demand for skill (see Goldin and Margo, 1992), but not due to increased specialization.

return as a low point is conservative. That is, the low 1949 is significantly lower than the mid-century average from 1939-1959 (8.1 percent). Using this mid-century average, the early century fall and late century increase would be just 4.3 and 3.2 percent, respectively, and the model would explain a much larger fraction of the total. Goldin and Margo (1992) argue that the exceptionally low Mincerian return in 1949 was the result of a brief deskilling technological change stemming from a restructuring of the labor market caused by the World War II. If their theory is true, requiring technical change to be skill-biased would be an extreme position, but the claim that supply effects play a very important role in the long run trend would still hold.

The fact that the model is less successful in explaining the late century increase in Mincerian returns is also of interest. In order to match this increase, the model would require both an acceleration in demand for schooling (i.e., skill-bias) and an increase in the (direct or indirect) costs of schooling. The evidence on college costs rising faster than the economy grows (potentially calibrated as an increase in $\tilde{\eta}$), together with the burgeoning literature on accelerating skill-bias, might be a plausible explanation.

A. Immigration

The change in immigration laws in the 1920s is an additional factor that may have influenced the mid-century decline. The argument is that the relative supply of low skill/education workers was lowered between 1914 and 1949 by the reduction in immigrants. While it is not easy to formally incorporate this idea into the model, the potential effects can still be considered less formally. In 1949, in the IPUMS data native born Americans constitute the overwhelming majority (96 %) of the male workforce aged 18-34. Furthermore, the difference in average years of education between native born and foreign born is just 0.6 years, so that the difference between average years of education of the full sample vs. the native born only sample is negligible. Hence, incorporating immigration is not likely to affect my results for 1949.

In contrast, however, immigrants constitute nearly one-fifth (18%) of the target population in 1914, and the education gap may have been substantial.[24] To the extent that these immigrants were in the United States during their school age years, they would already be incorporated into my 1914 target for average years of education, which is based on school life expectancy from enrollment flow data. Those who immigrated after school-age would affect the results, but primarily the predictions for the demand for skill with little effect on the Mincerian return results. Essentially, Mincerian

[24] Literacy requirements on immigrants were not introduced until the Immigration Act of 1917.

returns are pinned down by the fact that the wage returns to schooling have to be high enough to induce agents to obtain the target average years of schooling, given the calibrated costs and career length (recall equation (5)). The proper target to pin the Mincerian return down is therefore the average years of schooling of native workers (i.e., those making schooling decisions in the United States. Since this target is the one used, Mincerian returns would not be greatly affected. Of course, less educated immigrants in the workforce *would* imply that the average level of education in the workforce overall was less than that of native workers. By assuming the higher level of education in the workforce overall at the equilibrium Mincerian returns, I impute a higher demand for skill in 1914. Thus, ignoring immigration is likely to understate the increase in the demand for skill that occurred between 1914 and 1949.

6. Conclusion

Changes in the direct and indirect costs of schooling are a quantitatively important in explaining the long run trend in the skill premium over the century. The results are not only of historical interest, but also relevant to the current discussion on the recent acceleration in the returns to schooling. While researchers have focused on demand-side factors (e.g. skill-bias technical change, international trade) as a source of this upward trend, this paper shows that supply factors played important roles. Specifically, baseline calibrations explain over forty percent of the mid-century fall, even though they assume that the demand for skill increased throughout the century.

Still the model was relatively more successful in reproducing the early century fall than the late century increase in the skill premium. This fact opens up areas for further research. As noted, growth in the costs of schooling has been faster than wage growth, so incorporating this into the calibration might allow supply factors to explain a larger fraction of the recent rise in skill premia.

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7. Appendix

This provides a description of data sources and calculations for the Figure 1 and the calibration.

Sources: Data on children per woman, specialization, schooling levels and Mincerian returns for 1949 and 1999, are based on IPUMS U.S. census data (Ruggles et al, 2004). Mincerian returns for 1914 are from the 1915 Iowa census as reported by Goldin and Katz (1999c) adjusted to the national series following the methodology in Goldin and Katz (1999a). Schooling levels for 1914 are also based on Goldin and Katz, as well as school life expectancy data from U.S. Bureau of Education (1905). Life expectancy is based on life tables from the National Vital Statistics Report (Andersen, 1998). Retirement ages are from Gendell and Siegel (1992). Both schooling expenditure and enrollment data are from Snyder et al (2004): Tables 3 (enrollment at each level), 36 (primary and secondary education funding), and 333 (higher education funding). Youth unemployment and overall unemployment from 1948 to 2000 are Bureau of Labor Statistics data, while earlier unemployment as well as GDP estimates are from the NBER historical database.

Unemployment: Overall unemployment rates are calibrated based on averages over long career length periods. The years used are 1890-1930 for 1914, 1925-1965 for 1949 and 1975-2003 for 1999 (no later data is available). For youth unemployment rates prior to 1948, two initial series were imputed using (i) an estimated linear regression on overall unemployment with a constant term, and (ii) a estimated linear regression equation without a constant term. As stated in footnote 13, these regressions had strong fits. The baseline estimates are based on averages of (i) over time. The averages for 1914 are taken from 1895 (when a 34 year old in 1914 would have been 15 years old) to 1910 (when an 18 year old in 1914 would have been 14 years old). Similarly, the relevant years are 1929-1945 for 1949 and 1979-95 for 1999. Two other series were also created: (iii) a high value series equal to 1.1*max[series (i), series (ii)] and (iv) a low values series equal to 0.9*min[series (i), series (ii)]. Alternative A is based on the combination of these series that gave the greatest mid-century increase, while Alternative B is based on the series giving the smallest.

Women per children: This was based on completed fertility of women aged 45 to 54. However, data was only available in the 1900, 1910, 1940, 1950, 1960, 1970, 1980 and 1990 censuses, so data for women age 55-64 and 65-74 in other censuses were used to fill in the missing data. The use of a mother's age range of 38-69 encompasses workers age 18-34 having been born to women aged 20-35 at the time. For 1914, I therefore averaged women aged 45-64 in the 1910 census (49-68 in 1914) and women aged 63-74 in the 1940 census. For 1949, I average women aged 45-68 in the

1950 census and 48-54 in the 1960 census (38-44 in 1949). For 1999, lacking data from the 2000 census and beyond I used women aged 45-58 in the 1990 census (55-68 in 1999). Alternative E additionally includes women with incomplete fertility aged 28-44 from the 1990 census (aged 38-54 in 2000).

Life Expectancy and Potential Career: Life expectancy conditional on reaching age ten was used, assuming that age ten is the first age at which students are on the margin between dropping out of school (again, using age 15 produced nearly identical results). The ideal reference year for 18-34 year olds would be sixteen years prior – the year that the mid-point of the age range (26 year olds) were ten years old. These ideal years would be 1898 for 1914, 1933 for 1949 and 1983 for 1999. Since the data is available about once a decade the following dates were closest: 1900-1902 for 1914; 1929-1931 for 1949; and 1979-1981 for 1999.

Schooling Enrollments and Government Expenditures: The data for both enrollments and government expenditures is also decadal. The table below illustrates the timing decisions based on the time of attendance at each level.

	Decades Used for Expenditure Calibration		Decades Used for Enrollment Calibration		
Year	Primary and Secondary	Tertiary	Primary	Secondary	Tertiary
1914	1890-1910	None*	1890-1900	1890-1910	None**
1949	1930-1950	1940-1950	1930-1950	1930-1950	1940-1950
1999	1980-1990	1990-2000	1980-1990	1980-2000	1990-2000

*The earliest tertiary expenditure data was for 1920 and was less than 1/20th of one percent.

** No data was available, but any enrollment values would produce the result of no tertiary education.

Specialization: I used the IPUMS 1950 detailed 3-digit industry and occupation classification system. Figure 1 presents the log number of non-empty industry-occupation cells. For 1914, the average of the 1910 and 1920 censuses are used. Using only industry cells produced a smaller, though still positive increase from 1914 to 1949.