The Declining Quality of Teachers*

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July 31, 2001

Abstract

Concern is often voiced about the declining quality of American schoolteachers. This paper shows that, while the relative quality of teachers *is* declining, this decline is a result of technical change, which improves the specialized knowledge of skilled workers outside teaching, but not the general knowledge of schoolteachers. This raises the price of skilled teachers, but not their productivity. Schools respond by lowering the relative skill of teachers and raising teacher quantity. Growth in input prices hurts the productivity of primary schools and raises the unit cost of primary education. These predictions appear consistent with the data. Analysis of US Census microdata suggests that, from the 1900 birth cohort to the 1950 birth cohort, the relative schooling of teachers has declined by about three years, and the human capital of teachers may have declined in value relative to that of college graduates by as much as thirty percent, but the teacher-student ratio has more than doubled over the last half century in a wide array of developed countries. Moreover, the per student cost of primary school education in the US has also risen dramatically over the past 50 years.

*For their comments and suggestions, I especially wish to thank Gary S. Becker, Kevin M. Murphy, Tomas J. Philipson, and Sherwin Rosen. I am also grateful to Ashish Arora, Jay Bhattacharya, Edward Morrison, Curtis Simon, Bill Vogt, and George Zanjani, as well as seminar participants at Carnegie-Mellon University, Chicago, and Clemson University, for helpful comments and suggestions.

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1 Introduction

In today's knowledge-intensive economies, the school, not the factory, may be the most important site of capital accumulation. Since World War II, US investment in human capital has consistently accounted for over 80% of total annual investment.[1] Moreover, spending on *formal* schooling constitutes an increasingly large share of human capital investment. In 1948, formal schooling accounted for roughly 40 percent of human capital investment. Less than 40 years later, it accounted for 63 percent.[2] Overall, therefore, spending on formal schooling accounts for about half of *total* annual investment, and its importance may still be on the rise.

It seems undeniable that investments in schooling play a major role in economic growth. To this indisputable fact, however, Figure 1 appears to pose a challenge. This figure depicts the log change in the relative wages of primary school teachers for several advanced countries, from 1965 to 1994,[3] where teacher wage growth is deflated by growth in the wage of the average employee.[4] Figure 1 demonstrates that the relative wages of primary school teachers have plummeted in many advanced economies over the last half of the twentieth-century. In fact, only one country in this sample, Japan, shows evidence of *any* increase in this relative wage series.[5] Various researchers report results consistent with Figure 1. Bee and Dolton (1995) find that, after a brief upward swing during the post-World War II baby boom years,

[1]See Jorgenson and Fraumeni (1995a).

[2]See Jorgenson and Fraumeni (1995b).

[3]The log change in the teacher wage is constructed as log 1994 educational expenditures per teacher minus log 1965 educational expenditures per teacher. [OECD (1981, 1989, 1990, 1993), UNESCO (1976, 1989, 1993)] This estimate assumes that the proportion of expenditures on teacher salaries is constant. Where data on this proportion are available, this assumption seems to hold.

[4]Wage growth of the average employee is calculated using total employee compensation, from national accounts data, and dividing this by the number of employees. National accounts data are taken from OECD (1983, 1996), while labor force data are taken from OECD (1986, 1997).

[5]All of the Japanese increase took place from 1965 to 1975. It seems likely that this was driven by the entrance of large baby boom cohorts into Japanese primary schools, because Japanese fertility peaked during the mid- to late '60s. (Japanese population data are taken from OECD [1998].)

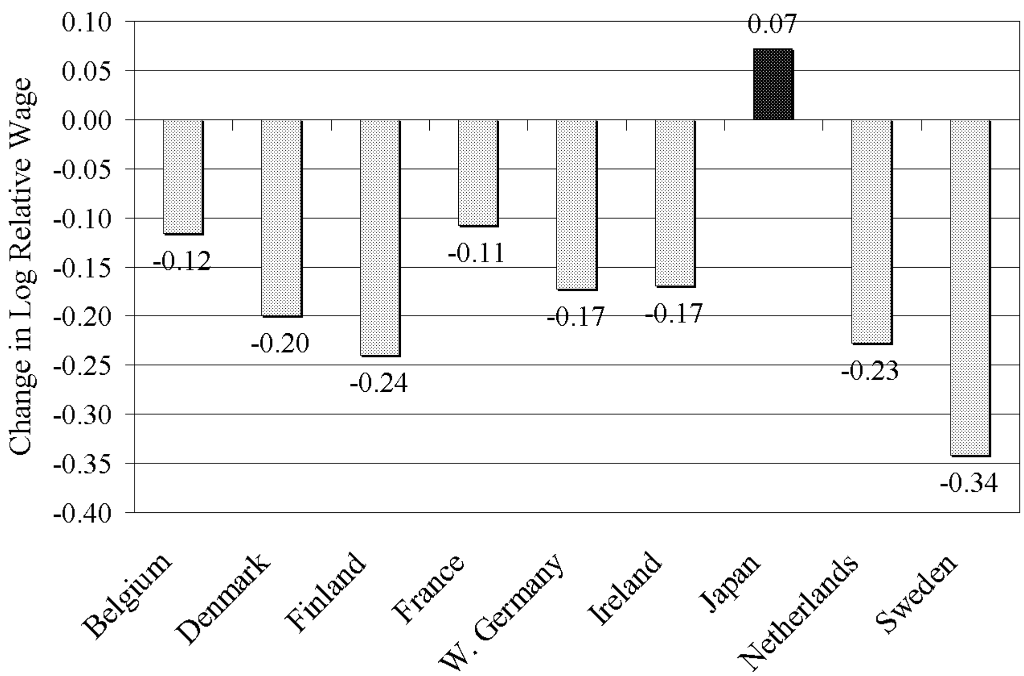

Figure 1: Change in log relative wage of primary school teachers in developed countries. 1965-1994.

the relative wages of British school teachers have fallen twenty percent since 1965. Across the Atlantic, Hanushek and Rivkin (1997) find that since 1940 the wages of US schoolteachers have declined relative to college graduates by ten to twenty percent. Correspondingly, US schoolteachers have skidded nearly twenty percentage points down the earnings distribution for all workers, and almost fifteen percentage points down the earnings distribution for college graduates.[6]

Perhaps most telling of all has been the dramatic decline in the relative quality of teacher training. In the late nineteenth century US, a degree from a teachers' college was so highly prized that non-teachers would often attempt to gain entrance under the pretext of an interest in teaching. This behavior was so pervasive that state-run teachers' colleges would actually require entering students to precommit to teaching careers (McNeil, 1930). Over the next century, however, the relative quality of teacher education declined precipitously. By 1970, teachers ranked near the bottom of their college classes in both achievement and intelligence tests (Manski, 1985). Surprisingly, this deterioration has occurred while the demand for education and educational attainment have been rising rapidly in the advanced economies.[7] Moreover, educational systems have been utilizing an increasing quantity of teachers. Table 1 demonstrates that the average class size in primary and secondary school has been falling steadily over the same period of time.[8] In other words, the relative wages of schoolteachers in advanced economies have fallen just as dramatically as the demand for schooling has risen, and as more teachers have been hired.

This puzzling set of facts raises three important questions. First, what forces can drive down relative teacher quality in the presence of a rising teacher-student ratio and growing

[6]Other researchers who have reported declines in teacher quality include: Weaver (1983), Kershaw and McKean (1962), along with Thorndike and Hagen (1960).

[7]It is interesting and significant to note that relative teacher quality in developing countries exhibits no clear patterns (Schultz, 1987).

[8]Table 1 is found at the end of the paper.

demand for schooling? Second, is this apparent decline empirically robust? Third, does this decline put at risk the future of today's students, or the quality of their schooling? This paper attempts to answer these questions. First, it proposes an explanation for how economic development results in both declining relative wages for schoolteachers and a rising teacher-student ratio. Second, using United States Census data, it examines the change in the relative schooling of teachers, and estimates the change in the relative value of teachers' human capital. The empirical investigation of relative teacher quality helps test the implications of the proposed model. It is of additional interest in its own right, since there has not so far been a systematic economic analysis of changes in teacher quality.[9] Finally, the theoretical and empirical results are used in order to assess the outlook for today's students.

This paper argues that the trends in Figure 1 and Table 1 are caused by skill-biased technical change outside education. The knowledge used by skilled workers outside teaching, such as doctors or engineers, is constantly growing and improving as a result of innovation. This raises the productivity of skilled non-teachers. The productivity of skilled teachers, on the other hand, remains constant, because the general knowledge used by schoolteachers, such as reading or arithmetic, remains largely unchanged.[10] Nonetheless, the price of skill rises, because the demand for skilled workers *outside* teaching rises. This makes skilled teachers more expensive, but no more productive. Since the price of teacher skill rises relative to the price of teacher quantity, schools respond by lowering the skill of teachers and raising the *quantity* of teachers employed. This prediction is consistent with the observed declines in the relative wages of teachers and increases in the teacher-student ratio. It is important to note that we are focusing here on grade school teachers, not college professors,

[9]There have, however, been investigations of teachers' relative wages. See, for example, Hanushek and Rivkin (1997). The work presented here will attempt to disentangle changes in relative quality from other changes that affect the relative wage.

[10]A related idea is presented by Baumol (1967), who argues that productivity growth tends to be lower in the education sector.

who teach specialized knowledge that may well evolve over time with technological progress.

This theory also helps to explain a puzzling feature of US educational data in the postwar period. Since teaching seems to be skill-intensive, the increase in the relative price of skill raises the overall cost of primary education.[11] This helps explain the consistent, but puzzling declines in the productivity of the education sector. US educational output, measured by student achievement, has been relatively stagnant, even though real costs per student have nearly doubled over the past 30 years.[12] Given the lack of growth in achievement, cost growth is likely to reflect real growth in unit costs, rather than growth in educational quality.

To test the predicted changes in relative teacher quality, US Census Data are used to estimate the change in the relative quality of schoolteachers, from the 1900 birth cohort to the 1950 birth cohort. Over this time period, schoolteachers appear to have lost more than four years of schooling relative to the average American worker. They have fared no better relative to skilled workers: among males, the value of college-educated workers' human capital seems to have risen by 15 or 20 percentage points more than the value of teachers' human capital; among females, it may have risen by 25 or 30 percentage points more. We obtain these estimates of the change in relative quality by exploiting some unique features of teachers' age-income profiles. The declining relative quality of teachers appears robust to several different methods of estimation, and no evidence seems to support the alternative hypothesis of rising relative quality for schoolteachers. The empirical investigation reveals that these declines have occurred for both male and female teachers, and for teachers in both public and private schools. This helps refute two alternative explanations for declining teacher quality: the expansion of demand for skilled women outside teaching, which would

[11] Tamura (1999), for example, finds that teacher quality is a more important input into educational production than class size.

[12] See Betts (1996) for the data on student achievement. See Hanushek and Rivkin (1997) for the data on educational costs.

imply falling quality for female teachers, but *not* for male teachers; and the slashing of public budgets, which would imply that quality should decline more rapidly for public school teachers than private school teachers.

The paper will proceed as follows. Section 2 lays out the model of teacher quantity and quality. It develops a two-sector growth model, with an educational sector and a goods sector. The model predicts declining relative teacher quality, rising teacher quantity, and rising primary school costs. Section 3 then uses US Census data to estimate the change in the relative quality of US schoolteachers. As predicted, schoolteacher quality appears to have declined, relative to both college-educated workers and college professors. In conclusion, section 4 assesses the impact of declining teacher quality on today's students.

2 A Theory of Educational Resources

The knowledge transmitted by schoolteachers changes little over time. However, the specialized fields of knowledge possessed by other skilled workers grow and improve. This is the key idea behind the model presented in this section. For example, in just under 50 years, new discoveries in genetics, ecology, and molecular biology have given new, more useful knowledge to doctors, environmental scientists, and chemists. On the other hand, the reading, writing, and arithmetic taught in primary school have changed little.

Throughout this analysis, education is treated as if it were efficiently provided. There are two reasons for this. First, if a standard model of efficiency can explain many important trends in the data, efficient forces are likely the dominant ones. It is almost certainly true that the educational system is influenced by standard market forces and non-standard forces, but it is also possible that the standard market forces drive trends in quality and quantity. In other words, productive motives may influence schools' quality-quantity choices more strongly than nonpecuniary ones. Second, based on previous research, it seems plausible to assume that efficiency plays at least some role in education production. Since education is often publicly provided, political forces undoubtedly move it away from efficient outcomes. The same may occur as the result of powerful teachers' unions, whose members may not always have an interest in efficiency.[13] On the other hand, however, the pioneering work by Tiebout (1956) argues that competition between local governments favors the efficient provision of public goods such as education.[14] Hoxby (2000) finds evidence that such competition is empirically significant. Becker (1983) makes a similar argument for efficiency at the level of a legislature, where competition between interest groups, such as parents and taxpayers, should favor the efficient delivery of education. Finally, Hoxby (1994) finds empirical evidence that competitive pressure from private schools helps promote efficiency in public schools.

Suppose that all education involves the transmission of general knowledge by schoolteachers; in other words, abstract from specialized, advanced stages of education.[15] This simplification allows us to focus on the relationship between technological change and teachers of general knowledge. Our hypothetical economy has two sectors, one devoted to goods production, and another devoted to education. Technological change improves the productivity of skilled workers in the goods sector, but not in the education sector. In other words, the goods sector experiences skill-biased technological change, while the education sector experiences none.

Suppose that people in this economy live for two periods, childhood and adulthood, and

[13]For analyses of unionization in education, see Hanushek and Rivkin (1997) or Hoxby (1996). An alternative explanation of inefficiency is given by de Bartolome (1990), who has argued that peer group effects among students create an externality and result in an inefficient allocation of educational resources.

[14]Epple and Zelenitz (1981), however, present an important qualification to Tiebout's work. They argue that since land is immobile, local governments will always be able to extract some rents from their citizens.

[15]Elsewhere, we have analyzed the more complicated case of a two-stage educational system, with primary schools and colleges.

may choose to be either skilled or unskilled workers. During childhood, a person may choose to attend school and acquire human capital $\bar{H}$, or she may choose to enter the labor force as an unskilled worker. Skilled workers, with human capital $\bar{H}$, are more productive than unskilled workers, but since it is costly to attend school, they are also more expensive. All skilled workers receive the wage w_s, while all unskilled workers receive w_u. Individuals choose the skill level which maximizes their lifetime income. The cost of acquiring skill is assumed to vary across people, who have different abilities. As a result, some people will strictly prefer skilled work, and some will strictly prefer unskilled work.

2.1 Education Production

In order to become a skilled worker, a person must accumulate $\bar{H}$ units of human capital in school. For simplicity, we assume that $\bar{H}$ remains fixed over time. Empirically, this seems a reasonable assumption. From 1960 to 1990, the achievement scores of US high school seniors stayed roughly level. Even though achievement declined during the '60s, a rebound during the '80s helped return it to its 1960 level.[16] To produce human capital, schools employ skilled teachers and unskilled teachers. Their output of human capital per student depends on the number of skilled teachers per student, T_s, and the number of unskilled teachers per student, T_u. The output of human capital per student can be written as $E(T_s, T_u)$, where E is increasing and concave in its two inputs.[17] In addition, E is such that skilled teachers are

[16]The evidence on achievement scores is presented in Bishop (1989). Note that if student achievement actually falls substantially over time, it is possible that the teacher-student ratio will fall along with the relative skill of teachers. However, the relative quality of teachers will continue to decline.

[17]There exists much controversy over whether teacher quantity or quality matter at all in educational outcomes. (See, for example, Card and Krueger [1992], Mosteller [1995] and Hanushek [1996] for contrasting views.) However, teaching inputs obviously matter at *some* level: no one could teach a class filled with one thousand 10 year-olds, and no graduate of the sixth grade could teach high school. The dispute in the empirical literature concerns the impact of input variation *within the observed range of input usage*. Therefore, it seems reasonable to assume that these inputs are productive over some, possibly unobserved, range.

more productive than unskilled teachers, in two senses. First, an additional skilled teacher always produces more than an additional unskilled teacher, so that $E_s > E_u$. Second, a one percent increase in the number of skilled teachers is more productive than a one percent increase in unskilled teachers: $\frac{E_s T_s}{E} > \frac{E_u T_u}{E}$.[18] Tamura (1999) provides some evidence for the latter assumption; he finds that educational output is more elastic to teacher quality than to class size.

While it may not be literally true that some teachers are unskilled, this assumption conveniently captures the trade-off between teacher quantity and quality. We are modeling average teacher quality quite simply, as a mix between high and low skill levels. The relative quantities of skilled and unskilled teachers could thus be interpreted as measuring the average quality of a homogeneous set of teachers, and probably should not be interpreted as a literal mix of skilled and unskilled teachers. By the same token, it may not be literally true that a school district actually differentiates, in salary schedules or hiring practices, between skilled and less skilled teachers. The model does not require this, provided we focus on its predictions for average quality, and not its specific predictions for the high and low skill "groups."

Faced with equilibrium wages w_s and w_u, the education sector chooses teaching inputs in order to minimize the cost of producing human capital:

$$c(\bar{H}; w_s, w_u) = \min_{T_s, T_u} w_s T_s + w_u T_u \quad (1)$$

$$s.t.\ \bar{H} = E(T_s, T_u) \quad (2)$$

[18]In the classical two-sector growth model, if the capital-producing sector is capital-intensive, this results in instability. (Jones 1965, Uzawa 1961) This instability will not pose a problem here, however, because workers are assumed to differ in their ability. This makes it increasingly costly to hire skilled workers, and it means that human capital growth cannot diverge from overall growth.

The first order condition for this problem can be written as:

$$\frac{w_s}{w_u} = \frac{E_s}{E_u} \tag{3}$$

Comparative statics reveals that an increase in $\frac{w_s}{w_u}$ leads to substitution towards unskilled teachers. However, since unskilled teachers are less productive, each skilled teacher must be replaced by more than one unskilled teacher in order to hold output at $\bar{H}$. Therefore, an increase in $\frac{w_s}{w_u}$ lowers T_s, but raises T_u by more. A rise in the relative price of skill will raise the overall teacher-student ratio. In sum, an increase in the price of skill leads to substitution toward teacher quantity and away from teacher quality.

We can make three important predictions from this cost-minimization analysis. As stated above, the overall teacher-student ratio, $T_s + T_u$, must rise with the price of skill; since a price increase will lower the number of skilled teachers hired, the education system must compensate by hiring more teachers overall.[19] Second, the average skill of teachers, $\frac{T_s \bar{H}}{T_s + T_u}$, will fall when skill becomes more expensive: T_s falls with the price of skill, while $T_s + T_u$ rises. Third, since education is skill-intensive, a relative increase in the price of skill will make education more costly to produce. Specifically, if w_s rises by $y\%$ and w_u falls by $x \leq y$ percent, $c(\bar{H}; w_s, w_u)$ will rise. This result depends only on the skill-intensity assumption that $\frac{E_s T_s}{E} > \frac{E_u T_u}{E}$. To see this, observe that Shephard's lemma and the first-order conditions for cost-minimization allow us to write:

$$\frac{\frac{\partial c}{\partial w_s} \frac{w_s}{c}}{\frac{\partial c}{\partial w_u} \frac{w_u}{c}} = \frac{T_s w_s}{T_u w_u} = \frac{\frac{E_s}{E} T_s}{\frac{E_u}{E} T_u}.$$

[19] If one allows the level of human capital $\bar{H}$ to vary, another possibility is that less human capital is produced. In this case, the teacher-student ratio might fall. This is theoretically possible, but it is hard to find evidence of large declines in absolute student achievement.

Since $\frac{E_s T_s}{E} > \frac{E_u T_u}{E}$, it follows that $\frac{\partial c}{\partial w_s}\frac{w_s}{c} > \frac{\partial c}{\partial w_u}\frac{w_u}{c}$, or that costs are more elastic to increases in w_s than to increases in w_u. In other words, the cost function will rise overall if w_s rises by a greater percentage than w_u falls.

If the education sector faces an increasing price of skill, it follows that the relative teacher quality falls, quantity rises, and that the unit cost of education rises as well. The price of skill will grow if the goods sector experiences skill-biased technological change, *and* if workers differ in their ability to acquire skill. The latter assumption gives an upward slope to the supply of skill. Intuitively, skill-biased technological change in the goods sector makes skilled workers more attractive. Skilled workers flow out of teaching and into the goods sector. The educational sector is then left with less able people, who face a higher price of becoming skilled. This leads to reductions in relative teacher quality, growth in teacher quantity, and growth in educational costs. The formal derivation of these results follows next.

2.2 The Goods Sector

Suppose that the goods sector hires skilled and unskilled workers, N_s and N_u, respectively, who face the wages w_s and w_u. Growth in technology is presumed to raise the productivity of skilled workers in this sector, and to expand the set of production possibilities. This assumption seems consistent with micro-level evidence. Bartel and Lichtenberg (1987) find that, in manufacturing industries, skilled workers have a comparative advantage in implementing new technologies. Innovation should thus raise the comparative advantage of skill.

The goods sector has access to a constant returns production technology of the form $F(N_s, N_u; q)$, where $\frac{F_s}{F_u}$ rises in q, and $F_q > 0$. If it maximizes its profits, this sector solves the problem.

$$\max_{N_s, N_u} F(N_s, N_u; q) - w_s N_s - w_u N_u$$

with the first order conditions,

$$w_s = F_s \tag{4}$$

$$w_u = F_u \tag{5}$$

Combining these conditions identifies the input ratio as a function of technology and relative prices:

$$\frac{w_s}{w_u} = \frac{F_s}{F_u} \tag{6}$$

Equation 6 implies that the relative demand for skilled workers falls with the price of skill, but rises with technological change.[20]

2.3 The Labor Market

We can fully characterize a steady-state equilibrium in this model by describing the labor market.[21] There are five quantities to identify in the model, but so far only three equilibrium conditions: the first order conditions in equations 3 and 6, and the educational output requirement in equation 2. Equilibrium in the labor market yields the remaining two conditions.

First, the labor market must clear. Define λ as the number of students in a cohort of children, so that the total number of skilled teachers is $T_s\lambda$. The total number of skilled workers can be written as $S = N_s + T_s\lambda$, the number of skilled goods workers plus the number of skilled teachers. Since $S = \lambda$ in a steady-state, it follows that $S = \lambda = \frac{N_s}{1-T_s}$. The total number of workers available, on the other hand, is equal to the number of adults

[20]These results follow, because $\frac{F_s}{F_u}$ increases in q but decreases in $\frac{N_s}{N_u}$.

[21]To solve for general equilibrium in this two-sector model we must abstract from dynamics by considering a steady-state. The dynamics of teacher quality and pay are considered by Ballou and Podgursky (1997), who analyze the time it takes for teacher quality to respond to changes in pay.

(which equals one) plus the number of working children (which equals $1 - \lambda = 1 - \frac{N_s}{1-T_s}$). This implies the labor market-clearing condition,

$$N_u + T_u \frac{N_s}{1 - T_s} + \frac{N_s}{1 - T_s} = 1 + (1 - \frac{N_s}{1 - T_s}).$$

which simplifies to

$$N_u + [T_u + 2] \frac{N_s}{1 - T_s} = 2 \qquad (7)$$

Second, in equilibrium, the marginal individual must be paid equally in skilled and unskilled work. Suppose ability is indexed over $[0, 1]$, where the individual $i = 0$ is the most able member of her generation, and $i = 1$ is the least able. The time cost of schooling goes down with ability. Specifically, if individual i chooses to become skilled, she must spend $1 - \rho(i)$ of her adulthood on her schooling, where ρ is some decreasing function of i.[22] Therefore, an individual who chooses to become skilled has the lifetime earnings $w_s \rho(i) - c(\bar{H}; w_s, w_u)$, where she has to pay back the cost of her own schooling.[23] An individual who chooses to remain unskilled has the lifetime earnings $2w_u$. People choose the skill level that maximizes their lifetime earnings.[24]

The marginal skilled worker will be individual $i = S$, or $i = \frac{N_s}{1-T_s}$, and the steady-state indifference condition can be written as:

$$w_s \rho(\frac{N_s}{1 - T_s}) - c(\bar{H}; w_s, w_u) = 2w_u \qquad (8)$$

[22]Note that the agent must spend her own time on school during her adulthood, without the help of any teachers. This assumption is made for tractability.

[23]For simplicity, the value of lifetime earnings is taken to be the total undiscounted value. This would be true under the simplifying assumptions that agents consume only when they are adults and can store income costlessly from one period to the next.

[24]In this steady-state analysis, individuals are assumed to have perfect foresight about future demand conditions. Zarkin (1985) considers the decision to become a teacher in the context of uncertainty, where people have rational expectations about future demand conditions.

Dividing by w_s transforms equation 8 into:

$$\rho(\frac{N_s}{1-T_s}) = \frac{c(\bar{H}; w_s, w_u)}{w_s} + 2\frac{w_u}{w_s} \tag{9}$$

We now have five equations–the first order conditions in 3 and 6, the educational output constraint in 2, the labor market-clearing condition in 7, and the labor market indifference condition in 9–that identify the four worker quantities along with relative prices. Using these five conditions, we can identify the response of relative prices to technological change.

Suppose the economy experiences skill-biased technological change. If prices fail to respond, T_s and T_u remain constant (according to equations 2 and 3), while $\frac{N_s}{N_u}$ rises, according to equation 6. However, without a price response, N_s remains constant as well, according to equation 9. This results in a shortfall of unskilled workers and a labor market that fails to clear. Therefore, the relative price of skilled workers must rise.[25] The rising relative price of skill lowers T_s and raises T_u by more, as we saw earlier. However, it will not offset the growth in $\frac{N_s}{N_u}$ caused by skill-biased technological change, because the price effect is second-order. The quantity of teachers $T_s + T_u$ rises, and the relative quality of teachers falls, both compared to the average goods worker and the average skilled goods worker.[26]

These implications are consistent with the declining relative wages of teachers in developed countries, depicted in Figure 1, and with the rising teacher-student ratios depicted in Table 1. They are also consistent with the estimates of section 3, which imply that the quality of US teachers has declined relative to other skilled workers. The final prediction, of

[25]The prediction of a rising relative price of skill is consistent with the findings of Juhn, Murphy, and Pierce (1993), who argue that the price of skill has risen consistently in the US, from around 1960 onwards.

[26]The average quality of teachers is $\frac{T_s \bar{H}}{T_s+T_u}$, and the relative quality of teachers simplifies to $\frac{1+\frac{N_u}{N_s}}{1+\frac{T_u}{T_s}}$. Compared to the average skilled goods worker, the relative quality of teachers is $\frac{1}{1+\frac{T_u}{T_s}}$, which also falls with skill-biased technological change.

rising educational costs, also appears consistent with the facts. In the US, real per student expenditures have risen consistently,[27] while scores on standardized achievement tests have either remained constant or fallen slightly over the past thirty years.[28] It has apparently become more costly to achieve the same level of educational output. Moreover, these trends seem to have more to do with formal schooling rather than with parental inputs which precede the start of schooling. Bishop (1989) reports that IQ scores for young children entering school have remained level or risen slightly, in spite of test score declines at later ages. Therefore, it seems that parental inputs into early childhood education, at the very least, have not declined significantly. As predicted, the *formal* schooling of children must have grown more costly over time.

3 An Empirical Analysis of Teacher Quality

So far, this paper has offered several key predictions about the market for teachers. First, it has predicted that the teacher-student ratio should rise. This prediction is consistent with the observations reported in Table 1. It has also predicted that, across successive educational cohorts of workers, the human capital and wages of schoolteachers will decline relative to the average worker and the average skilled worker. The empirical analysis offered in this section aims to test these predictions. Since there is no definitive way to measure human capital, several approaches are taken; all reveal declining relative quality for teachers. We will show that the schooling of teachers has declined relative to the schooling of other workers, and other skilled workers. Later, a regression framework is used to measure the

[27]Hanushek and Rivkin (1997) report that real spending per student has risen nearly tenfold from 1940 to 1990.

[28]See, for example, Betts (1996), who argues that Scholastic Aptitude Test (SAT) scores among college-bound 18 year-olds have fallen, even during periods in which the proportion of 18 year-olds taking the test has fallen. This suggests that selection bias is not to blame.

value of the relative human capital decline for teachers. The results appear quite consistent with the theory presented here, and do not support alternative explanations of the facts. As in the theoretical section, teacher "quality" will be viewed as synonymous with "human capital." It is possible to adopt alternative views of "quality"–such as effectiveness in the classroom–but from the point of view of understanding relative wage decline, the human capital interpretation is most useful. Broadly speaking, we assume that trends in relative human capital influence trends in relative schooling or trends in relative pay.

3.1 The Relative Schooling of Teachers

The central finding of this section is that the schooling of US teachers has been declining relative to other groups of workers. Consider Figure 2, which illustrates this point most simply. The figure depicts, for different birth cohorts of US teachers, the additional years of schooling possessed by a male or female schoolteacher, compared to the average male or female worker. For every birth cohort, schooling attainment is computed as an average over the years in which the cohort was between age 30 and 60.[29] Using narrower age intervals yielded similar results. Over the twentieth-century, there has been a steady and fairly rapid decline in the additional schooling possessed by schoolteachers. Teachers born at the beginning of the century received roughly six or seven more years of schooling than their non-teaching counterparts, but those born in the middle of the century received only two or three more. Significantly, this downward trend has been quite similar for male and female teachers. This suggests that the demand for skill outside teaching has been growing for *both*

[29] Data are from the US Census (Ruggles and Sobek, 1997). Five-year birth cohorts are defined, and cohort-specific educational averages are computed for schoolteachers, and for all workers in the labor force. A cohort's average schooling is constructed by taking the yearly educational averages for the years in which all members of the cohort are between the ages of 30 and 60, and then computing the unconditional average over these years.

males and females. In other words, the expansion in demand for skilled women outside teaching is not in itself enough to explain the observed declines in quality. There appears to have been an overall increase in the demand for skilled workers of any gender, as hypothesized in this paper.[30] In addition, this trend in relative schooling is similar for public and private schoolteachers. Figure 3 demonstrates that, from the 1900 to 1950 birth cohorts, female private schoolteachers lost about 3 years of relative schooling, which is exactly the amount of schooling lost by female teachers as a whole.[31] This supports the claim that the decline in quality stems from technological forces which affect the entire education sector. Since these declines are not confined to public education, it is harder to argue that they result entirely from idiosyncratic public policy decisions. It is also relevant to note here that teachers have lost considerable ground to other public employees. Male teachers, for example, have lost approximately four years of schooling to other male public employees.[32]

The similarity of public and private school teachers is also quite consistent with similarities between public and private school outcomes. For most American students, private Catholic schools do not seem to improve educational achievement (Noell, 1982).[33] Indeed, only urban minority students seem to benefit significantly from a private Catholic school education (Neal, 1997).[34] Presumably, if the vast majority of public schools were hiring teachers of sub-optimal quality, and producing a sub-optimal level of educational output,

[30]Later, however, we will find evidence that the demand for skill outside teaching has grown more for women than for men. Nonetheless, this force alone cannot explain the declining relative quality for both male and female teachers.

[31]The figure for male teachers, available from the author, shows a qualitatively similar pattern

[32]This figure is available upon request from the author.

[33]Contrary findings are reported by Coleman, Hoffer, and Kilgore (1982), who argue that private schools do raise student achievement. However, Goldberger and Cain (1982, 1983) point out that their study is of little value, because it overlooks issues of selection bias and nonrandom sampling.

[34]"Minority" here means black or Hispanic. Overall, black and Hispanic students accounted for about one-quarter of the school-age population, throughout the period beginning in 1970 and ending in 1993. Urban minorities will thus account for less than this. (Data are taken from the National Center for Education Statistics Web Site, http://nces.ed.gov/pubs/ce/c9540a01.html.)

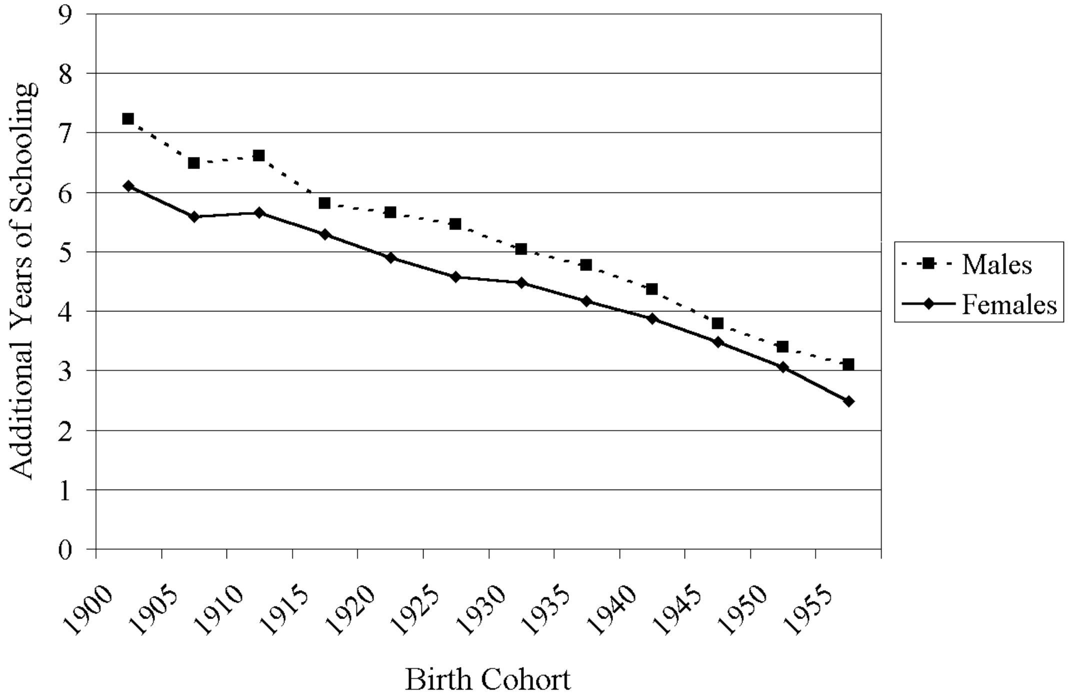

Figure 2: Schooling premium of US school teachers, compared to the average worker, by birth cohort and sex.

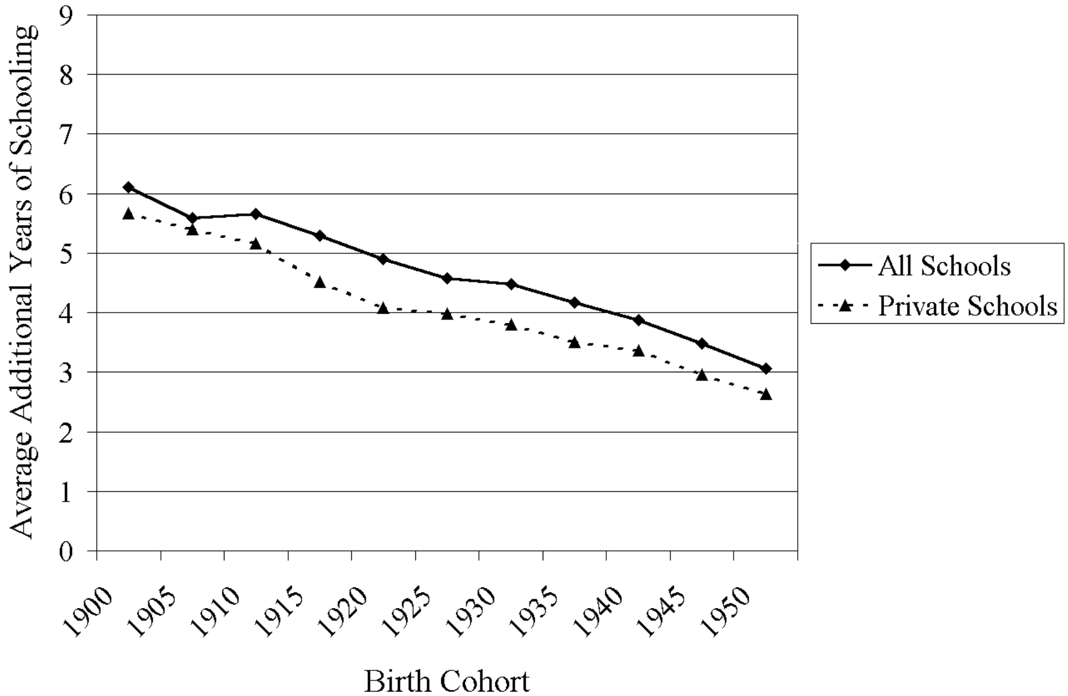

Figure 3: Schooling premium of US female teachers, compared to the average female worker, in all schools and in private schools.

private schools could attract students by producing higher quality education. If this were the case, private school education would benefit a wide cross-section of students, not just urban minorities. It is also significant to note that, while the share of black and Hispanic students enrolled in private schools has risen, the overall share of students enrolled in private schools has remained fairly stable, at around 11%, from 1970 to 1996.[35] The stable enrollment share is consistent with the claim that the quality of public schools has not declined substantially relative to the quality of private schools.

While Figures 2 and 3 usefully characterize the major trends in teacher schooling, they raise a few specific questions which must be investigated. First, over the last century, there has been a considerable shift in employment out of less skilled occupations and into more skilled occupations. Therefore, even if schooling remained constant within every occupation, the schooling of any given occupation would appear to have declined relative to the average worker.[36] To control for this force, we calculate the within-occupation schooling change. This is accomplished by first calculating the average change in schooling for each occupation, in each birth cohort.[37] The average change for each occupation is then weighted by the occupation's share of employment in the 1900 birth cohort.[38] Figure 4 illustrates the change in the schooling of male teachers, as well as the within-occupation change in the average male worker's schooling; the corresponding figure for female teachers and workers is quite similar. The schooling of teachers rises by about one year, while the schooling of the average worker rises within occupation by about three years. Teachers lose about two years of relative

[35]Data are from National Center for Education Statistics Web site, at http://nces.ed.gov/pubs/ce/c9744a01.html.

[36]See Murphy and Welch (1993) for a discussion of the shift in employment composition.

[37]Average schooling is constructed by taking the yearly educational averages for the years in which all members of the cohort are between the ages of 30 and 60, and then computing the unconditional average over these years.

[38]An occupation's share of employment is given by the number of workers in the occupation as a share of the total labor force. Different weighting schemes, such as that based on the occupation's share of total wages, or share of hours worked, produced roughly similar results.

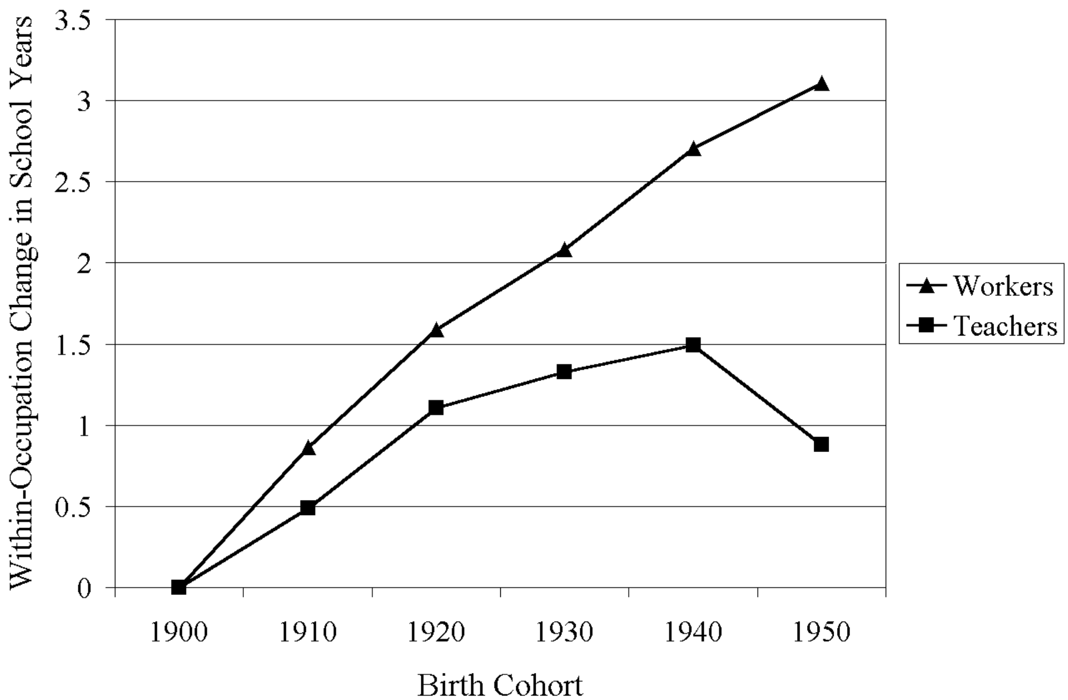

Figure 4: Within-occupation changes in schooling for male teachers and for male workers, by birth cohort.

schooling, when the composition of employment is held fixed, and about about three and a half years of schooling overall. Therefore, more than half of the decline in schooling results from within-occupation changes in schooling and is unrelated to changes in the composition of employment.

To test the model further, we should investigate whether or not teachers are losing ground relative to similarly skilled workers, as predicted. This distinction may be empirically important, since the opportunity cost of an additional year of education is much larger for highly skilled workers like teachers. Therefore, small increases in the schooling of teachers may be just as valuable as larger increases in the schooling of the average worker. To control for this, male teachers will be compared to a group of male workers which was similarly educated in the 1900 birth cohort.[39] Workers in the top educational decile appear to be an appropriate comparison group, because the average schooling for this group of workers in the 1900 birth cohort is almost identical to the average for male schoolteachers.[40] However, Figure 5 demonstrates that the schooling of workers in the top decile subsequently grew much more quickly than the schooling of teachers. In the 1900 birth cohort, the groups were virtually indistinguishable, but by the 1950 birth cohort, the top decile had roughly one and a half additional years of schooling. Therefore, teachers seem to have lost considerable ground to similarly skilled workers.[41] Teachers used to be among the most skilled workers in the economy, but that is no longer the case.

Finally, one might ask if teachers are receiving more value for each year of schooling than non-teachers. In this case, relative schooling may decline, even if the relative human

[39]A similar comparison cannot be made for female teachers, because virtually all skilled female workers were teachers for at least the first three birth cohorts.

[40]A worker is defined to be in the top decile if he is in the top ten percent of his cohort for any year during which he is between the ages of 30 and 60.

[41]Topcoding in the Census is probably not responsible for this relative decline. If we examine the proportion of teachers and top decile workers with at least 5 years of college, the figure looks qualitatively similar, but even more dramatic. This figure is available upon request from the author.

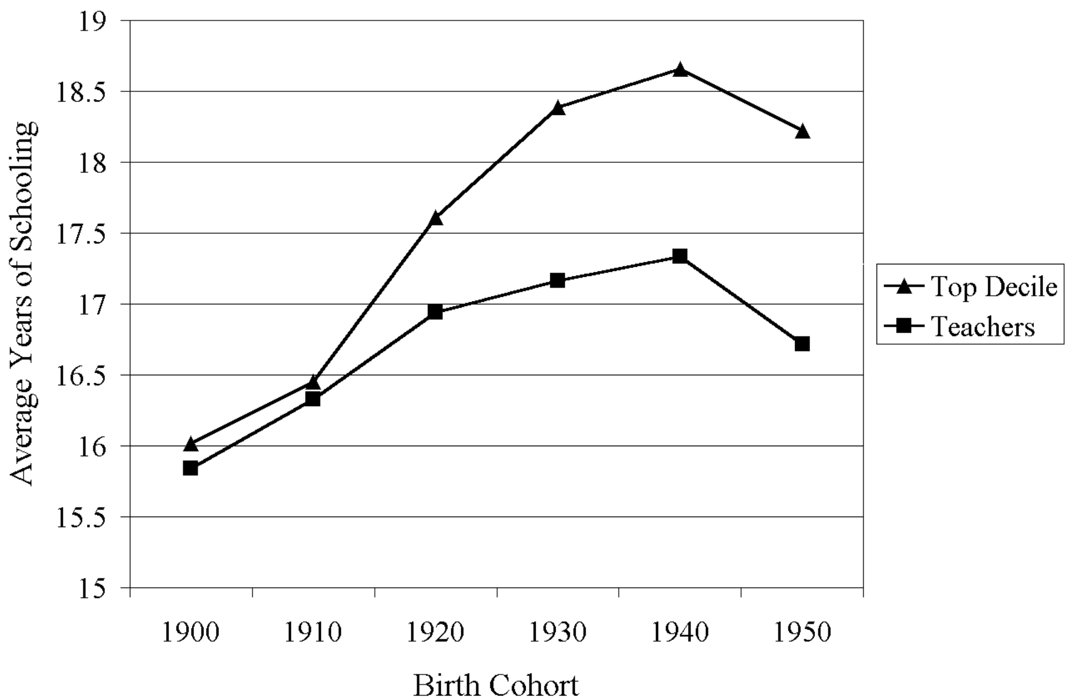

Figure 5: Average schooling of male teachers, and average schooling of male workers in the top decile of the educational distribution, by birth cohort.

capital of teachers does not. However, the relative wages of teachers would not decline in this case. To examine this hypothesis, we can measure the position of the average teacher in the earnings distribution. Figure 6 displays the results of this exercise. The figure shows that female teachers have fallen roughly 15 percentage points down the annual earnings distribution, while male teachers have fallen nearly 20 percentage points.[42] This suggests that the changes in relative schooling indeed reflect changes in the value of teachers' skill. The following section examines this issue in much greater detail.

3.2 Measuring Changes in Teacher Human Capital

Using wage and demographic data from the US Census, the change in the relative value of teachers' human capital, compared to the human capital of college graduates, can be estimated more precisely. These estimates can be used to test the prediction that the relative quality of teachers declines across successive cohorts of workers.

3.2.1 A Regression Model

The goal of this section is to infer from relative wage data the relative quality of teachers. This strategy presents a challenge, because the relative wage reflects various factors unrelated to quality. First, the relative wage includes relative price changes. For example, during a baby boom, teachers might get paid more even though they are of the same quality, simply because they are scarce relative to the student population. To isolate these relative price changes, we will use a dummy for the calendar year. This dummy can identify relative price changes,

[42] Once again, private school teachers have the same experience as public school teachers. The corresponding figure for male private school teachers, available from the author, demonstrates the male private school teachers seem to have lost just as much ground as male schoolteachers overall. Along the same vein, other public employees have hardly fallen at all in the earnings distribution. Other female public employees have lost barely five percentage points in this distribution, while other male public employees have held steady in it.

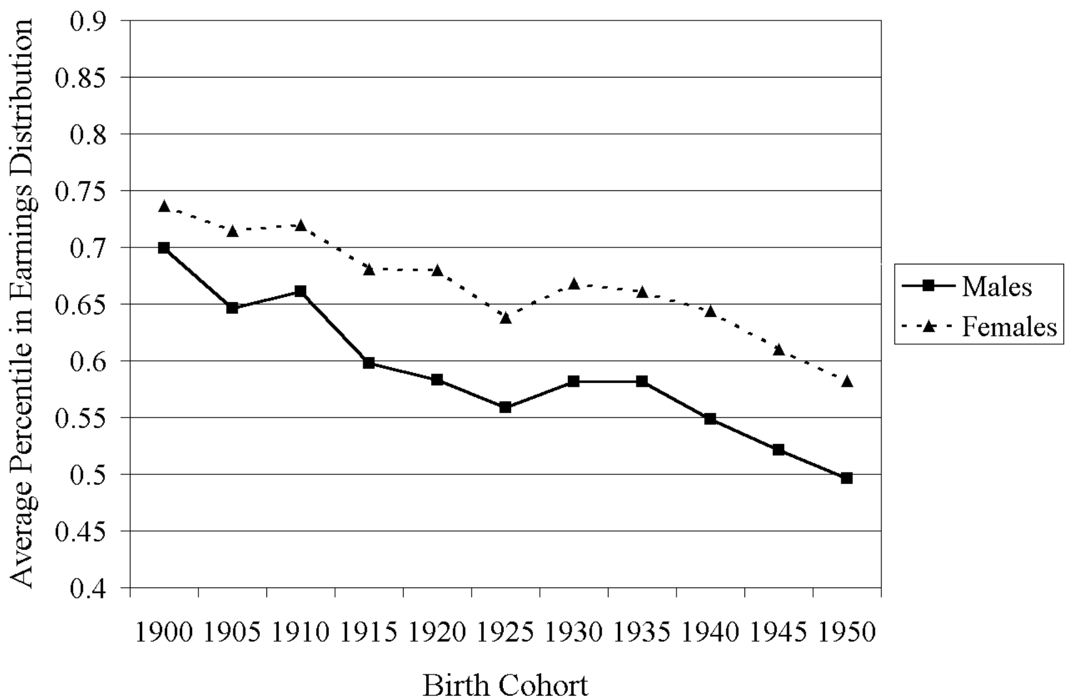

Figure 6: Changes in the position of the average teachers in the annual earnings distribution, by sex.

since a shock to relative supply or demand should affect the wages of all teachers in a given year. Second, the relative wage may reflect differences in the relative returns to experience.[43] That is, experience may benefit teachers more or less than other kinds of workers; changes in the relative wage could thus reflect nothing more than changes in the average experience of different occupational groups. To identify this second component, we will include a dummy variable for each group of similarly experienced workers, and interact these variables with occupational dummies. Once these two non-quality components are identified, a worker's quality is identified from two other elements: her schooling, and a cohort-specific fixed-effect. The estimated return to schooling measures the worker's observed quality. The cohort-specific fixed-effect, on the other hand, helps estimate unobserved differences in quality across cohorts. Since the relative quality of teachers is predicted to decline across cohorts, teachers in younger cohorts may be of lower relative ability, even if schooling is held constant.

This reasoning suggests a basic regression model, which may be adorned with additional explanatory variables. Consider worker i, in occupation j, cohort c, experience group x, at time t. This worker's log-earnings are modeled as:

$$\begin{aligned} \ln E_i^{ctxj} &= \beta_0^j + (\beta_1^j + \beta_2^{cj} Coh_c + \beta_3^{tj} Yr_t) * Sch_i + \\ &\quad \beta_4^{cj} Coh_c + \beta_5^{tj} Yr_t + \beta_6^{xj} Exp_x + \varepsilon_{ijctx} \end{aligned} \quad (10)$$

Observe that each coefficient is allowed to vary across occupations j. The variable Sch_i represents worker $i's$ years of schooling. Coh_c is a dummy variable which reflects a worker's membership in cohort c. Similarly, Yr_t and Exp_x are dummy variables for the calendar year

[43] It is possible that changes in relative quality could take place through changes in the relative returns to experience. We abstract from this possibility, in large part because it would be impossible to identify changes in both educational quality and the shape of the experience profile. For an investigation of economywide changes in the shape of the experience profile, see Murphy and Welch (1992).

t and experience group x.[44]

The returns to schooling are allowed to vary across occupation, cohort, and calendar year. In addition to the baseline return to schooling within an occupation, β_1^j, there is also a cohort-specific return to schooling, β_2^{cj}, and a year-specific return, β_3^{tj}. The cohort-specific return reflects the possibility that schooling quality changes across cohorts. The year-specific return, on the other hand, reflects transient changes in the demand for skilled workers. As a result, $\beta_1^j + \beta_2^{cj}$ represents the permanent return to schooling for a worker in cohort c. In addition to the schooling variables, there are dummy variables for the cohort, calendar year, and experience group.

Estimating equation 10 yields a natural measure of skill in an occupation. Suppose that $\overline{Sch}^{cj}$ represents the average schooling possessed by workers in occupation j and cohort c. The average value of skill in occupation j, and cohort c, is then given by:

$$V_c^j = \beta_1^j \overline{Sch}_c^j + \beta_2^{cj} \overline{Sch}_c^j * Coh_c + \beta_4^{cj} Coh_c \tag{11}$$

The first two terms represent the permanent return to schooling. The last term represents the unobserved quality common to occupation j in cohort c. If $j = tch$ for teachers and $j = col$ for other college graduates, $V_c^{tch} - V_c^{col}$ represents the skill of teachers relative to the skill of college graduates. We will be interested in measuring how $V_c^{tch} - V_c^{col}$ moves across birth cohorts c.

Before proceeding further, we must tackle a thorny identification issue raised by the model in equation 10. Cohort, calendar year, and experience group are linearly dependent. Identification of these three components thus requires some linear restriction on equation

[44]Since they are fundamentally unidentified, we are forced to exclude interactions among experience, year, and cohort. Murphy and Welch (1993) find some evidence that experience profiles have in fact changed over time. These changes will be absorbed into our cohort and period terms.

10.[45] Since such a restriction is fundamentally untestable, we will impose different kinds of restrictions and check whether or not they yield similar results. Two very different kinds of restrictions will be used; it is significant that both yield estimated declines in the relative quality of teachers. The first restriction assumes that the supply of teachers' labor is perfectly elastic.[46] In this case, price effects will be negligible, and the calendar year dummies, $\beta_5^{tj} Yr_t$, may be dropped from the regression. This elasticity restriction then yields an estimate of the change in the relative quality of teachers. The second restriction relies on prior information about the experience profile of teachers. It has been found that the earnings profile of teachers is approximately linear, while the earnings profile of other college graduates is concave (Flyer and Rosen, 1997). Early in their careers, the wages of teachers grow more slowly than the wages of other college graduates, while the reverse is true later in their careers. This generates a U-shaped relative earnings profile for teachers, compared to college graduates. Figure 7 bears witness to this fact. The figure depicts the unconditional log relative wage profile of male school teachers, relative to male college graduates, in each birth cohort.[47] Every birth cohort shows the same pattern, of initial wage decline for ten years and subsequent wage growth. The same trends appear for female teachers in the Census data.[48] This U-shaped relative earnings profile has also been found in Current Population Survey data, in which the relative wages of teachers decline for the first 11 years of experience, and rise thereafter (Flyer and Rosen, 1997).

The U-shaped relative earnings profile can be used to estimate lower and upper bounds

[45]For a detailed discussion of this "age-period-cohort identification problem," see Mason et al (1973).

[46]Zabalza (1979) estimates the elasticity of teaching supply for new entrants into the labor force. He finds elasticities which range from one to three.

[47]Each separate curve in the figure corresponds to a different birth cohort, while the x-axis represents the midpoint of the cohort's age range at the time of the observation. For example, the point for the 1910 cohort (individuals born between 1910 and 1919) at age 25 represents the log relative wage of this cohort in the 1940 census, during which cohort members were between 20 and 30.

[48]The figure for female teachers is available from the author upon request.

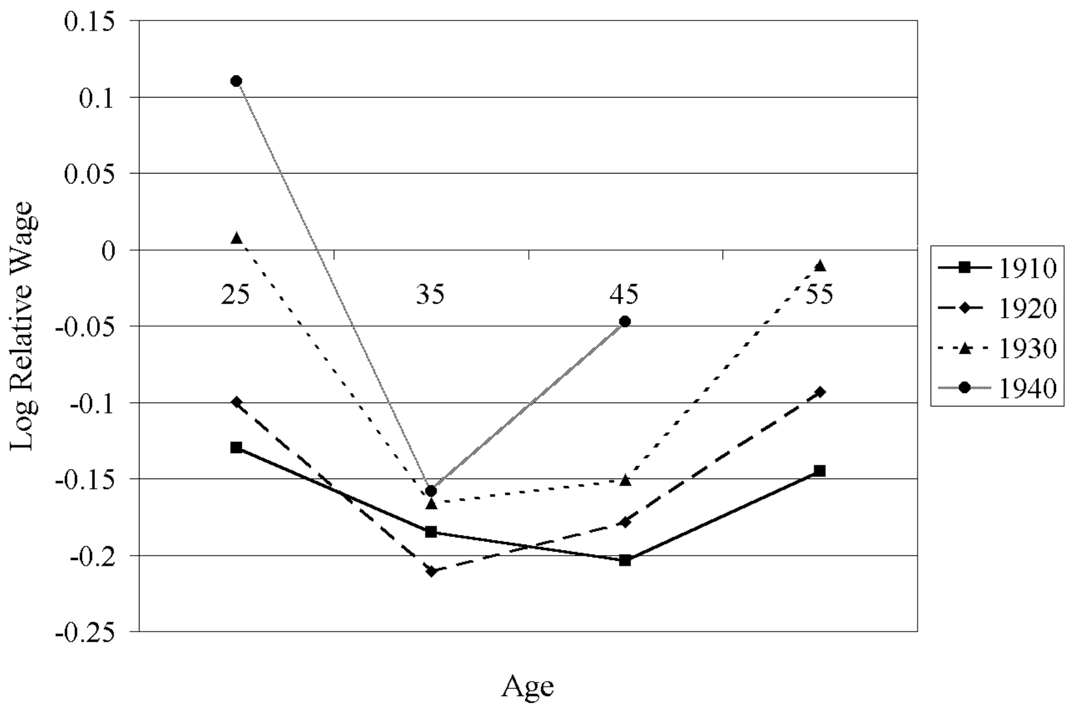

Figure 7: Unconditional log relative wage profile of US male teachers, relative to working male college graduates, by birth cohort.

on the decline in $V_c^{tch} - V_c^{col}$. To estimate an upper bound, we impose the restriction that the relative wage profile of teachers is flat for the first ten years of experience, when in reality it is decreasing. This amounts to the restriction that $\beta_6^{xj} Exp_x$ is constant for all workers with under ten years of experience. To understand why this restriction yields an upper bound, consider a comparison between a new cohort and a cohort with ten years of experience, in a single year. The older cohort has a lower relative wage, by virtue of its experience. However, the restriction forces us to overlook this. Instead, we infer incorrectly, from the lower relative wage, that the older cohort is of lower relative quality. Therefore, we intentionally understate the decline in relative quality from the older cohort to the younger cohort. We pursue the mirror image of this strategy to estimate a lower bound. Consider the restriction that the relative wage profile of teachers is flat after twenty years of experience, when in reality it is increasing. This is implemented by imposing the restriction that $\beta_6^{xj} Exp_x$ is constant for all workers with at least twenty years of experience. To understand the lower bound, think of a comparison between a cohort with thirty years of experience and one with twenty. The older cohort has a higher relative wage, due to its experience. As a result of our restriction, however, we infer that the older cohort is of higher relative quality. Effectively, we overstate the relative quality of the older cohort, and thus overstate the decline in relative quality from the older cohort to the younger cohort.

3.2.2 Data and Construction of Variables

The specification in equation 10 will be estimated by using annual earnings as the dependent variable, and including weeks worked as a regressor.[49] The data contain teachers, college professors, and other college graduates in the labor force. Here, college graduates are taken

[49]Annual earnings include all monetary earnings received as an employee. It will also include any wages earned in a secondary occupation other than the one reported. This may generate some bias in the estimation of occupation-specific parameters.

to be the group of skilled workers. An individual is classified as a schoolteacher if she reports being an elementary or high school teacher.[50] She is classified as a college professor if she reports being a college professor, dean, or instructor. Finally, a "college graduate" is defined as a worker with at least fourteen years of schooling.[51]

The data are taken from the Integrated Public Use Microdata Samples. (Ruggles and Sobek 1997) This set contains microdata from decennial US Census microdata samples on annual earnings, occupation, age, years of schooling, number of weeks worked, labor force status, and family characteristics;[52] these data are available every 10 years, from 1940 to 1990. Educational cohorts are constructed by birth year, where a cohort is defined as a group of individuals born in a given 10-year interval; throughout the analysis, we refer to a cohort by using the first year of the interval. For example, the 1900 cohort represents individuals born from 1900 to 1909. The experience variable is constructed as $(Age - 6 - Sch)$, where Sch represents the highest school grade completed.[53] Individuals are then divided into five-year experience groups, but all individuals with more than thirty years of experience are considered to be in the same experience group.[54] This experience measure is not as accurate

[50]Prior to the 1960 Census, it is impossible to distinguish between high school teachers and primary school teachers.

[51]The qualitative results are not sensitive to this definition of college graduate. Similar results are obtained for males if we define college graduates as those with sixteen years of schooling, but this definition severely compromises sample size in the early female birth cohorts. Moreover, during the first half of the 20th century, high school degrees–particularly in the South–often involved less than 12 years of schooling.

[52]Unfortunately, the Census data on earnings do not include fringe benefits, which represent a significant component of overall teacher compensation. However, it does not appear that teachers' benefits rose much more quickly than the benefits of other college graduates. Based on a very limited sample of teachers, Rothstein and Miles (1995) argue that fringe benefits rose by 5% annually for teachers, between 1967 and 1991. Over the same period, benefits rose at a 4% annual rate for the average worker, but benefits almost certainly rose significantly more quickly for college graduates. Therefore, there would appear to be little difference between the benefit growth for college graduates and that for teachers. Moreover, relative changes in fringe benefits would not explain the decline in the relative schooling of teachers.

[53]For example, completion of grade twelve is measured as $Sch = 12$, while completion of two years of college is measured as $Sch = 14$.

[54]Since the cohort and experience dummies are based on intervals of years, there will no longer be *exact* linear dependence between cohort, period, and experience. However, it is still not appropriate to estimate the model without an additional restriction, because in such a case, the coefficients β_4^{cj}, β_5^{tj}, and β_6^{xj} would

for women as it is for men, because women often take time out of the labor force for child-rearing. To account for this difference, the female regressions include the number of children born, *chborn*, as an independent variable.[55]

According to equation 11, estimating the average value of skill V_c^j requires the calculation of $\overline{Sch}_j^c$, the average years of schooling for occupation j within cohort c.[56] This is measured as the average schooling of a cohort for the years in which all cohort members are between the ages of 30 and 60.[57] The calculation is limited to workers over age 30, because younger workers may not have finished receiving their education. Observations for workers in their 60s are discarded, because these observations often differ wildly from those at other ages. It is quite likely that those still in the labor force during their 60s are not representative of their cohort; more educated workers should be likely to stay in the work force longer.

3.2.3 Estimates of the Decline

This section presents the estimated change in the relative quality of schoolteachers. The theoretical model in this paper predicts that the quality of schoolteachers should decline, both relative to the average worker, and relative to the average skilled worker. The latter claim, of a decline relative to skilled workers, is the stronger of the two. Therefore, we will attempt to test this claim, by measuring the quality of teachers relative to college graduates. To estimate the relative quality, the regression framework of equation 10 is used. Within this

be separately identified solely by the imposition of measurement error. The resulting set of point estimates would thus be no better than another set which differed by a linear term.

[55]It should be noted that the regressions for men and women will be run separately.

[56]Any calculation of the cohort educational average suffers from the problem of "educational drift," as a result of which older workers are more likely to overreport their education. It does not appear that this drift greatly affects the relative wage estimates, which were largely insensitive to several different methods of calculating $\bar{Y}_j^c$, such as computing the average for all cohorts at a single, fixed age.

[57]To construct this, we begin by computing the cohort's average education within each year. Next, we keep only the years in which all members of the cohort are between the ages of 30 and 60. Finally, we compute an unconditional average over these remaining years.

framework, workers will be split up into two occupational groups: schoolteachers, for whom $j = tch$, and college graduates, for whom $j = col$.[58] The fitted values from these regressions will be used to calculate for each cohort, $V_c^{tch} - V_c^{col}$, which represents the relative value of schoolteachers' skill, when compared with college graduates. Note that V_c^{tch} and V_c^{col} are defined according to equation 11.

The model is first estimated by assuming that the relative demand for teacher quantity is perfectly elastic. This yields an initial estimate of the change in the relative quality of teachers, or $V_c^{tch} - V_c^{col}$. To check these estimates, we then estimate lower and upper bounds on the change in $V_c^{tch} - V_c^{col}$, by exploiting the shape of the relative earnings profile for teachers. The results of the perfect elasticity restrictions are depicted by the solid line in Figure 8 for female teachers, and by the solid line in Figure 9 for male teachers. In each figure, the dashed lines represent the lower and upper bounds. The coefficient estimates themselves, and their associated t-statistics, are reported in the first four columns of Table 3, found at the end of this paper. The perfect elasticity restrictions produce an estimated decline in relative quality of nearly fifteen percentage points for male schoolteachers, and of nearly thirty percentage points for female schoolteachers. In other words, the human capital of the average college graduate is estimated to have risen in value by much more than that of the average teacher, by fifteen percentage points more for males, and thirty percentage points more for females. This occurs over roughly two generations, from the 1900 birth cohort to the 1950 birth cohort, and it represents significant evidence in favor of the predicted decline in the relative human capital of schoolteachers.

It is not hard to understand why the predicted decline is larger for females. Over this time period, there was a significant expansion of labor force opportunities for skilled women

[58]Since we are not yet concerned with the wages of college professors, workers will be classified into only two occupational groups.

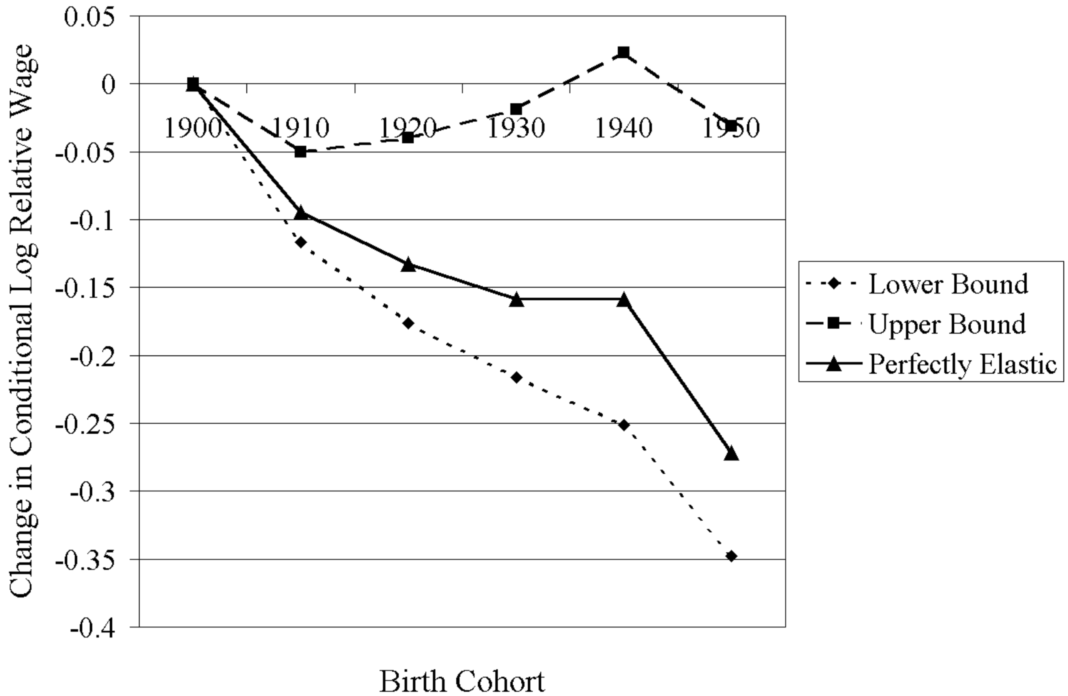

Figure 8: Estimated change in the value of human capital for US female schoolteachers, relative to working female college graduates, by birth cohort.

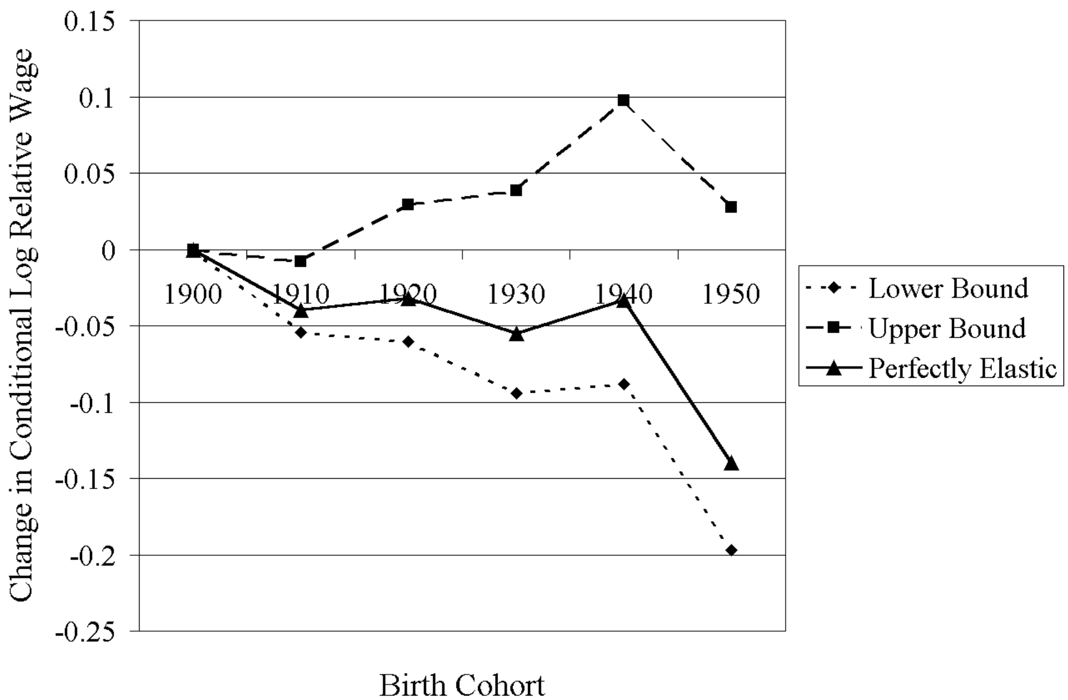

Figure 9: Estimated change in the value of human capital for US male schoolteachers, relative to working male college graduates, by birth cohort.

outside teaching.[59] In the 1900 birth cohort, over 90% of college-educated women in the labor force were teachers, but by the 1950 cohort, this share had dipped to under 15%.[60] Therefore, one would expect a flight of the most skilled women out of teaching. This force should magnify the decline in relative quality for female teachers. Therefore, the relative decline for males should be taken as the benchmark effect of technical change alone. If the labor market for teachers were driven entirely by the expansion of opportunities for skilled women, and not by technical change, one would expect declining relative quality for female teachers, but rising relative quality for male teachers.[61] The presence of declines for male teachers provides evidence of technical change outside education, above and beyond expansion in female labor force opportunities.

The estimated bounds on the change in quality tell a qualitatively similar story. According to the estimated bounds, the relative human capital of male schoolteachers can have risen by only two percentage points at best, and may have declined by as much as twenty percentage points. The relative human capital of female schoolteachers has declined anywhere from two to thirty-five percentage points. It is important to note that the upper bounds on the change in relative quality are, for the most part, horizontal. At the very most, the relative quality of teachers has remained constant. Moreover, we have reason to believe that these are *strict* upper bounds, insofar as the estimates are biased upwards. Even the use of overly favorable assumptions does not produce estimated increases in the relative quality of

[59]This expansion had observable impacts on the structure of teacher training in the US. As more skilled women chose occupations outside teaching, teacher-training colleges began to expand their offerings and to become full-fledged universities, particularly during the '50s and '60s (Haberman and Stinnett, 1973). Not coincidentally, these are the decades during which women began to migrate outside teaching in earnest.

[60]These figures are calculated by the author, using the data of Ruggles and Sobek (1997).

[61]Occupational desegregation would raise the price of skilled women, by raising the demand for their services. This would lower the quality of female teachers. However, it would *lower* the price of skilled men, who would face more competition in the non-educational labor market. As a result, occupational desegregation alone would lower the relative quality of female teachers, but raise the relative quality of male teachers.

teachers.

3.2.4 Measuring the Relative Quality of College Professors

The Census data also allow us to distinguish college professors from teachers and other skilled workers. This comparison is interesting in its own right, but it also provides some further insight into the theory. Professors teach more specialized forms of knowledge that are more likely to change over time. Today's engineering education, for example, probably differs significantly when compared to its antecedents from previous generations. Therefore, declines in relative quality ought to be much less for professors than for teachers, if in fact they take place at all. Indeed, the Census data reveal that the quality of professors has risen relative to that of teachers, particularly among females. Moreover, it seems possible that professor quality has entirely kept pace with college graduate quality.

The basic regression framework specified in equation 10 will still be used, but in this section, workers will be divided into three occupational groups: college professors, schoolteachers, and other college graduates. The change in the relative human capital of professors can be written as the change in $V_c^{prf} - V_c^{tch}$. An assumption of perfectly elastic labor supply will yield one estimate of the change in this quantity, while an assumption about the relative wage profile of college professors will yield a lower bound on the increase in $V_c^{prf} - V_c^{tch}$.

Suppose that the labor supply functions for schoolteachers and for college professors are perfectly elastic, conditional on a fixed level of relative human capital. In this case, there will be no price effects on the relative wages of schoolteachers or of college professors. In terms of equation 10, $\beta_5^{t,tch}$ and $\beta_5^{t,prf}$ will be uniformly zero for all time periods t. Just as in the estimation of teacher quality, this estimate can be checked against a lower bound. We can construct a lower bound on the change in relative quality, if we assume that the relative wage profiles of professors are upward sloping. This assumption makes theoretical sense if one regards tenure as a form of income insurance for older professors.[62] Such insurance for older professors would have to be financed by pay cuts for younger professors and would thus appear to result in rising relative wage profiles for professors, compared to other college graduates.[63] This idea is consistent with patterns in the Census data, according to Figure 10. This figure is constructed just like Figure 7, except that it depicts the log wage of male college professors relative to the log wage of other college-educated male workers. As a cohort ages, the wages of male professors on average tend to rise relative to the wages of male college-educated workers.[64]

To construct a lower bound, we impose the restriction that the relative wage profile of professors, compared to college graduates, is flat after twenty-five years of experience, even though it appears to be rising. To see how this works, consider a comparison between a cohort with thirty-five years experience and one with twenty-five. The older cohort has higher relative wages because of its experience; as a result of the restriction, however, this will be attributed to its higher quality. As a result, the restriction overstates the decline in the quality of college professors relative to college graduates, by making older cohorts look better than they are. This results in a lower bound on changes in $V_c^{prf} - V_c^{col}$. Moreover, we have already shown how to derive an upper bound on $V_c^{tch} - V_c^{col}$, by assuming that the relative wage profiles of teachers are flat early in their careers. Taking the difference of these two bounds results in a lower bound on $(V_c^{prf} - V_c^{col}) - (V_c^{tch} - V_c^{col}) = V_c^{prf} - V_c^{tch}$. This yields a lower bound on changes in the quality of professors relative to teachers.

The results of the perfect elasticity restrictions are depicted by the solid line in Figure

[62]Siow (1998) makes this case more specifically by arguing that, as a result of their high degree of specialization, professors need income insurance against the possibility that their skills may become obsolete.

[63]This conclusion relies on the fact that tenure is very uncommon outside academics.

[64]The corresponding figure for females, available from the author, shows similar patterns.

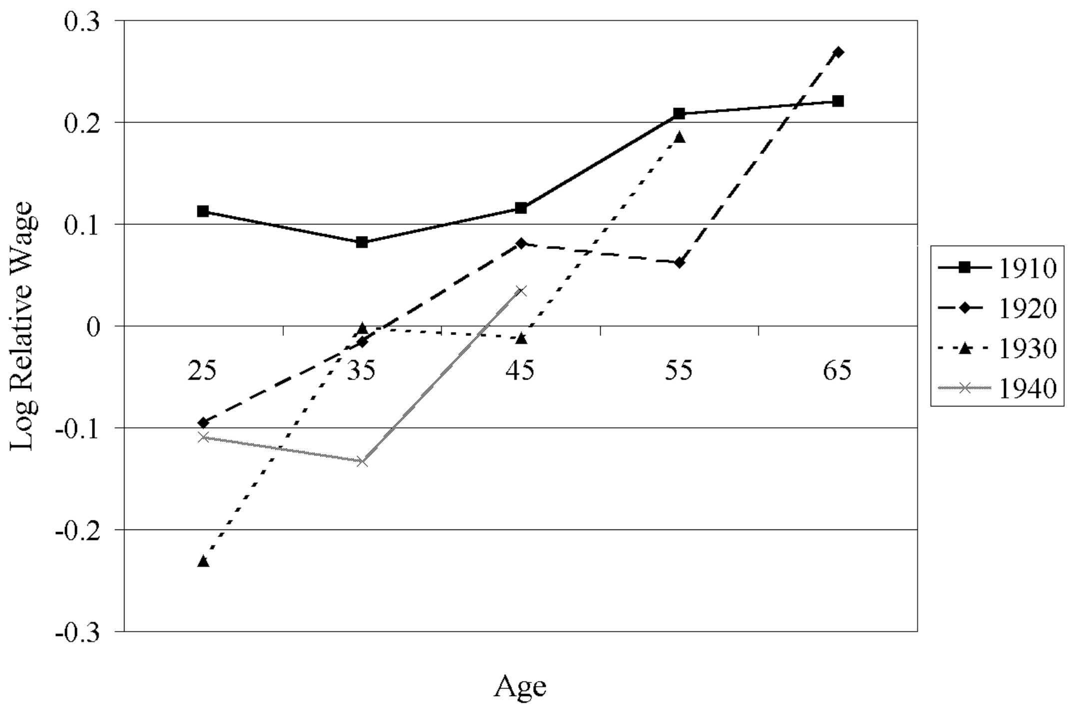

Figure 10: Unconditional log relative wage profile of US male college professors, relative to working male college graduates, by birth cohort.

11 for female professors, and by the solid line in Figure 12 for male professors. The lower bounds are depicted by the dashed lines in the figures. The associated coefficient estimates are reported in the first four columns of Table 4, found at the end of this paper.

According to the perfect elasticity restrictions, from the 1900 to 1950 birth cohorts, the relative quality of college professors is estimated to have risen by more than twenty percentage points for males and more than thirty percentage points for females. This represents a substantial rise in college professor quality relative to schoolteacher quality, as predicted by the theory. Once again, the decline in teacher quality is larger for women than for men. This is consistent with rising female labor force opportunities outside teaching, and it suggests that the estimates for males should be treated as the benchmark effects of technical change. Moreover, the figures show that the lower bounds are essentially horizontal. The relative quality of male college professors cannot have fallen by more than four percentage points, while the relative quality of female college professors has risen by at least ten percentage points.

4 Conclusions

This paper has presented the following key idea: innovation raises the productivity of skilled workers outside education, but not the productivity of skilled teachers. This has several implications. First, the skill of non-teachers, who benefit from innovation, will grow more rapidly than the skill of teachers. Second, the increased demand for skill outside teaching bids up its price. This reduces teacher quality and raises teacher *quantity*, which becomes relatively cheaper than quality. This helps explain why advanced countries experience the growth in primary school teacher-student ratios apparent in Table 1, while experiencing reductions in relative teacher quality. Furthermore, it explains why the relative quality of

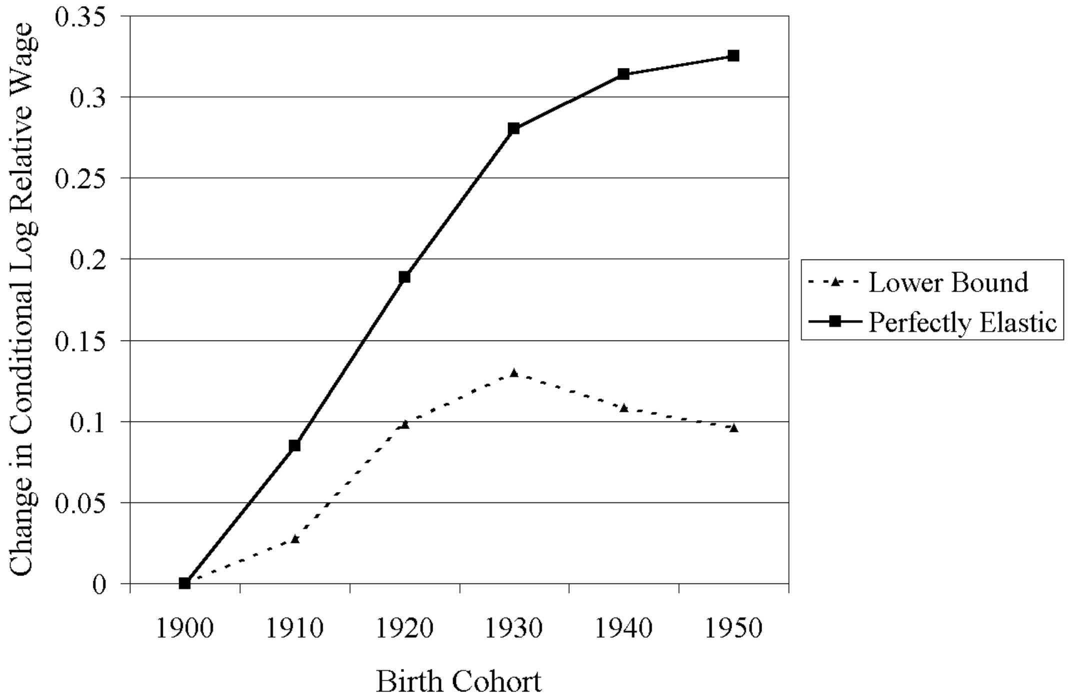

Figure 11: Estimated change in the value of human capital for US female college professors, relative to female schoolteachers, by birth cohort.

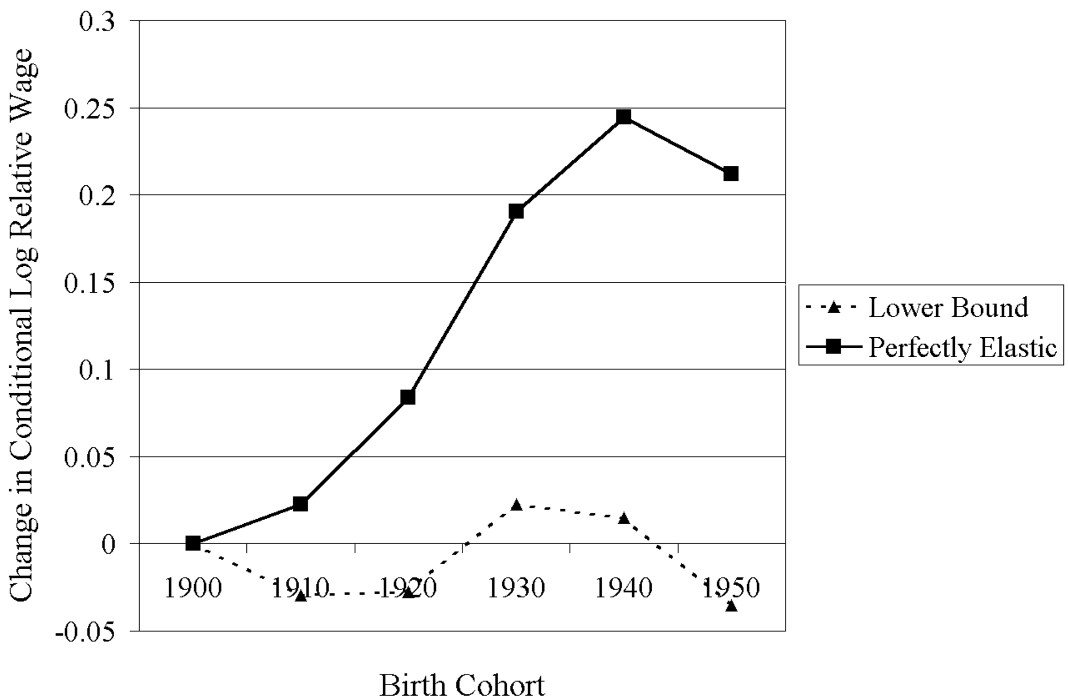

Figure 12: Estimated change in the value of human capital for US male college professors, relative to male schoolteachers, by birth cohort.

professors, whose specialized knowledge improves with innovation, has not fallen as well. Finally, the rising price of skilled teachers raises the cost of producing primary education and results in a shift towards college education. This prediction is consistent with apparent increases in primary educational costs: US primary school spending per student has nearly doubled since 1970, while student achievement has remained constant or fallen slightly.[65] It is also consistent with the finding that countries with higher rates of college participation (which may be correlated with higher demand for skill) exhibit *less* primary school achievement. (Simon and Woo 1995)

This paper has also tackled the important empirical question of how US teacher quality has changed; the evidence for teacher quality appears consistent with the predictions of the paper. First, along a variety of different dimensions, it appears that the relative schooling of teachers has declined considerably compared to other workers of all stripes. Second, during the twentieth century, the human capital of schoolteachers appears to have declined in value relative to college graduates, and *a fortiori* the overall labor force. The human capital of male schoolteachers may have fallen by about fifteen or twenty percentage points, relative to male college graduates or male college professors. The human capital of female schoolteachers may have fallen by roughly thirty percentage points relative to the same two groups.

Although the relative quality of schoolteachers appears to be falling, the theory suggests that this does not compromise the position of today's students. Innovation simply alters the relative efficiency of various educational inputs. This causes resources to flow away from schoolteacher quality, and towards other, more productive uses *within* the educational

[65] The spending data are reported in Hanushek and Rivkin (1997). Betts (1996) reports that SAT scores fell from 1970 to 1990, even though the proportion of 18 year-olds taking the test fell slightly as well. For a survey of the more general literature on the link between spending and student achievement, see Hanushek (1996). The link between school inputs and the eventual wages of graduates is less clear. Betts (1995) argues that there is little link between schooling inputs and the wages of workers. Card and Krueger (1992) argue for the opposite view.

system. This conclusion is consistent with the broad empirical evidence. Resources have not simply departed from the educational system.[66] The relative quality of schoolteachers has declined, but there has been simultaneous and dramatic growth in the teacher-student ratio. Moreover, the relative quality of professors has not suffered the same decline. These facts point to an important lesson: one cannot measure the quality of the educational system simply by measuring changes in one set of inputs, such as the quality of teachers. A decline in one set of educational inputs may be accompanied by growth in another set; similarly, a decline in output at one level of education may be accompanied by output growth at another level. The only reliable way to assess the quality of the educational system is to measure the quality of the workers who have graduated from it. This view would assign less importance to concerns about declining test scores at the primary school level. These declines may simply point to the rising cost of producing general human capital.

Several extensions of this discussion seem to merit future analysis. First, we have not focused on the issue of gender in teaching. Beginning in the nineteenth century, teaching became one of the few occupations open to educated women. From 1860 onwards, women constituted a majority among US schoolteachers, and around the same time, women were entering teaching in various nations throughout the now-developed world.[67] During the twentieth-century, however, educated women began to enter many different occupations outside teaching. In 1940, over half of college-educated American women in the labor force were teachers, but by 1990 only one-tenth were teachers.[68] It seems important to understand the conditions which precipitated the entry of educated women into fields outside teaching, and to evaluate empirically their effects on the price of teachers and other skilled workers.

[66] Indeed, Hanushek and Rivkin (1997) point out that US spending per pupil has grown significantly over the past century.

[67] See Clifford (1989).

[68] These statistics are calculated from US Census data, based on our previous definition of college graduates as workers with at least fourteen years of schooling.

Second, moving beyond the field of education, it seems that one of the key ideas of this paper, that innovation favors specialized fields of knowledge, could apply to other occupations which are subdivided into generalists and specialists. Medicine appears to be such a field; primary care-givers use general medical knowledge to provide general medical treatment, while surgeons, radiologists, and other medical specialists may use more specialized knowledge to provide highly specialized medical services. If innovation favors medical specialists, the quality of such specialists should rise more quickly than that of primary care-givers. The empirical methods set forth here could be used to estimate changes in the quality of medical specialists relative to generalists. However, any application of the theory to US data would have to cope with the explosion in the quantity of medical specialists; the proportion of US doctors who are specialists has more than quadrupled, from seventeen percent in 1931 to more than eighty percent in 1980.[69] It seems necessary both to understand the dramatic growth in the quantity of specialists, and to investigate empirically the change in the relative quality of specialist physicians.

Finally, it seems important to understand in more detail the cross-country patterns summarized in Figure 1 and Table 1. The predictions of the theory should apply with more force to developed countries than to developing countries. Since technology will be much less advanced in developing countries, school systems there should invest more in relative schoolteacher quality, but less in schoolteacher quantity. It would be useful to investigate whether this prediction is consistent with observed cross-country patterns. At the very least, it seems that the patterns of relative wage decline are not consistently present in developing countries (Schultz, 1987). Moreover, while Figure 1 reveals intriguingly similar wage patterns among various developed countries, it does not attempt to estimate directly the changes in

[69]See Noether (1983, p. 109). Intriguingly, other developed countries appear to have had different experiences.

teacher quality for other developed countries. Such estimation is necessary to assess the prevalence of declining relative quality. It may well turn out that the advanced economies, which value schooling most highly, exhibit the sharpest declines in the relative quality of schoolteachers.

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Table 1:

Table 2:

Table 3:

Table 4: