



The quantity and quality of teachers: Dynamics of the trade-off[☆]

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ABSTRACT

The paper addresses the two-fold rise in teacher–student ratio in the American K–12 school system in the post-World War II period accompanied by the evidence of a decline in the relative quality of teachers. We develop a dynamic general equilibrium framework for analyzing the teacher quantity–quality trade-off and offer an explanation to the observed trends. Our OLG model features two stages of education: basic and advanced (college), the latter required of teachers. The cost of hiring teachers is influenced by the outside opportunities for college graduates in the production sector. We show that the latter factor strengthens in the process of endogenous growth and that it affects the optimal trade-off between quantity and quality of teachers such that the number of teachers hired will grow over time while their relative, but not the absolute, human capital attainment will fall. This is accompanied by increasing inequality, among the group of college educated workers in particular. We show that this effect, which we call the *rising talent premium*, applies whether teacher salaries are determined based on *merit pay* or, alternatively, by *collective bargaining*. Moreover, the salary compression characterizing the latter regime exacerbates the loss of the more talented workers by the teaching profession. Further, we analyze a comparative dynamics effect of exogenous *skill-biased technological change* which raises the college premium. We show that the effect is detrimental to the aggregate quality of teachers and to the quality of basic education. An important insight from this analysis is that in the process of human capital driven economic growth the rise in premium for high ability outpaces that for the average, whereby this effect is accelerated by technological change. This puts a downward pressure on the “real” quality of education inputs and therefore can create a negative feedback effect on human capital development as a factor of economic growth.

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1. Introduction

A reduction of class sizes in K–12 schooling has been one of the main education policy priorities in the United States over the last several decades. This is evidenced by the dynamics of student–teacher ratio which fell from 25.8 in 1960 to 15.7 in 2005. Remarkably, this decline has persisted through the contemporaneous ups and downs of the enrollment dynamics (*Digest of Education Statistics, 2007*, table 61, reproduced in *Table 1* below). Research, however, has shown that students' test scores have not risen despite increased individualized instruction. This has compelled policy makers and researchers to

question the role of the quantity of teachers vs. their quality as factors in student performance (see *Hanushek et al., 2005*), particularly in light of a possible trade-off between the two.

Indeed the changes in education statistics between 1955 and 2005 displayed in our *Table 1* suggest the possibility of a quantity–quality trade-off in the supply of teachers over this period: a remarkable growth in the total number of teachers consistently outpacing the growth of student enrollments was accompanied by declining relative teacher salaries, despite essentially steady overall K–12 public education expenditures as a share of GDP since 1970. Another significant trend observed over about the same period is the decline in the aptitude of teachers relative to other educated workers. *Hoxby and Leigh (2004)* estimate that in 1963 41% of all teachers were of the “middle” aptitude relative to their educated peers, with 17% above and 42% below the average; by comparison, in 2000, 28% of all teachers were of the “middle” aptitude with 5% above and 67% below average. *Corcoran et al. (2004)* provide similar results.

Thus the dynamics of the K–12 system exhibits a trade-off between the quantity of teachers and their quality. The presence of the trade-off between the two variables creates the well-known endogeneity challenge for the empirical efforts to estimate one of

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Table 1
Historical data on public elementary and secondary schools, 1955 to 2005.

Year	Enrollment ^{1,a}	Teachers ^{1,a}	Pupil/teacher ratio ¹	Real expenditures per pupil ^{4e}	Expenditures per pupil ⁴	Expenditures to GDP ^{2,b}	Relative teacher salary ^{3,b,d}
1955	30,680	1141	26.9	234.2	294.2	3.3 ^c	
1960	36,281	1408	25.8	2606.3	375.1	3.6	43.0
1965	42,173	1710	24.7	3440.0	537.7	3.9	
1970	45,894	2059	22.3	4682.1	911.1	4.6	44.0
1975	44,819	2198	20.4	5534.6	1503.6	4.6	
1980	40,877	2184	18.7	5895.3	2501.6	4.0	41.0
1985	39,422	2206	17.9	7045.4	3755.6	3.8	
1990	41,217	2398	17.2	8014.7	5257.8	4.3	35.0
1995	44,840	2598	17.3	8121.8	6146.9	4.3	
2000	47,204	2941	16.0	9214.8	7903.7	4.5	36.5
2005	49,113	3137	15.7	10,041.5	9788.4	4.6	

Source:

¹ Digest of Education Statistics 2007, Table 61.

² Digest of Education Statistics 2007, Table 25.

³ Haunshek and Rivkin (2004).

⁴ Digest of Education Statistics 2007, Table 32.

Notes:

^a In thousands.

^b In percent.

^c 1959 data.

^d College educated females, age 20–29, earning less than average female teacher, age 20–29.

^e Deflated by CPI and in 2006 dollars.

the variables while controlling for the other.² These empirical results do not thus provide a conclusive basis to explain the observed policy bias in favor of the quantity of teachers (smaller classes) on the grounds of benefits to student performance. This underscores the need for a broader theoretical framework capturing the dynamic interaction between inputs in education as it is influenced by the labor market in the production economy.

Our paper develops a theoretical framework for analyzing the teacher quantity–quality trade-off and offers an explanation to the observed trend biased in favor of quantity. We present a model which incorporates the factors of education quality discussed above, in a dynamic general equilibrium framework where education policy decisions affect and are affected by individual education and employment decisions, whereas the dynamics of human capital accumulation and labor productivity has a feedback effect on both. In our model, a public education agency wishes to maximize the quality of basic education per student and, due to a budget constraint, faces a trade-off between the quality and quantity of teachers to be hired. We explore the following factors that may affect this trade-off: (i) the opportunity cost of teachers in terms of potential earnings in the alternative occupations in the production economy, and its evolution in the process of economic growth; (ii) collective bargaining driven by teacher unions as an institutional factor leading to wage compression among teachers³; (iii) the rise of skill premium resulting

² Indeed, Jepsen and Rivkin (2002) argue that using mandated class size reduction programs as natural experiments for estimating the class size effect is problematic when these changes are accompanied by a trade-off between the quantity and quality of teachers. They point out that California's class size reduction program came at the expense of hiring lower quality teachers to staff additional classrooms, which offset the benefits of smaller classes. Similarly, Hoxby (1996) finds that in unionized public school higher measured inputs may produce no gains to student achievement: the teachers' unions engage in rent-seeking which leads to lower productivity, via teacher quality or effort, enough to offset any gains from the additional resources, smaller student–teacher ratios in particular.

³ It is indeed well documented that teacher unions significantly contribute to the compression of seniority adjusted wages: unions provide tenure to teachers and tie their salary primarily to experience rather than performance; administrators wishing to hire higher quality teachers are forced by the unions to provide matching raises to teachers across the board. The wage compression in public schools imposes similar wage rigidity on the private school teacher market (Lakdawalla, 2006). It should be noted that unionization is not the sole factor responsible for the compression of teacher salaries. It is also due in part to the difficulty of measuring teacher productivity, especially in terms of educational value added given the unobservable student characteristics as well as student sorting into classes.

from technological change, which affects the opportunity cost of teachers.

In our model, basic education is publicly funded through an income tax, whose rate is set exogenously, and is administered by an education agency which allocates these funds while deciding on the levels of teacher salaries and the number of teachers to be hired. The model features two stages of education: basic and advanced (college), the latter being required of teachers. College graduates can also take jobs in the skilled labor force of the production sector and get paid a competitive wage according to their human capital attainment. This opportunity cost implies that the levels of teacher salaries set by the education agency will determine the quality (human capital levels) of teachers who can be hired. Thus the total cost of hiring teachers is affected in our model by the outside opportunities available to skilled individuals in the production sector.⁴ We show, moreover, that in the process of endogenous growth this effect strengthens and that it pushes the optimal trade-off between quantity and quality of teachers in the direction of the former. Namely, in the face of rising over time cost of highly able skilled workers, the education agency will find it optimal to opt for increasing the number of teachers hired while reducing the overall relative quality of the pool of teachers. (The absolute human capital attainment of teachers, however, will rise along with the overall human capital accumulation, while sliding toward the lower tail of the distribution of college educated population.) Furthermore, we show that this human capital dynamics is characterized by increasing inequality within the group of college educated workers as well as between it and the unskilled.

In order to assess the role of an institutional factor in the teacher quantity–quality trade-off, we consider two alternative teacher

⁴ Recent literature offers estimates of the effects of outside job market opportunities on the quality of teachers. Flyer and Rosen (1997) report that the three-fold increase in direct costs of education per student is attributable to the growing market opportunities for women. Hanushek and Rivkin (1997) document the decline in the earnings of women teachers relative to women in other occupations and suggest that the expansion of alternative opportunities reduced teacher quality. Hanushek and Rivkin (2004) estimate that in 1955, 50% (48%) of all educated male (female) workers earned less than male (female) teachers, compared to 36% (29%) in 2000. Similar analyses concerning the effect of the outside opportunities on teacher quality are offered by Goldhaber and Liu (2003), Stoddard (2003), and Bacolod (2007). Lakdawalla (2006) demonstrates that a rising skill premium of educated workers due to faster technological change coupled with low productivity growth of skilled teachers, has led to the substitution toward a larger quantity of unskilled teachers, away from the increasingly expensive skilled teachers.

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