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Measuring the Education Function of Government in the United States

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Introduction

The national income accounts of the United States currently estimate both the nominal and real value of government services using the value of the goods, services, and labor consumed by governments to produce those services. The resulting measure of government output, called the *input* measure, assumes that productivity in the government services sector is constant at zero. For example, the input measure implies that schools cannot produce more education without employing more inputs. It also implies that schools inevitably produce more education if they do employ more inputs.

An alternative to the input measure is a *volume* measure of output, which is an index that attempts to directly measure the output of government services. A volume measure allows government productivity to increase or decrease over time. In the sections that follow, I present new volume measures for public education, following up on earlier work presented in Fraumeni *et al* (2004). The new measures suggest that public education output grew at an annual rate of between 1.1 and 1.5 percent over 1980-2001, which is substantially slower than the 2.5 percent annual growth rate of the input measure of public education output.

Volume Indexes for Elementary and Secondary Education

The simplest volume index for the output of public elementary and secondary education is a count of students enrolled in public elementary and secondary schools. This count has grown significantly more slowly than the input index for public elementary and secondary education. Between 1980 and 2001, the number of students enrolled in public elementary and secondary schools grew at an annual rate of 0.7 percent.[1] In contrast, state and local government consumption and sales for public elementary and secondary education grew at a rate of 2.4 percent per year.[2] More detailed growth rates for these two series are presented in Table 1.

There are several drawbacks to measuring the output of education with a simple count of students. One is the failure of such a measure to capture possible increases in the quality of educational services provided. Another is the implicit assumption that education is the same across different grades and kinds of education. Both of these problems suggest that it may be a good idea to use a more sophisticated measure that makes some adjustments for changes in education over time.

Accounting for Special Education

One of the most frequently discussed changes in public elementary and secondary education over the past twenty years is the accommodation of students with special needs. The percentage of public elementary and secondary students who received special-education services increased from 9.4 percent to 12.1 percent between 1980 and 2001.[3] A review by Chambers *et al* (2004) finds that the cost of educating a special education student has been estimated as being between 1.9 and 2.3 times the cost of educating a regular education student. This suggests double-weighting special education students as an easy way to account for the rise of special education. Doing so increases the annual growth rate of a count of students from 0.7 percent to 0.9 percent.

Adjusting Output for the Quality of School Inputs

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[1] Elementary and secondary enrollment data are from the state nonfiscal surveys of the Common Core of Data and are published in various editions of the *Digest of Education Statistics*, which is published annually by the National Center for Education Statistics of the U.S. Department of Education.

[2] State and local consumption and sales for education are from unpublished data in the National Income and Product Accounts of the Bureau of Economic Analysis of the U.S. Department of Commerce.

[3] Special education data are from the annual reports to the U.S. Congress on implementation of the Individuals with Disabilities Act by the Office of Special Education Programs of U.S. Department of Education.

It is also possible that the quality of education has changed within regular and special education. One way to adjust for this kind of change in quality is to adjust for the quality of school inputs. For example, the pupil-teacher ratio in public elementary and secondary schools declined from 18.7 to 15.9 between 1980 and 2001.[4] How might this have affected the quality of education? Rivkin *et al*'s (2005) study of Texas elementary school students suggested that a one-student reduction in class size that persists over fourth through seventh grade would normally increase mathematics test scores by 0.02 standard deviations.[5] Presuming a class size of 20, this suggests that a one-year, one-percent drop in class size would improve test scores by 0.001 standard deviations.[6]

Translating a standard deviation of test scores into a greater volume of education output is a challenge. One approach is to compare the economic returns to test scores and years of education. Bowles, Gintis and Osborne's (2001) literature review suggests that the economic return to a standard deviation of cognitive skill is about equal to the economic return to a year of education. We could interpret this to mean that a standard deviation of test scores is the equivalent of one year of education. It is probably most appropriate to think of this as a lower bound on the rate of substitution; if the distribution of test scores is normal, it implies that an eighth grader in the 15th percentile is slightly less than the equivalent of a sixth grader in the 85th percentile.[7] At this rate of substitution, a one-year, one-percent reduction in class size that improves test scores by 0.001 standard deviations increases each student's education by the equivalent of 0.001 years. This could be interpreted as a $0.001 \times 100\% = 0.1$ percent improvement in quality. If a one-percent reduction in class size improves quality by 0.1 percent, the elasticity of school quality with respect to class size is implicitly $0.1\% \div 1\% = 0.1$.

Alternatively, one could translate test scores into education output simply by using the normal test score gain from a year of education. Analysis of National Assessment of Educational Progress (NAEP) math test scores suggests that a standard deviation of test scores is the equivalent of 3.3 years of schooling.[8] This probably best thought of as an upper bound on the rate of substitution; it implies that an eighth grader in the 15th percentile is slightly more than the equivalent of a *first* grader in the 85th percentile.[9] At this rate of substitution, a one-year, one-percent reduction in class size increases school quality by 0.33 percent, which implies that the elasticity of school quality with respect to class size is 0.33.

Class size is not the only variable that has changed in recent years. The number of inexperienced teachers has also changed; the preponderance of teachers with less than two

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[4] Teachers data are from the state nonfiscal surveys of the Common Core of Data and are published in the *Digest of Education Statistics.*

[5] The .02 estimate can be found by adding the first four coefficients in the third column of Table VII of Rivkin *et al* (2005). The sum is -.0197.

[6] If average class size is 20, then a one-student reduction in class size is a five-percent reduction in class size. Consequently, a four-year, five-percent reduction in class size increases test scores by 0.02 standard deviations. Dividing 0.02 by four to scale down to one year and again by five to scale down to a one percent class size reduction yields 0.001 standard deviations.

[7] In the normal distribution, the difference between the 15th and 85th percentiles is 2.06 standard deviations. If one year of education is the equivalent of one cross-sectional standard deviation of cognitive skill, then two years of education—say, between the sixth and eighth grades—erases nearly all of this difference.

[8] The standard deviation of math NAEP scores for 17-year-olds is about 31 points; this was approximated by observing the percentile distribution of scores in 1996 and assuming a normal distribution. The average math NAEP score improved from 231 age at 9 to 307 at age 17. Dividing the difference between these two scores by 8 yields an annual NAEP gain of 9.5 points, which is about 1/3.3 the cross-sectional standard deviation of 31.

[9] If 3.3 years of education is the equivalent of one cross-sectional standard deviation of cognitive skill, then seven years of education increases cognitive skill $7 \div 3.3 = 2.12$ standard deviations, which is slightly more than the difference of 2.06 standard deviations between the 15th and 85th percentiles.

years of experience rose from 5.3 percent in 1980 to 8.8 percent in 2000.[10] Suppose we assumed that having a teacher with fewer than two years of experience reduced test score gains by 0.10 standard deviations.[11] If this is the case, then the semi-elasticity of school quality with respect to the proportion of teachers with fewer than two years of experience is 0.10 × 1 = 0.1 under the lower-bound assumption that a standard deviation of test scores is the equivalent of one year of schooling. Under the upper-bound assumption that a standard deviation is the equivalent of 3.3 years of schooling, the semi-elasticity is 0.10 × 3.3 = 0.33.

The above discussion suggests two volume measures that adjust for quality of school inputs. Let Q equal the output of public elementary and secondary education, RE equal regular education enrollment, SE equal special education enrollment, PT equal the pupil-teacher ratio, and XP equal the proportion of teachers with fewer than two years of experience. Under the lower-bound assumption that a standard deviation in test scores is the equivalent of one year of schooling, the output of public elementary and secondary education is

$$Q = PT^{-0.1} e^{-0.1XP} (RE + 2SE)$$

since, under the lower-bound assumption, the elasticity of school quality with respect to class size and the semi-elasticity of school quality with respect to the proportion of inexperienced teachers are both 0.1. Under the upper-bound assumption that a standard deviation in test scores is the equivalent of 3.3 years of schooling, output is

$$Q = PT^{-0.33} e^{-0.33XP} (RE + 2SE)$$

Details on the growth rates of both measures are presented in Table 1.

These adjustments modestly increase the measured growth rate of the volume measure of elementary and secondary education. The upper-bound adjustment, in particular, increases the annual rate of growth over 1980-2001 to 1.1 percent. This is still much closer to the 0.7 percent growth rate of the unadjusted count of students than it is to the 2.4 percent growth rate of the input measure. It is important to note, however, that any attempt to adjust for quality using the quality of school inputs will necessarily be incomplete, as not all school inputs are measurable. Adjusting for school inputs is an additive process, from which one starts from zero; consequently, simple adjustments like those above are likely to have small impacts.

Adjusting for the Quality of Student Outcomes

Another way to adjust for changes in quality within regular and special education is to use changes in student outcomes. Test scores are probably the most natural outcome to use. Analytically, this is a simpler adjustment than school inputs. Previously, school inputs were used to adjust for quality of education, the size of the adjustment having been determined by looking at the various inputs' effects on test scores. Here, the intermediate step is skipped and the test scores themselves are used to adjust for quality.

The best test score for quality adjustment is probably twelfth-grade NAEP scores, which ostensibly measure the end result of elementary and secondary education: cognitive skill at around the time of completion. The average math NAEP score improved considerably over the period of time studied: from 298 in 1982 to 308 in 1999, or by nearly a third of a standard deviation. Changes in this score can be a result of improvement in any one of the twelve grades, so the changes are divided evenly among grades and it is assumed that a one-standard deviation change in twelfth-grade test scores reflects a one-twelfth of a standard

[10] Teacher experience data is from various editions of the *Status of the American Public School Teacher*, which is published quinquenially by the National Education Association. Other years are linearly interpolated.
[11] Rivkin *et al* (2005) found that, compared to teachers with more than five years of experience, test scores were 0.13 standard deviations lower when teachers had no experience, 0.06 standard deviations lower when teachers had one to two years of experience, and 0.03 standard deviations lower when teachers had three to five years of experience.

deviation change in test score gains in each year of education. It is also temporarily assumed that all change over time in test scores is caused by changes in the quality of education.

Let *TS* equal the average twelfth-grade test score, normalized to cross-sectional standard deviations. If we use the lower-bound assumption that a standard deviation of test scores is the equivalent of one year of education, a volume index adjusted for test score improvements is

$$Q = TS^{1/12}(RE + 2SE)$$

Under the upper-bound assumption that a standard deviation of test scores is the equivalent of 3.3 years of education, the adjusted volume index is

$$Q = TS^{3.3/12}(RE + 2SE)$$

Growth rates of these indexes using NAEP math test scores are presented in Table 1.[12]

The test scores adjustment increases the growth rate of the volume index by substantially more than the school inputs adjustment. After adjusting for improvements in test scores using the upper-bound adjustment, measured output of elementary and secondary education increases at a rate of 1.2 percent per year. Note, however, that this and the special education adjustment combined close less than one-third of the gap between the growth rate of an unadjusted count of students (0.7 percent) and the growth rate of the input measure (2.4 percent).

So far, we have assumed that all test score gains are a result of schooling. This is unlikely to be the case; family, peers, and environment all play an important role as well. The ideal measure of student outcome would strip away as many non-school influences as possible and identify the particular gains from schooling.

Parents' education is an especially important non-school variable, especially when using the NAEP; the parental background of the NAEP sample has tended toward more education over time. To account for these changes, the separate NAEP time series for children of parents of five education categories—less than high school, graduated high school, some education after high school, graduated college, and unknown—are averaged, using as weights the distribution of NAEP children's parents by education in 1996. The effect of using this parent-adjusted NAEP time series rather than the unadjusted NAEP time series is substantial. Using the adjusted NAEP reduces the growth rate of the volume index from 1.2 percent to 1.0 percent under the upper-bound rate of substitution between test scores and years of education.

The big picture on volume indexes for elementary and secondary education in the United States is illustrated in Figure 1, which plots three volume measures—an unadjusted count of students, a count adjusted for school inputs using the upper-bound adjustment, and a count adjusted for raw test scores using the upper-bound adjustment—alongside the currently employed input measure. The three volume indexes have more in common with each other than with the input measure. Even with adjustments for quality, growth in the output of public elementary and secondary education when measured by volume is much slower than growth as it is currently measured under the input approach.

Volume Indexes for Higher Education

Measuring the output of public higher education by volume is a different challenge from measuring the output of public elementary and secondary education by volume. The most substantial difference is that instruction is only one of many functions of higher education. State and local colleges and universities exist to teach students, but they also exist to conduct research and act in the public service.

In computing the volume index of output, I assume that the proportion of nominal public higher education output that is dedicated to instruction of students is equal to current

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[12] Linear interpolations are used for years in which the NAEP was not conducted.

expenditure by public institutions for instruction and student services divided by current expenditure by public institutions for instruction, student services, research, and public service. This proportion, devised by To (1987), was used by Winston and Yen (1995) to identify the component of operating and capital costs that is dedicated to instruction at individual institutions. Across all institutions, this proportion dropped from 0.75 in 1980 to 0.70 in 2000, which may indicate a decline in the relative importance of instruction in public higher education.[13] The input measure of the real output of public colleges and universities is also split between instruction and non-instruction using this proportion.

Basic Measures for Instruction

Like elementary and secondary education, the simplest volume measure of the instructional function of public higher education is an unweighted count of students. The annual growth rate of this count was 1.2 percent between 1980 and 2001, which is quite a bit slower than the 2.3 percent annual growth rate of the input measure for instruction.[14] Note, however, that the 1.1 percent gap between a simple headcount and the input measure for higher education is considerably smaller than the analogous 1.7 percent gap for elementary and secondary education. Double-weighting graduate enrollments and converting to full-time equivalents (FTEs) by counting part-time enrollments as one-third of a full-time enrollment has virtually no impact on the growth rate of public higher education instruction; the annual growth rate remains 1.2 percent. The composition of enrollment across full-time, part-time, undergraduate, and graduate enrollment is remarkably static over time. More details on these series are presented in Table 2.

Using degrees instead of enrollments to measure public higher education instructional output changes matters slightly. A simple count of degrees earned grows at an annual rate of 1.4 percent per year.[15] Weighting the count has little impact, as the composition of total degrees earned across associate's, bachelor's, master's, first-professional, and doctoral degrees has also remained very static over time. A series that weights degrees by the number of years typically required to completion, with graduate degrees counting double, still grows at an annual rate of 1.4 percent.[16]

Creating a Hybrid Index of Enrollments and Degrees

A hybrid index of enrollments and degrees can be constructed if a satisfactory approach to weighting enrollments and degrees is found. One criterion for assessing a weighting approach is how well it reflects the rate at which people would willingly substitute years of education for earned degrees. This rate of substitution could be measured by comparing economic rates of return from years of education and earned degrees. Such estimates exist in the literature on sheepskin effects, which is critically reviewed by Flores and Light (2004).

One of the best papers on sheepskin effects is by Jaeger and Page (1996), who used a matched sample from the March 1991 and 1992 demographic supplements to the Current Population Survey (CPS). Over this sample, Jaeger and Page regressed log hourly wages against a set of variables that included dummies for the number of years of education completed and dummies for degrees and diplomas earned. This regression estimated separate rates of return to individual years of undergraduate and graduate education; to associate's,

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[13] Data on school finances is from the Finance surveys of the Higher Education General Information Survey (HEGIS) and its successor, the Integrated Postsecondary Education Data System (IPEDS). The data are published in various editions of the *Digest of Education Statistics.*

[14] Data on enrollments is from the Fall Enrollments surveys of HEGIS and IPEDS. Men's and women's enrollments increased at annual rates of 0.8 percent and 1.6 percent over 1980-2001.

[15] Data on degrees from the Earned Degrees surveys of HEGIS and IPEDS, which are published in various editions of the *Digest of Education Statistics*.

[16] In this index, associate degrees receive a weight of 2, bachelor's degrees a weight of 4, master's degrees a weight of 4, first-professional degrees a weight of 6, and doctoral degrees a weight of 8.

bachelor's, and graduate degrees; and, surprisingly, to the mere act of having attending college in the first place. The last one is estimable because there are people in the data set who reported having attended college but having only completed twelve years of education, as well as people who reported having completed more than twelve years of education but who do not report having attended college.

Among white men, Jaeger and Page found that the total return to four years of undergraduate college is 17.8 percent and the additional return to two or more years of graduate school is 4.6 percent.[17] This could be interpreted as a 17.8 ÷ 4 = 4.45 percent return to a year of undergraduate schooling and a 4.6 ÷ 2 = 2.3 percent return to a year of graduate schooling. Additionally, Jaeger and Page found that white men with occupational associate's degrees earned 0.7 percent less than those with some college but no degree, while those with academic associate's degrees earned 10.8 percent more and those with bachelor's degrees earned 16.2 percent more.[18] If about half of associate's degrees are occupational and half are academic, this implies an average return to associate's degrees of (-0.7 + 10.8) ÷ 2 = 5.05 percent and a return to a bachelor's degree of 16.2 percent.[19] Finally, Jaeger and Page find returns of 5.0 percent to master's degrees, 28.6 percent to first-professional degrees, and 6.7 percent to doctoral degrees.

The economic returns above, if estimated correctly, give us an idea of rates of substitution. For example, the economic return to a year of graduate education is about half the economic return to a master's degree. This suggests that people will value a year of graduate school at about one-half the value of a master's degree, which means in turn suggests that years of graduate school should be weighted about half as much as master's degrees in an aggregated index of years of education and earned degrees. If we use the economic returns described above as weights, the aggregated index would weight undergraduate enrollments by 4.45, graduate enrollments by 2.3, associate's degrees by 5.05, bachelor's degrees by 16.2, master's degrees by 5.0, professional degrees by 28.6, and doctoral degrees by 6.7.

Unsurprisingly, the growth rate of the resulting hybrid index, 1.3 percent, is between the growth rates for the enrollments-only and degrees-only indexes. More details on this index are presented in Table 2.

Comparing Volume Indexes and the Input Index for Public Higher Education

In Figure 2, three volume indexes for public higher education instruction are plotted: the weighted enrollment series, the weighted degrees series, and the degrees-enrollment hybrid series. The input index is also plotted. The plot as a whole is similar to that for elementary and secondary education, but not identical; it is still the case that the volume series are all more similar to each other than they are to the input series, but the difference is not as dramatic.

The difference between the volume and input series for higher education instruction might have been even smaller were the volume series adjusted for quality. Despite rising inputs per student in higher education instruction, the volume series all implicitly assume that the quality of public higher education is constant over time. It is difficult to adjust for quality because there are few systematic studies of the performance of college students over time; this is in part because the college curriculum is not nearly as uniform across students as the elementary and high school curriculum, and so exactly what is supposed to be tested is not

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[17] See the fourth column of Table 2 of Jaeger and Page (1996). The 4.6 percent return to two or more years of graduate school is calculated by subtracting the 0.178 coefficient on 16 years of schooling from the 0.224 coefficient on 18+ years of schooling.

[18] These are also derived from the fourth column of Table 2 of Jaeger and Page (1996), by subtracting the .083 coefficient on "some college, no degree" from the coefficients on undergraduate degrees earned.

[19] The even split between occupational and academic associate's degrees is approximately the case in Jaeger and Page's data; see Table 1 of their paper.

very clear. If the quality of college instruction is rising over time, the difference in growth rates between the currently used input index and a properly adjusted volume index for higher education may be quite small.

Quantifying the non-instructional component of public higher education output for a volume measure is considerably harder than quantifying the instructional component. Adams and Clemmons (2006) used research papers and citations to measure the productivity of research faculty at a sample of 102 universities in the United States, which they found had risen substantially in public universities over 1981-1995. Rather than attempt to quantify the non-instructional component of public higher education, I used the input measure instead, which grew at a brisk 3.7 percent annual rate over 1980-2001.

The total output of public higher education is measured using a Fisher index of instructional and non-instructional public higher education output. When the enrollment, degrees, or hybrid volume measure is used to measure the instructional component and the input measure is used to measure the non-instructional component, the output of public higher education rises at an annual rate of between 1.9 and 2.0 percent. When the input measure is used for both the instructional and non-instructional components, the output of public higher education rises at an annual rate of 2.7 percent. The difference in annual growth between a simple (and partial) volume measure and the currently used input measure is a small 0.7 to 0.8 percent. Since there have been no quality adjustments to the volume index for the instructional component and since there is some evidence that research productivity has been rising, a more sophisticatedly measured gap might be even smaller.

Volume Indexes for the Entire Public Education Sector

Measuring the output of the entire public education sector involves combining three components: elementary and secondary education, higher education, and "other" education, which includes public libraries. Combining the three components is a straightforward application of the Fisher index. I used the input measure for "other" education, which ranges between 3.7 and 4.3 percent of nominal education output over the period studied. When "other" education is combined with the non-instructional component of higher education—the other part of education output for which I did not create a volume index—the resulting sum ranges between 10.1 percent and 11.9 percent of nominal education output. Put roughly, the "volume" indexes presented here for the entire public education sector are more approximately 90/10 volume/input indexes.

Growth rates for two combined volume indexes for public education are presented in Table 3. One combines the slowest-growing volume indexes: the unadjusted count of elementary and secondary students and the weighted FTE count of enrolled college and graduate students. The other combines the fastest-growing volume indexes: the count of elementary and secondary students adjusted for raw NAEP math scores, and the weighted count of earned college degrees. The slower-growing volume measure grows at a rate of 1.1 percent, while the fast volume measure grows at a rate of 1.5 percent. By comparison, the growth rate of the input index for public education is 2.5 percent.

The three general indexes are plotted in Figure 3. Unsurprisingly, the overall picture is not much different from the separate pictures for elementary and secondary and for higher education. The two volume measures resemble each other more closely than they resemble the input measure, and grow at a considerably slower pace. Overall, the results suggest strongly that volume measures of public education output grow substantially slower than the currently employed input measures.

Does the growth gap between the input measure and our volume measures for education suggest that there is a problem with either from a measurement perspective? Probably not. It is not the goal of a fully quality-adjusted output volume measure to replicate the input measure; indeed, there would be no point to estimating a volume measure were it not for the possibility that it might be different from the input measure. The availability of two different measures for education from two different approaches to measurement offers many chances for insight in the public education sector.

Conclusions

The previous sections presented and discussed volume measures for public education output. Volume measures of the output of the education function of government appear to grow at a slower rate than the currently employed input measure; over 1980-2001, the difference was between one and one and a half percent a year. BEA expects to continue investigation into volume measures and other alternative measures of government output for the United States, with the ultimate goal of providing a suite of alternative output measures for researchers and other users of the National Income and Product Accounts.

References

Adams, James, and J. Roger Clemmons (2006), "The Growing Allocative Inefficiency of the U.S. Higher Education Sector," Rensselaer Polytechnic Institute, mimeo.

Bowles, Samuel, Herbert Gintis, and Melissa Osborne (2001), "The Determinants of Earnings: A Behavioral Approach," *Journal of Economic Literature* 39(4), pp. 1137-1176.

Chambers, Jay, Thomas Parrish and Jenifer Harr (2004), "What Are We Spending on Special Education Services in the United States, 1999-2000?", Special Education Expenditure Project.

Flores-Lagunes, Alfonso, and Audrey Light (2004), "Identifying Sheepskin Effects in the Return to Education," mimeo., April 2004.

Fraumeni, Barbara, Marshall Reinsdorf, Brooks Robinson, and Matthew Williams (2004), "Price and Real Output Measures for the Education Function of Government: Exploratory Estimates for Primary and Secondary Education," Conference on Research in Income and Wealth, Conference on Price Index Concepts and Measurement, Vancouver, B.C., June 28-29.

Jaeger, David, and Marianne Page (1996), "Degrees Matter: New Evidence on Sheepskin Effects in the Returns to Education," *Review of Economics and Statistics* 78(4), pp. 733-740.

Rivkin, Steven, Eric Hanushek, and John Kain (2005), "Teachers, Schools, and Academic Achievement," *Econometrica* 73(2), pp. 417-458.

To, Duc-Le (1987), *Estimating the Cost Of a Bachelor's Degree: An Institutional Cost Analysis* (Washington, D.C.: Office of Educational Research and Improvement, U.S. Dept. of Education).

Winston, Gordon, and Ivan C. Yen (1995), "Costs, Prices, Subsidies, and Aid in U.S. Higher Education," The Williams Project on the Economics of Higher Education, Discussion Paper No. 32.

Table 1: Alternative Measures of Output Volume and Price Growth in Public Elementary and Secondary Education

	Annual output growth			Annual price growth		
	1980- -1990	1990- -2001	1980- -2001	1980- -1990	1990- -2001	1980- -2001
Input measure:						
State and local consumption and sales for elem./sec. education	2.15%	2.65%	2.41%	5.40%	2.87%	4.07%
Volume measures:						
Unweighted count of students	0.08%	1.33%	0.73%	7.58%	4.21%	5.80%
Weighted count, 1 special ed = 2 regular ed	0.18%	1.47%	0.85%	7.47%	4.07%	5.67%
Weighted counts with adjustments for school inputs:						
Lower-bound adjustment	0.25%	1.52%	0.92%	7.39%	4.01%	5.61%
Upper-bound adjustment	0.42%	1.64%	1.06%	7.22%	3.89%	5.46%
Weighted counts with adjustments for test scores:						
Lower-bound adjustment for raw scores	0.35%	1.53%	0.97%	7.30%	4.00%	5.56%
Upper-bound adjustment for raw scores	0.72%	1.68%	1.22%	6.90%	3.85%	5.29%
Lower-bound adjustment for scores with parents' ed controlled	0.24%	1.50%	0.90%	7.41%	4.03%	5.63%
Upper-bound adjustment for scores with parents' ed controlled	0.37%	1.58%	1.00%	7.28%	3.95%	5.52%

Notes:

All measures except the input measure and the unweighted count of students count special-education students as the equivalent of two regular-education students.

All adjusted measures adjust for quality by multiplying the count of students weighted for special education by a measure of school quality normalized to 1 in 1996.

The lower-bound adjustment for school inputs weights a 10 percent decline in the pupil/teacher ratio or a 10 percentage point decline in the percentage of teachers with fewer than two years of experience as the equivalent of a 1 percent increase in the quality of education.

The upper-bound adjustment for school inputs weights a 10 percent decline in the pupil/teacher ratio or a 10 percentage point decrease in the percentage of teachers with fewer than two years of experience as the equivalent of a 3.3 percent increase in the quality of education.

The lower-bound adjustment for test scores weights a 1 standard deviation (31-point) increase in NAEP math scores for 17-year-olds as reflecting an increase in the quality of education by a factor of one-twelfth.

The upper-bound adjustment for test scores weights a 1 standard deviation (31-point) increase in NAEP math scores for 17-year-olds as reflecting a 27.5 percent (3.3 ÷ 12 × 100%) increase in the quality of education.

Scores with parents' ed controlled sets NAEP test takers to their 1996 distribution across five parents' education categories: less than high school, high school degree, some college, college degree, and unknown.

Table 2: Alternative Measures of Output Volume and Price Growth in Public Higher Education Instruction

	Annual output growth			Annual price growth		
	1980--1990	1990--2001	1980--2001	1980--1990	1990--2001	1980--2001
Input measure:						
State and local consumption and sales for higher ed. instruction	2.15%	2.48%	2.33%	5.37%	2.77%	4.00%
Volume measures:						
Unweighted count of students	1.38%	1.10%	1.23%	6.18%	4.18%	5.13%
Weighted count, part time = 1/3 full time, grad = 2 undergrad	1.20%	1.25%	1.23%	6.36%	4.02%	5.13%
Unweighted count of degrees	1.23%	1.56%	1.40%	6.34%	3.71%	4.95%
Weighted count of degrees	1.23%	1.53%	1.39%	6.34%	3.73%	4.97%
Hybrid count of students and degrees	1.23%	1.31%	1.27%	6.33%	3.96%	5.09%

Notes:

State and local consumption and sales for higher education instruction is equal to chained-dollar (1996) state and local consumption and sales for higher education times instruction's share.

Instruction's share is equal to the proportion of current expenditures for instruction, research, public service, and student services at public institutions that is dedicated to instruction and student services.

Weighted count of degrees weights associate's degrees by 2, bachelor's degrees by 4, master's degrees by 4, first-professional degrees by 6, and doctoral degrees by 8.

Hybrid count of students and degrees weights FTE undergraduate enrollment by 4.45, FTE graduate enrollment by 2.3, associate's degrees by 5.05, bachelor's degrees by 16.2, master's degrees by 5.0, doctoral degrees by 6.7, and first-professional degrees by 28.6.

Table 3: Alternative Measures of Output and Price Growth in Public Education, All Levels

	Annual output growth			Annual price growth		
	1980--1990	1990--2001	1980--2001	1980--1990	1990--2001	1980--2001
Input measure:						
State and local consumption and sales for education	2.20%	2.71%	2.47%	5.40%	2.84%	4.05%
Volume measures:						
Slowest-growing volume measure	0.56%	1.56%	1.08%	7.12%	4.01%	5.48%
Fastest-growing volume measure	1.01%	1.86%	1.45%	6.65%	3.71%	5.10%

Notes:

Slowest-growing volume measure is a Fisher index of an unweighted count of elementary and secondary students, higher education FTE enrollment (graduate years count double), and input measures of the non-instructional function of higher education and "other" education.

Fastest-growing volume measure is a Fisher index of a count of elementary and secondary students adjusted for special education and raw NAEP test scores with the upper-bound adjustment, degrees earned weighted by typical years to completion (graduate years count double), and input measures of the non-instructional function of higher education and "other" education.

Figure 1. Public Elementary and Secondary Education Output Volume Indexes (1996=100)

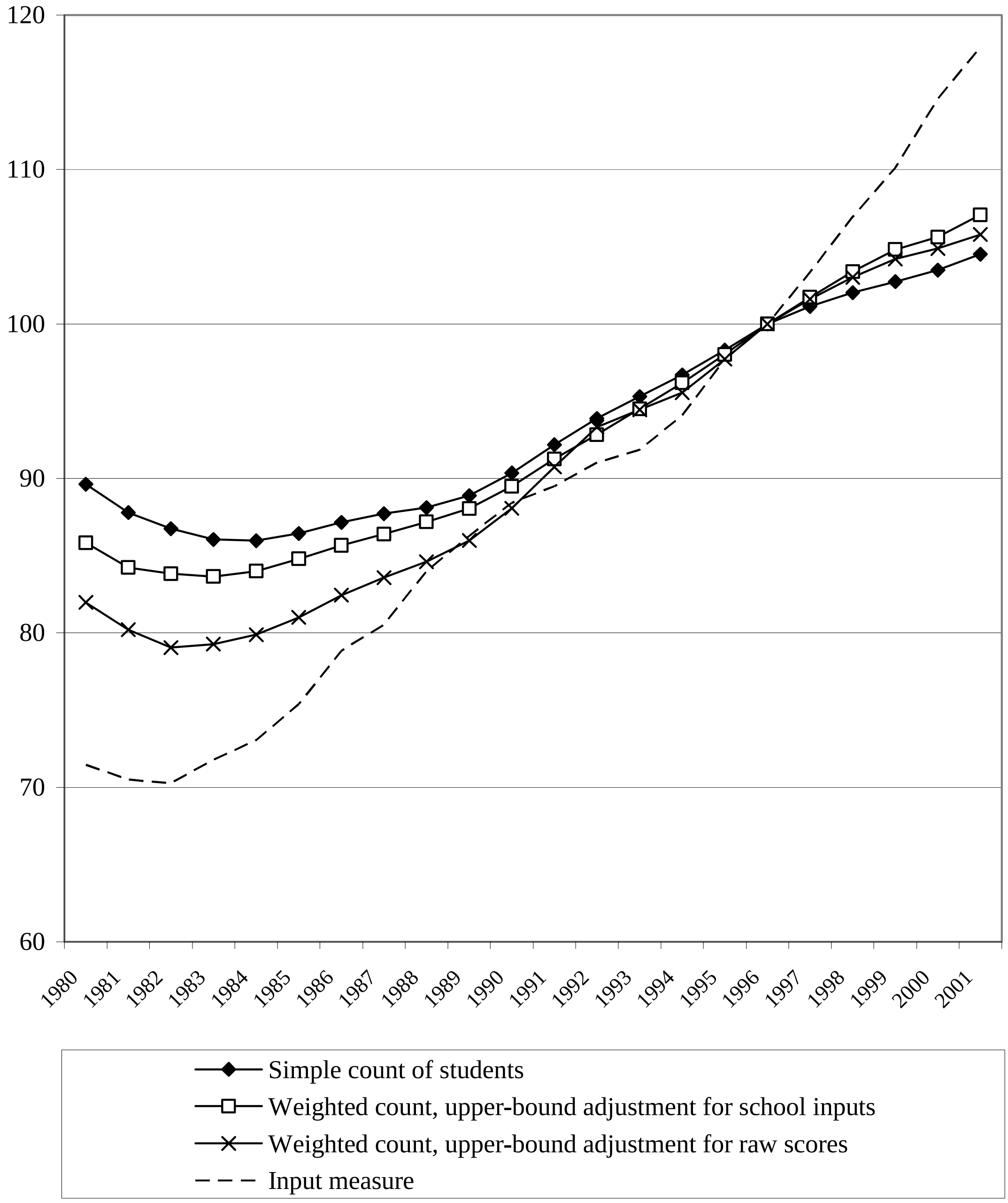

Figure 2. Public Higher Education Instruction Output Volume Indexes (1996 = 100)

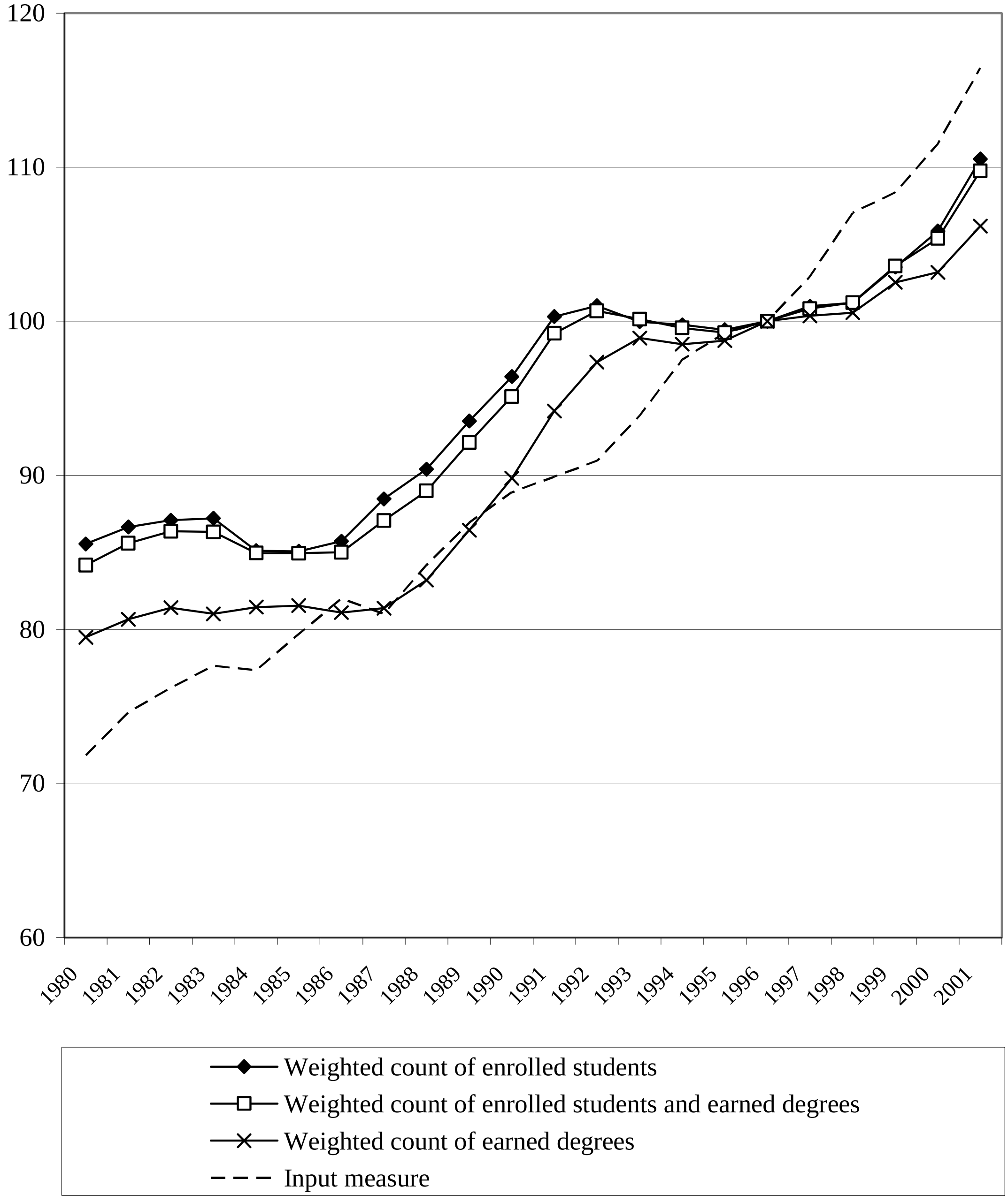

Figure 3. Alternative Total Public Education Output Volume Indexes
(1996 = 100)