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THE DETERMINANTS OF PUBLIC EDUCATION EXPENDITURES: EVIDENCE FROM THE STATES, 1950-1990

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ABSTRACT

We examine a panel data set for the US states over the period 1950-1990 and use it to assess the effects of growth in personal income and number of students on expenditure on public primary and secondary education. Our analysis suggests that the share of personal income devoted to education is roughly constant, implying that per student education expenditures grow at roughly the same rate as personal income per student. We also find evidence that additional factors accounted for an increase in education expenditures over the period 1950-1970.

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1. Introduction

The prominence of public education finance reform in public policy circles over the last twenty-five years has motivated a growing literature in which applied general equilibrium models are used to analyze the consequences of specific educational finance reforms. Inman (1978), one of the earliest papers in this area, investigates the normative features of several education finance systems. More recently, Epple and Romano (1993), Nechyba (1994) and Glomm and Ravikumar (1995) examine the effects of education vouchers, Silva and Sonstelie (1994) and Fernandez and Rogerson (1995) analyze the consequences of California's reform, and Fernandez and Rogerson (1993,1997) study the tradeoffs involved in moving from a local finance system to an equal-spending state financed system.

Not surprisingly, the predictions of these quantitative exercises can depend quite heavily on preferences over education spending, or alternatively, the "demand" for education spending. For example, in their evaluation of California's education finance reform, Fernandez and Rogerson (1995) show that predictions for the change in total spending can vary by as much as 40% depending upon income and price elasticities. Similarly, Reschovsky (1994) discusses the importance of these elasticities for predicting the effect of power-equalizing systems on the dispersion of per-student spending.

Cross-sectional analysis, using either individual survey data or data for a sample of school districts, has been a key source of information for putting restrictions on theoretical models (see Bergstrom, Rubinfeld, and Shapiro (1982) for a survey). We think that longer-run relationships in the data can provide useful complementary information, and hence in this paper we examine time-series evidence using a panel data set for the US states. One motivation for our analysis is the important role that longer-run relationships among wages, hours worked and factor shares, for example, have played in applied general equilibrium analysis for other public finance questions; requiring that a model be consistent with the "growth facts" provides strong restrictions on preferences and technology.

We present results for two time periods: 1970-1990 and 1950-1990. Holding demographic variables constant we find strong evidence that the share of personal income devoted to education is unaffected by growth in income or growth in number of students. It follows that, over the long run, a key determinant of growth in spending per student is the growth in personal income per student. While our results hold for both the shorter and longer time periods, we also find that the period 1950-1970 witnessed a large increase in resources devoted to education that is not accounted for by changes in income or demographics.

In addition to being a useful input into applied general equilibrium analyses of education finance, our findings should also be useful for a second method used to assess the impact of reform. In this literature, a statistical model is posited to describe the evolution of, say, per-student spending over time in response to changes in a set of factors, and asks to what extent dummies which capture the time of reforms (and/or litigation) are correlated with changes in per-student spending. Hickrod et al. (1992), Downes and Shah (1995), Manwaring and Sheffrin (1995) and Murray, Evans and Schwab (1995) are all recent examples of this approach. Since our results suggest relationships which should be embedded in a statistical model, they have implications for model specification. Interestingly, many of the studies mentioned above use specifications which do not embed a constant income share for educational expenditures.

Our analysis is similar in spirit to that contained in a recent paper by Poterba (1996), who examines a panel data set for states in the US over the period 1960-1990. His main focus, however, is on the effect of demographics, in particular age and ethnic composition, on public education spending, rather than the effect of growth in income and students. Nonetheless, some results are common to both studies. For example, each finds evidence that the fraction of the population older than 65 has a negative impact on resources devoted to education, and each finds that increasing the fraction of the population of school age has little effect on education spending.

The structure of the paper follows. In the next section we describe the empirical specification used, and Section 3 describes the data. Results are presented in Section 4 for the period 1970-1990 and in Section 5 for the longer period of 1950-1990. Section 6 discusses the implications of our findings, and Section 7 concludes.

2. Empirical Specification

Our goal is to examine the relationship between longer-run changes in personal income and educational expenditures. A basic principle underlying our empirical work is that expenditures on education will potentially respond differently to "permanent" and "temporary" changes in personal income. Consider the following benchmark specification:

$$\log(X_{it}) = a_i + b_1\log(Y_{it}) + b_2D_{it} + \epsilon_{it} \quad (1)$$

where X is real expenditure on public primary and secondary education, Y is the permanent component of real personal income, D is a vector of demographic variables (e.g. fraction of population of school age, fraction of population over 65) and ϵ is an error term. The indices i and t represent state i and time period t. The variable a_i is a state fixed effect, which may reflect differences in cost factors (e.g. population density), finance systems, or "tastes" for education.[1] Note that the coefficients b_1 and b_2 are assumed to be the same for all states.[2] The basic idea of our analysis is that knowledge of the parameter b_1 provides information on how income and educational expenditures covary over the long run.

A casual look at the data suggests that state fixed effects may be important since there are many examples of states that are similar in terms of income and demographics but that spend very different fractions of their personal income on public education. Moreover, these differences are persistent. As we document below, however, allowing for state fixed effects does not affect our estimates very much.

In a cross-section of states some of the variance in total education spending is accounted for by differences in the size (population) of states. One might suspect that this biases the estimates of b_1 toward one if, on average, states that are twice as large spend roughly twice as much on education. To deal with this issue we transform equation (1) so that size

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[1] Although there are substantial differences across states in the percentage of students in private schools, there is virtually no trend in these series. Hence we do not include any measures of private education in our regressions. Therefore, the state fixed effects will also capture whatever impact the cross-state differences in private education have on the level of funding for public education.

[2] One can write down an explicit model which generates equation (1). See, for example, Fernandez and Rogerson (1995). In such a specification, differences in policy across states which induce differences in the tax price of a unit of education spending show up as differences in the state fixed effects.

effects are removed. There are several ways in which this could be done. One way is to subtract the log of population from each side of equation (1), which makes the dependent variable education spending per capita. A second possibility, and the one we pursue, is to subtract the log of students from both sides of equation (1). We prefer this transformation because the dependent variable becomes the log of per student spending and this is the measure most commonly used in comparisons of educational funding. This transformation yields an equation of the form:

$$\log(x_{it}) = a_i + b_1\log(Y_{it}) + b_2D_{it} + b_3\log(S_{it}) + \epsilon_{it}, \qquad (2)$$

where x_{it} is spending per student and S_{it} is number of students. Though the error terms in (1) and (2) will be different, we use ϵ_{it} as the generic name for the error term. If the specification in (1) were correct, one should obtain an estimate of b_3 equal to negative one. In fact, our results are consistent with this.

An obvious issue is the need to construct a series for the permanent component of personal income. We carry out three different exercises. The first exercise uses actual personal income as a proxy for the permanent component of personal income. Because we use data at five year intervals this is possibly not a bad approximation--as the time between observations increases, one expects the variance in personal income to be dominated by its permanent component. Even if it is a bad approximation, these results are of interest in order to contrast them with those obtained using other methods.

The second exercise constructs a trend series for personal income for each state and identifies Y_{it} with the trend component. To generate the trend series we regress the log of personal income on a constant and a polynomial in time; our benchmark specification uses a linear time trend. Results based on a quadratic trend were basically the same and hence we do not report them.

The third exercise employs the standard technique of first-differencing in panels in order to eliminate fixed effects (see e.g. Chamberlain (1984)). If we first difference personal income between two years that are quite far apart, then the change in personal income is likely to be dominated by the change in the permanent component. First-differencing our data between 1970 and 1990 produces a cross section data set, which we use to estimate (1) and (2) in first-difference form.

There are several remarks related to the error terms ϵ_{it} in equations (1) and (2). We assume that the error term is not correlated contemporaneously with the other right-hand-side variables. If spending on education increases future productivity, it is possible that current values of Y are correlated with lagged values of ϵ. Contemporaneous correlation between these variables is not likely to be an issue, however, since it presumably takes some time for students currently in school to affect productivity.

A second remark concerns the serial correlation properties of the ϵ's. While it may be unrealistic in estimating equation (1) to assume that the ϵ's are independent for relatively close time periods, we do think it is reasonable to assume that they are close to uncorrelated over longer periods. Also, unless the error terms in (1) and (2) follow a random walk, the error terms in the differenced form of these equations are not normally distributed. While this does not bias the parameter estimates, the standard errors may be biased. In any case, we basically find the same results for both the second and third exercises.

Third, we assume in both cases that the ϵ_{it}'s are iid and normally distributed with mean zero and constant variance. If aggregate shocks impact state educational expenditures, then this assumption is violated. While we find some evidence for the existence of aggregate shocks, they are relatively small in comparison to the long-run changes in the data. Moreover, formal statistical analysis of the residuals does not suggest any issue.

One final point should be noted about our analysis. We focus exclusively on education expenditures and do not attempt to separate expenditures into quantity and price components. A key difficulty in performing this decomposition is that while teachers' salaries are the single most important component of educational expenditures, over longer horizons higher salaries presumably affect the quality of teachers and hence the quantity of educational services provided. Rather than take a stand on how to separate expenditures into price and quantity components, in this paper we focus on the behavior of expenditures, leaving these additional issues for future work.[3]

3. Data

We construct a panel data set for the forty-eight states of the continental US for the period 1950-1990. For reasons that will become clear soon, we split the sample into two sub-periods, 1950-1970 and 1970-1990. Our initial analysis focuses on the latter period. Since our interest is in longer-run relationships, we include data at five year intervals, implying

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[3]As discussed later, one interpretation of our findings for the period 1950-1970 is that the unionization of teachers lead to an increase in the relative price of a unit of educational services, and resulted in increased expenditures on education.

five data points for each state. The variables that we study (with notation reference in parentheses) are: real personal income (Y), average daily attendance (S), real current expenditures on public primary and secondary education (X), current expenditures on public primary and secondary education per student in average daily attendance (x). Our demographic variables are: the fraction of the population less than 18 (f18), the fraction of the population between the ages of 5 and 17 (f517), the fraction of the population over 65 (f65), and the fraction of the population over the age of 18 that is over 65 (f65v).[4] Many of these demographic measures are close substitutes and are included as a robustness check. Different stories about why the fraction of old individuals matters may suggest one measure over the other; for example, the last measure may be the more relevant if one has in mind people exerting influence on education expenditure through voting. Also, both f517 and f18 seem to be plausible measures of the fraction of the population for which schooling is relevant. It turns out, in any case, that the results are relatively insensitive to which measures are used.

Because the school year is not the same as the calendar year, we must adjust our data accordingly. Education variables for year t are for the school year ending in June of year t, and are deflated using the average of the CPI's for years t and t-1. Real personal income is computed as the average of real personal income for years t-1 and t. Personal income is also deflated using the Consumer Price Index. Demographic data is as of July 1 for the given year. Sources are listed in the appendix.

[4]We note for future reference that all demographic variables are measured in percentages.

A few points are worth making. First, although current expenditure is not the most comprehensive measure of educational spending, it is the series with the greatest comparability across time and across states. Other measures, such as total expenditures or total revenues are not necessarily comparable across states because of accounting differences in the treatment of retirement programs. Additionally, current expenditure per student is the measure most commonly used to compare the resources available on a per student basis across districts within a state or across states.

Second, the data for 1950 are not strictly comparable to data from 1959 and later because of changes in allocating expenditures to current expenditures. Since it appears that the extent of the incomparability is on the order of 1 or 2 percent, and hence not likely to be that significant for our purposes, we include the data for 1950 in order to lengthen the time series available.[5]

Finally, since the US CPI is used to deflate nominal quantities, no attempt is made to control for differential rates of inflation across states. To the extent that we deflate both income and educational spending by the same factor this should not be a significant issue.

Table One presents several summary statistics for our panel data set. We report statistics for the measure income per student (y), rather than income and students separately. Both y and x are measured in thousands of 1982 dollars.

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[5]Our results are basically unchanged if we only use the data from 1960 on.

Table One Summary Statistics

Variable	Statistic	1950	1960	1970	1980	1990
y	mean	37.7	37.8	45.5	67.2	87.9
	st.dev.	.130	.108	.104	.128	.246
	min	.140	.188	.278	.456	.450
	max	.645	.629	.735	.927	1.47
x	mean	.861	1.21	2.01	2.79	3.77
	st.dev.	.215	.265	.408	.566	.945
	min	.332	.702	1.33	2.03	2.17
	max	1.23	1.91	3.52	4.47	6.33
f517	mean	21.5	25.4	26.4	21.2	18.6
(%)	st.dev.	2.71	2.46	1.45	1.10	2.14
	min	17.3	18.5	23.7	18.4	13.1
	max	27.1	33.6	30.5	24.0	26.6
f65	mean	8.07	9.21	9.87	11.2	12.7
(%)	st.dev.	1.47	1.64	1.68	1.80	1.79
	min	4.90	5.40	6.30	7.50	8.70
	max	10.8	11.9	14.5	17.3	18.3
X/Y	mean	2.38	3.29	4.49	4.18	4.38
(%)	st.dev.	.455	.519	.597	.732	.668
	min	1.75	2.49	3.62	3.10	3.05
	max	3.45	4.32	6.00	5.43	6.95

Note: Y and x are measured in '000's of 1982 US dollars.

The last variable indicated, X/Y, is the percentage of personal income devoted to current expenditure on public primary and secondary education. It is apparent that there is a substantial increase in this fraction over the period 1950-1970 followed by relative constancy over the period 1970-1990. As we will see later, and perhaps not too surprisingly, the two subperiods produce different estimates of the parameter b_1.

It is instructive to examine the growth rates of several variables across states, since it is these differences which allow us to separate the effects of growth in students and income on educational spending. Table Two summarizes the data that result from first-differencing the data between 1970 and 1990, and Table Three displays the correlations among the growth rates.

Table Two Summary Statistics for First Differences, 1970-1990

Variable	Mean	Std.Dev.	Min	Max
Δlog(Y/S)	.65	.10	.38	.83
Δlog(x)	.62	.13	.27	.86
Δlog(X)	.52	.19	.12	.93
Δlog(Y)	.55	.20	.25	1.11
Δf517	-7.8	2.3	-12.4	-2.9
Δf65	2.1	.99	.60	4.7

Table Three Correlations Among Long-Run Changes Across States 1970-1990

	Δlog(Y)	Δlog(S)	Δlog(Y/S)	Δ(f517)	Δ(f65)	Δlog(x)	Δlog(X)
Δlog(Y)	1.00						
Δlog(S)	.87	1.00					
Δlog(Y/S)	.23	-.28	1.00				
Δ(f517)	.23	.15	.16	1.00			
Δ(f65)	-.09	-.25	.31	-.26	1.00		
Δlog(x)	-.08	-.39	.63	.07	.09	1.00	
Δlog(X)	.86	.79	.13	.21	-.20	.26	1.00

Note the strong positive correlation between the variables x and Y/S, a result that is emphasized in the subsequent work.

4. Results for 1970-1990

Though all three estimation exercises outlined in Section 2 yield broadly similar conclusions, the second and third exercises produce slightly larger estimates of the parameter b_1. This outcome seems intuitive, since a priori the first exercise seems most susceptible to the problem of confusing temporary and permanent components of personal income. Nonetheless, for completeness we report the results from all three exercises.

4.1 Results Using Raw Data

Table Four displays the results of estimating equation (1) with the raw data.

Table Four Estimation of Eq.(1) Using Raw Data
(standard errors in parentheses)

Dependent variable is log(X)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
log(Y)	.87	.95	.90	.97	.86	.96	.87
	(.05)	(.06)	(.03)	(.05)	(.05)	(.05)	(.04)
f18	-	.003	-	.013	-	.008	-
	-	(.003)	-	(.005)	-	(.004)	-
f517	-.003	-	-	-	-.001	-	-
	(.003)	-	-	-	(.004)	-	-
f65	-	-	-	.030	.006	-	.008
	-	-	-	(.011)	(.010)	-	(.008)
f65v	-	-	-	-	-	.020	-
	-	-	-	-	-	(.008)	-
Adj R^2	.9937	.9938	.9938	.9937	.9937	.9939	.9938

The specifications used in columns (1)-(3) of Table 4 seem a natural starting point since they contain the two primary components of the allocation problem: total resources and the fraction of the population that are of student age. The coefficient on income is highly statistically significant and close to .9 and total spending is approximately independent of the relative size of the school population. This last result is somewhat surprising since it implies that, holding income constant, increasing the fraction of the population of school age leads to no increase in total spending. Equivalently, the share of personal income devoted to education is independent of the size of the school population, so that an increase in the number of students, holding income constant, leads to an equal and opposite reduction in resources per child. This last result is also found in Poterba (1995).

The specifications above assume that it is the fraction of the population of school age that matters, not the actual size of the school age population. As a check on this feature we repeated the above analysis with the log of the number of students on the right-hand side. The previous parameter estimates were unaffected and the coefficient on students was small and not significantly different from zero.

Since it is often suggested that other demographic factors, in particular the fraction of the population over 65, may influence spending on education, we explore this in the specifications corresponding to columns (4)-(7) in Table 4. The main conclusion to note is that the estimated value of b_1 is relatively unaffected.

We do not report the estimated state fixed effects in the above table-- they are all highly significant statistically. Without state fixed effects, however, the other parameter estimates were basically identical, although the R^2's were marginally lower.

As argued earlier, the estimated value of b_1 obtained above is possibly biased toward one since some of the variation in total expenditure is related to variation in the size of states and, to a first approximation, a state that is twice as large will spend roughly twice as much on education. To examine this we consider results from estimation of equation (2). In addition, this provides a test of the specification in (1), since the estimated value of b_3 should be -1. Results are in Table Five.

Table Five Estimation of Eq.(2) Using Raw Data
(standard errors in parentheses)

Dependent variable is log(x)

	(1)	(2)	(3)	(4)
log(Y)	.91	.75	.89	.80
	(.03)	(.08)	(.08)	(.05)
log(S)	-.92	-.74	-.87	-.81
	(.06)	(.08)	(.10)	(.07)
f18	-	-	.007	-
	-	-	(.007)	-
f517	-	-.007	-	-.009
	-	(.004)	-	(.004)
f65	-	.021	.032	-
	-	(.010)	(.011)	-
Adj R^2	.9310	.9335	.9330	.9325

Two points are worth noting. First, the results do suggest a slight upward bias in the earlier estimates of b_1. Second, estimates of b_3 are sometimes significantly different than -1 at the five percent level.

4.2 Estimates Using Trend Components

Table Six reports results from estimating equations (1) and (2) using linear time trends to obtain measures of the permanent component of personal income.

Table Six Estimates of Eqs.(1) and (2) Using Linear Trend Components
(standard errors in parentheses)

Dependent variable is log(X)

	(1)	(2)	(3)	(4)	(5)
log(Y)	.93	1.02	.99	1.03	1.04
	(.03)	(.06)	(.05)	(.05)	(.06)
f517	-	-	-.007	-	-
	-	-	(.003)	-	-
f18	-	.006	-	-	.0004
	-	(.003)	-	-	(.005)
f65	-	-	-.033	-.023	-.022
	-	-	(.010)	(.008)	(.011)
Adj R^2	.9941	.9942	.9943	.9943	.9943

Dependent variable is log(x)

	(1)	(2)	(3)	(4)
log(Y)	.95	1.05	1.04	.94
	(.07)	(.09)	(.06)	(.03)
log(S)	-.92	-1.02	-1.01	-.90
	(.09)	(.11)	(.08)	(.05)
f517	-.008	-	-	-
	(.004)	-	-	-
f18	-	.001	-	-
	-	(.006)	-	-
f65	-.027	-.023	-.024	-
	(.012)	(.012)	(.012)	-
Adj R^2	.9378	.9362	.9365	.9356

While these results are similar to those obtained using the raw data, the estimated coefficient on income is close to 1 for estimates of both equations and the estimated coefficient on students in equation (2) is always within two standard errors of -1. These results are consistent with the intuition that because the raw data includes a larger amount of variance which is "temporary" in nature, estimates of b_1 based on the raw data are biased toward zero. The coefficient on f65 is consistently negative, while the variables f18 and f517 do not display any consistent pattern. Moreover, even when their estimated coefficient is significant the magnitude is small. For example, if the estimated coefficient is .008, then the mean change in f517 over this period, roughly 8%, implies an increase in spending of approximately 6%, while the changes in both total spending and spending per student average over 50%.

4.3 Results Using Difference Data

Table Seven reports the results based on differenced data, using the years 1970 and 1990.

Table Seven Estimates of Eqs. (1) and (2) Using Differenced Data
(standard errors in parentheses)

Dependent variable is Δlog(X)

	(1)	(2)	(3)	(4)
Δlog(Y)	.94	.90	.87	.94
	(.03)	(.05)	(.07)	(.05)
Δf517	-	-.009	-	-
	-	(.005)	-	-
Δf18	-	-	-.012	-
	-	-	(.008)	-
Δf65	-	-.017	-.024	-.001
	-	(.014)	(.018)	(.010)

Dependent variable is Δlog(x)

	(1)	(2)	(3)	(4)
Δlog(Y)	.93	.96	1.01	.94
	(.03)	(.08)	(.07)	(.20)
Δlog(S)	-1.06	-1.10	-1.15	-1.07
	(.07)	(.11)	(.10)	(.22)
Δf517	-	-.007	-	-
	-	(.006)	-	-
Δf18	-	-	-	.001
	-	-	-	(.015)
Δf65	-	-.024	-.018	-
	-	(.016)	(.015)	-

Once again, the results imply that the share of income devoted to education is roughly constant in the face of changes in income and number of students. Since the results of this exercise are virtually identical to that found in Table Six, we do not discuss them further.[6]

4.4 Specification

In this subsection we address several issues related to our specification. We begin by analyzing the residuals from our regressions. In

[6]We also repeated the above analysis splitting the sample of states in various ways (for example, we divided the states by region, by population growth and by income growth). The results were basically unaffected.

the interest of space we limit our analysis to the case of column (1) in the second panel of Table Six.

First, we compute the mean and standard deviation of the residuals for each of the time periods (i.e. the mean and variance of ϵ_{it} for t=1-5). These are reported below:

	1970	1975	1980	1985	1990
mean	.009	-.013	.005	-.040	.039
sdev	.059	.069	.056	.069	.061

The data for the means suggest that there may be aggregate factors which affect spending per student across states, although the effects do not seem particularly large. The standard deviation appears to be relatively constant over time.

Second, we examine the distribution of the residuals. Figure 1 provides a histogram of all of the residuals. By assumption, this distribution should be normal, and casual inspection of the histogram does not suggest any trouble. More formally, we carried out a Kolmogorov-Smirnov test for normality with mean zero and standard deviation equal to .0675 (the sample standard deviation) and do not reject normality at the 20% level.[7] We conclude that the specification employed is a reasonable one.

Until now we have treated the state level data as a panel. It is also of interest to see how the results are affected by treating each state

[7] We also carried out this test on the residuals year by year. The same results holds for 1970, 1975 and 1980. For 1985 and 1990 it fails at even the 1% level. This last finding may not be surprising since the means for these two years are not as close to zero. The residuals for these years did pass at the 20% level when the null was normal with the year specific sample mean. We also note that the residuals from the specification in column (1) of Table Eight also pass a Kolmogorov-Smirnov test at the 20% level.

individually. A difficulty arises in attempting to repeat the above analysis for a single state, since for some specifications this amounts to including several variables on the right hand side, each of which has a pronounced trend. This problem is easily handled, however, if one notes that the results obtained above suggest that personal income per student is an appropriate choice of variable for the right-hand side if spending per student is the dependent variable. In fact, if we use either estimation exercise two or three, the coefficient on income per student is not significantly different from one in such a regression.

Hence, Table Eight reports results from running a regression of the form:

$$\log(x_{it}) = a_i + b_i \log(y_{it}) \quad (3)$$

for each of the 48 states in our data set, using a linear trend to construct the permanent component for the variable y. The values in the table are the estimates of b_i, with standard errors in parentheses. We also estimated equations with total spending on the left-hand side and income on the right hand side--the results were very similar.

Table Eight State Regressions of Equation (3)

ST	b	ST	b	ST	b	ST	b	ST	b
AL	.86(.07)	ID	1.13(.15)	MA	.95(.19)	NM	.72(.19)	SD	.80(.12)
AZ	.71(.04)	IL	.86(.12)	MI	.86(.09)	NY	.90(.06)	TN	.88(.07)
AR	1.01(.01)	IN	1.10(.10)	MN	.65(.02)	NC	.87(.11)	TX	1.42(.20)
CA	.72(.11)	IA	.86(.11)	MS	.99(.17)	ND	1.12(.13)	UT	.76(.20)
CO	.91(.13)	KS	.92(.16)	MO	.94(.07)	OH	1.13(.06)	VT	1.13(.21)
CT	.96(.14)	KY	1.13(.13)	MT	1.14(.18)	OK	1.04(.20)	VA	.88(.06)
DE	.82(.10)	LA	1.04(.07)	NB	1.15(.03)	OR	.92(.08)	WA	.74(.19)
FL	.86(.09)	ME	1.09(.20)	NE	.64(.11)	PA	1.02(.03)	WV	1.41(.21)
GA	1.05(.10)	MD	.81(.06)	NH	.92(.11)	RI	.97(.02)	WI	.97(.06)
				NJ	1.08(.23)	SC	.94(.02)	WY	1.66(.28)

Not surprisingly, the standard errors are now much larger. Figure 2 shows a histogram for the b_1 estimates. Roughly two thirds of the estimates lie in the interval .85-1.15.[8]

Lastly, we contrast our findings with those that result from a cross-section regression that uses state-level data for a single year. The results vary a bit from year to year, but those presented in Table Nine for the 1990 cross-section are typical. The regressions included a constant term that is not reported in the table.

Table Nine Cross-Section Regression, 1990
(standard errors in parentheses)

Dependent variable is log(X)

	(1)	(2)	(3)	(4)	(5)
log(Y)	.94	.96	.95	.94	.94
	(.02)	(.02)	(.02)	(.02)	(.02)
f517	-.004	-	-	-.002	-
	(.010)	-	-	(.009)	-
f18	-	.022	.017	-	-
	-	(.010)	(.008)	-	-
f65	-.004	.012	-	-	-
	(.012)	(.012)	-	-	-
f65	-	-	-.10	-	-
	-	-	(.38)	-	-
Adj R^2	.9819	.9839	.9839	.9823	.9827

[8]Of those that lie outside this interval, some are cases where major reforms occurred and hence it is not expected that the coefficient will be equal to 1. For example, both California and Washington moved to very centralized systems over this period, and both witnessed growth in spending per student much lower than the growth rate in personal income per student. At the other extreme, Texas and West Virginia have two of the larger estimated coefficients and both are states that instituted reforms.

Dependent variable is log(x)

log(Y)	.78	.83	.77	.78	.77
	(.07)	(.12)	(.07)	(.07)	(.07)
log(S)	-.82	-.87	-.81	-.82	-.81
	(.08)	(.12)	(.08)	(.08)	(.08)
f517	-	-	-.007	-	-.007
	-	-	(.009)	-	(.009)
f18	-	.006	-	-	-
	-	(.013)	-	-	-
f65	-	-	-	.003	.001
	-	-	-	(.011)	(.011)
Adj R^2	.73	.72	.73	.73	.72

An important difference between these results and those obtained earlier is the estimated coefficient on income when the dependent variable is spending per student. The results in the second panel suggest that this coefficient is around .8, whereas the earlier results indicated a value near to one.[9]

There are at least two potential factors which account for the different results using cross section and panel techniques. First, in a cross-section a larger amount of the variance in income may be temporary in nature, and second, this procedure ignores the differences in fixed factors across states.

5. Results for 1950-1990

We now examine the data for the period 1950-1990. Our basic findings are as follows. First, over the period 1950 to 1970, spending on education grew at a significantly greater rate than personal income, and this holds for virtually all states in the sample. In particular, this pattern is not peculiar to states that were low spenders in 1950, had low income in 1950, or were in a specific geographic region. One interpretation of this finding is

[9]Although the first panel still produces estimates close to 1, as discussed earlier, these estimates are likely to be biased toward one. The demographic variables are not significant.

that the parameter b_1 exceeds one over this period and, therefore, is not stable over time. An alternative explanation for the difference in estimates across periods is that there are some omitted factors which are important in accounting for education spending in the first period but not in the second. In what follows we carry out an analysis that is in the spirit of this second interpretation.

What might these omitted factors be? There are two broad factors which we believe may be jointly relevant. One is that as of 1950 the country had been through the Great Depression and World War II. It is possible that this resulted in unusually low levels of public spending on education as of 1950 and hence that for some years spending would increase relative to income.[10] The other factor is that the period 1950-1970 corresponds to a period of major structural change in the education sector. Three aspects seem relevant. First, it is during this period that (at least) a high school education comes to be viewed as necessary for economic success later in life. Second, this period witnesses the formation of the education establishment, one aspect of which is the unionization of teachers and their becoming a political force. Third, at least partly in response to the Soviet launching of Sputnik, the federal government passed the National Defense Education Act of 1958 which led to a large increase in federal support for primary and secondary education. A simple calculation suggests that this last factor may be important. The amount by which the growth in real federal support over the period 1950-1970

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[10] In principle this would seem to be easy to verify, since it only requires checking the share of personal income devoted to education prior to 1930. However, as we argue, there is clearly a large structural change in the role of primary and secondary education over the period 1900-1950, thus making it very difficult to disentangle the two.

exceeded the growth in real personal income can account for an increase in spending of slightly more than 30% over this period.[11]

Accepting the potential importance of these factors during the period 1950-1970, one is lead to use a time dummy to distinguish the pre and post 1970 periods. In the interest of space we only report the results from regressions using first-differenced data. We construct a data set with 96 observations by first-differencing between both 1970 and 1950 and 1990 and 1970. We include a time dummy which is one if the observation is for the 1950-1970 period and zero otherwise. Table Ten displays the results.

Table Ten Estimates Using Differenced Data, 1950-1970 and 1970-1990
(standard errors in parentheses)

Dependent variable is Δlog(X)

	(1)	(2)	(3)	(4)	(5)	(6)
Δlog(Y) 70-90	-	-	-	-	.93	.91
	-	-	-	-	(.08)	(.07)
Δlog(Y) 50-70	-	-	-	-	.94	1.03
	-	-	-	-	(.03)	(.06)
Δlog(Y)	1.47	1.42	1.34	1.00	-	-
	(.04)	(.05)	(.05)	(.04)	-	-
Δf517	-	.043	-	-	-	-.003
	-	(.006)	-	-	-	(-.005)
Δf18	-	-	.045	-	-	-
	-	-	(.003)	-	-	-
Δf65	-	-	.048	-.017	-	-.029
	-	-	(.015)	(.008)	-	(.012)
1950-1970 dummy	-	-	-	.67	.70	.78
	-	-	-	(.03)	(.06)	(.08)

Several points are worth remarking. First, as mentioned earlier, if a time dummy is not used, the coefficient on income is much larger than 1 (see columns (1)-(3)). In column (4), a time dummy is used for the first period,

[11]Some care must be taken in interpreting this figure, since depending upon how the federal aid is administered it may be expected to displace some spending that was previously provided at either the state or local level.

and the coefficient on income is constrained to be the same in both periods. The estimated coefficient is 1.00, with a small standard error. Columns (5) and (6), however, show that once a time dummy is used for the 1950-1970 period, the coefficient on income is basically the same in the two periods, even if this is not imposed. The estimated coefficient for the time dummy is very large--expenditures increase by roughly 70% in excess of that accounted for by income and demographic factors.

Of course, these results do not account for why spending per student grew so quickly during the 1950-1970 time period. We leave a detailed analysis of this for future work.

6. Discussion

The main issue we discuss here is the extent to which our estimates are providing useful additional information to that obtained from the literature on cross-sectional estimates. There are a large variety of cross-sectional studies in the literature, much of which is surveyed in Bergstrom et al. (1982). Our discussion here is based on a generic example of this work rather than any one particular paper.

Assume, for simplicity, that one has data at the household level for a variety of variables, including preferred local tax rates for education spending.[12] Income is simply family income. The price of education is defined to be the amount by which taxes would have to increase in order to

[12]This last piece of information is usually not available. Bergstrom et al. (1982) have survey data which provides information on whether individuals prefer higher or lower tax rates than those currently in place. For the purposes of our discussion, it is simplest to assume the existence of data on the preferred tax rates.

increase per-student expenditures by one dollar, assuming a proportional tax on housing value. Implicit in this calculation is that all financing at the margin is done locally. This price is proportional to the ratio of the individual's house value to the district average housing times the inverse of the average number of children per family. Note that this price will vary across individuals. With this information one can run a regression of preferred tax rates on income and prices (all measured in logs), and possibly some other variables, such as age of household, or number of children present. The coefficients on the income and price variables obviously provide information on how preferred tax rates respond to changes in these variables.

The coefficient on income is actually a subtle object. Imagine initially that all the data is for households in a given school district. Then the coefficient on income in this exercise is the answer to the following question: In a given district, holding housing value constant, how does a change in an individual's income affect their desired expenditure on education? Typically, an individual with higher income might also be expected to have a different choice of housing, thereby implicitly affecting the price variable also. If the individuals come from different districts and people are stratified across districts, then the coefficient on income is partially picking up the effect of community choice, but still holds the price variable fixed. Moreover, if the communities are receiving different amounts of state aid, for example, the estimated income elasticity would also be picking up the manner in which these amounts covaried with income across districts.

Given the estimates obtained in this manner, it is not obvious how they would be used to answer the following question: If everyone's income increases by one percent, by how much will spending on education increase? The difficulty is that this change will presumably affect the volume of underlying state aid in addition to the marginal contribution from local sources captured above. In contrast, the estimates obtained in our paper are aimed at answering exactly this question.

The point is that the cross-sectional regressions referred to above and the time-series regressions employed in this paper provide answers to different questions, and each may be useful in assessing a given model specification. A stylized example taken from Fernandez and Rogerson (1995) may help to illustrate. Suppose that there are a large number of households that differ in their income level, but that each has identical preferences over non-education spending (c) and education spending (q), given by u(c,q). Assume a mechanism that sorts people a la Tiebout into communities that are homogeneous in income. Fernandez and Rogerson (1995) show that given a particular financing system (e.g., power equalizing, foundation, pure local, etc.) a given percentage increase in everyone's income that leaves community structure unchanged leads to an equal percentage increase in total educational spending if and only if the function u is homothetic.

For example, consider the utility function:

$$c^{\alpha}/\alpha + aq^{\gamma}/\gamma, \tag{3}$$

or any monotone transformation of this function. Homotheticity requires that α equals γ, but does not restrict the value of this parameter.[13] Given the

[13]Fernandez and Rogerson (1995) show, in the context of a California style reform, that this condition is quite powerful in restricting the potential outcomes. They assumed that collective choices are made by majority vote, but this could be generalized.

restriction $\alpha=\gamma$, however, the cross-sectional estimates referred to above provide information on the value of this single parameter, since in many finance systems this parameter affects the cross-sectional profile for spending as a function of income.

7. Conclusion

This paper examined a panel data set for the US states over the period 1950-1990 and used it to assess the effects of growth in personal income and students on public primary and secondary education expenditure. Our findings suggest an expenditure share for education that is roughly constant. One qualification that should be noted is that expenditures grew much more rapidly than did personal income over the period 1950-1970, although we found that this can be accounted for as a period-specific fixed effect common to all states.

Our results imply that over this period, per-student educational expenditures tended to grow at the same rate as personal income per student. An important implication of this finding is that increases in enrollment have equal but opposite effects on per-student expenditures. Our finding of a unitary coefficient on personal income in time series analysis is in contrast to the smaller coefficients found in cross-section analyses, but is not inconsistent with those measures, since the coefficients refer to different experiments conceptually. The information provided by the study of longer-run relationships such as the ones studied here should be valuable inputs for the anaysis of education finance reforms in applied general equilibrium models.

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Appendix

Data Sources:

Personal income is taken from State Personal Income 1929-1993, US Department of Commerce.

CPI is taken from Economic Report of the President 1992.

Education data for 1960, 1970, 1980, 1985 and 1990 is from Digest of Educational Statistics 1993, US Department of Education. Data for 1950 and 1975 are taken from US Statistical Abstract.

Demographic data are taken from: County and City Data Book 1994 for 1990, the State and Metropolitan Area Data Book 1991 for 1980 and 1970, the State and Metropolitan Area Data Book 1979 for 1950 and 1960, and the US Statistical Abstract for 1975 and 1985.

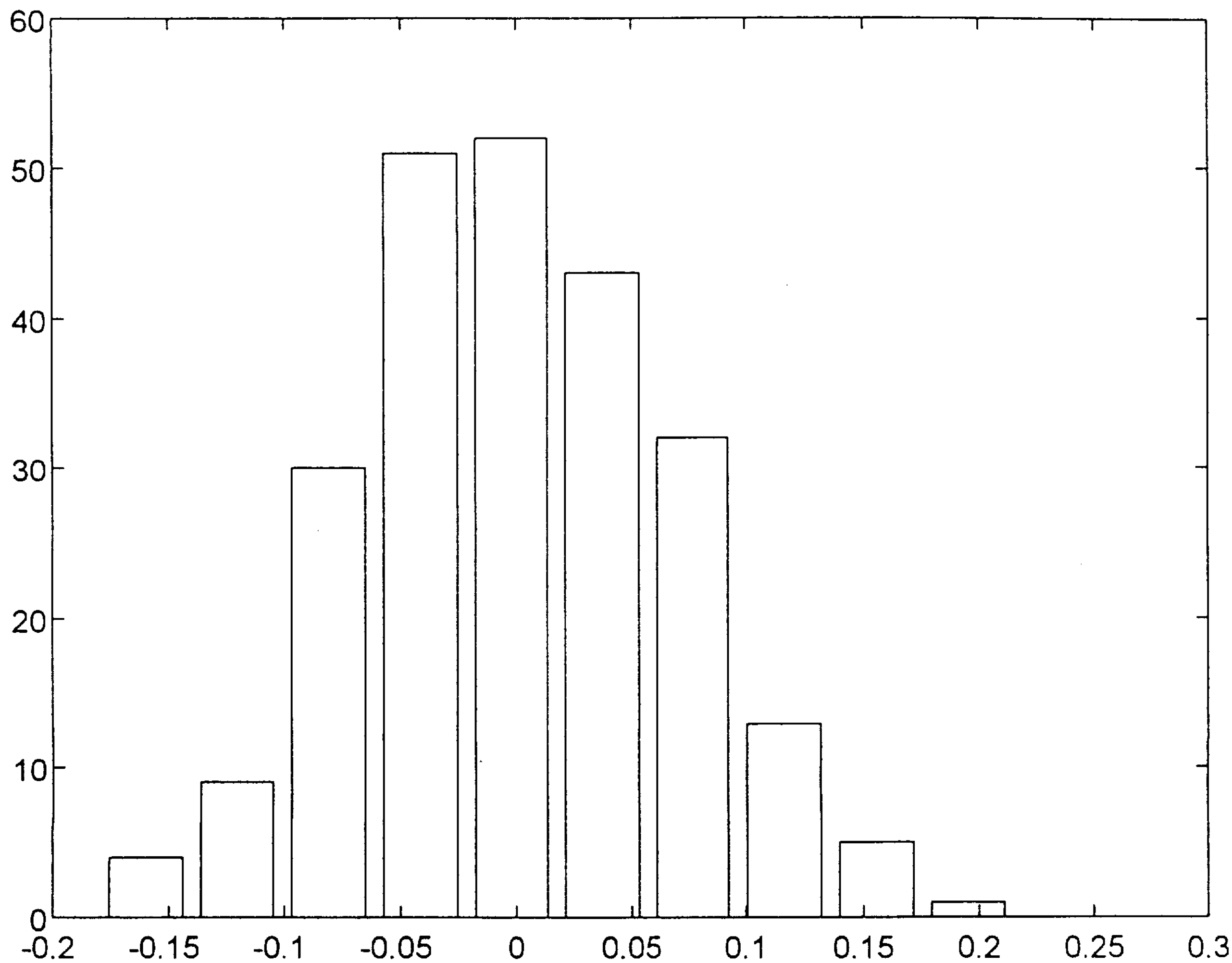

Figure 1
Histogram of Residuals

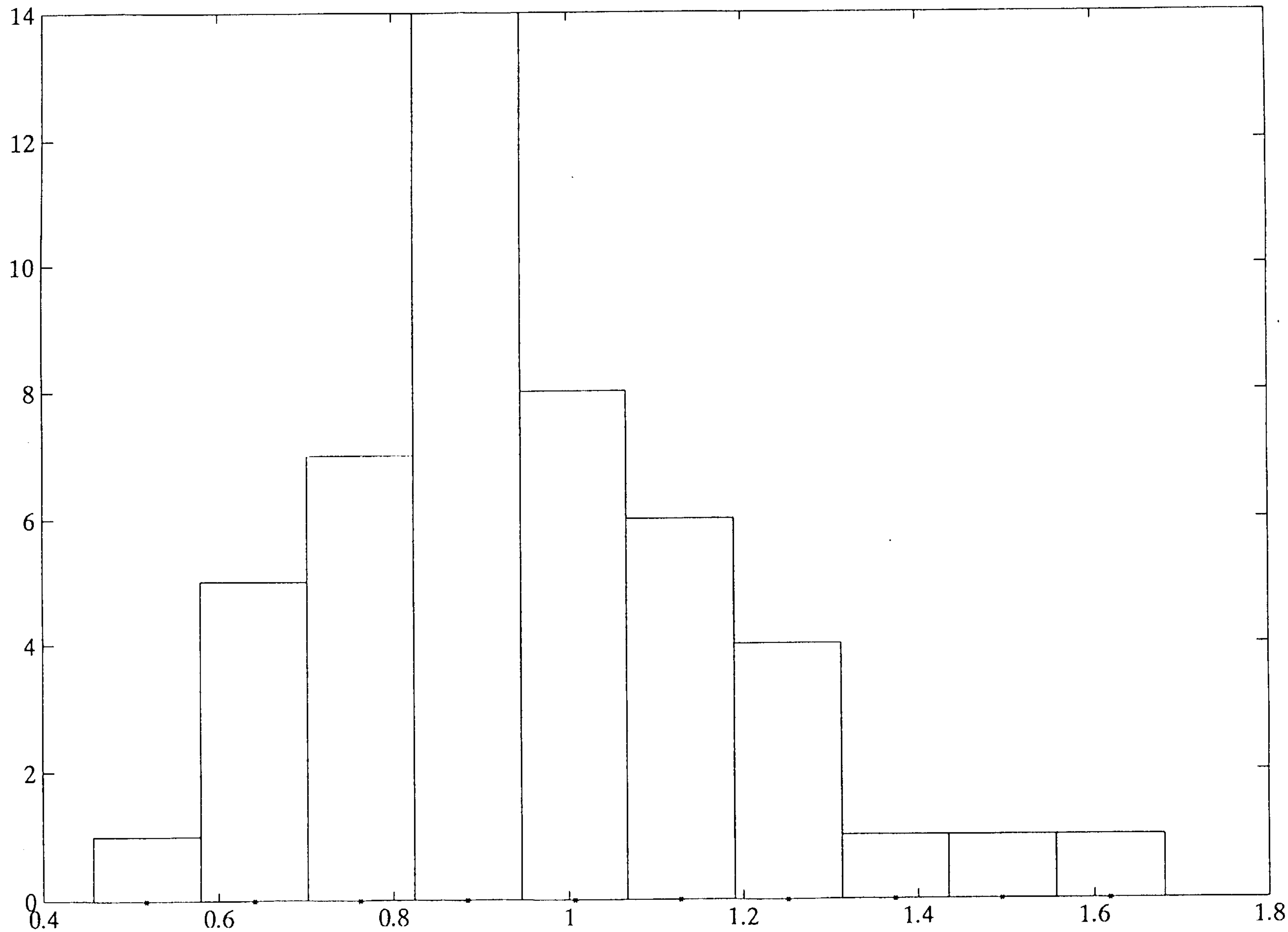

Figure 2
Histogram of b_1 Estimates