The Impact of Differential Expenditures on School Performance

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Two decades of research into educational production functions have produced startlingly consistent results: Variations in school expenditures are not systematically related to variations in student performance. Enormous differences in teacher quality exist, but differences in teacher skill are not strongly related to educational backgrounds, amount of teaching experience, or teaching in small classes. Further, more skilled teachers simply are not regularly paid more than less skilled teachers. These findings suggest that school decision making must move away from traditional "input directed" policies to ones providing performance incentives. The concentration on expenditure differences in, for example, school finance court cases or legislative deliberations, appears misguided given the evidence.

When considering schools and their capabilities, it is natural, particularly for an economist, to turn first to expenditures per student. After all, if schools are doing a good job of allocating money, the level of expenditures provides a readily available index of school quality. This index could be used to judge equity in the provision of schooling and could be the object of state level policy decisions about schools. But this assumes that "schools are doing a good job of allocating money." In truth, they do not seem to be doing very well with their expenditures, and, thus, the prevalent use of information on expenditures in state legislatures, in the courts, and in general policy discussions appears inappropriate.

This article reviews research on expenditure relationships in schools. Based on the review, it then considers a number of policy implications. The implications are most direct in the case of state school finance deliberations, but they are also important in other policy areas.

Production Functions and Educational Research

Although research into the determinants of students' achievement takes a variety of approaches, the most appealing and useful to economists is the *production-function approach* (also called the *input-output* or *cost-quality approach*). In this, primary attention focuses on the relationship between school outcomes and measurable inputs into the educational process.[1] If the production function for schools is known, it is then possible to predict what would happen if resources were added or subtracted and to analyze what actions should be taken if the prices of various inputs were to change. The problem, of course, is that the production function for education is not known and must be inferred from data on students and their schools.

The origin of estimation of input-output relations in schools is usually traced to the government's monumental study, *Equality of Educational Opportunity*, or, more commonly, the "Coleman Report" (Coleman et al., 1966). This report was the U.S. Office of Education's response to a requirement of the Civil Rights Act of 1964 to investigate the extent of inequality in the nation's schools, and, even though it was not the first such effort, the Coleman Report was much larger and more influential than any previous (or subsequent) study. The study involved surveying and testing six hundred thousand students in some three thousand schools across the country.

The study's fundamental contribution was directing attention to the distribution of student performance—the output with which we are concerned. Instead of addressing questions of inequality by producing an inventory of differences among schools and teachers by race and region of the country, it highlighted the relationship between inputs and outputs of schools.

The report captured attention not, however, because of this innovative perspective or its unparalleled description of schools and students. Instead, it was much discussed because of its conclusions. It found that schools are not very important in determining student achievement; families and, to a lesser extent, peers are the primary determinants of variations in performance. The findings were clearly controversial and immediately led to a large (but not concerted) research effort to compile additional evidence about input-output relationships in schools.[2] This paper reviews the now large number of studies that followed, with a focus on their views on the relationship between spending and school performance.

The underlying model guiding most of these analyses has been very straightforward. It assumes that the output of the educational process, that is, the achievement of individual students, is related directly to a series of inputs. Some of these inputs, for instance, the characteristics of schools, teachers, curricula, and so forth, are controlled by policy makers. Others, those of families and friends, plus the innate endowments or learning capacities of the students, are generally not controlled. Further, although achievement may be measured at discrete points in time, the educational process is cumulative; past inputs affect students' current levels of achievement.

Given this model, statistical analysis, typically some form of regression anal-

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ysis, is employed to infer specific determinants of achievement and the importance of the various inputs into student performance. The accuracy of the analysis and the confidence the answers warrant depend crucially on a variety of measurement, sampling, and technical estimation issues. This discussion sets aside these issues (for a full discussion, see Hanushek, 1979, 1986); instead it highlights the major findings and major unanswered questions from the research. (Other reviews and perspectives on this body of work can be found in Bridges, Judd, & Moock, 1979; Glasman & Biniaminov, 1981; Murnane, 1981b.)

A majority of studies into educational production relationships measure output by standardized achievement test scores, although significant numbers have employed other quantitative measures, such as student attitudes, school attendance rates, and college continuation or dropout rates. The general interpretation, particularly with the test scores, is that these are indicators of future success, either in schooling or in the labor market.[3]

Empirical specifications have varied widely in details, but they have also had much in common. Family inputs tend to be measured by socio-demographic characteristics of the families, such as parental education, income, and family size. Peer inputs, when included, are typically aggregate summaries of the socio-demographic characteristics of other students in the school. School inputs include measures of the teachers' characteristics (education level, experience, sex, race, and so forth), of the school's organization (class sizes, facilities, administrative expenditures, and so forth), and of district or community factors (for example, average expenditure levels). Except for the original Coleman Report, most empirical work has relied on data, such as the normal administrative records of schools, which were constructed for other purposes but that can be supplemented in some manner.[4]

Schools, Expenditures, and Achievement

There is a core set of factors, those that determine basic expenditures, that has been broadly investigated in the production-function context. Instructional expenditures make up about two-thirds of total school expenditures. Given the number of students in a school district, instructional expenditures are, in turn, determined mostly by teacher salaries and class sizes. Finally, most teacher salaries are directly related to years of teaching experience and educational levels. Thus, the basic determinants of instructional expenditures in a district are teacher experience, teacher education, and class size, and most studies, regardless of what other descriptors of schools might be included, analyze the effect of these factors on outcomes. (These are also the factors most likely to be found in any given data set, especially if the data come from standard administrative records.)

This commonality in the parameters of analysis permits easy tabulation of the effects of the expenditures. A relatively exhaustive search uncovered 187 separate "qualified studies"[5] in 38 separately published articles or books. These studies, although restricted to public schools, include all regions of the United States, different grade levels, different measures of performance, and different analytical and statistical approaches. Table 1 provides a summary of basic attributes of the data used in the studies. About one-third draw their data from a single school district, whereas the remaining two-thirds compare school performance across multiple districts. Additionally, a majority of the studies (104) use individual students as the unit of analysis, with the remainder relying upon aggregate school, district, or state-level data. As shown in Table 2, the studies are about evenly split between primary schooling (grades 1-6) and secondary schooling (grades 7-12). Over 70% of the studies measure school performance by some kind of standardized test. However, those that use nontest measures (such as dropout rates, college continuation, attitudes, or performance after school) are for obvious reasons concentrated in studies of secondary schooling. There is no indication that differences in sample and study design lead to differences in conclusions, and thus only an overall tabulation of results is presented.[6]

Table 3 summarizes the expenditure parameters of the 187 studies. Because not all studies include each of them, the first column in Table 3 presents the total number of studies for which an input can be tabulated. For example, 152 (of the 187) studies provide information about the relationship between teacher-student ratio and student performance. The available studies provide regression estimates of the partial effect of given

TABLE 1
Sample and Unit of Analysis of Included Studies

	Unit of observation		
School sampling	Individuals	Aggregates	All studies
Single district	43	17	60
Multiple districts	61	66	127
All studies	104	83	187

TABLE 2
Grade Level and Output Measurement of Included Studies

	Output measure		
Grade level	Test score	Nontest measure	All studies
Grades 1-6	80	10	90
Grades 7-12	56	41	97
All studies	136	51	187

TABLE 3

Summary of Estimated Expenditure Parameter Coefficients from 187 Studies of Educational Production Functions

Input	Number of studies	Statistically significant		Statistically insignificant			
		+	−	Total	+	−	Unknown sign
Teacher/pupil ratio	152	14	13	125	34	46	45
Teacher education	113	8	5	100	31	32	37
Teacher experience	140	40	10	90	44	31	15
Teacher salary	69	11	4	54	16	14	24
Expenditures/pupil	65	13	3	49	25	13	11
Administrative inputs	61	7	1	53	14	15	24
Facilities	74	7	5	62	17	14	31

Sources: Armor et al., 1976; Behrendt, Eisenach, & Johnson, 1986; Beiker & Anschel, 1973; Boardman, Davis, & Sanday, 1977; Bowles, 1970; Brown & Saks, 1975; Burkhead, 1967; Cohn, 1968, 1975; Dolan & Schmidt, 1987, Dynarski, 1987; Eberts & Stone, 1984; Hanushek, 1971, 1972; Heim & Perl, 1974; Henderson, Mieszkowski, & Sauvageau, 1976; Jencks & Brown, 1975; Katzman, 1971; Kenny, 1982; Levin, 1970, 1976; Link & Mulligan, 1986; Link & Ratledge, 1979; Maynard & Crawford, 1976; Michelson, 1970, 1972; Murnane, 1975; Murnane & Phillips, 1981; Perl, 1973; Raymond, 1968; Ribich & Murphy, 1975; Sebold & Dato, 1981; Smith, 1972; Strauss & Sawyer, 1986; Summers & Wolfe, 1977; Tuckman, 1971; Winkler, 1975.

inputs, holding constant family background and other inputs. These estimated coefficients have been tabulated according to two pieces of information: the sign and the statistical significance (set at the 5% level) of the estimated relationship.

According both to conventional wisdom and generally observed school policies, each tabulated factor should have a positive effect on student achievement. More education and more experience on the part of the teacher both cost more and are presumed to be beneficial; smaller classes (more teachers per student) should also improve individual student learning.[7] More spending in general, higher teacher salaries, better facilities, and better administration should also lead to better student performance. Having a positive sign in the production function is clearly a minimal requirement for justifying a given expenditure or input, but quantitative magnitudes of estimated relationships are ignored here, and only the direction of any effect is analyzed.[8]

Of the 152 estimates of the effects of class size, only 27 are statistically significant, and only 14 show a statistically significant relationship of the expected positive sign.[9] Thirteen display a statistically significant negative relationship. An additional 125 are not significant at the 5% level. Nor does ignoring statistical significance help to confirm benefits of small classes, because the insignificant coefficients lack the expected sign by a 46 to 34 margin.[10]

The entries for teacher education tell a similar story. In a vast majority of cases (100 out of 113), the estimated coefficients are statistically insignificant. The statistically significant results are split between positive and negative relationships, and forgetting about statistical significance and just looking again at estimated signs does not allow a better case for the importance of added schooling for teachers.[11]

Teacher experience is possibly different. At least a clear majority of estimated coefficients point in the expected direction, and almost 30% of the estimated coefficients are statistically significant by conventional standards. But these results are hardly overwhelming; they appear strong only relative to the other school inputs. Moreover, because of possible selection effects, they are subject to additional interpretive questions. In particular, these positive correlations may result from senior teachers being permitted to select schools and classrooms with better students. In other words, causation may run from achievement to experience and not the other way around.[12]

The results are startlingly consistent in finding no strong evidence that teacher-student ratios, teacher education, or teacher experience have the expected positive effects on student achievement. According to the available evidence, one cannot be confident that hiring more educated teachers or having smaller classes will improve student performance. Teacher experience appears only marginally stronger in its relationship.

The remaining rows summarize information on other expenditure factors, including administration, facilities, teacher salaries, and expenditures per student.[13] Administration and facilities also show no systematic relationships with performance. This could be explained partly by variations in how they are measured. The quality of administration is measured in a wide variety of ways, ranging from characteristics of the principal to expenditures per pupil on noninstructional items. Similarly, the character of facilities is identified through both spending and a range of physical characteristics. Nevertheless, the available evidence again fails to support the conventional wisdom. Finally, and not surprisingly, measures of teacher salaries and expenditures per student provide no definite indication of their importance in determining achievement.[14] After all, the underlying determinants of these expenditures are themselves unrelated to achievement.

Without systematic tabulation of the results of the various studies, it would be easy to conclude that the findings are inconsistent. But there is a consistency: *There is no strong or systematic relationship between school expenditures and student performance.* This is the case when expenditures are decomposed into underlying determinants and when expenditures are considered in the aggregate.

There are several obvious reasons for caution in interpreting the evidence. For any individual study, incomplete information, poor quality data, or faulty research could distort statistical results. Even without such problems, the actions of school administrators could mask any relationship. For example, if

the most difficult students to teach were consistently put in smaller classes, any independent effect of class size could be difficult to disentangle from mismeasurement of the characteristics of the students. Finally, statistical insignificance of any estimates may indicate lack of relationship, but it also may reflect a variety of data problems. In other words, as in most research, virtually any of the studies is open to some sort of challenge.

Just such uncertainties about individual results has motivated this tabulation of estimates. If the studies' common parameters were in fact central to variations in student achievement, the tabulations would almost certainly show more of a pattern in the expected direction. The reasons for caution are clearly more important in some circumstances than others, but the consistency across these very different studies is nonetheless striking. Furthermore, given the general biases toward publication of statistically significant estimates, the paucity of statistically significant results is quite notable. Although individual studies may be affected by specific analytical problems, the aggregate data provided by the 187 separate estimates seem most consistent with the conclusion that the expenditure parameters are unrelated to student performance (after family backgrounds and other educational inputs are considered).

Other Inputs into Education

Since the publication of *Equality of Educational Opportunity*, the Coleman Report, intense debate has surrounded the fundamental question of whether schools and teachers are important to the educational performance of students. This debate follows naturally from the report's having commonly been interpreted as finding that variations in school resources explain a negligible portion of the variation in students' achievement. If true, this would indicate that it does not matter which teacher a student has—something most parents, at least, would have a difficult time accepting.

A number of studies provide direct analyses of differential effectiveness of teachers by estimating differences in the average performance of each teacher's students (after allowing for differences in family backgrounds and initial achievement scores).[15] The findings (Hanushek, 1971; Murnane, 1975; Armor et al., 1976; Murnane & Phillips, 1981) are unequivocal: *Teachers and schools differ dramatically in their effectiveness.* The formal statistical tests employed in these studies confirm that there are striking differences in average gain in student achievement across teachers.

The faulty impressions left by the Coleman Report and by a number of subsequent studies about the importance of teachers have resulted primarily from a confusion between the difficulty of explicitly measuring components of effectiveness and true effectiveness. In other words, existing measures of characteristics of teachers and schools are seriously flawed and thus are poor indicators of the true effects of schools; when these measurement errors are avoided, schools are seen to have important effects on student performance. Although a number of implications and refinements of this alternative approach still need addressing,[16] the conclusion that schools and teachers are important is very firm.

These production function analyses have also investigated a wide variety of other school and nonschool factors. Some generalizations about these factors are possible, although their specifications across studies are idiosyncratic and precise summaries, like those for teacher parameters, are impossible.

First, family background is clearly very important in explaining differences in achievement. Virtually regardless of how measured, better educated and wealthier parents have children who perform better on average. These studies, however, have seldom gone into any detail about the mechanisms by which families influence education, but have generally stopped with the introduction of proxies for family differences in education.[17] Moreover, from a policy perspective, it is very important to understand such issues as whether or not inputs can feasibly be changed, either in the short run or the long run, and this requires understanding the underlying causal structure.[18]

Second, considerable attention has been given to the characteristics of peers or other students within schools. This line of inquiry was pressed by the Coleman Report and pursued by a number of subsequent studies (e.g., Winkler, 1975; Henderson, Mieszkowski & Sauvageau, 1976; Summers & Wolfe, 1977). It is especially important in considering issues that revolve around the racial compositions of schools. The educational effect of differing student bodies has also been important in the debate about public versus private schooling. Nevertheless, the findings are ambiguous, in large part because of data and measurement questions.[19] For example, one important critique of the estimated importance of private schools found in Coleman, Hoffer, and Kilgore (1982) asserts that the effect of private schools is inflated because of mismeasurement of student body characteristics (see, for example, Murnane, 1983).

Finally, an enormous range of additional measures of schools', teachers', curriculas', and especially instructional methods' effects on achievement have been pursued. Various studies have included indicators of organizational aspects of schools, of specific curricular or educational process choices, and of such things as time spent by students working at different subject matters. Others have compiled very detailed information on teachers' cognitive abilities, family backgrounds, and such educational factors as where they went to school, what their majors were, what their attitudes are about education or different kinds of students, and so forth. Similarly detailed information has been gathered about school facilities and school administrators and other personnel. Although Table 3 presents some evidence on facilities and administrators, disparities in the measurement of all of these factors certainly add to difficulties in uncovering any consistent relationships. Perhaps the closest thing to a consistent conclusion across the studies is the finding that teachers who perform well on verbal ability tests do better in the classroom, but even there the evidence is not very strong.[20]

One simple interpretation of the combined results of these studies is that an important element of skill is involved in successfully teaching.[21] Some teachers have an ability to promote higher achievement of students. But, unfortunately, it is currently impossible to measure with any precision any readily identifiable components or elements of this skill. Moreover, it is unclear whether any form of teacher training could be organized to foster high levels of skill in teachers.

This interpretation has implications for other kinds of analyses of educational performance. As mentioned,

most educational research does not follow the production-function paradigm, but concentrates more on specific elements of the teaching process and how those relate to student achievement. Certain variations in the curriculum, in the content or form of teaching materials, in the time devoted to individual student-teacher or group-teacher interactions, and so forth have been examined. These studies, although frequently not employing the same research methodologies as the production-function studies, are nonetheless subject to the same influences from variations in teacher skill. Neglecting those influences (or including inadequate measurements) renders these studies as "inconsistent" in their results as the input-output studies.

These research implications are, at root, conceptual problems that also pervade some of the large evaluations of educational programs. For example, analyses of HeadStart, Title I, and other compensatory programs frequently view the research design in quasi-experimental terms: They look for differences in mean performances among those students in or out of the program (after statistically controlling for observable differences). But, to the extent that they do not appropriately measure the wide variations in teacher skill, they are prone to yield misleading results about programmatic impacts.

Policy Implications

Two policy conclusions spring immediately from the findings about variations in expenditures. First, because within the current institutional structure expenditures are not systematically related to performance, policies should not be formulated principally on the basis of expenditures. Second, because common surrogates for teacher and school quality (class size, teachers' education, and teachers' experience, among the most important) are not systematically related to performance within the current institutional structure, policies should not be dictated simply on the basis of such surrogates.

These conclusions appear obvious and indeed seem to be subscribed to in principle by many policy makers. But violations occur frequently and go unchallenged. Take, for example, the financing of local schools, the instance of clearest policies by both state legislators and the courts. Virtually all of the discussions and court cases related to school finance are phrased entirely in terms of the pattern of expenditure variations across districts. The argument for this practice is frequently that of expediency: Because there is ambiguity about which factors affect performance and because legislators cannot realistically assess or implement management in local schools, expenditures offer the only reasonable policy instrument. The research findings presented here suggest that such a view, at the very least, leads to wasteful policies.

Or, in just as obvious an instance, local school boards are content to focus on class sizes and to negotiate contracts setting teacher salaries exclusively on the basis of teacher education and experience. State legislators themselves also enter into regulating salaries and class sizes in different programs and mandating that teachers obtain a master's degree.

The reliance on expenditures or now conventional proxies for teacher performance reflects, in part, an oft-repeated view that performance itself cannot be adequately or objectively measured. Clearly, there are serious issues related to measurement and to implementation of any system based on performance. Nevertheless, an important sidelight of the production-function investigations is that decision makers might be able to identify, with fair accuracy, underlying differences in skills among teachers. Murnane (1975) and Armor et al. (1976) found that principals' evaluations of teachers were highly correlated with estimates of total effectiveness (that is, adjusted mean gains in achievement by the students of each teacher). This ability to identify effective teachers is exactly what is needed to implement a merit pay scheme.

It would be valuable to know exactly which characteristics of schools and teachers help effect good student performance. But, decades, indeed centuries, of inquiry and research suggest that this information is unlikely to be forthcoming in the near future. For many purposes, however, it is almost as useful to identify good performance after the fact as it is to identify differences among teachers ex ante. Policies are needed that are keyed to student performance directly instead of to the levels of different inputs (that may or may not be related to performance).

Again, note the caveat that applies throughout these conclusions. All of the results cited reflect generalizations that are based upon the structure and operating procedures of schools today. A changed organizational structure, with different incentives, could produce a new configuration of results. For example, almost every economist would support the argument that increasing teacher salaries would expand and improve the pool of potential teachers. Whether or not this would improve the quality of teaching, however, would depend on whether or not schools systematically chose and retained the best teachers from the pool.[22] The results cited here on salary differentials might be very different if schools were to have a greater incentive to produce student achievement and if mechanisms for teacher selection were altered. In other words, there seems little question that money *could* count—it just does not consistently do so within the current organization of schools.

Moreover, the consistency standard for judging the results and the potential for policy improvements does not entail the view that money never counts. The results are entirely compatible with some schools' using funds effectively whereas others do not. This work is most directly applicable to the potential actions and policies of states, or the courts, or, perhaps, of school boards, where aggregate policies are applied without any real sensitivity to the effects at the levels of the classroom or the child. Sometimes macro policies work, but just as often they do not, so higher expenditures fail to produce commensurate gains in achievement.

Conclusions

Although most data on the simple correlation between school expenditures and achievement show a strongly positive affiliation, the strength of relationship disappears when one controls for differences in family background. Indeed, detailed research spanning two decades and observing performance in many different educational settings provides strong and consistent evidence that expenditures are not systematically related to student achievement. Moreover, the dramatic differences that exist in teachers' performance have not been captured by any account of differences in their backgrounds or classroom behaviors.

School reform discussions that begin with the premise that constraints on expenditures are the most serious roadblock to improved student performance

are, at best, misguided. Expenditure increases, if undertaken within the current institutional structure, are likely to be dissipated on reduced class sizes or indiscriminate raises in teacher salaries, with a result that growth in costs will almost surely exceed growth in student performance.

This research raises a number of obvious questions to which, embarrassingly, we have no answers. What causes the apparent waste of resources? Why is there so little pressure for efficient operation of our schools? What incentives will help schools increase their effectiveness? Can the institutional structure be altered to facilitate improved performance? Answering these questions will be key in the long-run improvement of our system of education. □

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[1]This is a contrast to a more common approach in educational research, *process-outcome studies*, where attention rests on the organization of the curriculum, the methods of presenting materials, the interactions of students, teachers and administrators, and the like. An entirely different approach—true experimentation—has been much less frequently applied, particularly when investigating the effects of expenditures.

[2]There were also extensive analyses of the report's methodology and of the validity of its inferences. See, for example, Bowles and Levin (1968), Cain and Watts (1970), and Hanushek and Kain (1972).

[3]One rather commonly held presumption is that better educated individuals are able to perform more complicated tasks or are able to adapt to changing conditions and tasks (see Welch, 1970; Nelson & Phelps, 1966). This hypothesis, which has been tested in both developed and less developed countries, has important implications for studying the productivity and outputs of schools, because it provides some rationale for favoring measures of analytical ability.

Alternative theories are built on ideas of screening (e.g., Berg, 1970; Spence, 1973; or Riley, 1979), of luck (e.g., Jencks et al., 1972), or of the influences of social structure (e.g., Bowles & Gintis, 1976). None of these alternatives, however, offer any guidance on the evaluation of the performance of schools.

[4]As discussed elsewhere (Hanushek, 1979, 1986), a variety of empirical problems enter into estimation and the subsequent interpretation of results. The most significant general problems are the lack of measurement of innate abilities of individuals and the imprecise measurement of the history of educational inputs. Both the quality of the data and the estimation techniques are very important in interpreting particular findings, but, as discussed below, these problems have less impact on the aggregate findings illuminated here.

[5]A qualified study was defined as a production-function estimate that is: (1) published in a book or refereed journal; (2) relates some objective measure of student output to characteristics of the family and the schools attended; and (3) provides information about the statistical significance of estimated relationships. Note that a given publication can contain more than one estimated production function by considering different measures of output, different grade levels, or different samples of students (but different specifications of the same basic sample and outcome measure are not duplicated). (This is an expanded version of tabulations in Hanushek, 1981, 1986.)

[6]The tabulations, when stratified by grade level, by whether individual or aggregate data were used, by output measure, and by value-added or level form of estimation yield the same qualitative conclusions reported below.

[7]Tabulated results are adjusted for variables being measured in the opposite direction; for example, the sign for estimated relationships including student-teacher ratios is reversed.

[8]It would be extremely difficult to provide information of quantitative differences in the coefficients because the units of measure of both inputs and outputs differ radically from one study to another. One attempt to provide quantitative estimates of varying class sizes is by Glass and Smith (1979). This work, however, has been subjected to considerable criticism, largely because of the ultimate difficulties in doing such analyses.

[9]Teacher-pupil ratios are treated here as being synonymous with class sizes. This is not strictly the case and, in fact, could be misleading today. Several changes in schools, most prominently the introduction, in the mid-1970s, of extensive requirements for dealing with handicapped children, have led to new instructional personnel, without large changes in typical classes. Because much of the evidence here refers to the situation prior to such legislation and restrictions, it is reasonable to interpret the evidence as relating to class sizes.

[10]Note that not all studies report the sign of insignificant coefficients. For example, 45 studies report insignificant estimated coefficients for teacher-student ratios but do not report any further information.

[11]Note that only 113 studies report evidence about teachers' education. Because data on teacher education is so readily available, it seems likely that a number of additional studies investigated teacher education effects but, after finding negative or insignificant effects, discarded the results without reporting them.

[12]Greenberg and McCall (1974) and Murnane (1981a) analyze teacher selection and arrive at different conclusions about the underlying behavior and its potential impact on production-function estimation. The estimates of experience effects in value-added models that look at gains in achievement are somewhat stronger than those in level models. This suggests that selection does not explain all of the experience findings.

[13]Information on each of these is less frequently available. This is partially explained by common reliance on administrative records which do not record each. The form of the analysis offers an additional explanation; for example, since expenditures per student are generally measured for districts, any of the 60 analyses for individual districts would find no variation in this input and thus could not include it.

[14]The expenditure and salary estimates are generally more difficult to interpret. Their interpretation is sometimes clouded by including them in addition to teacher experience, education, and/or class size. Additionally, because prices can vary across the samples in the separate studies, it is more difficult to interpret the dollar measures than the real input measures. Finally, in terms of the results in Table 3, 8 of 13 significant positive expenditure results also come from the different estimates of Sebold and Dato (1981). In this study, imprecise measurement of family inputs suggests that school expenditures may in fact mainly be a proxy for family background.

[15]These studies are analyses of covariance or, equivalently, of individual teacher dummy variables in addition to measures of prior student achievement, family background factors, and other explicitly identified inputs.

[16]It would be useful to know about the stability of teacher effects over time and the possibility of interactions between classroom composition and teacher skill. Replication of these studies in samples representing different educational circumstances would also be useful.

[17]One interesting subset of these analyses, however, involves investigating more detailed aspects of family structure and size. The large changes in birth rates and divorce rates of the past two decades have created a concern about their potential effects on learning and achievement. General discussions and reviews of the issues can be found in Easterlin (1978) and Preston (1984). For the most part, these ignore influences of schools on achievement, although it may not be too problematical in a time-series context. A preliminary investigation of family factors based upon simple time allocation models can be found in Hanushek (1987).

[18]Since the publication of *Equality of Educational Opportunity*, there has been a fascination with the question of whether families, peers, or schools are most important in determining the performance of students, but such questions simply cannot be answered very easily within the production-function framework. The primary information provided by knowledge of the production function is how much student performance will change when given inputs are varied; that is, what is the marginal effect on achievement from changing the level of a particular input. By contrast, questions of the relative importance of, say, family inputs to education versus the inputs of schools commonly refer to decompositions of variations of student achievement. These decompositions, while bearing some relationship to the marginal effect of each variable, also involve the sample variations of the observed inputs and make it impossible to evaluate specific policies. Moreover, from a policy perspective, most attention is concentrated on inputs that are malleable through policy.

[19]Assessing the impact of desegregation has been especially difficult because such studies demand historical information on the course of desegregation—data that are seldom available along with the other information needed for production-function studies.

[20]Tabulations similar to those in Table 3 indicate 31 studies that have analyzed teachers' verbal scores. Of these, 8 find positive and significant relationships and another 10 find positive but insignificant relationships.

[21]Further discussion of skill differences in the production-function context can be found in Hanushek (1986).

[22]The dismal level of current understanding of teacher labor markets has been described by the National Research Council (1987).

Acknowledgement: This paper benefitted from helpful comments by Henry Levin and the editors.

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tion is working hard to prevent this sort of cultural insensitivity from undermining the AIDS education that must perforce be offered to a broad array of widely divergent cultures.

[5]Thus, Palincsar also missed the footnote in which we explicitly stated that we did not wish to criticize the students who, in Miller and Gildea's (1987) study, struggled erroneously with a dictionary.

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