# PRODUCTION-FUNCTION LITERATURE REVIEW

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Ask most teachers or school administrators if they could do a better job educating children if they had more money, and virtually every one of them will offer a resounding "yes." Ask them what they would do with that money, and their answer is less clear. Many educators do not have a strategic sense of how the money could be used, and more often than not the answer will conflict with what other teachers or administrators say is needed.

Today's school reformers increasingly call for greater productivity in our schools. As Monk (1992) shows, productivity is a difficult concept to apply to a public good like education. Nevertheless, for the purpose of this book, here is a straightforward working definition of *educational productivity*: the improvement of student outcomes with little or no additional financial resources, or a consistent level of student performance at a lower level of spending. Although a simple idea, improvements in student achievement absent large amounts of new money have been relatively rare in public schools in the United States.

One of the difficulties in discussing educational productivity is the many different ways it can be addressed. The first section of this paper reviews the literature that seeks to answer the question, "Does money matter?"

The second section discusses how educational productivity can be improved through decentralized management structures. The literature on school-based management and decentralized decision-making is analyzed to determine whether and how these tools can be used to make schools better or more productive.

## MEASURING EDUCATIONAL PRODUCTIVITY

One can measure educational productivity through three lenses: efficiency, effectiveness, and equity. *Efficiency* refers to the allocation of resources and their use in schools. Specifically, efficiency concerns revolve around how much money schools have, and how that money is used. *Effectiveness* encompasses the linkage between student outcomes and the level and use of financial resources in the schools. This topic, a matter of considerable debate in educational and economic circles, is the focus of this section. The third approach to measuring productivity is *equity*, the equitable distribution of funds to all children.

Virtually all effectiveness studies rely on an economic method known as the *production function*. While this is not necessarily the only way to measure the effectiveness or productivity of a school system, it has been the method most frequently used. This section begins with a discussion of production functions and how they are used. The next part considers the use of production functions more generally in trying to ascertain the connection between money and student learning.

### The Current Debate: Does Money Matter?

While interest in the question of whether money matters has always been high, the publication of an article by Hedges, Laine, and Greenwald (1994a) in the April 1994 *Education Researcher* sparked renewed debate over this issue. Prior to publication of this article, the most often cited research in this field was the work of Eric Hanushek (1981, 1986, and 1989). In those articles, as well as his most recent research, Hanushek (1997) argues that there does not appear to be a systematic relationship between the level of funding and student outcomes.

Hanushek has now analyzed 90 different publications, with 377 separate production-function equations. In the summer 1997 issue of *Educational Evaluation and Policy Analysis*, he continues to argue that "these results have a simple interpretation: There is no strong or consistent relationship between school resources and student performance. In other words, there is little reason to be confident that simply adding more resources to schools as currently constituted will yield performance gains among students" (Hanushek 1997, p. 148).

To reach this conclusion, Hanushek followed a process that separates the studies on the basis of the outcome measures employed by the authors, and then looks at the regression results. The regressions use a series of independent or descriptor variables to estimate the value of the dependent or, in this case, outcome variable. The regression estimates the nature of the relationship between the independent variables and the dependent variable, measures the estimated strength of that relationship, and indicates whether the estimate of the effect is statistically significant (whether one can say with some level of confidence that the answer is different from zero).

For example, let's say the researcher is interested in whether more money leads to higher test scores. If the sign on the coefficient of expenditures is positive, the implication is that higher spending leads to higher test scores. However, one needs to be sensitive to the magnitude of that relationship and the confidence one has about that estimate (the statistical significance).

Hanushek, using this same method, divided the results of the 377 equations into five categories as follows:

- A positive relationship that is statistically significant
- A positive relationship that is not statistically significant
- A negative relationship that is statistically significant
- A negative relationship that is not statistically significant
- A situation where the direction of the relationship can not be determined

In addition to school expenditures, some of the studies relied on other measures of school district resource allocation; they looked at teacher/pupil ratios,[1] expenditures for central or school-site administration, teacher education, and teacher experience.

Hanushek analyzed the studies and placed them in one of the five categories based on the estimated effect described above. In looking across studies, at different outcome measures and different types of inputs, Hanushek argues that the variation in findings is such that systematic relationships between money and outcomes have not yet been identified. He states:

> The concern from a policy viewpoint is that nobody can describe when resources will be used effectively and when they will not. In the absence of such a

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[1] While it is generally easier to think in terms of a pupil/teacher ratio, the advantage of reversing this ratio and considering a teacher/pupil ratio is to simplify discussion. Typically a lower pupil/teacher ratio is more expensive and considered a positive step toward improving student performance. However, if smaller classes lead to higher student performance, then the relationship between the pupil/teacher ratio and the outcome measure will be negative. If the ratio is reversed, so that it is a teacher/pupil ratio, the higher the teacher/pupil ratio, the smaller the class size. Thus if small class size leads to improved student performance, the sign on the coefficient will be positive.

> description, providing these general resources to a school implies that sometimes resources might be used effectively, other times they may be applied in ways that are actually damaging, and most of the time no measurable student outcome gains should be expected. (Hanushek 1997, pp. 148-9)

He then suggests that what is needed is to change the incentive structures facing schools so that they are motivated to act in ways that use resources efficiently and that lead to improved student performance.

One of the most interesting findings in Hanushek's (1997) recent work is the impact of aggregation on the results. Studies that use data aggregated to the state level, he found, are far more likely to find statistically significant and positive relationships than are studies that focus on the classroom or school level. What is not clear from his work at this point is whether the aggregation is masking much of the variance that exists (a likely occurrence), or if we simply do not yet have tools that are refined enough to adequately measure the effects of different inputs at the most disaggregated levels in the system.

Others have looked at the same studies as Hanushek and concluded that they show money does make a difference. Hedges, Laine, and Greenwald (1994a, 1994b; see also Laine, Greenwald, and Hedges 1996; and Greenwald, Hedges, and Laine 1996a, 1996b) conclude that, in fact, money can make a difference. They argue that while in those studies only a minority of relationships indicate a positive, statistically significant relationship, the number with such a relationship exceeds what one would expect to find if the relationship were random. They also point out that one would expect the statistically insignificant studies to be evenly divided between positive and negative effects, yet in this category as many as 70 percent of the relationships between per pupil expenditures and student performance are positive. Relying on this and other evidence, Hedges, Laine, and Greenwald (1996a) conclude that school spending and achievement are related. In his rejoinder, Hanushek (1994b) argues that while there is evidence that the relationship exists, there is not evidence of a strong or systematic relationship.

A number of other studies have looked at this issue. Ferguson (1991) examined spending and the use of educational resources in Texas. He concluded that "hiring teachers with stronger literacy skills, hiring more teachers (when students-per-teacher exceed 18), retaining experienced teachers, and attracting more teachers with advanced training are all measures that produce higher test scores in exchange for more money" (Ferguson 1991, p. 485).

Ferguson's findings also suggest that the education level of the adults in the community, the racial composition of that community, and the salaries in other districts and alternative occupations affect teachers' selection of districts in which they want to teach. This implies, according to Ferguson, that better teachers will tend to move to districts with higher socioeconomic characteristics if salaries are equal. If teacher skills and knowledge have an impact on student achievement (and Ferguson, as well as others, suggest that they do), then low socioeconomic areas may have to offer substantially higher salaries to attract and retain high-quality instructors. This finding would help confirm a link between expenditures and student achievement.

In a more recent study, Weglinsky (1997) used regression analysis of three large national databases to see if expenditures had an impact on student achievement of fourth- and eighth-graders. He found that the impact of spending was in steps or stages. For fourth-graders, Weglinsky concluded that increased expenditures on instruction and on school district

administration increase teacher-student ratios. Increased teacher/student ratios (smaller class sizes) in turn lead to higher achievement in mathematics.

In the eighth grade the process was more complex. Weglinsky found that increased expenditures on instruction and central administration increase teacher/student ratios (reduce class size). This increased teacher/student ratio led to an improved school environment or climate, and the improved climate and its lack of behavior problems resulted in higher achievement in math.

Equally interesting was Weglinsky's (1997) finding that capital outlay (spending on facility construction and maintenance), school-level administration, and teacher-education levels could not be related to improved student achievement. This is particularly intriguing in light of his finding that increased spending for central or district administration was associated with improved student outcomes. These findings, certain to be controversial, conflict to some extent with the "conventional wisdom" about school administration. Why additional spending on district administration leads to improved teacher/student ratios, whereas that is not the case with school-site administration, is not clear, but this anomaly should be investigated further and considered by school districts when they evaluate the move to site-based management.

In summary, there remains considerable disagreement over the impact of additional resources on educational outcomes of students. The complexity of the educational system, combined with the wide range of outcomes we have established for our schools, and the many alternative approaches we use to fund our schools make it difficult to come to any firm conclusions about whether or not money matters.

*Methodological Challenges*

One of the problems with all the studies described above is that they do not take into consideration the similarity with which school districts spend the resources available to them. Research by Picus (1993a and 1993b), Picus and Fazal (1996), and Cooper (1993 and 1994), shows resource-allocation patterns across school districts to be remarkably alike, despite differences in total per-pupil spending, student characteristics, and district attributes. This does not mean that all children receive the same level of educational services. As Picus and Fazal (1996) point out, a district spending $10,000 per pupil and $6,000 per pupil for direct instruction is able to offer smaller classes, better paid and presumably higher quality teachers, and higher quality instructional materials than is a district spending $5,000 per pupil and only $3,000 per pupil for direct instruction.

What we do not know is what the impact on student performance would be if schools or school districts were to dramatically change the way they spend the resources available to them. In 1992, Odden and Picus suggested that the important message from the research summarized above was that, "if additional education revenues are spent in the same way as current education revenues, student performance increases are unlikely to emerge" (Odden and Picus 1992, p. 281). Therefore, knowing whether high-performing schools use resources differently than other schools would be helpful in resolving the debate over whether money matters.

Nakib (1995) studied the allocation of educational resources by high-performing high schools in Florida and compared those allocation patterns with the way resources were used in the remaining high schools in that state. A total of seven different measures were used to compare student performance. In his findings, Nakib shows that per-pupil spending and per-pupil spending for instruction were not statistically significantly higher in high-performing high schools, largely because of the highly equalized school-funding formula used in Florida. On the

other hand, he found that the percentage of expenditures devoted to instruction was lower in the high-performing high schools, implying high-performing high schools may actually spend more money on resources not directly linked to instruction than do other high schools.

Unfortunately, the results of this Florida analysis do little to clarify the debate on whether money matters. The comparison of high-performing high schools with all other high schools in Florida did not show a clear distinction in either the amount of money available or in the way resources are used. As with many other studies, student demographic characteristics were found to have the greatest impact on student performance.

More recently, Odden (1997) has found that the schooling designs developed as part of the New American Schools project have generally led to increased student performance. In each of the seven models he studied, schools are required to make substantial reallocations of resources. They hire fewer aides and teachers with special assignments and instead employ a greater number of regular classroom teachers, thus lowering average class size. In addition, each of the designs requires substantial investments, in both time and money, for professional development. Odden suggests that this can often be funded through elimination of a position through attrition. His optimistic assessment is that for relatively little additional money, schools can fund existing programs and organizational structures that will help them improve student learning.

## WHY IS EDUCATIONAL PRODUCTIVITY SO ELUSIVE?

To date, economists who have attempted to define a production function for education have been largely unsuccessful. Much of the variation in student performance from school to school is related to student characteristics over which schools have no control. Moreover, recent research on educational resource-allocation patterns shows little variation in the way school districts use the funds they have, regardless of per-pupil spending levels (see, for example, Odden, Monk, Nakib, and Picus 1995; Picus and Fazal 1996).

As a result, it has been difficult to identify productive uses of school funds. Before looking at potential ways to break these patterns and improve productivity, it will be helpful to consider some possible reasons these patterns exist.

### Financial Organization of School Districts

School districts are typically organized in a top-down fashion, particularly with regard to their fiscal operations. There are a number of reasons for this. First, since schools spend public funds, it is essential that district administrators ensure the money is spent as budgeted and approved by the school board. Considerable expense goes into developing systems that provide this accountability, and it is easier to manage these systems centrally. Moreover, few school-site administrators have the training or desire to become financial managers. Thus school district accounting systems have become highly centralized.

Central fiscal management has its benefits in terms of centralized purchasing and common reporting formats, but it can also reduce local creativity. Most school districts rely on allocation mechanisms to distribute resources to school sites (Hentschke 1986). These mechanisms typically allocate resources such as teachers on a per-pupil basis, and others on either a per-pupil or dollar-per-pupil basis. Depending on the level of detail in a district's

system, these allocation mechanisms often leave very little discretionary authority to the school site.

Moreover, most systems do not allow school sites the flexibility to carry over funds if expenditures are below budgeted levels. Although this pattern is changing, to the extent it still exists, schools have little incentive to create long-term plans, and they find themselves better off looking for ways to be sure they have spent all the funds allocated to their site each fiscal year.

*SCHOOL DISTRICT BUDGETING*

Budgeting systems also work to limit variation in school spending patterns. Wildavsky (1988) describes public budgeting systems as being incremental. The bulk of a public organization's budget, he notes, is based on the same allocation pattern as the previous year, adjusted for changes in costs due to inflation, salary increases, and price increases. Consequently, changes in spending patterns are unlikely, and when they occur, do so at the margin. That is, it is only after current expenditures are "covered" that new programs are considered, if more money is available.

It is not surprising that school districts have highly incremental budgets. The basic organization of a school district is to put a number of children in a classroom with a teacher. The balance of a school system is designed to support that structure. Depending on local preferences, this includes a central administrative office, school-site administrators, specialists and student-support personnel, aides, and classified staff to handle clerical, custodial, transportation, and other activities. Each year the typical district budgets funds to cover the staff, materials, and fixed costs of the previous year. If funds are inadequate, then it is forced to make reductions, usually at the margin. If new programs are desired, new resources must be found.

Assuming large gains in productivity are desired, it seems that dramatic changes in the ways resources are allocated and used will be needed. Doing so requires breaking the patterns noted above.

## LINKING SPENDING TO STUDENT OUTCOMES: ECONOMIC RESEARCH

Despite these methodological challenges, a considerable number of research studies have examined production function in education. Such research has taken two approaches to considering whether spending on education leads to improved student outcomes. The first focuses on defining outcomes as student achievement, usually measured through state or local assessment systems, and usually in the form of standardized tests. Most production-function research attempts to link changes in school spending to changes in test scores. Other measures of student performance that are sometimes used include school attendance, dropout rates, college enrollment, and job longevity following high school.

While this approach makes a great deal of sense, many economists argue that the way to measure the impact of additional educational resources is to assess its impact on lifetime earnings. They suggest that education is an investment, and high investment in education will yield higher returns in the form of higher lifetime earnings. In fact, many studies that consider this "human capital" approach find that money makes a difference.

## WHAT IS A PRODUCTION FUNCTION?

Understanding the effect of class size on student achievement is related to the larger question of how money impacts student performance. As Picus (1997) points out, nearly all would agree that more money is better than less. Moreover, most would agree that the expenditure of additional funds on education should lead to improved student learning. However, there is considerable disagreement among researchers whether a statistical link can be found between student outcomes and money (or what money buys, such as lower class size, teacher experience and degrees, and so forth). The single largest expenditure item for a school district is teacher compensation (salary and benefits). So, for example, for a district of a given size, the more money or revenue available to the system, the more teachers it can hire and the smaller the average class size will be.

Production functions are an economic tool used to measure the contribution of individual inputs to the output of some product. In simple terms, a production function takes the following form:

(1) $O = f(K,L)$

Where:

O = some measurable output

K = Capital or nonlabor inputs to the production process

L = Labor

By estimating equations that include these variables, as well as other variables that control for exogenous factors known to impact the production process, it is possible to predict the impact that the application of additional units of labor and capital will have on the number of units of output produced.

This concept can be applied to education as well.[2] For example, it is possible to estimate an educational production function with the following form:

(2) $P = f(R,S,D)$

Where:

P = A measure of student performance

R = A measure of resources available to students in the school or district

S = A vector of student characteristics

D = A vector of district and school characteristics

One possible measure of R would be the pupil-teacher ratio at a school or school district. In fact, the pupil-teacher ratio is in many ways a good choice for this particular variable as it provides a proxy for the level of resources available for children (that is, it is highly correlated with per-pupil spending), and it is a proxy for class size.

### Difficulties with the Educational Production-Function Research

There are substantial methodological difficulties with estimating equations of the form presented above. First and foremost is reaching agreement on the proper measure of student

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[2] For a more detailed description of production functions as they apply to education, see Monk, 1990.

performance to serve as the outcome indicator. Although there is considerable discussion about this in the education community, in recent years, the policy community—as well as most educators—have focused on the results of standardized tests as the outcome measure. The studies described below generally follow this trend.

There are a number of other methodological problems to consider. There is substantial evidence that children from minority backgrounds, children from low-income families, children who do not speak English as their first language, and children with disabilities do not do as well in school as other children. Therefore, if our model is to identify the impact that smaller classes have on student performance, it is necessary to control for differences in student characteristics. Unfortunately, it is often difficult to collect these data in ways that facilitate the estimation of a production function.

For example, it is often possible to collect data on student performance and student characteristics at the individual student level. However, other data related to school or district characteristics may be available only at the district level. This is often the case with fiscal data such as per-pupil expenditures and even pupil-teacher ratios. As a result, the regression equations contain variables with varying levels of precision. Unfortunately, the accuracy of the estimates of the impact of resources on student performance is only as good as the lowest level of precision. This is often the district-level fiscal or resource data that are of interest to the researcher. There are statistical techniques to minimize this problem, in particular, Hierarchical Linear Modeling (HLM). However, many of the early studies on the effect of class size did not use this tool.

Another problem is that most education production-function studies rely on cross-sectional data. This approach allows for a snapshot of one point in time. Yet many of the student characteristic and schooling variables used in these equations are subject to substantial change over time. Thus it is not clear that reliance on a one-time measure of these characteristics will adequately control for their effects on student performance. Longitudinal data sets, which would resolve many of these problems, are expensive to collect, and few are available to researchers today.

In addition, there are substantial problems with the inputs actually measured for this research. The pupil-teacher ratio often used as a proxy for class size is an example. Picus (1994b) shows that there is considerable variation between the computed pupil-teacher ratio in a district or school and teachers' self-reported class size. While self-reported class size averaged 50 percent larger than the computed pupil-teacher ratio, this figure ranged widely from one or two students more than the computed ratio to more than double that figure. Thus, if one is trying to estimate the effect of class size on student performance in a school or district, the pupil-teacher ratio may not accurately reflect either the class size or the variation that exists in the number of students each teacher sees in a day.

A final problem with this research is that it is generally impossible to establish a true experimental design with both an experimental and a control group. Instead, student performance at a given grade level before class size is reduced is compared with student performance at that grade level following the implementation of the treatment, in this case the smaller class size. This too reduces the confidence with which one can make statements about the relationship between class size and student performance.

**Summary**

Production-function research has been used extensively to try to understand whether and how money matters. To date, the research findings have been mixed. This does not imply that money does not matter, only that when using this economic technique, we have yet to conclusively find *how* it matters. What this discussion shows is that the relationship between money and student learning is not clear cut, but rather is influenced by a wide range of factors in our schools. Understanding the impact of these factors on students, teachers, and other participants in the educational process will help further our ability to learn the best ways to ensure that the money we spend on schools leads to improved student outcomes.