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Concepts of Economic Efficiency and Educational Production

I. INTRODUCTION

The education industry has two characteristics which make it a prime candidate for a study of efficiency: size and rising costs. Education represents one of the largest industries in the nation with estimated total direct expenditures of about $108 billion in 1974–75, representing about eight per cent of the gross national product (Bell 1974). During the same period, estimated employment was over 3 million for student enrollments of about 59 million. Beyond its sheer magnitude, the education industry has experienced very steep increases in costs. For example, between 1961–62 and 1971–72 the current expenditure per pupil in *real* terms (1971–72 dollars) rose from $569 to $934 at the elementary-secondary level and from $1,676 to $2,367 at the college level (U.S. Department of Health, Education and Welfare 1972: 3). These represent increases in real costs over the decade of about 64 per cent and 41 per cent respectively.

Of course, one possible explanation for rising costs might be qualitative increases in educational output. Yet, there seems to be no evidence of such a trend. Rather there appears to be increasing concern with the quality of schools as reflected in public opinion surveys (Gallup 1970), educational critiques (Silberman 1970; Greer 1972; Carnoy 1972), and voter support. For example, in 1962 voters approved about 80 per cent of school bond issues, while in 1969 the proportion of approvals had declined to only 44 per cent (Gallup 1970: p. 100).

The substantial increase in resource costs, coupled with growing dissatisfaction with the schools, has surely raised important questions about the performance of the educational sector. In response, economists have increasingly devoted their attentions to studying the internal efficiency of the educational sector, and their early efforts suggest a natural bifurcation into camps of optimism and pessimism.

The pessimists have suggested that the very nature of such activities as education must inevitably lead to higher real costs per unit of output. William Baumol has systematized this analysis by viewing education as a "technologically unprogressive" activity, where the latter term is applied to those activities which cannot benefit from innovation, capital accumulation and economies of large scale (Baumol 1967). According to Baumol, the labor intensive nature of education is an end in itself, so that the possibilities for capital-labor substitution are limited severely. Assuming that money wages rise according to increases in labor productivity within the technologically progressive industries, these increases are passed along to the nonprogressive sectors such as education in the form of higher real costs per unit of output. Baumol concludes that the real costs of even a constant level of output for nonprogressive industries such as education will increase indefinitely and without limit. Note that the Baumol model does not see costs rising because of inefficiency; rather they are rising because of inevitability. Accordingly, his palliative seems to be: "Don't send advice, send money."

Nevertheless, since economists have a greater predilection for providing advice than for fund raising, most economists who have concerned themselves with the educational sector have tactitly assumed that productivity in education can be improved. They are the optimists, since they see their own approaches as ones which will lead to greater efficiency in educational spending. While both Adam Smith and Milton Friedman belong in this school, it is primarily the economists who have attempted to estimate educational production functions that are included in the present analysis.[1] Their studies have generally been addressed to estimating the production set for education with the hope that the marginal products obtained can be compared with prices to obtain a least-cost solution to educational production (Bowles 1970; Katzman 1971; Perl 1973; Winkler 1972; Thomas 1971; Burkhead et al. 1967; Brown and Saks 1975; Kiesling 1967; Hanushek 1968, 1972; Levin 1970a, 1970b; Michelson 1970; Murnane 1974). The tacit assumption underlying such investigations is that schools are allocatively inefficient, and that these studies can lead to the information necessary for better

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resource allocation in the educational sector. Some of the formidable obstacles to estimating these relationships have also been explored in some detail (Bowles 1970; Bowles and Levin 1968a and 1968b; Michelson 1970; Levin 1970a and 1974). Moreover the findings of these studies have been discussed in a public policy context (Guthrie, Kleindorfer, Levin, and Stout 1971; Kiesling 1971; Hanushek 1972; Bowles 1970; Levin 1970b; Hanushek and Kain 1972; Cain and Watts 1970; and Jencks et al. 1972).

Yet, in my opinion, scant attention has been devoted to the relevance of these approaches to questions of efficiency in educational production. The purpose of this paper is to explore several concepts of efficiency with regard to their role in enabling us to evaluate the production of education. That is, if the purpose of the educational production-function literature is to derive prescriptive decision rules for improving the effectiveness of resource use in the educational sector, it is crucial that we examine the nature of the problem and the relevance of our tools for solving it *before* applying them to the evaluative task.

Educational Production Functions

The general production function that appears common to most educational studies is reflected in (1).

(1) $$A_{it} = g\,(F_{i(t)}, S_{i(t)}, P_{i(t)}, O_{i(t)}, I_{it})$$

The i subscript refers to the ith student; the t subscript in parentheses (t) refers to an input that is cumulative to time period t.

A_{it} = a vector of educational outcomes for the ith student at time t;
$F_{i(t)}$ = a vector of individual and family background characteristics cumulative to time t;
$S_{i(t)}$ = a vector of school inputs relevant to the ith student cumulative to time t;
$P_{i(t)}$ = a vector of peer or fellow-student characteristics cumulative to time t;
$O_{i(t)}$ = a vector of other external influences (community, etc.) relevant to the ith student cumulative to time t; and
I_{it} = a vector of initial or innate endowments of the ith student at the time t.

We might view (1) as a capital-embodiment approach to education, since output in time period t is mainly a function of inputs cumulative to t from some earlier time.[2] That is, clearly the educational outcomes at a point in time for an individual, a school, or a larger social collectivity are influenced not only by present observed circumstances but by past ones as well. It is reasonable to believe that from the time a child is conceived various environmental characteristics combine with his innate characteristics to mold his behavior. In the context of (1) the educational outcome for the individual is determined by the cumulative amounts of "capital" embodied in him by his family, his school, his community, and his peers as well as by his innate traits. The greater the amount and the quality of investment from each of these sources, the higher will be the output. More specifically, the family provides a material, intellectual, nutritional, and emotional set of inputs which are embodied in the child; and the schools, peer groups, media, and so on also provide flows of inputs over time which increase capital embodiment.[3]

The operational formulation of (1) is subject to large errors in the equations and in the variables (Bowles 1970; Michelson 1970; Levin 1970a). Most studies have used only a single measure of output, scores on standardized achievement tests, despite the fact that schools are expected to produce a variety of attitudes and skills. Specification of the input structure has been based in part upon what data are available, in part upon the researcher's hunch, and only to a very small degree on theories of development and learning.[4]

Family and background inputs generally include such measures of social class as parental education, father's occupation, family possessions, family structure, race and sex of students. School characteristics have included such facilities as libraries, laboratories, age and nature of buildings; personnel inputs (with special emphasis on class size) and such teacher traits as experience, education, attitudes, and verbal aptitudes. Peer influences include the social class and racial characteristics of fellow students, and other influences include community variables and certain residual variables. The difficulty of obtaining valid measures of innate characteristics has meant that such variables have been omitted from the econometric models. These omissions have probably resulted in an upward bias in the estimated coefficients of family and background variables.[5]

In all of these studies, student background measures appear to be highly related to educational achievement.[6] Among school characteristics, some facilities measures appear to show significant statistical relationships, but the most consistent relations are found between teacher variables and academic achievement. Specifically, virtually all of the studies that have measured teacher verbal aptitudes have found that variable to be significantly related to student achievement (Coleman 1966; Hanushek 1972; Bowles and Levin 1968; Michelson 1970; Levin 1970a). Indeed, the consistency of this finding is buttressed by the fact that separate studies have been carried out at several grade levels and for samples of black, white, and Mexican-American students (Hanushek 1972). Of course, it is important to point out that in the light of

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specification biases, the teacher's verbal score may be a proxy for a large number of possible cognitive and personal traits of the teacher; so that the observed relationship between the teacher's verbal pattern and student achievement may derive from these associated traits rather than the teacher's verbal proficiencies per se (Griliches, 1957).

While teacher experience has also been found to be related to student achievement on a fairly regular basis, the teacher's degree level has rarely shown such an effect. Moreover, variables reflecting the teacher's certification status on the basis of existing state requirements seem to show no apparent association with student achievement. Finally, most studies have found no statistical effect of differences in class-size on pupil performance.

II. SOME CONCEPTS OF EFFICIENCY

Technical and Allocative Efficiency in Educational Production

It is useful at the outset to define two types of efficiency, technical and allocative. *Technical efficiency* refers to organizing available resources in such a way that the maximum feasible output is produced. That is, no alternative organization would yield a larger output. *Allocative efficiency*, or price efficiency, refers to use of the budget in such a way that, given relative prices, the most productive combination of resources is obtained. That is, no alternative combination of resources, given the budgetary constraint, would enable the organization to produce a higher output (Farrell 1957; Leibenstein 1966).

One of the major assumptions that tacitly underlies the estimation of educational production functions is that schools are technically efficient, that is, that they are maximizing output given the input mix that they have selected.[7] In Figure 1 the production frontier is depicted by the production isoquant *AoAo'*, where the individual observations can be thought of as schools using various combinations of S_1 and S_2 to produce constant educational output *Ao*. Schools *a*, *b*, and *c* are on the production frontier and are thus technically efficient. All of the other schools are to the northeast of the production frontier suggesting that they are not technically efficient. That is, all schools other than *a*, *b*, and *c* require higher levels of factor inputs to obtain the output *Ao*. The reasons for such inefficiencies will be suggested below, but if technically inefficient schools are prevalent, then statistical estimates of the educa-

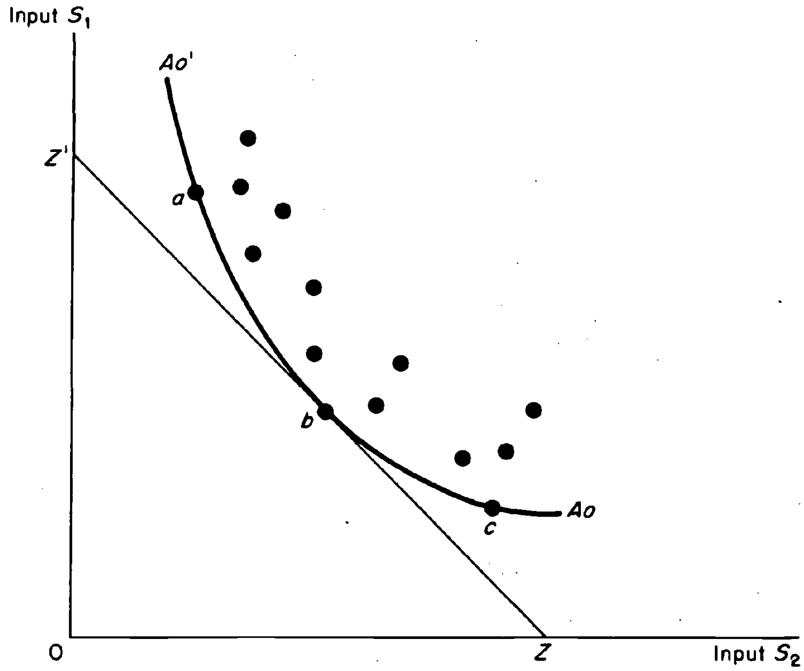

FIGURE 1 Production Frontier for Schools

tional production will not be frontier ones even in the absence of errors in the equations or variables.

If we assume that Z'Z is the relative price or iso-cost line facing all schools for the two factors, only school *b* is both technically efficient and price or allocatively efficient. Firms *a* and *c* are technically efficient, but they are clearly allocatively inefficient since they require a higher budget to achieve output *Ao'* than would be required if they were at point *b*. Indeed, the underlying goal of the educational production function studies is that of determining where point *b* lies on the production function.

Social Welfare Efficiency in Educational Production

Figure 1 assumes a single-valued output for the educational firm that is signified by *A*. Yet, schools are multi-product firms, so $A = (a_1, a_2, a_3, \ldots, a_n)$. By assuming a value for *A*, the analysis overlooks another important

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efficiency aspect which we might call overall social efficiency. That is, somehow the A obtained for any given budget must maximize social welfare. Since the various outputs comprising A probably have different corresponding values for different individuals, it may be impossible to derive a structure of outputs for any given input that maximizes individual welfare and total social welfare (Arrow 1951; Little 1950; Dahl and Lindblom 1953). Perhaps even more important, without having some way of communicating true "social" preferences among outcomes to the schools, it is possible that emphasis on productive efficiency may lead simply to the efficient production of nonoptimal bundles of outputs (Williams 1970).

Figure 2 illustrates this situation for the two output case. AA' represents a product transformation schedule between educational outputs a_1 and a_2. I_0 and I_1 represent social indifference curves for the two outputs such that I_1 represents a higher level of satisfaction than I_0. It is obvious that given the production possibilities and community preferences, the highest level of welfare is represented by E_1.

Now suppose that the actual combination of outputs produced is represented by E_0. E_0 represents an efficiently produced bundle of outputs since it lies on the production frontier. It is evident that E_0 gives the community less satisfaction than E_1, but more importantly any choice of outputs within the shaded portion of the diagram (e.g., E_2) will yield a higher level of welfare than E_0. That is, a large number of subfrontier choices make the community happier than any point on the frontier except E_1. Stated another way, it may be better to produce inefficiently that which is highly desirable to the community than to produce with perfect efficiency that which is of low value.[8]

Efficiency and Scale

Thus, we have identified three types of efficiency which might be applied to an analysis of the educational sector: technical efficiency, allocative efficiency, and social welfare efficiency. A fourth type is one that we shall not explore here in detail, that of size efficiency. Even given technical and allocative efficiency as well as the "correct" choice of outputs for all firms in the education industry, inefficiencies might be introduced if the firms are too large or too small. Given the enormous size variation of individual schools and school districts, it is possible that both economies and diseconomies of scale exist.[9] Empirical work in this area has been carried out, but findings must be heavily qualified, given the enormous errors that are imposed by lack of a sound theoretical structure and measurement problems (Kiesling 1967; Kiesling 1968; Riew 1966; Cohn 1968).

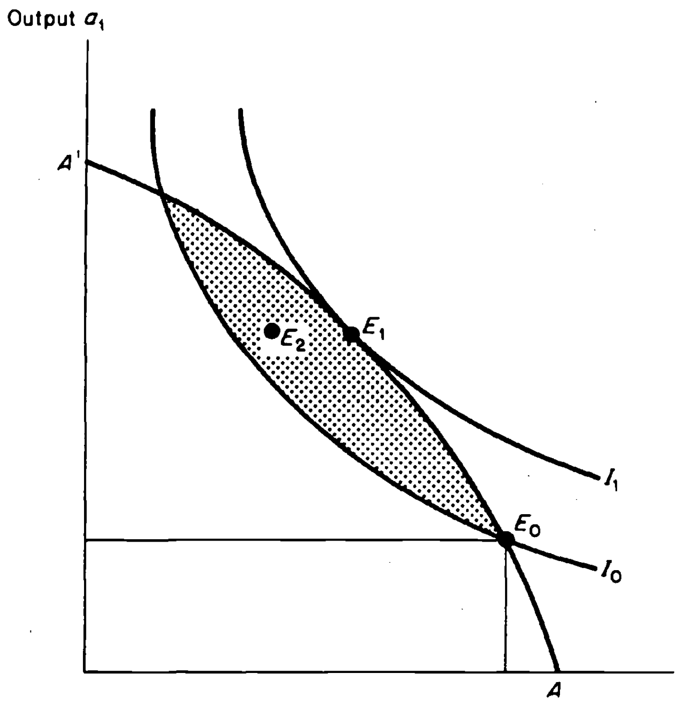

FIGURE 2 Social Welfare and Choice of Output Combinations

III. BEHAVIORAL ASSUMPTIONS FOR EDUCATIONAL FIRMS

The major reason for believing that private firms are efficient derives from market theory. The incentive of profit maximization in combination with the pressure of competition can be reasonably expected to move firms (and the industry) towards both technical and allocative efficiency, provided that certain other conditions exist. Moreover, the existence of market prices for outputs enables the multi-product firms (and the industry) to evaluate all outputs in terms of their contribution to revenue.[10]

Let us list explicitly a few of the conditions which underlie our expectations of efficiency in the private sector.[11] While these categories are not mutually exclusive, each emphasizes an aspect of competitive supply that can be scrutinized for its applicability to educational suppliers in the public sector. The first two categories refer to technical efficiency considerations; the next two refer to assumptions on market

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structure and market information; and the final two refer to the existence and visibility of managerial incentives that relate to the outcomes of the firm. Technical efficiency for an industry presumes that there exist:

1. managerial knowledge of the technical production process;
2. substantial managerial discretion over input mix;
3. a basic competitive environment with all of its attendant assumptions (freedom of entry, many firms, perfect information);
4. managerial knowledge of prices for both inputs and outputs;
5. an objective function that is consistent with maximizing output such as profit maximization; and
6. clear signals of success or failure (profits, losses, sales, costs, rate of return, share of market).

Of course, to the degree that these do not hold, private firms can be expected to be inefficient, both technically and allocatively and with regard to scale. Indeed, in recent years economists have recognized increasingly the possibilities of technical inefficiency for firms, a possibility that was once assumed away by the textbook version of pure competition (Farrell 1957; Leibenstein 1966; Nerlove 1965, Chapter 7; Aigner and Chu 1968; Timmer 1969 and 1971; Comanor and Leibenstein 1969; Lau and Yotopoulas 1971 and 1973).

The question that we wish to pose is: Do parallel conditions exist for such public firms as schools or school districts that would ensure efficient behavior in producing education? The answer seems to be a resounding No. For virtually every condition stipulated above, the schools appear to be at the opposite end of the spectrum from that of the supplier in the competitive marketplace.

1. *The educational managers at all levels lack knowledge of the production set for obtaining particular outcomes.* The educational process is so complex and outputs are so diverse that relations between inputs and outputs are difficult to derive whether by casual observation or research. Salter defines three levels of technological knowledge that relate to production: (a) the basic principles of physical (or behavioral) phenomena; (b) the application of these principles to production, the engineering level; and (c) the level that relates to day-to-day operations (Salter 1960, p. 13). The sparsity of data at all three levels confronts the educational manager, just as it confronts the educational researcher. Moreover, schools do not possess management information systems that are sophisticated enough to obtain even approximate relationships between changes in practices and educational outcomes (Hanushek and Levin 1969). The result is that neither science nor trial and error yields much insight to the educational manager on the nature of the production set.

2. *Substantial management discretion does not exist over which inputs are obtained and how they are organized in educational production.* School administrators make very few decisions regarding the purchase and organization of school inputs. In part, this dereliction is due to direct limitations on managerial discretion; in part it derives from the lack of knowledge of the production set; and in part it derives from an inbred reverence for existing practices. Each of these phenomena reinforces the other, for when production relations are ambiguous and organizations are governed by mandates, managers learn to avoid decisions and obey the rules. Any violation of the rules or the status quo is a risk for which educational payoffs can rarely be demonstrated convincingly to all observers.

The "rules" for operating the schools derive from many sources, federal, state, local, and the vast legacy of traditional and, thus, sacrosanct practices. At the federal level there exist particular guidelines for the expenditure of federal educational funds for each category for which funds are available. More inhibiting is the fact that in many states the laws regulating the schools fill so many volumes that they require a substantial bookshelf for nesting. These codes affect virtually every portion of school operations from the important to the minuscule. In addition, the state departments of education possess their own labyrinths of operational minutiae which are imposed upon local school systems. While matters of personnel licensing and personnel ratios are two of the better known areas of control, most states can even dictate the specific books that will be used in a particular class.[12]

Other factors that circumscribe the ability of managers to make substantial changes include local regulations and regional accreditation requirements. Moreover, negotiated contracts with educational personnel have increasingly been used to stipulate in great detail the most uniform system of employment for a productive activity that lacks inherent uniformity. Finally, as we shall note below, the reward structure for managers discourages risk taking, since salaries and promotion are based primarily on seniority and docility rather than on any educationally meaningful sense of leadership. All of these factors inhibit substantial managerial discretion in operating educational institutions.

3. *Little or no competition exists among schools.* With the exception of nominal competition among school districts for families who can afford to migrate, there is no competition for students.[13] Usually the school that a child attends is determined simply by the attendance area in which he lives. Rarely does he have a choice of schools to attend, even among those within the school district. Thus, most schools possess monopoly powers that would be the envy of any monopolistic industry. The combination of assignment practices and compulsory attendance

laws promises a clientele for the school no matter how poorly the school performs. Indeed, as we shall see below, these factors assure that good performance goes unrewarded and poor performance is uncensured, since a captive audience is always guaranteed.[14]

Of course, the schools are not market institutions, but political ones. Thus, one must ask what system of political sanctions exists for an individual family or group of citizens to ensure that schools will be responsive. The answer to this must surely be that the public has very little ability to affect what is happening in the schools. First, the public lacks information on both local schools and education itself as evidenced by extensive public opinion sampling (Gallup 1969, pp. 4–7). Moreover, many states have laws preventing citizens from "interfering" in school operations in any way including visiting of schools without permission, and the schools seem to be exceedingly deficient in providing desirable data on the educational process (Gallup 1969, pp. 8–9; Hanushek and Levin 1969; Coleman and Karweit 1969; Wynne 1972). Second, the school boards themselves seem to lack the ability to respond to demands, since they tend to identify more with the educational professionals than with their citizens on matters of educational policy, and they themselves lack the sanctions to change most outcomes (Lyke 1970; Gittell 1967; Iannacone 1967).

Perhaps worst of all, the school bureaucracies have generally shown themselves to be incapable of carrying out major changes in policy, whether these be school desegregation, curriculum reform, or compensatory education (Rogers 1968; Schrag 1967; Gittell and Hollander 1968). Indeed, they can best be described as suffering from "organizational sclerosis," a malady that makes a movement from the status quo both painful and unnatural (Jencks 1966; Rogers 1968). This frustration is characterized by demands for accountability, and even the pressures for community control of schools are principally a reaction to the red tape thrown in the paths of citizens who seek information about, or changes in, the traditional school regimen (Levin 1970c).

4. *Prices of both inputs and outputs are not readily available to educational managers*. In part, this is due to the inadequacy of school information systems, but in larger measure it is due to the complexity of the markets for educational inputs and outputs. On the input side, most of the characteristics that have been associated with higher educational productivity have been such teacher traits as attitudes, verbal score, and so on. Clearly, it is difficult to disembody these particular characteristics for purposes of pricing, and it may also be difficult to obtain more of any one of these characteristics per se without obtaining others that are embodied in the same person (Levin 1968, Chapters 6–8). Available data on costs are not related to homogeneous inputs. Rather, they are

linked to line-item accounts or to objects that are not standardized with regard to quality, such as principals' salaries, materials, and so on (U.S. Department of Health, Education and Welfare 1957). Even the planning, programming, and budgeting systems that have been designed for the schools do not begin to make inroads into the quests for obtaining specific prices or unit costs (Hartley 1968; Mushkin and Pollak 1970).

Prices for outputs are nonexistent in a market sense. Yet, the schools are expected to produce a large number of outcomes including job preparation, literacy, transmission of knowledge, and democratic values.[15] In theory, referendums and representative governance of schools might be used to reasonably reflect priorities among outputs in the absence of prices. Unfortunately, the political realities suggest that the values of significant proportions of the population are not reflected in the decision process because of imperfect information, inadequate political institutions, and communication gaps between those whose values should be considered and those who actually implement the decisions (Lyke 1970; Jencks 1966; Gittell 1970; Rogers 1968).

5. *The incentive or reward structures characteristic of schools seem to have little relation to the declared educational goals of those institutions.* Financial rewards and promotions for school personnel are handed out primarily on the basis of seniority and accumulation of college credits rather than on demonstrated effectiveness. Individual schools, teachers, or administrators who are successful in achieving important educational goals are treated similarly to those who are unsuccessful, mediocre, or incompetent. In lockstep fashion, the schools reward equally all personnel with the same nominal characteristics, regardless of differences in performance (Kershaw and McKean 1962; Levin 1968). That is, success is not compensated or formally recognized, and the reward structure is divorced systematically from educational outcomes.[16]

In contrast, commercial enterprises tend to compensate their personnel on the basis of the contributions of employees to the effectiveness of the organization. Commissions for sales personnel, bonuses, promotions, profits, and salary increases all represent rewards for individual or organizational proficiencies that do not seem to have their counterparts, in an output-oriented sense, in the schools.

6. *Finally, there are no clear signals of success or failure for the schools that are comparable to sales, profits, losses, rates of return, or shares of market.* Such standard measures as test scores and proportion of students graduating or gaining college entry are so heavily determined by factors beyond the school's control, such as students' social class and cultural antecedents, that it is difficult to disentangle school influences from nonschool influences.[17] Moreover, since education is essentially a dynamic process, the effects of present policy changes may

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only be discernible in the distant future. Furthermore, observation of dynamic effects is obscured by mobility and dynamic changes in social structure that prevent observations on how well school policies have succeeded or failed. Moreover, the multiplicity of outcomes and the lack of concise measures for most of them substantially limit the ability just to observe the school's effects, even if the influence of other factors could be removed. Thus, informational feedback on operational performance of the schools is neither visible nor easily obtainable from existing data.

Standardized Achievement as Educational Output

But if schools cannot be appropriately viewed as acting like competitive suppliers, it is erroneous to assume that they are maximizing the socially optimal mix of educational outputs for any given set of resources. This fact becomes especially important when one considers that most studies of educational production functions have simply assumed that schools are maximizing a single output, the achievement scores of their students. Even those analyses that do acknowledge the multi-product nature of schools generally limit their inquiry exclusively to test scores (Hanushek 1972, pp. 20–26). The usual presumption is that we know very little about the nature of measurement of other outputs in comparison with our understanding of, and ability to measure, cognitive skills. Yet the omission of other outputs in the estimation of educational production functions will lead to a biased set of estimated production coefficients *even for the achievement output* if the other outputs are not strict complements of achievement in the production process.

The evidence suggests that schools are not attempting to maximize achievement scores even when their official rhetoric indicates this as a goal. This is best illustrated by the experience under Title I of the Elementary and Secondary Education Act of 1965. Since 1965–66 over one billion dollars a year has been allocated by the federal government to schools educating children from low-income families. In applying for the money local school districts were required to state the purposes and design of their Title I programs, and they were required to evaluate the results of their efforts. Thus, we can take for granted that the school's specific goals under the program were the ones that they stated, and we can focus on those outcomes. Moreover, the funds allocated to such programs represented approximately half again as much as what was presently being spent on each eligible child, so one might have expected their marginal impact to be substantial.

Since most of the programs concentrated on reading skills, it is useful to evaluate the effect of Title I funds on that outcome. In evaluating the

1966–67 and 1967–68 Title I funded reading programs, the U.S. Office of Education found that on the basis of reading test scores, "a child who participated in a Title I project had only a 19% chance of a significant achievement gain, a 13% chance of a significant achievement loss, and a 68% chance of no change at all [relative to the national norms]" (Picariello 1969, p. 1). Further, the projects included in the investigation were "most likely to be representative of projects in which there was a higher than average investment in resources. Therefore more significant achievement gains should be found here than in a more representative sample of Title I projects."

This inability to create even a nominal direct impact on specific objectives appears to be endemic. Among many thousands of Title I project evaluations, the U.S. Office of Education selected the 1,000 most promising for purposes of further scrutiny by an independent research contractor. Of these, only 21 seemed to have shown sufficient evidence of significant pupil achievement gains in language or numerical skills (Hawkridge, Chalupsky, and Roberts 1968). A more recent analysis has shown a similar pattern of failure to improve test scores (Wargo et al. 1972).

Moreover, studies of school processes and organization suggest that there are other agenda that dominate the educational production function (Jackson 1968; Dreeben 1968). Gintis (1971) has found that grades and other social rewards of schooling are more consistently correlated with the personality attributes of students than with their cognitive achievement scores. It is not even apparent that the cognitive component of schooling as reflected by student test scores has as large an economic impact as other outputs of the educational process. For example, studies of earnings functions suggest that the inclusion of a variable measuring the cognitive performance of individuals (as reflected in test scores) reduces by only a modest amount the observed earnings coefficient for schooling (Taubman and Wales 1973; Griliches and Mason 1972; and Gintis 1971). Presumably, the explanation for this phenomenon is that the other outputs of education that are quite independent of test scores tend to be the ones that have the principal impact on earnings (Bowles and Nelson 1974; Bowles and Gintis 1973).

A more insightful analysis of the relationship between educational production and labor market success seems to be reflected in the recent work of Bowles (1972) and Gintis (1971) and Bowles and Gintis (1975). These studies suggest that the principal purpose of schools is to reproduce the social relations of production, and that achievement scores are only one component of the productive hierarchy. "The school is a bureaucratic order with hierarchical authority, rule-orientation, stratification of 'ability' (tracking) as well as by age, role differentiation by sex

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(physical education, home economics, shop) and a system of external incentives (marks, promise of promotion, and threat of failure) much like pay and status in the sphere of work" (S. Bowles, 1973, p. 353). This analysis suggests that educational achievement is only one of the many outputs of schooling, and it is not necessarily the most important one.

Yet, in order to estimate a production function for educational achievement, we must assume that all schools are operating on the production frontier for *this* output, so that the observed relations represent the maximum output that can be produced with the inputs that are being utilized. The fact that schools are producing other outputs besides cognitive achievement raises serious questions about this assumption, since it is reasonable to believe that the production of other outputs reduces the amount of cognitive learning that will be produced. In this case, it is obvious that statistical estimates among existing schools that consider only the achievement score outcomes of students will not give us estimates of the production frontier, since more achievement could be obtained by reducing the levels of all noncomplementary outputs to zero.

The obvious answer to estimating production functions in the multiproduct case is to specify a system of equations that takes into account all of the outputs of schooling. Unfortunately, our overall ignorance of the conceptual outputs of schools, their measurement, and their structural relationships to one another and to inputs, limits our ability to include nonachievement outputs in the analysis. The result of these limitations is that almost every study that has attempted to estimate educational production functions has considered only educational achievement as an output.[18] In most cases, the obvious problems involved are either ignored or the assumption is made that all other outputs are produced as perfect joint products in exact fixed proportion to achievement scores. As we noted, there is no empirical substantiation for this assumption.

IV. TECHNICAL INEFFICIENCY IN PRODUCING STUDENT ACHIEVEMENT AND ITS IMPLICATIONS FOR EVALUATION

In the previous section we noted that there are many reasons for believing that schools are not technically efficient in producing achievement and that the inefficiencies may be substantial.[19] There is no counterpart for the competitive environment of firms that would stimulate the production of achievement. Even if the school attempted to maximize achievement, the effort would be limited by the imperfect knowledge and limited discretion of school managers. Moreover, other outputs compete with achievement for school resources. Yet, attempts to estimate educational production functions that use achievement as the output are based upon the tacit assumption that schools are producing as much achievement as can be obtained with their resources. That is, they are producing on the "achievement" frontier. But given the high probability of technical inefficiency, estimates of the production functions on this output are likely to yield biased coefficients and misleading implications.

This situation is shown in Figure 3, which represents a hypothetical input-input space where S_1 and S_2 represent two different school inputs into the production of student achievement. Each observation represents the combination of S_1 and S_2 that a particular school is using to produce a given amount of achievement output, Ao. That is, each school in the sample is using a different input mix, even though the apparent output is the same.

Isoquant Ao_1 represents the production frontier defined as the locus of all observations that minimize the combinations of S_1 and S_2 required to produce constant product Ao. Presumably, these schools are producing only the socially minimal required levels of other school outputs.[20] Since Ao_1 is a mapping of the most efficient points for producing achievement Ao, it is the production frontier. All observations to the northeast of Ao_1 are of "inefficient" schools that are using higher input levels to produce the same achievement.[21] Now assume that we fit the observations statistically via normal regression procedures. We obtain the statistical equivalent of Ao_2 for all schools (both efficient and inefficient ones). Of course, all points on Ao_2 are farther from the origin than those on Ao_1, showing that the average production relationship is a less efficient one than the frontier relationship.

Since virtually all estimates of educational production have been based on the performance of both average and efficient schools rather than efficient ones only, the existing statistical studies of educational production are not production function studies in the frontier sense. Moreover, their results may suggest erroneous conclusions about which combination of inputs (programs) maximizes achievement for a given budget constraint. For example, assume the two-input production function

(2) $$A = h(S_1, S_2)$$

In equilibrium, we would wish to satisfy the conditions set out in (3), where P_1 and P_2 represent the prices of S_1 and S_2 respectively.

(3) $$\frac{\partial A/\partial S_1}{P_1} = \frac{\partial A/\partial S_2}{P_2}$$

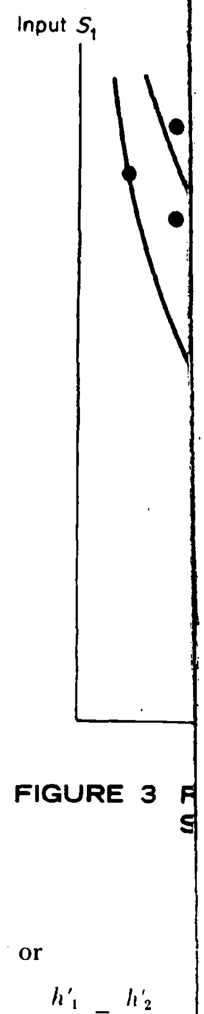

FIGURE 3 F
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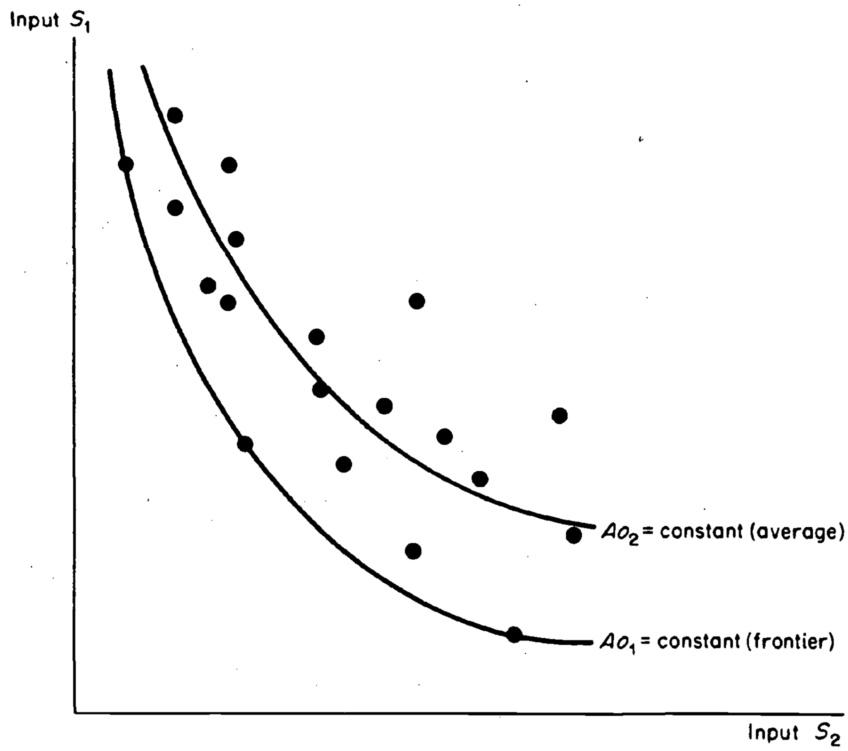


FIGURE 3 Frontier and Average Production Isoquants for Student Achievement

or

$$\frac{h'_1}{P_1} = \frac{h'_2}{P_2}$$

Now consider two different values for h'_1 and h'_2. At the frontier, $h'_1 = \hat{h}'_1$, and for the average of all schools, $h'_1 = \bar{h}'_1$. The symbols for h'_2 can be defined in the same way.

(4) $$\frac{\hat{h}'_1}{\hat{h}'_2} = \frac{\bar{h}'_1}{\bar{h}'_2} = \frac{P_1}{P_2}$$

(4) reiterates the necessary conditions for a maximum, both for frontier estimates and for average estimates of the production function. In both

cases, we wish to select the combination of inputs that equates the ratios of marginal products (first derivatives) to the ratios of prices.

Efficiency Implications of the Estimates

If we estimate only the average production function or only the frontier production function, can the optimal ratio of inputs derived from one estimate also apply to the other? The answer to this question clearly depends on whether there are differences in the structural parameters associated with each input.

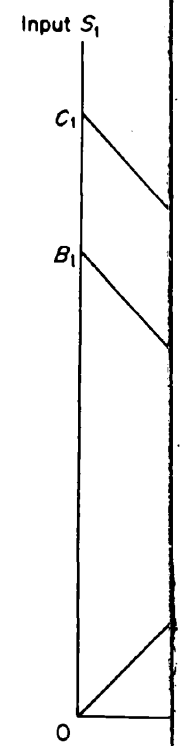
For example, it is possible that the inefficiencies of nonfrontier schools are neutral among inputs so that at every level of input and for every combination of inputs the ratios of the marginal products are identical for both frontier and average functions. That is, (5) holds.

$$\hat{h}_i' = \gamma \bar{h}_i' \quad (i = 1,2) \qquad \gamma \geq 1 \tag{5}$$

This can be represented by Figure 4, where Ao_1 signifies the production isoquant for Ao for all efficient schools and Ao_2 represents the same level of output for the entire set of schools, efficient and inefficient. B_1B_2 and C_1C_2 represent budget or iso-cost lines reflecting the various combinations of S_1 and S_2 obtainable for two given cost constraints, B_1B_2 and C_1C_2, where $C_1C_2 > B_1B_2$. The slope of the iso-cost lines is determined by the ratio of the prices, P_2/P_1. Thus, E and F represent equilibrium points which reflect (4). That is, the combination of S_1 and S_2 that obtains Ao for budget constraint B_1B_2 is determined by the tangency of Ao_1 to B_1B_2 at point E for efficient or frontier schools and of Ao_2 to C_1C_2 at point F for schools on the average.

It can be shown that the relative intensities of the two inputs will be identical for both groups of schools if a ray drawn from the origin intersects both points of tangency. $0M$ satisfies that condition, so the same ratio of S_1/S_2 is optimal for both groups of schools. Whether we use the estimates of frontier schools or of all schools, the findings on the optimal combinations of S_1 and S_2 will be binding for both. In such a case it does not matter which group we use to estimate the production function, although the absolute product will be higher for the set of schools at the frontier for any input level.

The situation depicted in Figure 4 and defined by (5) is a kind of happy state of affairs which would be desirable indeed for purposes of evaluation. Yet, there is no evident reason that such a fortuitous case should hold (Bowles 1970, pp. 16–17). Given technical inefficiencies in the production of education, it is likely that such inefficiencies are not



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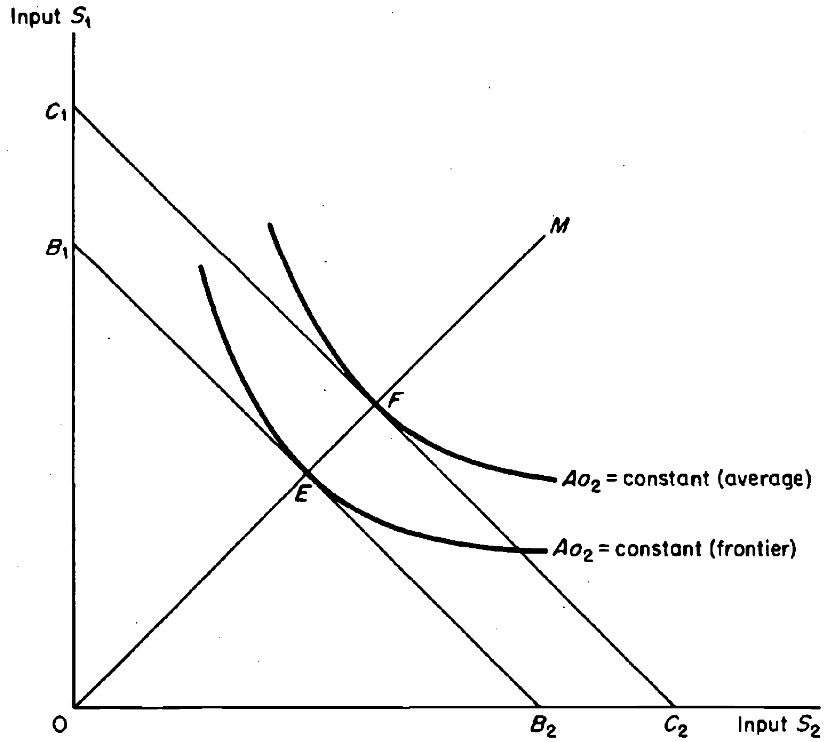

FIGURE 4 Technical Inefficiency that is Neutral between Inputs

neutral among inputs. That is, the inefficient school may be organized in such a way that the relative inefficiency in the use of one input may be greater than for another.[22] This can be shown in Figure 5, and it is also evident in Figure 3. Here the relative inefficiency in the use of S_1 appears to be greater than that for S_2. For example, if S_1 represents physical school facilities and S_2 represents teachers, Figure 5 suggests that the organizational arrangements in inefficient schools are relatively more harmful to the productivity of the facilities in increasing student achievement than to that of the teachers. In this case, a ray drawn through the origin representing a constant ratio of inputs will not intersect both points of tangency. That is, the optimal ratio of S_1/S_2 for frontier schools represented by $0M$ intersecting point E will not intersect point F; rather it intersects the production isoquant for the average schools at point G, which is a more costly combination of inputs than that represented at F. In short, the optimal ratio of S_1/S_2 for frontier schools will be different from that for nonfrontier ones, and if we impose

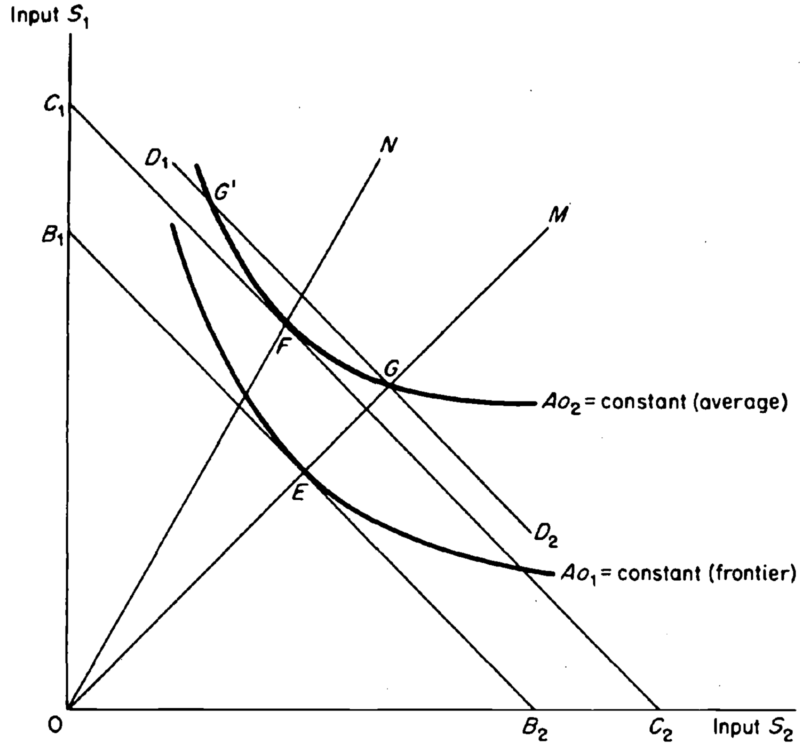

FIGURE 5 Technical Inefficiency that Is Biased between Inputs

that input ratio (represented by 0 M) on the nonfrontier production set, we shall recommend an *allocatively inefficient* set of inputs for the nonfrontier firms.

Of course, the obverse is also true. If we were to base our estimates of the production set on the entire group of schools, and we derived an optimal input ratio based upon 0 N which intersects tangency point F, we would impose an allocatively inefficient decision on frontier firms. That is, in either case, the results that we obtain for one group of schools cannot be applied to the other group. Rather each set of schools will have its own optimal combination of S_1/S_2 depending on the relative efficiencies with which these inputs are used. The point to be emphasized is that even with estimates based upon perfectly specified systems of equations for educational achievement, the input combinations that might be considered optimal for the industry will actually lead to a reduction in allocative efficiency for some educational firms. More specifically, those schools on Ao_2 using any combination of inputs within

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$G\ G'$ would operate with greater price or allocative efficiency by ignoring the advice of economic studies of "frontier" firms.

Now it becomes obvious that under reasonable conditions, the advice of economists using econometric approaches to estimating production functions can actually lead to recommendations that *would decrease the allocative efficiency* of the educational sector. Even with the same set of prices, if every firm has a different set of marginal products such that the marginal rates of substitution of factors differ from firm to firm, then any prescriptive decision rule on optimal input combinations for the educational sector would have a high probability of producing a decrease in allocative efficiency.

This prospect becomes clearer if we depict an industry composed of three firms, Z_1, Z_2, and Z_3. If we assume that each firm is operating on its own "production function," we can depict the individual unit product isoquants for each firm as in Figure 6. Each firm is producing the same level of achievement output, but the mappings of feasible factor combinations differ. The assertion of this kind of idiosyncratic behavior derives primarily from our contention that educational managers lack the competition, incentives, information, and discretion to move toward the production frontier for achievement in any consistent way.

Further, assume that we wish to obtain a unit production isoquant for the industry. Fitting a convex hull to points *a*, *b*, and *c*, we obtain an approximation to the industry production frontier, *ac*.[23] Though in this case every firm's production surface is on the industry frontier, this condition should not be assumed ordinarily. Rather the unit production isoquants of some firms will be tangent to the frontier, while for others this will not be true. Such a situation is perfectly consistent with that described in Figure 1.

Figure 7 shows the conditions for maximizing allocative efficiency in this three-firm case. If we assume that $B_1\ B_2$ is the relative price or iso-cost line facing the industry, then tangency with *ac* is at point *b*. That is, at point *b* it would appear that we would be obtaining the optimal combination of S_1/S_2 for maximizing allocative efficiency. Now assume that each educational firm accepts the recommendation of this industry evaluation with regard to the optimal ratio of S_1/S_2 for maximizing its allocative efficiency. Line $0\ M$ is drawn from the origin through point *b* to indicate the constant ratio of S_1/S_2 that was derived for the industry. In following this recommendation, firm Z_1 would select combination *R;* firm Z_2 would select combination *b;* and firm Z_3 would select combination *Q*. What is the effect on allocative efficiency for each firm?

By coincidence, the iso-cost line $B_1\ B_2$, the production isoquant for firm Z_2, and the estimated frontier for the industry *ac* are all tangent at the same point. Therefore the choice of *b* is allocatively efficient for firm Z_2. Following the evaluation recommendations, firm Z_1 selected point *R*

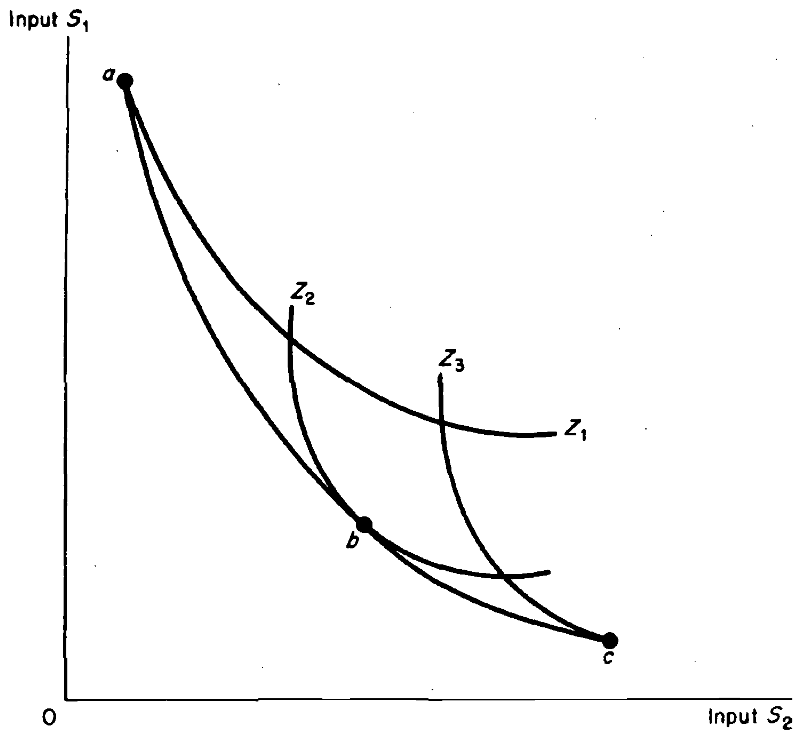


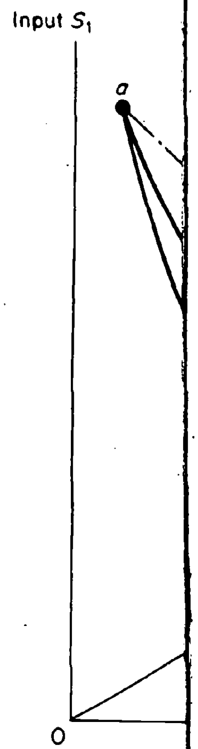
FIGURE 6 Approximating the Industry Production Surface for Three Firms

on iso-cost line aR. Yet it is obvious that Z_1 would be more efficient by producing at R_1 which is tangent to iso-cost line $C_1 C_2$. Indeed, even if firm Z_1 were not at point R_1, the choice of combination R could decrease its efficiency; for any selection of input combinations between point a and point R would be superior to R.

A similar situation exists for firm Z_3. The manager of Z_3 believes fully in using the findings of "scientific" research and evaluation activity in making his choices. Accordingly, he selects input combination Q with the expectation that his firm will be allocatively efficient. Yet, factor combination Q_1 is tangent to a lower iso-cost line D_1D_2, and any input combination between c and W would be superior to Q.

Introducing Further Inefficiencies in Educational Production

In summary, by believing and implementing the results of the industry evaluation, the industry became less efficient rather than more efficient.



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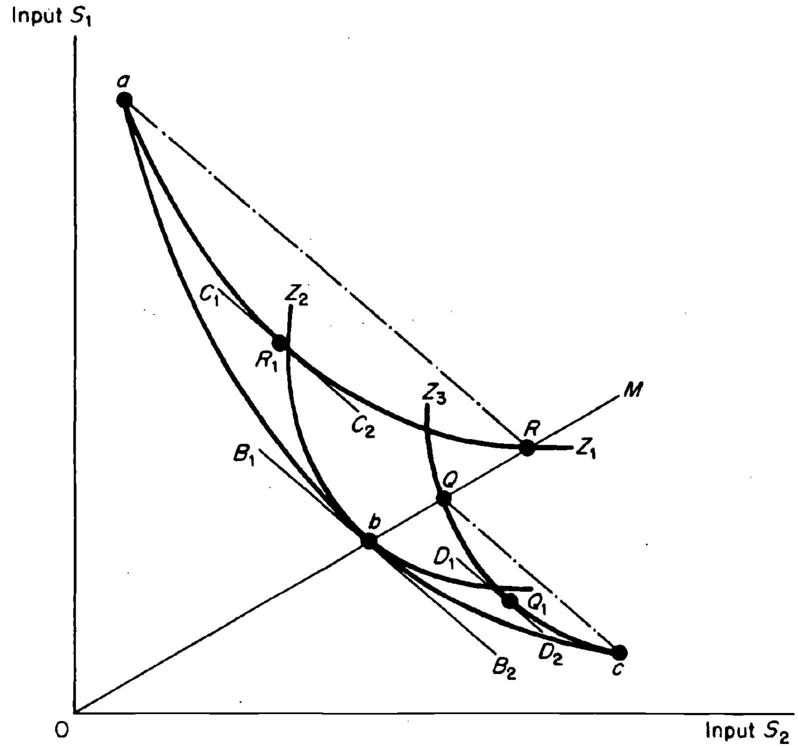

FIGURE 7 Maximizing Allocative Efficiency for the Three-Firm Industry

Yet, the techniques of evaluation were based upon the enormously useful tools of microeconomic analysis. Further, as Figure 7 suggests, no single estimate of the industry's production function for achievement will solve this problem. That is, optimal factor proportions will vary from firm to firm, and a uniform adoption for the industry will reduce overall allocative efficiency. Moreover, even this analysis has assumed that there will be no errors in the estimation of the relationships and that the same relative prices are applicable to each firm. The fact that neither of these assumptions are valid buttresses further the argument that efficiency recommendations based upon statistical production functions of student achievement for the education industry (or a segment of it) can be more harmful than beneficial to sectoral efficiency.

Bear in mind that at the present time we cannot identify or measure most educational outputs, and we are woefully ignorant of the proper specification and measurement of the input structures. Further, since the lion's share of the school budget is spent on personnel, one must raise the question whether teacher "prices" are the same for every school or school district. Among labor markets this is not likely to be so, but even within a school district a set of teachers with given characteristics are not indifferent about the schools in which they teach. For the same salary level, teachers prefer to work in schools attended by middle-class youngsters, and in suburban areas, rather than those attended by lower-class and minority youngsters in rural or highly urbanized areas (H. Becker 1952; Herriott and St. John 1966, Chapter 5). As one might expect, the relative preferences of teachers for specific school sites is reflected in the salaries required to obtain teachers for particular schools.[24]

For the very reasons stated above, it is not possible to test adequately the hypothesis that the production set differs among educational firms. Such a test would require a better specified model than the present state of the art will support. Nevertheless, for those who like the feel of numbers (even unreliable ones), I have used the appendix to compare estimates of educational production functions at the "frontier" with those for a large sample of sixth graders, in toto. Such an empirical operation is relegated to the appendix because it is meant to be provocative rather than definitive. Indeed, no numerical result derived from this exercise should be taken seriously.[25]

Of course, it is possible that parallel and serious problems arise in an analysis of private sector industries, leaving those studies open to erroneous conclusions. Yet, there is a quantum difference in the possible impact of erroneous findings in those cases in comparison with such findings in an evaluation of the education industry. The main difference is that private firms will tend to decide their input combinations on the basis of the peculiar circumstances facing them rather than on average "results" for the industry.[26] Further, the higher the level of aggregation of firms, the more inapplicable the results would appear to any reasonably proficient manager. Since most studies of the industry production function use state averages as units of observation, it would be unlikely that any particular firm would identify with such results.[27]

For example, Griliches carried out a set of studies on agricultural production functions (Griliches 1963, 1964). Using 39 states as "firms" and an unrestricted Cobb-Douglas equation, he found a ratio of marginal revenue product to marginal cost of about 3 to 5 for fertilizer (Griliches 1964). At the time, he notes that fertilizer use was growing at a tremendous rate in reaction to the disequilibrium (p. 968). What is noteworthy here is that Griliches saw natural market forces moving agriculture toward allocative efficiency in a dynamic setting. He did not intend his study to be used by individual farmers to make decisions. Rather he tacitly viewed their managerial behavior as being a function of

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The situation is entirely different for the schools and other public enterprises. The U.S. Office of Education, state departments of education, educational researchers, and school managers search out the uniform decision or recommendation with the hope of applying it generally. This penchant for standardizing input proportions is reflected in the laws of many of the states that require very specific ratios of administrators to teachers, and of teachers and other professional staff to students. It is reflected in the policy prescriptions of most educational reports.[28] Moreover, the fact that results derived from modern analytic tools often go unquestioned because many decision makers lack training in these areas just intensifies the problem. There is an increasing desire to try on the "emperor's new clothes" by educational managers who find this attire preferable to the dull and monotonous garb which makes them indistinguishable from other bureaucratic chieftains.

V. SUMMARY

Rising costs of education in conjunction with persistent concerns about quality have raised questions about the efficiency of the educational sector. One approach to improving the effectiveness of resource use in education is to estimate the technical production set for educational output; to relate the technical coefficients to prices of the inputs; and to make policy recommendations on the basis of these analyses that will raise the allocative efficiency of the educational enterprise. Within recent years a large number of studies have estimated an educational production function for student achievement, and an attempt has been made to compare marginal products with prices.

But, in order for observed statistical relations between inputs and outputs to reflect the maximum amount of input that can be obtained with the resources being utilized, all firms in the sample must be on the production frontier. In conventional analyses of industry production functions, it is assumed that the nature of a competitive environment in conjunction with the goal of profit maximization would tend to ensure that firms operating in competitive industries would be both technically and allocatively efficient. But, schools neither operate in a competitive environment nor do they have most of the other characteristics that we ascribe to competitive firms. Accordingly, it is not reasonable to believe that schools are operating on the production frontiers for the particular outputs that we believe that they *should be* producing.

Virtually all attempts to estimate educational production have specified educational achievement as reflected in test scores as the appropriate output of the educational process. We have shown that there is abundant evidence in conflict with the view that schools are attempting to maximize achievement scores. Accordingly, it does not seem reasonable that educational firms are operating on the production frontier for student achievement, and estimates of production functions among schools will not be likely to yield the appropriate technical coefficients that show the maximum amount of educational achievement that can be obtained with a given set of resource inputs. Moreover, it is likely that using the results of such studies for policy could decrease the economic efficiency of the educational industry with respect to the production of achievement rather than improving it.

It would seem that a more productive approach to future research in this area would be to attempt to ascertain a behavioral theory of schools that describes what schools are producing and how they are doing it.[29] Such studies would investigate the internal processes of educational enterprises as well as the various types of outcomes that they produce. They would also study the interface between schools and their external environment in order to determine the types of political sanctions and other characteristics that create the existing operations of the schools (Bowles and Gintis, 1975; Carnoy and Levin, 1976). This type of study might also begin to explain what aspects of schooling in addition to cognitive achievement affect adult income and other social outcomes. At the present time, our understanding of these relations is so inadequate that we are applying concepts derived from the competitive theory of the firm to bureaucratic, nonmarket institutions, and such an application seems unjustified.

An important start in this direction is reflected in the work of Gintis (1971) and Bowles (1972 and 1973). According to their analyses, schools serve to reproduce the social relations of production required by capitalist enterprise. They trace the evolution of the American schools through two periods of great change in the capitalist order (1830–90 and 1890–1930), and they assert that the changes in characteristics of schooling tended to mirror the changes in the demands of capitalist enterprises (Bowles and Gintis 1975). They have also related the internal activities of schooling, including school organization and grading practices, to worker characteristics that have been linked to productivity and earnings in hierarchical work settings. At the very least, their findings suggest that the function of schools is considerably more complex than the maximization of student achievement. It would seem that research endeavors in

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this direction would yield much more information about efficiency in the production of schooling than the present naive approach to "estimating" production sets. The most that can be said about the present production function studies is that they are interesting and harmless; unfortunately, they may also be misleading.

APPENDIX

A Temerarious Empirical Application

The major difficulty in demonstrating some of the empirical implications of the foregoing analysis is that the necessary relationships are much easier to obtain mathematically and geometrically than they are statistically. The particular problems in deriving educational production functions have been described elsewhere, so they will not be detailed here (Bowles 1970; Michelson 1970; Cain and Watts 1970; Levin 1970a). Yet it is useful to note that the statistical work in this area is subject to errors in the equations as well as errors in the variables. In the former case, the proper specification of the model is still in the exploratory stage. The structure of the model, the specific variables to be included, and their relationship to one another have not been well established, and there are many gaps in our knowledge. Moreover, most of the operational variables used in the models are subject to varying degrees of measurement error.

Thus, no strict application of our findings to public policy is warranted. Rather, the empirical aspects are meant to be provocative in generating new directions and thought on the process of evaluation. The results that we derive must surely be subject to replication and further analysis before they can be considered acceptable for policy evaluation.

The Sample

The data set used in this analysis represent a subsample drawn from the Survey on Equal Educational Opportunity of the U.S. Office of Education for the school year 1965–66. Specifically, it is composed of some 597 white sixth graders who had attended only the school in which they were enrolled at the time of the survey.[30] These data were reanalyzed and recoded extensively for purposes of estimating the present relationships, so they differ in important ways from other studies that have utilized information from the same survey. There are some 29 schools represented in the sample, and teacher characteristics represent the averages for each school for all teachers who were assigned to grades 3 through 5. These averages were intended to reflect the teacher characteristics that had influenced student behavior up to the time of the survey. Moreover, it was assumed that the observed measures of family background and other educational influences were related systematically to the cumulative impacts of each of these variables.

The equation that we will use to explore differences between frontier and average estimates will be a linear equation based on (1). Linearity not only violates our assumptions about the second derivative, but it also runs counter to our intuition about the real world. Yet, the difficulties of estimating particular nonlinear functions and the risk of greater specification biases in the coefficients by imposing another arbitrary functional form suggest that the linear equation might yield reasonable first approximations to the estimates that we seek. Of course, this limits our comparison of the frontier and average estimates to that of the linear marginal products and price ratios.

The variables in the equation are shown in Table A-1. These variables are taken from the reduced-form equation for verbal achievement derived from a four-equation system encompassing three simultaneous equations and one that represents a recursive relationship. Once that system is estimated one can solve for the reduced-form equation for any of the three endogenous variables. Since the estimation of that system is discussed elsewhere, we shall concern ourselves only with the reduced form of the verbal equation.[31] This equation was fitted to the entire sample of observations. Consequently, it represents the average production relation for the sample of schools. Results are shown for this estimate in the right column of Table A-2.

Obtaining Frontier Estimates

Using the same set of data and variables, we wish to obtain estimates of the equation for only the most efficient observations, those on the frontier. While there are several ways of doing this, we have chosen the programming approach in input-output space suggested by Aigner and Chu (1968). Since our individual observations are students rather than schools, we wish to seek those students who show a particular outcome with the lowest application of resources. Using the general notation from (1), the problem is to minimize (1-a).

$$\sum_{i=0}^{n} \hat{\alpha}_i \overline{X}_i \qquad \text{(1-a)}$$

where $\hat{\alpha}_i$ is the parameter for the ith input, $\overline{X}_i$ is the mean of X_i, and $\overline{X}_o$

TABLE A-1 List of Variables

Name of Variable	Measure of:	Coding
Verbal score	Student performance	Raw score
Sex	Male-female differences	[illegible]

TABLE A-1 List of Variables

Name of Variable	Measure of:	Coding
Verbal score	Student performance	Raw score
Sex	Male-female differences	Male = 0, female = 1
Age	Overage for grade	Age 12 or over = 1, less than 12 = 0
Possessions in student's home	Family background (socioeconomic status)	Index of possessions: television telephone dictionary encyclopedia automobile daily newspaper record player refrigerator vacuum cleaner (Yes = 1, No = 0, for each; index is sum)
Family size	Family background	Number of people in home
Identity of person serving as mother	Family background	Real mother at home = 0, real mother not living at home = 1, surrogate mother = 2
Identity of person serving as father	Family background	Real father at home = 0, real father not living at home = 1, surrogate father = 2
Father's education	Family background	Number of years of school attained
Mother's employment status	Family background	Has job = 1, no job = 0
Attended kindergarten	Family background	Yes = 1, no = 0

TABLE A-1 (concluded)

Name of Variable	Measure of:	Coding
Teacher's verbal score	Teacher quality	Raw score on vocabulary test
Teacher's parents' income	Teacher socioeconomic status	Father's occupation scaled according to income (000's of dollars)
Teacher experience	Teacher quality	Number of years of full-time experience
Teacher's undergraduate institution	Teacher quality	University or college = 3, teacher institution = 1
Satisfaction with present school	Teacher's attitude	Satisfied = 3, maybe prefers another school = 2, prefers another school = 1
Per cent of white students	Student body	Percentage estimated by teachers
Teacher turnover	School	Proportion of teachers who left in previous years for reasons other than death or illness
Library volumes per student	School facilities	Number of volumes divided by school enrollment

TABLE A-2 Frontier and Average Production Relations for White Sixth Graders, Eastmet City

Variable	Frontier Function				Average Function
	Run 1	Run 2(− 9)	Run 3(− 23)	Run 4(− 38)	
Sex	0.0	1.649	0.982	0.01956	0.817

TABLE A-2 Frontier and Average Production Relations for White Sixth Graders, Eastmet City

Variable	Frontier Function				Average Function
	Run 1	Run 2(– 9)	Run 3(– 23)	Run 4(– 38)	
Sex	0.0	1.649	0.982	0.01956	0.817 (1.41)
Age	−7.714	−4.642	−4.769	−5.553	−6.010 (4.49)
Family size	−0.502	−0.500	−0.089	−0.770	−0.552 (3.50)
Father's identity	0.0	0.0	−0.283	−0.420	−0.327 (0.64)
Mother's identity	−0.878	−1.342	−1.190	−1.202	−0.433 (1.90)
Father's education	0.509	0.179	0.0	0.103	0.273 (3.22)
Mother's employment	−1.726	−2.293	−1.089	−0.951	−0.509 (1.31)
Possessions	1.865	1.464	1.070	1.020	1.229 (5.08)
Kindergarten	0.0	2.866	1.920	2.106	2.372 (2.47)
Teacher's verbal ability	0.810	0.218	0.695	0.791	0.250 (1.70)
Teacher's parents' income	0.0	0.0	0.0	−0.00006	−0.118 (0.65)
Teacher's undergraduate institution	3.736	5.269	1.991	8.307	6.525 (2.09)

TABLE A-2 (concluded)

Variable	Frontier Function: Run 1	Frontier Function: Run 2(− 9)	Frontier Function: Run 3(− 23)	Frontier Function: Run 4(− 38)	Average Function
Teacher experience	0.0	−0.500	−0.264	−0.616	0.787 (4.93)
Teacher satisfaction	3.630	7.078	4.666	3.608	1.960 (1.50)
Per cent white students	0.0	−0.500	−0.264	−0.178	−0.047 (0.25)
Library volumes per student	0.0	0.571	0.509	0.156	0.565 (1.53)
Teacher turnover	0.0	0.0	0.0	−0.035	−0.101 (1.27)
Constant	0.0	0.0	−0.944	−4.051	−7.902 (0.84)
					n = 597
					R^2 = .48

NOTE: t statistics are in parentheses.

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= 1 in order to obtain a constant term. More specifically, we wish to minimize (1-a) which can be rewritten as (2-a) subject to the constraints (3-a).

(2-a) $$\text{Min. } \hat{\alpha}_o + \hat{\alpha}_1 \overline{X}_1 + \ldots + \hat{\alpha}_n \overline{X}_n$$

subject to:

(3-a) $$\begin{aligned} &\hat{\alpha}_o + \hat{\alpha}_1 X_{11} + \ldots + \hat{\alpha}_n X_{n1} \geq Y_1 \\ &\quad \vdots \\ &\hat{\alpha}_o + \hat{\alpha}_1 X_{im} + \ldots + \hat{\alpha}_n X_{nm} \geq Y_m \\ &\hat{\alpha}_i \geq 0 \end{aligned}$$

Since this is essentially a linear programming problem, there will be as many "efficient" observations as there are inputs into the production function (assuming that no two observations are identical). Yet, clearly some of these firms will appear to be efficient when in fact the figures represent measurement errors.[32] Accordingly, a problem arises in that it is impossible for us to know a priori whether a particular observation is efficient or spurious. Following Timmer we have discarded extreme observations in order to eliminate what might be spurious points (Timmer 1969). This is particularly important for the frontier estimates, since very few observations determine the structural coefficients.

Table A-2 contrasts the frontier estimates with those for the average function. Each of the coefficients represents the first derivative or marginal product of the function.[33] Four linear programming runs were used to obtain frontier estimates. Run 1 eliminated no observations; Run 2 discarded the nine most "efficient" points; Run 3 eliminated 23 observations; and Run 4 discarded the 38 most extreme points (or about 6 per cent of the sample). We shall focus on the comparisons between the frontier function from Run 4 and the average function. In doing this we shall examine two properties of the estimates: (1) the relative magnitudes of the coefficients; and (2) implications for allocative or price efficiency.

Recall that in order for evaluation findings of optimal input intensities to yield the same relative applications of inputs for both average and frontier schools, the marginal products for both functions must bear a constant relation to each other as reflected in (5). Table A-3 shows the ratios of marginal products for the two sets of estimates for all of the school variables. According to this table, there is no obvious systematic relationship between the two sets, and some of the coefficients, such as teacher's verbal score, are different at statistically significant levels. At the frontier, such inputs as the teacher's verbal facility and the propor-

TABLE A-3 Ratio of Marginal Products at "Frontier" to Marginal Products for Entire Sample

School Variables	MP (frontier) / MP (average)
Kindergarten	.888
Teacher's verbal ability	3.164
Teacher's parents' income	.001
Teacher's undergraduate institution	1.273
Teacher experience	.783
Teacher satisfaction	1.841
% white students	3.787
Library volumes per student	.276
Teacher turnover	.347
Constant	.513

tion of white students show marginal products that are more than three times their counterparts derived for the sample as a whole. On the other hand, such variables as teacher turnover, teacher experience, and library volumes per student show much smaller coefficients for the frontier function.

If these estimates are truly unbiased, the implications are that so-called frontier schools are more efficient in the use of some inputs and less efficient in the use of others. Thus any optimal combination of inputs for any set of schools or any individual school is likely to be nonoptimal for any other set of schools or individual ones. In other words, for any given array of prices ($P_1, P_2, \ldots, P_n$) the optimal set of factor or input proportions may vary significantly from school to school.

For purposes of generalization, this is the worst of all possible worlds. That is, while we might be able to derive the optimal input structure for frontier schools or for schools on the average as represented by equilibrium conditions stated in (4), it is likely that the desirable combination of input intensities will differ between the two sets of schools (and in all probability will differ significantly from school to school).

An illustration of this is found in Table A-4, which shows the estimated ratios of prices of two inputs as well as the two sets of marginal products for those inputs. The prices reflect the increments to annual teacher salaries for each of the characteristics as derived from an equation relating teacher attributes to earnings in the Eastmet teacher market.[34] The marginal products associated with a unit change in teacher verbal score and teacher experience are taken from Table A-2. In equilibrium the ratios of the marginal products of the inputs should be

TABLE A-4

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TABLE A-4 Relative Prices and Marginal Products for Teacher Experience and Teacher Verbal Score

	Teacher Verbal Score (1)	Teacher Experience (2)	Ratio (1) ÷ (2) (3)
Price	$24.00	$79.00	0.303
Marginal product at frontier	0.791	0.616	1.284
Marginal product on average	0.250	0.787	0.317

equal to the ratios of their respective prices. For the average production estimates these ratios are almost identical, so that allocative or price efficiency is implied even though the average estimates are assumed to be based upon technically inefficient (nonfrontier) schools.

On the other hand, the frontier estimates show a ratio of marginal products four times as great as the price ratio for the two inputs. This suggests that the utilization of more verbally able teachers yields four times as much output per dollar as the utilization of additional teacher experience. If this is correct, the schools on the frontier could increase total output by reallocating their budgets in favor of teacher verbal score while reducing teacher experience.[35]

The significant aspect of this analysis is that the output maximizing combination of inputs differs between the two estimates. If these differences persist among schools of different efficiencies, the hope of obtaining general rules for decision making which can be applied across schools seems to be frustrated. That is, the lack of similarities among the production techniques used by different schools may mean that neither average nor frontier findings can be applied to any particular school. Indeed, in the extreme case each individual school is on its own production function, and evaluation results for any group of schools will not be applicable to individual schools in the sample.

NOTES

1. Both Smith and Friedman are concerned about inefficiencies that result when state-run schools have little or no incentive to fulfill their stated objectives. (Smith 1937, p. 737; Friedman 1955 and 1962).
2. The rudiments of this specification were first suggested by Hanushek 1968.
3. For a more literal interpretation see Dugan (1969). Dugan has calculated the monetary value of parents' educational investment in their offspring by calculating the opportunity cost or market value of such services. The values of father's educational

investment, mother's educational investment, and school investment (all measured in dollars) seem to have high combined predictive value in explaining achievement levels. Also see Leibowitz, 1974.

4. These "theories" are essentially "black-box" hypotheses, based upon correlational findings or upon man-machine analogies. They do not specify general input-output structures or the physical, psychological, biological, and physiological processes underlying them. Indeed, there is no engineering knowledge of the educational process that is remotely analogous to those in agriculture and manufacturing. See for example, Bloom (1964).
5. The reasons for this assertion are found in Levin (1970a, pp. 65–66).
6. For general reviews of findings see Bowles (1970); Guthrie et al. (1971, Chapter 3); Kiesling (1971); and Averch et al. (1974).
7. This assumption has been questioned by Michelson (1970, pp. 134–149); Bowles (1970, pp. 16–17); and Levin (1970a, pp. 57–59).
8. Certainly this can be related to the criticisms of the schools made by many commentators who see the schools focusing on the wrong outputs. For a more sophisticated, but related, social welfare argument see Gintis (1969 and 1971) and Levin (1974a).
9. School districts in the United States vary in enrollments from a handful of students to the over 1 million enrollees in New York City. Individual schools show enrollments varying from a few children into the 10,000 student range. There were some 19,000 operating school systems and 44.5 million public-school students in 1969. Of these systems, only 1 per cent of them had 25,000 or more pupils. Yet, almost one-third of the students were in the 25,000 and over category while less than 2 per cent were in school systems with less than 300 pupils (Sietsema and Mongello, 1970, p. 6).
10. For an analysis of the production decisions faced by the multi-product firm generally and the joint product firm specifically, see Sune Carlson (1956, Chapter V); and Pfouts (1961).
11. The conventional "theory of the firm" has come increasingly under attack by those who charge that it is a theory of an environment rather than a theory of behavior. See Cyert and Hedrick (1972) for a review of this controversy.
12. In California, the state department of education even prints many of the books required at the elementary level. The cumbersomeness of this arrangement has resulted in a perennial ritual by which several hundred thousand youngsters have lacked their reading and arithmetic books for periods of up to two or three months following the opening of school. For greater detail on the degree of external control see Levin (1974a).
13. While Tiebout has suggested that such a public market exists, its efficiency must be questioned. Costs of migration are high, preventing frequent movement in response to disequilibria. Moreover, zoning and other impediments limit the usefulness of the housing market as a vehicle for educational choice. (See Tiebout 1956.) Of course, private alternatives exist for those willing and able to make substantial financial sacrifices.
14. For some approaches to implementing competition among the public schools see Downs (1970). Data on the voucher-inspired federal experiment in San Jose, California, are found in Weiler et al. (1974).
15. For an extensive taxonomy of educational objectives see Bloom (1956); and Krathwohl, Bloom, and Masia (1964).
16. For a more general analysis of the relation between institutional performance and incentive structures see Schultze (1968) and Rivlin (1971). Educational applications are found in Pincus (1974).
17. Multicollinearity among such inputs is a major basis of criticism for some of the

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earlier work done in the area of estimating educational production. See Bowles and Levin (1968a and 1968b).

18. Exceptions to this are the multi-product estimations of Levin (1970a) and Michelson (1970), as well as the work of Boardman et al. (1973).

19. Of course, many private firms are likely to be technically inefficient to the degree that the competitive assumptions do not hold for them. See Leibenstein (1966) for a variety of examples illustrating substantial differences in technical efficiency or "x-efficiency" of firms. Nevertheless, while the inefficiency club is not an exclusive one, it would appear a priori that public schools have even fewer of the characteristics that would promote efficient production than do private firms. See Aigner and Chu (1968); Timmer (1971); and Farrell (1957).

20. In theory, schools on the frontier for student achievement are producing no other outputs. That is, the production of other outputs is assumed to detract from the production of student achievement. But, in fact, it is likely that there is a socially minimal level of other outputs (such as citizenship, work attitudes, and so on) that all schools produce. In this case, the schools that appear to be on the achievement frontier are on a "modified frontier," which assumes a socially minimal level of other outputs. That is, short of an experiment, we are unable to obtain production data on schools that are producing only student achievement.

21. Inefficiency is used here in a very narrow way. Specifically, it refers to the case in which more of a particular output could be obtained by reallocating existing resources from other outcomes to the one under scrutiny. The case of "technical inefficiency" or "x-inefficiency" is just a misnomer for this condition. Under conditions of technical inefficiency, it appears that more output could be obtained with the same level of inputs. But, as we have shown elsewhere (Levin and Muller, 1973), the physical laws of production must surely behave according to the principles of conservation of mass and energy, so that nothing is "lost" in the production process. One is always on the production frontier in that there is a mapping of outputs on inputs for any production process. When a steel mill is producing less steel for a given set of inputs than another mill, it is producing more heat energy or worker leisure or other outputs. It just happens that the most-valued or preferred output from the perspective of the analyst is steel rather than heat energy or worker leisure. Thus, so-called technical inefficiency can always be shown to reduce to allocative or price inefficiency, since it is a function of values rather than energy losses in a physical sense. For reference to the concept of technical efficiency or x-efficiency, see Farrell (1957) and Leibenstein (1966). In our view, the conception is erroneous for reasons mentioned above and outlined more systematically in Levin and Muller (1973). Also see Knight (1923).

22. There is an obvious similarity between this issue and the question of neutrality of technological progress. See Salter (1960); Brown (1966).

23. For discussion of techniques for deriving such a convex hull, see Aigner and Chu (1968).

24. For evidence of price differences attributable to teacher preferences for particular types of schools and teaching environments, see Toder (1972) and Levin (1968).

25. These results are also reported in Levin (1974).

26. See Hall and Winsten (1959) for a discussion of complications arising from interfirm differences in environmental conditions.

27. See the comments by Walters (1963, pp. 5–11).

28. See for example James S. Coleman et al. (1966, Chapter 1); and U.S. Commission on Civil Rights (1967). For criticism of such policy uses see Bowles and Levin (1968a), and Cain and Watts (1970).

29. There is an obvious parallel with the behavioral theory of the firm. See Cyert and March (1963) and Cyert and Hedrick (1972).
30. See Levin (1970a) for details.
31. Ibid.
32. Unfortunately each observation is a student rather than a firm. The proper approach is to seek efficient firms (schools) rather than students. The reason that students are used rather than firms is due to the limited sample size of schools, 29. Since it would require 18 of these firms to fit the frontier—given 18 parameters—one could hardly maintain that the frontier coefficients were based *only* on efficient firms.
33. Since $\alpha_i \geq 0$, those variables that showed negative coefficients for the average function represented problems for the programming estimates. The array for each such variable was multiplied by (-1) for the programming estimates, and the signs were reversed in turn when reporting the results in Table A-2. The author is indebted to Richard C. Carlson for computing the programming estimates. See his paper "Educational Efficiency and Effectiveness," May 1970, prepared for the Seminar in Economics of Education, Stanford.
34. These are taken from Levin (1968). For a similar application of these prices see Levin (1970c).
35. For a similar finding, see Levin (1970c).

REFERENCES

Aigner, D. J., and Chu, S. F. "On Estimating the Industry Production Function." *American Economic Review* 58 (Sept. 1968): 826–839.

Arrow, Kenneth. *Social Choice and Individual Values.* New York: John Wiley and Sons, 1951.

Averch, Harvey R. *How Effective is Schooling? A Critical Review of Research.* Englewood Cliffs: Educational Technology Publications, 1974.

Baumol, William. "Macroeconomics of Unbalanced Growth: The Anatomy of Urban Crisis." *American Economic Review* 57 (June 1967): 415–426.

Becker, G. S. *Human Capital.* Princeton: Princeton University Press, 1964.

Becker, Howard S. "The Career of the Chicago Public School Teacher." *American Journal of Sociology* 57 (Mar. 1952): 470–477.

Bell, Terrel. "Statement to Press on the Opening of Schools, 1974–75." Reported in *Education-Training Market Report* 10 (Sept. 16, 1974): 1.

Bloom, Benjamin S. *Stability and Change in Human Characteristics.* New York: John Wiley and Sons, 1964.

Bloom, Benjamin, ed. *Taxonomy of Educational Objectives, Handbook I: The Cognitive Domain.* New York: David McKay and Co., 1956.

Boardman, Anthony E.; Davis, Otto A.; and Sanday, Peggy. "A Simultaneous Equations Model of the Educational Process: The Coleman Data Revisited with an Emphasis upon Achievement." Paper presented at the Annual Meeting of the American Statistical Association, New York, Dec. 28, 1973.

Bowles, Samuel S. "Towards an Educational Production Function." In W. Lee Hanson, ed. *Education, Income, and Human Capital.* New York: NBER, 1970, pp. 11–60.

———. "Understanding Unequal Economic Opportunity." *American Economic Review Papers and Proceedings* 63 (May 1973): 346–356.

———. "Unequal Education and the Reproduction of the Social Division of Labor." In Martin Carnoy, ed. *Schooling in a Corporate Society.* New York: David McKay and Co., 1972a, pp. 36–66.

Bowles, Samuel, a
(Nov./Dec.
Bowles, Samuel, an
Books, Inc.,
Bowles, Samuel, an
Critical Ap
(Winter 196
———. "More on
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Bowles, Samuel, an
Reproductio
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Brown, Byron, and
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Dahl, R. A., and Li
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Downs, Anthony. "
Community C
Dreeben, Robert. C
Co., 1968.
Dugan, Dennis. "T
Achievement
Statistical As
Farrell, Michael. "
Statistical So

Bowles, Samuel, and Gintis, Herbert. "IQ in the U.S. Class Structure." *Social Policy* 3 (Nov./Dec. 1972, Jan./Feb. 1973).

Bowles, Samuel, and Gintis, Herbert. *Schooling in Capitalist America*. New York: Basic Books, Inc., 1975.

Bowles, Samuel, and Levin, Henry M. "The Determinants of Scholastic Achievement—A Critical Appraisal of Some Recent Evidence." *Journal of Human Resources* 3 (Winter 1968): 3–24.

———. "More on Multi-collinearity and the Effectiveness of Schools." *Journal of Human Resources* 3 (Summer 1968b): 393–400.

Bowles, Samuel, and Nelson, Valerie. "The 'Inheritance of IQ' and the Intergenerational Reproduction of Economic Inequality." *Review of Economics and Statistics* 56 (Feb. 1974): 39–51.

Brown, Byron, and Saks, Daniel. "The Production and Distribution of Cognitive Skills Within Schools." *Journal of Political Economy* Vol. 83, No. 3 (1975): 571–594.

Brown, Murray. *On the Theory and Measurement of Technological Change*. New York: Cambridge University Press, 1966.

Burkhead et al. *Input and Output in Large City High Schools*. Syracuse: Syracuse University Press, 1967.

Cain, Glen G., and Watts, Harold. "Problems in Making Policy Inferences from the Coleman Report." *American Sociological Review* 35 (Apr. 1970): 228–242.

Carlson, Richard C. "Educational Efficiency and Effectiveness." Paper prepared for the Seminar in Economics of Education, Stanford University (May 1970).

Carlson, Sune. *A Study on the Pure Theory of Production*. New York: Kelley and Millman, 1956.

Carnoy, Martin, ed. *Schooling in a Corporate Society*. New York: David McKay and Co., 1972.

Carnoy, Martin, and Levin, Henry M. *The Limits of Educational Reform*. New York: David McKay and Co., 1976.

Cohn, Elchanan. "Economics of Scale in Iowa High School Operations." *Journal of Human Resources* 3 (Fall 1968): 422–434.

Coleman, James S., and Karweit, Nancy. "Multi-Level Information Systems in Education." Rand Document 19287-RC. Santa Monica, Calif.: Rand Corporation, 1969.

Coleman, James S., et al. *Equality of Educational Opportunity*. U.S. Office of Education, OE 38001. Washington, D.C.: GPO, 1966.

Comanor, W., and Leibenstein, H. "Allocative Efficiency, X-Efficiency, and the Measurement of Welfare Losses." *Economica* 36 (Aug. 1969): 304–309.

Cyert, R. M., and March, J. G. *A Behavioral Theory of the Firm*. Englewood Cliffs, N.J.: Prentice-Hall, 1963.

Cyert, Richard M., and Hedrick, Charles L. "Theory of the Firm: Past, Present, and Future." *Journal of Economic Literature* 10 (June 1972): 398–412.

Dahl, R. A., and Lindblom, C. E. *Politics, Economics, and Welfare*. New York: Harper and Brothers, 1953.

Downs, Anthony. "Competition and Community Schools." In Henry M. Levin, ed., *Community Control of Schools*. Washington, D.C.: Brookings Institution, 1970.

Dreeben, Robert. *On What is Learned in School*. Reading, Mass.: Addison Wesley and Co., 1968.

Dugan, Dennis. "The Impact of Parental and Educational Investment Upon Student Achievement." Paper presented at the Annual (129th) Meeting of the American Statistical Association, New York City, August 21, 1969, processed.

Farrell, Michael. "The Measurement of Productive Efficiency." *Journal of the Royal Statistical Society*, Series A (General), Vol. 120, Part 3 (1957): 253–281.

Friedman, Milton. "The Role of Government in Education." In *Capitalism and Freedom.* Chicago: University of Chicago Press, 1962, Chapter VI.

———. "The Role of Government in Education." In Robert A. Solo, ed., *Economics and the Public Interest.* New Brunswick, N.J.: Rutgers University Press, 1955.

Gallup, George. *How the Nation Views the Public Schools.* Princeton, N.J.: Gallup International, 1969.

———. "Second Annual Survey of the Public's Attitude Toward the Public Schools." *Phi Delta Kappan* 52 (Oct. 1970): 99–112.

———. Sixth Annual Gallup Poll of Public Attitudes Toward Education." *Phi Delta Kappan* 56 (Sept. 1974): 20–32.

Gintis, Herbert. "Education, Technology and the Characteristics of Worker Productivity." *American Economic Review* 61 (May 1971): 266–279.

———. "Production Functions in the Economics of Education and the Characteristics of Worker Productivity." Ph.D. diss., Howard University, 1969.

Gittell, Marilyn. *Participants and Participation.* New York: Praeger, 1967.

Gittell, Marilyn, and Hollander, T. Edward. *Six Urban School Districts: A Comparative Study of Institutional Response.* New York: Praeger, 1968.

Greer, Colin. *The Great School Legend.* New York: Basic Books, 1972.

Griliches, Zvi. "Estimates of the Aggregate Agricultural Production Function from Cross-Sectional Data." *Journal of Farm Economics* 45 (May 1963): 419–428.

———. "Research Expenditures, Education, and the Aggregate Agricultural Production Function." *American Economic Review* 54 (Dec. 1964): 961–974.

———. "Specification Bias in Estimates of Production Functions." *Journal of Farm Economics* 39 (Feb. 1957): 8–20.

Griliches, Zvi, and Mason, W. "Education, Income, and Ability." *Journal of Political Economy* 80, Supplement (May/June 1972): S. 74–S. 103.

Guthrie, James W.; Kleindorfer, George B.; Levin, Henry M.; and Stout, Robert T. *Schools and Inequality.* Cambridge: Massachusetts Institute of Technology Press, 1971.

Hall, Lady, and Winsten, C. B. "The Ambiguous Notion of Efficiency." *Economic Journal* 69 (Mar. 1959): 71–86.

Hanushek, Eric. *Education and Race.* Lexington, Mass.: D. C. Heath, 1972.

———. "The Education of Negroes and Whites." Ph.D. diss., Department of Economics, Massachusetts Institute of Technology, 1968.

Hanushek, Eric, and Kain, John F. "On the Value of Equality of Educational Opportunity as a Guide to Public Policy." In F. Mosteller and D. D. Moynihan, eds., *On Equality of Educational Opportunity.* New York: Random House, 1972, pp. 116–145.

Hanushek, Eric, and Levin, Henry M. "Educational Information Systems for Management and Evaluation—A Proposed Program." D-2073. Santa Monica, Calif.: Rand Corporation, 1969.

Hartley, Harry J. *Educational Planning, Programming, Budgeting: A Systems Approach.* Englewood Cliffs, N.J.: Prentice-Hall, 1968.

Hawkridge, David G.; Chalupsky, Albert B.; and Roberts, A. Oscar H. "A Study of Selected Exemplary Programs for the Education of Disadvantaged Children." Parts I and II, Final Report, Project No. 08-9013 for the U.S. Office of Education. Palo Alto, Calif.: American Institutes for Research, 1968, processed.

Herriott, Robert E., and St. John, Nancy H. *Social Class and the Urban School.* New York: John Wiley and Sons, 1966.

Iannacone, Laurence. *State Politics and Education.* New York: CARE, Inc., 1967.

Jackson, Philip W. *Life in Classrooms.* New York: Holt, Rinehart, and Winston, 1968.

Jencks, Christopher, et al. *Inequality: A Reassessment of the Effect of Family and Schooling in America.* New York: Harper-Row, 1973.

———."Is the Public School Obsolete?" *Public Interest*, 2 (Winter 1966): 18–27.

Katzman, Martin. *The Political Economy of Urban Schools.* Cambridge: Harvard University Press, 1971.

Kershaw, J. A., and McKean, R. N. *Teacher Shortages and Salary Schedules.* New York: McGraw Hill, 1962.

Kiesling, Herbert J. *High School Size and Cost Factors.* Final Report for the U.S. Office of Education, Bureau of Research, Project No. 6-1590, Mar. 1968, processed.

———. "Measuring a Local Government Service: A Study of School Districts in New York State." *Review of Economics and Statistics* 59 (Aug. 1967): 356–367.

———. "Multivariate Analysis of Schools and Educational Policy." P4595. Santa Monica, Calif.: Rand Corporation, 1971.

Knight, Frank. "The Ethics of Competition." *Quarterly Journal of Economics* 37 (Aug. 1923): 579–624.

Krathwohl, D. R.; Bloom, B. S.; and Masia, B. B. *Taxonomy of Educational Objectives, Handbook II: The Cognitive Domain.* New York: David McKay and Co., 1964.

Lau, Lawrence J., and Yotopoulos, Pan A. "A Test for Relative Economic Efficiency: Some Further Results." *American Economic Review* 63 (Mar. 1973): 214–223.

———. "A Test for Relative Efficiency and Application to Indian Agriculture." *American Economic Review* 61 (Mar. 1971): 94–110.

Leibenstein, Harvey. "Allocative Efficiency vs. 'X-Efficiency.' " *American Economic Review* 56 (June 1966): 392–415.

Leibowitz, Arleen. "Home Investments in Children." *Journal of Political Economy* 82 (Mar./Apr. 1974): S111–S131.

Levin, Henry M. "A Conceptual Framework for Accountability in Education." *School Review* 82 (May 1974): 363–391.

———. "A Cost-Effectiveness Analysis of Teacher Selection." *Journal of Human Resources* 5 (Winter, 1970): 24–33.

———. "Educational Reform and Social Change." *Journal of Applied Behavioral Science* 10 (Aug. 1974a): 304–320.

———. "Measuring Efficiency in Educational Production." *Public Finance Quarterly* 2 (Jan. 1974): 3–24.

———. "A New Model of School Effectiveness." In *Do Teachers Make a Difference?* U.S. Department of Health, Education and Welfare, Office of Education, OE-58042. Washington, D.C.: GPO, 1970b, Chapter 3.

———. *Recruiting Teachers for Large-City Schools.* Washington, D.C.: Brookings Institution 1968, processed.

Levin, Henry M., ed. *Community Control of Schools.* Washington, D.C.: Brookings Institution, 1970c.

Levin, Henry M., and Muller, Jurgen. "The Meaning of Technical Efficiency." Oct. 1973, processed.

Little, I. M. D. *A Critique of Welfare Economics.* Oxford: Oxford University Press, 1950.

Lyke, Robert F. "Representation and Urban School Boards." In H. M. Levin, ed., *Community Control of Schools.* Washington, D.C.: Brookings Institution, 1970, pp. 138–168.

Michelson, Stephan. "The Association of Teacher Resourceness With Children's Characteristics." In *Do Teachers Make a Difference?* U.S. Department of Health, Education and Welfare, Office of Education, OE-58042. Washington, D.C.: GPO, 1970, Chapter 6.

Murnane, Richard. "The Impact of School Resources on the Learning of Inner City Children." Ph.D. diss., Department of Economics, Yale University, 1974.

Mushkin, Selma, and Pollak, William. "Analysis in a PPB Setting." In R. L. Johns et al., eds., *Economic Factors Affecting the Financing of Education*, Vol. 2. Gainesville, Fla.: National Educational Finance Project, 1970, pp. 329–372.

Nerlove, Marc. *Estimation and Identification of Cobb-Douglas Production Functions*. Chicago: Rand McNally, 1965.

Pfouts, Ralph W. "The Theory of Cost and Production in the Multi-Product Firm." *Econometrica* 29 (Oct. 1961): 650–658.

Picariello, Harry. "Evaluation of Title I." U.S. Office of Education, Office of Program, Planning, and Evaluation, 1969, processed.

Pincus, John. "Incentives for Innovation in the Public Schools." *Review of Educational Research* 44 (Winter 1974): 113–144.

Riew, John. "Economies of Scale in High School Operation." *Review of Economics and Statistics* 48 (Aug. 1966): 280–287.

Rivlin, Alice M. "Forensic Social Science." In *Perspectives on Inequality*. Reprint Series No. 8. Cambridge: *Harvard Educational Review*, 1973, pp. 25–39.

———. *Systematic Thinking for Social Action*. Washington, D.C.: Brookings Institution, 1971.

Rogers, David. *110 Livingston Street*. New York: Random House, 1968.

Salter, W. E. G. *Productivity and Technical Change*. Cambridge: Cambridge University Press, 1960.

Schrag, Peter. *Village School Downtown*. Boston: Beacon Press, 1967.

Schultze, Charles L. *The Economics and Politics of Public Spending*. Washington, D.C.: Brookings Institution, 1968.

Sietsema, John P., and Mongello, Beatrice O. *Education Directory 1969–70 Public School Systems*. U.S. Department of Health, Education and Welfare, National Center for Education Statistics, OE-20005-70. Washington, D.C.: GPO, 1970.

Silberman, Charles. *Crisis in the Classroom*. New York: Random House, 1970.

Smith, Adam. *The Wealth of Nations*. Modern Library Edition. New York: Random House, 1937.

Taubman, Paul J., and Wales, Terence J. "Higher Education, Mental Ability and Screening." *Journal of Political Economy* 81 (Jan./Feb. 1973): 28–55.

Thomas, J. Alan. *The Productive School*. New York: John Wiley and Sons, 1971.

Tiebout, Charles M. "A Pure Theory of Local Expenditures." *Journal of Political Economy* 64 (Oct. 1956): 416–424.

Timmer, C. P. "On Measuring Technical Efficiency." Ph.D. diss., Department of Economics, Harvard University, 1969.

———. "Using a Probabilistic Frontier Production Function to Measure Technical Efficiency." *Journal of Political Economy* 79 (July/Aug. 1971): 776–794.

Toder, Eric. "The Supply of Public School Teachers to an Urban Area: A Possible Source of Discrimination in Education." *Review of Economics and Statistics* 54 (Nov. 1972): 439–443.

U.S. Department of Health, Education and Welfare, Office of Education. *Financial Accounting for State and Local School Systems*. State Educational Records and Reports Series: Handbook II, OE 22017. Washington, D.C.: GPO, 1957.

U.S. Department of Health, Education and Welfare. *Projections of Educational Statistics to 1981–82*. National Center for Educational Statistics, Office of Education. Washington, D.C.: GPO, 1972.

Walters, A. A. "Production and Cost Functions: An Econometric Survey." *Econometrica* 31 (Jan./Apr., 1963): 1–66.

Wargo, Michael J.; Tallmadge, G. Kasten; Michaels, Debbra D.; Lipe, Dewey; and Morris, Sarah J. "ESEA Title I: A Reanalysis and Synthesis of Evaluation Data

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Weiler, Daniel, et al. *A Public School Voucher Demonstration: The First Year at Alum Rock*. Santa Monica, Calif.: Rand Corporation, June 1974.
Williams, Andrew T. "Education and the Joint Product Production Function." Paper prepared for the Seminar in Economics of Education, Stanford University, 1970, processed.
Winkler, Donald R. *The Production of Human Capital: A Study of Minority Achievement*. Ph.D. diss., Department of Economics, University of California at Berkeley, 1972.
Wynne, Edward. *The Politics of School Accountability*. Berkeley, Calif.: McCutchan Publishing Co., 1972.

4 | COMMENTS

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It always helps to take stock periodically of what we are doing and where we are going. Educational research is certainly no exception. It is simply too easy to continue doing what we know best. However, after being forced by Levin into a reappraisal of the directions of educational research, I remain unpersuaded that drastic modification is called for. I have some serious reservations about the conclusions and implications both for research and public policy drawn from Levin's analysis, particularly as it pertains to technical inefficiency in the schools.

In many ways, Levin's viewpoint does not diverge significantly from my own. We start from the same data; there is no disagreement about the constraints on the system or about the amount of knowledge and information available to the participants in the educational process. We also agree on many of the results that develop from constraints on information and possible actions. Our major points of disagreement arise from nomenclature of observed output differences and the subsequent implications for future research and public policy.

In his taxonomy of types of inefficiency, Levin argues that there are reasons to believe that schools are not operating on the production frontier (technical inefficiency), are not operating with the best input mix (allocative inefficiency), and are not providing the desired output mix (social welfare inefficiency). The heart of his analysis is directed toward the evidence concerning technical inefficiency and its implications for research and public policy. That is also the central issue in my discussion.

Before entering that debate, however, I wish to make two points relating to allocative and social welfare efficiency. These are not points of disagreement with Levin; they are simply added to emphasize certain aspects of the discussion. First, allocate inefficiency has not only been the central concern of economists but is also almost a necessary condition for analysis. In the absence of large differences in the relative prices of inputs, allocative inefficiency is needed to analyze educational production functions. Otherwise we would observe one point on the production function, and our statistical techniques are noticeably weak at drawing multidimensional planes through one point. Second, the whole issue of social welfare efficiency, or producing the best mixture of outputs, has the same elusive character as choosing the right quantity and mixture of general public goods. The optimum marginal conditions on the social welfare function are easy enough to derive, but the operational questions have generally been beyond the economist's ability to answer. Nevertheless, in my subjective evaluation, this is probably the most important area of concern in education today. The question of whether or not schools are producing the outputs desired and needed in society remains important but unresolved. We are not sure what the outputs of schools are, how to measure the outputs, how to produce each, or what tradeoffs exist among outputs. Not only space limitations on this discussion but also the difficulty of the issue preclude my going into more detail on this.

The main message delivered by Levin is that there are compelling reasons to believe that what have paraded under the banner of educational production functions are not really production functions in the economist's usage of the term, because they do not describe the frontier of possible production. Instead they are a weighted average of the practices of efficient, or "frontier," schools and inefficient, or "nonfrontier," schools. With these average relationships, blind application of well-known optimization rules could even degrade the production by a school system which is almost universally cited as inefficient.

A crucial facet of the debate is how one should define technical inefficiency. Past discussions, for example, Leibenstein's development of X-efficiency [2] and Levin's presentation, rest heavily upon a microeconomic textbook treatment of production, where output is a function of a quantity of homogeneous capital and homogeneous labor. Then, noting that these inputs are really not homogeneous, firms with poorer "homogeneous" inputs are observed to produce less output than firms with identical quantities but better quality "homogeneous" inputs. The availability of better or worse "homogeneous" inputs can be related to incomplete labor contracts, lack of knowledge of the production function, motivational differences, or simply general managerial ability. Differences in output for "equal" inputs are used as a measure of technical inefficiency.

A real problem remains in specifically defining technical inefficiency. In reality, technical inefficiency or X-inefficiency is a measure of the strength of variables omitted from a model of the production process. These omitted variables may take the form of education, motivation, laziness, or what have you. They are just the explanations given for efficiency differences. In these terms, defining technical inefficiency becomes very difficult. Before any analysis of technical inefficiency can be developed, one must define what the base model of the production process should look like. Amounts of inefficiency then become difficult to measure, since they are a function of the chosen degree of misspecification in the base model. A common way to set the frame of reference appears to be using the model which can be developed from available data. This, of course, creates problems, because the amount of inefficiency can change over time simply due to better data becoming available.

A different way of looking at this "inefficiency," however, is to use a well-specified model as the standard and to view observed production differences in terms of model misspecification. The traditional production function that pictures output as a function of the quantity of man-hours or man-hours within given human capital classifications provides an incomplete view of the labor input to production. There are more attributes to labor than are represented in these functions. These omitted attributes often tend to be correlated with management ability or firm size or nationality in Leibenstein's international examples. Estimated production functions can then give a distorted view of the production potential. There is, however, no reason why the analyst cannot specify or attempt to specify all of the attributes that go into production. He need not be bound to specifying just those inputs as seen in a microeconomic text or those explicitly purchased by the firm.

In point of fact, this extension of the list of inputs has been the order of the day in educational research. Educational production functions of the past decade have not looked at schools as providing a given number of homogeneous teachers; nor have they looked at schools as providing only the set of purchased inputs (class size, experience, and graduate education). Instead they have looked at schools as providing a set of attributes, such as teacher verbal ability. The attributes explicitly measured may well be proxies for other attributes which have direct causal relationships with achievement. However, to the extent that a set of stable proxies which represent a fair proportion of the real teacher inputs to education have been analyzed, the importance of the technical inefficiency argument is considerably diminished.

If we map achievement outputs against only those inputs explicitly purchased by schools (class size, teacher experience, and teacher graduate education), we will certainly find the picture indicated by Levin's Figure 1. This will happen because, according to past analyses, the purchased factors have a small or nonexistent effect on output, but other nonpurchased characteristics of teachers do have an important effect. Since these other factors are not randomly distributed by schools—as shown in Levin [3], schools with apparently the same input levels will show different outputs. Yet, within the context of educational production functions, the real question is: Do schools have different outputs after the relevant teacher inputs are held constant?

It is reasonable that past discussions in fields other than education have centered upon technical inefficiency in production. This arises largely from having poorer data sources for, say, aggregate manufacturing firms than for educational firms. Research in education has been aided by having detailed measures of relevant inputs. Further, the emphasis within educational research has been on refining the measures of inputs. This is not to say that we now have perfectly specified models of educational production. We have a long way to go in that regard. It does imply that attention has been placed where I think it properly should be—on model specification and, to a certain extent, on experimental design.

The case by Levin for technical inefficiency derives chiefly from the observations that school managers do not know what the production function for education looks like and that these managers are severely constrained in their operating and hiring practices. Other factors relating to technical inefficiencies are the general lack of competition in education and lack of both incentives and clear-cut signals of success or failure.

From a specification point of view, the implications to be drawn from Levin's observations of current school operations change considerably. First, I am uncertain how the school principal, whether he knows the production function or not, affects technical efficiency. If, as past research would suggest, the main school inputs to education under the current technology are attributes of the teacher, it is hard to see how the principal affects the relationship between these attributes and achievement by very much. In terms of managing teachers, the principal may assign his best reading teacher to teach physical education; this is an allocatively poor decision that would reduce total achievement in a school for his expenditures, but not necessarily one that falls off the production frontier for education. It indicates that the analyst must be careful to separate the characteristics of the physical education teacher and the reading teacher. But, given this, there seems to be no reason to require the principal to know that he is making a mistake.

The fact that there are constraints on the manager's actions does not seem to destroy the usefulness of estimated production functions either. Constraints imply that he can only operate on a limited portion of possible input mixes. For example, a principal probably does not have the option to install a Computer-Assisted Instruction (CAI) program on his own. Nevertheless, he can attempt to suboptimize within the portion of the production frontier available to him. There is no reason to suspect that any such suboptimization attempts lead to technical inefficiency.

The other conceptual reasons for concluding that technical inefficiency is probably large produce a similar discussion. Such reasons seem to imply that schools could be allocatively very inefficient but not technically inefficient.

There is an empirical question about the importance of variables relating to facilities, curriculum, and management which may be systematically related to achievement and not generally included in production models. I have made a modest attempt to answer this question with a sample of 515 students from blue-collar families within one school system. The data sam-

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ple and estimated educational models are reported elsewhere [1]. After standardizing for different teacher inputs, I attempted to find out whether there were characteristics of schools and principals which systematically affected output. For this analysis, each of twenty-three schools in the sample was allowed to have its own intercept value, and statistical tests were performed to ascertain whether these intercepts differed by school. The intercept dummy variables provide estimates of the systematic school effects, regardless of whether the components of these effects can be adequately specified or measured. These effects would be equivalent to a measure of technical efficiency.

Within this sample, only one school out of twenty-three (comprising two per cent of the students) produced significantly higher outputs after standardizing for teacher inputs.[1] This appears to be very weak evidence for the existence of important technical inefficiencies. Matched against this is the finding that the total wage bill could be reduced by approximately 22 per cent with no decrease in achievement by not hiring individuals possessing superior experience or graduate education, or by not paying for such experience and graduate education, which were shown to have no impact on achievement. (In other words, by improving allocative efficiency, a savings of 22 per cent could be realized.)

Finally, we know that there is a large random component associated with individual achievement. There is no reason to suspect that we get more or better information about educational production by looking at a smaller sample, whether by linear programming or least squares. Also, even in the context of viewing "efficient" production with linear programming, there is no reason to believe that specification problems are any less severe. If we wish to make decisions about educational production from considering "efficient" schools, we are still left with trying to decide why such schools are efficient. In other words, we are left with the same specification problems.

CONCLUSIONS

It is not evident to me that technical inefficiency is a particularly large problem, unless we use obviously misspecified models as the standard. Within the context of well-specified models, similar to those developed within the past few years, emphasis upon allocative efficiency appears warranted. I do not wish to indicate that we know all there is to know about educational production. Yet, both conceptually and empirically, allocative inefficiency seems more important than technical inefficiency.

The difference in my approach and Levin's is more than a question of semantics. First, use of the term inefficiency tends to imply that there is a free lunch, that some organizational changes within the school will bring about significant changes in outputs at little or no cost. On the other hand, when viewed in terms of omitted variables, it is immediately obvious that bringing "inefficient" schools up to the level of "efficient" schools may not be free. Second, the term technical inefficiency seems to imply that the observed differences in outputs are related almost exclusively to management differences. However, my work has led me to suspect that the real efforts should be directed toward better specifying teachers and their inputs to education. Third, the concept of technical efficiency appears vacuous from a public policy viewpoint. Even if some consensus could be arrived at as to how this inefficiency should be measured, we are at best led to trying to explain these differences in order to reduce the differentials involved.

If the problem is looked upon as one of specification problems, it leads to intensifying data collection efforts and broadening the scope of our measurement of teacher attributes. It also calls for experimentation in order to observe other parts of the production frontier. If instead, one concludes that school management in terms of approaching the production frontier is the key issue, a different course of action is called for. In this case, much more effort should be directed toward analyzing organizational behavior and the relationship between management, teachers, and facilities. In my judgment, the former course of action will have much higher payoffs.

On the other hand, Levin's observations about the definition and measurement of educational outputs cannot be disregarded. Even though cognitive ability, as measured by test scores, is undoubtedly an important aspect of elementary and secondary schools, this is not the sole output of schools. While the joint product problem is not completely developed by Levin, it represents a very important issue for future research. Unfortunately, the methodology for handling joint production when there are no prices (or weights) to combine the different dimensions of output is an underdeveloped area of economics.

NOTE

1. Another significant aspect of this estimation was the finding that the dummy variable for this school had a very low correlation with each of the included school variables. (The simple correlation was always less than .1.) This implies that even if we were to believe that the dummy variable represented some omitted management aspects for this school, its effect on the included coefficient estimates is small; that is, the amount of specification bias would be small.

REFERENCES

1. Hanushek, Eric A. *Education and Race*, Lexington, Mass.: D.C. Heath, 1972.
2. Leibenstein, Harvey. "Allocative Efficiency vs. 'X-Efficiency'," *American Economic Review* 56 (June 1966): 392–415.
3. Levin, Henry M. "Recruiting Teachers for Large-City Schools." Washington, D.C.: Brookings Institution, 1968, processed.

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The primary conclusion Levin arrives at in this paper is that valid prescriptions for improving efficiency of the educational process (or that part of it which takes place in public schools) cannot be derived from existing estimated production functions. He argues that the world is much more complicated than the available econometric models of educational production and that naive attempts to draw normative conclusions from such models could be counter-productive. These conclusions seem appropriate enough as warnings or expressions of humility, but they also seem quite anticlimactic at the end of so many pages of analytic threshing about.

Levin opens by attempting to motivate our interest in efficiency by observing the rising costs of education combined with dissatisfaction over the quality of schools and loss of voter support for bond issues. It is quite clear that improvements in efficiency, if any are available, would offset for a while some of the increase in costs and might produce a more popular product. But the existence of inefficiency, in any of its varieties, does not imply either rising costs or consumer dissatisfaction. If inefficiency were getting worse at some steady rate, we might expect the consequences of rising costs and/or falling quality, but Levin does not provide evidence of progressive inefficiency. In no sense does the hypothesis of inefficiency provide an alternative to the "pessimistic" view of Baumol that "unprogressive" sectors will suffer cost increases as other sectors enjoy productivity gains and consequent wage increases.

But there is probably plenty of interest in efficiency as a property of the educational system and further motivation is unnecessary. Levin proceeds to use production isoquants and output transformation loci to illustrate various kinds of inefficiency and also to introduce various ways that model misspecification can foul up econometric estimates of production functions. Here one principal point is that productive units that are not using efficient techniques will not lie on the production frontier and will result in the estimation of a subfrontier production function. A second one is that output measurements may be incorrectly specified (either in one or many dimensions) and that spurious inefficiencies or "second bests" may be perceived as a consequence of that misspecification.

The next section of Levin's paper presents a long a priori argument in support of the proposition that schools must be inefficient! The main premise seems to be that they are unlike private competitive firms in a number of critical respects, and without those characteristics educational "firms" have no basis for achieving efficiency. I find myself quite convinced that the education "industry" is poles apart from the straw-man industry which has all the perfect properties of the competitive model. However, it seems that most of the real world of productive enterprises share enough of those imperfections to invalidate for them the simpleminded empirical analysis that Levin criticizes for education. Again, I can easily accept the argument that our public schools leave something to be desired in terms of efficiency, but I cannot agree that the contrast with other private or public production is particularly unfavorable.

The other part of the section spells out the limitations of standardized achievement tests as measures of school output. I fully share all Levin's reservations here and would welcome any progress toward satisfactory measures of neglected aspects, but again, this is a problem of measuring the outputs of a human-service industry and that is an unsolved problem everywhere.

The next section explores the GIGO[1] production function as applied to econometric research and derived policy prescriptions in education. Levin is quite persuasive about the various kinds of mischief that can result from a zealous application of intermediate theory to the estimated production functions for education which have appeared in respectable journals. He is motivated in this analysis by a belief that there is a real danger of these half-baked conclusions being promulgated by ukase, and even worse, that they will affect school practice.

My own appreciation of how hard it is to get any real change in the way schools and teachers behave, combined with Levin's own sense about how varied schools are, both on and off the efficiency frontier, make the threat of lockstep imitation of the latest econometric optimality formula pretty remote. Consequently, I can accept his analysis of what-if-everyone-acted-silly without agreeing on the likelihood of the premise.

In the end, Levin pleads for better models—always a popular plea—and suggests that a "behavioral theory of schools" may be under construction by Bowles and Gintis. Clearly one can begin to be relevant once a reasonably comprehensive concept of the objectives or outputs of schools has been specified; and maximum standardized achievement test scores do not fill the bill. Better models also include more attention to how observations are generated and to the implications for econometric estimation. The use of programming techniques to form "envelope" estimates is one possible improvement and Levin's numerical example shows that it may be of some importance. Clearly our economic and econometric analyses of the education industry in general and its production function in particular are very crude and are not strong enough to support policy recommendations. I am more optimistic than Levin that the work to date has been harmless and may even have been helpful in moving toward more useful models. I am quite pessimistic about the chance of an estimated second derivative ever becoming the basis of a universally followed command which will halt or reverse the upward trend of educational costs.

PART TWO

NOTE

1. Garbage In Garbage Out.