373-76

# INSTITUTE FOR RESEARCH ON POVERTY DISCUSSION PAPERS

## A COST-EFFECTIVENESS ANALYSIS OF REDUCTIONS IN SCHOOL EXPENDITURES: AN APPLICATION OF AN EDUCATIONAL PRODUCTION FUNCTION

Barbara Wolfe

UNIVERSITY OF WISCONSIN - MADISON

# A Cost-Effectiveness Analysis of Reductions in School Expenditures: An Application of an Educational Production Function

Barbara Wolfe

November 1976

The research reported here was supported in part by funds granted to the Institute for Research on Poverty at the University of Wisconsin-Madison by the Department of Health, Education, and Welfare pursuant to the provisions of the Economic Opportunity Act of 1964. The author wishes to thank Anita A. Summers for her insight and suggestions, Brad Freeman for programming, David Blau for research assistance, Michael Kean, Elliot Alexander, and others of the School District of Philadelphia, and Edgar Rosenthal of the Pennsylvania Economy League for providing needed information. The opinions expressed are those of the author.

# A Cost-Effectiveness Analysis of Reductions in School Expenditures: An Application of an Educational Production Function

Demographic shifts and changes in the economy are causing administrative changes in school districts. Major declines in pupil enrollment and severe financial duress are forcing budget freezes or cutbacks in many large urban school districts. New York, Chicago, and Washington, D.C. are just a few of the cities that are attempting to reduce costs by early closings, payless furloughs for teachers, abolition of interscholastic sports, attrition of staff, increases in class size, slashes in pupil transportation and so forth. At the same time, there is an increasing demand for improvement in the education system, for increased output, and for greater "equality of educational opportunity."

These problems of increased demand for quality education and greater opportunity for the disadvantaged, coupled with budget cutbacks or freezes, call for the systematic evaluation of the effectiveness of school resources. An evaluation of the most "bang for the buck" can help both in providing greater educational equality and in budgeting limited dollars.

The type of evaluations that can help school policymakers make rational decisions involve (1) defining the goal or goals of the system, (2) collecting a good deal of data which is specific to each pupil, and (3) analyzing the information in a systematic way that relates the inputs to the defined goal. In this process, only the value added or the growth in attaining the goal during the period under examination should be analyzed. Pupils do not enter schools with a "clean slate," so educational systems should be evaluated on the incremental effect they have had toward achieving the defined goal rather than the absolute level of attainment.

This type of analysis is problematic in several ways: (1) there is disagreement on the appropriate goal, (2) the data can be difficult to acquire, (3) a school system may not have the funds or the technical expertise to carry out this type of research, (4) there is little theory relating school inputs to educational goals, and (5) political considerations can make it difficult to implement the results. However, decisions on budget allocations must be made. The systematic analysis suggested here can lead to a more efficient use of resources and greater output than the other alternatives frequently suggested--across-the-board cuts, cuts by attrition, or those cuts most politically advantageous.

The method is applied here to the large urban school system of Philadelphia, and the study is based on input-output relations that were developed for grades three through six on the basis of pupil-specific information. It is a longitudinal study covering a three-year period (end of 1967/68-1970/71). The cost figures used in the analysis are based on the school year 1975-1976 for the School District of Philadelphia.

Section 1 describes the method, while section 2 describes the data. Section 3 provides the production-function relationship between school inputs and outputs and the cost figures for these school inputs. In section 4, the results of the cost-effectiveness work are reported, and conclusions are suggested in section 5.

## Section 1. Method

Before a systematic evaluation can be made of school inputs and their cost effectiveness, a goal or measurable output must be defined. The output used here is pupil achievement growth; the increment in pupil achieve-

ment over the period under study is measured by the Iowa Test of Basic Skills. Alternative measurable goals could be used, however.

Once a goal is defined, the methodology for answering the question of which school and teacher characteristics should be purchased to maximize pupil achievement growth involves (1) identifying which school and teacher characteristics influence student achievement, and to what extent, and (2) combining this with cost information to find the most effective inputs per dollar. To do this, first estimate a production function with change in achievement score ($\Delta A$) as the dependent variable for the time period under study. The inputs under study are teacher quality ($T_1$, $T_2$, $T_3$, $T_4$) and school quality ($S_1$, $S_2$,...$S_n$). We also include genetic endowment socioeconomic status (GSES) and peer group characteristics (PG) in the model for correct specification. Interaction effects are included since not all school and teacher quality inputs have the same effect on all types of students. In a sense, there is more than one production function being estimated. This is consistent with the concept of individualized instruction. We assume, however, that the nonschooling and nonteaching factors cannot be controlled by the school board. Thus, we have

$$\Delta A = f(T_1, T_1 \cdot GSES,\ T_2, T_2 \cdot GSES,\ \ldots,\ S_1, S_1 \cdot GSES, \ldots S_n, S_n \cdot GSES/GSES, PG) \quad (1)$$

as the production function. This provides information on what factors make a difference, that is, what school and teacher inputs can affect pupil growth in achievement, and to what extent. It indicates what might occur if teacher quality or school quality were changed.

Second, we need to include cost figures in order to measure cost-effectiveness. We introduce dollar effectiveness of inputs into the model

in the form of a budget constraint where the total budget (B) equals the cost of the teacher and school inputs--the price ($P_{T1}, \ldots P_{T4}, P_{S1}, \ldots P_{Sn}$) times the number of units, or

$$B = P_{T1}T_1 + P_{T2}T_2 + + + P_{S1}S_1 + + + P_{Sn}S_n). \qquad (2)$$

Now, in order to learn which inputs are most cost effective, we should maximize pupil achievement growth (1) subject to the budget constraint (2). We can write this constrained maximum as a Lagrangian expression,

$$\Delta A = f(T_1, T_1 \cdot GSES \ldots\ldots\ldots S_n, S_n \cdot GSES/GSES, PG) + \lambda[(\Sigma_{Ti} P_{Ti} T_i + \Sigma_{Si} P_{Si} S_i) - B].$$

The equilibrium conditions are found by taking partial derivatives. They suggest that we hire school and teacher quality inputs so that the additional contribution from the last unit of each school and teacher quality input relative to its price is equal for all school and teacher quality characteristics and for all types of pupils. Alternatively, if all of these marginal benefit to cost ratios are not identical, we should cut back on those characteristics where $\frac{\partial \Delta A}{\partial T_i} / \partial P_{Ti}$ is less than that of other inputs and hire more of those for which the ratio is greater.

If the ratios differ for different types of pupils, reallocation between groups, not just increases and decreases in the quantity hired, becomes possible cost-efficient decisions for school boards. This reallocation may, however, require defining goals in terms of different types of pupils; that is, a weighting system may be necessary.

The general cost-effectiveness method applies equally well to situations of budget increases, budget cutbacks, and budget freezes. It is a systematic procedure for analyzing the effectiveness per dollar of school and teacher inputs in relationship to a defined goal.

## Section 2. Data

This study utilizes very rich pupil-specific information from the Philadelphia Public School System on a random sample of 627 pupils from the third through sixth grades over a three-year period, 1967/68-1970/71, plus cost information based on the school year 1975/76. The pupil data were collected from individual pupil records found in the schools the pupils attended. The information on each pupil is combined with individual teacher information, school information on the 103 schools attended, and estimated family income figures based on the 1970 Block and Tract Censuses of Income and Housing [Summers and Wolfe, 1975]. The cost figures are based on December 1975 salary rates, the average rate of 1976 capital bonds of the school system and other cost figures from the detailed school budget and capital budgets of the Philadelphia School District, direct information provided by employees of the School District, and information provided by the Pennsylvania Economy League.

In using 1975-1976 cost data with an input-output relationship estimated for 1967/68-1970/71, an assumption of homogeneity or stability in the input-output relationship is made.

Enrollment, class size, and other school input system information on available inputs are also based whenever possible on the 1975-1976 school year. This includes, for example, average size of elementary school, average class size, number of schools, and pupil enrollment.

The achievement information on each pupil includes their sixth and third grade scores on the Iowa Test of Basic Skills. The average (mean) growth for this sample over the three-year period in grade-equivalent terms was 20.3 months. For low achievers (those with third grade scores below

the sixteenth percentile) the average growth was 17.7 months, for middle achievers (those with third grade scores from the sixteenth through the fiftieth percentile) the growth was 20.7 months, while for high achievers (those with third grade scores above the fiftieth percentile) the average growth was 24 months.[1]

Table 1 presents the cost figures used in this study: cost per additional teacher, capital and operating costs of a new school and cost of teacher experience and additional teacher education.

## Section 3. Production Function Results

The "educational production function" results are based on the Summers and Wolfe [1974] estimates for Philadelphia public school children from the third through sixth grades, 1967/68-1970/71. The dependent variable is difference or growth between the Iowa Test of Basic Skills grade-equivalent score in the third and sixth grades. Interaction terms were used in the study to capture the existence of individualized school effects by type of pupil. These were done on the basis of achievement as measured by the earlier score (third grade), race, and family income. Most results are presented here with reference to low, middle, and high achievement breakdowns as defined in section 2. The school input variables that made a difference, as reported in Table 2, are rating of the teacher's undergraduate institution (based on Gourman [1967]), National Teacher Exam Score, teacher experience, class size, school size in terms of pupil enrollment, and library books per pupil. Educational level of the teacher and other measured characteristics of schools, such as playground footage, date built, and condition of the school made no difference to pupil achievement growth. However,

Table 1

Cost Figures for 1975-1976
School District of Philadelphia

| School Input Variable | | Amount |
|---|---|---|
| Cost per additional teacher:[a] | | |
| Average salary | $14,673 | |
| Employee benefits | 16.3% | |
| Total | | $17,065 |
| Capital cost of new school: | | |
| Total estimated capital cost | $4,000,000 | |
| Rate paid on capital bounds | 6.3% | |
| Annual cost of interest | $ 252,000 | |
| Annual cost of depreciation | $ 66,666 | |
| Total annual cost | | $318,660 |
| Operating cost of new school: capacity of 600 | | |
| Personnel other than teachers[b] | $ 97,803 | |
| Employee benefits | 12.3% | |
| Educational supplies and books | 11,000 | |
| Utilities and custodial supplies | 29,000 | |
| Total cost | | $149,833 |
| Cost of teacher experience[c] | | |
| 1 to 2 years | $ 596 | |
| 2 to 3 | 769 | |
| 3 to 4 | 618 | |
| 4 to 5 | 656 | |
| 5 to 6 | 659 | |
| 6 to 7 | 618 | |
| 7 to 8 | 499 | |
| 8 to 9 | 729 | |
| 9 to 10 | 387 | |
| 10 to 11 | 2020 | |
| Cost of additional education[d] | | |
| M.A. | $ 988 | |
| M.A. + 30 | 1,111 | |

Table 1 (cont.)

---

SOURCES: School District of Philadelphia. 1976b. Facts and Figures 1976; Additional data supplied by Edgar Rosenthal, Pennsylvania Economy League, and Elliot Anderson, School District of Philadelphia.

[a]December 1975

[b]Includes Principal, Librarian, Counselor, Secretary and six Custodians.

[c]Weighted by distribution of education of teachers in sample; 65.05% B.A., 30.27% M.A. and 4.68% M.A. + 30.

[d]Weighted by distribution of experience of teacher sample, 1 - 3.28%; 2 - 13.57%; 3 - 13.57%; 4 - 9.98%; 5 - 6.86%; 6 - 8.27%; 7 - 2.65%; 8 - 2.65%; 9 - 2.34%; 10 - 2.96%; 11 - 33.86%.

there is an important caveat: these results refer to the current observed range of those characteristics, and not to much larger declines or far greater increases.

Low achievers benefitted from being in classes with fewer than twenty-eight pupils; they "grew" over one month more when they were in this size class. They also benefitted from having teachers who attended higher-rated undergraduate institutions, "growing" approximately five months more. They gained from being in smaller schools; for each ten fewer pupils the growth was 2/100 of a month--quite small, but school size changes can themselves be in the hundredths, which would increase the significance of this finding. They did not gain from greater teacher experience.

Middle achievers also benefitted in terms of increased achievement growth from smaller schools and from having teachers who attended higher-rated institutions. They did not grow more from smaller classes, but possibly gained (the results are not quite significant) from more experienced teachers.

Higher achievers clearly gained from having teachers with more experience--more than a third of a month gain per year of increased experience from being in classes of twenty-eight to thirty-three pupils--over three months gain compared to smaller or larger classes, from smaller schools, and again from having teachers who attended higher-rated undergraduate institutions.

For all pupils there was a negative relationship between pupil achievement growth and more library books, and pupil achievement growth and higher National Teacher Exam scores. Thus, some inputs "mattered" to all pupils, some inputs "mattered" to a subgroup of pupils, and some inputs "mattered" differentially to different types of pupils.

Table 2

School Input Variables with Significant Relationships to Pupil Achievement Growth

| School Input Variable | Achievement Subgroups | | |
|---|---|---|---|
| | Low (3rd G. score = 2.3) | Middle (3rd G. score = 3.3) | High (3rd G. score = 4.6) |
| Teacher experience | -.13(-1.10) | +.09( .00) | +.38( 2.63) |
| National Teacher Exam score | -.01(-2.58) | -.01(-2.58) | -.01(-2.58) |
| School size (Enrollment) (divided by 10) | -.02(-1.21) | -.03(-2.41) | -.05(-3.14) |
| Class size 28 - 33 | -1.69(-1.08)[a] | +.41( .29) | +3.14( 1.77) |
| Class size ≥ 33 | -.47(- .31) | -.47(- .31) | -.47(- .31) |
| Library books per pupil | -.35(-1.65) | -.35(-1.65) | -.35(-1.65) |
| | Income Subgroups | | |
| | (Income=$5,000) | (Income=$8,000) | (Income=$12,000) |
| Rating, Teacher's College[b] | | | |
| ≥ 525 | +8.48( 2.90) | +5.64( 3.28) | +1.85( .86) |

NOTE: Dependent variable: Sixth grade grade-equivalent score on Iowa Test of Basic Skills (composite) minus third grade score.

[a]Results are 3.37(-1.81) at third grade score = 1.5.

[b]Conversion of rating to achievement:

| Low | Middle | High |
|---|---|---|
| +5.01 | +4.35 | +4.27 |

## Section 4. Cost Effectiveness: Results

By combining the cost and "production function" results we hope to determine where it is least damaging to cut back, how resources should be reallocated, whether certain resources should be increased even in a budget crunch, and whether certain changes need to be of large magnitude in order to be effective. Certain trade-offs between achievement groups may also be present, requiring further definitions of goals.

There are four possible results of applying the cost-effectiveness technique: (1) a resource, at least at the current range of use in the system, has no positive effect on attaining the goal; the amount of this resource can and should be reduced for it provides no advantage to any pupil in terms of the defined goal(s); (2) a resource is related to achievement growth for a particular type of pupil but not all pupils; it should either be reallocated toward the group which gains most from the resource, or if it is less cost-effective than alternatives it should be reduced (though possibly both strategies can be combined); (3) certain resources may be very effective in terms of the defined goal; it may be wise to increase the amount of this resource, while cutting back on others, in order to maximize output; and (4) if the school system is forced to limit the budget, it may be necessary to decide between the use of inputs among alternative groups of students; i.e., one more unit of $S_1$ might add one month's growth to low achievers, one unit of $T_3$ might add two months growth to high achievers at equivalent costs.

In using these results it is well to remember that additional goals may be important, and the "nonproductive" inputs may be related to these other goals. Outside of the observed range, the impact of an input may

differ. Also, this example is presented primarily for illustrative purposes, rather than as a model for immediate policy implementation.

The cost-production function and current distribution of resources are combined in Table 3. The effect on achievement growth of a ten dollar per pupil expenditure is shown by type of pupil by school input. Briefly, it shows that a ten dollar expenditure on class size reducing class size to twenty-seven has a larger positive impact on low achievers than do alternative expenditures. Increasing the number of teachers from the colleges rated at 525 or higher is the strategy with the largest positive effect on middle achievers, while a ten dollar expenditure on class size change to thirty-two and additional teacher experience are the most effective strategies for high achievers. If a system is concerned only with change from the initial point, these are the relevant relationships to utilize.

Much more use can be made of these relationships, however. One can illustrate the possible inpacts of the cost-effectiveness technique via a comparison of alternative expenditure programs under the current budget.

Under the first scenario the current budget is maintained, with the option of reallocating current resources among the achievement subgroups. An assumption is made that a maximum of one-third of any resource can be reallocated.

Table 3

Effect of a Ten-Dollar Change Per Pupil in School Inputs, by Type of Pupil

| School Input Variables | Achievement Subgroups | | | Comments |
|---|---|---|---|---|
| | Low[a] | Middle[a] | High[a] | |
| School Size | | | | |
| Increased dollars | +.02 | +.03 | +.06 | |
| Decreased dollars | -.07 | -.11 | -.19 | Assumes savings limited to operating costs |
| Library books | -.7 | -.7 | -.7 | Estimated at $5 per book |
| Class Size | | | | Because of nonlinearities, not estimated for straight across-board changes |
| 1) Reduce all class sizes to 32 | - | - | +.83 | |
| 2) Middle and High at 32, low to 27 | +1.12 | - | +1.21 | |
| Experience | | | | |
| All teachers, all students | -.11 | +.07[b] | +.31 | |
| All spent on increasing experienced teachers of high achievers | - | - | +.94 | |
| Additional teacher education | - | - | - | |
| Higher-rating Teachers' Colleges - 10% of teachers | +.50 | +.44 | +.43 | At $10 per pupil, an expenditure of $2,500 per teacher recruited |

[a] Assumes one-third of the pupils are in each group

[b] Not significant at the 5 percent level

Scenario 1

Maintain current budget; Can reallocate resources among achievement subgroups (maximum reallocation permitted: one-third of each resource).

| School Input Variable | Achievement Subgroups | | |
|---|---|---|---|
| | Low | Middle | High |
| **Alternative 1a** | | | |
| Experience of teachers: less to low, more to high | +.12 | | +.36 |
| Teachers with college rating $\geq$ 525 to low | +.084 | -.036 | -.036 |
| Class size: low toward 27, rest toward 32 | +.04 | - | +.22 |
| Total achievement growth change | +.24 | -.036 | +.62 |

but if constrain to no loss for anyone, do not reallocate teachers with college rating $\geq$ 525 away from middle achievers, resulting in:

| | | | |
|---|---|---|---|
| **Alternative 1b** | | | |
| Teachers with college rating $\geq$ 525 | +.04 | - | -.036 |
| Total achievement growth change | +.20 | - | +.58 |

The achievement growth of low and high achievers is expected to increase while maintaining the current resources by simply reallocating. The low achiever can be helped more at the expense of the middle achiever, with a slightly greater overall growth in achievement for the system. But this illustrates the necessity of further defining the system's goals.

The second scenario permits greater flexibility. The same amount of dollars can be spent by the system but up to one-third of most resources can be reallocated either among achievement subgroups or among school inputs. One-third used to buy most cost-efficient inputs.

Scenario 2

Maintain current budget; Can reallocate resources among achievement groups and/or among school inputs, applying cost-effectiveness technique (maximum reallocation permitted: one-third of each resource).

| School Input Variable | Achievement Subgroups | | |
|---|---|---|---|
| | Low | Middle | High |
| Alternative 2a | | | |
| One less library book per pupil | +.35 | +.35 | +.35 |
| Decrease class size of low achievers to 27; move others to classes of 32 (movement limited to one-third of pupils) | +.52 | - | .40 |
| Decrease size of each school by building additional schools (4) | .03 | .04 | .07 |
| Reduce additional education of teachers (or payments), one-third reduction | - | - | - |
| Shift experience of teachers and decrease level to low | +.48 | - | +.36 |
| Increase by 10 percent hiring of teachers with college rating $\geq$ 525 | +.50 | +.44 | +.43 |
| Increase experience of 1/3 of teachers of high achievers by average of 5.6 years | - | - | +.71 |
| Total achievement growth change | 1.88 | .83 | 2.32 |
| Alternative 2b | | | |
| Same as 2a but all of increase of teachers with high college rating to low | +1.50 | - | - |
| Total achievement growth change | 2.88 | .39 | 1.89 |

Thus, on average, pupil achievement growth may be increased by up to 9 percent, not by increasing the budget but by merely changing the combination of inputs purchased. Or low achievers' achievement growth may be increased by up to 16 percent. (These reallocations leave approximately .5 million dollars for costs of reallocation). Of course trade-offs are again present. But the important point is that a movement toward increased efficiency within the current budget leads to a sizeable increase in pupil achievement growth.

In the last two scenarios, the budget is to be cut by $30 per pupil; this can be done across the board or by cost effectiveness.

Scenario 3

Across-the-board budget reduction of $30 per pupil.

| School Input Variable | Achievement Subgroups | | |
|---|---|---|---|
| | Low | Middle | High |
| School size increase | -.04 | -.06 | -.10 |
| One library book per pupil | +.35 | +.35 | +.35 |
| Class size | -.56 | - | -.60 |
| Experience of teachers | +.06 | - | -.16 |
| (Payment for) additional teacher education | - | - | - |
| Fewer teachers with college rating $\geq$ 525 | -.25 | -.22 | -.21 |
| Total achievement growth change | -.44 | +.07 | -.72 |

Thus, an across-the-board decrease of $5 per pupil on each of the six school inputs under analysis would result, according to scenario 3, in reductions for most pupils.

Scenario 4

Cost-effectiveness budget reduction of $30 per pupil.

| School Input Variable | Achievement Subgroups | | |
|---|---|---|---|
| | Low | Middle | High |
| Alternative 4a | | | |
| One less library book per pupil | +.35 | +.35 | +.35 |
| Reduction in (payment for) additional teacher education | - | - | - |
| Change class size to 32 and 27, and rearrange 1/3 | .04 | - | .40 |
| Decrease experience of teachers of low achievers | +.48 | | |
| Decrease class size of low achievers (cost of $5 per pupil) | +.23 | | |
| Increase number of teachers with college rating $\geq$ 525 to low ($5 per pupil) | +.75 | | |
| Total achievement growth change | +1.85 | +.35 | +.75 |
| Alternative 4b | | | |
| Same as 4a but increase experience of teachers of high, do not decrease class size of low | | | +.31 |
| Total achievement growth change | +1.62 | +.35 | +1.06 |
| Alternative 4c | | | |
| Same as 4a but increase number of teachers with college rating $\geq$ 525 to all | +.25 | +.22 | +.21 |
| Total achievement growth change | +1.35 | +.57 | +.96 |

In scenario 4, by using the cost-effectiveness technique, achievement growth can actually be increased while cutting the budget, but achievement growth is reduced by across-the-board cuts. Using the cost-effectiveness procedure, certain expenditures are decreased by more than they are reduced in across-the-board cuts, but other expenditures are actually increased, including the costs of smaller classes for low achievers and the number of teachers from higher-rated institutions. It is in no way a budget freeze in all expenditures, but rather a budget reduction combined with a move to greater efficiency.

Thus, this also demonstrates that even though the budget is reduced overall, it is cost effective to increase expenditures on certain school inputs.

## Section 5. Summary

The use of a cost-effective approach to school resource allocations is one way of meeting the combined problems of financial stress and demands for an increase in school productivity, and equality of educational opportunity. While the results here are to be considered illustrative rather than definitive, several recommendations may be warranted:

(1) The systematic evaluation of inputs in relation to outputs, combined with cost figures, can increase the effectiveness of educational dollars. This does necessitate the defining of a goal or goals and requires a good deal of data collection.

(2) The cost per pupil is not directly tied to pupil achievement growth. Current resources can be used more effectively by reallocation. Different expenditure patterns yield very different results.

(3) A systematic budget cut yields more satisfactory results than an across-the-board cut.

(4) Even in times of budget cuts it may be best to increase expenditures on certain resources (i.e., smaller classes for low achievers, more experienced teachers for high achievers) and compensate with larger cuts elsewhere to maximize the output of a school system.

(5) Finally, it is wise to remember that teachers have a variety of characteristics which may make it difficult to implement these policies, and costs may change as hiring and usage patterns differ. However, the general implications make a strong case for expenditures on cost-effective analyses even during times of financial stringency.

Perhaps there is a further glimmer of hope in this approach. If output increases, budget pressures may diminish in the long run. School enrollment is generally declining due to lower fertility rates. The results here suggest that smaller enrollment benefits all pupils in a large urban school system.

## Appendix A

Distribution of Third Grade and Sixth Grade Iowa Test of Basic Skills Scores of Sixth Grade Sample, by Race and Income Groups

### Third Grade Scores

| Scores (in Grade Equivalent Form)[a] | Total | Black | Non-Black | Income < $7,000 | Income $7,000 - 9,000 | Income $9,000 + |
|---|---|---|---|---|---|---|
| 1.0 - 1.9 | 3.67 | 4.24 | 2.66 | 5.99 | 2.5 | 3.0 |
| 2.0 - 2.9 | 43.86 | 50.13 | 32.74 | 47.31 | 55.0 | 36.0 |
| 3.0 - 3.9 | 29.03 | 26.43 | 33.63 | 25.75 | 28.13 | 31.33 |
| 4.0 - 4.9 | 18.02 | 15.71 | 22.12 | 16.77 | 12.50 | 21.67 |
| 5.0 + | 5.42 | 3.49 | 8.85 | 4.19 | 1.88 | 8.00 |
| $\bar{x}$ | 3.21 | 3.07 | 3.47 | 3.06 | 2.99 | 3.42 |
| $\sigma$ | .97 | .92 | 1.00 | .96 | .85 | .99 |

### Sixth Grade Scores

| | | | | | | |
|---|---|---|---|---|---|---|
| < 3.0 | 4.32 | 4.49 | 3.98 | 4.79 | 8.13 | 2.00 |
| 3.0 - 3.9 | 18.66 | 23.44 | 10.18 | 20.96 | 25.0 | 14.00 |
| 4.0 - 4.9 | 24.40 | 27.68 | 18.58 | 37.72 | 20.63 | 19.00 |
| 5.0 - 5.9 | 20.89 | 19.70 | 23.01 | 17.96 | 23.75 | 21.00 |
| 6.0 - 6.9 | 17.38 | 14.96 | 21.68 | 10.78 | 14.38 | 22.67 |
| 7.0 - 7.9 | 8.93 | 5.99 | 14.16 | 4.79 | 5.00 | 13.33 |
| 8.0 + | 5.42 | 3.74 | 8.41 | 3.00 | 3.13 | 8.00 |
| $\bar{x}$ | 5.24 | 4.97 | 5.72 | 4.83 | 4.89 | 5.66 |
| $\sigma$ | 1.52 | 1.43 | 1.55 | 1.36 | 1.43 | 1.53 |
| Number in sample | 627 | 401 | 226 | 167 | 160 | 300 |

SOURCE: School District of Philadelphia, Individual Pupil Records, Form EH-7.

[a]The Grade Equivalent Score is measured on a scale indicating the grade level and month in which the median student would receive the corresponding raw score, i.e., 4.0 indicates that the median of the students in the norming population attained this raw score when they entered the fourth grade.

## Appendix B

## Initial Distribution of Resources

143, 432 pupils in elementary schools

197 schools

Average class size 75/76 = 30.4

Average enrollment in school = 728

Distribution of class sizes of sample, in percentages (averaged over three-year period, fourth, fifth, and sixth grades)

| | |
|---|---|
| 24-<26 | 1.43 percent |
| 26-<28 | 5.88 percent |
| 28-<30 | 21.78 percent |
| 30-<32 | 27.82 percent |
| 32-<34 | 23.53 percent |
| 34-<36 | 17.17 percent |
| 36-<38 | 2.07 percent |
| 38-<40 | .32 percent |

Percentage of Teachers who attended Colleges Rated $\geq$ 525 = 5 percent

Appendix C

Teachers Salary Scedule
December 1975

| | Bachelor's | Master's | Master's Plus 30 | Doctorate |
|---|---|---|---|---|
| a† | $ 8,900 | $ 9,200 | $ 9,780 | $10,380 |
| b† | 9,410 | 9,710 | 10,410 | 11,070 |
| 1 | 10,324 | 10,672 | 11,345 | 12,041 |
| 2 | 10,914 | 11,262 | 12,074 | 12,843 |
| 3 | 11,683 | 12,031 | 12,843 | 13,746 |
| 4 | 12,296 | 12,644 | 13,556 | 14,200 |
| 5 | 12,911 | 13,375 | 14,303 | 15,115 |
| 6 | 13,524 | 14,104 | 15,148 | 16,033 |
| 7 | 14,142 | 14,722 | 15,766 | 16,714 |
| 8 | 14,641 | 15,221 | 16,265 | 17,284 |
| 9 | 15,370 | 15,950 | 16,994 | 18,202 |
| 10 | 15,753 | 16,346 | 17,377 | 18,434 |
| 11 | 17,161 | 19,432 | 20,960 | 22,600 |

†For teachers appointed after April 1, 1973.

SOURCE: School District of Philadelphia. 1976b. Facts and Figures 76, pp. 45, 49, 55, 72

Appendix D

Dollars Saved or Spent Using Cost-Effectiveness Technique

Scenario 2

| Action | Total Dollars Saved or Spent[a] | Dollars Saved or Spent Per Pupil |
|---|---|---|
| Reduce additional education of teachers (or payments) by one-third | 561,597 MA<br>697,637 MA+30 | 3.92<br>.68 |
| One less library book per pupil | 717,160 | 5.00 |
| Decrease experience of teachers of low achievers | 4,936,590 | 34.00 |
| Increase hiring of teachers with college rating $\geq$ 525 | -1,408,000 | 9.82 |
| Build four schools | -1,873,972 | 13.06 |
| Increase experience of teachers of high achievers | -1,640,470 | 11.44 |
| Decrease class size of low achievers to 27; move others to classes of 32 (movement limited to one-third of pupils) | - 836,185 | 5.83 |
| Total Savings | 554,357 | 3.86 |
| Amount left for costs of implementation | 554,357 | 3.86 |

[a]Computations are based on 5633.5 teachers. Costs and percentages are presented in Table 1, distribution of resources in Appendix B, and teachers' salary scale in Appendix C.

Appendix D

Dollars Saved or Spent Using Cost-Effectiveness Technique

Scenario 4

| Action | Total Dollars Saved or Spent[a] | Dollars Saved or Spent Per Pupil |
|---|---|---|
| One less library book per pupil | 717,160 | 143,432 x $5 |
| Decrease experience of teachers of low achievers | 4,936,590 | 34 |
| Decrease by 86 percent class size of low-achievers | -717,160 | 5 |
| Reduction in (payment for) additional teacher education | 717,160 | 5 |
| Increase experience of teachers of high achievers | -717,160 | 5 (44% of 1/3 of high achievers) |
| or | | |
| Increase number of teachers with college rating $\geq$ 525 | (717,160) | 5 |
| Total Savings | 4,936,590 | 34.4 |
| Amount left for costs of implementation | 633,630 | 4.4 |

[a]Computations are based on costs and percentages presented in Table 3, distribution of resources in Appendix B, and teachers' salary scale in Appendix C.

## NOTES

[1]The traditional definition of high achievers is those who score above the 84th percentile, but this group is too small in this sample for estimation purposes.

# BIBLIOGRAPHY

Barron, William E. 1967. "Measurement of Educational Productivity." In The Theory and Practice of School Finance, ed. Gauerke and Childress, pp. 279-308. Chicago: Rand McNally Co.

Cain, Glen and Watts, Harold. 1968. "Problems on Making Inferences from the Coleman Report." Discussion Paper No. 28-68. Madison: Institute for Research on Poverty, University of Wisconsin.

Gourman, J. 1967. The Gourman Report Phoenix: Continuing Education Institute.

Guthrie, James W. 1970. "A Survey of School Effectiveness Studies." In Do Teachers Make a Difference?, pp. 25-54. Washington, D.C.: U.S. Department of Health, Education, and Welfare.

Heim, John and Perl, Lewis. 1974. The Educational Production Function: Implications for Educational Manpower Policy. Ithaca, N.Y.: Institute of Public Employment Monograph, Cornell University.

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

Levin, Henry M. 1970. "A Cost-Effectiveness Analysis of Teacher Selection." Journal of Human Resources 5:24-33.

School District of Philadelphia. 1975. Proposed 1975-1976 Capital Budget 1976-1981 Capital Program.

School District of Philadelphia. 1976a. Detail of Proposed Operating Budget for the Fiscal Year Beginning July 1, 1976.

School District of Philadelphia. 1976b. Facts and Figures 76. Philadelphia: Office of Informational Services.

Summers, Anita A. and Wolfe, Barbara L. 1974. "Equality of Educational Opportunity Quantified: A Production Function Approach." Paper presented at the Econometric Society Winter Meetings, San Francisco, December 1974.

Summers, Anita A. and Wolfe, Barbara L. 1975. "Manual on Procedure for Using Census Data to Estimate Block Income." Philadelphia Federal Research Papers (June 1975).