

Toward a New Adequacy in Public School Finance: Analytical and Political Issues

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Efforts to improve the fairness and quality of our public education system through school finance reform date back to the dawn of the twentieth century with the work of Cubberly and others.¹ These efforts, carried out in universities, state legislatures, and the courts, have focused on the concepts of equity, adequacy, and educational need. Litigation over these issues dates back more than forty years, beginning with the *McInnis and Burruss* cases in Illinois and Virginia, respectively.² These cases, which challenged the constitutionality of differences in school district expenditures across each state, were prompted by the increasing use of the federal equal protection clause to enforce rights for individuals who had been subject to discrimination.³ However, in addition to the claim that education is a fundamental right, plaintiffs argued that differences in per pupil spending had to be related to “educational need” and not to educationally irrelevant factors such as local taxable wealth. During the late 1960s, however, educators had no widely accepted definition of “educational need,” let alone any means to measure it. Consequently, in both cases the court ruled that the suits were non-justiciable because the court lacked a standard by which to assess plaintiffs’ claims.

In the wake of *McInnis and Burruss*, advocates for more equal school funding sought a legal theory that not only was grounded in equal protection doctrine but also provided the court with a standard with which to determine whether the school finance system met equal protection requirements. Such a standard was provided in the landmark case of *Serrano v. Priest*, when plaintiffs focused attention on the basic unfairness of spending disparities arising from differences in local school district wealth.⁴ Although the U.S. Supreme Court closed the door to school finance reform in federal court in *San Antonio School District v. Rodriguez*,⁵ numerous lawsuits in state courts followed in *Serrano*’s wake. These challenges generally rested upon the principle of fiscal neutrality. This principle, crafted by Northwestern University law professor John Coons and two law students, William Clune and Stephen Sugarman,⁶ and invoked by the California Supreme Court in *Serrano*, holds that the resources available for a child’s education should depend not on the wealth of the child’s local community but on the wealth of the state as a whole. Thus, a fiscally neutral finance system displays no systematic relationship between per pupil spending and local property wealth. Such a system is usually pursued through a guaranteed tax base (GTB) or district power equalizing (DPE) formula.⁷

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These formulas, however, began to lose their appeal for policymakers by the mid-1980s. Not only are they unlikely to equalize spending levels across local communities, they will not in theory sever the relationship between local wealth and per pupil spending.⁸ Local voters make decisions about school spending on the basis of local tax price, income, and taste preferences. To the extent these determinants are correlated with wealth, local spending will vary with wealth, regardless of a GTB or DPE aid formula.⁹ Further, school district spending levels may be both fiscally neutral and horizontally equitable and yet be insufficient in the eyes of parents, educators, and policymakers. In order to reduce uncertainty about local support for public schools, many states adopted foundation formulas to assure a minimum level of per pupil revenue in every local district. By 1998-99, 44 states had a foundation program or foundation component to their school aid program.¹⁰

Nevertheless, despite the judicial activism and finance reforms of the post-*Serrano* era, spending disparities across local districts did not change much in the 1980s and 1990s.¹¹ More significantly, the finance reforms of the last three decades, with their emphasis on the fiscal capacity of local districts, do not appear to have seriously addressed the fundamental matter of student achievement; that is, systems of school finance should help foster high levels of learning for all students, regardless of their background or degree of socioeconomic disadvantage. Levels of achievement remain distressingly low in many poor inner city schools, particularly among African-American, Hispanic, and Native-American children.¹² Accordingly, finance reform advocates sought to move the focus of reform from the wealth-spending nexus to the linkage of finance to student achievement.¹³

This new concept of educational adequacy received its first dramatic judicial expression in *Rose v. Council for Better Education*.¹⁴ The Kentucky Supreme Court ruled that the state’s constitution required the state to provide all students with equal access to educational opportunities and ordered a complete overhaul of the state’s educational system.¹⁵ This concept of adequacy, which seeks to link school finance explicitly to the quality of educational resources provided to children, has been applied by a number of state courts since *Rose*.¹⁶ In all, courts in at least 10 states have declared state school financing systems unconstitutional because they have failed to provide all students with, in the words of the courts, an adequate education.¹⁷

Education Goals and School Accountability

In 1989, the year in which the Kentucky Supreme Court handed down the landmark decision in *Rose*, President George H.W. Bush convened the first-ever education summit in Charlottesville, Virginia, with the governors of the states and territories. At this unprecedented summit, political leaders at the federal and state levels agreed to establish national education goals for America’s public schools. This national focus on educational goals culminated in the 1994 passage by the U.S. Congress of legislation declaring that “all students can learn and achieve to high standards and must realize their potential if the United States is to prosper.”¹⁸

The 1994 reauthorization of the Elementary and Secondary Education Act of 1965 established “adequate yearly progress” as the accountability measure for Title I schools and districts. Each state was required to develop its own formula based on state assessments in at least reading and mathematics. States varied considerably in their approaches to adequate yearly progress, with the result that Title I schools and districts were held to different standards across the states. The 2001 reauthorization of Title I, the No Child Left Behind (NCLB) Act, sought

to bring more uniformity to the states' adequate yearly progress requirements.¹⁹ This legislation also substantially changed how adequate yearly progress results are used, focusing on low-performing Title I schools and establishing a set of reforms and sanctions for schools and districts that fail to achieve adequate yearly progress results.

In response to these federal mandates, the states have adopted or refined outcome goals for schools and students and placed new emphasis on school accountability for student achievement. By 2000, forty-eight states had implemented standardized testing, including tests in mathematics and English or reading, as an integral part of statewide school accountability programs.²⁰ The other two states – Iowa and Nebraska – required their districts to test students in specified grades or grade spans. Other elements of this educational reform movement include standards for student and school performance, teacher competency testing, and school accreditation programs. This school accountability movement, of course, has been given greater urgency by the requirements and sanctions imposed by NCLB on schools and districts that fail to meet adequate yearly progress requirements.

Money Matters

The shift of focus from equity or wealth neutrality to adequacy in school finance debates ascribes greater importance to the money and achievement nexus. Equity refers to fairness in the distribution of some resource or burden. In the context of school finance, the resource has generally been money. Reformers, of course, generally believed that money directly influenced, or could influence, student achievement, but the design of equity-based finance formulas did not involve measures of student achievement. Indeed, research in school finance and school effectiveness often proceeded along separate tracks. The concept of adequacy, on the other hand, depends crucially on the relationship between money and achievement. Put another way, adequacy rests on the proposition that expenditures make a difference in the quality of education.

This proposition holds that higher salaries attract better teachers; smaller classes allow for increased attention and more individualized instruction, particularly effective with younger children from low-income families; and individual technology in the hands of talented and trained personnel improves teaching and learning. The considerable skepticism surrounding this proposition, which dates back to the landmark “Coleman Report”²¹ and attained considerable influence in policy debates through Hanushek’s summaries of the quantitative research literature, have been alleviated to some degree by more careful and sophisticated studies published recently.²² For example, the rise in achievement for economically disadvantaged students appeared to coincide with the concentration of increased resources on their education.²³

This line of research is more crucial to discussions of funding adequacy than funding equity because adequacy is based on outcomes, either expected or desired, while equity is not. For this reason, school efficiency is a key variable in constructing an adequacy-based funding formula, while far less important in fashioning equity-based formulas such as GTB or DPE. Indeed, under an adequacy-based funding regime, both funding levels and school efficiency become explicit policy targets.

Determining the Cost of an Adequate Education

The adequacy standard for public school finance enjoys substantial support among legislators and the courts in the abstract. Operationalizing the concept, however, has proved difficult and controversial,

largely because this approach reverses the traditional approach to school funding. Traditionally, legislatures have set school appropriations based upon government revenue levels and political decisions about tax rates and competing public budgets. Expenditures on various educational resources, such as classroom teachers, support personnel, facilities, and equipment, were constrained by appropriations levels and a distribution of achievement outcomes across groups of children results. The decision variable was the money, not the outcomes. The adequacy standard reverses this decision process. Policymakers determine target achievement levels. The educational programs and services required to reach these achievement targets are specified, along with their dollar costs, and the associated appropriations are approved. School efficiency, the transformation of inputs into outcomes, is explicitly or implicitly factored into the analysis.

Attempts by states to link their school finance systems with various definitions of educational adequacy, however, have uncovered several conceptual and technical challenges that remain unresolved.²⁴ For example, what specific competencies should be included in the high minimum outcomes for all students, and how should they be measured?²⁵ Once these competencies and associated performance measures are determined, what educational resources or ingredients are needed for their achievement, and what are their costs? How should these ingredients vary with student, school, and geographic characteristics, and how do their prices vary over time?²⁶ To address the linkages between educational resources, processes, and outcomes and translate them into school finance systems, researchers and policy analysts have created four different methodologies.²⁷

Statistical Modeling

This approach, the most analytically sophisticated of the four, begins with the specification of an acceptable level of student performance and then uses multiple regression analysis to estimate the dollar cost of the ingredients (i.e., programs and services) that produced those outcomes; that is, expenditure per pupil is the dependent variable, and the independent variables are student and district characteristics and the desired achievement levels. This method assumes the existence of an educational production function but does not explicitly account for school or district efficiency in transforming inputs into outcomes.²⁸ In effect, this approach assumes that inefficiency is randomly distributed across all local schools and is not associated with particular school or district characteristics.

This method suffers from several shortcomings. First, its complexity, while appealing to economists and other quantitative analysts, is ill-suited for public policymaking. Consequently, it has not yet been used by any state to construct a school aid formula. A further problem is the method’s theoretical dependence on an educational production function, the existence of which remains at issue despite a huge research literature that has examined the relationship between educational resources and outcomes.²⁹ Analysis of education production is notoriously difficult.³⁰ First of all, education is characterized by multiple outcomes. Schools are charged with developing cognitive skills in a number of areas, as well as affective traits, like promoting democratic values and furthering other social goals. Some outcomes are jointly produced, e.g., cognitive skills and self-esteem, while others may be mutually exclusive, e.g., higher academic standards and higher graduation rates. Second, even if it were possible to separate outcomes, there is no obvious way to assign *a priori* weights to reflect the relative value of each. Consequently, there is no unambiguous way

to sum the various production activities into a single outcome measure. Researchers have responded to the problem of joint production of educational outcomes by focusing on one relatively easy to measure and assuming the other outcomes are produced as by-products. This approach emphasizes student learning and the testing of cognitive skills in key subjects, such as reading and mathematics, and simplifies the analysis of school performance. This approach also enjoys a wide political consensus across the states and provides the basis of school accountability in NCLB. Indeed, the requirements of NCLB provide increased impetus to adequacy approaches to school finance, but the statistical modeling approach remains solely in the realm of research and not policy.

Empirical Observation

A simpler approach to estimating the cost of educational adequacy involves identifying schools or districts where pupil performance is deemed acceptable and determining their expenditures. Like statistical modeling, this approach requires an operational definition of acceptable student performance but may accommodate a set of outcome measures rather than the single measure required by regression analysis. This approach assumes that any district or school can replicate another's results with the same per pupil revenue, adjusted for variations in the cost of educational resources. As such, this method fails to control for variation in student characteristics, thus providing a biased estimate of the true cost of an adequate education for each school or district. The magnitude of this bias could be reduced, of course, by adjusting estimated school or district costs with an index of student need, thereby sacrificing some simplicity.³¹

Further, the selection of a particular school or district as exemplary will have enormous fiscal consequences for the state. Consider two districts with roughly equal achievement levels but substantially different expenditures, adjusted for cost and need differentials. The total cost of an adequacy formula may vary enormously with the choice of benchmark district. At the same time, the "printout politics" surrounding the choice of benchmark may cloud the central issue of selecting an efficient district where the level of student performance could be reasonably expected of all local districts.³²

Professional Judgment

A third approach to determining school finance adequacy is to consult professional educators. Here the state would create several teams of education leaders who independently identify successful education programs and their key ingredients. The ingredients are then priced and total program costs calculated for a school. As with the empirical observation approach, estimated costs could be adjusted for differences in student characteristics. Originally developed by Jay Chambers and Tom Parrish as the Resource Cost Model (RCM), this approach has been used in school finance adequacy studies in at least nine states.³³ Unlike the two approaches described above, this strategy does not require a statewide assessment system. A challenge with this approach, however, is to find consensus among the educators as to the requisite education programs and ingredients.

Whole-School Designs

A final approach to educational adequacy draws upon the considerable work done since 1990 in crafting "whole school designs" that would support high achievement by all students.³⁴ Although the relative effectiveness of these designs has yet to be established in controlled, experimental research, anecdotal evidence suggests these designs are

effective in improving student performance, and careful analysis of their associated costs can inform efforts at funding educational adequacy. At the same time, however, care must be taken in drawing general conclusions about educational costs and effects from a relatively small number of cases of effective school reform.³⁵

Cost Adjustments

Once the ingredients of an adequate educational program have been identified, costs must be determined. It is well-established that these costs vary across local districts because of variations in resource costs (primarily personnel) and student needs. Educational costs, however, received little attention in school finance debates until the late 1990s when growing interest in school finance adequacy led some policy makers to adjust aid formulas for cost differentials.³⁶

The most important school input in terms of both cost and educational importance is teachers. Teacher compensation levels reflect both cost and quality variables. Matters of teacher quality, indicated by characteristics such as advanced degrees, academic records, and professional recognition, are largely controllable by the hiring district. In contrast, factors influencing cost, such as the characteristics of the student body, working conditions in the schools, and the hospitality and living costs of the communities, are generally beyond the district's control. An adequacy-based school finance system should compensate local districts for uncontrollable cost factors. A teacher salary index that quantifies such factors has been developed by Jay Chambers.³⁷

Much work has been done on geographic cost differences, but state aid distribution formulas rarely include explicit adjustments for these differentials.³⁸ On the other hand, states often adjust aid for the higher cost of educating children with exceptional needs. Such aid is provided through either adjustments in general aid formulas or categorical grants. There appears to be little consistency across states in how these adjustments are determined however. Moreover, these adjustments generally appear to be based on expenditures rather than costs since they are not directly related to some measure of student performance.³⁹

Conclusions

The adequacy approach to public school finance represents the convergence of two previously separate movements in public education: the finance equity movement that began with *Minnis*, *Burruss*, and *Serrano*; and the educational standards and accountability movement that dates from the publication of *A Nation at Risk*, gathered momentum with the adoption of national education goals and reached its most urgent stage with passage of No Child Left Behind Act of 2001. The success of this approach, however, depends on the synchronicity of both analytical and political efforts. At this time, it is clear that the former have eclipsed the latter. Through the good work of researchers and policy analysts, we have moved beyond the question "Do resources matter?" and now understand more clearly how schools succeed or fail. We now understand the importance of teacher quality, for example, and the promise and pitfalls of reducing class size. Further, we appreciate the extent to which contextual variables, both observed and unobserved, affect student achievement; and we have learned how to design aid distribution formulas to compensate districts for the differential costs of bringing children to a designated level of achievement.

However, while much progress has been made on the analytical side, school finance decisions continue to be driven by revenue limita-

tions and political sentiment. Further, such sentiment has produced current state and local tax burdens that are at historical lows. At the same time, it is entirely likely that school finance adequacy studies will find current funding levels to be wholly inadequate, particularly in urban areas. In the absence of increased resource levels or dramatic improvements in school productivity, the achievement gap is not likely to narrow significantly. To the extent that actual school funding levels fall below levels considered adequate by educators and school advocates, the states and Congress will face increasing pressure to relax current requirements and sanctions for poorly performing schools. In that sense, adequacy is the price of school accountability.

Endnotes

¹ James W. Guthrie, Walter I. Garms and Lawrence C. Pierce. *School Finance and Education Policy: Enhancing Educational Efficiency, Equality, and Choice*, 2d ed. (Boston, Massachusetts: Allyn and Bacon, 1988).

² *Melinnis v. Shapiro*, 293 F. Supp. 327 (N.O. Ill. 1968) affirmed; *Burruss v. Wilkerson*, 310 F. Supp. 572 Virg. (1969), affirmed, 397 U.S. 44 (1970).

³ Allan R. Odden and Lawrence O. Picus. *School Finance: A Policy Perspective* (Boston,: McGraw Hill, 2d ed., 2000), 26.

⁴ *Serrano v. Priest*, 96 Cal. Rptr. 601, 487 P. 2d 1241, 5 Cal. 3d 584 (1971).

⁵ *San Antonio Independent School District v. Rodriguez*, 411 U.S. 1 (1973).

⁶ John E. Coons, William H. Clune III and Stephen D. Sugarman. *Private Wealth and Public Education* (Cambridge, Massachusetts: Harvard University Press, 1970).

⁷ James L. Phelps and Michael F. Addonizio, "District Power Equalizing: Cure-All or Prescription?," *Journal of Education Finance* 7 (Summer 1981): 64-87.

⁸ Martin S. Feldstein, "Wealth Neutrality and Local Choice in Public Education," *American Economic Review* 65 (June 1975): 75-89.

⁹ Michael F. Addonizio, "Intergovernmental Grants and the Demand for Local Education Expenditures," *Public Finance Quarterly* 19 (March 1991): 209-232.

¹⁰ Catherine C. Sielke, John Dayton, Thomas Holmes and Anne L. Jefferson, ed. *Public School Finance Programs of the United States and Canada: 1998-1999* (Washington, D.C.: U.S. Department of Education, National Center of Educational Statistics, 2001).

¹¹ Helen F. Ladd and Janet Hansen, ed. *Making Money Matter: Financing America's Schools* (Washington, D.C.: National Academy Press, 1999).

¹² Christopher Jencks and Meredith Phillips, ed. *The Black-White Test Score Gap* (Washington, D.C.: Brookings Institution Press, 1998).

¹³ See, for example, Allan Odden and William H. Clune, "School Finance Systems: Aging Structures in Need of Renovation," *Educational Evaluation and Policy Analysis*, 20 (Fall 1998): 157-177; Allan Odden and Carolyn Busch, *Financing Schools for High Performance: Strategies for Improving the Use of Educational Resources* (San Francisco, California: Jossey-Bass, 1998).

¹⁴ *Rose v. Council for Better Education*, 790 S.W. 2d 186 (Ky. 1989).

¹⁵ The decision of the court in *Rose* was dramatic, but not unprecedented. In the 1982 *Pauley v. Bailey* case in West Virginia, the trial court ruled that a "thorough and efficient" education required equal programs and services across all school districts. This ruling, which the state did not appeal, led to the development of a state Master Plan of standards for all operating programs and facilities. Funding the plan would have required a near doubling of resources in the state; so the plan was only partially implemented. However, in 1997 a court ordered the state to fully fund the plan. See *Pauley v. Bailey*, C.A. No. 75-126 (Cir. Ct. Kanawha Cty., W.Va. 1982), initially decided as *Pauley v. Kelley*, S.E. 2d 859 (W. Va. 1979).

¹⁶ See, for example, *Abbott v. Burke*, 575 A. 2d 359 (N.J. 1990); *Campbell County School District, State of Wyoming, et. al. v. State of Wyoming*, 907 P. 2d 1238 (Wy. 1995); *McDuffy v. Secretary of the Executive Office of Execution*, 615 N.E. 2d 516 (Mass. 1993).

¹⁷ Paul A. Minorini and Stephen D. Sugarman, "Educational Adequacy and the Courts: The Promise and the Problem of Moving to a New Paradigm," in *Equity and Adequacy in Education Finance: Issues and Perspectives*, Helen F. Ladd, Rosemary Chalk, and Janet Hansen, ed. (Washington, D.C.: National Academy Press, 1999), 175-198.

¹⁸ Goals 2000: Educate America Act, P.L. 103-227, Section 301(1).

¹⁹ No Child Left Behind Act of 2001, Public Law 107-110.

²⁰ Margaret E. Goertz and Mark C. Duffy with Kerstin Carlson Le Floch, *Assessment and Accountability in the 50 States: 1999-2000*. CPRE Research Report Series RR-046 (Philadelphia, Pennsylvania: Consortium for Policy Research in Education, 2001).

²¹ James S. Coleman, Ernest Q. Campbell, Carol J. Hobson, James McPartland, Alexander M. Mood, Frederic D. Weinfeld, and Robert L. York. *Equality of Educational Opportunity* (Washington, D.C.: U.S. Department of Health, Education and Welfare, 1966).

²² Eric Alan Hanushek, "A More Complete Picture of School Resource Policies," *Review of Educational Research* 66 (1996): 397-409; Eric Alan Hanushek, "Assessing the Effects of School Resources on Student Performance: An Update," *Educational Evaluation and Policy Analysis* 19 (Summer 1997): 141-164. For an example of more recent work, see Henry M. Levin and Patrick J. McEwan, *Cost-Effectiveness and Educational Policy* (Larchmont, New York: Eye on Education, 2002).

²³ David Grissmer, Ann Flanagan, and Stephanie Williamson, "Does Money Matter for Minority and Disadvantaged Students: Assessing the New Evidence," in *Developments in School Finance: 1997*, William J. Fowler, Jr., ed., NCEs 98-212 (Washington, D.C.: U.S. Department of Education, 1998), 15-30.

²⁴ For a more detailed discussion of these issues, see William S. Koski and Henry M. Levin, "Twenty-Five Years after *Rodriguez*: What Have We Learned?" *Teachers College Record* 102 (March 2000): 480-513; Andrew Reschovsky and Jennifer Imazeki, "Achieving Educational Adequacy through School Finance Reform," *Journal of Education Finance* 26 (Spring 2001): 373-396.

²⁵ As noted earlier, virtually every state has answered this question with their adoption of standardized testing programs.

²⁶ The considerable challenge of achieving vertical equity is noted by Koski and Levin (2000). They argue that no set of school interventions can fully compensate for differences in socioeconomic background. They further contend that schools alone may be incapable of meeting adequacy requirements; that is, for children from impoverished families, educational adequacy may well require increased public investment in health care, housing, nutrition, preschool enrichment, and job training for parents.

²⁷ For a detailed discussion of these methods, see Andrew Reschovsky and Jennifer Imazeki, "Let No Child Be Left Behind: Determining the Cost of Improving Student Performance," *Public Finance Review* 31 (May 2003): 263-290; James W. Guthrie and Richard Rothstein, "Enabling 'Adequacy' to Achieve Reality: Translating Adequacy into State

School Finance Distribution Arrangements," in Ladd et al., 209-259; William D. Duncombe and John M. Yinger, "Performance Standards and Educational Cost Indices: You Can't Have One Without the Other," in Ladd et al., 260-297.

²⁸ These adequacy models are themselves cost functions, not production functions. Cost functions and production functions contain the same information, and one can be derived from the other. For a discussion of this duality property, see Hal R. Varian, *Microeconomic Analysis*, 2d ed. (New York: Norton & Co., 1984), 62-73.

²⁹ For a brief sampling of this literature, see Eric A. Hanushek, "The Economics of Schooling," *Journal of Economic Literature* 24 (September 1986): 1141-1177; Rob Greenwald, Larry V. Hedges and Richard D. Laine, "The Effect of School Resources on Student Achievement," *Review of Educational Research* 66 (Fall 1996): 361-396; Eric A. Hanushek, "Assessing the Effects of School Resources on Student Performance: An Update," *Educational Evaluation and Policy Analysis* 19 (Summer 1997): 141-164; Alan B. Krueger, "Experimental Estimates of Education Production Functions," *The Quarterly Journal of Economics* 114 (May 1999): 497-532.

³⁰ For a summary of these difficulties, see Robert Bifulco and Stuart Bretschneider, "Estimating School Efficiency: A Comparison of Methods Using Simulated Data," *Economics of Education Review* 20 (October 2001): 417-429. For an overview of the debate about the existence of an educational production function, see David H. Monk, *Educational Finance: An Economic Approach* (New York: McGraw-Hill, 1990), especially chapter 11. This brief summary draws upon Monk's overview.

³¹ See, for example, Michael F. Addonizio, "From Fiscal Equity to Educational Adequacy: Lessons from Michigan," *Journal of Education Finance* 28 (Spring 2003): 457-484.

³² For a simulation of this method and an estimate of the sensitivity of total state formula cost to the selection of benchmark district, see Addonizio, "From Fiscal Equity to Educational Adequacy."

³³ For a discussion of the RCM, see Jay G. Chambers and Thomas B. Parrish, *The Development of a Resource Cost Model Funding Base for Education Finance in Illinois* (Stanford, California: Associates for Education Finance and Planning, 1983); Jay G. Chambers and Thomas B. Parrish, "State-Level Education Finance," in *Advances in Educational Productivity*, Herbert J. Walberg, ed., (Greenwich, Connecticut: JAI Press, 1994), 45-74.

³⁴ Odden and Busch, *Financing Schools for High Performance*; Odden and Picus, 332-345.

³⁵ Reschovsky and Imazeki, "Achieving Educational Adequacy through School Finance Reform."

³⁶ Pathbreaking work in this area was done in the 1980s. For a discussion of intrastate cost-of-education indices, see Jay G. Chambers, "Cost and Price Level Adjustments to State Aid for Education: A Theoretical and Empirical View," in *Perspectives in State School Support Programs*, Forbis Jordan and Nelda H. Cambron-McCabe, ed. (New York: Ballinger, 1981), 39-85. For more recent work, see William D. Duncombe, John Ruggiero, and John M. Yinger, "Alternative Approaches to Measuring the Cost of Education," in *Holding Schools Accountable: Performance-Based Reform in Education*, Helen F. Ladd, ed. (Washington, D.C.: The Brookings Institution, 1996): 327-356.

³⁷ Using 1990-91 data from the national *Schools and Staffing Survey*, Chambers constructed a teacher salary index for every district in the U.S. based on cost factors (e.g., crime rates, student body characteristics, etc.) beyond the control of local school districts. Jay G. Chambers, *Public School Teacher Cost Differences Across the United States*. Analysis/methodology Report (Washington, D.C.: U.S. Department of Education, National Center for Education Statistics, October 1995), NCE 95-758.

³⁸ The few states that do account for geographic differences include Ohio, which uses state wage indices, and Colorado, Florida, and Wyoming, which use consumer price indices. For a discussion of the strengths and weaknesses of these approaches, see Richard Rothstein and Lawrence Mishel, "Alternative Options for Deflating Education Expenditures over Time," in *Developments in School Finance*, 1996, ed. William J. Fowler, Jr. (Washington, D.C.: National Center for Education Statistics, 1997), 159-182.

³⁹ Reschovsky and Imazeki, "Achieving Educational Adequacy through School Finance Reform." For a comprehensive discussion of the use of cost adjustments in education, see William Fowler and David H. Monk, *A Primer for Making Cost Adjustments in Education* (Washington, D.C.: OERI, U.S. Department of Education, 2001).

Appendix

A Brief Discussion of Production and Cost Functions

The existence of an education production function is a subject of some controversy. It is not surprising, therefore, that statistical modeling has not yet been used by any state to design an adequacy-based school aid system. This appendix will briefly discuss the properties and equivalence of production and cost functions and their use in the construction of adequacy-based school aid distribution formulas.

A Basic Production Model

A production function is a model of the economic relationship between the maximum level of output that can be produced from any given combination of inputs. The production function allows for inputs to be combined in varying proportions to produce an output in many ways. Production functions describe what is technically feasible when the firm operates efficiently; that is, when the firm uses each combination of inputs as efficiently as possible. If the supply levels of the various inputs are known and the production function is also known, the maximum level of production can be determined. Anything short of maximum attainable output indicates technical inefficiency.

A second dimension to production efficiency involves input costs. Consider, for example, two alternative manufacturing processes that utilize different input combinations to produce the same product, say, an automobile. One process may be labor-intensive while the other relies more heavily on robotics. Assuming each process makes the best possible use of each set of inputs – that is, each process is technically efficient – the least costly input combination is preferred on allocative efficiency grounds. Production efficiency requires both technical and allocative efficiency.

Minimizing production costs

If there are two inputs, capital K and labor L , the production function $F(K,L)$ describes the maximum output that can be produced for every possible combination of inputs. Production theory assumes that each of the inputs has positive but decreasing marginal products.¹ A competitive firm takes the prices of labor w and capital r as given and seeks to minimize the cost of producing a fixed level of output. This cost-minimization problem can be written as

$$\text{Minimize } C = wL + rK \quad (1)$$

Subject to the constraint that a fixed level of output Q_0 be produced:

$$F(K,L) = Q_0 \quad (2)$$

C represents the cost of producing the fixed output level Q_0 and w and r are the prices of labor and capital, respectively.

This constrained optimization problem can be solved using the method of Lagrange multipliers to determine how much capital and labor the firm should hire.² The solution tells us that the firm is minimizing costs when it chooses its inputs or factors of production so as to equate the ratio of the marginal product of each factor by its price.³ Intuitively, we can see this if we suppose that at some (nonoptimal) input combination MP_K/r is greater than MP_L/w . Here, the firm could lower its cost while still producing the same output by using more capital and less labor.

Maximizing production output

A firm's input decision has a dual nature; that is, the optimum choice of K and L can be analyzed not only as the problem of choosing

the lowest-cost input combination that will produce the given level of output, but also as the problem of maximizing the level of output given a cost (i.e., budget) constraint and input prices. This output maximization problem can be written as

$$\text{Maximize } F(K,L) \quad (3)$$

Subject to the cost constraint that

$$wL + rK = C \quad (4)$$

As with the cost minimization problem, this constrained optimization problem can be solved by the method of Lagrange multipliers to determine the input levels the firm should hire. This solution is identical to that of the cost minimization problem: Output is maximized when the firm chooses its inputs so as to equate the ratio of the marginal product of each factor divided by its price— hence the equivalence of production functions and cost functions. Given a specific production function $F(L,K)$, we can derive the equivalent cost function $C(Q)$.

Toward an Education Production Function

Hanushek has proposed a framework for an education production function that distinguishes among family backgrounds, peer, and school inputs.⁴ This production function can be expressed as

$$O_{it} = g(X_{it}, S_{it}, B_{it}) \quad (5)$$

Where O_{it} represents all outcomes, X_{it} is a vector of all school inputs, S_{it} is a vector of peer inputs, and B_{it} is a vector of family background characteristics. The subscript i indexes the school or district, and subscript t indexes the year. Thus, the school district's problem is to employ the school inputs so as to maximize outcomes given the peer and family inputs.

To derive a cost function from the production function, the analyst estimates a school district expenditure equation, which specifies the relationship between school expenditures and school inputs. This expenditure equation can be expressed as

$$E_{it} = f(X_{it}, P_{it}, D_{it}) \quad (6)$$

Where E_{it} represents per pupil expenditures, P_{it} is a vector of school input prices and D_{it} is a vector of unobserved school district characteristics that influence district spending (e.g., the inefficiency of the district).

Finally, equation (5) is solved for X_{it} , the school inputs, which are then plugged into the expenditure equation (6). This gives the cost function, represented by equation (7):

$$E_{it} = h(O_{it}, P_{it}, S_{it}, B_{it}, D_{it}, \mu_{it}) \quad (7)$$

where μ_{it} is a random error term.

Equation (7) is typically estimated in log-linear form with district-level data. The dependent variable is the log of per-pupil expenditures, and the estimated coefficients indicate the contribution of the various district characteristics to the cost of education, holding constant the level of outcome.⁵ Once the cost function is estimated, a cost index can be constructed for each district. This index is then used to calculate the amount a district would have to spend, given the input prices and contextual influences it faces, to produce the specified level of outcome.

Of the four approaches to estimating the cost of an adequate education, this is the most conceptually complete; that is, the statistical modeling approach most efficiently controls for district efficiency and the unobserved influences on school outcomes when estimating educational costs.

Endnotes

¹ Writing the marginal product of capital as $MP_K(K,L) = \partial F(K,L)/\partial K$, we assume $MP_K(K,L) > 0$ and $\partial MP_K(K,L)/\partial K < 0$. Similarly, if the marginal product of labor is given by $MPL(K,L)$, we assume $MP_L(K,L) > 0$ and $\partial MP_L(K,L)/\partial L < 0$.

² For an explanation of the method of Lagrange multipliers see, for example, Robert S. Pindyck and Daniel L. Rubinfeld, *Microeconomics*, 3d ed. (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1995), 130-137.

³ Mathematically, this is given by $MP_K(K,L)/r = MP_L(K,L)/w$.

⁴ Eric A. Hanushek, "Conceptual and Empirical Issues in the Estimation of Education Production Functions," *Journal of Human Resources*, 14 (Summer 3): 351-388.

⁵ Estimation of this equation involves several major conceptual issues, including the endogeneity of educational outcomes, i.e., a district's spending decision will influence outcomes, the measurement of an index of educational outcomes, and the equation's two error terms. For a discussion of these issues and econometric techniques to address them, William D. Duncombe and John Ruggiero, and John M. Yinger, "Alternative Approaches to Measuring the Cost of Education," in *Holding Schools Accountable: Performance-Based Reform in Education*, Helen F. Ladd, ed. (Washington, D.C.: Brookings Institution Press, 1999), 327-356.