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POLICY BRIEF

Using Cost Modeling to Inform Education Funding Formulas

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Education cost modeling can be used either for evaluating existing school finance systems or for informing the design of new school finance formulas. In either case, the goal of cost modeling is to establish accurate measures of the cost of providing equal educational opportunity across children and settings to achieving specific outcome targets. Using education cost modeling helps inform policy in several ways:

- Cost model estimates provide reasonable empirically based measures of the cost of providing educational services.
- They provide estimates for the cost of students with different circumstances achieving a common desired level of achievement or other outcomes.
- Introducing this evidence into deliberations over new state aid formulas can help to inform the creation of equitable aid distribution formulas.

Cost models introduce rigorous empirical evidence on education costs (tied to outcomes) into formula deliberations, with the modest goal of achieving a fairer, more equitable, and adequate formula for funding schools than might otherwise have occurred in the absence of such information.

From Cost Model to Funding Formula

The AIR study team has developed a three-step process for using education cost models to inform the design, redesign, or recalibration of state school finance formulas. This process was recently used in Vermont (Kolbe, Baker, Atchison, & Levin, 2019):

- **Step 1:** Estimate an elaborate Education Cost Model (ECM) on historical district-level panel data using rigorous, standard statistical methods. This model determines the predicted cost of meeting defined outcome targets, accounting for differences in a host of factors related to student needs and district characteristics that drive educational costs (cost factors).
- **Step 2:** Generate a reasonable number of formula weights to determine the relative importance of different cost factors to be used in the funding formula. These weights are generated by fitting a statistical model of the relationship between the predicted costs from the cost model in Step 1 and cost factors commonly found in state aid formulas (e.g., measures of student need, district enrollment size and remoteness).

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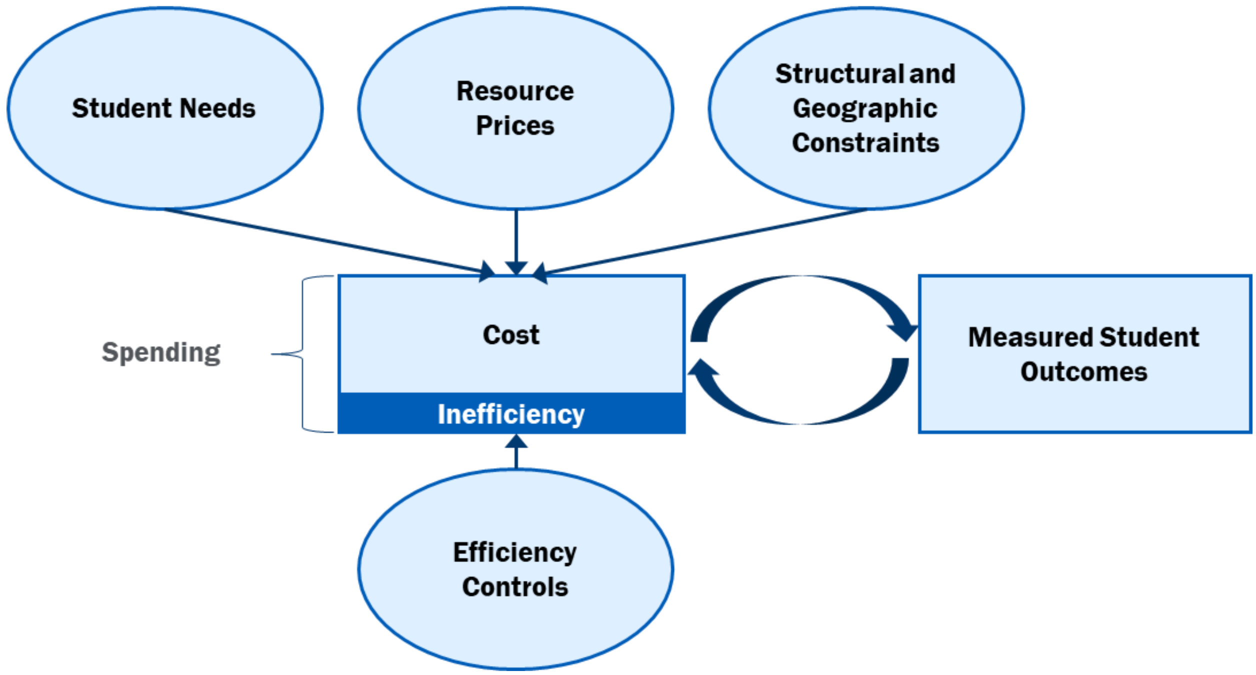
- **Step 3:** Apply the weights generated in Step 2 in a formula simulation to generate district-level "adequacy" projections.

In Step 1, the study team estimates an ECM using data on operational education spending,[1] outcomes such as student achievement, and a variety of factors influencing the cost of achieving these outcomes.[2] The ECM allows us to generate the predicted cost per pupil of achieving a predetermined outcome for districts for which we have complete data for the years included in the model. The ECM includes the components identified in Figure 1.

Figure 1. Education Cost Model Components



Notes: Student needs usually include measures of economic disadvantage, English learners, and students with disabilities. Resource prices refers to the exogenously determined geographic variation in the price of resources (e.g., teacher salaries). Structural and geographic constraints often include size of districts or schools (economies of scale) and population density (to measure rurality or sparsity). Efficiency controls often include measures of fiscal capacity, degree of competition (e.g., from neighboring school districts), and public monitoring of public spending.

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[1] Operational spending refers to expenditures devoted to the ongoing operation of a district and generally excludes large-scale capital investments in buildings and land, which regularly require long-term financing.

[2] The dominant modeling approach in recent peer-reviewed literature is one in which

a) the dependent measure is a measure of current operating expenditures per pupil;
b) the potential simultaneous determination of the dependent spending measure and the assumed independent measure of student outcomes requires a statistical approach called an "instrumental variables technique," where the independent portion of the student outcomes is isolated using measures of the competitive context within which local public school districts operate; and,
c) attempts are made to control for inefficiencies in the spending measure (spending that does not affect the outcomes included in the model) by including measures of variations in fiscal capacity and local monitoring of public spending.

This approach is largely the product of years of peer-reviewed cost function estimation by William Duncombe, John Yinger, and colleagues of the Maxwell School at Syracuse University (Duncombe, 2002; Duncombe, Lukemeyer, & Yinger, 2003; Duncombe & Yinger, 2004, 2011).

The ECM depicted in Figure 1 includes some necessary complexities along with some more basic elements. The dependent measure in the cost model is a measure of per-pupil spending. The ovals across the top are the basic elements included in the cost model. These are factors that affect the differential cost of achieving any given level of outcome and assumed to be outside of the control of districts: (a) variation in student needs, (b) geographic variation in the prices of educational inputs (e.g., teacher salaries), and (c) structural or geographic factors such as district size and population density.

The goal of the ECM is to determine the relationship between spending and student outcomes across districts while accounting for the various cost factors described previously. Therefore, the cost-function model must include measured student outcomes in the model (shown in the rightmost rectangle of Figure 1). The relationship between spending and student outcomes is circular, meaning that increased spending can drive student outcomes, but higher outcomes may also drive increased spending (e.g., by making the district more attractive, leading to increased property values and locally raised revenue). The ECM uses appropriate statistical techniques to account for the circular relationship between outcomes and spending.

Lastly, education spending includes expenditures that contribute to student outcomes (represented by the "cost" portion of spending) and expenditures not related to student outcomes (represented by "inefficiency"). Specifically, districts may make investments that do not necessarily contribute to the outcomes under consideration, and the model should account for this potential inefficiency. The ECM does so by including efficiency controls that predict increased spending behavior but do not contribute to higher outcomes (shown in the bottom oval of Figure 1). Common controls used for this purpose include measures of district fiscal capacity and local monitoring of public spending. Once we have accounted for these statistical complexities, we can use our model to predict per-pupil spending levels needed (i.e., "costs") for each district to achieve specific outcome targets.

In Step 2, we take the district-level predicted cost estimates corresponding to a level of outcome that is considered adequate and identify a smaller set of "cost factors" that can be used as weights in a simulated funding formula. We fit a *weight estimation model* that relates these factors to the predicted costs, with the purpose of generating a set of weights that can be used in simulating per-pupil costs for all districts in future years, using updated district data. The weight estimation model produces a *base per-pupil cost*, which represents the predicted cost per pupil for a district that assumes none of the factors that put upward pressure on cost (e.g., a large school district located in a population-dense area with no students who are economically disadvantaged, English learners, or students with disabilities). *Formula weights* are calculated as the differential cost per pupil for a given cost factor divided by the base per-pupil cost. Formula weights have a simple interpretation as the percentage increase in the cost of providing an adequate education when the associated cost factor is present. For example, a calculated formula weight for student economic disadvantage of 0.65 would indicate that it costs 65% more than the base cost per pupil to provide an economically disadvantaged pupil an opportunity to achieve at the adequate outcome standard.

In Step 3, the study team uses the formula weights estimated in the second step to build a simulation that generates per-pupil spending projections for all districts. The difference between these cost estimates and the most recent available data on operational spending determines spending gaps, the amount of additional spending needed to achieve target outcomes. This type of simulation, which is based on a formula derived from an empirically estimated ECM, can be translated directly into legislation and incorporated into state finance systems. Many state school finance formulas take a similar form to the formulas used to simulate the distribution of dollars in our simulations, including New Jersey's School Funding Reform Act (SFRA) and Kansas's School District Finance Act (SDF). Current efforts are under way in Vermont to pass legislation based on recommendations and simulations that came out of a study of school funding in Vermont using the approach outlined here (Kolbe et al., 2019).

Unique Advantages

Using cost modeling to inform school finance formula design has unique advantages over other methods. First, cost modeling allows for testing the sensitivity of costs to different outcome goals. That is, once the relationship between spending, outcomes and other factors is determined, we can estimate how costs differ when outcome standards are raised or lowered. As one would expect, it costs more to achieve higher standards, and less to achieve lower ones.

Further, once a successful modeling approach and data have been identified for estimating costs in any given state or context, that model can usually be updated with relative ease. That is, as additional years of data become available, they can be added to the panel data for cost modeling, and the models can be reestimated for the purposes of recalibration of the state school finance formula. If changes occur in terms of labor market conditions, student need demographics, or other cost factors (e.g., district enrollment), then an updated model will pick up changes in the weights required for these factors. Further, if the state has adopted reforms, such as changes to the provision of special education services or consolidation of smaller districts and schools, an updated model would reflect the efficiency gains achieved by these policy initiatives.

Finally, cost modeling lends itself to further exploration into those districts that are shown to operate relatively efficiently. That is, the model results can be used to identify those districts that are producing outcomes at a higher level than expected given their spending level and cost factors. Extended analysis into their programming, staffing, and use of nonpersonnel inputs usage can then be performed to better understand unique best practices across New Hampshire districts.

Summary

Cost-function modeling can play an important role in informing policy around the design of school funding formulas. The use of an ECM has several unique advantages, including the ability to assess how necessary spending levels change when applying different outcome targets and the ability to easily update the model over time. Although cost-function modeling can be viewed as a complex procedure, we take an approach that pares down the original and complex cost-function model into a relatively simple weight estimation model that uses a small number of cost factors, which lend themselves to incorporation into state school funding formulas. In addition, the results generated from the weight estimation model can be used to simulate the distribution of funding under a formula that takes into account actual differences in providing equal opportunities to students by applying cost-based weights.

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