THE UNINTENDED CONSEQUENCES OF PROPERTY TAX RELIEF: NEW YORK'S STAR PROGRAM

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Abstract

New York's School Tax Relief Program, STAR, provides state-funded property tax relief for homeowners. Like a matching grant, STAR changes the price of education, thereby altering the incentives of voters and school officials and leading to unintended consequences. Using data for New York State school districts before and after STAR was implemented, we find that STAR increased student performance, school district inefficiency, and school spending by 2 to 4 percent in most districts, leading to an average school property tax rate increase of 14 percent. The STAR-induced tax rate increases offset about one third of the initial STAR tax savings and boosted property taxes for business property. STAR did little to offset the existing inequities in New York State's education finance system, particularly compared to an equal-cost increase in state aid. This article should be of interest to policy makers involved in property taxes or other aspects of education finance.

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1. INTRODUCTION

Thanks to a relatively low state share of funding for education and a wide range in property values per pupil, New York State has long faced the dual problem of high property tax rates and severe funding disparities across school districts. In 1997, New York State enacted a state-funded homestead exemption, the School Tax Relief Program (STAR), to provide property tax relief for homeowners. Although it was not recognized in the policy debates at the time STAR was passed, the use of state tax sources to lower the school property tax burden on homeowners significantly alters the way public schools are financed and magnifies the funding disparities. Moreover, the design of STAR has resulted in unintended consequences for spending, property tax rates, and student performance. This impact on school finance and these unintended consequences are the subjects of this paper.

These issues were first raised by Duncombe and Yinger (1998a, 2001). Building on the equivalence theorems of Bradford and Oates (Oates 1972; Bradford and Oates 1971a, b), Duncombe and Yinger argued that the STAR homestead exemption was equivalent to a form of matching aid. Like matching aid, STAR lowers voters' tax prices and therefore is likely to increase the demand for education (as measured by student performance) and lead to higher education spending and higher property tax rates. Duncombe and Yinger also argued that the STAR-induced decline in tax price lowers voters' incentives to monitor school officials and therefore may result in less efficient school districts. In this paper we estimate the impact of STAR on student performance, school district expenditures, and school property tax rates. Our estimates also provide indirect evidence about the effect on efficiency.

Many studies find that tax prices have a significant impact on the demand for local services.[1] Fisher and Rasche (1984), Addonizio (1990, 1991), and Rockoff (2010) explore the impact of property tax relief programs on school spending. The first two of these studies examine a circuit breaker implemented in Michigan in the 1970s that altered tax prices. Both studies find evidence that these tax-price changes had a significant impact on public spending. Rockoff (2010) examines STAR. He finds that replacing 10 percent of school property taxes with STAR funds would raise school spending by 1.6 percent.[2] These studies all estimate the elasticity of expenditure per pupil with respect to tax price. This approach has the practical advantage of not requiring a measure of the final output (in the sense of Bradford, Malt, and Oates 1969) of education, such as student test scores. It also has a major disadvantage, however: It

1. For reviews of this literature, see Rubinfeld (1987), Ladd and Yinger (1991), Duncombe (1996), and Fisher and Papke (2000).
2. Rockoff (2010) sets district tax price equal to one minus the fraction of local property taxes paid by STAR; this formulation differs from the one derived herein.

cannot examine directly how an expensive state property tax relief program has affected student performance or provide any evidence about its impact on efficiency.

In contrast to the previous literature, this study estimates a demand model and a cost model based on a measure of student performance. The paper is organized into five sections. In the next section we provide some basic information on the STAR program and how tax savings have been distributed across regions in the state. We then present the conceptual foundation of the paper, which involves models of demand, cost, and efficiency. In section 4, we describe our data and empirical methods. Estimation results are presented in section 5, as well as simulations of the impacts of STAR on student performance, spending, educational costs, and property tax rates. We conclude with some suggestions for reforms in the STAR program to minimize its unfairness and unintended consequences.

2. THE STRUCTURE OF STAR AND THE DISTRIBUTION OF STAR BENEFITS

The STAR program provides partial exemptions from school property taxes for owner-occupied primary residences.[3] The basic STAR exemption is available to all taxpayers who own their primary residence in New York State, including owners of one-, two-, and three-family houses, condominiums, cooperative apartments, mobile homes, or residential dwellings that are part of mixed-use property. Renters receive no exemption. An enhanced STAR exemption is available for homeowners above age 64. An income limit has always been part of enhanced STAR and was added to the basic STAR in 2012.

The basic exemptions were $10,000 in 1999–2000, $20,000 in 2000–2001, and $30,000 in 2001–2002 and thereafter. The enhanced exemption was set at $50,000 starting in 1998–1999 and was gradually raised to $62,200 in 2012–13. A homeowner's savings equal the exemption amount multiplied by the school property tax rate in the homeowner's school district. As of FY 2012, this STAR savings cannot increase by more than 2 percent per year. STAR has special provisions for the "big five" cities, New York City (NYC), Buffalo, Rochester, Syracuse, and Yonkers, in which schools are a department of city government and there is no separate school tax rate. The STAR exemption is 50 percent of the basic exemption for NYC and 67 percent of the basic exemption for the other four districts; this exemption applies to all city property taxes, not just those devoted to schools.

3. This discussion of STAR draws on New York State Department of Taxation and Finance (2013a,b,c,d), New York State Division of the Budget (2013), and Office of the New York State Comptroller (2012). See these citations for more details.

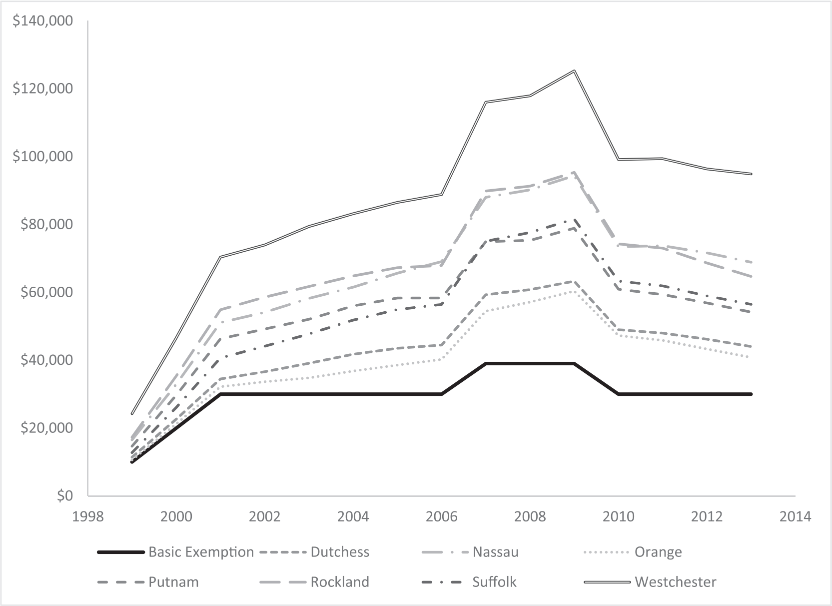

Figure 1. STAR Exemptions in Various Counties, Including Rebates.

STAR exemptions are subject to two adjustments in many districts. First, to make them an equivalent share of market value, they are adjusted based on the assessment/sales ratio in each assessing unit. Second, they are adjusted upward by a "sales price differential factor" (SPDF) in counties in which the median residential sales price exceeds the statewide median sales price.[4] The higher exemptions resulting from the SPDF are primarily in so-called downstate counties, which include NYC and its suburbs, plus the rest of Long Island.

Because NYC, unlike other districts, raised a large share of its school revenue from an income tax, the original legislation also provided an income tax credit to all NYC residents, including renters. In addition, a STAR income tax rebate equal to 30 percent of the savings from the basic STAR exemption was implemented for all homeowners in the state in 2007. This rebate was eliminated in FY 2009. Elderly homeowners received a higher rebate during this period.

As summarized in figure 1, these provisions generate extensive variation in STAR exemptions both over time and across districts. Time variation results

4. The first adjustment simply ensures the benefits of the STAR exemptions do not depend on assessing practices. The SPDF cannot fall below 1.0, so it provides higher exemptions in high-housing-value districts but does not change exemptions elsewhere. All districts in downstate counties have a SPDF greater than one. Moreover, a homeowner's exemption cannot drop by more than 11 percent even when housing prices drop.

from the phase-in and the income tax rebate in 2007–09, which was equivalent to an increase in the exemption. The SPDF results in variation across district and time.[5] The basic exemption in Westchester County, for example, reached as high as 3.31 times the minimum amount in 2011.

Although New York has several other property tax exemption programs, STAR is unique in two ways (Office of the New York State Comptroller 2012). First, it is the only exemption funded by the state. STAR exemptions lower a homeowner's tax bill, and the state writes a check to the school district for the lost revenue. All other exemptions erode the local tax property base and shift the burden of the tax toward property owners not eligible for the exemptions. Second, STAR is unique in terms of its scope and the size of the exemption. Although some other exemption programs have applied to a significant number of taxpayers, including 650,000 veterans and 180,000 senior citizens, none of them has come close to the breadth of the STAR program, which applies to about 3.3 million taxpayers. The cost of STAR has risen from $1.5 billion in 2002 to $3.3 billion in 2012.[6] These features also stand out at the national level. Most states have some form of property tax exemption but only a few other states, including Indiana and Massachusetts, have general property tax exemptions with state reimbursement (Duncombe and Yinger 2001).

As shown in table 1, STAR revenues or savings increased from 2002 (the first year in which the basic STAR was fully implemented) to 2006 and 2011. In 2011, STAR provided property tax relief per pupil ranging from $2,090 in the downstate small cities to $369 in the upstate big three districts (Buffalo, Rochester, and Syracuse). These large cities received relatively less benefit from STAR because of their high renter populations and because they receive no benefit from the SPDF. Compared with other school districts, STAR, as a percent of state aid and total operating expenditures, was the largest for downstate small city school districts followed by their downstate suburban peers.

3. CONCEPTUAL FOUNDATIONS

The sole objective of STAR was to provide property tax relief, but STAR has many unintended consequences because it alters voters' tax prices. A voter's tax price reflects the interplay between the voter's budget constraint and the government budget constraint. In this section we derive an expanded tax price that reflects both STAR and school district efficiency and incorporates this tax

5. Although not shown in the figure, the special treatment of the big five districts also yields variation across districts.
6. The STAR income tax rebate was estimated to have added an additional $1.1 billion to the cost of STAR in 2008 (Mauro 2008).

Table 1. School District STAR Savings by NYSED Regions

	STAR Savings per Pupil ($)			STAR Savings as % of State Aid			STAR Savings as % of Total Operating Spending		
	2002	**2006**	**2011**	**2002**	**2006**	**2011**	**2002**	**2006**	**2011**
Downstate small cities	1,498	2,061	2,090	39.7	50.1	49.2	10.7	11.3	9.7
Downstate suburbs	1,316	1,669	1,856	37.6	41.8	39.5	9.9	9.9	8.9
Yonkers	1,190	1,546	1,414	13.6	18.3	15.3	8.4	9.0	8.1
Big three	318	393	369	4.1	3.8	4.7	3.0	2.9	2.2
Upstate small cities	841	1,047	1,012	13.9	15.2	11.6	8.2	8.1	6.4
Upstate rural	773	1,024	1,034	11.1	12.8	10.2	7.7	7.9	6.2
Upstate suburbs	1,010	1,244	1,295	20.8	22.6	19.7	10.5	10.3	8.6

Notes: This table presents savings from both basic and advanced STAR exemptions. The available data do not allow us to separate between the two exemptions.
Source: Authors' calculations.

price into demand and cost/efficiency models. We show that STAR has direct impacts on the demand for school quality and indirect impacts on demand that arise through STAR's effect on efficiency.

The Demand for School Quality

Let V stand for the market value of a voter's home and t indicate the effective property tax rate. Without STAR, the property tax payment would be tV. STAR exempts the first X dollars of market value from tax, so the property tax payment with STAR is $t(V - X)$. As noted earlier, the value of X in our sample period was $30,000 in most districts in most years of full implementation, but was sometimes adjusted upward for high county sales prices.[7] If Y is a voter's income and Z is spending on everything except school property taxes, then a voter's budget constraint with STAR is

$$Y = Z + t(V - X) \tag{1}$$

The school district faces a cost function, $C\{S\}$, where C is total cost per pupil and S is measure of school quality. As discussed subsequently, we select measures of S that are linked to New York State's accountability system. The derivative of this function, $\partial C/\partial S$, equals marginal cost, MC. Spending per pupil, E, equals $C\{S\}$ divided by district efficiency, e. This efficiency measure, which is discussed more fully in what follows, is scaled to equal 1.0 in a fully

7. The adjustment for assessing practices is not relevant here because our model is already based on market values, not assessed values.

efficient district (i.e., in a district that makes full use of the best available technology for producing S) and to fall below one in less efficient districts. Hence, this formulation indicates that inefficient districts spend more than the amount indicated by $C\{S\}$ to obtain a given level of S.

District revenue comes from property taxes and lump-sum state aid.[8] Now let $\bar{V}$ indicate total property value per pupil and A indicate state aid per pupil. Then the district budget constraint is

$$E \equiv \frac{C\{S\}}{e} = t\bar{V} + A. \tag{2}$$

Because the state compensates a district for revenue lost through the STAR exemptions, these exemptions have no impact on the district budget constraint. In other words, the district loses $t\bar{X}$ to the STAR exemptions but receives $t\bar{X}$ in compensation from the state.

Solving equation 2 for t and substituting the result into equation 1 yields

$$Y + A\left(\frac{V}{\bar{V}}\right)\left(1 - \frac{X}{V}\right) = Z + \frac{C\{S\}}{e}\left(\frac{V}{\bar{V}}\right)\left(1 - \frac{X}{V}\right). \tag{3}$$

Tax price, TP, is what an increment in S costs a voter, so it can be derived by differentiating a voter's spending (the right side of equation 3), by S:

$$TP \equiv \frac{\partial \text{Spending}}{\partial S} = \frac{dC}{dS}e^{-1}\left(\frac{V}{\bar{V}}\right)\left(1 - \frac{X}{V}\right) = (MC)e^{-1}\left(\frac{V}{\bar{V}}\right)\left(1 - \frac{X}{V}\right). \tag{4}$$

The direct impact of STAR appears in the last term of equation 4. An exemption, X, is equivalent to a matching aid program with a matching rate $m = X/V$. This matching rate varies across districts and across time because of the phase-in, the SPDF, the temporary income tax rebate, and variation in V. Throughout this paper, we refer to X/V as the implicit STAR matching rate and $(1 - X/V)$ as the STAR tax share or STAR component of tax price.

In a standard median-voter model, the demand for school quality, S, is a function of median income (as augmented by state aid), of median tax price, and of various demographic factors. In a district of homeowners, the median tax price is equation 4 with V defined to be median house value. Within a district, STAR cuts every homeowner's tax share by $X/\bar{V}$, so it does not change the order of demands—or the identity of the median voter. As pointed out by Rockoff (2010), renters complicate this analysis; the introduction of

8. The largest operating aid program in New York uses a foundation formula, which gives more aid to districts with lower property wealth per pupil or a higher student poverty rate. See https://stateaid.nysed.gov/. Our empirical work combines revenue from all operating aid programs.

STAR exemptions for homeowners but not renters could change the identity of the median voter. Following the theoretical literature (reviewed in Ross and Yinger 1999), we assume renters do not care about (or vote on) S because any benefits or costs from a change in S will be offset by a change in rents.[9] Interpreting equation 1 as the median voter's budget constraint, using a standard multiplicative form for demand, and adding a flypaper effect, f, we find[10]

$$S = K(D)^{\phi}\left(Y + f\,A\left(\frac{V}{\bar{V}}\right)\left(1 - \frac{X}{V}\right)\right)^{\theta}\left((MC)e^{-1}\left(\frac{V}{\bar{V}}\right)\left(1 - \frac{X}{V}\right)\right)^{\mu} \tag{5}$$

where K is a constant, D represents demographic demand determinants, θ is the income elasticity of demand, and μ is the (negative) price elasticity of demand. Our principal hypothesis is that the STAR term, $(1 - X/V)$, is a price variable and therefore has a negative coefficient.

Tax price in equation 5 has four components: marginal cost, (the inverse of) efficiency, tax share, and STAR. These components all enter tax price in the same way but may have different elasticities in practice. Voters may be more aware of, and hence more responsive to, the STAR component than to the tax-share component, for example, because they must apply for the STAR rebate. Thus, we estimate all four elasticities and use them in our simulations. To simplify the presentation, however, we use a single elasticity in the text.

Equation 5 also reveals that STAR affects the value of aid to voters. In the standard model, the value of state aid to a voter depends on the voter's tax share, that is, on the voter's share of the money saved by cutting local taxes (Oates 1972; Duncombe and Yinger 2011). This effect explains why tax share appears in the augmented income term. Equation 5 shows that STAR exemptions also lower a voter's valuation of aid. We later test for this effect, which is discussed in Duncombe and Yinger (1998a, 2001) and Rockoff (2010).

Educational Cost and School Efficiency

Equation 2 indicates district spending, E, is the ratio of costs, C, to efficiency, e. Following standard practice (Downes and Pogue 1994; Duncombe and Yinger 1997, 1998b, 2000, 2005, 2008, 2011; Reschovsky and Imazeki 1998,

9. This approach is supported by studies (e.g., Duncombe and Yinger 2011) that find no impact of renter concentration on price elasticities. We cannot test this hypothesis about renters, however, so an alternative interpretation of our approach is that we use key elements of a demand model to approximate voting outcomes concerning school quality in different districts. Brunner and Ross (2010) also find voting outcomes are affected by household heterogeneity within a jurisdiction, a factor roughly captured by our district fixed effects and other controls.

10. For a review of the literature on the flypaper effect, see Hines and Thaler (1995); for a recent contribution, see Roemer and Silvestre (2002).

2001, 2003), we assume educational cost depends, in a multiplicative way, on teacher salaries, W, student enrollment, N, and pupil characteristics, P. Following Duncombe and Yinger (2011), we also identify returns to quality scale (as defined in Duncombe and Yinger 1993). In symbols,

$$C\{S\} = \kappa S^{\sigma} W^{\alpha} N^{\beta} P^{\lambda} \tag{6}$$

where κ is a constant and σ measures returns to quality scale; $\sigma < 1.0$ indicates increasing returns and $\sigma > 1$ indicates decreasing returns. With this cost function, marginal cost is not constant:

$$MC \equiv \frac{\partial C\{S\}}{\partial S} = \sigma \kappa S^{\sigma - 1} W^{\alpha} N^{\beta} P^{\lambda}. \tag{7}$$

In our framework, inefficiency arises when a district is wasteful or when it spends money on an educational outcome other than the ones specified in S. These two types of inefficiency cannot be separated (in our model or any other). Our approach is to identify variables conceptually linked to either or both of these types of inefficiency and to include them in an efficiency equation. As shown subsequently, this approach allows us to estimate e and to determine STAR's indirect impact on demand, which operates through efficiency.

As pointed out by Duncombe, Miner, and Ruggiero (1997) and Duncombe and Yinger (1997, 1998b), income may affect efficiency in two ways. First, a higher income may weaken voters' incentives to monitor school officials. Second, a higher income may encourage voters to push for a broader set of objectives. Because efficiency must be defined relative to spending on a particular objective, such as student performance on certain tests, spending to promote other objectives is, by definition, inefficient. Given this role of voter demand and monitoring, we use the same definition of income in the efficiency equation as in the demand equation.

These studies also provide evidence that a tax-price decrease, like an income increase, weakens voters' incentives to monitor school officials and boosts their demand for a broad set of objectives. Thus, tax price also belongs in the efficiency equation. As in the case of income, the role of voter behavior in this analysis indicates the tax-price term in the efficiency equation, like the one in the demand equation, should reflect tax share, marginal cost, and STAR.[11]

11. We exclude the efficiency component of tax price from the efficiency equation. It makes no sense to argue that voters will monitor school officials more actively when a low level of monitoring leads to inefficiency. An additional complexity is that MC refers to the marginal cost of S, whereas inefficiency includes spending on school quality measures other than S. If these other measures and S have similar cost functions, then $MC\{S\}$ is likely to be correlated with, and hence is a good proxy for, the MC of these other measures. In other cases, $MC\{S\}$ may not influence e at all. However, dropping the impact of $MC\{S\}$ on e has little impact on our results.

Because e reflects demand for school quality measures other than those in S, we use the same form for the efficiency equation as we use for the demand-for-S equation 5, namely, a multiplicative form based on augmented income and tax price. This approach not only has a clear conceptual foundation, but also, as we will show, facilitates identification of key parameters. For expositional purposes (but not in our estimations), we assume the flypaper effect is the same in the efficiency equation as in the demand equation. Determinants of efficiency other than augmented income and tax-price, which are discussed in the following, are represented by M. This approach leads to efficiency equation 8, where γ is the income elasticity of efficiency, δ is the price elasticity of efficiency, and k is a constant:

$$e = k M^{\rho} \left(Y + f A \left(\frac{V}{\bar{V}} \right) \left(1 - \frac{X}{V} \right) \right)^{\gamma} \left((MC) \left(\frac{V}{\bar{V}} \right) \left(1 - \frac{X}{V} \right) \right)^{\delta}. \tag{8}$$

Based on the literature, we expect that a higher augmented income leads to less efficiency ($\gamma < 0$) and that a higher tax price leads to more efficiency ($\delta > 0$).

Efficiency cannot be measured directly, but its determinants can be incorporated into the estimation of a cost function (Duncombe and Yinger 2001). Substituting equations 6–8 into the definition of E in equation 2, we find:

$$\begin{aligned} E = k^{*} (S^{\sigma - \delta(\sigma - 1)}) (W^{\alpha} N^{\beta} P^{\lambda})^{1-\delta} \left(M^{-\rho} \left(Y + f A \left(\frac{V}{\bar{V}} \right) \left(1 - \frac{X}{V} \right) \right)^{-\gamma} \right. \\ \left. \times \left(\left(\frac{V}{\bar{V}} \right) \left(1 - \frac{X}{V} \right) \right)^{-\delta} \right) \end{aligned} \tag{9}$$

where k^{*} combines the constants in equations 6–8. Taking logs and, for augmented income, using the simplification that $\ln\{1 + \alpha\} \approx \alpha$ when α is less than one, yields our estimating equation:

$$\begin{aligned} \ln\{E\} = \ln\{k^{*}\} + (\sigma - \delta(\sigma - 1)) \ln\{S\} + \alpha(1 - \delta) \ln\{W\} + \beta(1 - \delta) \ln\{N\} \\ + \lambda(1 - \delta) \ln\{P\} - \rho \ln\{M\} - \gamma \ln\{Y\} - \gamma f \left[\left(\frac{A}{Y} \right) \left(\frac{V}{\bar{V}} \right) \left(1 - \frac{X}{V} \right) \right] \\ - \delta \ln\left\{ \frac{V}{\bar{V}} \right\} - \delta \ln\left\{ 1 - \frac{X}{V} \right\}. \end{aligned} \tag{10}$$

This equation identifies all the parameters in equations 6 and 7 except the constant terms, which are not needed to calculate cost and efficiency indexes. The efficiency price elasticity, δ, equals the negative of the coefficient of the tax-share variable. Once δ is known, the values of the cost parameters, α, β, and λ, can be determined from the coefficients of the cost variables. Because

δ is expected to be positive, omitting this correction is likely to result in an *understatement* of the impact of wages, enrollment, and student characteristics on educational costs. The efficiency income elasticity, γ, is the negative of the coefficient of $\ln\{Y\}$, and the flypaper effect, f, is the coefficient of the aid variable divided by $-\gamma$. The economies-of-scale parameter, σ, can be found using the coefficient of $\ln\{S\}$ and the estimate of δ.

The three components of tax-price in equation 8, like those in equation 5, may not have the same elasticities. We can estimate separate elasticities for the last two terms, but not for the first, which appears in all the coefficients in the first line of equation 10. We assume that the elasticity of e with respect to MC equals the estimated elasticity of e with respect to $V/\bar{V}$.[12]

An alternative approach to estimating efficiency was developed by Ray (1991) and McCarty and Yaisawarng (1993). It involves two steps.[13] The first step is to estimate the minimum spending frontier for any combination of student outcomes using Data Envelopment Analysis (DEA).[14] DEA produces an index that captures variation across districts in both efficiency and educational costs. The second step is to regress the DEA index on cost variables and on variables thought to influence efficiency. The coefficients of this regression can then be used to remove the impact of the cost variables from the DEA index, leaving a measure of efficiency. DEA is designed to identify production frontiers with multiple outputs; it is not necessary or appropriate with a single output, as in the case of our education-performance index, and is difficult to incorporate into a model of cost and demand.

Implications of the Link between Demand and Efficiency

Once equation 10 has been estimated, two approaches are available for estimating the demand equation 5, and hence for determining the indirect impact of STAR on demand through efficiency. The first approach is to use the estimated parameters from equation 10, along with equations 6 and 8, to calculate indexes of MC and e for every district. The problem with this approach is that both MC and e (through MC) are functions of S, so that these two variables are endogenous by definition. Moreover, it may be impossible to find instruments for addressing this endogeneity because variables correlated with the impact

12. In principle, the value of γ might differ for the tax-share components in augmented income, but separate γs cannot be identified, and voters are only concerned about their net impact.
13. Ruggiero (1996) shows how to develop a DEA measure that directly removes the impact of cost factors. We have not used this clever approach because it requires a very large data set.
14. DEA uses linear programming to determine a "best-practice frontier" for production. It was developed by Farrell (1957), Charnes, Cooper, and Rhodes (1978), and Färe and Lovell (1978). Strengths and weaknesses of DEA are discussed in Seiford and Thrall (1990) and Ruggiero (1996). DEA is popular for evaluating productive efficiency in the public sector because it handles multiple outputs, is nonparametric, and can be applied to both production and cost.

of scale economies in MC and e, which operate through S, are, by definition, correlated with the dependent variable, namely, S.

The second approach is to exploit the multiplicative form of these equations to solve for S, that is, to eliminate S from the right side of the demand equation. This approach complicates the interpretation of the estimated parameters in the demand equation, but it eliminates the troublesome type of endogeneity just described. The first step in this approach is to calculate indexes for the exogenous components of cost and efficiency, that is, the components that do not involve S:

$$C^* = \sigma \kappa^* W^\alpha N^\beta P^\lambda \tag{11}$$

and

$$e^* = k^{**} M^\rho \left(Y + f A\left(\frac{V}{\bar{V}}\right)\left(1 - \frac{X}{V}\right)\right)^\gamma \left(C^*\left(\frac{V}{\bar{V}}\right)\left(1 - \frac{X}{V}\right)\right)^\delta \tag{12}$$

where κ^* is defined so that C^* equals 1.0 in the average district and k^{**} is defined so that e^* equals 1.0 in the most efficient district. This scaling alters the constant term in our demand regression, but does not alter any other estimated coefficient.

Now substituting equations 6 and 8 into equation 5 and making use of equations 11 and 12, we can write the demand function as:

$$S = K^*(D)^{\phi*}\left(Y + f A\left(\frac{V}{\bar{V}}\right)\left(1 - \frac{X}{V}\right)\right)^{\theta^*} \left((C^*)(e^*)^{-1}\left(\frac{V}{\bar{V}}\right)\left(1 - \frac{X}{V}\right)\right)^{\mu^*} \tag{13}$$

where

$$\theta^* = \frac{\theta}{1 - \mu(\sigma - 1)(1 - \delta)}; \mu^* = \frac{\mu}{1 - \mu(\sigma - 1)(1 - \delta)}; \text{ and}$$
$$\phi^* = \frac{\phi}{1 - \mu(\sigma - 1)(1 - \delta)}. \tag{14}$$

Equation 13 can be estimated by taking logs and using the approximation for the aid term derived earlier. The values of σ and δ come from the estimation of equation 10. Equation 14 can be used to find μ, θ, and ϕ. Note that $\theta = \theta^*$ and $\mu = \mu^*$ when there are constant returns to quality scale ($\sigma = 1$).

Because e^* depends on augmented income and tax-price, substituting equation 12 into equation 13 yields another form for the demand function, namely,

$$S = K^{**} M^{-\rho\mu^*} \left(Y + f A\left(\frac{V}{\bar{\bar{V}}}\right)\left(1 - \frac{X}{V}\right)\right)^{\theta^* - \gamma\mu^*} \left((C^*)\left(\frac{V}{\bar{\bar{V}}}\right)\left(1 - \frac{X}{V}\right)\right)^{\mu^*(1-\delta)}. \tag{15}$$

Equation 15 has two important implications. First, when efficiency is omitted from the demand equation, the estimated "income" elasticity is $(\theta^* - \gamma\mu^*)$ and the estimated "price" elasticity is $\mu^*(1 - \delta)$, which are smaller (in absolute value) than θ and μ, respectively (or than θ^* and μ^*).

The same issues arise when e is omitted from an expenditure form of the demand equation, which is equation 15 multiplied by MC/e with the assumption of constant returns to scale ($\sigma = 1$). With this approach, which is used by Rockoff (2010) and implemented here, the coefficient is $[\theta - \gamma(\mu + 1)]$ for the income term and $[\mu - \delta(\mu + 1)]$ for the tax-price term.[15] Even with constant returns, the estimated coefficients cannot be interpreted as income and price elasticities of demand unless γ and δ are assumed to be zero. Including district fixed effects and regional time trends to account for efficiency, the Rockoff (2010) strategy does not eliminate the extra terms in these coefficients because e is directly affected by STAR and varies over time in each district.

The Rockoff approach provides a demand interpretation for an expenditure equation that is quite different from the cost/efficiency interpretation we give to equation 9. Nevertheless, these two interpretations are not inconsistent. Under the demand interpretation, an expenditure equation explores the demand for a broad but unspecified set of educational outcomes, whereas we explore cost and efficiency in providing a specific school performance index. A finding that the demand for a broad set of education outcomes increases with district income or decreases with district tax price implies that an income increase or a tax-price decrease encourages a district to provide a broader set of educational outcomes, which is equivalent to becoming more inefficient in delivering the performance index in our analysis. Overall, both interpretations are legitimate, but the cost interpretation has the advantage that it does not require the assumptions that σ equals 1 and that γ and δ equal zero.[16]

The second implication of equation 15 is that, even with constant returns, the impact of STAR on the demand for S has two direct components, a price effect and a change in the value of A, and two indirect components, which operate through efficiency. By lowering tax price, STAR gives a direct boost to

15. This step also adds 1 to the exponent of the C^* ($=MC$) term.

16. These assumptions about these three parameters might hold with the unspecified broad school performance measure in the demand interpretation even if they do not hold with the specific measure in the cost interpretation, but there is no way to determine whether or not this is true.

demand, but it also lowers efficiency, which indirectly results in lower demand. The net impact of these two responses is summarized by the $\mu(1-\delta)$ exponent. The (negative) price elasticity, μ, indicates the direct effect; it is offset to some degree by the product of δ, which is positive, and μ. In addition, by lowering the value of aid to a voter, STAR lowers demand, but this drop in augmented income also leads to higher efficiency, which indirectly boosts demand. The net impact of these two responses is summarized by the $(\theta - \gamma\mu)$ exponent. The positive income elasticity, θ, is offset, at least in part, by the product of γ (negative) and μ.

The simulations in a later section incorporate the exact form of these indirect effects but it is instructive at this point to examine them using calculus approximations. With constant returns, differentiating equation 15 with respect to $m = X/V$ reveals that the impact of STAR on S is[17]

$$d\ln\{S\} = -\left(\frac{(\theta-\gamma\mu) f A\left(\frac{V}{\bar{V}}\right)}{Y + f A\left(\frac{V}{\bar{V}}\right)} + \mu(1-\delta)\right)\left(\frac{X}{V}\right). \tag{16}$$

The first term in equation 16 is the net income effect and the second term is the net price effect. The second term shows the direct positive price impact of STAR on S, $-\mu$, is offset to some degree by the indirect effect, $\mu\delta$, that arises because STAR has a price impact on efficiency, which in turn affects S. Without constant returns, θ and μ in equation 16 must be replaced by θ^* and μ^* as defined by equations 14 and 15.

Using the expenditure form of the demand equation, again with constant returns, we can also derive the impact of STAR on E:

$$d\ln\{E\} = -\left(\frac{(\theta-\gamma(\mu+1)) f A\left(\frac{V}{\bar{V}}\right)}{Y + f A\left(\frac{V}{\bar{V}}\right)} + \mu - \delta(1+\mu)\right)\left(\frac{X}{V}\right). \tag{17}$$

In this case, the elasticity expressions in the numerators summarize the direct impacts of STAR on efficiency and the direct and indirect impacts of STAR on S and hence on C.[18]

The district budget constraint, equation 2, implies

$$dt = \left(\frac{d\ln\{E\}}{\frac{X}{V}}\frac{E}{\bar{V}}\right)\left(\frac{X}{V}\right) = d\ln\{E\}\left(\frac{E}{\bar{V}}\right). \tag{18}$$

Not surprisingly, the impact of STAR on property taxes has the same sign as its impact on spending, regardless of scale economies. Finally, we can

17. These derivatives are evaluated at $m = 0$ (which corresponds to a starting point without STAR), with $dm = X/V$ (which corresponds to implementing STAR), and with $\sigma = 1$.
18. Without constant returns, the coefficients in the numerators become $[(\theta^* - \gamma\mu^*)(\sigma(1-\delta)+\delta) - \gamma]$ (first term) and $[\mu^*(1-\delta)(\sigma(1-\delta)+\delta) - \delta]$ (second term).

differentiate equation 6 to determine the impact of STAR on school district efficiency. The result with $\sigma = 1$ is:[19]

$$d \ln \{e\} = -\left(\frac{\gamma f A(\frac{V}{\bar{V}})}{Y + f A(\frac{V}{\bar{V}})} + \delta \right) \left(\frac{X}{V} \right). \tag{19}$$

STAR raises efficiency by cutting the value of aid to voters (the first term) but also lowers efficiency by lowering voters' tax prices (the second term). Without constant returns, the coefficient in the numerator of the first term becomes $[\gamma + \theta^*(\sigma - 1)\delta]$ and the coefficient in the numerator of the second term becomes $[\delta + \mu^*(\sigma - 1)\delta]$. The increase in S caused by STAR raises the marginal cost of S, thereby boosting efficiency and offsetting, at least in part, the drop in efficiency associated with the STAR implicit matching rate.

4. DATA AND MEASURES

Our conceptual framework calls for the estimation of the cost/efficiency (equation 10) and the demand (equation 13). In this section we describe our data and our strategy for estimating each of these equations. Our sample is most New York school districts for the academic years 1998–99 to 2010–11. This period is ideal for studying STAR because it includes one year before STAR was implemented—and New York's tests, accountability measures, and school aid system remained fairly stable over this period.[20] We exclude New York City from the sample because of both missing data for some variables and the fact that most of the STAR benefit to New York City comes in the form of an income tax rebate. We exclude non-K–12 districts, because we are using performance measures that include test scores in grade 8. After dropping a few observations with missing variables, the final sample includes 8,038 observations. The number of districts in the sample ranges from 607 to 627 over the sample period.[21]

Table 2 describes changes in tax-price components and other key variables before and after STAR was implemented. The first column shows that in all regions, tax share ($V/\bar{V}$) was lower in 2006 and 2011 than in 1999. The second column indicates that the average STAR tax share across districts was 77 percent in 2011, which is equivalent to a matching rate of 23 percent, and ranged from 71 percent in small city districts outside the New York City region (upstate) to 86 percent in suburban districts near NYC or on Long Island (downstate). This difference, which tends to favor needy districts, would be

19. Without constant returns, the coefficient in the numerator becomes $[\gamma + \theta^*(\sigma - 1)\delta]$ (first term) and $[\delta + \mu^*(\sigma - 1)\delta]$ (second term).
20. The federal No Child Left Behind Act was passed in 2001, but including federal aid has little impact on the results.
21. Our results are virtually unchanged if we reduce the sample to create a balanced panel.

Table 2. Changes in Key Variables from 1999 to 2011 by NYSED Region

Region	Tax Share	STAR Tax Share	Effective Tax Rate	Real Per Pupil Operating Spending	Student Performance Index
			1999		
Downstate small cities	0.583	1	1.974	19,024	56.6
Downstate suburbs	0.485	1	1.835	18,979	66.8
Yonkers	0.674	1	1.854	18,526	40.3
Big three	0.448	1	1.446	14,138	41.8
Upstate small cities	0.408	1	1.864	13,242	57.6
Upstate rural	0.365	1	1.543	13,043	59.7
Upstate suburbs	0.418	1	1.766	12,694	63.6
Average District	0.419	1	1.720	14,474	62.5
			2006		
Downstate small cities	0.506	0.810	1.563	21,467	71.7
Downstate suburbs	0.422	0.848	1.413	21,050	81.4
Yonkers	0.551	0.836	1.072	19,419	52.2
Big three	0.486	0.710	1.601	15,296	46.7
Upstate small cities	0.420	0.673	2.166	14,547	68.1
Upstate rural	0.322	0.667	1.777	15,512	70.9
Upstate suburbs	0.387	0.734	2.032	14,206	75.9
Average District	0.380	0.738	1.801	16,390	74.8
Percent change since 1999	–9.3	–26.2	4.7	13.2	19.7
			2011		
Downstate small cities	0.495	0.820	1.627	21,000	73.9
Downstate suburbs	0.460	0.856	1.592	22,192	81.9
Yonkers	0.641	0.841	1.259	16,782	55.7
Big three	0.434	0.729	1.540	16,144	51.1
Upstate small cities	0.371	0.710	1.930	14,932	68.9
Upstate rural	0.256	0.714	1.546	16,931	71.9
Upstate suburbs	0.327	0.765	1.856	15,241	77.2
Average District	0.344	0.769	1.700	17,497	75.7
Percent change since 1999	–17.9	–23.1	–1.2	20.9	21.1

Notes: Tax share is $(V/\bar{V})$; STAR tax share is $(1 - X/V)$; effective tax rate is equal to total property tax revenues divided by total equalized property values; and student performance index is simple average of non-dropout rates, Regents diploma rates, and percent of students reaching proficiency levels in grade 8 reading and grade 8 mathematics.
Sources: As indicated in table 3.

much greater were it not for the SPDF. Table 2 also shows that the average effective property tax rate increased by 17.7 percent from 1999 to 2006 and by 7.9 percent from 1999 to 2011. Real spending per pupil increased by 13.2 percent from 1999 to 2006 and by 21 percent from 1999 to 2011, and student performance (discussed subsequently) increased between 19.7 and 21.1 percent. Our objective is to determine the extent to which these changes can be attributed to STAR.

Table 3 provides summary statistics and sources for all of the variables we use in our estimations. The dependent variable in the expenditure model is spending per pupil. We use two spending measures: current expenditures and operating expenditures. Current expenditures are derived by subtracting payments on debt service from total expenditures, whereas operating expenditures equal current expenditures minus transportation spending. Because transportation spending is not directly related to student performance and involves a unique set of cost factors (such as district area and population density), the effects of STAR on operating expenditures are our primary concern.

Student performance is a key variable in both the expenditure and demand functions. Our approach is to design performance indexes that (1) cover a range of student performance measures, (2) are linked to the types of measures in previous studies and in the New York school accountability system, and (3) are based on variables measured consistently across the years in our panel. In 1998–99, New York initiated a new testing system, which is focused on testing student proficiency, particularly in math and English. The examinations are central to New York State's accountability system and New York State Education Department (NYSED) publishes the test results as part of each school's annual report card. This system was used throughout our sample period. Our first index, S_1, is the equally weighted average percentage of students reaching the state's proficiency standard on math and English exams in fourth and eighth grades. Our second index brings in the share of students receiving a Regents Diploma by passing at least five Regents exams and the share of students not dropping out of high school (=100 – dropout rate).[22] More specifically, this index, S_2, is the equally weighted average of the components in the first index together with Regents Diploma rates and non-dropout rates.[23] Our preferred measure is S_2 because it is more comprehensive.

22. Dropout refers to "any student, regardless of age, who left school prior to graduation for any reason except death and did not enter another school or high school equivalency preparation program or other diploma program" (NYSED 2003).

23. Although combining outcome measures requires an arbitrary decision about the weights, we do not find that our results are sensitive to the weights we use. New York's accountability system focuses on the same test outcomes included in our performance index, and an estimate of a cohort graduation rate. Because a consistent measure of a cohort graduation rate is not available during our sample period, we used the non-dropout rate instead.

Table 3. Summary Statistics (1999–2011)

	Mean	Standard Deviation	Min	Max	Source
Key Variables					
Current expenditures per pupil	16,726	4,297	9,718	79,252	(1)
Operating expenditures per pupil	15,788	4,054	9,164	74,269	(1)
Adjusted performance index 1 (S_1)	70.7	13.8	15.8	100	(1)
Adjusted performance index 2 (S_2)	75.8	11.6	29.2	98.2	(1)
Cost-Related Variables					
Teacher salary (1–5 year experience)	21,781	9,279	1	61,744	(1), (4)
Enrollment (average daily membership)	2,746	3,435	60	46,550	(1)
Percent of students with severe disabilities	1.4	0.8	0	7.5	(1)
Percent of LEP students	1.7	3.4	0	33.2	(1)
Percent of free lunch students	27.0	17.4	0	89	(1)
Demand/Efficiency-Related Variables					
Local tax share ($V/\bar{V}$)	0.40	0.15	0.02	1.05	(1), (2)
STAR tax share ($1 - X/V$)	0.75	0.14	0.17	1	(1), (2)
State aid term $[(A/Y)(V/\bar{V})(1 - X/V)]$	0.02	0.02	0.0001	0.38	(1), (2)
Income per pupil	129,887	117,775	27,725	1,962,731	(1)
Percent of college graduates	25.7	14.1	4.9	83.4	(1), (2)
Percent of youths (aged 5–7)	17.4	2.5	4.5	30.7	(1), (2), (3)
Percent of owner-occupied housing units	81.0	11.4	20.0	100	(1), (2), (3)
Percent of seniors (aged 65 and over)	14.8	3.3	3.1	38.9	(1), (2), (3)
Instrumental Variables (IVs)					
Average percent of high cost students in the rest of the county	1.3	0.4	0	3.1	(1), (4)
Average percent of LEP students in the rest of the county	2.2	2.3	0	8.5	(1), (4)
Annual county average salary of manufacturing jobs	49,560	14,837	21,882	103,054	(4)
STAR tax share with 1999 property values (X_{IV})	0.8	0.1	0.46	1	(1), (2), (4)
Adjusted state aid ratio with 1999 property values (A_{IV})	0.02	0.02	0.000031	0.38	(1), (2), (4)

Notes: Monetary variables (e.g., state highway spending per capita, federal apportionments per capita) are adjusted for inflation (using state and local government price indexes published by the Bureau of Economic Analysis) and in 2010 dollars. Performance index 1 is simple average of percent of students reaching proficiency levels in fourth-grade reading and mathematics, in eighth-grade reading and mathematics, percent of Regents diploma recipients and non-dropout rates.
Sources: (1) New York State Education Department (NYSED); (2) American Community Survey (ACS); (3) U.S. Censuses in 1999 and 2009 (The annual values for inter-census years between 1999 and 2009 were interpolated by using the linear growth rate between 1999 and 2009.); and (4) U.S. Census, County Business Patterns.

One complication is that starting in 2009–10, NYSED raised the scores required for a student to be judged "proficient," called "cut scores," leading to a substantial drop in proficiency levels across the state. For 2009–10 and 2010–11, therefore, we calculated adjusted proficiency rates based on the cut scores that applied before these years.[24]

Teacher salary data come from the "personnel master file" produced by NYSED. Our salary variable is the average salary a district pays to teachers with one to five years of experience, controlling for the actual experience and education of the teachers in that district. This variable captures the relative generosity of a district's salary schedule instead of the average quality of a district's teachers, at least as measured by experience and education. Measures of student characteristics include the share of students eligible for a free lunch (a measure of student poverty), the share of students classified as having limited English proficiency (LEP), and the share of students having severe disabilities defined as requiring teacher consultation services or spending at least 60 percent of their time out of their regular classroom.[25] The measure of enrollment is average daily membership adjusted for the residency of the student. Following standard practice, we allow a nonlinear relationship between per pupil spending and enrollment. Based on Rockoff (2010) and Duncombe and Yinger (2011), we also include the change in district enrollment. Because it takes time for a district to adjust to a new enrollment level, an increase in enrollment lowers costs per pupil (and a decrease in enrollment raises costs per pupil) in the short run. Demographic factors included in our regressions include income per pupil and the shares of the population that graduated from four-year college, youth (5–17 years of age), homeowners, and seniors (over age 64).[26]

24. To correct the proficiency rates for a change in the cut score, we assume the distribution of student scores in each district follows a normal distribution. We then approximate the cumulative standard normal with: $F\{Z\} = 1/[1 + \exp\{-1.702\ Z\}]$, where $Z = (X - \mu)/\sigma$, X is the test score, and μ and σ are its mean and standard deviation, respectively. The proficiency rate at any given Z is $(1 - F\{Z\})$. Because our data set includes μ for each test in each district, we can use this equation to solve for σ using the observed new cut score, X_{NEW}, and the associated proficiency rate. With this estimate of σ we can then calculate $Z_{OLD} = (X_{OLD} - \mu)/\sigma$, where X_{OLD} is the old cut score. The proficiency rate at the old cut score is $(1 - F\{\ Z_{OLD}\})$. More detailed notes on this procedure are available from the authors.

25. These variables are logged in our expenditure regressions. These variables have somewhat higher standard errors if they are not logged, but other results are not affected.

26. We do not have annual data for median household income. If differences between income per pupil and median household income are constant over time, they are captured by our district fixed effects and other controls; if not, the use of income per capita represents another reason to say that our approach only approximates the underlying public choice mechanism.

5. EMPIRICAL METHODS AND RESULTS

Methodology

We estimate the structural expenditure and demand models in equations 10 and 13. We treat the STAR tax share, $(1 - X/V)$, and the adjusted aid ratio, $[(A/Y)(V/\bar{V})(1 - X/V)]$, as endogenous variables in both models because STAR-induced changes in spending or student performance may be capitalized into property values. Our instruments substitute predicted V and $\bar{V}$ into the above expressions. These predictions are 1999 values inflated by the Case-Shiller home price indices for New York published by the Federal Reserve Bank of St. Louis. This approach allows us to capture growth in V and $\bar{V}$ while removing the impact of X. For ease of reference, these two instrumental variables (IVs) for STAR tax share and adjusted aid ratio are referred to as X_{IV} and A_{IV}, respectively.

Following the literature in education cost functions (reviewed in Duncombe and Yinger 2008), we also treat both the teacher salary variable and student performance measure as endogenous in the expenditure model, because unobserved school district traits may affect spending and student performance as well as salaries.[27] The IV for the teacher salary variable is the average manufacturing wage in a district's county. Following Duncombe and Yinger (2011) and Nguyen-Hoang and Yinger (2014), the IVs for student performance are exogenous traits of school districts in the rest of a district's county. A district's own choices are likely to be influenced by the choices of nearby districts, and the choices of nearby districts are influenced by their exogenous traits. The specific IVs we use are the average percentage of high-cost students (i.e., those with severe disabilities) and of LEP students in the rest of the county. We also examine the appropriateness of these IVs using two instrument tests: overidentification and weak instrument tests. We discuss the results of these tests in detail in the next section. Also, we use the Fuller's (1977) estimator (k = 4), which, according to Hahn, Hausman, and Kuersteiner (2004), proves to be less subject to potential bias from weak instruments than two-stage-least squares.

The regressions also include demographic factors. The expenditure regression accounts for a district's share of college graduates and of youth. These shares could influence either the monitoring of school officials or the demand for student performance measures other than the ones captured by our indexes. The demand regression accounts for the percent of housing-units that are owner-occupied and the share of the population over age 64; a relatively high share of owners might signify a cohesive community with a higher

27. Moreover, one possible type of inefficiency, as defined here, is overly generous teacher salaries. Treating these salaries as endogenous ensures the salary variable only picks up costs, not inefficiency.

commitment to high-quality public schools, and a relatively high share of elderly voters might lead to the opposite effect. Because efficiency and demand are related concepts, no theoretical argument can clearly assign any of these four demographic traits to one of our equations over the other. We have assigned them to maximize explanatory power, but other assignments lead to little change in our main results.

Finally, the structural models are estimated with district and year fixed effects. In the expenditure regression, the district fixed effects control for unobserved, time-invariant district traits that influence efficiency or cost. In the demand regression, they control for unobserved time-invariant district traits that influence the demand for school quality as measured by our index. These factors include those who might lead households with certain incomes to sort into districts with certain school performance outcomes.[28] These fixed effects do not, of course, rule out the possibility that our results are affected by unobserved time-varying district traits but we believe the most important time-varying district traits are already included in our regressions.

For both regressions, our hypothesis tests are conducted with robust standard errors adjusted for clustering at the school district level.[29]

Empirical Results

Table 4 presents the results of the expenditure model for both current and operating expenditures (as dependent variables) together with two performance indices described earlier. The results are similar across the four columns of this table. Most of the variables are statistically significant at the 5 percent or 1 percent level. Our preferred specification is in column 4, which refers to operating expenditures and the performance index that includes Regents Diploma rates and non-dropout rates. We find educational spending increases with the share of students eligible for a free lunch or who have severe disabilities. The impact of LEP students on spending is close to zero and not significant. Enrollment and spending have the expected U-shaped relationship, but the squared term is not significant. Spending per pupil is also strongly affected by short-run changes in enrollment. After the adjustment in equation 10, these results also apply to educational costs.

28. Households may sort across districts with different school quality based on unobservable traits, resulting in “Tiebout bias” (reviewed in Ross and Yinger 1999). This possibility is addressed with our fixed effects. A second-order bias could arise if unobserved household traits are correlated with changes in school quality but the changes we observe do not result in significant reordering of school quality rankings, and we control for many time-varying variables.
29. Because the demand model includes two variables (predicted cost and efficiency) derived from the expenditure model, it is possible the standard errors are biased. In fact, however, bootstrapped robust standard errors are actually lower than the ones in the table.

Table 4. Structural Cost Function Results (1999–2011) (Dependent variable: Logged education expenditures per pupil)

	Current Expenditures		Operating Expenditures	
	Performance Index 1	Performance Index 2	Performance Index 1	Performance Index 2
Variable	**(1)**	**(2)**	**(3)**	**(4)**
Performance Measure[a]	***0.38***	***0.62***	***0.34***	***0.55***
	(2.49)**	(2.56)**	(2.27)**	(2.31)**
Cost-Related Variables				
Teacher salary[a]	***0.20***	***0.21***	***0.20***	***0.21***
	(4.32)***	(4.35)***	(4.40)***	(4.42)***
% of free lunch students[a]	0.014	0.016	0.013	0.015
	(2.90)***	(2.95)***	(2.72)***	(2.76)***
% of LEP students*	–0.0020	–0.0014	–0.0020	–0.0015
	(–1.02)	(–0.70)	(–1.03)	(–0.75)
% of students with severe disabilities[a]	0.010	0.011	0.0098	0.010
	(2.56)**	(2.57)**	(2.46)**	(2.44)**
Enrollment[a]	–0.58	–0.53	–0.66	–0.62
	(–2.78)***	(–2.46)**	(–3.20)***	(–2.90)***
Enrollment squared[a]	0.0078	0.0044	0.013	0.010
	(0.56)	(0.31)	(0.95)	(0.70)
% three-year log enrollment change if positive	–0.035	–0.035	–0.034	–0.035
	(–8.28)***	(–8.25)***	(–8.24)***	(–8.20)***
% three-year log enrollment change if negative	–0.026	–0.027	–0.025	–0.026
	(–5.21)***	(–5.30)***	(–5.06)***	(–5.12)***
Efficiency-Related Variables				
STAR tax share $(1 - X/V)$[a]	***–0.11***	***–0.10***	***–0.12***	***–0.11***
	(–2.11)**	(–1.97)**	(–2.28)**	(–2.15)**
Adjusted aid ratio $[(A/Y)(V/\bar{V})(1 - X/V)]$	***2.06***	***2.00***	***2.02***	***1.97***
	(5.62)***	(5.76)***	(5.50)***	(5.61)***
Local tax share[a]	–0.041	–0.040	–0.042	–0.041
	(–2.21)**	(–2.15)**	(–2.27)**	(–2.21)**
Income per pupil[a]	0.036	0.031	0.037	0.033
	(2.31)**	(1.96)**	(2.39)**	(2.07)**
% of college graduates	0.00039	0.00054	0.00054	0.00070
	(0.35)	(0.50)	(0.49)	(0.65)
% of youths	0.0034	0.0042	0.0031	0.0038
	(1.65)*	(1.93)*	(1.49)	(1.73)*
Selected Structural Parameters				
σ for performance	0.29*	0.60**	0.25*	0.53**
δ_1 *for STAR tax share*	0.11**	0.10**	0.12**	0.11**
δ_2 *for local tax share*	0.07***	0.04**	0.07***	0.04**

Table 4. Continued.

	Current Expenditures		Operating Expenditures	
Variable	**Performance Index 1 (1)**	**Performance Index 2 (2)**	**Performance Index 1 (3)**	**Performance Index 2 (4)**
γ for income	–0.04***	–0.03**	–0.04**	–0.03**
f for flypaper effect	53.5**	63.8*	51.3**	59.8**

Notes: There are 8,058 observations. All financial measures are inflation-adjusted in 2010 dollars. Regressions are estimated with year and district fixed effects, the Fuller (k = 4) estimator, and robust standard errors adjusted for clustering at the school district level. Coefficients in ***bold italics*** are treated as endogenous with five IVs: the average percentage shares of high cost and LEP students in the rest of the county (for performance measures); logged annual county average salary of manufacturing jobs (for teacher salary), X_{IV} and A_{IV} constructed with growth-adjusted property values in 1999 (for the STAR tax share and adjusted aid ratio). Numbers in parentheses are *t*-statistics.
[a]Variable is log-transformed.
***Statistically significant at the 1% level; **statistically significant at the 5% level; *statistically significant at the 10% level.

Turning to the efficiency variables, we find the reduction in the tax share caused by an increase in STAR encourages spending on school outputs other than those in our index, which indicates lower efficiency as defined in this paper. In contrast, STAR also lowers the value of existing state education aid to voters and therefore leads to less spending on these other outputs, that is, to more efficiency. Our simulations in the next section explore the net impact of these two effects. We also find, as expected, that a lower non-STAR tax share or higher district income leads to inefficiency, again because they encourage spending on outputs other than those in our index and/or because voters have lower incentives to monitor school officials. This type of spending is also encouraged by a more educated population.

These results are derived from estimations with IVs. On the basis of the Hansen (1982) *J* test (*p* values from 0.61 to 0.97), we fail to reject the null that the IVs are jointly valid (i.e., our IVs are jointly exogenous). Our IVs are also strongly correlated with the endogenous variables. As reported in table 5, they are highly significant with expected signs in the first stages of the two-stage estimations.[30] Moreover, the *F*-statistics in the first-stage regressions of our IVs range between 21.6 and 1,205, higher than the rule-of-thumb threshold value of 10 suggested in Staiger and Stock (1997). These statistics, together with use of the Fuller (k = 4) estimator, suggest our results are highly unlikely to be biased by weak IVs.

30. The Kleibergen–Paap *rk* statistics for these regressions are above 4.5, but there is no direct test for weak IVs for multiple endogenous regressors and robust standard errors.

Table 5. First-Stage Regression Results of Column 4 of Table 4

	Dependent Variables			
IVs	**Performance Index 2**	**Teacher Salary**	**STAR Tax Share**	**Adjusted Aid Ratio**
Average percent of LEP students in the rest of the county	0.0099 (3.15)***	0.031 (2.54)**	0.039 (16.69)***	0.0010 (5.94)***
Average percent of high cost students in the rest of the county	0.0017 (0.45)	0.074 (2.77)***	–0.0081 (–2.54)**	–0.00022 (–0.79)
Logged annual county average salary of manufacturing jobs	–0.040 (–2.23)**	0.30 (2.74)***	0.079 (5.93)***	0.0012 (0.91)
X_{IV}	–0.16 (–5.04)***	0.28 (0.95)	1.41 (40.21)***	0.012 (4.61)***
A_{IV}	–0.52 (–1.97)**	–1.64 (–1.53)	0.47 (2.59)***	1.18 (25.09)***

Note: Other variables in these first-stage regression results are not reported.
***Statistically significant at the 1% level; **statistically significant at the 5% level.

The results of the expenditure model can be used to derive the structural parameters in equation 10, which are reported in the second panel in table 4. The (significant) economies of quality scale parameter (σ) is 0.53, which indicates strong economies of quality scale for New York school districts in delivering our measure of school quality. The efficiency elasticity for the STAR tax share (δ_1) is nearly three times as large as that for local tax share (δ_2) (0.11 versus 0.04). This difference, which is significant at the 1 percent level, indicates an increase in STAR induces double the impact on efficiency compared to an equivalent increase in the standard tax share. This result suggests a high-visibility policy, such as STAR, has a larger impact on voters' perceptions of tax share than do differences in $V/\bar{V}$. The efficiency elasticity for income (γ) and the flypaper effect in the efficiency equation (f) indicate an increase in community income is associated with slightly lower efficiency and the efficiency loss is much higher for an equivalent increase in state aid.

Because operating expenditures are of primary interest, table 6 presents the results of the demand model for the two performance indices associated with operating expenditure estimations. The two STAR variables are treated as endogenous using the instruments described earlier.[31] In our preferred regression (column 2), the elasticity of performance with respect to the STAR tax share is –0.63 and is highly significant. The adjusted aid ratio is also highly significant. The other coefficients in table 6 are generally significant

31. These instruments are significant in the first-stage regression and the associated F-statistics range from 53.4 to 219.0—signs that the demand equation is not subject to weak instrument bias.

Table 6. Demand Results (1999–2011) (Dependent variable: Logged performance index)

Variable	S_1 (1)	S_2 (2)
Adjusted Income		
Income per pupil[a]	0.33	0.17
	(5.74)***	(7.18)***
Adjusted aid ratio	***16.7***	***8.81***
	(4.96)***	(6.14)***
Tax Price Variables		
STAR tax share[a]	***–1.16***	***–0.63***
	(–6.02)***	(–7.59)***
Local tax share[a]	–0.39	–0.22
	(–5.67)***	(–6.95)***
Cost index[a]	–0.026	–0.034
	(–0.62)	(–1.29)
Efficiency index[a]	8.64	4.67
	(5.57)***	(7.12)***
Preference Variables		
% of owner-occupied housing units	0.00085	0.00037
	(3.28)***	(2.15)**
% of senior citizens (aged 65 or over)	–0.0099	–0.0068
	(–5.01)***	(–5.57)***
Average % of LEP students in the rest of the county	0.029	0.017
	(5.51)***	(5.00)***
Average % of high cost students in the rest of the county	0.0049	0.000039
	(0.85)	(0.01)
Selected Structural Parameters		
μ_1 for local tax share	–0.31***	–0.19***
μ_2 for STAR tax share	–0.92***	–0.57***
μ_3 for efficiency	–6.84***	–4.22***
μ_4 for cost	–0.02	–0.03
θ for income	0.26***	0.15***
f for flypaper effect	50.2***	52.1***

Notes: There are 8,060 observations. S_1 and S_2 are performance indices 1 and 2. Regressions are estimated with year and district fixed effects, the Fuller (k = 4) estimator, and robust standard errors adjusted for clustering at the school district level. Coefficients in ***bold italics*** are treated as endogenous. The two IVs for the adjusted aid ratio and STAR tax share are those constructed with growth-adjusted property values in 1999. Cost and efficiency indices in this table are derived based on regressions in columns 3 and 4 of table 4, using equations 11 and 12.
[a]Variable is log-transformed.
***Statistically significant at the 1% level; **statistically significant at the 5% level.

and have the expected signs. For example, the tax price variables for the local tax share and cost index are negatively related to demand, and higher efficiency is associated with greater demand for student performance. The coefficient of per pupil income is positive and significant.

In the second panel of table 6, we report the structural parameters in equation 13. For our preferred specification, the price elasticities equal –0.19 for the tax share and –0.57 for the STAR tax share.[32] As in the case of the expenditure equation, tax shares in the highly visible STAR program appear to elicit a greater response than standard tax shares. Somewhat surprisingly, the price elasticity for inefficiency, –4.22, is even larger; voters in districts that provide a relatively wide range of services and/or are wasteful select a significantly lower level of the services in our school performance index. The income elasticity of demand for our index is small, 0.15. The flypaper effect is 52.10, which indicates that $1 of tax-share-adjusted state aid has the same impact on demand as $52.10 of voter income. This estimate is much larger than the estimate in previous studies, but not quite as large as the estimate in table 4. Except for the cost index coefficient, all of these parameters are statistically significant.

For purposes of comparison, table 7 presents reduced form estimates similar to those in Rockoff (2010). The estimating equation is 15 multiplied by MC/e, assuming constant returns to quality scale ($\sigma = 1.0$). When the STAR tax share variable (which Rockoff calls the community tax price) is treated as endogenous, our estimated elasticity, –0.15, is similar to his (–0.23). Without an endogeneity correction, his estimated coefficient for the adjusted aid ratio, 0.88, is also similar to our result in column 1, at 0.78.[33] Because our estimate of δ is small, the discussion after equation 15 implies the coefficient of the STAR tax share variable would yield an accurate price elasticity of demand if σ were equal to 1.0. Because our estimate of σ is below one, however, this STAR coefficient appears to underestimate the underlying structural parameter (μ_2 in table 6) by more than 70 percent.

Simulating the Net Effects of STAR

Table 8 presents simulated impacts of STAR on student performance, school district efficiency, school spending, and property tax rates. These impacts are based on the results in the last column of table 4 and the second column of table 6 combined with data on individual districts and the equations derived

32. This price elasticity is about twice as large as the elasticity estimated by Wang, Duncombe, and Yinger (2011) for open-ended matching grants for school capital spending in New York.
33. Rockoff estimated a regression that treated this variable as endogenous but does not present the results. The form of this variable in Rockoff's equation 7 is the same as ours, but the form listed in his table 2 is different. If he used the latter form, our results are not comparable to his.

Table 7. Reduced-Form Expenditure Results (1999–2011) (Dependent variable: Logged operating expenditures per pupil)

STAR tax share (1 – *X/V*)[a]	–0.011	***–0.14******	***–0.15******
	(–0.83)	***(–7.28)***	***(–8.10)***
Adjusted aid ratio [(*A/Y*)($V/\bar{V}$)(1 – *X/V*)]	0.78***	1.34***	***1.39******
	(4.28)	(5.61)	***(5.96)***
Cost-Related Variables			
Average county manufacturing salary[a]	0.053***	0.054***	0.054***
	(3.51)	(3.56)	(3.55)
% of free lunch students[a]	0.0041*	0.0030	0.0029
	(1.86)	(1.35)	(1.29)
% of LEP students[a]	0.0014	0.0013	0.0013
	(1.60)	(1.47)	(1.46)
% of students with severe disabilities[a]	0.0071***	0.0065***	0.0064***
	(5.07)	(4.53)	(4.48)
Enrollment[a]	–0.85***	–0.82***	–0.82***
	(–8.89)	(–8.44)	(–8.38)
Enrollment squared[a]	0.027***	0.029***	0.029***
	(4.18)	(4.42)	(4.44)
% three-year log enrollment change if positive	–0.030***	–0.031***	–0.031***
	(–12.71)	(–13.22)	(–13.21)
% three-year log enrollment change if negative	–0.017***	–0.018***	–0.019***
	(–10.06)	(–10.89)	(–10.93)
Efficiency-Related Variables			
Local tax share[a]	–0.049***	–0.063***	–0.064***
	(–5.27)	(–6.39)	(–6.51)
Income per pupil[a]	0.038***	0.064***	0.067***
	(5.57)	(8.19)	(8.35)
% of college graduates	–0.00023	0.00059	0.00067
	(–0.49)	(1.24)	(1.40)
% of youths	0.0019**	0.0017**	0.0017**
	(2.26)	(2.04)	(2.01)

Notes: Coefficients in ***bold italics*** are treated as endogenous using the IVs described in the text. Numbers in parentheses are *t*-statistics.
[a]Variable is log-transformed.
***Statistically significant at the 1% level; **statistically significant at the 5% level.

earlier.[34] Although the derivatives in equations 16 to 19 provide some helpful initial intuition about these calculations, they are approximations and they

34. We calculate the impact of STAR using equations 2, 5, and 6–8, with separate coefficients for each tax-price term and with separate flypaper effects for the efficiency and demand equations. These equations are used to derive the percentage changes in *S*, *C*, *e*, *E*, and *t* when the STAR matching rate goes from zero to *X/V*. These equations are then combined with our estimates of the parameters and data from school districts in the state to obtain the results in table 7. A technical appendix containing these equations is available from the authors. Simulation results with our alternative performance measure or without our cut-score correction are similar to those in table 8.

Table 8. Simulated Impacts (%) of STAR on Sending, Efficiency, Performance, and Property Taxes

Region	E	e	C	S	t	Offset
Panel A: STAR Exemptions in 2011						
Downstate small cities	3.22	–1.99	1.17	2.13	4.68	19.52
Downstate suburbs	2.58	–1.60	0.93	1.70	3.64	20.02
Yonkers	2.54	–1.53	0.97	1.77	6.54	34.54
Upstate big three	4.55	–2.68	1.74	3.19	29.74	77.42
Upstate rural	5.42	–3.21	2.01	3.68	22.15	44.83
Upstate small cities	5.37	–3.18	2.00	3.67	19.33	39.95
Upstate suburbs	4.29	–2.58	1.58	2.90	11.69	32.35
Statewide mean	4.34	–2.61	1.60	2.94	13.85	34.29
Median District	3.82	–2.32	1.41	2.58	7.93	28.05
Panel B: STAR Exemptions in 2011 Plus 30 Percent Income Tax Rebate						
Downstate small cities	4.39	–2.68	1.58	2.90	6.48	19.03
Downstate suburbs	3.47	–2.14	1.25	2.29	4.93	19.66
Yonkers	3.42	–2.05	1.30	2.38	8.92	34.18
Upstate big three	6.33	–3.69	2.41	4.43	46.73	82.12
Upstate rural	7.76	–4.51	2.84	5.24	32.79	43.31
Upstate small cities	7.68	–4.45	2.82	5.21	29.86	39.41
Upstate suburbs	5.97	–3.54	2.19	4.02	17.49	32.17
Statewide mean	6.10	–3.60	2.23	4.11	20.57	33.64
Median District	5.23	–3.16	1.91	3.51	11.09	27.43

Notes: E = expenditure per pupil; e = efficiency index; C = best practices spending; S = student performance index; t = effective property tax rate; Offset = share of original tax break (*tX*) offset by property tax rate increase.
Source: Authors calculations based on estimation results.

make two assumptions not used for table 8, namely, equal flypaper effects in the cost/efficiency and demand equations and equal elasticities for the various components of tax price.[35]

As shown in panel A of table 8, we estimate that STAR resulted in a statewide average increase in spending of 4.34 percent. This spending effect ranged from 2.54 percent in Yonkers to 5.42 percent in upstate rural districts. In addition, STAR resulted in an across-district average decline of 2.61 percent in the efficiency with which our student performance index is delivered.

35. These simulations do not account for property tax capitalization, which has complex, but secondary, impacts on the results in table 8. With capitalization, for example, higher STAR exemptions lead to higher values for owner-occupied property, which lowers the STAR implicit matching rate and raises the tax share (since its numerator includes other types of property). These changes have offsetting effects. We hope to conduct formal simulations with capitalization in future research.

The average operating spending was \$17,666 in 2011 and there were about 1.63 million students in the state's public schools outside of New York City. The total efficiency loss, $17{,}666 \times 1.63$ million $\times$ 0.0316, comes to about \$750 million. As explained earlier, this efficiency loss may include waste in the traditional sense but we suspect that it mainly reflects the fact that the incentives in STAR lead voters to push for spending on objectives other than the ones in our index. In other words, STAR induced school districts in New York State to increase their annual spending on objectives other than boosting standard test scores and keeping students in high school by three quarters of a billion dollars. Although these other objectives are valued by voters, the state's expressed interest in these test scores and graduation rates as central elements of its accountability program implies this is an expensive unintended consequence of STAR. This efficiency cost could be higher or lower, of course, for another set of performance objectives.

Because the increase in E is greater than the decrease in e, the definition in equation 2 implies that STAR boosts best-practice spending, C. This result is also presented in table 8. Because of our estimated economies of quality scale (i.e., $\sigma < 1$), this increase in C leads to a more-than-proportional increase in S. In fact, the average across-district impact of STAR on S was 2.94 percent. Moreover, the increases in S were somewhat greater in some needier districts, such as the upstate big three (3.19 percent) or upstate rural districts (3.68 percent), than they were in the wealthy downstate suburbs (1.70 percent). Thus, one surprising unintended consequence of STAR is that it slightly moderated performance disparities across districts in the state. One important exception is Yonkers, which is a needy district but received a below-average boost in its performance from STAR.

An accompanying unintended consequence that works in the other direction appears in the last two columns of table 8. This column shows that STAR boosted property tax rates in all types of districts. The across-district average increase was 13.85 percent, and the increase ranged from only 3.64 percent in the downstate suburbs to 29.74 percent in the upstate big three. In other words, the moderation of performance disparities was accompanied by a disproportionate increase in the property tax rates in the neediest districts. This property tax increase actually offset a large share of the initial STAR tax savings in many districts.[36] This offset ranges from 77.42 percent in the upstate big three to 19.52 percent in downstate small cities. Moreover, these property tax increases apply to all property, including property that does not receive a STAR exemption. By raising the property tax rate on business property, STAR

36. The STAR tax savings is tX. The impact on a voter's tax payment from a change in t (=dt) with STAR in place is $(dt)(V - X)$. The entry in table 8 is $dt(V - X)/(tX)$.

contributes to the widespread perception that New York State in general and upstate New York in particular is not friendly to business.

Panel B of table 8 provides comparable simulations with a 30 percent boost in the STAR exemptions, as with the 2007–09 income tax rebate program. This increase leads to a 33 to 43 percent increase in the first four columns of this table. The statewide average impact of STAR on student performance, for example, rises from 2.94 to 4.11 percent (an increase of 40 percent). The impacts on upstate tax rates are somewhat larger than this, but in most cases the offset to the initial STAR savings actually goes down, even though the tax rate changes are larger, because the initial savings are 30 percent larger in this case.

These simulated impacts can be compared to the post–pre differences in table 2, which reflect both STAR and other factors. This comparison suggests that STAR helps to explain the increased student performance, district spending, and property tax rates over the 1999–2011 period. Between 1999 and 2006, for example, the average impact of STAR on performance, 2.94 percent, accounts for about 14 percent of the overall performance increase in the state, 21.1 percent. STAR explains even more, over one fifth, of the 20.9 percent increases in spending. The average across-district increase in property tax rates was 7.9 percent, which is somewhat more than half of the predicted average change in table 8. This result suggests that some other factors, such as the recession, partially offset STAR's unintended impact on property tax rates.

6. CONCLUSIONS AND POLICY IMPLICATIONS

A state education finance system consists of local property taxes, state-funded property tax exemptions, state aid to education, and sometimes other revenue sources. Each of these components alters both the incentives facing voters and school officials, and the distributions of educational outcomes and tax burdens. Proposed changes to any component of this system should be evaluated in terms of its impact on the system as a whole.

By all accounts, elected officials in New York State thought that STAR would simply provide homeowners with some relief from their school property taxes. These officials did not recognize that by significantly lowering voter's tax prices, STAR would also initiate behavioral changes by voters and school officials and thereby result in many unintended consequences, some of which offset the original intent of the program. To be specific, we find that STAR has led to substantial increases in property tax rates and has provided homeowners with far less property tax relief than advertised. In the median district, tax rate increases have offset 28 percent of the initial tax savings. We also find that STAR has had significant, unintended impacts on student performance, school district efficiency, and school spending. In the median district, STAR increased spending by 3.8 percent, decreased efficiency by 2.3 percent, and raised performance by 2.6 percent.

Although the distribution of STAR compensation from the state is profoundly inequitable, STAR has a small equalizing impact on student performance because the price subsidies in poor upstate cities are so large. We estimate, for example, that STAR resulted in a 3.7 percent increase in student performance in small upstate cities, compared with only 1.7 percent in downstate suburbs. This equalization comes at a price, of course, as it is accompanied by higher property tax rate increases in poor districts than in wealthy districts. In the upstate big three districts, for example, our estimates imply that STAR-induced property tax rate increases have offset three quarters of the initial property tax relief for homeowners and raised the effective property tax rate on business property by more than 25 percent. Moreover, STAR has led to a smaller decline in inter-district performance disparities than would have occurred if the STAR funds had been placed in the state aid program implemented in 2007 but effectively canceled after New York entered the recession two years later.[37]

A revised STAR program with a more equitable formula for exemption amounts, and hence with more equitable impacts on student performance, could be designed. One approach would be to eliminate the SPDF; another would be to set exemption amounts consistent with a cost-adjusted power-equalizing formula.

The design of STAR also encourages school districts to increase spending, both in ways that boost the measures of student performance that are included in the state's accountability program and in other ways that cannot be identified. These spending increases are not necessarily bad but they are unintended and are therefore not the products of thoughtful analysis or policy design.

The STAR price incentives that led to these effects could easily be eliminated by reimbursing a district based on a state-determined property tax rate, perhaps the statewide average, rather than the property tax rate selected by the district. This change would, in effect, convert STAR from an open-ended matching grant to a lump-sum grant. As noted earlier, New York recently took a step in this direction by limiting the growth in exemption benefits to 2 percent annually.

37. A description of the 2007 New York State aid formula, including its large cost adjustment for students from poor families, can be found at https://stateaid.nysed.gov/generalinfo/. The implicit matching rates in STAR are also less equalizing than the matching rates in a guaranteed-tax-base program, which is used in several states, particularly if a cost adjustment is included (see Duncombe and Yinger 1998b).

Finally, our analysis shows that property tax relief programs and state aid reforms can have complex impacts on school district behavior, even when they are not intended to do so. We urge state policy makers to recognize these effects and to design programs that—intentionally—lead to the types of behavior the policy makers are attempting to promote.

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