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MCGUIRE, MARTIN C

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A METHOD FOR ESTIMATING THE EFFECT OF A SUBSIDY ON THE RECEIVER'S RESOURCE CONSTRAINT: WITH AN APPLICATION TO U.S. LOCAL GOVERNMENTS 1964–1971

Martin McGUIRE*

University of Maryland, College Park, MD 20742, U.S.A.

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Most studies of the effects of subsidies or recipient behavior accept the nominal legal provisions of a grant as defining the actual effective resource constraint faced by the receiver. This paper argues that to the contrary the true effect of a subsidy on the receiver's resource constraint can not be read from nominal administrative requirements. Therefore, an indirect statistical method is required to discover the shape of the post subsidy budget line. This paper develops such a method, which is then applied to U.S. local government expenditure decisions on education for the period 1964–71.

1. Introduction

When one government desires to influence the budget allocation decisions of another government, of a citizen, or within a federal system of a subsidiary government, one common tool, of increasing popularity, is a subsidy. Examples range from foreign aid, to food stamps or rent subsidies, to our multiplying federal grant-in-aid programs. For the case of intergovernmental grants especially, an extensive literature has studied the fiscal effects of grant subsidy programs.¹ Usually such grant or subsidy payments are nominally conditional on certain cooperative behavior on the part of the receiver, such as spending the subsidy only for certain purposes and/or matching the subsidy with own funds. A feature common to all the literature on grants is an acceptance of the nominal legal provisions of a grant as defining the actual and effective resource constraint faced by the grant receiver. Thus, several sophisticated studies of local government response to federal grants assume that a grant nominally described as open-ended and matching in fact alters the budget constraint of a local community from $\mathcal{D}\mathcal{D}$ to $\mathcal{D}A$ (in fig. 1) [e.g. Feldstein (1975) or O'Brien (1971)] while an unconditional bloc grant

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¹See Gramlich (1976) for a timely summary of the state of art.

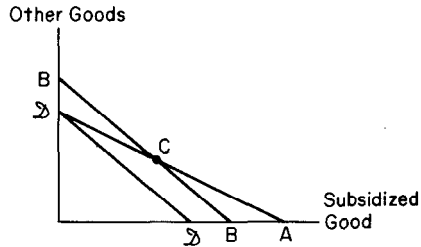


Fig. 1

results in BB and a nominal closed-end matching grant results in the kinked DCB .²

The thesis of this paper is that for various reasons this crucial assumption in the literature is probably false, that the true resource constraint facing subsidy receivers can not be read from nominal administrative or legal requirements, and that instead an indirect statistical method is required to uncover the shape of the post-subsidy budget line. This paper develops a method for estimating the effective post-subsidy resource constraint, the innovation in the analysis being that unlike conventional demand studies we will not make use of independent information on the price and income components of subsidies since none is available. The method is then tested against U.S. local government expenditure decisions on education for the period 1964–71. The method, however, is applicable to numerous other foreign or domestic subsidy programs.

2. Nominal vs. effective grant provisions

It is assumed for our purposes, that the consumer model of utility maximization can properly be applied to explaining a grant receiver's response to a grant. In the instance of intergovernmental grants this entails assumptions that bureaucracies act in some coordinated consistent fashion, that marginal choices in the allocation of resources are common, and that price changes and income changes are perceived differently in the resource allocation process. The consumer model has been widely criticized and alternative theories suggested [e.g. McGuire and Garn (1969) or McGuire (1973)]. The innovation in this paper, however, is a method for inferring the

²Our nomenclature corresponds to Gramlich's case A (budget supplementing), B (closed-end matching), and C (open-end matching) grants. A defect of earlier studies in this area was to lump all grants together regardless of even their nominal differences. In as sophisticated a study as Ehrenberg (1973, pp. 369–72), all grants are aggregated regardless of character. This defect was corrected by Gramlich and Galper (1973) but their work also accepts the nominal provisions of grants at face value.

operational resource constraint in a resource allocation process which proceeds *as if* based on constrained preference maximization. Therefore, we shall retain the classical model.

When governments set up large and complicated subsidy programs to influence allocative decisions of individuals or of other governments, acceptance of the face value provisions of the subsidy program as reflecting true constraints is suspect. In the first place even nominal constraints introduced by a grant or subsidy may be practically impossible to observe. Government programs are typically complicated; nominal grant constraints may vary widely with the characteristics of the recipients; and program administrators may have wide latitude as to contingencies and constraints to impose. Moreover, as programs grow so do the bureaucracies both of givers and receivers. Increasingly therefore the nominal constraints placed on grants are the outcome of evolving bargains struck between giver and receiver in a legislative-executive cycle. At times the grantor with appropriated money to obligate in a short time will be largely at the 'mercy' of receiving officialdom (since showing sizeable unobligated funds at fiscal year end will surely cause humiliation and harassment for the giver). At other times the roles may be reversed. There may even be a systematic trend in the transfer of bargaining power from giver to receiver as programs age. For all these reasons it strikes me as fruitless to comb through administrative regulations to discover the effective change in resource constraint imposed by a grant.

In the second place, even if it were possible to discover the nominal conditions of a grant, there are strong arguments for expecting the effective conditions to differ. This point having been argued elsewhere [McGuire (1975)] only requires summary. Essentially there are a variety of steps a recipient, especially if it is a local government, can take to transform a conditional or categorical grant into fungible resources. The subsidized good may be resold or traded to some one else. Alternatively an equivalent non-subsidized good may be exchanged in the market for fungible resources. Trades through time may be made among local agencies with capital expenditures. And by judicious redefinitions of expenditure categories or allocations of overhead costs, local officials may in part convert a contingent grant into a pure budget supplement. Accordingly some method to infer the degree of such circumvention of nominal grant restrictions must be constructed to interpret the recipients response to the grant.³

3. A model for estimating price and income components of grants

Figures 2a and 2b capture the essential idea of a model in which the

³A closed-end categorical, 'case C' grant if effective may often result in a corner solution at the kink in curve RC of figure 1. In this case we wish to infer the price-income mix which would generate a choice of that point.

U^1 or $R_T^2-U^2$ (etc.) caused point 'X' to be chosen. We can however estimate statistically which combination best explains the choice of 'X'. To do this we first assume that some unknown portion of the grant is a pure unrestricted resource supplement, while the remainder is devoted to changing the price of Q_a faced by the local decision unit. That is, we postulate that G_1 —a part of the total grant—is effectively a revenue sharing supplement. G_1 therefore (and not G) is an addition to local fungible resources, $R_T = R_L + G_1$. Total fungible resources available to the local decision unit then become

$$R_T = Y + L_a + G_1. \quad (1)$$

In selecting point 'X' the local community actually chose to expend $(L_a + G_1)$ of its total fungible resources on Q_a , paying an effective price of

$$p = \frac{L_a + G_1}{L_a + G} = 1 + \frac{G_1 - G}{L_a + G}, \quad (2)$$

(as fig. 2b shows, p is equal to the slope of the post-grant budget line). The variable p therefore represents the post-subsidy price of the aided category—local expenditures on Q_a as a percent of total cost of Q_a . Thus we have broken the total grant in aid down into two component parts, G_1 an income changing component and $(G_1 - G)$ a price changing component. We should stress the distinction between what a local community expends on Q_a , and what Q_a costs. Local decision makers choose to expend fungible resources, made up of local resources and the fungible component of grants. While communities spend $L_a + G_1$ of their fungible resources on the aided function, the quantity they receive cost $L_a + G$.

Although this formulation allows one to separate price from income effects of grants in theory, the problem remains that neither component is directly observable. In fig. 2a, G_1 might have equalled G in which case R_T^1 is the appropriate resource constraint; or G_1 might have been zero with R_T^2 the corresponding constraint; or G_1 might have been between zero and G , for instance G_1^3 giving R_T^3 . To estimate R_T some relation of G_1 to G or other variables in the system must be hypothesized. Various conjectures as to the relation between G_1 and G might be entertained. In this paper we make the very simple assumption that G_1 is some constant proportion ϕ of G over all observations,⁴ i.e.

$$G_1 = \phi G. \quad (3)$$

⁴Alternative hypothesis might include (1) taking G_1 to be a constant, (2) taking ϕ to be some function of G on grounds that a big grant may be more or less easily converted to fungible money, or (3) taking ϕ to be a function of Y on grounds that a grant of given size is less visible in the accounts of a rich than a poor recipient. Given the diversity of state-local governments a next logical step in this model would be to incorporate variable ϕ .

Assuming linearity of the unknown budget line through X, it lies between R_T^1 and R_T^2 (the former being at 45°). The parameter ϕ then measures the proportionate distance the true R_T is between these extremes. We can therefore write the budget constraint as

$$R_T = Y + pQ_A = R_L + \phi G. \quad (4)$$

Figure 2b illustrates this model for the true resource constraint (not actually known since ϕ is unknown).

The assumption that ϕ is a constant across decision units is of course open to challenge. Future research may validate other more subtle hypotheses. Any hypothesis about ϕ , however, will imply a particular bureaucratic process, of interaction between grantor and grantee bureaucracies. In the interests of clarity the specific bureaucratic process implied by our constant- ϕ assumption should be described explicitly. The simple case of constant ϕ , implicitly characterizes bureaucratic behavior as follows:

- (1) The total amount of a grant to the receiver is given, determined exogenously by legislative fiat.
- (2) The receiver has flexibility to divert a portion, ϕ , of the subsidy to fungible resources (we might interpret this to mean that federal enforcement allows a constant proportion of grants to 'leak' into the revenue sharing category).
- (3) The administrative bureaucracy of the grantor attempts to 'maximize' local provision of Q_a with the remaining $(1-\phi)$ of the grant. To accomplish this the grantor offers to pay $M\%$ of expenditures on Q_a , and M is set so that when the local government chooses some Q_a^* , it turns out that $M \cdot Q_a^* = (1-\phi)G^*$.⁵

Roughly speaking we envisage the local bureaucracy as trying to convert conditional grants into unconditional funds and the federal bureaucracy as trying to stimulate local supply of Q_a to the maximum, but without resort to infra-marginal price discrimination. *Under this scenario both G and p are variables of choice for the grantor-authorities.* I have chosen this approximation to a very complex process of legislative-executive bargaining for several reasons: first because the idea that federal agencies do in fact, and indeed should use grants to roughly maximize local provision has been advanced by critics such as Schultze (1969); second because among many possible uses of price to influence local behavior simple discriminatory pricing is the simplest and has been extensively analyzed in theory; third because in some grant programs such partial price discrimination has been implemented and reported in the literature [McGuire and Garn (1969b)];

⁵Normative formulas for maximizing local participation are developed in McGuire (1973).

fourth for the case to be tested, evidence by O'Brien (1971) indicates the assumptions that grants are predetermined to be realistic;⁶ and last, for heuristic purposes the more complex formulations should be taken up later.

To summarize the model so far, both the local grant inclusive resource constraint of

$$R_T = Y + L_a + \phi G, \quad (5)$$

and the local price for the aided function of

$$p = \frac{L_a + \phi G}{L_a + G} = 1 + \frac{(\phi - 1)G}{L_a + G} \equiv 1 + (\phi - 1)M_a, \quad (6)$$

depend on observed data plus an unknown parameter. As we shall now demonstrate this hypothesis can be subjected to econometric test and the parameter ϕ can be estimated.

When data on prices, quantities, and budgets are all available, the analyst ordinarily has wide latitude as to alternative functional forms of the utility function. In our problem, however, prices and budgets are not given as data. The parameter ϕ , which determines the division of a grant between price and income components, is unknown. Consequently, it turns out that only certain functional forms permit linear estimation techniques to identify the key parameters of interest. More specifically local *expenditures* must be taken to depend on a *polynomial in budget and price*. For example the linear expenditure function is identifiable whereas theoretically more desirable logarithmic or exponential forms with constant price elasticities are not. Thus one utility function which will allow us to separate out and estimate the price and income changing components of a grant is the Stone-Geary form.⁸

To demonstrate how ϕ , and other parameters of interest can be estimated we assume that local communities maximize:

$$U = (Y - \gamma_y)^{\beta_y} (Q_a - \gamma_a)^{\beta_a} (Q_n - \gamma_n)^{\beta_n}, \quad (7)$$

subject to

$$R_T = Y + p_a Q_a + p_n Q_n = R_L + \phi_a G_a + \phi_n G_n, \quad (8)$$

⁶Note that this formulation assumes away simultaneity of grants and receiver expenditures, and is therefore consistent with the single equation estimation procedures reported later.

⁷We define $M_a \equiv G/(L_a + G)$.

⁸Other utility functions such as a quadratic will also generate expenditure equations which are polynomials in budget and price. The Stone-Geary system was chosen for its simplicity and for its ability to accommodate the local need variables in a clear cut systematic fashion.

(here for later use the previous two-sector model is expanded to include a third category of expenditure on good, Q_n —another publicly supplied good—with local outlays $L_n = p_n Q_n$). Tests of a model such as this are likely to involve data from diverse recipients at various dates. Therefore various social, demographic, or locational variables, S_i^j are introduced as indicators of local need for the purpose of washing out underlying differences in preferences. The γ variables then become indices

$$\gamma_i = \gamma_i^0 + \sum_{j=1}^k (\gamma_i^j S_i^j), \quad i = y, a, n, \quad (9)$$

representing minimum subsistence consumption and giving the origin of the utility function. Note once again that the grant-inclusive resource constraint consists of all local resources R_L plus only the fungible portion of grants, i.e. ϕG . The remaining proportion of a grant $(1 - \phi)$, does *not* augment the recipients money income, instead it changes the price of the subsidized category. Maximization of this utility function yields expenditure equations:

$$\begin{aligned} \text{Expenditure on } Q_a = p_a Q_a = L_a + \phi_a G_a = -\beta_a \gamma_y + \beta_a R_T \\ + (1 - \beta_a) \gamma_a p_a - \beta_a \gamma_n p_n, \end{aligned} \quad (10)$$

$$\begin{aligned} \text{Expenditure on } Q_n = p_n Q_n = L_n + \phi_n G_n = -\beta_n \gamma_y + \beta_n R_T \\ - \beta_n \gamma_a p_a + (1 - \beta_n) \gamma_n p_n, \end{aligned} \quad (11)$$

where the price of the private good, Y , is assumed to be one. Substituting for R_T from eq. (8) for p_a and p_n from (6) and rearranging terms gives:

$$\begin{aligned} L_a = +\beta_a R_L + \beta_a \pi \phi_n G_n + (\beta_a \pi - 1) \phi_a G_a \\ + (1 - \beta_a) \left[1 + (\phi_a - 1) \cdot \frac{G_a}{L_a + G_a} \right] (\gamma_a^0 + \sum \gamma_a^j S^j) \\ - \beta_a \left[1 + (\phi_n - 1) \frac{G_n}{L_n + G_n} \right] (\gamma_n^0 + \sum \gamma_n^j S^j) \\ - \beta_a (\gamma_y^0 + \sum \gamma_y^j S^j), \end{aligned} \quad (12)$$

and

$$\begin{aligned}
 L_n = & + \beta_n R_L + (\beta_n \pi - 1) \phi_n G_n + \beta_n \pi \phi_a G_a \\
 & - \beta_n \left[1 + (\phi_a - 1) \frac{G_a}{L_a + G_a} \right] (\gamma_a^0 + \sum \gamma_a^j S^j) \\
 & + (1 - \beta_n) \left[1 + (\phi_n - 1) \frac{G_n}{L + G} \right] (\gamma_n^0 + \sum \gamma_n^j S^j) \\
 & - \beta_n (\gamma_y^0 + \sum \gamma_y^j S^j). \tag{13}
 \end{aligned}$$

In eqs. (12)–(13) we have included an extra parameter, π , to allow for the possibility that the receiver of an unconditional grant, especially if it is a public authority, may retain more for public purposes than it would tax away if the same increment to resources came from internal growth in R_L . Numerous studies suggest that this is the case [see Gramlich (1976, p. 23) for a summary]; thus eqs. (12)–(13) assume that a \$1 increase in internal resources causes purchases of Q_a and Q_n to increase by $(\beta_a + \beta_n)$, while \$1 in unconditional grants causes such expenditures to increase by $\pi(\beta_a + \beta_n)$. One should expect some tax relief effect from unconditional grants even if only slight, so $\pi(\beta_a + \beta_n)$ should be less than unity. Figure 3 portrays the local public sector of the two equation system (12)–(13) and illustrates the idea of a differential between the retention of fungible grants in the public sector,

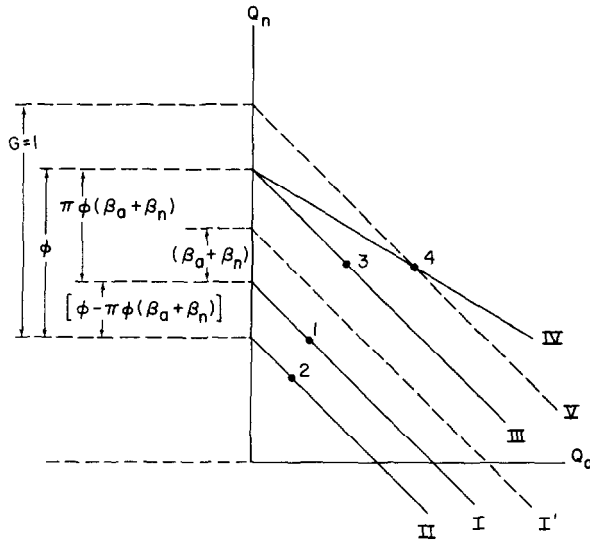


Fig. 3

and the diversion of private income into the public sector through local taxation. Line I shows an assumed public budget in the absence of grants, and I' the assumed increase in public expenditures in the amount $(\beta_a + \beta_n)$ caused by $\Delta R_L = 1$. Assume now that a conditional grant $G_a = 1$ (shown as the distance between II and V) is given to spur production of good Q_a , resulting in choice of point (4). The diagram shows that ϕ (distance between II and III) of this grant is converted into fungible resources, that $\pi(\beta_a + \beta_n)\phi$ (distance between I and III) is retained in the public sector—shown as substantially more than $(\beta_a + \beta_n)$; and $[\phi - \pi(\beta_a + \beta_n)\phi]$ is absorbed as tax relief (distance between I and II). Thus the effect of the grant can be analyzed into a tax relief effect shown as the movement from point (1) to (2); then an income effect from funds retained for public use shown as a movement from point (2) to (3); and finally a price effect shown as the movement from (3) to (4).

4. Empirical estimates of the structure of federal-local allocations to education

This section of the paper reports on empirical estimates of several versions of the foregoing model. In essence, we ask: 'Assuming the observed pattern of local government expenditures to result from a free, utility maximizing choice by local officials, what combination of budget constraint and preference pattern (adjusted for differences in need) best explains the observations?'

In framing this question and estimating an answer to it, we are constructing one research tool for application in comprehensive systems analyses of complex government allocation processes. The primary purpose of this empirical section therefore remains largely methodological, although the specific parameters developed in this study have important policy implications. The regression models to be estimated are as follows:

Model I: Examines the hypothesis that all grants have only an income effect on local allocation decisions, by assuming a priori that grants in aid are in effect unconditional budget supplements. In eqs. (12)–(13) both ϕ_a and ϕ_n are assumed to equal 1.

Model II: Examines the hypothesis that education grants G_a cause both price and incomes changes for good Q_a , while other grants G_n have only an income effect. In eqs. (12)–(13) $\phi_n = 1$.

Model III: Same as II except that both types of grants are assumed to affect prices.

4.1. The data

In view of the diversity of governmental decision units at the state-local

level and the variety of programs involved, we have necessarily been driven to compromise in the selection of data for testing the above models. The particular compromises we made were governed by three considerations: the data selected reflect a desire for comparability of our results with previous estimates; data were selected and aggregated to fit our two level (federal-local) model; data was also aggregated so that one aided function would be as homogenous as possible. Q_a is defined as 'primary and secondary education', while all other locally provided public goods and services are aggregated under Q_n . For comparability with previous studies, we have aggregated all state-local expenditures within a state as if they emanated from a single decision unit. Lastly, since we are using a two-level model to approximate a multi-level (state-county-district-municipality, etc.) allocation process, in place of federal grants we have used state 'intergovernmental expenditures'.⁹ State by state per capita cross section data on this aggregated basis were collected for fiscal 1964-71 for the 48 states, giving 336 observations. The data sources and definitions are summarized in the following table.

Definition of expenditure categories¹⁰

R_L = per capita personal income.

G_a = per capita 'intergovernmental expenditures' for education.

G_n = per capita 'intergovernmental expenditures for all categories except education.

L_a = State-local expenditures from own resources, on education.

L_n = State-local expenditures from own resources on all other functions except education.

Preference normalizing or need variables S_i = % population which was urbanized in 1960; population; population density; student population.

So as to convert to constant 1964 dollars, per capita income was deflated by the implicit price deflators of private sector GNP relative to 1964, and all governmental expenditures were deflated by the implicit price deflator of

⁹The spending being explained is that of state-local aggregates, while grants include both federal and state aid. Admittedly, in principle local governments may realize that in the aggregate the burden of funding state aid falls on the same citizens. Still this seems to be a reasonable practical compromise since for education disbursement is made overwhelmingly by the local level, and since the bulk of federal grants to states are passed on directly to local jurisdictions.

¹⁰ $(G+L)$ were obtained from per capita state-local 'General expenditure' figures in *Governmental Finances*, Bureau of the Census, 1964-71.

G was taken from *State Government Finances*, Bureau of the Census, 1965-72.

L was then calculated: $L = (G + L) - G$.

R_L was taken from *State Government Finances*, op. cit.

The social demographic variables were obtained from *The Statistical Abstract of the United States*, U.S. Commerce Department, except for student population from *Digest of Educational Statistics 1965-72*, U.S. Department of HEW.

governmental GNP relative to 1964.¹¹ The choice of variables as socio-economic indicators for normalizing preferences among states was governed by previous studies. These variables have been used repeatedly to 'explain' state-local expenditures and therefore have a degree of historical status.¹²

4.2. Model I: Tests of the hypothesis that education grants have income effects only

If grants were in effect solely revenue sharing instruments and therefore induced no price changes, one should expect a \$1 increase in grants to call forth π times the increment in local expenditure on aided functions that a \$1 increase in local resources would generate. This is equivalent to an assumption that $\phi_a = \phi_n = 1$ in the price-income eqs. (12)–(13). Substitution of $\phi = 1$ simplifies that model to:

$$L_a = \beta_a R_L + \beta_a \pi G_n + (\beta_a \pi - 1) G_a + \text{constant}, \quad (14)$$

$$L_n = \beta_n R_L + (\beta_n \pi - 1) G_n + \beta_n \pi G_a + \text{constant}. \quad (15)$$

Table 1 shows OLS regression results for this simple model.¹³ These regressions show that one dollar in grants is far more stimulative of local expenditures on the aided category than is a one dollar increase in local budget. Moreover, a dollar's grant for education causes total local expenditures from total resources to increase by \$1.22, $(1 + 0.66 - 0.44)$ implying

Table 1^a

Explanatory variables		Dependent variable: Local expenditures	
		on education L_a (I.1)	on non-education L_n (I.2)
Constant		30(3.0)	47(2.8)
Local resources	R_L	0.048(10.5)	0.074(9.6)
Education grants	G_a	-0.441(6.0)	0.662(5.3)
Non-education grants	G_n	0.278(4.0)	-0.455(3.9)
(Social-demographic need variables)			
Students per capita	S_1	0.002(0.14)	0.011(0.51)
Population density	S_2	-0.07(8.3)	-0.01(0.6)
% urban	S_3	-0.12(0.78)	-0.68(2.7)
R^2		0.43	0.32

^at-statistics shown in parentheses.

¹¹*Economic Report of the President* (1975, p. 253).

¹²The historical benchmark is: Solomon Fabricant, 1952, *The Trend of Government Activity in the United States Since 1900* (NBER).

¹³The regression for L_a corresponds very closely with O'Brien's (1971, p. 73) based on 48 states 1958–66.

either private consumption is inferior (which seems unlikely) or some other mechanism causes grants to have a strong impact on local public expenditures. These results suggest that a simple income effect (even combined with high retention of grants in the public sector) is not sufficient to explain the strong impact which education grants have on local expenditures.¹⁴ One obvious alternative hypothesis is that grants encourage substitution among functions at the local level by altering effective prices. We shall explore this possibility presently. Before doing so two other explanations should be mentioned. One is suggested by the fact that the estimates of $[(\beta_a + \beta_n)\pi - 1]$ in model I are not very far from zero.¹⁵ Hence the observed data could be generated not by any local choice at all, but rather by very specific highly policed federal grants. This is an unlikely explanation in view of the variety of options local authorities have for circumventing the categorical intent of federal grants and I believe the hypothesis should be rejected. There is a second possible explanation for the tax stimulative effect of education grants; maybe grants have only a pure income effect on the local resource constraint, but an independent federal grant allocation strategy, gives big grants to big spenders. This possibility deserves further exploration.

4.3. Model II: Incorporating price and income effects

Results from model I indicate that the impact of grants on local expenditures does not consist solely in the income-plus-grant-retention effects of those grants. Another plausible explanation for the highly 'stimulative' character of education grants is that they alter the effective *price* local decision makers face for the aided categories of expenditure. Accordingly, we will now test for price effects in education grants by setting $\phi_n = 1$ and estimating ϕ_a . Making this substitution in eqs. (12)–(13) gives:

$$L_a = \beta_a R_L + \beta_a \pi G_n + (\beta_a \pi - 1) \phi_a G_a \\ + (1 - \beta_a)[1 + (\phi_a - 1)M_a](\gamma_a) - \beta_a \gamma_n + \text{constant}, \quad (16)$$

$$L_n = \beta_n R_L + (\beta_n \pi - 1)G_n + \beta_n \pi \phi_a G_a \\ - \beta_n [1 + (\phi_a - 1)M_a] \gamma_a + (1 - \beta_n) \gamma_n + \text{constant}. \quad (17)$$

¹⁴This result lies in the middle of the range of Gramlich's tabulation (1976, p. 23) of local response to 'case-C' (i.e. closed-end matching) grants.

¹⁵The standard error of the sum of education grant coefficients ($0.662 - 0.441 = 0.221$) is 0.145, which suggests (at 93 percent confidence) that even Gramlich's 'fly-paper' theory of response to grants ('money sticks where it hits') is inadequate for explaining local behavior.

Table 2

Explanatory variables	Dependent variable: Local expenditure	
	on education L_a (II.1)	on non-education L_n (II.2)
Constant	-246(4.0)	-51.4(0.4)
Local resources	R_L 0.026(6.4)	0.069(7.6)
Education grants	G_a -0.494(8.5)	0.551(4.2)
Non-education grants	G_n 0.283(5.0)	-0.216(1.7)
Donor's % of education	M_a 684(4.3)	81.9(0.23)
(Social-demographic need variables)		
Students per capita	S_1 2.01(8.5)	1.80(3.4)
Population density	S_2 0.038(1.1)	0.327(4.3)
% urban	S_3 -1.41(2.7)	-6.50(5.6)
Need-price interaction	$\widehat{M}_a S_1$ -5.11(8.5)	-4.59(3.4)
terms	$\widehat{M}_a S_2$ -0.250(2.0)	1.07(3.8)
	$\widehat{M}_a S_3$ 5.02(3.0)	19.0(5.2)
R^2	0.70	0.39

ϕ_a is calculated from II.1 as $-0.494/(0.283-1)=0.69$; π is calculated as $0.283/0.026=10.9$.

ϕ_n is calculated from II.2 as $0.551/(1-0.216)=0.70$; $\pi=(1-0.216)/0.069=11.4$.

Instrumental variables added are teachers, students per teacher, per capita income per teacher, population, students.

Price elasticity of demand for Q_a is -0.15 and for Q_n is -0.90 as calculated from the first eight coefficients in II.1 and II.2.

The two-stage least-squares regression model II is shown in table 2. Regression coefficients are more reliable than in model I, thereby lending support to the idea of a price effect.¹⁶ Derived structural parameters for model II are also shown in the table. These structural parameters indicate that about 70 percent of aid to education has been equivalent to unconditional, bloc grants while the remaining 30 percent has altered the effective price of education. The differential impact of bloc grants versus matching grants, however, is not very great since price elasticity of demand for education is low.¹⁷ Table 2 also implies that the tax relief effects of bloc grants are probably very slight. Table 2 shows that a dollar increase in fungible aid to education would raise total expenditures from local resources by 7 cents $(-0.494+0.551)/(0.70)$. But the likelihood that this figure is a

¹⁶OLS would regress L against its inverse, in the matching ratio $M=G/(L+G)$. Instrumental variables added were, number of teachers, students per teacher, per capita income per teacher.

¹⁷In the limit with zero income compensated price elasticity, matching and bloc grants would have identical consequences so that matching grants become really concealed income supplements.

chance deviation from a true mean of zero is quite high, and the results can legitimately be interpreted as showing a zero tax relief effect.

Allocations to the public sector (Q_a and Q_n) in this model can be approximated for the average community-year in the sample as the outcome of maximizing:¹⁸

$$U = Y^{0.905}(Q_a - 152.7)^{0.026}(Q_n - 31.3)^{0.069}, \quad (18)$$

subject to:

$$R_T = Y + Q_n + p_a Q_a = R_L + [(\phi_a) \cdot (G_a) + G_n] \pi$$

or

$$3339 = Y + Q_n + 0.91 Q_a = 2628 + [(0.7)(52.8) + 26.5] 11.2.$$

Utility maximizing choices give

$$Q_a^* = 175.5, \quad Q_n^* = 250.5, \quad L_a^* = 122.7, \quad L_n^* = 224.1.$$

A counterintuitive result of this model is the zero tax relief estimate. Although the result is consistent with earlier work, as reported by Gramlich later studies estimate the tax relief of a dollar in bloc grants $-(1 - \pi(\beta_a + \beta_n))$ in our notation—to range between \$0.15 and \$0.50. One reason for introducing an unknown price change in model II was that the tax relief implications of a pure income effect model (i.e. model I) were unsatisfactory. Consequently we now extend the model to include price effects in the non-education sector.

4.4. Model III: Price effects of non-education grants included

'Non-education' is an aggregate of highly heterogenous functions; the purpose here is not to explain those allocation decisions so much as to observe the impact on education allocations. Thus we now wish to estimate both ϕ_a and ϕ_n from eqs. (12)–(13).

Table 3 shows the results of these estimates. The parameters $(\beta_a + \beta_n)\pi$ and ϕ are over determined. Alternative estimates are as follows:

¹⁸The price $p_a = 1 + (\phi - 1)G_a / (L_a + G_a) = 1 - (0.3)(52.8) / (52.8 + 122.7) = 0.91$. In eq. (18) the differential impact of grants on taxes is captured by inflating fungible grants $(G_n + \phi_a G_a)$ by π . Thus fungible grants are treated as more powerful money than local resources, and (18) does not summarize or approximate choices of private goods Y .

Assuming $\phi_a \neq \phi_n$	Assuming $\phi_a = \phi_n$
Regression III.1 & 2 $\phi_a = 0.51$; $\pi(\beta_a + \beta_n) = 0.18$	Regression III.1 $\phi = 0.64$; $\pi(\beta_a + \beta_n) = 0.98$
Regression III.1 & 2 $\phi_n = 0.76$; $\pi(\beta_a + \beta_n) = 0.82$	Regression III.2 $\phi = 0.36$; $\pi(\beta_a + \beta_n) = 0.26$

Table 3

Explanatory variables	Dependent variable: Local expenditure		
	on education L_a (III.1)	on non- education L_n (III.2)	on both $0.80 L_a + 0.20 L_n$ L_n (III.3)
Constant	-400(6.4)	-350(3.1)	-390(7.0)
Local resources R_L	0.021(5.4)	0.067(9.5)	0.030(8.7)
Education grants G_a	-0.491(7.9)	0.072(0.6)	-0.378(6.7)
Non-education grants G_n	0.150(2.4)	-0.287(2.5)	0.063(1.1)
Donor's % of ed. expend. \hat{M}_a	1355(8.6)	939(3.2)	1272(9.0)
Donor's % of non-ed. expend. \hat{M}_n	-1064(2.5)	384(0.5)	-774(2.0)
(Socio-demographic variables)			
Students per capita S_1	2.49(10.2)	2.44(5.5)	2.48(11.3)
Population S_4	-16.8(0.8)	45.8(1.1)	-4.30(0.22)
Student population S_5	0.057(0.6)	-0.273(1.5)	-0.009(0.1)
Need-price interaction terms			
$\hat{M}_a S_1$	-6.96(10.9)	-4.84(4.1)	-6.54(11.4)
$\hat{M}_a S_4$	16.7(0.3)	-106(1.1)	-7.85(0.16)
$\hat{M}_a S_5$	-0.120(0.5)	0.492(1.1)	0.002(0.01)
$\hat{M}_n S_1$	4.32(2.3)	-6.74(1.9)	2.11(1.2)
$\hat{M}_n S_4$	130(2.9)	-50.1(0.6)	94.1(2.4)
$\hat{M}_n S_5$	-0.354(1.8)	0.781(2.2)	-0.127(0.7)
R^2	0.77	0.68	0.79

From III.1 $\phi_a = \phi_n$ is calculated as $0.150 + 0.491 = 0.64$; π is calculated as $(0.150)/((0.021)(0.150 + 0.491)) = 11.3$.

From III.2 $\phi_a = \phi_n = 0.072 + 0.287 = 0.36$; $\pi = 0.072/((0.067)(0.072 + 0.287)) = 3.0$.

From III.1 and III.2 ϕ_a is calculated as $(0.072)(0.021)/(0.067) + 0.491 = 0.51$; with $\pi = 0.072/((0.51)(0.067)) = 2.1$.

ϕ_n is calculated as $(0.150)(0.067)/(0.021) + 0.287 = 0.76$; with $\pi = 0.150/((0.76)(0.021)) = 9.4$.

The structural and reduced form coefficients in III.3 are related as follows:

$$0.030 = 0.8\beta_a + 0.2\beta_n$$

$$-0.378 = [0.8\beta_a + 0.2\beta_n]\pi\phi - 0.2\phi$$

$$0.063 = [0.8\beta_a + 0.2\beta_n]\pi\phi - 0.8\phi$$

There $\phi_a = \phi_n$ is calculated as $(0.063 + 0.378)/(0.6) = 0.735$

with $\pi = ((0.80)(0.735) - 0.378)/((0.030)(0.735)) = 9.5$.

Price elasticity of demand for $Q_a = -0.02$ and for $Q_n = -0.27$ as calculated from the first 9 coefficients in III.1 and III.2.

Instrumental variables added are teachers, students per teacher, per capita income per teacher, population, students, population density, percent urbanization, per capita income per student.

The estimates $\phi_a=0.51$, $\pi(\beta_a+\beta_n)=0.18$, $\phi=0.36$, and $\pi(\beta_a+\beta_n)=0.26$ are suspect since they all depend on an estimated coefficient of low reliability (in regression III.2, the coefficient 0.072 has a t -statistic of 0.6), accordingly values of ϕ in the range 0.64 to 0.76, and values of tax relief effect between 2% (1.0–0.98) and 18% (1.0–0.82) seem the more credible.

Thus extending the decomposition of subsidies into price and income components to non-education grants gives a more successful account of the effects of education subsidies. It yields a more plausible account of tax relief effects, more in accord with other estimates; and the decomposition of grants into income and price components is much the same as in model II. Whereas the marginal propensity to tax internal resources is on the order of 9 percent ($0.021+0.067=8.8\%$), the propensity to 'tax' external gifts to the community is 82 to 98 percent. The estimate that about 70 percent of education grants are converted to fungible resources holds up as does the estimate of inelastic demand for education.

One computationally manageable and consistent (though inefficient) way to average these estimates is to take a weighted average of III.1 and III.2. Regression III.3 shows this result when the weights are in inverse proportion to the sum of squared residuals of III.1 and III.2. This procedure gives $\phi=0.74$ and $\pi(\beta_a+\beta_n)=0.85$.

Again in summary, allocations to the public sector in this model can be approximated as the outcome of the average local community maximizing:

$$U = Y^{0.912}(Q_a - 173)^{0.021}(Q_n - 196)^{0.067},$$

subject to:

$$R_T = Y + p_a Q_a + p_n Q_n = R_L + [\phi_a G_a + \phi_n G_n] \pi,$$

or

$$3185 = Y + 0.92Q_a + 0.97Q_n = 2628 + [(0.74)(52.8 + 26.5)] 9.5.$$

4.5. Trends in the fungible components of education grants

The parameter ϕ indicates the proportion of grants which one way or another have entered local budget constraints as fungible resources. A question of interest is whether grantors or grantees have increased their control over expenditure decisions over the course of time. To check for trends in this parameter eqs. (III.1) and (III.2) were run for three time periods between 1964–71.

The following results show quite clearly that control has shifted to the recipients.

	Sub-periods			All years
	1964-67	1966-69	1968-71	1964-71
ϕ_a : Regression III.1 & 2	0.45	0.47	0.59	0.51
$\phi_a = \phi_n$: Regression III.1	0.55	0.63	0.79	0.64

Whether eqs. (III.1) and (III.2) are combined or treated separately for calculating structural parameters, the percent of education grants converted into fungible resources has risen substantially over the period. Apparently, local bureaucracies over the course of time have become increasingly proficient at circumventing any conditions or restrictions on 'education' grants, progressively finding better ways to treat contingent grants as revenue supplements. By the time revenue sharing was introduced in 1972, the states and their local governments it would seem had transformed nominally contingent, conditional subsidy system into effective revenue sharing already.

5. Conclusions

We have shown in this paper how to break a grant down into price changing and income changing components and how to estimate each component from data on the receiver's expenditures. Whenever a question arises of the enforceability of subsidy condition as often it must, analysis along the lines of this paper should inform the donor of the efficacy of the conditions he imposes on the receiver.

For the case of local expenditures on education it would seem that restrictions placed by donors have been ineffective on two counts. First a large (and growing) fraction of education grants have been converted into fungible monies; second, rather inelastic demand reduces the leverage of the effective matching provision. This is not to say, however, that education grants have not altered the composition of local spending within the education category. To answer that question a finer disaggregation would be necessary.

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