The Flypaper Effect: Methods, Magnitudes, and Mechanisms

On-line Appendix

Part A: Further Results

Part B: Further Analysis

Table A1. Summary Statistics (1999-2011)

	Obs.	Mean	Std. Dev.	Min	Max	Source
Dependent Variables						
Performance index	8,016	75.8	11.6	29.2	98.2	1
Operating expenditures per pupil	8,016	15,766	4,003	9,164	74,269	1
STAR- and Rebate-Related Variables						
$\tilde{A}_{S0}$ (year = 1999)	607	0.040	0.027	0.0010	0.257	1, 2, 3
$\tilde{A}_{S1}$ (year = 2000)	618	0.038	0.025	0.0010	0.216	1, 2, 3
$\tilde{A}_{S2}$ (year = 2001)	613	0.035	0.022	0.0013	0.199	1, 2, 3
$\tilde{A}_{S3}$ (year = 2002)	614	0.031	0.018	0.0012	0.157	1, 2, 3
$\tilde{A}_{S4}$ (year = 2003-07 and 2011)	3,718	0.029	0.019	0.0009	0.213	1, 2, 3
$\tilde{A}_{S5}$ (year = 2008-09)	1,247	0.030	0.019	0.0011	0.185	1, 2, 3
$\tilde{A}_{S6}$ (year = 2010)	599	0.029	0.019	0.0011	0.177	1, 2, 3
$\tilde{A}_{F0}$ (year = 1999)	607	0.002	0.002	0.000	0.025	1, 2, 3
$\tilde{A}_{F1}$ (year = 2000)	618	0.003	0.003	0.000	0.049	1, 2, 3
$\tilde{A}_{F2}$ (year = 2001)	613	0.002	0.002	0.000	0.033	1, 2, 3
$\tilde{A}_{F3}$ (year = 2002)	614	0.002	0.003	0.000	0.046	1, 2, 3
$\tilde{A}_{F4}$ (year = 2003-07 and 2011)	3,718	0.003	0.003	0.000	0.045	1, 2, 3
$\tilde{A}_{F5}$ (year = 2008-09)	1,247	0.002	0.002	0.000	0.033	1, 2, 3
$\tilde{A}_{F6}$ (year = 2010)	599	0.005	0.003	0.001	0.034	1, 2, 3
$\tilde{T}_1$ (year = 2000)	618	0.891	0.042	0.751	0.984	1, 2, 3
$\tilde{T}_2$ (year = 2001)	613	0.793	0.082	0.514	0.968	1, 2, 3
$\tilde{T}_3$ (year = 2002)	614	0.698	0.121	0.287	0.949	1, 2, 3
$\tilde{T}_4$ (year = 2003-07 and 2011)	3,718	0.731	0.110	0.303	0.946	1, 2, 3
$\tilde{T}_5$ (year = 2008-09)	1,247	0.751	0.104	0.373	0.939	1, 2, 3
$\tilde{T}_6$ (year = 2010)	599	0.761	0.096	0.430	0.937	1, 2, 3
Tax share	8,016	0.399	0.149	0.022	1.053	1, 2, 3
Other Demand/Efficiency-Related Variables						
Median homeowner income	8,016	67,059	27,458	28,188	250,000	2, 3
Percent of owner-occupied housing units	8,016	76.2	10.9	31.2	97.5	2, 3
Percent of seniors (aged 65 and over)	8,016	14.8	3.3	3.1	38.9	2, 3
Percent of college graduates	8,016	25.7	14.1	4.9	83.4	2, 3
Percent of youths (aged 5-17)	8,016	17.4	2.5	6.2	30.7	2, 3
Cost-Related Variables for Expenditure Estimations						
Teacher salary (1-5 year experience)	8,016	18,417	8,415	143	60,290	1
Enrollment (average daily membership)	8,016	2,756	3,441	66	46,550	1
Percent of high cost students (with disabilities)	8,016	1.4	0.8	0	7.5	1
Percent of LEP students	8,016	1.7	3.4	0	33.2	1
Percent of free lunch students	8,016	23.3	15.5	0	90.8	1
Selected Instrumental Variables (IVs)						
$\tilde{T}_1^{IV}$ (year = 2000)	618	0.898	0.038	0.773	0.985	1, 2, 3
$\tilde{A}_{S2}^{IV}$ (year = 2000)	618	0.037	0.025	0.001	0.224	1, 2, 3
$\tilde{A}_{F2}^{IV}$ (year = 2000)	618	0.003	0.003	0.000	0.045	1, 2, 3
Mean % of high cost students in rest of county	8,016	1.2	0.4	0	10.6	1

Mean % of LEP students in rest of county	8,016	1.6	1.8	0	6.0	1
Annual county mean manufacturing salary	8,016	49,549	15,057	21,882	103,054	4

Notes: $\tilde{T}$ indicates $\{1-X/V\}$ and $\tilde{A}_S$ represents $\left[\left(V/\overline{V}\right)\left(A_S/Y\right)\left(1-X/V\right)\right]$, where A_S is state aid per pupil. The formula for $\tilde{A}_F$ is the same as $\tilde{A}_S$, except that federal aid per pupil (A_F) substitutes for state aid (A_S). To construct each instrumental variable ($\tilde{T}^{IV}$, $\tilde{A}_S^{IV}$, or $\tilde{A}_F^{IV}$) for the corresponding endogenous variable ($\tilde{T}$, $\tilde{A}_S$, or $\tilde{A}_F$), V (and $\overline{V}$) in the endogenous variable is replaced with the product of V (and $\overline{V}$) in 1999 and the ratio of the Case-Shiller New York home price index (the CS index) for the year indicated in parentheses to the CS index in 1999. The number of observations for $\tilde{T}$, $\tilde{A}_S$, $\tilde{A}_F$, $\tilde{A}_S^{IV}$, and $\tilde{A}_F^{IV}$ are for the years indicated in parentheses, not for the entire sample period as other variables.

Sources: (1) New York State Education Department; (2) Mid-year values of 5-year American Community Survey (ACS) estimates, i.e., 2009-2013 for 2011 (The ACS data are available for 2007-2011.); (3) U.S. Census 1999 (The annual values for 2000 and 2006 were interpolated using the linear growth rate between 1999 and 2007.); and (4) U.S. Census, County Business Patterns.

Table A2. Results Using Income Net of Income Tax

Key Variable [*Coefficient*]	Partial weighting	Full weighting without IV	Fully-weighted expenditure-based	Fully- weighted performance-based
	(1)	(2)	(3)	(4)
$\ln(Y_n)$ [θ]	0.18***	0.18***	0.20***	0.39***
	(4.62)	(4.42)	(4.58)	(7.10)
$(A_S/Y)(V/\bar{V})$ [ϕ_S]	1.97***			
	(10.69)			
$(A_F/Y)(V/\bar{V})$ [ϕ_F]	3.69***			
	(5.01)			
$(A_S/Y)(V/\bar{V})(1\text{-}X/V)$ [ϕ_S]		2.24***	**2.67*****	**6.16*****
		(8.34)	(8.52)	(8.93)
$(A_F/Y)(V/\bar{V})(1\text{-}X/V)$ [ϕ_F]		5.92***	**5.89*****	**14.7*****
		(5.96)	(4.28)	(7.74)
$\ln(1\text{-}X/V)$ [μ]		-0.14***	**-0.27*****	**-0.69*****
		(-3.65)	(-7.20)	(-9.74)
$\ln(V/\bar{V})$ [μ]	-0.14***	-0.13***	-0.15***	-0.29***
	(-7.46)	(-6.78)	(-7.01)	(-9.97)
State aid flypaper effect	9.92***	11.8***	12.4***	15.0***
Federal aid flypaper effect	19.4***	32.7***	28.7***	37.0***

Notes: There are 8,016 observations. All controls are the same as those in Table 2. The dependent variable for columns 1 to 3 is logged operating expenditures per pupil. The dependent variable for column 4 is the log of school quality measure, *S*. Coefficients in bold are treated as endogenous. The flypaper effects are calculated by $\left(\left(\frac{\phi}{\theta}\right) - 1\right)$. z-statistics are in parentheses. *** = p<0.01

Table A3. Impact of Misspecification on the Flypaper Effect Using Income Per Pupil

(Y_n = income per pupil)

Key Variable	Linear	Multiplicative	Nonlinear	Nonlinear with tax share
	(1)	(2)	(3)	(4)
θY	0.020			
	(1.43)			
ϕA_S	0.33***			
	(6.78)			
ϕA_F	0.83***			
	(3.02)			
$\theta ln(Y)$		0.072**		
		(2.09)		
$\phi ln(A_S)$		0.14***		
		(10.12)		
$\phi ln(A_F)$		0.032***		
		(5.74)		
$\theta ln(Y_n)$			0.17***	0.16***
			(4.25)	(4.11)
$\phi(A_S/Y)$			0.55***	0.55***
			(4.94)	(5.15)
$\phi(A_F/Y)$			1.15**	1.18***
			(2.51)	(2.72)
$ln(V/\bar{V})$				-0.036**
				(-2.17)
Flypaper effect formula	$\left(\frac{\phi}{\theta}\right)-1$	$\left(\frac{\phi}{\bar{\bar{A}}}-\frac{\theta}{\bar{\bar{Y}}}\right)/\left(\frac{\theta}{\bar{\bar{Y}}}\right)$	$\left(\frac{\phi}{\theta}\right)-1$	$\left(\frac{\phi}{\theta}\right)-1$
State aid (A_S) flypaper effect magnitude	15.7	38.9**	2.3***	2.5***
Federal aid (A_F) flypaper effect magnitude	40.6	65.0**	5.9**	6.5**

Notes: There are 8,016 observations between FY1999 and FY2011. $Y = Y_n(n/h^*)$, where n = number of pupils, $h^* = n(Y_n)$/(median homeowner income). The dependent variable is logged operating expenditures per pupil. All models are estimated with all cost factors (with teacher salary treated as endogenous), demand factors (percent of college educated population and youths), year and district fixed effects, and ln(n/h^*) (only for columns 3 and 4). *z*-statistics are in parentheses.

* = p<0.10, ** = p<0.05, *** = p<0.01

Table A4. Impact of Weighting on the Flypaper Effect Using Income Per Pupil

(Y_n = income per pupil)

Key Variable	Partial weighting	Full weighting without IV	Fully-weighted expenditure-based	Fully- weighted performance-based
	(1)	(2)	(3)	(4)
$\theta ln(Y_n)$	0.19***	0.19***	0.21***	0.33***
	(5.60)	(5.30)	(5.76)	(7.08)
$\phi(A_S/Y)(V/\bar{V})$	2.16***			
	(10.14)			
$\phi(A_F/Y)(V/\bar{V})$	3.99***			
	(4.78)			
$\phi(A_S/Y)(V/\bar{V})(1-X/V)$		2.63***	**2.85***	**4.43***
		(8.34)	**(7.80)**	**(8.54)**
$\phi(A_F/Y)(V/\bar{V})(1-X/V)$		6.55***	**6.09***	**10.1***
		(5.70)	**(3.87)**	**(6.76)**
$ln(1-X/V)$		-0.16***	**-0.28***	**-0.47***
		(-3.89)	**(-7.19)**	**(-10.12)**
$ln(V/\bar{V})$	-0.12***	-0.12***	-0.12***	-0.18***
	(-7.35)	(-6.89)	(-6.29)	(-8.35)
State aid (A_S) flypaper effect	10.4***	12.9***	12.3***	12.3***
Federal aid (A_F) flypaper effect	20.1***	33.7***	27.4***	29.3***

Notes: There are 8,016 observations. $Y = Y_n(n/h^*)$. All controls are the same as those in Table 2. The dependent variable for columns 1 to 3 is logged operating expenditures per pupil. The dependent variable for column 4 is the log of school quality measure, *S*. Coefficients in bold are treated as endogenous. The flypaper effects are calculated by $\left(\left(\frac{\phi}{\theta}\right) - 1\right)$. *z*-statistics are in parentheses.

*** = p<0.01

Table A5. Impact of No District Fixed Effects on the Flypaper Effect

Key Variable	Partial weighting	Full weighting without IV	Fully-weighted expenditure-based	Fully- weighted performance-based
	(1)	(2)	(3)	(4)
$\theta ln(Y)$	0.56***	0.73***	0.77***	-0.072
	(2.83)	(4.83)	(4.79)	(-1.19)
$\phi(A_S/Y)(V/\bar{V})$	2.82***			
	(7.79)			
$\phi(A_F/Y)(V/\bar{V})$	5.30**			
	(2.15)			
$\phi(A_S/Y)(V/\bar{V})(1-X/V)$		3.62***	3.49***	-2.51***
		(9.48)	(7.13)	(-5.31)
$\phi(A_F/Y)(V/\bar{V})(1-X/V)$		7.43**	7.79**	-7.22**
		(2.32)	(2.44)	(-2.01)
$ln(1-X/V)$		-0.35***	-0.40***	0.24***
		(-5.98)	(-8.28)	(5.08)
$ln(V/\bar{V})$	-0.32***	-0.34***	-0.34***	0.17***
	(-9.75)	(-13.80)	(-10.56)	(5.85)
State aid (A_S) flypaper effect	4.1**	4.0***	3.5***	33.8
Federal aid (A_F) flypaper effect	8.5	9.2*	9.1**	99.2

Notes: There are 8,016 observations. All controls are the same as those in Table 2. The dependent variable for columns 1 to 3 is logged operating expenditures per pupil. The dependent variable for column 4 is the log of school quality measure, *S*. Coefficients in bold are treated as endogenous. The flypaper effects are calculated by $\left(\left(\frac{\phi}{\theta}\right) - 1\right)$. *z*-statistics are in parentheses.

* = p<0.10, ** = p<0.05, *** = p<0.01.

Table A6. Impact of Endogenous Aid and Income on the Flypaper Effect

Key Variable	Partial weighting	Full weighting without IV	Fully-weighted expenditure-based	Fully- weighted performance-based
	(1)	(2)	(3)	(4)
$\theta ln(Y)$	**0.20*** **	**0.20*** **	**0.24*** **	**0.40*** **
	(4.54)	**(4.58)**	**(5.16)**	**(6.41)**
$\phi(A_S/Y)(V/\bar{V})$	**2.19*** **			
	(10.35)			
$\phi(A_F/Y)(V/\bar{V})$	**3.99*** **			
	(4.81)			
$\phi(A_S/Y)(V/\bar{V})(1\text{-}X/V)$		**2.69*** **	**3.50*** **	**5.63*** **
		(8.40)	**(6.37)**	**(7.60)**
$\phi(A_F/Y)(V/\bar{V})(1\text{-}X/V)$		**6.65*** **	**6.47*** **	**12.2*** **
		(5.74)	**(4.15)**	**(7.15)**
ln(1-X/V)		**-0.15*** **	**-0.29*** **	**-0.57*** **
		(-3.92)	**(-6.87)**	**(-9.32)**
$ln(V/\bar{V})$	-0.13***	-0.13***	-0.16***	-0.22***
	(-6.90)	(-6.68)	(-6.49)	(-9.08)
State aid (A_S) flypaper effect	10.1***	12.2***	13.4***	13.1***
Federal aid (A_F) flypaper effect	19.1***	31.6***	25.6***	29.4***

Notes: There are 8,016 observations. All controls are the same as those in Table 2. The dependent variable for columns 1 to 3 is logged operating expenditures per pupil. The dependent variable for column 4 is the log of school quality measure, *S*. Coefficients in bold are treated as endogenous. The flypaper effects are calculated by $\left(\left(\frac{\phi}{\theta}\right) - 1\right)$. *z*-statistics are in parentheses.

* = p<0.10, ** = p<0.05, *** = p<0.01.

B1: The Lutz Estimating Equation

Lutz (2010) provides a new method for estimating the flypaper effect that is consistent with the Bradford/Oates equivalence theorem. This section explains the Lutz method and why it does not provide reliable estimates of the flypaper effect. The notation here comes from our paper, not from Lutz. However, we follow Lutz in modelling total spending and total aid in the district budget constraint, not spending and aid per pupil as in our paper.

The Budget Constraints

The household budget constraint is simplified with housing expenses other than the property tax payment incorporated into the composite good, *Z*. The property tax payment is *t* (the effective property tax rate) multiplied by *V* (house value). This leaves the following household budget constraint (implicitly for the decisive voter):

$$Y = Z + tV \tag{1}$$

Total education spending, E^T, is spending per pupil, *E*, multiplied by number of pupils, *n*. The school district budget constraint sets E^T equal to total property taxes, $t\Sigma V$ (summed over all properties in the district) plus total state aid, A^T, or

$$E^T \equiv (E)(n) = t\Sigma V + A^T \equiv L^T + A^T \tag{2}$$

The right side of this equation equals the sum of local, L^T, and state, A^T, spending.

Solving equation (2) for *t* and substituting the result into (1) yields:

$$Y^* \equiv Y + A^T\left(\frac{V}{\Sigma V}\right) = Z + (E)(n)\left(\frac{V}{\Sigma V}\right) \tag{3}$$

With this combined budget constraint, the voter's augmented income, *Y**, is the left side and the price per unit of *E* appears on the right side. Thus, Lutz writes the demand for *E* as

$$E = E\left\{ n\left(\frac{V}{\Sigma V}\right), Y + A^T\left(\frac{V}{\Sigma V}\right)\right\} \tag{4}$$

Differentiating this demand function yields

$$\frac{\partial E}{\partial Y} = \frac{\partial E}{\partial Y^*}\,;\; \frac{\partial E}{\partial A^T} = \frac{\partial E}{\partial Y^*}\left(\frac{V}{\Sigma V}\right);\; \frac{\partial E}{\partial A^T} = \frac{\partial E}{\partial Y}\left(\frac{V}{\Sigma V}\right) \tag{5}$$

Lutz then differentiates the community budget constraint (2) to obtain:

$$\frac{\partial E^T}{\partial A^T} = \frac{\partial L^T}{\partial A^T} + 1 \text{ or } \frac{\partial L^T}{\partial A^T} = \frac{\partial E^T}{\partial A^T} - 1 \tag{6}$$

Based on equation (5), this result can be re-written as follows, where *h* is the number of households in the district and $\hat{V}$ is property value per household:

$$\left(\frac{\partial L^T}{\partial A^T}\right) = \left(\left(\frac{\partial E}{\partial A^T}\right)n\right) - 1 \text{ or } \left(\frac{\partial L^T}{\partial A^T}\right) = \left(\left(\frac{\partial E}{\partial Y}\right)\left(\frac{V}{\Sigma V}\right)n\right) - 1 \text{ or } \left(\frac{\partial L^T}{\partial A^T}\right) = \left(\left(\frac{\partial E}{\partial Y}\right)\left(\frac{V}{\hat{V}}\right)\left(\frac{n}{h}\right)\right) - 1 \tag{7}$$

The Assumptions

At this point, Lutz makes four strong assumptions. The assumptions are implicit: (1) $\partial E/\partial Y$ equals a constant, say α, and (2) that there is no non-residential property. The two explicit assumptions are (3) that all houses in the district have the same value, so $V = \hat{V}$, and (4) that each household has one student, so that $n = h$. With these assumptions, equation (7) simplifies to:

$$\left(\frac{\partial L^T}{\partial A^T}\right) = \alpha - 1 \tag{8}$$

This result leads to Lutz's estimating equation:

$$\Delta L^T = (\alpha - 1)\Delta A^T \tag{9}$$

According to Lutz, previous studies have found that the propensity of voters to spend an additional dollar of income on education, α, is about 0.10, so a flypaper effect does not exist if the absolute value of the coefficient of ΔA is about 0.9. An absolute value for this coefficient below 0.9 indicates therefore that voters have a higher propensity to spend out of aid than they do out of income, which is the flypaper effect.

To put it another way, his estimating strategy really involves two αs. The first α, say α_Y, is the value of α that would arise if voter responses to aid and income are equivalent. The second α, say α_A, is the estimated response of local spending to aid. A flypaper exists if $\alpha_A > \alpha_Y$, that is, if the estimated coefficient in (9) is smaller in absolute value than 0.9.

Lutz does not estimate α_Y; instead, he makes an assumption about its value. As he put it (p. 321, note 13; reference omitted):

> Although the use of 0.05 to 0.1 as the marginal propensity to spend on public goods is nearly ubiquitous in the empirical intergovernmental grants literature, a caveat concerning its use should be noted. The estimate pertains to government services at the state level. It is possible that the marginal propensity to spend at the local level differs from the propensity at the state level. Note also that the estimate refers to all public goods, not just education.

His claim in the first sentence is not true. Most of the studies cited in this paper estimate the impact of income on the demand for local public education—they do not assume it. Moreover, as Lutz recognizes, his assumption may not be accurate for local public education.

Another problem with the Lutz approach is that each of his four major assumptions is contradicted by the available evidence. (1) A constant value for $\partial E/\partial Y$ requires a restrictive utility function, such as a Cobb-Douglas, with unitary income and price elasticities. Our estimates of these elasticities, which are similar to others in the literature, are far from unitary. We find an income elasticity of about 0.25 and a price elasticity with respect to the tax share of about -0.15. (2) Many school districts have extensive non-residential property. (3) No district comes close to equal values for all houses. (4) The number of students is not close to the number of households. Lutz's Table 2 indicates that the average district contained 1,199 students and

7,268 people in 2000. The only way these numbers are consistent with one student per household is if there were 1,199 households with 1 student and an average of 5.06 non-students.

The key issue, of course, is whether the lack of realism in these assumptions affects the estimates of the flypaper effect.

First, consider the case in which assumption (1) holds but the others do not. Then according to equation (7), the estimating equation really is:

$$\Delta L = \left(\alpha_A \left(\frac{V}{\hat{V}} \right) \left(\frac{n}{h} \right) - 1 \right) \Delta A \tag{10}$$

Because the two ratios added to this expression are both below 1.0, α_A must be considerably greater than 0.1 for the coefficient to be 0.9. In other words, equation (9) is likely to severely underestimate the flypaper effect.

Second, consider the case in which assumptions (2) to (4) hold, but assumption (1) does not. In this case, α has to be replaced by a function of E and Y^*. One example can be found by differentiating equation (7) in our paper with respect to Y under the assumption that there is no flypaper effect. This leads to $\partial E/\partial Y = \theta E/Y^*$ and to a new version of the estimating equation:

$$\Delta L = \left(\theta \left(\frac{E}{Y^*} \right) - 1 \right) \Delta A = \theta \left(\frac{E}{Y^*} \right) \Delta A - \Delta A \tag{11}$$

This version has an interaction between (E/Y^*) and ΔA and a separate ΔA variable. In principle, it could be estimated. A value of θ above the estimated value for income in other studies, say 0.25, along with a unitary coefficient on the second term would support the existence of a flypaper effect. In practice, however, the interaction term is endogenous, as districts with high changes in L^T with respect to aid may be the districts with high E to begin with. In any case, this is not the equation Lutz estimates, and estimating equation (9) when equation (11) is appropriate almost certainly leads to significant bias.

B2. Deriving the Impact of Aid on Spending

This section shows how to derive the link between the estimated flypaper effect, *f* in the equations in the text, and the impact of intergovernmental aid on school-district spending, *dE/dA*.

The Expenditure-Based Demand Model

The expenditure-based demand model is equation (8) in the text. After adding the STAR tax share, this model is.

$$\begin{aligned}\ln\{E\} = \ln\{(S)(AC)\} = K + \theta\ln\{Y\} + \left(\theta(1+f_S)\right)\left(\frac{A_S}{Y}\right)\left(\frac{V}{\overline{V}}\right)\left(1-\frac{X}{V}\right) \\ + \left(\theta(1+f_F)\right)\left(\frac{A_F}{Y}\right)\left(\frac{V}{\overline{V}}\right)\left(1-\frac{X}{V}\right) + \mu\ln\left\{\frac{V}{\overline{V}}\right\} + (\mu+1)\ln\{AC\} + \beta\ln\{Z\} + \varepsilon\end{aligned} \tag{12}$$

Note that *E* and *A* are expressed in per pupil terms. Then simple differentiation leads to:

$$\frac{dE}{dY} = \left(\frac{E}{Y}\right)\theta\left(1 - W_S(1+f_S) - W_F(1+f_F)\right) \tag{13}$$

and

$$\frac{dE}{dA_i} = \left(\frac{E}{A_i}\right)\theta(1+f_i)W_i \tag{14}$$

where

$$W_i = \left(\frac{A_i}{Y}\right)\left(\frac{V}{\overline{V}}\right)\left(1-\frac{X}{V}\right) \tag{15}$$

and $i = S, F$. Because the two *A* terms are small relative to *Y* and because the two tax-share terms are less than one, the derivative defined by equation (2) is always positive.

These result allow us to compare the impacts of intergovernmental aid and income on spending [$(dE/dA_i)/(dE/dY)$], to determine the extent to which aid leads to higher spending

[dE/dA_i], and to determine the extent to which aid leads to tax relief [$1 - (dE/dA_i)$]. A key point is that these outcomes vary across districts. They are influenced by the flypaper effect, f, which is the (constant) impact on spending of state aid, weighted by its value to taxpayers, relative to the impact of income. However, dE/dA_i is not a measure of the flypaper effect as we have defined it. A linear demand equation with spending as the dependent variable yields a flypaper effect that is the same as this ratio of derivatives. As the text makes clear, however, this approach ignores the fundamental nonlinearity of aid and the impact of tax share on the value of aid to voters.

Further manipulation of equations (2) and (3) reveals that

$$\frac{dE / dA_i}{dE / dY} = \left(\frac{Y}{A_i}\right)\left(\frac{(1+f_i)W_i}{1-(1+f_S)W_S-(1+f_F)W_F}\right) \tag{16}$$

Simple differentiation reveals that this expression increases with Y/A_i, f_i, and W_i. Not surprisingly, the impact of aid on spending relative to the impact of income on spending increases with the flypaper effect.

The Performance-Based Demand Model

The comparable calculations for the performance-based demand model are more complicated because the cost and efficiency functions are involved. The demand model indicates the impact of A on S, and the cost and efficiency models indicate the impact of A on the spending required to achieve S. More specifically, we want to find dE/dA by differentiating $E\{S\{A\}\} = C\{S\{A\}\}/e\{S\{A\}, A\}$. This derivative is:

$$\frac{dE}{dA} = \left(\frac{1}{e}\right)\left(\frac{\partial S}{\partial A}\left(\frac{\partial C}{\partial S} - E\left(\frac{\partial e}{\partial S}\right)\right) - E\left(\frac{\partial e}{\partial A}\right)\right) \tag{17}$$

The equations needed to evaluate this derivative are as follows, where K indicates a special constant term that consists of variables that do not need to be specified. The meaning of K varies from one equation to the next, but in each case, K does not appear in the final derivative.

The relevant equations start with the cost function:

$$C\{S\} = KS^{\sigma}. \tag{18}$$

Note that $MC = dC\{S\}/dS = \sigma C/S$ and $\ln\{MC\} = (\sigma - 1)\ln\{S\}$. The next equation is the efficiency equation:

$$\ln\{e\} = K + \gamma \ln\{Y\} + \gamma(1+g_S)W_S + \gamma(1+g_F)W_F + \delta \ln\{MC\} \tag{19}$$

where g_i is the efficiency flypaper effect for aid type i. The third equation is the student performance equation:

$$\ln\{S\} = K + \theta \ln\{Y\} + \theta(1+f_S)W_S + \theta(1+f_F)W_F + \mu_2 \ln\{MC\} + \mu_3 \ln\{e\}\ , \tag{20}$$

where W_i is given by equation (4). As discussed in the text, the *f*s in (9) have a different interpretation than the *f*s in (1). After inserting the above expressions for MC and e and solving for S, this equation becomes:

$$\ln\{S\} = K + Q_1 \ln\{Y\} + Q_S W_S + Q_F W_F \tag{21}$$

where

$$Q_1 = \frac{\theta + \mu_3 \gamma}{1 - (\sigma - 1)(\mu_2 + \mu_3 \delta)} \tag{22}$$

and

$$Q_S = \frac{\theta(1+f_S) + \mu_3 \gamma(1+g_S)}{1 - (\sigma - 1)(\mu_2 + \mu_3 \delta)} \tag{23}$$

and

$$Q_F = \frac{\theta(1+f_F) + \mu_3 \gamma(1+g_F)}{1 - (\sigma - 1)(\mu_2 + \mu_3 \delta)} \tag{24}$$

By differentiating equations (7), (8), and (10) with respect to A and/or S, as appropriate, we can obtain expressions for all the derivatives in (6). After plugging in these derivatives and simplifying, we obtain

$$\frac{dE}{dA_i} = \left(\frac{E}{A_i}\right) W_i \left(Q_i(\sigma - \delta(\sigma - 1)) - \gamma(1 + g_i)\right) \tag{25}$$

Aid not spent on education turns into tax relief, so we can also write:

$$\frac{dT}{dA_i} = 1 - \frac{dE}{dA_i} \tag{26}$$

where T is the jurisdiction's average property tax payment. These expressions obviously vary across districts.

The same equations can be differentiated with respect to Y to derive a comparable formula for dE/dY. This formula is:

$$\frac{dE}{dY} = \left(\frac{E}{Y}\right)\Big(\big((Q_1 - Q_S W_S - Q_F W_F\big)\big(\sigma - \delta(\sigma - 1)\big) - \Big(\gamma\big(1 - W_S(1 + g_S) - W_F(1 + g_F)\big)\Big)\Big) \tag{27}$$

The impact on of aid on spending relative to the impact of income is still (dE/dA_i)/(dE/dY). However, the expression comparable to equation (5) is now too complex to be illuminating.

A final question is whether all the terms in equations (13) and (15) can be identified. The form we use to estimate the cost/expenditure model, equation (7) in log form minus equation (8), yields estimates of $\left(\sigma - \delta(\sigma - 1)\right)$, γ, and the g's. Moreover, Q_1, Q_s, Q_F, are coefficients of the demand equation (10). Thus, all the terms in equations (13) and (15) are identified.

B3: Analysis of the Hamilton/Dahlby Model

One explanation for the flypaper effect comes from Hamilton (1986), updated by Dahlby (2011). These authors argue that the marginal cost of public services includes the deadweight loss from the taxation required to fund it. Intergovernmental grants lower this marginal cost at the before-grant level of services and therefore provide a price incentive for higher government service provision. This incentive does not exist for income increases. As Dahlby puts it (p. 305):

> We show that a lump-sum grant has a price effect when a recipient government uses distortionary taxes to finance its spending because the effective price of its public services is the product of its marginal cost of public funds (MCF) and the marginal production cost of the service. When a subnational government receives a lump-sum transfer, it can reduce its tax rate and still provide the same level of service. At the lower tax rate, the MCF will, under plausible assumptions be lower and, therefore, the effective price of providing the public service is reduced. The price effect of a lump-sum grant will be greater when the ratio of the lump-sum transfers to the own-source tax revenues collected by the subnational government is higher and when the subnational government's MCF is higher.

This appendix examines whether this argument holds up in the context of the simple model provided by Dahlby.

The Dahlby Model

Dahlby (2011) provides a simple model that leads to a flypaper effect without missing data or misperceptions or politics. She starts with the following utility function

$$U = \alpha \ln\{x_1\} + \beta \ln\{x_2\} + \gamma \ln\{g\} \tag{28}$$

where x_1 is the taxed good, x_2 is another consumption good, g is the government service, all three goods have a unitary price, all the coefficients are positive, and the coefficients are normalized so that $\alpha + \beta = 1$. Each household picks x_1 and x_2 to maximize (1) subject to the budget constraint:

$$Y = x_1(1+t) + x_2 \tag{29}$$

where t is the tax rate. (We drop Dahlby's subscript on t.) The resulting demand equations are:

$$x_1 = \frac{\alpha Y}{1+t};\ \ x_2 = \beta Y \tag{30}$$

Next, Dahlby substitutes the demand functions in (3) back into (1) to produce the following indirect utility function:

$$V = \alpha \ln\left\{\frac{\alpha Y}{1+t}\right\} + \beta \ln\{\beta Y\} + \gamma \ln\{g\} \tag{31}$$

This indirect utility function is then maximized (by the government) to find the optimal level of g, which is funded by the tax on x_1 and an intergovernmental grant, T, i.e.,

$$g = \frac{t}{1+t}\alpha Y + T \tag{32}$$

The solutions to this problem are

$$t = \frac{\gamma Y - T}{\alpha Y + T} \tag{33}$$

and

$$g = \left(\frac{\gamma}{\alpha+\gamma}\right)(\alpha Y + T) \tag{34}$$

Finally, by differentiating (7), Dahlby finds that

$$\frac{dg}{dY} = \alpha \frac{dg}{dT} \tag{35}$$

Dahlby interprets this as a flypaper effect: given that $\alpha < 1$, the impact of Y on g is always less than the impact of T.

A More Realistic Dahlby Model

Dahlby's two-stage model is unconventional and not compelling, at least not in the local government context. Households are voters. It does not makes sense to say that voters first pick the *x*s without considering *g* and then pick g (or allow a government to pick *g* for them) without adjusting the *x*s. Households/voters select x_1, x_2, and *g* simultaneously.

With this approach, the problem is to select x_1, x_2, and *g* so as to maximize (1) subject to (2) and the community budget constraint, now written as:

$$g = x_1 t + T \tag{36}$$

Explicit solutions for x_1, x_2, and *g* in this model can be obtained when γ equals 0.5. In this case,

$$g = \frac{\gamma\left(Y - \left(\frac{Y(\gamma-\alpha)-\alpha T}{\gamma-(\alpha-\beta)}\right) + T\right)}{\beta+\gamma} \tag{37}$$

Taking the derivatives of this expression with respect to *Y* and *T* and simplifying leads to the conclusion that there will be a flypaper effect, $(\partial g/\partial T) > (\partial g/\partial Y)$, whenever

$$\gamma \equiv 0.5 > (\alpha - \beta) \tag{38}$$

In this one special case, therefore, a flypaper effect does emerge so long as the utility weight on the taxed good is not large relative to the utility weight on the untaxed good. This result appears to fit with one of Dahlby's results, namely, that "the flypaper effect will be larger if the subnational government's taxes are a small share of personal income" (p. 313).

An Alternative Model with Myopic (and Homogeneous) Voters.

In the Dahlby model (and the above variant) each voter assumes that everyone will act just like he or she does. With this approach, the selected level of the taxed good can be treated as the tax base. As discussed by Ross and Yinger (1999), models of the demand for local public services generally make a different assumption, namely, that voters are unware that their individual decision about a taxed commodity will influence the community tax base. Even in a homogeneous community, this strikes us as a more reasonable assumption. A survey of models with this assumption appears in Ross and Yinger.

To implement a myopic-voter model, define $\overline{x}_1$ as the tax base per household and re-write the community budget constraint as:

$$g = \overline{x}_1 t + T \tag{39}$$

Selecting x_1, x_2, and g to maximize (1) subject to (2) and (12) leads to:

$$x_1 = \frac{(\alpha - \gamma) Y \overline{x}_1}{\overline{x}_1 - T} \tag{40}$$

and

$$t = \frac{\gamma(\overline{x}_1 - T) - (\alpha - \gamma)(\gamma \overline{x}_1 + \beta T)}{(\alpha - \gamma)(\beta + \gamma)\overline{x}_1} \tag{41}$$

Because we are looking at a homogeneous community, the average level of x_1 will be the same as the x_1 selected by a single voter. To find the long-run equilibrium with this model, therefore, we must add the condition that $\overline{x}_1 = x_1$. Combining this condition with (12)-(14) yields:

$$g = \frac{\gamma Y \left(1 - (\alpha - \gamma)\right)}{\beta + \gamma} \tag{42}$$

This is a surprising result. The value of g does not depend on T ! This is a negative flypaper effect. This extreme result undoubtedly reflects the use of a Cobb-Douglas utility function, but the intuition is revealing. When voters receive an intergovernmental grant, they gain more utility from using it to lower the tax rate, and hence to lower the distortion in the market for the taxed good, than they do from spending it on the government service. Other utility functions might lead to intermediate cases in which some of the aid is used for both purposes.

The difference between this result and the ones in the previous models comes directly from the treatment of the community budget constraint. In standard voting models, voters care about their tax price, which is the ratio of their property value to property value per household (or per pupil). The Dahlby model eliminates the tax price concept by assuming that voters treat their own consumption of the taxed good as the tax base (per household).

One way to see this is to solve (12) for g and (2) for x_2, substitute the results into (1), and find the derivative of this utility function with respect to g. The result:

$$\frac{\partial U}{\partial g} = \left(\frac{-\beta}{Y - x_1\left(1 + \frac{g - T}{\bar{x}_1}\right)} \right) \left(\frac{x_1}{\bar{x}_1} \right) \tag{43}$$

This equation shows the key role played by the tax price, $x_1 / \bar{x}_1$ in determining the level of g. When voters respond to the tax price, not the tax rate, Dahlby's argument for a flypaper effect disappears. A large empirical literature supports the hypothesis that voters respond to tax price.

Conclusion

In short, a standard, simple model of local voting does not lead to a flypaper effect. The unusual assumptions in the Dahlby model, not something intrinsic about public choice, are the source of the flypaper effect she identifies. In a standard voting model with voters who do not predict changes in the tax base, responses to aid are influenced by tax price, not by tax rate, and the distortions that drive the Dahlby model are not present.

On-Line Appendix References

Dahlby, Bev. 2011. "The Marginal Cost of Public Funds and the Flypaper Effect." *International Tax and Public Finance* 18 (3) (June): 304–321.

Hamilton, Jonathon. 1986. "The Flypaper Effect and the Deadweight Loss from Taxation." *Journal of Urban Economics*, 19 (March): 148–155.

Lutz, Bryon. 2010. "Taxation with Representation: Intergovernmental Grants in a Plebiscite Democracy." *The Review of Economics and Statistics* 92 (2) (MAY): 316-332.

Ross, Stephen, and John Yinger. 1999. "Sorting and Voting: A Review of the Literature on Urban Public Finance." In *Handbook of Urban and Regional Economics, Volume 3, Applied Urban Economics*, P. Cheshire and E. S. Mills (eds.), North-Holland, 2001-2060.