Applying S-Index to Transportation Financing Alternatives

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A one-number measure of the progressivity of a funding source has recently been developed by Suits. This paper applies the measure to various transportation financing alternatives. This S-index can range from +1 (indicating maximum progressivity) to -1 (maximum regressivity). The index can be calculated for any funding source by ranking families by income and noting the cumulative percentage of burden associated with the cumulative percentage of income. By using data from the Bureau of Labor Statistics Consumer Expenditure Survey, the index is calculated for a number of currently used or proposed household-based transportation funding sources. Subject to certain qualifications, the results suggest the general redistributive impact of alternative financing sources. In particular, it was found that most household-based sources are regressive. The most regressive alternatives were a household tax, cigarette tax, lottery, and public transit fares. Least regressive sources were parking, income, and stock-transfer taxes.

In a 1977 article, Daniel Suits (1) presented a one-number measure of the burden of a funding source. Called the S-index, it summarizes the incidence (that is, who pays) of a financing alternative or combination. The result indicates the degree of progressivity or regressivity of the source. It is the purpose of this paper to discuss the index and its application to transportation financing alternatives.

In recent years, the issue of increased funding for transportation has become more critical. Transit systems and highway funds, for example, have reached crisis stages in many regions. A number of important considerations surface in this area: legal, political, and economic. Notably absent from most discussions of transportation finance is the concern for how different income groups would be affected by the employment of different funding sources. The question to be explored here is how financing alternatives differ in terms of progressivity.

Suits' index is related to the Lorenz curve of income distribution and the resulting Gini concentration ratio. The former is a graphic description of a society's income distribution, comparing population percentiles with the percentage of total income received. It illustrates the equality or inequality of the distribution of income under various alternatives. The Gini ratio summarizes this in a number that can vary between 0 (complete income equality) and +1 (complete income inequality).

To apply the S-index, families are ranked from lowest to highest income, and the accumulated percentage of tax burden associated with the corresponding accumulated percentage of income needs to be obtained. The resulting data can be plotted as in Figure 1. A funding source whose burden is always proportional to income would lie coincident with the diagonal (45°) line. A source lying below the 45° line indicates that the percentage of tax burden borne by low-income groups is smaller than their share of total income; hence, it is a progressive source such as the federal income tax (e.g., the dashed line in Figure 1).

A source lying above the 45° line indicates the opposite, a regressive source. The percentage of tax burden imposed on low-income families exceeds their percentage share of income (e.g., the dotted line).

The S-index is defined in terms of K (the area of triangle OAB) and L [the area OABC (or OABC')] contained between the curve and the horizontal axis OA:

$$S = (K - L)/K = 1 - (L/K) \tag{1}$$

For a proportional tax, the curve will be coincident with the 45° line, so L = K and S = 0. A progressive source, such as the dashed line, lies below the diagonal, so L < K and S > 0. In the limiting case of maximum progressivity, L = 0 and S = 1. With a regressive source above the 45° line, L > K and S < 0. In the limiting case of maximum regressivity, L = 2K and S = -1. Thus, the index varies between -1 (absolute regressivity) through 0 (proportional) to +1 (absolute progressivity).

For numerical calculation, K is a triangle with base and height of 100; therefore, it is defined as follows:

$$K = 5000 \tag{2}$$

An approximation to the value of L, for 10 population deciles ranking families from the 10 percent with lowest income (decile 1) to the 10 percent with highest income (decile 10), is as follows:

$$L \approx \sum_{i=1}^{10} (\tfrac{1}{2})[T_x(y_i) + T_x(y_{i-1})](y_i - y_{i-1}) \tag{3}$$

where $T_x(y_i)$ is the accumulated percentage of total burden for given tax x, associated with the accumulated percentage of income y represented by population decile i.

Suits' analysis was both criticized and broadened in two subsequent comments. Davies (2) raised three concerns, but only the third related to the S-index itself. First, the data generally used to calculate the S-index rely on one year's family income. Optimally, data on permanent (lifetime) income would permit a more accurate measure but such data are seldom available. Second, the value of in-kind transfers needs to be monetized and included with income. A third problem is that the index is an average over the entire income spectrum. The resulting aggregation could mask portions of the income distribution where a tax is regressive and another portion where it is progressive.

Kienzel (3), by using different assumptions of incidence, showed that the S-index is sensitive to these alternatives. Although both Davies and Kienzel recognize the drawbacks and ambiguities in Suits' analysis, this does not diminish its usefulness as a tool in tax-policy analysis. Even with the potential biases, the S-index can be an important addition to public finance issues, because it is the best (and only) summary measure available of the relationship between tax burden and income.

ANALYSIS

It will be assumed that the basic groups benefiting from the use of transportation funding sources will be the same. In fact, since funding mechanisms may affect the relative price of transportation modes, the groups benefiting from the subsidy may not be independent of the subsidy source. However, such a change will likely be small. Therefore only the difference in groups paying for the sources will be examined, by comparing the differential tax incidence of one source with that of another source. Musgrave and Musgrave (4) suggest that this concept offers the best approach for tax-policy analysis, since actual tax-policy decisions usually involve issues such as comparing alternative ways of raising revenue.

Figure 1. Tax burden versus income.
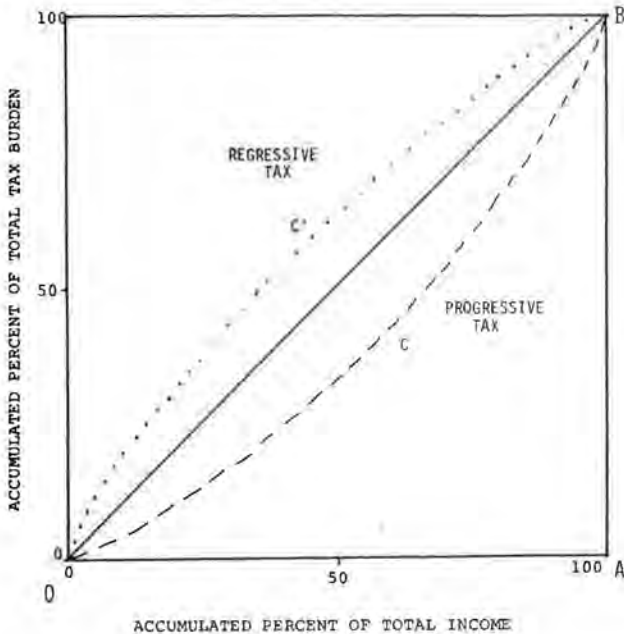
Calculation of incidence will depend on the extent to which the initial distribution of burdens differs from the final distribution. If adjustments by consumers or firms are made in response to tax changes, these should be determined. For example, consumers may alter the amount and/or location of durable goods purchases due to a change in the state or local sales tax. A series of studies have examined the shifting and incidence of local taxes to determine the impact of competition from firms in areas not subject to the taxation. In one of the most recent and most comprehensive, Mikesell (5) found less than complete shifting to the consumer. However, his estimates suggest that approximately 90 percent of the burden is shifted in the form of higher prices. In a second study, Sidhu (6) also concluded that proximity to a political border reduces the ability of sellers to shift tax burdens. Unfortunately, these empirical works did not try to determine who bears the unshifted portion of the burden or which income classes are affected and by how much.

Many of the funding sources suggested for transportation (7) are taxes levied on households' consumption, income, wealth, etc. The conventional wisdom [although not unanimously (8)] suggests that incidence lies with the consumer on the basis of expenditures, ownership, or tax payments. The incidence of other potential sources (e.g., property tax, corporate income tax, payroll tax) is more controversial, particularly if they are levied initially on businesses. The final incidence of such sources depends on changes in wages, prices, and profits as a result of the tax. Data on the shifting of tax burdens are scarce and there is little consensus on the result. For this reason, the taxes levied primarily on households will be studied.

The data analyzed by Suits and Kienzel were developed by Pechman and Okner (9) and are inadequate since all sales and excise taxes are lumped together as well as personal property and all motor vehicle taxes. What is necessary are data on detailed spending patterns and tax payments by families in different income brackets for funding sources currently used or proposed. Such data are provided by the Consumer Expenditure Survey (CES) of the Bureau of Labor Statistics (10).

Calculating the incidence of each tax or fee requires that relevant expenditures be noted by income level. A convenient breakdown available from the CES data necessary to calculate the S-index is to arrange families by population decile from the 10 percent of families with the lowest income (decile 1) to the 10 percent of families with the highest income (decile 10). For four selected deciles (1, 4, 7, 10), gross expenditure or ownership is noted in Table 1 (10). Each figure represents the average expenditure on an item by a family in a particular decile. It is seen that decile-1 families spend an average of between $823 and $1407 on goods subject to sales tax, whereas a decile-10 family spends between $6847 and $8676. For reference, the average incomes for families in the four deciles reported are $1559, $7063, $13 466, and $31 974, respectively. It is noted that since taxes on expenditure items are generally proportional to spending, the S-index for both expenditures and taxes on expenditures would be the same.

The data necessary to calculate the S-index by using Equations 1, 2, and 3 require the accumulated percentage of both income and each funding source represented by each population decile; these are presented in Table 2 (10). It is seen that although decile-1 families account for 10 percent of the population, they account for only 1.31 percent of the income but pay 2.6-3.2 percent of total sales tax collections, a regressive result. The decile-2 row considers both decile-1 and decile-2 families, which represent 20 percent of the population, 4.07 percent of the income, and about 7 percent of sales tax collections, etc. The S-index results are displayed in Table 3. The sources are ranked from the most progressive (stock-transfer tax) to the most regressive (household tax).

There have been few other studies that have applied S-indices to various taxes by using a compatible data set. However, the comparisons that are available (e.g., all sales and excise taxes and income taxes) generally support the findings in Table 3. The results of these comparisons are shown below (1,3,13) together with estimates for selected business-based taxes. The wide range for such taxes as corporate income or property levies illustrates the uncertainty and variance as to final incidence.

Source	S-Index
Individual income tax	+0.17 to +0.19
Corporate income tax	+0.03 to +0.36
Property taxes	-0.07 to +0.23
All sales and excise taxes	-0.15 to -0.16
Payroll taxes	-0.13 to -0.17
Personal property and motor vehicle taxes	-0.09 to -0.12
Lottery	-0.20 to -0.40

QUALIFICATIONS

Some qualifications need to be made to the above analysis. The data reflect spending patterns and thus incidence in 1972-1973. If the distribution of these spending patterns has changed, tax incidence could change. The omission of in-kind transfers in income and the use of a single year's income can be criticized, as suggested by Davies. Although no data are readily available to correct the latter problem, the CES data do include the value of food stamps in the definition of family income. Although not included in income, data on food received from welfare organizations and medical care paid by others are reported. Since these amounts were small (average of $5 and $21 reported per family, respec-

Table 1. Yearly expenditures on taxable goods and services and other sources.

Item	Expenditure ($) by Decile			
	1	4	7	10
Taxable goods[a]	1407	3262	5139	8 676
Taxable goods [b]	823	2201	3723	6 847
Gasoline	98	270	449	561
Parking and towing	1	5	9	32
Tolls	0	2	4	8
Alcoholic beverages	33	79	127	252
Cigarettes	57	107	146	142
Gas and electric tax	135	222	320	432
Telephone	81	152	193	270
Vehicle registration[c]	10	28	40	53
State and local income taxes	7	84	263	906
Title transfer fee[d]	1	3	4	5
New-car purchases[e]	100	281	514	1 005
Used-car purchases[e]	73	191	338	407
Admissions and fees	11	26	54	116
New mortgage debt	180	410	1206	1 462
Household tax[f]	18	18	18	18
Public transportation fares	33	56	42	88
Stock ownership[g]	145	1313	2168	13 736

[a] Goods subject to general sales tax, assuming food purchased for home consumption and medicine and drugs are subject to sales tax. See paper by Rock (11) for more details.
[b] Assuming the items in note a are not subject to sales tax.
[c] Assuming a $25/vehicle fee.
[d] Based on the percentage of families purchasing a car and a fee of $10.
[e] Net outlay (excluding trade-in values).
[f] Assuming $18/family.
[g] Market value of holding.

Table 2. Accumulated U.S. income and tax burden by population decile, 1972-1973.

Item	Expenditure (cumulated percentage) by Decile									
	1	2	3	4	5	6	7	8	9	10
Family income	1.31	4.07	8.35	14.30	21.98	31.46	42.81	56.40	73.05	100.00
Sales tax 1	3.20	7.68	13.59	21.00	29.92	40.14	51.81	65.15	80.29	100.00
Sales tax 2	2.60	6.24	11.36	18.30	26.93	37.07	48.81	62.55	78.41	100.00
Gasoline tax	2.85	6.68	12.70	20.51	30.24	41.65	54.65	68.56	83.77	100.00
Parking tax	0.69	2.57	6.20	11.35	17.49	25.44	35.82	48.47	64.24	100.00
Tolls	1.14	4.39	7.92	14.48	21.96	32.41	44.13	57.46	75.11	100.00
Alcohol tax	2.87	6.69	12.86	19.72	29.54	39.62	50.65	62.99	78.11	100.00
Cigarette tax	4.85	10.86	18.26	27.38	37.70	48.66	61.10	74.69	87.88	100.00
Gas and electric tax	4.96	11.12	18.53	26.71	35.86	46.12	57.90	70.25	84.13	100.00
Telephone tax	4.75	11.20	18.67	27.53	37.29	47.79	59.11	71.08	84.23	100.00
Vehicle registration	3.03	7.58	14.39	22.73	32.58	43.94	56.06	69.70	84.09	100.00
State and local income tax	0.30	0.89	2.33	5.74	11.38	19.57	30.32	44.21	62.96	100.00
Title transfer fee	3.46	8.23	14.90	23.50	33.87	45.86	58.16	71.97	85.55	100.00
New-car tax	2.30	4.46	8.48	14.95	22.71	33.30	45.15	59.81	76.80	100.00
Used-car tax	2.76	6.86	12.71	19.89	30.80	42.65	55.35	69.90	84.71	100.00
Admissions tax	2.20	4.99	11.30	16.68	24.40	34.62	45.93	59.34	75.74	100.00
New mortgage tax	2.31	4.29	7.20	12.45	19.99	31.36	46.82	61.32	81.27	100.00
Household tax	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	90.00	100.00
Transit fares	6.91	15.36	23.77	35.49	44.40	52.78	61.50	69.46	81.63	100.00
Stock-transfer tax	0.53	2.36	5.36	10.18	15.91	21.61	29.58	36.52	49.51	100.00

Table 3. S-index for funding alternatives.

Source	S-Index	Source	S-Index
Stock transfer tax[a]	+0.24	Gasoline tax	-0.16
State and local income tax	+0.18	Used-car excise tax	-0.17
Parking and towing tax	+0.11	Vehicle registration fee	-0.19
Tolls	-0.02	Title transfer fee	-0.21
New-car excise tax	-0.04	Utility tax	-0.22
Admissions and fees	-0.05	Telephone tax	-0.23
Mortgage tax	-0.05	Cigarette tax	-0.26
Sales tax B[b]	-0.09	Public transportation fares	-0.26
Alcohol tax	-0.11	Household tax	-0.39
Sales tax A[c]	-0.13		

[a] Based on ownership.
[b] Sales tax based on Table 1, note b.
[c] Sales tax based on Table 1, note a.

tively), these can be omitted without affecting the results. The implicit assumption was made that in response to tax changes, households would continue to buy taxable items or pay taxes in the same relative pattern that they did before. Any other assumption would vastly complicate empirical calculations. If a tax used for transportation funding is incremental to an existing source, the incidence would be essentially the same as the source to which it is attached.

Since national data were used, regional incidence could differ significantly from the reported figures due to local variations in tax rates, exceptions, expenditures, etc. The results should thus be viewed as a national aggregate. In addition, data on alcohol expenditures, public transportation expenditures, and cigarette purchases suffered from serious underreporting, according to the U.S. Bureau of the Census (12). If the degree of underreporting

was related to income, the reported figures could be biased.

It is noted that analysis of who pays is one input necessary to examine the overall redistributive impact of transit services. That is, combining the profile of who pays with that of who benefits would complement and expand this research. Also, improved data and analysis on the incidence of business-based taxes would be a fruitful direction for further research in this area. Computing and comparing the S index for different localities would be an additional application.

CONCLUSIONS

The burden of increasing transportation funding through a variety of household-based sources has been examined by employing data provided by the Bureau of Labor Statistics and applying the S-index of tax progressivity developed by Suits. A number of potential sources have been compared as to incidence. Subject to certain qualifications, the analysis suggests the following conclusions:

1. Most household-based funding sources are regressive, placing a greater financing burden on the poor.

2. Choosing a new source, or replacing one source with another, has implications for the distribution of burdens.

3. Particular pro-poor sources would be parking taxes, income taxes, or stock-transfer taxes.

4. Particularly burdensome sources for the poor would be a household tax, cigarette tax, or a lottery.

5. Considering transit financing, of the sources studied, virtually all of them place less of a burden on the poor than increasing fares.

ACKNOWLEDGMENT

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Managing Cash in Pennsylvania Department of Transportation

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Although the benefits of cash management are well known to private industry, public agencies have lagged in the application of cash-management techniques. The near-bankrupt condition of Pennsylvania's Motor License Fund in 1979 forced the use of tight cash controls as part of an initial survival strategy. The Pennsylvania Department of Transportation (PennDOT) immediately developed a cash-forecasting methodology and inventoried its outstanding cash receivables, with particular emphasis on outstanding Federal Highway Administration (FHWA) reimbursements. At the same time, PennDOT discontinued bond sales, which had been used in the previous administration to amass $2.2 billion of highway debts. In the succeeding three years, PennDOT (a) sold no highway bonds, (b) tripled the flow rate for FHWA reimbursements and simultaneously cut FHWA receivables by almost $50 million, (c) put new state tax revenue immediately to work in support of a massive Pennsylvania highway restoration program, and (d) consistently paid all bills on time, typically within 30 days.

PennDOT could not have achieved all four of these results without a tight framework of cash management. Although the circumstances of the Motor License Fund are unusual, three lessons of its cash-management experience have broad applicability: (a) cash-flow forecasting provides greater management control—deviations from the cash plan are often early warning signals of trouble; (b) if an organization cannot precisely answer the question—Who owes us how much money and when are we going to get it?—its management is deficient; and (c) large cash balances are a luxury that many transportation agencies can no longer afford—PennDOT has run a fiscally responsible highway program for three years, with an average cash balance equivalent to only two weeks' expenditures.