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Highway Bond Financing—
A Current Analysis

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This study reviews the highway borrowing practices of the States and, to a lesser extent, of the local governments during the 11-year period 1950-60. To be as current as possible, some bond-financing programs of 1961 and early 1962 are also covered.

Highway debt is examined in terms of its magnitude, its relation to other types of debt, and the comparative costs to the highway user of guaranteed and revenue bond financing. The effects of constitutional limitations on creation of debt are measured and evaluated. As the study shows, these have been largely ineffectual in restricting highway borrowing.

The development and impact of the authority device in financing highways by means of revenue bonds is thoroughly analyzed. Some 75 highway and bridge authorities were functioning in 1960, and those that issued bonds during the 1950-60 period account for nearly one-half of all highway debt.

The study compares interest costs and scheduled maturities of revenue bonds with those of other types of highway bonds, and measures the differential in terms of financing costs of the various bond types.

The latter part of the paper deals with specific bond-financing programs as they have been developed in selected States. The recent resurgence in toll road financing is covered in detail, as is the use of the authority device to finance toll-free highway programs.

The study concludes that the method of financing accelerated highway programs depends on the decision to "pay-as-you-go" or to resort to credit financing. If the latter choice is made, the selection of the debt vehicle is most important in holding the cost of borrowing to a minimum. The study points out that the levy of tolls need not presage the use of toll revenue bonds, which are the most costly to service, but may be used successfully in conjunction with bond issues that are secured by a further pledge of road-user taxes, or guaranteed by the State. In this fashion, the costs of borrowing to the public, via the highway user, can be held within satisfactory limits.

•ACCORDING TO a recent estimate by the Bureau of Public Roads (1), the total long-term highway debt of the States and their political subdivisions is expected to reach $14.4 billion by the end of 1962. This is an increase in indebtedness of $10 billion since 1950, more than a threefold advance. Although the highway debt of local governments has doubled (from $2.1 billion in 1950 to an estimated $4.2 billion in 1962), the debt of State agencies has shown a spectacular rise from $2.1 billion in 1950 to an expected $10.2 billion by the end of 1962.

The purpose of this paper is to weigh the significance of this increase in highway debt, measure its effect on highway financing programs and policies, and examine the nature and the technique of current borrowing practices.

Paper sponsored by Committee on Financing Highway Facilities Through Borrowing.

The 11-year period 1950-60 has been selected for study, because it largely encompasses the era of major toll revenue bond financing and of the growth of the public authority device. Moreover, an earlier paper (2) explored rather thoroughly the history of highway borrowing, and the immediate post-war trends in bond financing during the years 1946-50; this study may be thought of as a sequel to the earlier paper.

Background

Borrowing in anticipation of future tax revenue has long been an important method of financing highway and other public improvements. Before 1900, borrowing was largely done by local governments. Massachusetts, in 1893, was the first State to borrow for highway purposes (although the territory of Idaho issued "wagon road" bonds as early as 1890). Thereafter, State borrowing for highways increased steadily, reaching peaks in the 1920's and again in the middle 1950's. During the past 70 years, only 2 States (Arizona and Nebraska) have not incurred debt for highways.

Throughout this study, bond financing is examined in light of the type of bond used or, more precisely, according to the security underlying the debt. The distinction between guaranteed and nonguaranteed debt is so fundamental to an analysis of highway borrowing practices as to justify a brief review and explanation of each type.

Definitions

Throughout this paper, highway bonds are referred to by type; i.e., according to the security behind the bond issue. The following are the three major types of bonds:

General Obligation Bonds. —Also known as guaranteed bonds, or "full-faith" bonds, general obligation bonds are guaranteed as to payment of interest and principal by the State or local government selling the bonds. The full resources and taxing power of the government are irrevocably pledged to meet debt payments.

Limited Obligation Bonds. —Sometimes called tax bonds, and often (erroneously) "revenue" bonds, limited obligation bonds are secured by a pledge of the proceeds of a specific tax, usually road-user imposts, or revenues of a specified fund, but not limited to earnings of the projects to be built. They carry no further guarantee or commitment by the issuing government in the event the pledged revenues prove inadequate to meet debt service.

Revenue Bonds. —Revenue bonds are obligations to finance alledged by self-supporting toll facilities, and are secured only by the tolls and other earnings of the project. Should these prove inadequate, the sole remedy of the bond holders is to require an adjustment in toll rates designed to improve earnings.

Interest on bonds is variously referred to as the rate of return to the lender, the cost to the borrower, or the rate declared and posted on the bond document. The following terms of distinctions are used:

Yield Rate. —The yield rate is the effective rate of return to the lender determined by the price he pays for the bond, the declared interest rate, and the length of time until maturity of the bond.

Net Interest Cost. —The net interest cost is the cost of a bond issue to the borrower. It is a function of the declared interest rate (or rates), the premium or discount on the par value of the bonds at the time of sale, and the length of maturity. It is, in effect, a weighted interest cost.

Coupon Rate. —The coupon rate is the declared rate of interest posted on the bond instrument.

General Obligation Bonds

It was common practice in the earlier years to issue highway bonds secured by a general pledge of the taxing power of the State or local issuing authority. Bonds of this type are still predominant among the obligations of the States to finance toll-free capital projects.

With the development of the road-user tax structure in the 1920's and 1930's, and the growing importance of these taxes as a source of highway funds, many States began to issue general obligation bonds secured by a specific pledge of road-user tax revenue. Today, nearly all general obligations of the States for highways are secured by a pledge of all or a portion of these tax revenues, behind which lies the guaranteed commitment, without recourse, of the full taxing power of the issuing State.

At the end of 1960, 22 States had outstanding a total of nearly $2.7 billion of general obligation highway bonds, or more than one-fourth of the $9.4 billion of State highway debt then outstanding.

Limited Obligation Bonds

For purposes of simplification, the remaining highway debt of the States can be labeled nonguaranteed agency debt, for which there is pledged as security the revenue from selected taxes, fees, rentals, and tolls, including the earnings of self-supporting enterprises, but for which there is no additional pledge of the general taxing power of the States. For purposes of this paper, however, it is convenient to subdivide these bonds into two major classes (limited obligations and toll revenue bonds) and a third, minor class (reimbursement obligations).

Limited obligations are those bonds secured by a pledge of road-user tax revenues, highway fund lease or rental payments under contract agreements, or in some instances by a combination of these sources together with earnings of the projects financed from the bond proceeds, such as tolls. The security for such bonds is therefore much broader than that of a true revenue bond or self-liquidating issue, but in theory is not as great as that of a general obligation bond.

New Mexico was the first State to use limited obligation bonds secured by road-user revenues. The State began issuing highway debentures in 1929, and by the end of 1960 had $8.5 million of these debentures outstanding. Most of the issues have carried maturities of 10 years or less, and the present indebtedness matures in its entirety by 1964. These debentures carry an investment rating of "Aaa," the highest given by National rating agencies (3, p. 1303), and in fact higher than the rating given New Mexico's general obligation bonds. It is evident, at least in this State, that bonds secured by road-user tax revenues alone are a more attractive investment than bonds secured by the general taxing power of the State.

During the 1930's, other States began issuing limited obligation bonds, prompted in some instances by their attractiveness to investors, and in others because of constitutional restrictions on borrowing that made it necessary to place the issue before the electorate either by a referendum or a constitutional amendment, with the attendant uncertainties and delays in obtaining approval. The courts have generally held that the "special fund doctrine" under which limited obligation bonds have been sold is not in contravention of constitutional bans on borrowing. An example of this is found in Colorado, which in 1936 issued $25 million of revenue anticipation warrants payable only from State highway revenues. Because the State constitution prohibits borrowing, beyond the usual exceptions for defense and casual deficits, the constitutionality of the revenue warrant act was challenged in the courts. In 1934, the voters had approved a constitutional amendment dedicating highway revenues for road purposes[1], and the State Supreme Court held that, inasmuch as highway funds by constitutional provisions were no longer available for general State purposes, the bond act was valid[2].

During the 1950's, additional States launched programs of bond financing with limited obligations; notably, Alabama, Florida, Georgia, Maryland, Michigan, Mississippi, Ohio, Pennsylvania, and Washington. In these States, security for the bonds is usually a pledge of motor fuel tax revenues or motor vehicle fees, or both; or, as in Georgia and Pennsylvania, by rental payments from State highway funds to an authority issuing the bonds, in annual amounts sufficient to meet interest and principal requirements.

At the end of 1960, seven States had limited obligations outstanding for specific projects or facilities for which tolls were pledged for debt service, together with a lien on road-user tax revenues or on State highway funds. Usually, these funds are drawn

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[1] Colo. Const., Art. X, §18.
[2] Johnson v. McDonald, 97 Colo. 324, 49 P.2d 1017.

on only in the event that tolls are insufficient to meet debt requirements, but their availability nonetheless has been a significant factor in the marketability of the bond issues.

As of December 31, 1960, 16 States and the District of Columbia had outstanding $2.2 billion of limited obligations with varying pledges of road-user tax revenues and State highway funds. These constituted slightly less than one-fourth of all State obligations outstanding as of that date, and these bonds, together with the general obligations of the States, totaled 50 percent of all State debt for highways.

Revenue Bonds

The term "revenue" bonds as used in this paper refers to obligations issued for specific facilities and secured solely by a pledge of the earnings of the facility. In all instances, State obligations of this type are for toll road or toll crossing facilities, and at the end of 1960, revenue bonds of $4.5 billion were outstanding in 25 States—nearly one-half of all State debt for highways.

Revenue bond financing of highway facilities began with the Port of New York Authority issues of 1926. These and other early issues were limited to bridges and tunnels, and it was not until 1946 that a fully self-supporting toll road revenue bond issue was first marketed by the Maine Turnpike Authority. The Pennsylvania Turnpike, although opened to traffic six years earlier, was not financed as a wholly self-supporting facility. Nearly 42 percent of the initial cost of the project was provided by a grant from the Federal Public Works Administration, and the remainder was financed by bonds sold to the Reconstruction Finance Corporation. Subsequent extensions of the Pennsylvania Turnpike, however, have been financed as self-liquidating projects, as have most of the other major turnpike projects. Certain major exceptions to this practice have been made, however, which are discussed in a subsequent section.

Reimbursement Obligations

The last group of State obligations are those known as "reimbursement" or State-assumed debt. Between 1920 and 1940, many States undertook to reimburse the counties for their contributions to the cost of State highways or for local roads subsequently taken into the State systems. The obligations usually took one of two forms: (a) an agreement between the State and the local governments whereby the State would reimburse the local government in annual amounts for costs incurred initially in building roads that later became part of the State systems, or (b) an agreement whereby the State would pay to counties an annual amount equal to the interest and principal on local highway bonds issued for such purposes. In either case, security for this type of obligation is somewhat obscure except in instances where the State has funded or refunded the obligation from the proceeds of its own bond issues. More than $750 million of these obligations have been assumed by the States, but the remaining indebtedness is now less than $40 million in seven States.

BORROWING PRACTICES, 1950-60

Borrowing by States

During the 11-year period covered by this study, 39 States and the District of Columbia incurred highway obligations of all types totaling nearly $9.8 billion (Table 1). The geographic distribution of these borrowings is shown in Figure 1. Eleven States incurred no debt during this period and, except for Alaska, they comprise a contiguous group of west-north-central and mountain States. Borrowing, quite obviously, is not uniformly practiced by the States, and much of the State highway debt is concentrated among a few States.

Four States (Massachusetts, New Jersey, New York, and Ohio) accounted for nearly two-fifths of all bond issues, and the 10 States that issued $400 million or more bonds accounted for two-thirds of all obligations.

Figure 1 shows that these 10 States are concentrated in the north-central and Atlantic Coastal areas, where the pattern of highway congestion, traffic densities, and highway costs is typically high.

TABLE 1

HIGHWAY OBLIGATIONS ISSUED OR ASSUMED BY STATES, 1950-60[1]

($ $\times 10^3$)

State	General Obligation Bonds	Limited Obligation Bonds	Toll Revenue Bonds		Reimbursement Obligations Assumed	Total
			Crossing Bonds	Road Bonds		
Ala.	25,000	99,000	-	-	4,528	128,528
Alaska	-	-	-	-	-	-
Ariz.	-	-	-	-	-	-
Ark.	14,000	-	7,000	-	-	21,000
Calif.	-	-	167,374	-	-	167,374
Colo.	-	43,688	-	-	-	43,688
Conn.	155,840	347,500	30,000	-	-	533,340
Del.	91,225	-	8,450	-	-	99,675
Fla.	-	194,804	20,880	74,000	27,125	316,809
Ga.	-	140,335	6,650	-	-	146,985
Hawaii	-	12,500	-	-	-	12,500
Idaho	-	-	-	-	-	-
Ill.	-	-	-	479,000	-	479,000
Ind.	-	-	-	280,000	-	280,000
Iowa	-	-	-	-	-	-
Kans.	-	19,500	-	160,000	-	179,500
Ky.	100,000	-	9,361	38,500	-	147,861
La.	100,000	75,000	-	-	-	175,000
Me.	52,500	-	-	58,806	-	111,306
Md.	-	266,320	145,963	-	-	412,283
Mass.	610,000	-	53,781	239,000	-	902,781
Mich.	-	471,000	116,050	-	-	587,050
Minn.	46,000	-	-	-	-	46,000
Miss.	-	42,659	18,360	-	2,218	63,237
Mo.	-	17,900	200	-	62	18,162
Mont.	-	-	-	-	-	-
Neb.	-	-	-	-	-	-
Nev.	-	-	-	-	-	-
N.H.	67,150	-	899	-	-	68,049
N.J.	291,600	-	25,500	511,200	-	828,300
N.Mex.	-	11,000	-	-	-	11,000
N.Y.	712,860	-	128,122	440,000	-	1,280,982
N.C.	150,000	-	-	-	-	150,000
N.Dak.	-	-	-	-	-	-
Ohio	-	438,000	3,500	326,000	-	767,500
Okla.	-	-	-	106,000	-	106,000
Ore.	92,600	-	-	-	-	92,600
Pa.	-	105,000	89,157	298,000	-	492,157
R.I.	32,000	-	3,100	-	-	35,100
S.C.	52,000	-	1,500	-	1,668	55,168
S.Dak.	-	-	-	-	-	-
Tenn.	52,000	-	725	-	-	52,725
Texas	-	-	-	58,500	948	59,448
Utah	-	-	-	-	-	-
Vt.	40,800	-	-	-	-	40,800
Va.	-	-	328,651	75,150	-	403,801
Wash.	-	146,353	73,257	-	-	219,610
W.Va.	84,500	-	5,000	133,000	-	222,500
Wis.	-	-	-	-	4,099	4,099
Wyo.	-	-	-	-	-	-
D.C.	-	2,000	-	-	-	2,000
Total	2,770,075	2,432,559	1,243,480	3,277,156	40,648	9,763,918

[1]Excluding refunding issues.

Toll revenue bond financing was employed by 29 of the 39 borrowing States during the 1950-60 period, and in 6 States (California, Illinois, Indiana, Oklahoma, Texas, and Virginia) was the only major type of bond financing used. Even excluding this type of debt (and the small amount of reimbursement obligations) does not change the geographic concentration of the remaining indebtedness (Fig. 2). The 7 northern and eastern States that issued $200 million or more of general and limited obligation bonds accounted for nearly two-thirds of all such bonds issued.

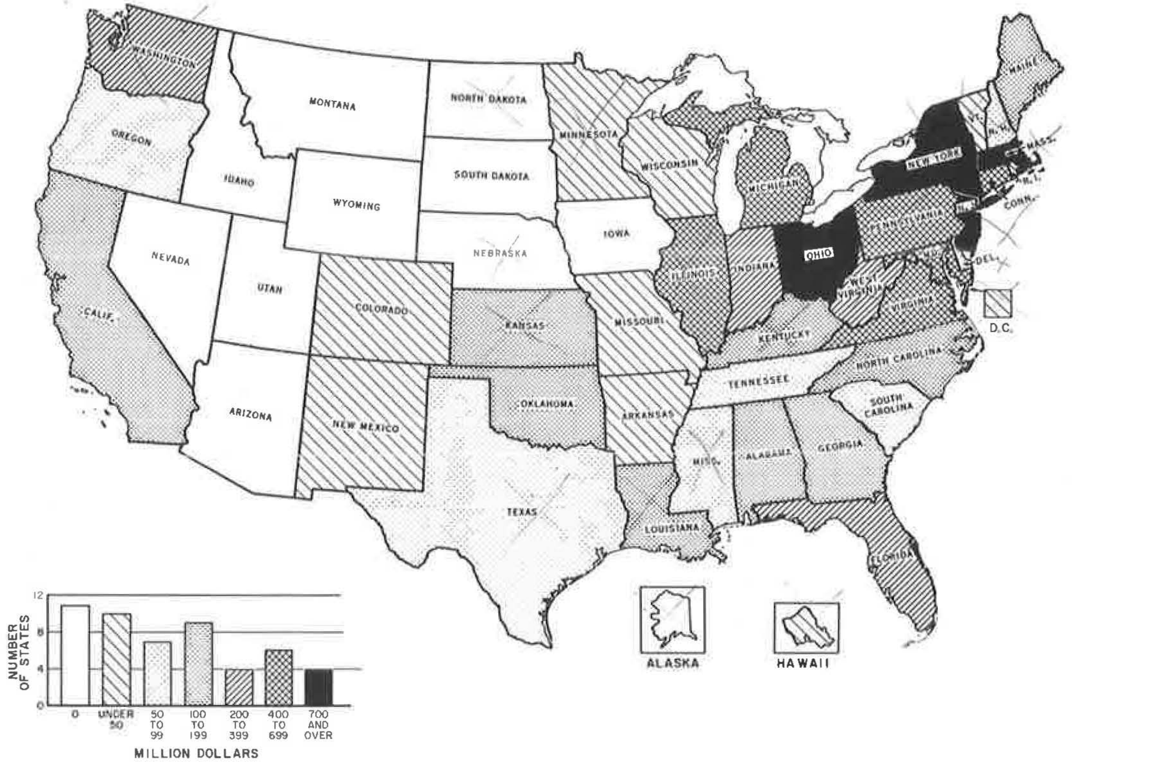

Figure 1. Borrowing States, 1950-60.

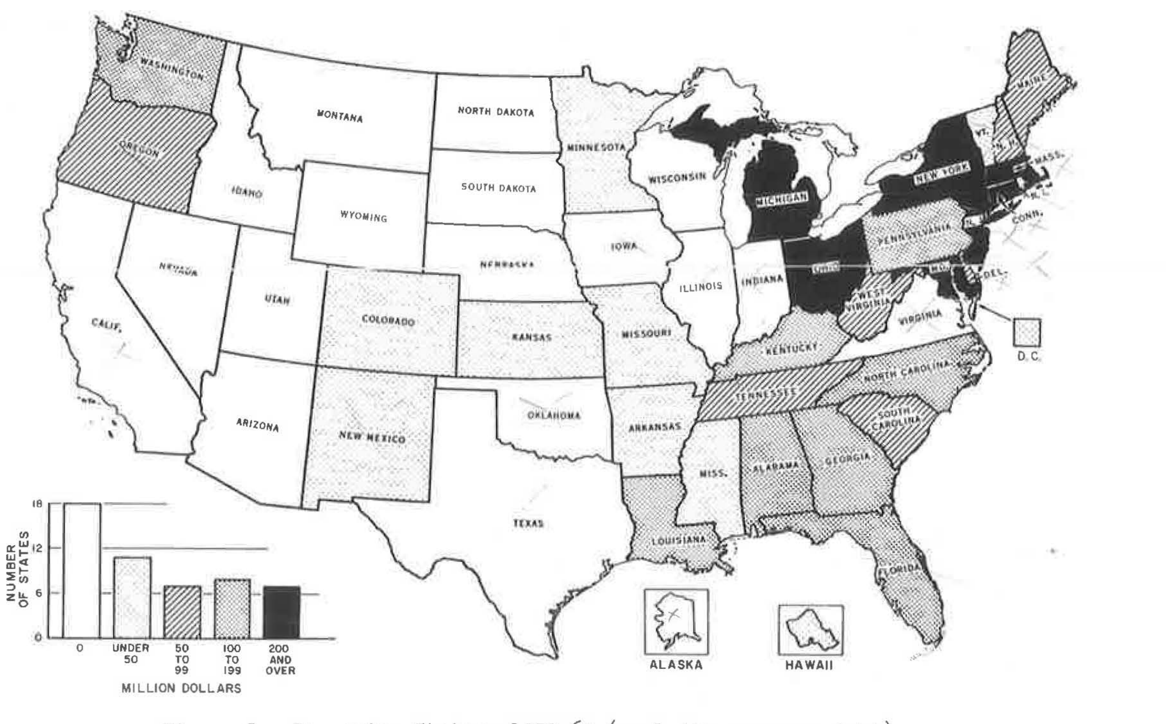

Figure 2. Borrowing States, 1950-60 (excluding revenue debt).

General obligation bonds were used by 19 States, and exclusively so in 4 States (Minnesota, North Carolina, Oregon, and Vermont). Sixteen States and the District of Columbia issued limited obligation bonds, and this was the only type of bond used by Colorado, Hawaii, and New Mexico. In the District of Columbia, the obligations consist of interest-bearing loans from the Federal Treasury.

Seven States assumed obligations of local governments, and this was the only type of debt incurred in one State (Wisconsin).

Highway bond financing by a selection of two of the three major types of obligations was found in 24 States, and 1 State (Connecticut) issued all three major types of bonds.

During the span of years covered in this paper, some States borrowed annually, or at least over a considerable period of years under authority of various bond-financed capital programs. Delaware, Massachusetts, New York, and West Virginia entered the bond market during each of the 11 years from 1950 through 1960 (Table 2). Several other States were nearly as active, issuing bonds in all but one or two of the years covered, whereas at the other extreme, among those States that borrowed, Indiana sold bonds only in 1954, and North Carolina has not marketed bonds since 1951. Bond sales are recorded for Hawaii only in 1959, the year of Statehood; but the Territory sold highway bonds in all but one of the preceding nine years.

The most active year in terms of magnitude of bond issues was 1954 when $2.3 billion of highway bonds were sold by 26 States. However, 1958 saw the most States (27) enter the bond market. In no year did less than 18 States issue bonds, and the average during the period was 22 States.

Table 3 and Figure 3 show that outstanding highway debt at the beginning of the study

TABLE 2

HIGHWAY OBLIGATIONS ISSUED OR ASSUMED BY THE STATES, 1950-60[1]

($ × 10^3)

State	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	Total
Ala.	-	784	25,000	323	-	16,944	15,000	21,317	4,000	20,000	25,160	128,528
Alaska	-	-	-	-	-	-	-	-	-	-	-	-
Ariz.	-	-	-	-	-	-	-	-	-	-	-	-
Ark.	7,000	7,000	-	-	-	-	-	-	-	7,000	-	21,000
Calif.	-	8,350	14,024	65,000	-	46,000	-	-	-	34,000	-	167,374
Colo.	6,300	-	-	-	2,388	-	8,000	16,000	5,000	6,000	-	43,688
Conn.	-	-	-	-	100,000	-	100,000	150,000	77,000	70,900	35,440	533,340
Del.	2,000	8,900	7,500	7,455	8,045	3,559	10,441	13,050	18,675	10,700	9,350	99,675
Fla.	28,000	21,755	800	-	6,000	104,050	6,500	47,892	11,085	48,872	41,855	316,809
Ga.	-	-	-	9,750	27,535	14,500	15,500	35,000	44,700	-	-	146,985
Hawaii[2]	-	-	-	-	-	-	-	-	-	12,500	-	12,500
Idaho	-	-	-	-	-	-	-	-	-	-	-	-
Ill.	-	-	-	-	-	-	415,000	-	64,000	-	-	479,000
Ind.	-	-	-	-	280,000	-	-	-	-	-	-	280,000
Iowa	-	-	-	-	-	-	-	-	-	-	-	-
Kans.	-	-	-	-	160,000	-	-	19,500	-	-	-	179,500
Ky.	-	-	-	4,361	43,500	-	-	-	70,000	-	30,000	147,861
La.	10,000	-	-	15,500	81,400	-	-	-	8,100	30,000	30,000	175,000
Me.	-	-	13,500	78,206	-	-	4,600	-	5,500	9,500	-	111,306
Md.	25,000	25,000	-	25,000	172,253	40,048	16,567	32,088	27,657	26,986	21,684	412,283
Mass.	60,000	44,000	32,000	34,250	308,750	40,000	136,000	70,500	92,500	69,781	15,000	902,781
Mich.	-	-	80,000	20,000	109,800	5,000	61,000	52,000	100,000	75,000	84,250	587,050
Minn.	-	-	-	-	-	-	10,000	12,000	12,000	12,000	-	46,000
Miss.	2,218	8,400	-	9,960	13,000	5,159	-	2,500	4,000	11,000	7,000	63,237
Mo.	-	-	16,000	62	1,750	200	-	-	-	-	150	18,162
Mont.	-	-	-	-	-	-	-	-	-	-	-	-
Neb.	-	-	-	-	-	-	-	-	-	-	-	-
Nev.	-	-	-	-	-	-	-	-	-	-	-	-
N.H.	-	7,000	10,000	-	9,500	899	12,500	-	23,150	5,000	-	68,049
N.J.	75,500	180,000	55,000	270,000	182,200	40,600	25,000	-	-	-	-	828,300
N.Mex.	-	-	-	-	-	-	5,000	4,000	2,000	-	-	11,000
N.Y.	22,000	77,911	6,000	255,917	395,850	73,400	101,000	32,260	103,844	131,800	81,000	1,280,982
N.C.	75,000	75,000	-	-	-	-	-	-	-	-	-	150,000
N.Dak.	-	-	-	-	-	-	-	-	-	-	-	-
Ohio	-	-	326,000	-	30,000	52,000	75,000	128,500	125,000	31,000	-	767,500
Okla.	31,000	-	7,000	-	-	68,000	-	-	-	-	-	106,000
Ore.	-	15,000	15,000	42,000	-	-	-	20,600	-	-	-	92,600
Pa.	-	25,000	65,000	109,157	253,000	-	-	-	20,000	10,000	10,000	492,157
R.I.	-	-	5,000	-	7,000	3,100	-	10,000	10,000	-	-	35,100
S.C.	10,000	5,000	820	10,000	100	2,000	450	5,298	15,000	6,500	-	55,168
S.Dak.	-	-	-	-	-	-	-	-	-	-	-	-
Tenn.	-	725	-	17,000	-	-	-	-	15,000	10,000	10,000	52,725
Texas	338	-	-	533	77	58,500	-	-	-	-	-	59,448
Utah	-	-	-	-	-	-	-	-	-	-	-	-
Vt.	2,800	-	-	-	-	-	6,000	6,000	8,000	10,000	8,000	40,800
Va.	23,000	-	-	-	79,803	69,000	20,000	-	6,150	-	205,848	403,801
Wash.	-	17,150	500	54,710	2,590	782	20,175	22,203	30,150	15,450	55,900	219,610
W.Va.	18,500	7,500	117,000	8,500	42,000	2,000	3,000	1,400	10,000	5,000	7,600	222,500
Wis.	1,468	968	691	469	340	-	-	163	-	-	-	4,099
Wyo.	-	-	-	-	-	-	-	-	-	-	-	-
D.C.	-	-	-	-	-	-	-	-	-	-	2,000	2,000
Total	400,124	535,443	796,835	1,038,153	2,316,881	645,741	1,066,733	702,271	912,511	668,989	680,237	9,763,918

[1]Excluding refunding bonds. [2]Bonds issued during Territorial status before 1959 are omitted.

TABLE 3

TYPES OF STATE HIGHWAY OBLIGATIONS ISSUED, REDEEMED, AND OUTSTANDING, 1950-60[1]

($ x 10^3)

Type of Obligations	Outstanding Dec. 31, 1949	Issued 1950-60	Redeemed 1959-60	Outstanding Dec. 31, 1960
General obligation bonds	994,952	2,770,075	1,112,129	2,652,898
Limited obligation bonds	160,873	2,432,559	386,958	2,206,474
Toll revenue bonds	614,789	4,520,636	651,766	4,483,659
Reimbursement obligations	68,205	40,648	69,429	39,424
Total	1,838,819	9,763,918	2,220,282	9,382,455

[1]Excluding refunding issues.

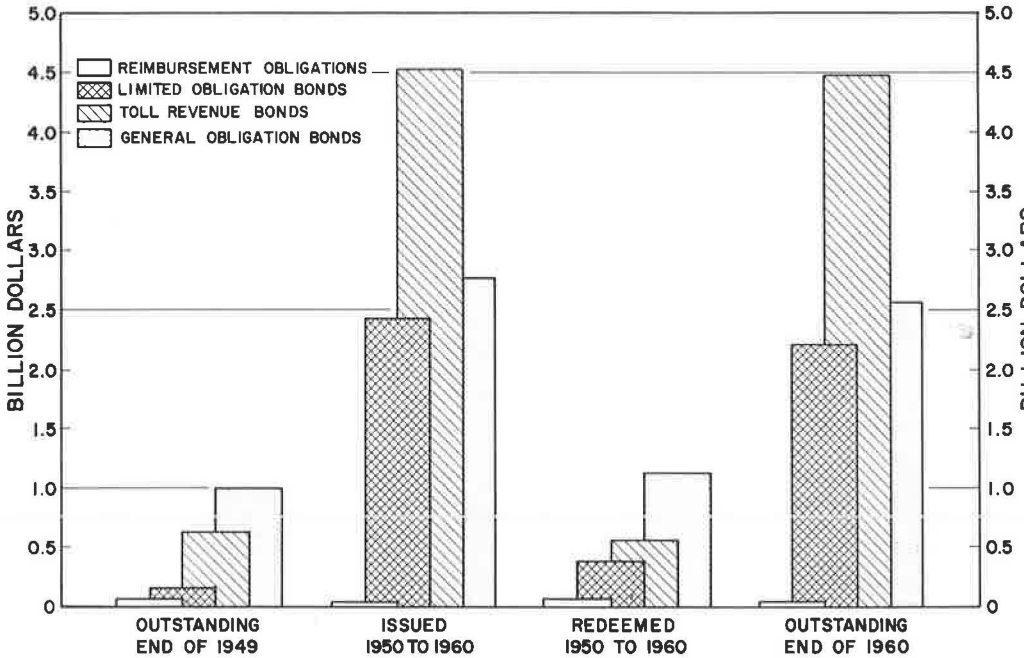

Figure 3. Types of State highway debt.

period totaled $1.8 billion. During the period 1950-60, $2.2 billion of bonds were redeemed, so that at the end of 1960, the $9.4 billion outstanding indebtedness of the States was only slightly less than the amount of bonds issued during the 11-year period.

With the exception of reimbursement obligations, the outstanding debt in each of the three major categories increased substantially, but not, however, at equal rates. General obligation debt increased from $995 million at the end of 1949 to $2,653 million at the end of 1960, or 2.67 times; toll revenue debt exceeded 7 times its 1949 level; and limited obligation debt showed more than a thirteenfold increase during this period.

Although revenue bond financing has occupied a position of prominence throughout the 1950's, and indeed into the 1960's, road-user tax bonds and other limited obligations have evidenced a significant increase, which is discussed later.

Borrowing by Local Governments

It is estimated that $2.5 billion of road and street debt of cities and other local municipalities was outstanding at the end of 1960 (Table 4) and that the road debt of counties, townships, and other rural governments would reach nearly $1.3 billion.

It is likely that the road and street debt of the municipalities has been understated. Many jurisdictions issue "general purpose" or "capital improvement" bonds and apply the proceeds to various capital projects including, but not specified as to, road and street improvements. Undoubtedly some of this debt escapes detection as a "highway" debt. However, municipal finance studies have been conducted in all but one State since 1954, and data for the later years may be expected to be reasonably inclusive.

Municipal highway debt has shown a much faster rate of growth than has that of counties and other rural governments. If the outstanding debt at the beginning of 1950 is assigned an index value of 100, by the end of 1960, municipal debt stood at 215.5 and local rural debt at 148.0 of the base year.

The more pervasive demand for credit financing by the municipalities compared with the rural units undoubtedly is due in part to the relatively greater State assistance for highways granted the rural units. In 1960, for example, municipalities applied $1.79 billion toward highway capital outlay, maintenance, administration, and debt service. Of this amount, $390 million (22 %) was derived from State grants-in-aid. Rural units applied about the same amount ($1.67 billion) for these purposes in 1960, but received $845 million in State grants (51 % of total) (1, Table HF-1). Thus, the municipalities have had to rely on their own financial resources much more than have the rural units. The latter, on the average, continue to enjoy a favored position with respect to State grants-in-aid and shared tax revenues.

Another factor, or course, has been the rapid growth of metropolitan areas and traffic volumes during the 1950's that has severely taxed the cities' resources in attempting to alleviate traffic congestion and at the same time to provide for expanded

TABLE 4

TYPES OF LOCAL GOVERNMENT HIGHWAY DEBT, ISSUED, REDEEMED, AND OUTSTANDING, 1950-60[1]

($ × 10³)

Issuing Government	Year	Issued			Redeemed			Outstanding at End of Year		
		General Obligation and Special Assessment Bonds	Toll Revenue Bonds	Total	General Obligation and Special Assessment Bonds	Toll Revenue Bonds	Total	General Obligation and Special Assessment Bonds	Toll Revenue Bonds	Total
Municipalities	1949	-	-	-	-	-	-	851,947	308,724	1,160,671
	1950	148,066	14,857	162,923	79,067	17,129	96,196	920,946	306,452	1,227,398
	1951	168,028	10,423	178,451	87,375	23,901	111,276	1,005,369	292,518	1,297,887
	1952	200,201	8,246	208,447	91,418	12,235	103,653	1,106,166	288,529	1,394,695
	1953	189,034	11,126	200,160	108,948	9,816	118,764	1,182,245	289,828	1,472,073
	1954	239,975	14,041	254,016	148,387	8,049	156,436	1,293,440	295,821	1,589,261
	1955	222,115	112,583	334,698	133,770	7,199	140,969	1,371,417	399,524	1,770,941
	1956	295,784	17,528	313,312	136,471	5,242	141,713	1,541,499	412,556	1,954,055
	1957	359,636	5,858	365,494	157,600	22,703	180,303	1,757,107	395,673	2,152,780
	1958	294,211	5,196	299,407	177,806	19,017	196,823	1,872,639	381,852	2,254,491
	1959	308,394	27,810	336,204	197,083	13,231	210,314	1,988,455	397,741	2,386,196
	1960[2]	234,000	102,000	336,000	200,000	20,000	220,000	2,022,000	480,000	2,502,000
Counties and other rural governments	1949	-	-	-	-	-	-	795,248	70,121	865,369
	1950	77,924	10,674	88,598	78,774	3,210	81,984	794,398	77,585	871,983
	1951	66,920	11,750	78,670	78,015	3,689	81,704	780,828	87,074	867,902
	1952	87,941	15,250	103,191	78,762	3,524	82,286	797,067	98,785	895,852
	1953	104,780	850	105,630	81,704	3,460	85,164	817,500	96,175	913,675
	1954	87,828	6,759	94,587	83,261	2,475	85,736	833,087	100,007	933,094
	1955	159,277	46,225	205,502	85,663	3,530	89,193	884,364	142,736	1,027,100
	1956	96,541	5,350	101,891	87,401	3,500	90,901	892,439	144,560	1,036,999
	1957	121,785	1,156	122,941	87,937	3,618	91,555	942,729	142,079	1,084,808
	1958	133,889	6,219	140,108	86,310	4,060	90,370	986,304	144,238	1,130,542
	1959	152,845	-	152,845	87,443	4,641	92,084	1,045,571	140,543	1,186,114
	1960[2]	189,000	1,000	190,000	90,000	6,000	96,000	1,145,000	135,000	1,280,000

[1]Excluding refunding bonds and short-term notes. When it was not possible to distinguish between toll revenue bonds and general obligations issued for toll facilities, both were included as toll bonds. Computed outstanding debt does not necessarily balance issues and redemptions because of incomplete data.

[2]Estimated.

services of all types. Many of the counties and other so-called rural units have been faced, too, with the need for expanded credit financing programs brought about by the climbing demand for highway and other public works, particularly in the metropolitan counties where the population explosion has occurred.

General obligation bonds are the predominant type of local issues, although recently an upward trend in the issuance of special assessment paper by municipalities has been evident, but in many instances these, too, are guaranteed by the issuing authority. The nonguaranteed assessment bonds are not popular, and are least acceptable to the bond market.

Local toll revenue bond financing, though small in proportion, has been firm throughout the 1950-60 period. Concentrated within a few States, the revenue bond has been used to finance local toll crossing facilities, frequently by means of the authority device.

Compared to the States, the local governments have made by far the greater use of short-term obligations. Short-term financing has been used in the main to anticipate the collection of current taxes or in the form of bond anticipation notes. Further reference to short-term financing is made later in this study.

Table 5 and Figure 4 show the gross amount of State and local highway debt outstanding at the end of each of the years 1950-60. State obligations accounted for about one-half of all highway debt in 1950, but had risen to more than two-thirds by 1960.

Magnitude of Existing Debt

In comparison with total public and private debt, or even in terms of public debt alone, the $13.2 billion of outstanding State and local highway borrowing at the end of 1960 does not assume a dominant role. According to the 1961 annual report of the Council of Economic Advisors (4), the Nations's net public and private debt stood at $882.9 billion at the end of 1960. The composition of this debt and its growth since 1950 (Table 6) is indicative of the demand for credit financing in the economy.

Although modest in terms of total debt, the obligations of State and local governments, which include both highway and nonhighway issues, have shown the largest percentage increase since 1950, save that of mortgage debt, of any class of obligation.

TABLE 5

GROSS HIGHWAY DEBT OUTSTANDING BY ALL UNITS OF GOVERNMENT, 1950-60[1]

($ × 10^6)

Year	States	Counties and Other Local Rural Units	Municipalities	Total
1950	2,096	872	1,227	4,195
1951	2,476	868	1,298	4,642
1952	3,116	896	1,395	5,407
1953	4,006	914	1,472	6,392
1954	6,155	933	1,589	8,677
1955	6,609	1,027	1,771	9,407
1956	7,491	1,037	1,954	10,482
1957	7,936	1,085	2,153	11,174
1958	8,598	1,131	2,254	11,983
1959	9,002[2]	1,186	2,386	12,574
1960	9,382	1,280[3]	2,502[3]	13,164

[1]Values include debt of highway toll authorities.
[2]Hawaii included in 1959 and following year.
[3]Estimated.

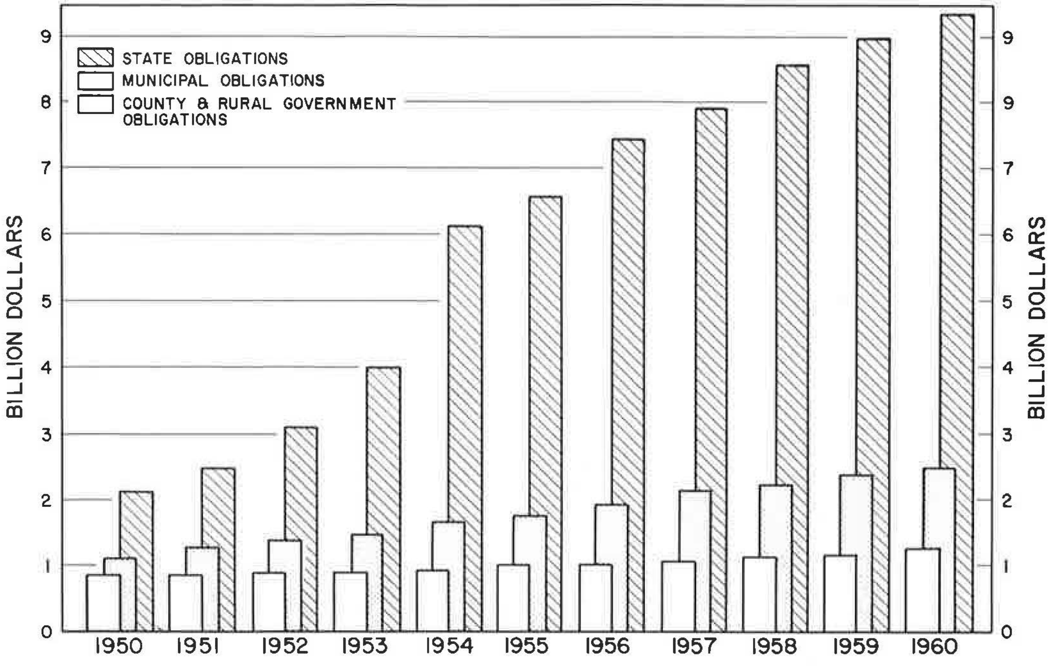

Figure 4. Gross highway debt outstanding, 1950-60.

TABLE 6

NET PUBLIC AND PRIVATE DEBT
($ × 10^9)

Type of Debt	1950	1960	Percentage Increase
Public:			
Federal government	218.7	241.0	10.2
State and local governments	20.7	60.0	189.8
Private:			
Corporate	142.1	295.0	107.6
Farm	12.2	25.4	108.2
Mortgage	59.4	173.9	192.8
Commercial and consumer	37.2	87.6	135.5
Total	490.3	882.9	80.1

Lest this comparison suggest an unwarranted degree of abandon in State and local borrowing policies, it is necessary to examine the highway debt component in terms of other related factors. One of these is automobile credit paper. Table 7 and Figure 5 compare the extension of credit on vehicle purchases with highways borrowings, and the amount of each outstanding at the end of the years 1950-60. Although this comparison is between short-term automobile credit, and long-term highway borrowing, and thus is imprecise on its face, the public acceptance of credit financing to acquire highway vehicles would seem to parallel similar acceptance of credit financing to acquire the modern highway plant such vehicles use demands.

TABLE 7

TOTAL HIGHWAY BONDS ISSUED AND OUTSTANDING, AND INSTALLMENT CREDIT ON PASSENGER CARS EXTENDED AND OUTSTANDING, 1950-60
($ $\times 10^6$)

Year	Installment Credit Extended on New and Used Passenger Cars During Year[1]	Total Highway Bonds Issued During Year	Installment Credit Outstanding at End of Year on New and Used Passenger Cars[1]	Total Highway Debt Outstanding at End of Year
1950	8,530	652	6,074	4,195
1951	8,956	793	5,972	4,642
1952	11,764	1,108	7,733	5,407
1953	12,981	1,344	9,835	6,392
1954	11,807	2,665	9,809	8,677
1955	16,745	1,186	13,472	9,407
1956	15,563	1,482	14,459	10,482
1957	16,545	1,191	15,409	11,174
1958	14,316	1,352	14,237	11,983
1959	18,001	1,158	15,590	12,574
1960	18,250	1,206[2]	18,350	13,164[2]

[1] Board of Governors of Federal Reserve System, quoted in "Automobile Facts and Figures" (1961).
[2] Debt of local governments estimated.

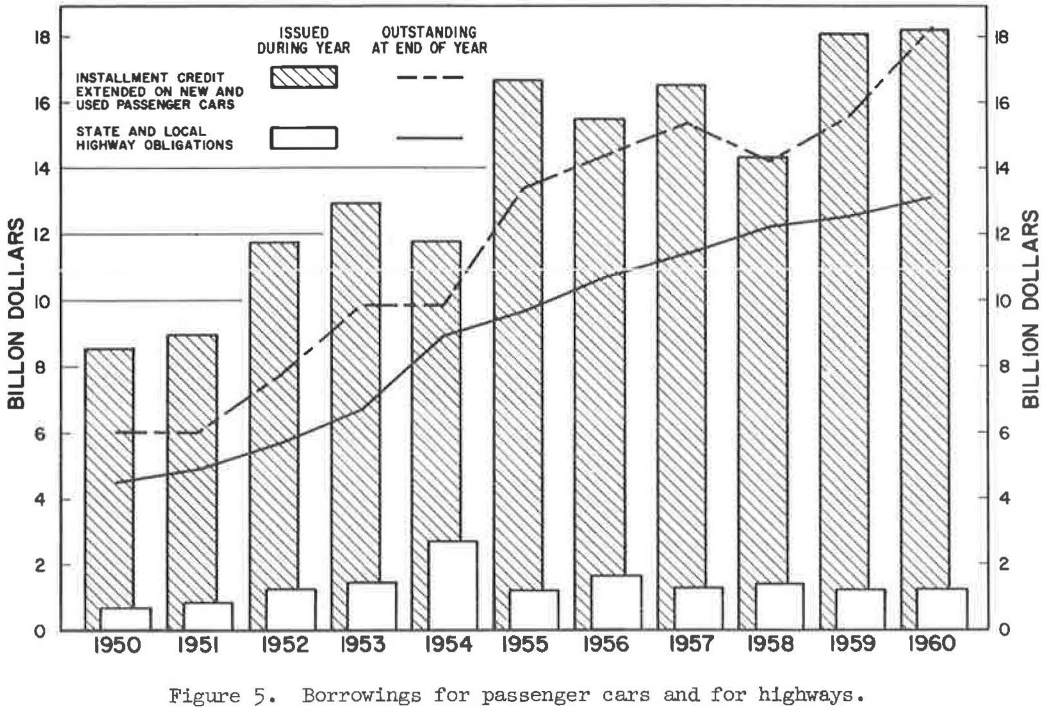

Figure 5. Borrowings for passenger cars and for highways.

The relative burden of highway debt is also measured by the degree to which credit financing draws on tax revenues for debt service. Table 8 compares for 1960 the amounts of State road-user tax revenues available to the States for highway purposes, with the portions of such revenues allocated for debt service; i. e., for interest and redemption of bonds. Because these taxes can be pledged only for general and limited obligation bonds, there is no claim on them to service the revenue debt of the States. In computing the amount of revenues available to the States, nonhighway allocations and payments of grants-in-aid to local governments are deducted.

Thirty-four States paid debt service in 1960 from road-user tax revenues, although in 4 States (Delaware, New Jersey, New York, and Rhode Island) payments technically were made from a general revenue fund into which road-user taxes were deposited, and thence considered to be drawn on for debt service.

Nationwide, 8. 58 percent of available revenues in 1960 were assigned to debt service on State obligations. Excluding the nonborrowing States, this percentage rises to 10. 57. The median payment in Table 9 interpolates to 13. 71 percent of revenues, with a range from a low of 0. 27 percent in Tennessee to a high of 58. 76 percent in Delaware. Only 6 States assigned as much as 25 percent of revenues to debt service, and in only 3 of these States did the total exceed one-third of revenues.

Figure 6 shows the geographic distribution of 1960 payments for debt service from road-user tax revenues. It is significant that of the 7 States having the greatest amounts of borrowings (Fig. 2), only three (Maryland, Massachusetts, and Michigan) also appear among those States assigning 25 percent or more of revenues to debt service (Fig. 6). Thus, the magnitude of the debt is not necessarily indicative of the relative burden such debt places on the State's resources. Table 8 and Figure 6 show that in only a few of the borrowing States has highway debt service reached significant levels, based on the magnitude of indebtedness at the end of 1960.

TABLE 8

STATE SHARE OF ROAD-USER TAX REVENUES AVAILABLE FOR HIGHWAYS, 1960, COMPARED WITH PORTION ALLOTTED FOR DEBT SERVICE[1]

($ × 10^3)

State	State Share, Road-User Tax Revenues[2]	Portion for Debt Service	
		Amount	Percent
Ala.	48,765	9,223	18.91
Alaska	4,583	-	-
Ariz.	29,256	-	-
Ark.	40,823	8,819	21.60
Calif.	340,412	2,135	0.63
Colo.	34,764	3,607	10.38
Conn.	42,375	2,045	4.83
Del.	11,642	6,841	58.76
Fla.	114,590	12,955	11.31
Ga.	75,662	10,093	13.34
Hawaii	7,948	3,876	48.77
Idaho	17,205	-	-
Ill.	131,215	-	-
Ind.	75,656	-	-
Iowa	70,214	-	-
Kans.	52,865	-	-
Ky.	78,941	3,737	4.73
La.	64,293	15,326	23.84
Me.	29,648	4,110	13.86
Md.	53,360	16,249	30.79
Mass.	86,649	39,728	45.85
Mich.	109,105	28,148	25.80
Minn.	68,052	3,367	4.95
Miss.	29,153	6,046	20.74
Mo.	83,902	803	0.96
Mont.	21,134	-	-
Neb.	30,327	-	-
Nev.	9,379	-	-
N.H.	20,529	4,687	22.83
N.J.	129,641	2,846	2.20
N. Mex.	29,222	2,849	9.75
N.Y.	271,577	24,340	8.96
N.C.	123,421	15,030	12.18
N. Dak.	14,930	-	-
Ohio	192,338	30,786	16.01
Okla.	44,558	-	-
Ore.	44,476	6,886	15.48
Pa.	210,587	8,763	4.16
R.I.	12,820	2,290	17.86
S.C.	51,947	7,042	13.56
S. Dak.	18,851	-	-
Tenn.	58,376	159	0.27
Texas	221,537	661	0.30
Utah	22,623	-	-
Vt.	10,815	2,844	26.30
Va.	94,247	-	-
Wash.	56,212	8,489	15.10
W. Va.	58,170	8,185	14.07
Wis.	61,040	339	0.65
Wyo.	13,567	-	-
D.C.	13,736	-	-
Total	3,537,138	303,544	8.58
Total, borrowing States	2,872,792	303,544	10.57

[1] Data from BPR table DF in "Highway Statistics 1960."
[2] Excluding nonhighway allocations and amounts paid as highway grants-in-aid to local governments.

Constitutional Prohibitions and Limitations

The growing popularity of revenue and limited obligation bonds can be attributed in a large measure to the limitations and restrictions on general obligation bond issues which require as security a pledge of the general credit of the State. The nonguaranteed obligations require no such

TABLE 9

LOCATION OF AUTHORITY TO BORROW FOR STATE PURPOSES AS OF JANUARY 1, 1962

In Electorate		In Legislature
By Constitutional Amendment	By Referendum	
Ala.	Alaska	Conn.
Ariz.	Ark.	Del.
Colo.	Calif.	Hawaii
Fla.	Idaho	Md.
Ga.	Ill.	Mass.
Ind.	Iowa	Miss.
La.	Kans.	N. H.
Mich.	Ky.	N. Dak.
Minn.	Me.	S. C.
Neb.	Mo. [a]	Tenn.
Nev.	Mont.	Vt.
N. Mex.	N. J.	
Ohio	N. Y.	
Ore.	N. C.	
Pa.	Okla.	
S. Dak.	R. I.	
Texas	Wash.	
Utah		
Va.		
W. Va.		
Wis.		
Wyo.		

[a]Authority may be granted either by constitutional amendment submitted by the legislature or on initiative by the people. To avoid duplication, State is listed only once.

pledge, and the courts have usually held that the issuance of such bonds does not come under the purview of general constitutional prohibitions and limitations on State borrowing.

The present restrictions on the legislatures' power to pledge the States' credit reflect the efforts of the electorate to correct the evils of capricious borrowing and the accompanying financial embarrassment that arose from time to time in the 19th century[3].

The constitutional restriction on State borrowing is not, of course, an absolute ban, because it can be modified or eliminated by amendment. Its chief functions have been to provide for a delaying action when a question involving a pledge of the State's credit is concerned, and also to compel the submission of proposed loans to popular referendum.

Although the present constitutional limitations on State borrowing are extremely varied and individualistic, they can be di-

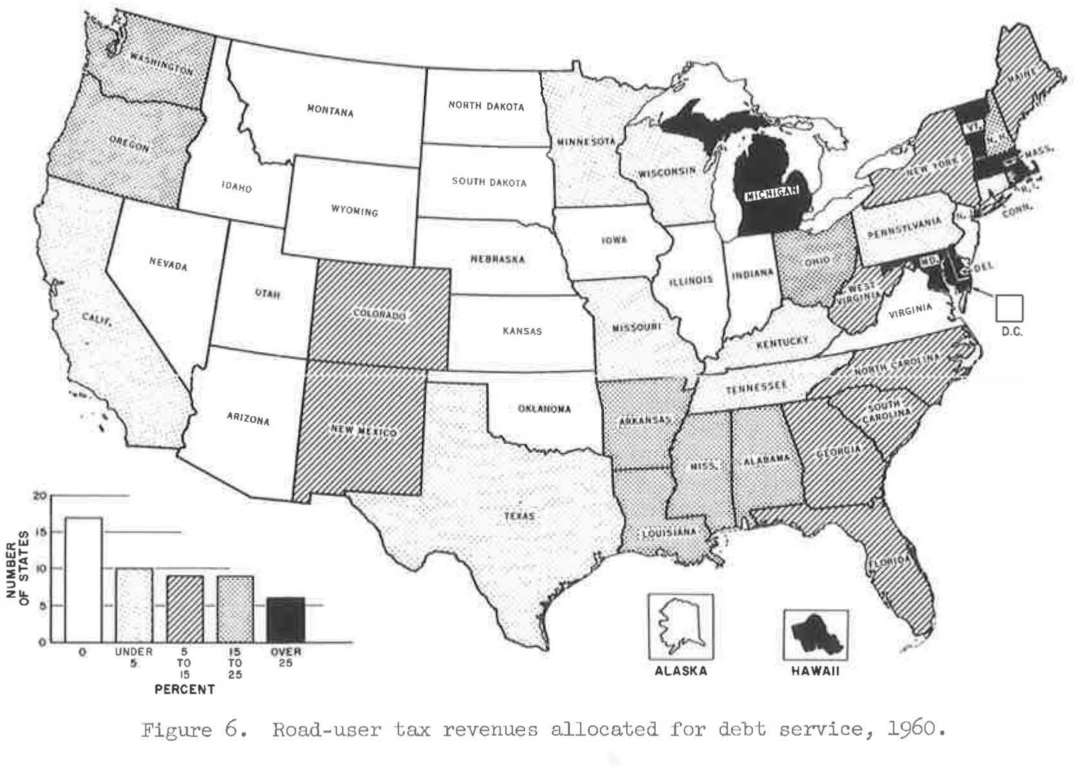

Figure 6. Road-user tax revenues allocated for debt service, 1960.

[3]Further discussion given elsewhere (5,6).

vided for purposes of analysis, into three groups according to the methods used to regulate borrowing. Table 9 gives the States according to those groupings.

The constitutions of 22 States flatly prohibit borrowing, with the usual exceptions for such purposes as meeting casual deficits, refunding prior debts, repelling invasion, suppressing insurrection, and defending the State. In these States each proposal involving borrowing must be authorized by a constitutional amendment approved by the electorate, under various prescribed procedures.

In the second group of States, the procedure is not as elaborate, and borrowing can be accomplished by means of a popular referendum. In these 17 States the electorate also make the final decision.

The third group consists of 11 States in which the authority to incur debt is vested in the legislature without necessity for popular approval. The legislature may assume this authority in cases where the constitution is silent regarding debt limitations, or where the limitation is so general as to impose no real restriction on the borrowing power of the legislature. South Carolina has been included in this group, although the constitution requires that any bond issue must be approved by popular referendum. In practice, the legislature in that State as early as 1929 authorized highway bond issues not to exceed $65,000,000 without a referendum vote. Subsequent laws have raised the limits to $70,000,000. Within this ceiling, the State may issue bonds whenever desired.

It is possible, of course, for the States in either the second or third groups to authorize borrowing by means of a constitutional amendment, if this procedure is found desirable. Similarly, the States in the third group may submit proposals to popular vote, even though such action is not required. However, in some States there is a limit on borrowing even though approved by popular vote[4].

Table 10 compares the borrowing pattern of the States relative to the degree of constitutional limitations on borrowing. Both the lateral and vertical comparisons in this table are useful in measuring the effect of statutory restrictions on the type of bond program selected. Figure 7 also shows these comparisons.

Among the 22 States that require a constitutional amendment to issue guaranteed bonds, only 5 issued this type of highway bond, and in the modest amount of $348 million. Yet this same group of States accounted for $3.8 billion of all debt incurred during the period, and in the process issued 65 percent of all limited obligations, and 40 percent of all toll revenue bonds. Thus, although constitutional restrictions have had an influence on the issuance of general obligation bonds in these States, they have been largely ineffectual in restricting highway debt financing as a whole. In effect, these States have found it expedient to turn to the use of nonguaranteed bonds, despite the higher financing costs that these almost invariably entail.

Among those States that require referendum approval of bonding (technically a less stringent requirement than that of the constitutional amendment) a somewhat different pattern emerges. A much greater proportion of the borrowing in these States was by general obligation bonds; yet even here, nonguaranteed bonds accounted for nearly two-thirds of the debt incurred.

The third group of States, in which the choice of borrowing is determined by the legislature, made by far the greater use of guaranteed obligations. Here, given a somewhat greater freedom of choice, nearly one-half of all borrowings were by means of general obligation bonds.

In summary, it must be evident that the demands for highway capital funds to finance urgently-needed facilities, or even to finance Statewide accelerated highway programs, have encouraged the circumvention of constitutional barriers to State-created debt, either by the less frequent, but direct, method of the amendatory or referendum process or by the speedier, and hence more popular, device of the nonguaranteed bond which requires no approval by the electorate. The cost to the public of financing with nonguaranteed bonds is almost invariably higher than with general obligation bonds, but this may be accepted as a justifiable premium by those States that wish to avoid the consequences and delays in seeking voter approval of a guaranteed bond issue.

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[4] Additional discussion given elsewhere (7, p. 38 et seq.).

TABLE 10

STATE BORROWING FOR HIGHWAYS, 1950-60, RELATIVE TO CONSTITUTIONAL RESTRICTIONS ON GUARANTEED STATE DEBT
($ × 10^3)

Type of Debt	To Issue Guaranteed Bonds			Total Bonds Issued
	Requires Electorate to Approve		Requires Only Legislative Approval (11 States)	
	Constitutional Amendment (22 States)	Referendum Proposal (17 States)		
Guaranteed Bonds:				
Amount issued ($1,000)	348,100	1,352,960	1,069,015	2,770,075
Number of States	5	7	7	19
Percent of line total	12.6	48.8	38.6	100.0
Percent of column total	9.2	36.1	47.7	28.4
Limited obligation bonds:				
Amount issued ($1,000)	1,577,827	183.753	668,979	2,430,559
Number of States	9	3	4	16
Percent of line total	64.9	7.6	27.5	100.0
Percent of column total	41.8	4.9	29.9	24.9
Toll Revenue bonds:				
Amount issued ($1,000)	1,814,538	2,207,420	498,678	4,520,636
Number of States	9	12	8	29
Percent of line total	40.1	48.9	11.0	100.0
Percent of column total	48.0	58.9	22.2	46.3
State-assumed debt:				
Amount issued ($1,000)	36,700	62	3,886	40,648
Number of States	4	1	2	7
Percent of line total	90.2	0.2	9.6	100.0
Percent of column total	1.0	0.1	0.2	0.4
All obligations:				
Amount issued or assumed ($1,000)	3,777,165	3,744,195	2,240,558	9,761,918
Number of States	16	13	10	39
Percent of line total	38.7	38.3	23.0	100.0
Percent of column total	100.0	100.0	100.0	100.0

Federal Role in Borrowing

A section of the Federal Highway Act of 1950 (later codified as Section 122, Title 23, U. S. Code) provided that any State or local government that issues bonds and uses the proceeds to accelerate construction of toll-free facilities on the Federal-aid Interstate or primary systems, or extensions of Federal systems within urban areas, may apply authorized Federal funds to aid in the retirement of such bonds[5]. The Act stipulates that (a) the proceeds of such bonds must have been actually expended in the construction of the Federal-aid systems, (b) the construction is in accordance with plans and specifications approved in advance by the Bureau of Public Roads, (c) payments shall not exceed the pro rata Federal share specified by law, and (d) payments shall be made from funds authorized by Congress, and no commitment or obligation exists to provide such payments in the absence of Congressional authorizations.

Federal funds may not be claimed in reimbursement of interest payments nor for bond proceeds expended on the Federal-aid secondary system.

That the States have found this provision of Federal law useful in accelerating highway programs, is attested to by the fact that, at the end of December 1961, bond-financed programs totaled nearly $395 million, of which the Federal fund share was over $253 million (Table 11).

Although this program is in no sense a Federal lending device but rather results in postponing reimbursement of the Federal share of authorized Federal-aid projects, it does have two advantages to the States: (a) programs involving Federal-aid work can be planned and financed in advance of the availability of Federal funds (the expenditure

[5] P.L. 769, §5, 81st Congress. Also codified as 23 U.S.C. 122.

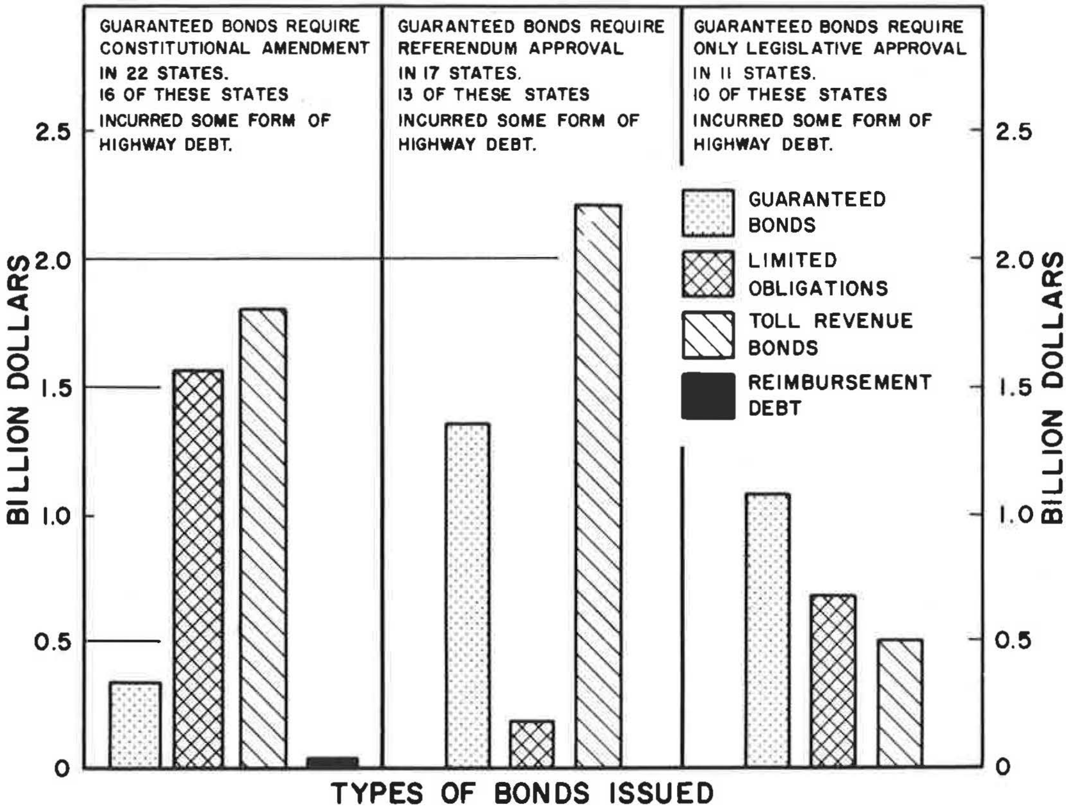

Figure 7. State borrowing for highways, 1950-60, relative to constitutional restrictions on guaranteed State debt.

TABLE 11

BOND FINANCED PROJECTS IN ANTICIPATION OF FEDERAL AID AS OF DECEMBER 31, 1961

State	No. of Projects	Cost ($ x 10⁶) Total	Cost ($ x 10⁶) Federal Funds	Miles	Bridges
Colo.	18	8.9	4.7	41.7	12
Fla.	2	3.8	3.5	-	-
Hawaii	16	30.9	15.0	30.9	27
Ill.	154	143.1	111.8	20.8	63
Me.	1	3.7	1.8	3.8	3
Mich.	90	110.9	55.4	207.2	110
Minn.	1	2.2	1.1	0.2	1
N.H.	5	5.4	2.6	8.5	5
Ore.	50	47.2	27.5	228.4	89
Wash.	38	38.5	29.8	83.5	36
Total	375	394.6	253.2	625.0	346

of which is governed by availability of revenues in the Federal Highway Trust Fund), thus permitting the State to accelerate its Federal-aid program where desirable and feasible to do so, and (b) Federal funds may be claimed at times, and in the amounts, determined by the maturity schedule of the bond issue, thus reducing the demand for State funds for debt service during the period that the bonds are maturing. In this manner, a minimum of current State tax revenue need be committed for the cost of financing the accelerated bond issue construction program.

Short-Term Financing

As used in this study, short-term financing has reference to obligations issued for a term of two years or less. Usually these obligations take the form of repayable advances, tax anticipation warrants, or bond anticipation notes. This form of borrowing, used rather frequently by local governments, has not been extensively employed by the States to finance highway capital expenditures. Notable exceptions to this, however, have occurred in recent years, and particularly in connection with the financing of toll projects.

The 1947 New Hampshire legislature authorized construction of a toll road from Seabrook to Portsmouth and granted the State treasurer authority to borrow $7.5 million for this purpose. However, during the period of construction the entire cost was financed from the proceeds of 90-day renewable notes purchased by Boston banks. By this device, the State was able to effect a savings in interest expense during construction by drawing down funds only as needed. The discount rate was scaled from 0.635 percent per annum on the first sale in March 1949 to a peak of 1.04 percent on a December 1950 renewal. The average annual rate was slightly under 1 percent. In 1951, these notes were retired from the proceeds of a $7 million general obligation serial bond issue bearing a coupon rate of 1.6 percent. Thus, the interest savings during construction was in the area of two-thirds of a percentage point.

The Delaware River Joint Toll Bridge Commission used short-term notes to supplement a regular bond sale and provide funds primarily for construction of a toll bridge between Trenton, N. J., and Morrisville, Pa. These bond anticipation notes were sold in 1949 at a coupon rate of 1¾ percent, and were funded in 1950 from proceeds of a revenue bond issue with a coupon rate of 2.3 percent. Here again, a savings of more than ½ percent interest was realized during the initial construction period.

On a broader scale, the New Jersey Turnpike Authority obtained its original financing by means of a "forward commitment" agreement with some 50 institutional investors whereby the Authority was able to defer the immediate sale of $220 million of 3¼ percent revenue bonds, and draw down only the amounts required to meet construction costs as they came due. The forward commitment provided for interest at a standby fee of 0.5 percent on the undrawn balance. By this device, the Authority was able to realize a considerable savings in interest cost.

The New York Thruway Authority also obtained its first financing with short-term notes; a $10 million loan in 1950, and a $60 million load in 1952, the latter bearing an interest cost of 1.1 percent. These were sold to a syndicate of 21 banks. In 1953, the notes were retired from proceeds of the Authority's first issue of State-guaranteed bonds, sold at a net interest cost of 2.638 percent. More recently, the Authority borrowed $50 million in April 1959, on State-guaranteed notes at an interest cost of 2.15 percent. These were renewed one year later for an additional six months at a rate of 2⅝ percent per year, and were subsequently funded in September 1960 from proceeds of a State-guaranteed bond issue sold at a net interest cost of 3.46124 percent. As a result of the short-term financing, and hence postponement of the bond issue, the Authority (8, p. 40) estimates savings of $7 million over the life of the bond issue.

Several States have recently sold notes in anticipation of the receipt of Federal-aid funds or in anticipation of the sale of bonds to finance Federal-aid construction. Typical of these is Rhode Island where the legislature in 1960 authorized, subject to referendum approval, issuance of State-guaranteed notes during the fiscal years 1960-72[6]. These

[6] Ch. 86, P.L. 1960, ratified May 24, 1960.

notes are issued in anticipation of receiving reimbursement from the Federal Government for the Federal share of the cost of the Interstate System in Rhode Island. The Act stipulates the principal amount of notes that can be outstanding at any one time, with a maximum of $63 million for the 1965-66 fiscal year. The notes may be sold at public auction or private sale, or to the State board of commissioners of sinking funds. Each Interstate note may be issued for a period of no more than two years, but may be refunded or renewed for additional two-year terms. Final maturity, however, must occur not later than eight years from the date of original issue. Proceeds from the sale of notes are placed in a special account, the "interstate reimbursement fund," and expended only for the purposes of financing the Federal share of the cost of the Interstate System. All receipts of the Federal Interstate highway monies are deposited in the fund, and are used to discharge the notes.

Companion bills approved by the electorate of Rhode Island grant authority for the State to issue bonds and bond anticipation notes, and to finance the State's share of the cost of the Interstate System and of the Federal-aid primary and secondary systems[7].

Under these statutes, the State issued Interstate and bond anticipation notes in 1960-61 (Table 12) at interest rates of 1.5 to 1.8 percent. As an illustration of the interest rate differential, Rhode Island sold $6 million of highway improvement loan bonds in April 1961 at a coupon rate of 3½ percent. Thus for interim financing purposes, the State has been able to realize substantial interest savings from its short-term loan program.

Both Connecticut and Delaware have authorized issuance of highway bond anticipation notes in connection with bond-financing programs[8]. Connecticut, for example, sold on October 28, 1959, two series of one-year bond anticipation notes: Series A in the amount of $15 million, at a rate of 2.9256 percent, and Series AA for $10 million, at a rate of 2.94 percent. However, when these notes were retired in 1960 from proceeds of definitive bonds, the latter carried a coupon rate of only 2.90 percent. In this instance, there seems to have been no advantage in short-term financing, and the State has not subsequently sold anticipation notes of this type.

Two other methods of anticipatory borrowing have been used by the States to a varying degree. The first of these comprise appropriation advances or repayable advances from State sources other than regular highway funds. New York, for example, has for many years made annual "first instance" appropriations out of State general funds, for the purpose of providing the anticipated Federal share of the cost of Interstate and other Federal-aid system projects. The fiscal year 1963 budget (9, pp. 705-908), for example, recommends an appropriation of $177 million as an advance of the Federal-aid apportionment expected to be made in August 1962. Because the apportionment to be made at approximately that time will be for fiscal 1964 and must be obligated not later than the end of fiscal 1966, with final reimbursements of Federal funds probably extending beyond that date, the effect of the "first instance" appropriation by the legislature is to make available an interest-free loan in anticipation of the receipt of Federal funds. Because of the interest-free feature, this method of financing offers a savings in highway costs compared to interest-bearing anticipation notes.

The other method used rather extensively during the 1950's, stems from a provision in Federal highway statutes, permitting advances to the States of the Federal share of the cost of projects on any of the Federal-aid systems, including the Interstate system[9]. Following adoption in 1956 of the accelerated Federal-aid highway programs, a number of States applied for and were granted advances to expedite financing of the program.

During the 3-year period 1956-58, advances totaling $43,375,000 were made to 16 States. However, in subsequent years, the Bureau of Public Roads has discouraged further advances in order to provide better control of available Federal-aid funds and avoid possible deficits from occurring in the Federal Highway Trust Fund. Nonetheless, this method has been useful to many States in meeting the impact of an expanded highway program.

[7] Chs. 85 and 88, Public Laws 1960.
[8] Conn., P.A. No. 132, 1959 Session; Del. H.B. 221, ch. 40, vol. 53, Laws of Delaware, approved 1961.
[9] §6, Federal-Aid Highway Act of 1944 (58 Stat. 838) codified as 23 U.S.C. 124.

TABLE 12

RHODE ISLAND SHORT-TERM FINANCING, 1960-61

Type	Purchaser	Interest Rate (%)	Par Value ($1,000)	Issued	Matures
Interstate notes	Morgan Guaranty Trust Co., N.Y.	1.625 & 1.75	4,000	12/9/60	6/9/61
	Industrial National Bank, Providence, R.I.	1.70	1,000	12/9/60	6/9/61
	First Boston Corp., N.Y.	1.55	500	12/9/60	6/9/61
Bond anticipation notes	Morgan Guaranty Trust Co., N.Y.	1.70	2,000	12/9/60	6/9/61
Interstate notes	Morgan Guaranty Trust Co., N.Y.	1.50	1,500	6/9/61	2/9/62
		1.55	8,500	6/9/61	2/9/62
	Solomon Bros., & Hutzler, N.Y.	1.65 & 1.70	7,750	2/9/62	11/9/62
		1.80	7,000	2/9/62	5/9/63
	Morgan Guaranty Trust Co., N.Y.	1.65 &	1,250	2/9/62	11/9/62
		1.80	2,000	2/9/62	5/9/63

Local governments, both counties and municipalities, make proportionately greater use of short-term financing than do the States. Table 13 compares the reported amounts of short-term road and street obligations issued by local governments during the four years 1956-59, with the amounts of long-term debt issued.

The large increase noted in sales by municipalities in 1959 was the result of issues totaling $100 million by the Triborough Bridge Authority of New York. This Authority's definitive bonds, issued in 1952 in the amount of $215 million, carry maximum coupon rates of 2⅛ percent, whereas the 1959 notes were sold at 2½ and 3 percent interest, reflecting, of course, the rising cost of borrowing during this period. The 3 percent notes, incidently, were retired in 1960 from the proceeds of a $100 million bond issue sold at a net interest cost of 4.033408 percent.

Authority Device

The use of the public corporation, or authority, as a device to build and operate public enterprises is not new, even in the highway field, but its widespread development and acceptance during the 1950's has been an economic phenomenon. According to Preston (10), the number of State and local authorities reached a total of approximately 1,800 by the beginning of 1959, exclusive of housing and redevelopment authorities.

TABLE 13

A COMPARISON OF SHORT-TERM NOTE AND LONG-TERM BOND ISSUES BY LOCAL GOVERNMENTS FOR ROADS AND STREETS, 1956-59 ($ × 10^3)

Year	Counties and Townships			Municipalities		
	Bonds	Notes	Percent Notes Are of Bonds	Bonds	Notes	Percent Notes Are of Bonds
1956	101,891	22,989	22.6	313,312	51,047	16.3
1957	122,941	17,759	14.4	365,494	59,792	16.3
1958	140,108	25,180	18.0	299,407	46,212	15.4
1959	152,845	28,156	18.4	336,204	165,712[1]	49.3

[1] Including $100 million by Triborough Bridge Authority of New York.

As of January 1, 1961, some 75 authorities were active in the highway field (Table 14), and of this number, 45 were created in the postwar period, 1946-60. Several others are in existence, but were not active during the study period. Moreover, a number of additional authorities have appeared, and subsequently disappeared, during the 40-year period since creation of the archetypal Port of New York Authority in 1921. Some of these, like the Michigan Turnpike Authority, have been established and later abolished when it was found that the project for which it was created was not feasible; others, like the Cairo Bridge Commission, have gone out of existence when bonds issued to finance construction had been amortized; still others have been merged with authorities having similar or broader functions, such as the Mystic River Bridge Authority which was integrated with the Massachusetts Port Authority.

TABLE 14

STATUS OF HIGHWAY AND BRIDGE AUTHORITIES AS OF JANUARY 1, 1961

State	Authority	Year Created	Type of Facilities[1]	Bonds Issued 1950-60[2] ($1,000) General Obligations	Limited Obligations	Revenue Bonds	Total
Ala.	Alabama Highway Authority	1955	F		95,000		95,000
	Alabama Highway Finance Corporation	1943	F		4,000		4,000
Calif.	California Toll Bridge Authority	1929	TX			167,374	167,374
Colo.	State Highway Department Office Building Authority	1951	F[3]		2,388		2,388
Fla.	Florida Development Commission	1955	T&F		148,662	20,880	169,542
	Ocean Highway and Port Authority	1951	TR		4,600		4,600
	Santa Rosa Island Authority	1947	TX				-
	Jacksonville Expressway Authority	1955	T&F		70,000		70,000
	Florida State Turnpike Authority	1953	TR			74,000	74,000
Ga.	State Highway Authority	1953	F		36,835		36,835
	State Toll Bridge Authority	1953	TX			6,650	6,650
	Rural Roads Authority	1955	F		103,500		103,500
	Costal Highway District[4]	1950	TX			12,500	12,500
Ill.	State Toll Highway Commission	1953	TR			479,000	479,000
	White County Bridge Commission[4]	1941	TX				-
Ind.	Indiana Toll Road Commission	1951	TR			280,000	280,000
	Indiana Toll Bridge Commission[4]	1939	TX				-
	Sullivan County Bridge Commission	1948	TX				-
Iowa	Clinton Bridge Commission[4]	1944	TX			7,445	7,445
	Davenport Bridge Commission[4]	1929	TX			4,200	4,200
	Muscatine Bridge Commission[4]	1956	TX				-
Kans.	Kansas Turnpike Authority	1953	TR		19,500	160,000	179,500
	Leavenworth Bridge Commission[4]	1953	TX			3,000	3,000
Ky.	The Turnpike Authority of Kentucky	1960	TR				-
La.	Mississippi River Bridge Authority	1952	TX		65,000		65,000
	Greater New Orleans Expressway Commission	1954	TX		45,963		45,963
	Ascension-St. James Bridge and Ferry Authority	1960	TX				-
Me.	Maine Turnpike Authority	1941	TR			58,806	58,606
	Maine Port Authority	1929	TX	2,500			2,500
Md.	Baltimore County Revenue Authority	1955	TX			5,400	5,400
Mass.	Massachusetts Turnpike Authority	1952	TR			291,800	291,800
	Massachusetts Port Authority	1956	TX			981	981
Mich.	Mackinac Bridge Authority	1950	TX			99,800	99,800
	International Bridge Authority of Michigan[4]	1954	TX			16,250	16,250
	State Bridge Commission of Michigan[4]	1935	TX				-
Neb.	Bellevue Bridge Commission[4]	1943	TX			2,800	2,800
	Burt County Bridge Commission[4]	1943	TX			2,195	2,185
	North Omaha Bridge Commission[4]	1943	TX			3,450	3,450
	Richardson County Parkway Authority[4]	1943	TX				-
N.H.	Maine-New Hampshire Interstate Bridge Authority[4]	1937	TX			899	899
N.J.	New Jersey Turnpike Authority	1948	TR			466,200	466,200
	New Jersey Highway Authority	1952	TR	285,000		45,000	330,000
	Delaware River Joint Toll Bridge Commission[4]	1934	T&F			25,500	25,500
	Burlington County Bridge Commission[4]	1948	TX				-
	Cape May County Bridge Commission	1939	TX				-
N.Y.	Jones Beach State Parkway Authority	1933	TR			40,000	40,000
	Nassau County Bridge Authority	1945	TX			6,300	6,300
	New York State Bridge Authority	1932	TX			21,900	21,900
	New York State Thruway Authority	1950	TR	500,000		400,000	900,000
	Niagara Falls Bridge Commission[4]	1939	TX			20,000	20,000
	Port of New York Authority[4]	1921	TX			85,344	85,344
	Thousand Islands Bridge Authority[4]	1939	TX				-
	Triborough Bridge and Tunnel Authority[4]	1946	TX			301,705	301,705
	Lake Champlain Bridge Authority	1927	TX				-
	Buffalo and Fort Erie Public Bridge Authority[4]	1933	TX			878	878
	Ogdensburg Bridge and Port Authority[4]	1960	TX				-
	Adirondack Mountain Authority	1929	TR				-
	St. Lawrence Seaway Development Corporation[4]	1954	TX				-
	East Hudson Parkway Authority	1960	T&F				-
Ohio	Ohio Turnpike Commission	1949	TR			326,000	326,000
	Ohio State Bridge Commission	1935	TX			3,500	3,500
Okla.	Oklahoma Turnpike Authority	1947	TR			106,000	106,000
Ore.	Port of Hood River Commission	1950	TX			1,192	1,192
Pa.	State Highway and Bridge Authority	1949	F		105,000		105,000
	Pennsylvania Turnpike Commission	1937	TR			298,000	298,000
	Delaware River Port Authority[4]	1931	TX			89,157	89,157
R.I.	Jamestown Bridge Commission	1937	TX				-
	Mount Hope Bridge Authority	1954	TX			3,100	3,100
Texas	Texas Turnpike Authority	1953	TR			58,500	58,500
Va.	Elizabeth River Tunnel Commission	1942	TX			48,857	48,857
	Richmond-Petersburg Turnpike Authority	1954	TR			75,150	75,150
	Chesapeake Bay Bridge and Tunnel Commission	1054	TX			199,991	199,991
Wash.	Washington Toll Bridge Authority[4]	1937	TX			103,257	103,257
W. Va.	West Virginia Turnpike Commission	1947	TR			133,000	133,000
	Dunbar City Bridge Commission	1947	TX			4,450	4,450
Summary	Authorities operating toll crossing facilities (46)			2,500	110,963	1,222,575	1,338,038
	Authorities operating toll roads (19)			785,000	24,100	3,291,456	4,100,556
	Authorities operating both toll and free facilities (4)			-	218,662	46,380	265,042
	Authorities operating free highway facilities (6)			-	346,723	-	346,723
	Total (75)			787,500	700,448	4,560,411	6,048,359

[1]TX = toll crossing (bridges, tunnels, and ferries); TR = toll road; F = free roads and bridges; T&F = both toll and free facilities. [2]Excluding refunding issues, where possible. [3]Office building (included with free roads and bridges). [4]Interstate or international in operation.

Table 14 shows that 46 authorities operate toll crossing facilities (i.e., bridges, ferries, or tunnels), and of this number, 26 are Interstate or international in character, if not in organization. The seven international authorities include two in Michigan and five in New York.

Of the 19 Interstate agencies, only 5 are true Interstate authorities; that is, created by Interstate compact: the Delaware River Joint Toll Bridge Commission, and the Delaware River Port Authority (Pennsylvania and New Jersey); the Lake Champlain Bridge Commission (New York and Vermont); the Maine-New Hampshire Interstate Bridge Authority; and the Port of New York Authority (New Jersey and New York).

Although the three bridge authorities are concerned solely with highway crossing facilities, the two port authorities are not so limited. The Port of New York Authority in particular is concerned with the financing and operation of a variety of transportation and terminal facilities in addition to six toll highway bridge and tunnel structures.

Although the "youngest" of these five authorities was created in 1937, this is not necessarily indicative of the potential of the Interstate authority device in the future. It is significant that the two Interstate port authorities serve heavily-populated metropolitan areas, and such areas have been increasing rapidly in numbers and size the past two decades. Because many of them encompass a bi-State area, or border closely to State boundary lines, it seems probable that the Interstate authority device may prove to be the solution to many complex metropolitan problems, including, but not necessarily limited to, highway and other transportation problems. In summarizing the future prospects of Interstate authorities, Leach (11) states:

> The efficiency with which the few existing interstate authorities are now meeting their assigned responsibilities, and the increasing number of interstate problems which demand cooperative action for their solution both seem to suggest...that far greater use may be made of the device in the years ahead.

The remaining 14 Interstate authorities were established as agencies of only one of two contiguous States, but operate highway toll bridges crossing State boundaries. Most of these are located in Illinois, Indiana, Iowa, Kansas, and Nebraska. Three of the agencies (the White County Bridge Commission, the Clinton Bridge Commission, and the Muscatine Bridge Commission) were created by act of Congress, and are subject to certain Federal audit controls. Although included with this group, the Washington Toll Bridge Authority also has financed and operates a number of intrastate bridge and ferry facilities in addition to two Interstate bridges across the Columbia River.

Of the 19 toll road authorities, 15 were created since 1945, and 10 of these between 1951 and 1960, thus indicating the great popularity of this financing device during the 1950's. It was also during this period that most of the nontoll authorities were created.

During the 11-year span of this study, 57 of the 75 authorities sold bonds for highway projects in an aggregate amount of $6 billion, as shown in Table 13. Because highway bonds issued by all governmental agencies during these years totaled $14.1 billion (Table 7), the authorities thus accounted for 43 percent of all highway issues. It would appear that authorities are firmly intrenched in the field of highway finance.

Seventeen of the 19 toll road authorities sold bonds during the 1950-60 period, in the amount of $4.1 billion, or two-thirds of all debt incurred by authorities. One of the 2 remaining road authorities (the Turnpike Authority of Kentucky) entered the bond market in 1961, and by early 1962 had sold $186 million of turnpike revenue bonds.

The features that distinguish highway financing by the authority device from those by traditional methods are not always clear cut. For example, a number of State highway departments and local governments finance and operate toll projects. However, this is not the primary function of a highway or public works department, and hence for purposes of this paper, authorities are restricted to those instrumentalities whose primary responsibility is the financing of highway facilities by means of revenue or limited obligation bonds, and which do not rely on general tax support nor have the power to levy taxes.

The authority concept (12, p. 1) has flourished because it has proven successful in most instances in meeting three basic needs: (a) a means of financing capital projects that would not conflict with constitutional limitations on creation of debt; (b) a flexible instrument to manage commercial or "self-supporting" enterprises; and (c) an effective agency to administer international, interstate, or intercommunity projects[10].

Preston (10, p. 206) classifies authorities in four basic categories, in terms of their administrative powers: (a) "standard" authorities, having all the necessary powers to plan, finance through revenue bonds, construct or purchase, maintain, operate or lease, and support through rates, tolls, rentals, or other charges any project that can be made to pay its way (for example, the Port of New York Authority); (b) "building" authorities, which may plan, finance, and construct, but which derive their revenues from a rental contract with the State or highway department, at rates sufficient to cover only annual debt service and reserve requirements; further, these authorities rarely maintain or operate the facilities (for example the Georgia Rural Roads Authority and the Pennsylvania State Highway and Bridge Authority); (c) "financing" authorities, which do not plan, construct, or operate facilities, but serve merely as financing vehicles (for example, the Alabama Highway Authority, which sold $95,000,000 of bonds between 1955-60, the proceeds of which were turned over to the State Highway Department for construction of State highways and which are secured by a pledge of a portion of State gasoline tax revenue); and (d) "managing" authorities, which may be responsible for operating, and possibly constructing, a facility, but which do not provide the financing (for example, the Greater New Orleans Expressway Commission, created as an instrumentality of Jefferson and St. Tammany Parishes, in whose names the bonds were issued).

Although examples of each type in its "pure" form are found in the highway field, the highway authority is in many respects an anomaly. For example, two of the "standard" authorities (most common device for financing major toll road projects) have financed both with revenue bonds and with general obligation bonds guaranteed by the State—the New York State Thruway Authority and the New Jersey Highway Authority. In other instances, authorities have received direct or contingent support for their bonds by a pledge of certain State tax revenues. For example, to enhance marketability of bonds to finance the Southwestern Turnpike, the Oklahoma legislature in 1959 created a Turnpike Trust Fund to receive no more than $1,000,000 annually from taxes levied on motor fuel consumed on turnpike projects. An amount equivalent to three years' interest can be accumulated in the Fund and drawn if needed by the Oklahoma Turnpike Authority to meet interest requirements on the Southwestern Turnpike bonds.

The Kansas Turnpike Authority has a contract with the State Highway Commission whereby the Commission will advance as a loan from the State Highway Fund any amount required to meet deficiencies in meeting debt service payments on bonds issued for the Kansas City Expressway.

The Turnpike Authority of Kentucky receives lease-rental payments from the Highway Department equal to the principal and interest requirements on its bonds; in Louisiana, each of three authorities (the Mississippi River Bridge Authority, the Greater New Orleans Expressway Commission, and the Ascension-St. James Bridge and Ferry Authority) receives contributions from State highway funds to augment toll revenues.

In Washington, the Toll Bridge Authority has agreements with Pierce and King Counties whereby Pierce County sold $1.5 million of bonds and placed the proceeds in a trust fund for use in the event tolls on the Authority's Tacoma Narrows Bridge were insufficient to cover bond interest; King County has pledged up to $9 million over a 19-year period out of its share of State road-user taxes as added security for the Authority's Second Lake Washington Bridge project. The 1961 legislature placed $0.0025 of a gasoline tax increase into the Puget Sound Reserve Account to serve as added security for the Authority's refunding bonds for the Puget Sound ferry system, and Hood Canal Bridge.

The Florida Development Commission in financing a toll causeway to Cape Canaveral pledges not only tolls as security for the Causeway bonds, but also Brevard County's

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[10] For a later symposium on public authorities (11).

share of surplus (20%) gas tax revenues; if these prove insufficient, it pledges the full faith and credit of the Canaveral Causeway Special Road and Bridge District. If required, an ad valorem tax may be levied on all property in the District.

Because of the relatively late appearance of the Authority in governmental financing and operation, most of the State constitutions are silent concerning the legal status of such institutions. For this reason it has been necessary, particularly where bonded indebtedness is involved, to test constitutionality of these agencies in courts. The courts have generally held that the "special-fund doctrine" applies to bonds issued by special State authorities; i.e., that indebtedness repaid from proceeds of special taxes or fees, levied for that express purpose, are not in violation of constitutional provisions regarding the creation of State indebtedness. This interpretation has undoubtedly contributed to the success and modern prominence of limited and revenue bond financing, and particularly the creation of the separate authority.

Critics of this type of financing are quick to comment that these are but devices to circumvent the prudent and precautionary safeguards written into the State constitutions for the purpose of preventing creation of an overburdening State debt. They also point out that the authority is frequently a "synthetic" organization, and that its operations are in many instances integrated with those of existing State highway departments, and this being the case, the need for a separate authority is not self-evident.

It is also argued that if a separate authority is warranted, it does not justify the pledge of the credit of the State government in support of the authority's obligations as was done, for example, in the case of the New York Thruway and the Garden State Parkway (N. J.). Stated in reverse, if a public improvement justifies support of the State's credit, it does not require creation of an Authority. The critics would further use this argument in support of the contention that creation of a separate authority does not absolve the State of responsibility for any indebtedness incurred. Not only is there a mutual interest in the objectives to be achieved but also the State has a moral responsibility to insure that its credit rating will not be impaired by any potential default of the authority's bonds.

Although, fortunately, the States have faced this dilemma only rarely in modern times, when the occasion has arisen, action has usually been prompt. For example, Florida quickly took steps to refund the debt of the Fernandina Port Authority in 1951 following default in payment of a semiannual interest coupon, and in 1961, the State of Illinois approved an ordinance of the City of Chicago to advance $2 million out of road-user tax revenues to meet interest requirements on the revenue bonds of the Calument Skyway and avoid a default in payment of the January 1962 coupon. West Virginia, however, has not as yet found a means to improve the earnings of the Turnpike Authority (which defaulted on the June 1958 interest coupon, and presently is running about two years behind schedule in meeting these semiannual payments). Any long-term solution will probably have to await improvement of connecting highways that may help generate additional traffic for the turnpike, but these benefits are still in the future.

Perhaps the most compelling argument against authority financing, particularly that of toll authorities, is the almost inevitable higher financing cost of revenue bonds—often at interest rates from one to two percentage points higher than for general obligation bonds.

The advocates of authority financing point out the flexibility of this method over that of the general obligation bond, authority for which frequently must be obtained both through the legislature and from the electorate with the attending uncertainties. It has been particularly effective where large capital programs are involved, and the need is urgent.

Many authorities, as was seen, have been created where the scope of the program extends into two political jurisdictions, or where international boundaries are involved. In these situations, an authority is undoubtedly the most logical organization and may well be the only feasible one.

It is also claimed that the Authority is as subject to public control and policy as any other State agency, inasmuch as it is a creature of the legislature which can (and does) limit the powers and duties of the Authority, require public audit of accounts, and set debt limitations, among other things. Furthermore, elaborate safeguards as to management of funds are usually written into the trust agreements or indentures under which bonds are sold to the public.

Although the experience is limited, the non-toll authorities have demonstrated an ability to borrow funds at interest rates not unfavorable in comparison with those the central government can obtain for general financing. Interest costs on bonds of the Georgia and Pennsylvania Bridge and Highway Authorities have been considerably lower than interest costs on the bonds sold by the toll Authorities in those States. Moreover, to strengthen the security back of the Georgia road authority bonds, the voters in November 1960 ratified a constitutional amendment, making it obligatory for the legislature to appropriate the amounts necessary to meet the lease rental payments on the authority bonds[11]. The State Attorney General subsequently ruled that by such action, the bonds have become general obligations of the State.

Other States have been studying the experience of the Pennsylvania "free road" Authority, and it is likely that similar agencies will make an appearance in other areas, particularly where the machinery for meeting the problem of modern highway financing is cumbersome and outmoded.

Interest Rates

The earlier study of bond financing (2) ended at a time (1951) that bond interest rates were near their lowest point during this century. During the period of this study, bond interest rates have shown a steady upward trend, reflecting a general tightening of the money market.

As measured by the Bond Buyer's monthly index of the State-local government bond market, the average yield of 20 selected bond issues rose from a low of 1.58 percent in early 1951 to a high of 3.81 percent during 1959. Thereafter, the index declined slightly, but remained at 3.51 percent at the end of 1961.

The values of this index are given by years in Table 15 and the monthly values are shown graphically in Figure 8. This index of calculated yields is obtained by averaging the market value of general obligation bond issues of selected States and local governments. According to the "Bond Buyer" (13), the bonds selected are those having a maturity of about 20 years and selling at a price close to par, with few exceptions. Although the same bond issues are not used year after year (because of trading inactivity or other factors, the selection is changed to make the index more representative of the market), the average rating of the 20 bonds used in the index falls midway between the four top groups as classified by recognized rating agencies.

The value of this index to the highway administrator is evident, even though it is not indicative of the rates at which specific State and local highway bonds are sold. It does measure a trend in the financing cost of borrowing, and can be useful in planning the timing of bond sales programs.

Just as the yield rate is an indicator of the rate of return to the investor, the "net interest cost" is the factor typically used in measuring the cost of a bond issue to the borrower. Prospective bidders for highway bond issues usually express their bid in terms of an effective interest rate, which is computed by determining at the interest coupon rate or multiple rates specified by the bidder (or by the

TABLE 15

THE BOND BUYER'S INDEX OF THE MUNICIPAL BOND MARKET (20 BONDS)

Year	Index of Yield[1]
1950	2.07
1951	1.66
1952	2.11
1953	2.40
1954	2.54
1955	2.38
1956	2.56
1957	3.23
1958	2.97
1959	3.40
1960	3.78
1961	3.39

[1] January of years 1950-61.

[11] Georgia Constitution; Art. VII, §VI, paragraph I (a).

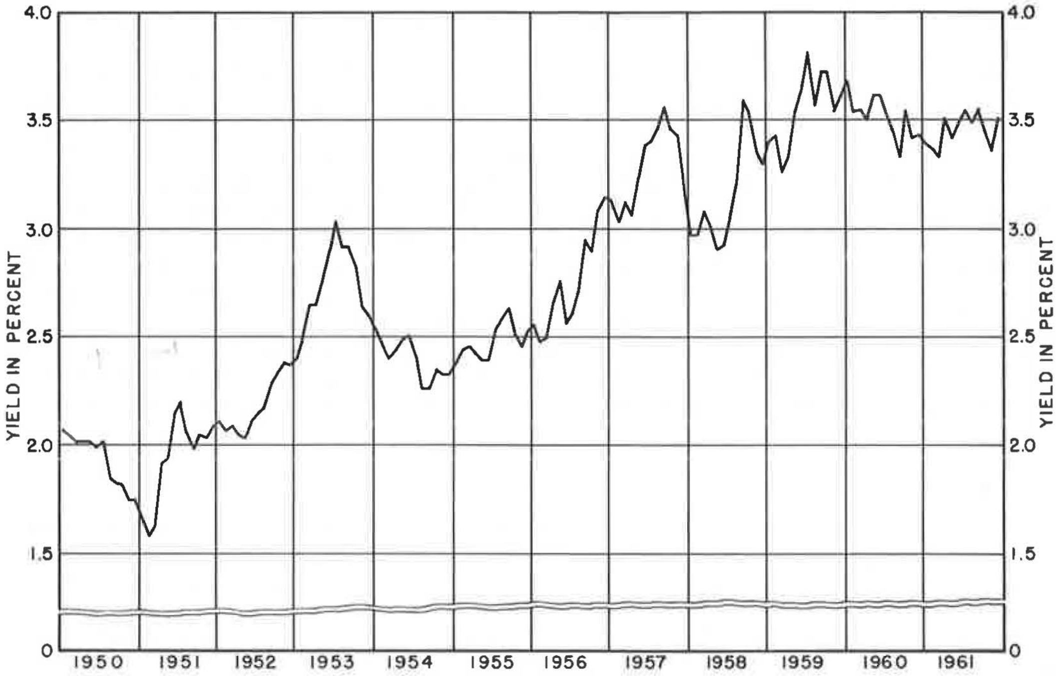

Figure 8. Bond buyer's index of municipal bond market, 1950-61.

borrower, in some instances) the cumulative total dollar value of all interest on the bonds from date of issue, or from date of settlement, to their maturity and deducting therefrom any premium (or adding thereto any discount). The resulting net interest cost is then expressed in terms of an effective rate of interest to the borrower. In reality, it is the weighted average interest rate of a bond issue. Under competitive bidding, the banking institution, investment house, or bond syndicate offering the lowest net interest cost is awarded the sale.

The net interest cost has been computed for nearly all highway bond issues of State agencies during the 11-year period of this study, with the costs identified separately for toll revenue bond issues, for general obligations, and for limited obligation bonds. Table 16 gives the bond sales by net interest cost class intervals. From the frequency distribution in the table, the average net interest cost has been computed for each year for each major class of bonds and shown in Figure 9 as the value of the weighted arithmetic mean.

As the figure shows, the sales of general obligation bonds have followed reasonably well the trend shown by the Bond Buyer's index of yields, with the average of sales during 1950-52 falling below 2 percent, those during the next 4 years falling mostly in the $2\frac{1}{2}$ percent range, and those in 1957-60 pushing beyond the 3 percent mark.

Except for convergence in 1953, the net cost of limited obligation bonds has consistently exceeded that of the guaranteed bond, and since 1956 the average differential has been about one-half a percentage point.

It is interesting to compare the interest cost of general and limited bonds with the cost of issuing toll revenue bonds which for the most part during the years 1950-55 sold at average net interest costs within the 3 to $3\frac{1}{2}$ percent range, then increased beyond the 4 percent range, and by 1960 had reached the $4\frac{1}{2}$ percent level. During the 11-year span covered by this study, the average interest cost of toll revenue bonds was in the range of $1\frac{1}{4}$ to $1\frac{1}{2}$ percentage points higher than for general obligation bonds, and as much as 1 percentage point higher than for limited obligations. Although such general comparisons are hazardous because the differential in costs is influenced by many factors (such as the condition of the money market at the time of sale, size of issue, and magnitude of prior debt of the issuing agency), the inherent factor of risk cannot be overlooked. The unhappy earnings record of some revenue bond facilities has undoubtedly had an effect in establishing an interest rate differential for this class of bond.

Although a comparison of the net interest cost of various bond sales must be weighed carefully in the light of the preceding factors, it has been possible to select a few illustrations of sales occurring closely together in point of time and, in most instances, within the same State, which emphasize the differential in cost of revenue bond financing versus that of general or limited obligations.

On July 1, 1953, the New Jersey Highway Authority sold $150,000,000 of State-guaranteed bonds with serial maturities to 1988 at a net interest cost of 2.997 percent. On the same date, the New Jersey Turnpike Authority also sold $150,000,000 of nonguaranteed toll revenue bonds, maturing as a term issue in 1988 at a net interest cost of 3.4923 percent.

On January 1, 1958, Connecticut sold $77 million of general obligation expressway bonds with serial maturities to 1997 at a net interest cost of 3.258 percent. On the same date, the Illinois Toll Highway Commission sold $64 million of revenue bonds, with a term maturity in 1998 at a net cost of 4.970 percent.

On September 21, 1960, the State of Michigan sold $25,000,000 of Trunk Line Highway Bonds as limited obligations secured by road-user tax revenues. These bonds mature serially over a 25-year period and were sold at a net interest cost of 3.78 percent. On August 11, 1960, the International Bridge Authority of Michigan floated a $16,250,000 revenue bond issue comprising a Series A issue of $8,400,000 sold at a net interest cost of 5.125 percent and a $7,850,000 Series B issue at 6.0 percent. Both series are 40-year term bonds maturing in the year 2000.

The State of Kentucky sold $15,000,000 of general obligation highway bonds on June 14, 1961, at a net interest cost of 3.6042 percent. These are 30-year serial bonds. On June 23, 1961, the Kentucky Turnpike Authority issued $118,000,000 of limited obligation bonds (secured by

TABLE 16

STATE OBLIGATIONS FOR HIGHWAYS ISSUED 1950-60 IN TERMS OF NET INTEREST COST
($ × 10^3)

Type of Bond	Interest Cost Intervals (%)	1950		1951		1952		1953		1954		1955		1956		1957		1958		1959		1960	
		Bonds Sold	Percent	Bonds Sold	Percent	Bonds Sold	Percent	Bonds Sold	Percent	Bonds Sold	Percent	Bonds Sold	Percent	Bonds Sold	Percent	Bonds Sold	Percent	Bonds Sold	Percent	Bonds Sold	Percent	Bonds Sold	Percent
General obligation	Less than 1½	103,300	52.3	76,500	33.2	10,450	8.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1½ and less than 2½	94,000	47.7	153,000	66.4	116,500	91.4	133,205	23.9	99,595	41.1	52,159	51.1	185,941	66.7	6,000	2.6	81,000	17.6	-	-	-	-
	2½ and less than 3½	-	-	-	-	-	-	416,500	74.8	142,500	58.9	50,000	48.9	93,000	33.3	140,010	62.2	379,925	82.4	154,200	72.0	124,300	80.6
	3½ and less than 4½	-	-	1,000	0.4	500	0.4	7,500	1.3	-	-	-	-	-	-	79,175	35.2	-	-	60,000	28.0	30,000	19.4
	4½ and over	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total		197,300	100.0	230,500	100.0	127,450	100.0	557,205	100.0	242,095	100.0	102,159	100.0	278,941	100.0	225,185	100.0	460,925	100.0	214,200	100.0	154,300	100.0
Limited obligation	Less than 1½	25,000	37.8	-	-	-	-	-	-	30,000	9.9	-	-	-	-	-	-	-	-	-	-	-	-
	1½ and less than 2½	2,220	3.3	62,875	98.8	84,600	83.4	40,000	31.4	66,925	22.0	75,900	46.0	33,000	10.9	2,000	0.4	-	-	-	-	-	-
	2½ and less than 3½	34,300	51.9	784	1.2	16,800	16.6	87,250	68.6	140,536	46.2	83,304	50.4	267,867	88.4	166,500	36.1	278,772	78.8	51,450	16.6	52,344	23.0
	3½ and less than 4½	4,600	7.0	-	-	-	-	-	-	66,750	21.9	6,000	3.6	2,200	0.7	290,433	63.1	74,170	20.9	257,966	83.4	147,435	64.9
	4½ and over	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,750	0.4	1,000	0.3	-	-	27,510	12.1
Total		66,120	100.0	63,659	100.0	101,400	100.0	127,250	100.0	304,213	100.0	165,204	100.0	303,067	100.0	460,683	100.0	353,942	100.0	309,416	100.0	227,289	100.0
Toll revenue	Less than 1½	-	-	725	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1½ and less than 2½	24,500	17.1	36,261	15.0	30,000	5.2	3,000	0.7	5,850	0.3	2,100	0.5	-	-	-	-	-	-	-	-	-	-
	2½ and less than 3½	119,000	82.9	175,700	72.5	425,000	73.4	270,278	63.9	1,389,350	76.4	208,100	52.7	9,300	1.9	-	-	13,666	13.9	500	0.3	300	0.1
	3½ and less than 4½	-	-	29,650	12.2	124,000	21.4	149,670	35.4	424,390	23.3	183,000	46.4	474,975	98.1	4,900	12.3	500	0.5	110,800	55.7	12,750	3.9
	4½ and over	-	-	-	-	-	-	-	-	-	-	1,700	0.4	-	-	34,900	87.7	84,100	85.6	87,551	44.0	316,950	96.0
Total		143,500	100.0	242,336	100.0	579,000	100.0	422,948	100.0	1,819,590	100.0	394,900	100.0	484,275	100.0	39,800	100.0	98,266	100.0	198,851	100.0	330,000	100.0

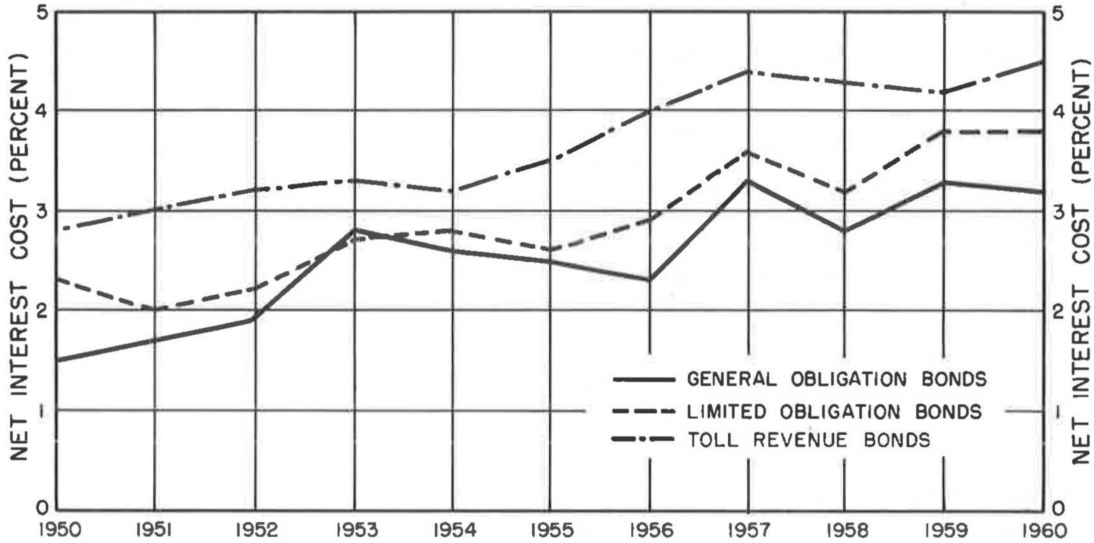

Figure 9. State obligations for highways, by weighted average net interest costs.

tolls and/or State lease-rental payments) at a net interest cost of 4.928 percent. The issue comprises $20,000,000 of 25-year serial bonds and $98,000,000 of 40-year term bonds.

Also during 1961, the State of Ohio sold on November 22 $30,000,000 of limited obligation highway bonds (secured by road-user taxes) at a net cost of 2.88 percent, and three weeks earlier (November 3) the Oklahoma Turnpike Authority sold $56,500,000 of bonds secured by tolls and a pledge of gas tax earnings at a net interest cost of 4.85 percent.

On February 1, 1962, Delaware sold $10,000,000 of general obligation highway bonds at a net interest cost of 2.83 percent. On February 21, the State sold $28,000,000 of turnpike revenue bonds at a net cost of 4.1875 percent.

It would be hazardous to draw too positive conclusions based on the differentials illustrated by these examples, yet all evidence points to the fact that the cost to the public of revenue bond financing, and even of limited obligation bonds that are dependent to some extent on earnings of the facility, is consistently higher than that of the guaranteed bond issue.

Maturity Schedules

Another factor that influences the cost of borrowing is the length of maturity of the bond issues. Table 17 and the weighted averages in Figure 10 show the span of years to maturity of the various State highway bond issues sold during the period 1950-60. Because the maturity features are not dissimilar, general and limited obligations are treated as one group. Here again, the maturities for toll revenue bond issues are consistently for longer terms than are those for general and limited bonds. Except in 1953, 1957, and 1959 when the differential was less than 10 years, Figure 10 shows that the average revenue bonds issue carries a 10- to 15-year longer term to maturity than do general and limited obligation bonds.

Toll revenue obligations are usually issued as term bonds; that is, they mature on a fixed future date and will be redeemed from the accumulations of a sinking fund. The term may vary from 10 to 50 years, but most bonds of this type in recent years have been for terms of 35 to 40 years. Interest on term bonds remains constant, of course, so long as the bonds are outstanding. The sinking fund is accumulated by annual contributions out of current revenues expected to be sufficient to meet current interest charges and, together with investment earnings, to redeem the bonds at maturity. The earnings estimates on which the sale of revenue bonds are predicated, are usually so favorable as to anticipate call and redemption of the obligations well in advance of stated maturities. However, only time will prove the validity of these estimates for many toll-financed projects.

General and limited obligations are usually issued as serial bonds; that is, the principal is retired on an annual schedule, and interest payments decline as the loan is amortized. No sinking fund is required, because the annual debt service payments are met from current revenues. For purposes of Table 17, serial bond issues are grouped according to their longest maturities to make them as comparable as possible with term bond maturities. The bond-financing policies of State agencies have been so varied, however, as virtually to eliminate in many instances the features that distinguish term from serial bonds. Some States, for example, issue serial bonds by name, but schedule maturities in such a manner that redemptions are relatively light, or even deferred, in early years and are concentrated heavily in the final 4 or 5 years. In other States, term issues are being called for redemption on an annual basis, and sinking fund requirements are minimized or eliminated.

Debt Refunding

For this study, bond issue and redemption as results of refunding operations have been excluded for the most part from the tabulations and analyses. This has been done to avoid giving a misleading picture of the magnitude of borrowing as a device to raise capital funds, which would result if both original and refunding bonds were to be included.

The use of refunding bonds, however, has been a time-honored device for the States as well as local governments to take advantage of lowered interest rates or adjust the maturities of bond issues. This usually requires, of course, the inclusion of a call feature in the original bond issue that will permit the bonds to be redeemed in advance of maturity.

During the decade of the 1930's, State agencies sold or assumed $2,049 million of highway obligations, of which $550 million (27 percent) were refunding bonds. During this depression period, most re-

TABLE 17

STATE OBLIGATIONS FOR HIGHWAYS, 1950-60, ACCORDING TO MATURITIES IN YEARS[1]
($ \times 10^3$)

Type of Bond	Maturities (yr)	1950 Bonds Sold	1950 Percent	1951 Bonds Sold	1951 Percent	1952 Bonds Sold	1952 Percent	1953 Bonds Sold	1953 Percent	1954 Bonds Sold	1954 Percent
General and limited obligation	Less than 10	-	-	4,000	1.4	8,400	3.6	20,250	3.0	300	0.1
	10 and less than 15	62,800	23.8	73,784	25.1	48,950	21.4	86,000	12.6	30,000	5.5
	15 and less than 20	68,500	26.0	111,500	37.9	36,600	16.0	71,250	10.4	64,313	15.4
	20 and less than 25	95,820	36.4	85,000	28.9	25,000	10.9	89,455	13.0	98,045	17.9
	25 and less than 30	2,000	0.8	19,000	6.4	86,000	37.6	2,000	0.3	17,250	3.2
	30 and less than 35	34,300	13.0	875	0.3	21,400	9.4	250,500	36.6	143,900	26.3
	35 and less than 40	-	-	-	-	-	-	165,000	24.1	7,500	1.4
	40 years and over	-	-	-	-	2,500	1.1	-	-	165,000	30.2
Total		263,420	100.0	294,159	100.0	228,850	100.0	684,455	100.0	546,308	100.0
Toll revenue	Less than 10	10,000	7.0	6,911	2.9	30,000	5.2	3,000	0.7	-	-
	10 and less than 15	-	-	6,725	2.8	21,500	3.7	-	-	5,850	0.3
	15 and less than 20	-	-	6,800	2.8	-	-	1,210	0.3	2,590	0.2
	20 and less than 25	-	-	-	-	-	-	-	-	-	-
	25 and less than 30	-	-	12,250	5.1	2,500	0.4	760	0.2	-	-
	30 and less than 35	23,000	16.0	174,650	72.0	96,000	16.6	130,978	31.0	58,850	3.2
	35 and less than 40	79,500	55.4	35,000	14.4	103,000	17.8	225,000	53.2	310,000	17.0
	40 years and over	31,000	21.6	-	-	326,000	56.3	62,000	14.6	1,442,300	79.3
Total		143,500	100.0	242,336	100.0	579,000	100.0	422,948	100.0	1,819,590	100.0

Type of Bond	Maturities (yr)	1955 Bonds Sold	1955 Percent	1956 Bonds Sold	1956 Percent	1957 Bonds Sold	1957 Percent	1958 Bonds Sold	1958 Percent	1959 Bonds Sold	1959 Percent	1960 Bonds Sold	1960 Percent
General and limited obligation	Less than 10	-	-	5,500	0.9	5,000	0.7	10,500	1.3	2,000	0.4	1,000	0.3
	10 and less than 15	-	-	22,800	3.9	11,000	1.6	174,985	21.5	45,800	8.7	46,640	12.7
	15 and less than 20	115,154	43.1	140,067	24.1	295,208	43.1	115,457	14.2	53,986	10.3	43,734	11.5
	20 and less than 25	68,159	25.5	197,441	33.9	225,180	32.8	307,675	37.7	178,700	34.4	124,630	32.7
	25 and less than 30	2,000	0.7	15,200	2.6	10,000	1.5	71,750	8.8	116,000	22.5	74,900	19.6
	30 and less than 35	25,450	9.5	1,000	0.2	35,000	5.1	-	-	61,650	11.8	31,685	8.3
	35 and less than 40	6,600	2.5	200,000	34.4	-	-	134,500	16.5	82,500	11.9	50,000	13.1
	40 years and over	50,000	16.7	-	-	104,500	15.2	-	-	-	-	7,000	1.8
Total		267,363	100.0	582,008	100.0	685,868	100.0	814,867	100.0	523,636	100.0	381,569	100.0
Toll revenue	Less than 10	-	-	-	-	-	-	-	-	-	-	-	-
	10 and less than 15	5,400	1.4	-	-	-	-	5,200	5.3	-	-	-	-
	15 and less than 20	-	-	9,300	1.9	-	-	1,500	1.5	-	-	2,050	0.6
	20 and less than 25	-	-	-	-	3,500	8.8	-	-	50,000	25.1	-	-
	25 and less than 30	10,000	2.5	-	-	1,400	3.5	-	-	500	0.3	3,600	1.1
	30 and less than 35	64,000	16.2	54,975	11.4	34,400	86.4	6,986	7.1	26,800	13.5	11,000	3.3
	35 and less than 40	68,000	17.2	-	-	-	-	6,650	6.8	68,751	34.6	4,400	1.3
	40 years and over	247,500	62.7	420,000	86.7	500	1.3	77,950	79.3	52,800	26.5	306,950	93.7
Total		394,900	100.0	484,275	100.0	39,800	100.0	98,266	100.0	198,851	100.0	330,000	100.0

[1] Serial bond issues grouped according to their longest maturities so as to be on a comparable basis with term bonds.

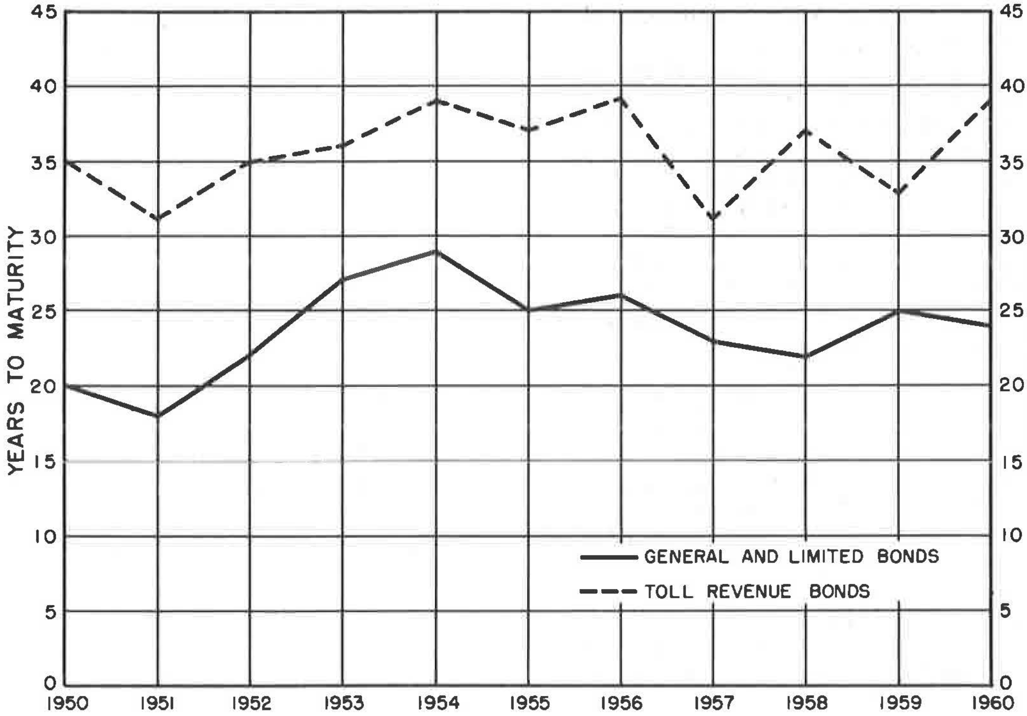

Figure 10. State obligations for highways, by average maturities in years.

funding was dictated by economic necessity to avoid or correct for default in meeting interest and maturity requirements, and had little relevance to interest rates, which by the mid-1930's had reached the highest levels since 1900.

Between 1940 and 1949, the States sold $1,579 million of highway obligations, of which $708 million were refunding bonds (nearly one-half). Most of this refunding was to take advantage of declining interest rates which, according to the Bond Buyer's index (13), dropped from a yield rate of 5.48 percent in 1934 to 1.42 percent by 1946.

From 1950 to 1960, the States sold only $268 million of refunding bonds in addition to the $9,764 million of original issues, or 2.7 percent of all bond sales. Virtually all the refunding was in connection with toll facility financing, and interestingly enough, the refunding issues in nearly all instances bore a higher rate of interest than the bonds that were retired from the proceeds. For example, the New Jersey Turnpike Authority redeemed $30 million of 1⅞ percent revenue bonds sold in 1952 from the proceeds of a $150 million revenue bond issue sold in 1953 at 3⅜ percent interest. In 1959, from the proceeds of 4¾ percent bonds, the Massachusetts Port Authority redeemed the remaining $21,620,000 debt of the Mystic River Bridge originally issued in 1947 at 2⅞ percent interest rate.

In 1946, the Maine Turnpike Authority sold $20 million of toll road revenue bonds bearing coupon rates of 2½ and 2¾ percent, and maturing as term bonds in 1976. In 1953, the Authority sold $75 million of revenue refunding and extension bonds bearing an interest rate of 4 percent and maturing in 1989. From the proceeds of the 1953 sale, the 1946 issue was retired. Thus, the users of the original turnpike section must now bear an added interest expense of at least 1¼ percent yearly, extended over an additional 13 years.

Much the same thing occurred more recently in Florida, where the Turnpike Authority in 1961 sold 4¾ percent revenue bonds to extend the present turnpike an additional 158 miles and to redeem the remaining bonds outstanding on the original toll road project, issued in 1955 at an interest rate of 3¼ percent. In addition to providing for the increased interest cost of $1\frac{1}{2}$ percent, the toll road user finds that the refunding bonds have moved the final maturity date six years further into the future.

Most of these refunding operations have in reality been consolidations, whereby the authorities have sought to improve marketability of bonds issued to finance new ventures by pledging the resources of established facilities. This could not be done, of course, where indebtedness existed on prior facilities unless the underlying debt could first be retired or a majority of the bondholders would agree to a diminution of their security.

In contrast to this, the Pennsylvania Turnpike Commission financed its East-West turnpike system under a 1948 "closed-end" indenture. As a result, bonds to finance the later northeast extension from Philadelphia to Scranton had to be issued under a 1952 indenture that could not pledge as security revenues of the east-west system until all the 1948 indenture bonds were retired. The Commission has since found to its embarrassment that revenues on the northeast extension have been inadequate to meet debt service requirements, whereas those on the east-west system far surpass needs. As a result, the 1948 indenture bonds are being retired in advance of maturity as rapidly as possible so that tolls may be pledged to the 1952 indenture bonds before default can occur. The timing may be very close.

Perhaps the classic example of debt consolidation by means of refunding relates to the bond issues of the Port of New York Authority. Between 1926 and 1938, this Agency sold a total of $131.3 million of revenue bonds to construct three Staten Island toll bridges and the George Washington Bridge and to acquire the Holland Tunnel. All these early issues were serial bonds secured by a pledge of the revenues from each specific facility. The effects of the depression and of a general lowering of interest rates after 1934 led the Authority to issue general and refunding bonds as term bonds and to apply the proceeds to retire all of the original serial bonds, and to provide funds for construction of the Lincoln Tunnel and certain other facilities. Under this plan, revenues of all facilities were pooled as security for the entire debt.

The postwar period saw a great increase in the Port Authority's activities. Truck and bus terminal facilities were constructed, and the Authority took over operation of the Port Newark marine terminal and the four major airports in the New York area. General and refunding bonds were issued to finance the inland terminals, but special marine and air terminal bonds were issued to finance improvements at Port Newark and the four airports.

Beginning in 1952, the Authority adopted a plan to unify the debt structure further. All future financing was to be by means of consolidated bonds, to be secured by revenues of all facilities not otherwise pledged. By the end of 1961, through refunding and new financing ventures, including major improvements to the George Washington Bridge and to other facilities, some 82 percent of the Authority's outstanding debt was represented by consolidated bonds.

Between 1950 and 1960, an estimated $85 million of consolidated bonds were issued to finance improvements and expansion of the bridge and tunnel facilities. Thus, there is no longer any identity of debt structure as it applies to specific facilities, and the highway user will be expected to continue paying tolls on the crossing facilities so long as any consolidated debt is outstanding.

CURRENT DEVELOPMENTS IN HIGHWAY BOND FINANCING

The remainder of this study is concerned with an examination of some of the more prominent and perhaps novel State highway bond-financing programs. Although this study generally covers the period 1950-60, some bond programs initiated in 1961 and during the early months of 1962 are included because of their significance or timeliness. A review is made of general, limited, and revenue bond financing.

General Obligation Issues by Constitutional Amendment

As mentioned previously, 22 States constitutionally prohibit borrowing, except by means of an amendment. During the 1950's, 5 States among this group sold general obligation bonds.

Alabama. —Alabama voters in December 1951 approved a constitutional amendment authorizing a $25 million bond issue. These guaranteed bonds were issued in 1952 at a coupon rate of 1⅝ percent, and the proceeds applied to match Federal-aid highway funds. Since then, the State has sold nearly $100 million of limited obligation highway bonds, but has not again resorted to the amendatory process.

Louisiana. —Between 1950 and 1960, Louisiana issued $100 million of general obligation bonds under 3 separate constitutional amendments. Under an Act of the 1946 legislature[12], the State sold $10 million of highway bonds in 1950, payable from $0.04 of the gasoline tax. In 1953, 1954, and 1958, the State sold an aggregate amount of $30 million under a second amendment[13]. These bonds are also payable from gasoline taxes.

By an act of the 1955 legislature[14], the State adopted a 10-year, long-range highway program, with an initial authorization of $60 million in bonds. Under this authorization, $30 million of long-range highway bonds were issued in each of the years 1959-60, at net interest costs ranging from 3.4973 percent on a 1959 sale, to 3.79 percent on a 1960 sale. As security for these bonds, the State pledged proceeds of certain motor-fuel taxes, vehicle license fees, and mineral leases on State-owned lands. No additional bonds may be issued unless the pledged revenues for the preceding year are equal to twice the maximum annual principal and interest requirements of the outstanding bonds.

All highway bonds issued under the provisions of these three constitutional amendments carry the further pledge of the full faith and credit of the State of Louisiana.

Minnesota. —For a 20-year span between 1936 and 1956, Minnesota issued no highway bonds. In 1956, a constitutional amendment[15] was adopted which, among other things, created a trunk highway fund to receive certain road-user taxes, and from which debt service would be paid, and which authorizes issuance of trunk highway bonds, with not more than $150 million to be outstanding at any one time. The amendment further stipulated that bonds must mature not later than 20 years after issue, be sold at not less than par, and not bear interest in excess of 5 percent. The bonds will be full-faith obligations of Minnesota.

During the years 1956-59, the State issued a total of $46 million of trunk highway bonds under enactments specifying the purpose for which the proceeds would be used, as follows:

Purpose	Amount ($)
Highway office building	6,000,000
Trunk highway bridges	20,000,000
Right-of-way acquisition	20,000,000

These bonds were sold at net interest costs ranging from a low of 2.326 percent on 1956 sales to 3.0323 percent on 1959 sales.

Under a 1959 Act[16], the State is authorized to finance construction of trunk highways within the city limits of St. Paul by issuing to the city non-interest-bearing trunk highway bonds in repayment of advances by the city of cash and/or engineering services. The city elected to sell its own interest-bearing bonds to provide funds to advance to the State, and during 1961, it sold $4,750,000 of 3.1 and 3.2 percent serial bonds. The State, in turn, deposited with the city a like amount of trunk highway bonds having approximately the same maturities.

[12] Adopted as amendment to Art. VI, §22, Louisiana State Constitution.
[13] Louisiana Constitution, Art. VI-A, §5, adopted November 4, 1952.
[14] Act 141, 1955 Session, adopted April 17, 1956 as Art. VI, §23 of Louisiana Constitution.
[15] Minnesota Constitution, Art. XVI, §12, amended November 6, 1956, effective July 1, 1957.
[16] Ch. 538, 1959 Session Laws of Minnesota.

By earmarking bond proceeds for specific purposes and within specific areas, Minnesota has departed somewhat from the usual practice of issuing general obligation highway bonds for unspecified highway projects. In the case of the St. Paul bonds, the State has, in effect, shared the financing costs with the city, in that the State will meet the principal and the city the interest requirements of the bonds.

Oregon. —Oregon adopted a constitutional amendment[17] in 1920 permitting borrowing for highways not to exceed 4 percent of the assessed valuation of all property of the State. Within this limitation, the legislature may authorize borrowing without voter ratification. During the years 1951-53, the State issued $72 million of highway bonds as general obligation and pledged road-user tax revenues for debt service. In 1957, the State sold an additional $20.6 million of bonds, of which $12.6 million was earmarked for construction of a scenic coastal highway on US 101 between Gold Beach and Brookings. At the end of 1961, the State had slightly over $55 million of bonds outstanding. Under its limitation and based on a 1961 assessed valuation of approximately $3 billion, the State can issue up to a ceiling of $120 million of highway bonds.

West Virginia. —West Virginia issued $84.5 million of general obligation bonds between 1950 and 1960, pursuant to constitutional amendments. A 1920 amendment authorized the issuance of not to exceed $50 million of State highway bonds. A unique feature of this amendment was the specification that the State may issue bonds, "the aggregate outstanding amount of which, at any one time, shall not exceed fifty million dollars." Under this provision the State may "reissue" bonds from time to time, as the outstanding debt authorized under this amendment falls below $50 million. During the period 1950-60, the State "reissued" $39 million of these bonds, represented by sales in 9 of the 11 years, and at the end of 1960 had outstanding $49.6 million of bonds under this authorization, consisting entirely of reissues. This type of amendment is somewhat similar to that in Oregon.

The limitation is expressed in dollars in West Virginia, whereas, in Oregon it is expressed as a percentage.

West Virginia's practice of reissuing bonds has the effect of funding a perpetual revolving debt of $50 million with interest (at present reissue rates) of about 3½ percent per year. Because the annual sales are approximately the same amount of annual retirements, the State is creating no additional capital funds through this method of financing and, as interest rates have risen, has in effect refunded low interest-bearing obligations by the substitution of bonds carrying higher rates. Moreover, the 1961 legislature appropriated $6,345,000 from general revenues to aid in payment of principal and interest on outstanding road bonds, although these bonds are a first charge against the State road fund which receives proceeds of road-user taxes.

A West Virginia constitutional amendment ratified in 1948 authorized an issue of $50 million of bonds to build secondary and farm-to-market roads. Under terms of the enactment, these bonds cannot be reissued. Between 1950 and 1953, inclusive, $45.5 million of these bonds were sold, all with 15-year maturities, with final retirement scheduled for 1968.

The West Virginia general obligations carry a Moody's rating of "A," sharing with Louisiana's bonds the lowest rating for State-guaranteed obligations sold during the period of this study.

General Obligation Issues by Referendum

Among the 17 States that require referendum approval of general obligation bonds, 7 (Arkansas, Kentucky, Maine, New Jersey, New York, North Carolina, and Rhode Island) undertook this method of borrowing during the 1950-60 period. The following discussion concerns some of the more significant of these.

Maine. —From 1952 through 1959, Maine issued a total of $52.5 million of voter-approved general obligation bonds, of which $39.5 million financed statewide construction of road and bridge projects, and $13 million were for specific crossing facilities, including the Bangor-Brewer and Jonesport Reach toll bridges, as well as toll ferries

[17] Oregon Constitution, Art. XI, §7.

operated by Maine Port Authority. By virtue of the State guarantee, bonds in the amount of $2.5 million for the Bangor-Brewer bridge were sold in 1952 at a net interest cost of 1.639 percent; those for the Jonesport Reach bridge in 1956 at 2.499 percent net cost, and those for the ferry service for 2.928 and 3.0726 percent in 1958 and 1959, respectively. In contrast to this, nonguaranteed bonds of the Maine Turnpike Authority were sold in 1953 at a net interest cost of 4.114 percent.

New Jersey.—New Jersey voters in November 1952 ratified an Act[18] that authorized the pledge of the State's full faith and credit back of an issue of bonds not to exceed $285 million to finance portions of a 164-mile toll highway from Paterson to Cape May, known as the Garden State Parkway. The act also specified that the bonds would have to mature within 35 years and would bear interest at not to exceed 3 percent per annum.

As early as 1945, the State Highway Department had begun construction of sections of this route, known as the Route 4 Parkway, as part of the State highway system. Funds appropriated were sufficient to complete only 22 miles of the parkway in 6 years, and it became apparent that if the parkway was to be completed within the foreseeable future, either legislative appropriations would have to be increased considerably or credit financing would be required.

Studies of the toll potentiality of this route were made, and it was concluded that a closed-type toll road, similar in design to the New Jersey Turnpike, would not be feasible because of the heavily urbanized area extending some 30 miles north of the Raritan River which the parkway would traverse. It was therefore planned to build the parkway as a barrier-type facility (with toll-free entrance and departure between barriers); i.e., the vehicle would pay a predetermined toll at each gate through which it passed, without regard to the distance traveled between gates.

Although this barrier system of toll collections had been used earlier in Connecticut on the Merritt and Wilbur Cross Parkways, and on the Westchester County, N. Y., parkways, it had not previously been used on any road that was planned to be entirely self-liquidating from tolls. There was, therefore, some doubt that investors would be willing to finance a venture of this kind, requiring so great an outlay. It was this factor that prompted the legislature to call for a referendum to place the State's guarantee back of the bond issue. It was felt that this would assure a market for the bonds, and that lower interest rates could be obtained.

It was decided that the parkway would be made free of tolls on the sections built by the State Highway Department. The original plan for a road on which commercial vehicles would be banned was modified to permit use by buses and to allow truck traffic south of the Ocean County line (near Lakewood)—approximately three-fifths of the parkway length.

Initial financing of the parkway by the Highway Authority was undertaken in the summer of 1952 when invitations were tendered to New Jersey banks and trust companies to subscribe to $10,000,000 of Series A notes. This plan was modified within a week when Federal Reserve Bank officials indicated these short-term notes or bonds would be speculative and therefore might not be acceptable in any bank that was a member of the Federal Reserve System. The Authority then proposed to obtain $10,000,000 to $20,000,000 in loans from New Jersey banks at 2 percent interest. In August 1952, 138 New Jersey banks made a short-term loan of $17,000,000 maturing July 1, 1953, and the first construction contracts were awarded by the Authority.

In September 1952, the State Department of Law ruled that the Authority had sufficient legal power to extend the parkway from its northern terminus at Paramus to the New York State line. The Authority had sought such a ruling in order to increase use of the road and expand its revenues.

In November, the voters approved by nearly 2 to 1 the referendum authorizing a State guarantee of the Authority bonds, but plans for permanent financing were delayed when constitutionality of the act was challenged. By January 1953, an additional $11,000,000 temporary loan had been negotiated with New York and Philadelphia banks, as the Authority marked time while the question of State guarantee of Authority bonds

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[18] Ch. 17, New Jersey Laws of 1952.

was being decided in the courts. In May, the New Jersey Supreme Court upheld the constitutionality of the statute, and plans for issuing permanent bonds were quickly completed.

In July, $150,000,000 of Series A serial bonds were sold at a net interest cost of 2.997 percent. In November, the remaining $135,000,000 of bonds authorized was sold at a net interest cost of 2.7652 percent. Final maturity of these bonds is scheduled for 1988.

From proceeds of the Series A bonds, the $28,000,000 of temporary loans was redeemed. Reinvestment of these loans had reduced the net interest cost to less than 1 percent during the period of temporary financing.

As construction proceeded, the Authority adopted the policy of opening sections of the parkway as soon as completed. The first section on which tolls were levied was opened in January 1954, and other sections followed. On July 1, 1955, the parkway began full operation.

In May 1954, the Authority announced plans for a $25,000,000 extension to the New York line to be completed by 1955, and for construction later of a ferry to link the Cape May end of the parkway with Lewes, Delaware, across the Delaware Bay. Legislation was enacted in July authorizing tolls on the northern extension. It was also determined that an additional $15,000,000 to $25,000,000 would be needed to complete the original parkway. Because the State guarantee had been exhausted, additional funds had to come from revenue bond financing.

Accordingly, in November 1954, the Authority sold $20 million of Series C revenue bonds maturing in 1988, at a net interest cost of 3.236 percent. In July 1956, financing was completed with the sale of $25 million of Series D and E revenue bonds to extend the parkway to the New York line. These bonds were sold at a net interest cost of 4.4534 percent.

The financing of the facility illustrates quite forcefully the interest cost differential in general vs revenue bond financing. Indicative of the security features, Moody ratings were "Aaa" for the general obligation of the the Authority and "Baa" for the revenue bonds even though the earnings of the facility since its opening have been adequate to meet all debt service requirements, and the State has not had to draw on other resources (motor fuel or property taxes) to supplement them.

New York.—The New York electorate in November 1951 ratified an amendment to the State constitution[19] authorizing the guarantee by the State of a maximum of $500 million of bonds to be issued by the New York Thruway Authority. This action, and that taken by New Jersey with respect to the Garden State Parkway bonds, are the only instances where voters have pledged the faith and credit of the State back of toll road Authority bonds. This has led some critics to question whether, under the circumstances, the creation of an independent State Authority is justified. The use of the authority device has been frequently used in conjunction with the financing of highway projects, both toll and toll free, where the use of limited or revenue bonds was indicated because of constitutional limitations. In retrospect, it appears that both New Jersey and New York could have successfully undertaken their toll highway programs under sponsorship of the existing highway department organizations, and thus avoided, or at least minimized, some of the administrative costs necessarily incurred by a separate authority.

The New York Thruway system, a network of 559 miles of highway, was in 1951 expected to be completed at a cost that could be financed within the limits of the guaranteed bond authorization. It soon became apparent that costs of the initial Thruway and subsequent additions would far surpass these limits, and in 1954 the legislature granted the Authority power to issue revenue bonds to finance completion. Accordingly, the Authority sold $350 million of revenue bonds in 1954 and an additional $50 million in 1959.

From 1953 through 1960, the Authority sold a total of $900 million of general and revenue bonds (Table 18).

The $400 million of revenue bonds have first claim on toll and other revenues of the Authority, even before that of the guaranteed bonds. This may have played an im-

[19] New York Constitution, Art. X, §6.

TABLE 18

BOND STATUS OF NEW YORK THRUWAY AUTHORITY[1]

Type	Date Sold	Par Value ($)	Net Interest Cost (%)
State guaranteed:			
1st	5/5/53	125,000,000	2.6382
2nd	9/15/53	125,000,000	2.6981
3rd	10/11/55	50,000,000	2.51464
4th	12/7/55	50,000,000	2.7370
5th	2/15/56	50,000,000	2.41836
6th	2/6/58	50,000,000	3.12365
7th	9/8/60	50,000,000	3.46124
Subtotal		500,000,000	2.765542
Revenue:			
Series A	6/16/54	300,000,000	3.0716
Series B	12/7/54	50,000,000	2.6828
Series C	8/12/59	50,000,000	4.1996
Subtotal		400,000,000	3.1519
Total		900,000,000	2.9567

[1] Source: (14, p. 34).

portant part in holding the net interest cost spread to an average of 0.4 percentage points.

During the period covered by this study, New York also issued a total of $213 million of highway and grade-crossing elimination bonds as guaranteed obligations of the State.

Following defeat by the voters in 1955 of a proposed $750 million highway bond authorization coupled with an increase in motor fuel taxes, a new proposal was drafted in 1956 and ratified by the voters in November of that year[20]. It authorized issuance of $500 million of guaranteed highway bonds, but did not provide for a tax increase (this was to come 2 years later). Under this authorization, the State sold during 1958 and 1959 a total of $90 million of bonds, maturing serially over a 20-year period, and at net interest costs ranging from 2.368 percent on a 1958 sale to 2.9527 percent on a 1959 sale. No subsequent sales have been made, and $410 million of authorized bonds remain unissued.

The State also sold $77 million of grade-crossing elimination bonds in 1950-51, and an additional $46 million in 1957-59, to comprise the remainder of the guaranteed obligations.

General Obligation Issues by Legislative Enactment

Seven (Connecticut, Delaware, Massachusetts, New Hampshire, South Carolina, Tennessee, and Vermont) of the 11 States that require only legislative approval of borrowing, sold general obligation bonds during the period 1950-60. (If limited and revenue bonds are included, all but one State—North Dakota—in this group sold bonds.) Some of these States are reviewed later in connection with revenue bond financing. Suffice it here to limit study to one State (Connecticut) that has financed highway work from the proceeds of bonds of each of the three major types. Connecticut's record of sales is given in Table 19.

[20] Ch. 761, Laws of 1956, State of New York.

TABLE 19
CONNECTICUT BOND ISSUES
($ × 10³)

Year Sold	General Obligations		Limited Obligations		Revenue Bonds	
	Amount	Net Interest Cost	Amount	Net Interest Cost	Amount	Net Interest Cost
1954			100,000	2.857		
1956			100,000	2.8798		
1957	35,000	3.6	50,000	3.689	30,000[1]	4.75
1958	77,000	3.258	35,000	3.99		
1959	38,000[1]	3.72998	62,500	4.2998		
1960	35,440	2.89				
Total	185,440		347,500		30,000	

[1] 1957 revenue bond issue of $30 million retired from proceeds of $38 million general obligation bonds of 1959.

Connecticut Turnpike Bonds.—The 1957 and 1958 sales of general obligations, and all of the limited obligations given in Table 19 comprise the $459.5 million total of bonds authorized to finance the Connecticut Turnpike, a 127-mile expressway from Greenwich to Killingly, that was opened to traffic January 2, 1958. Although tolls are collected at 8 barrier points, only 23 miles of the route are considered to be toll sections (i.e., sections on which the toll cannot be avoided); on the remaining 104 miles, vehicles are permitted ingress and egress without payment of toll. Connecticut chose to place responsibility for financing, maintaining, and operating this facility under the existing State Highway Department, rather than to create an independent authority. The Department covenants to meet all maintenance and operating expenses from other than turnpike revenues, thus permitting gross tolls and other income of the facility to be applied to debt service. Should these be inadequate, the Act provides a lien on motor fuel tax revenues, and in the case of the two general obligation issues, the further pledge of the State's full faith and credit.

Because of the difficulties encountered by the State in obtaining financing for this project, more than a superficial review of the bond issues is warranted. The 1953 legislature authorized[21] the State highway commissioner to construct the expressway and to issue bonds secured not only by toll earnings but also by a firmly indentured claim on the State's gasoline tax revenues. The comprehensive Act also created an expressway bond committee to consist of the Governor, State Treasurer, Comptroller, Attorney General, Commissioner of Finance and Control, and the Public Works Commissioner. The functions of the committee, included providing financial management for the project, prescribing bond issue terms, conditions, and interest rates, and approving toll schedules.

In April 1954, the committee adopted a bond declaration authorizing the issue of $398 million of expressway bonds, based on the then estimated cost of completing the project. Limitations were placed on annual debt service requirements, annual maturities of the serial bond issues, redemption premiums for advance retirements, and interest rates. The last was set at a maximum of 4 percent.

The first $100 million bond issue was sold in May 1954. A second sale of $100 million was scheduled for December 1955, but was postponed because of market conditions until February 1956. Meanwhile, the 1955 legislature had amended the expressway Act[22] to provide that the first bond issue should have prior claim on motor fuel taxes (if needed) and that subsequent issues should be subordinate in that respect. The

[21] Connecticut, Public Act 411, 1953 Session.
[22] Connecticut, Public Act 52, 1955 Session.

1955 Act also authorized the State to finance free roads through issuance of bonds payable from gasoline taxes and other highway fund revenues, but restricted all further bond issues to those for which debt service would not exceed 50 percent of the gasoline tax receipts from the preceding year at a rate of $0.04 per gallon then covenanted for benefit of bondholders. This Act also authorized the sale of not to exceed $50 million of 1-year bond anticipation notes.

Despite the subordinate security pledged for the second series bonds, they sold at about the same net interest cost as the first series. In October 1956, however, the State scheduled sale of a third series of bonds in amount of $75 million, but found a reluctance on the part of banking groups to accept the issue. Although the issue was then scaled to $54 million in hopes of attracting a better bid, and reoffered in November 1956, no bids were received. It was reported that the 4 percent interest rate limitation was unrealistic in the light of market conditions. To provide stop-gap financing, the bond committee in January 1957 sold $16 million of 9-month notes at 2.18 percent, and shortly thereafter obtained approval from the 1957 legislature to increase the amount of bond anticipation notes that could be issued from $50 to $100 million. The statute[23] also pledged the full faith and credit of the State to these notes.

A third issue of bonds in the amount of $50 million was successfully marketed in April 1957, after the bond committee had taken steps to improve terms of the issue. The committee assigned priority of financing to the western part of the expressway from the Connecticut River to the New York State line (estimated to account for 88 percent of costs and 94 percent of revenues), and provided that no expressway bonds would be issued for the eastern section until all costs of the western section had been permanently financed and until it could be verified that the entire expressway would be self-supporting from revenues. Provision was made to finance completion of the eastern section from proceeds of short-term notes. Despite these terms, the third series bonds sold at a net interest cost of 3.689 percent, substantially above the cost of the 1956 issue but not out of line with then current market rates.

To provide financing for the added cost of the expressway, the second 1957 Act raised the limit on short-term notes from $100 to $150 million, and also authorized the State to issue $150 million of general obligation bonds to complete the financing.

The fourth definitive bond issue, and the first to carry the State's guarantee, was sold in August 1957 in amount of $35 million as 40-year serial bonds. This issue was sold at a net interest cost of 3.6 percent. As the bond market was improving, the State offered a fifth series of limited obligations in November 1957 in the amount of $35 million, and these were sold at a net interest cost of 3.99 percent, just under the 4 percent self-imposed limitation.

When the expressway was opened on January 2, 1958, the State had outstanding $79.5 million of short-term notes, of which $31.1 million had financed the western section, in addition to $320 million of bonds. In February of that year, the State sold its sixth series of bonds, and the last increment of general obligations, with a $77 million issue, which sold at a net cost of 3.258 percent. The proceeds were applied to complete financing of the western section, including retirement of the $31.1 million of notes.

Financing the expressway was completed more than a year later when in June 1959 the seventh, and final, series of limited obligations was issued in amount of $62.5 million to fund the cost of the eastern section, including retirement of $57 million of general obligation notes. This issue bore the highest net interest cost (4.2998 percent) of any of the sales.

Although beset with financial difficulties, the State exercised prudent management in financing this important expressway facility (some 87 miles of which are on Interestate 95). By borrowing funds as needed, and making extensive use of short-term notes, interest costs were held to a minimum during the four-year construction and six-year financing period. However, had the State chosen to make use of general obligation bonds exclusively, the interest costs to final maturity in 1997 of the present bond series would undoubtedly have been substantially reduced (the cost of the 1958 general obligation issue

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[23] Connecticut, Public Act 2, 1957 Session.

was a full percentage point below the 1959 limited bond issue), and the State would have had less difficulty in marketing its securities.

Other Connecticut Bond Issues.—The $73,440,000 of general obligation bonds sold in 1959 and 1960 (Table 19) were the first increments of a $346 million, 4-year highway bonding program approved by the 1959 legislature[24]. In 1961, the State sold an additional $28,980,000 of bonds under this authorization at a net cost of 2.83 percent. As contemplated in the program, bonds would be supplemented with State and Federal-aid funds to bring the total financing to $522 million. Of the total bond issues, $222 million are to be grant anticipation bonds; i.e., bonds to finance the Federal share of Interstate projects for which the State will receive reimbursement after 1963. By this method the State will be able to accelerate Federal-aid Interstate system construction beyond the pace governed by the amount of Federal funds available annually to the State.

The 1961 legislature increased the borrowing authority by an additional $125 million to build 24 specific highway projects, permitted issuance of grant anticipation notes and made optional the issue of bonds as general or limited obligations of the State[25]. The Act also created a highway debt service fund to receive all State motor-vehicle registrations and license fees after July 1, 1961.

Limited Obligation Bonds

As explained previously, this class of bonds comprises those issues secured wholly or in part from the proceeds of highway funds, but which do not carry the further guarantee of the full faith and credit of the State. During the period, 1950-60 covered by this study, the amount of limited bonds issued for highways ($2,433 million) was almost as great as the amount of general obligation bonds ($2,770 million), indicating the popularity of this type of bond.

According to the nature of the security, limited bonds can be divided into two groups: (a) those secured entirely from the proceeds of State tax revenues and highway funds, and (b) those secured partly from such revenues and partly from toll and other earnings of the specific facilities to be financed. Examples of financing through the use of the authority device are found in both groups. Some of the more prominent examples of each type are described.

Road-User Tax Bonds in Ohio.—The Ohio voters in November 1953 approved a constitutional amendment authorizing the issuance of tax revenue bonds up to $500 million. Under terms of the resolution, not more than $125 million could be issued in any one year, and none after 1962. All bonds must mature by 1972. The bond authorization was part of a $1 billion highway construction program to cover an 8-year period, and to be financed, in addition to the bond proceeds, by revenues from an added $0.01 per gallon motor fuel tax, and a highway use (axle-mile) tax, both of which were enacted in 1953. Remaining funds would be derived from other highway and Federal-aid funds.

Ohio's constitution prohibits borrowing, and before adoption of the bond amendment, the State's only experience with bond financing had been in connection with the revenue bond financing of Ohio River toll bridges by the State Bridge Commission during the 1930's, and the sale in 1952 of $326 million of toll road revenue bonds by the Ohio Turnpike Commission. Thus, the financing of major toll-free highways by means of tax revenue bonds represented a departure in the State's highway financing policies. Under the amendatory device, the State could have sought voter approval for a general obligation bond issue, and this might have further reduced the cost of borrowing, because Ohio's guaranteed debt is rated "Aaa," whereas the tax revenue bonds are rated only "Aa" by bond-rating houses.

The $500 million of major thoroughfare construction bonds, as the tax revenue bonds were called, were issued over an 8-year period (Table 20). The State has managed its bond program wisely. The spacing of sales in small increments, and only as required to meet construction commitments, has resulted in financial savings, both as to initial interest costs as well as interest rates. The reasonably short serial maturity schedule will also result in interest savings over the life of the bond issues. The total cost to

[24] Connecticut, Public Act 132, 1959 Session.
[25] Connecticut, Public Act 605, 1961 Session.

road users for this bond program is computed as follows:

Bond principal	$500,000,000
Interest, 1954-72	108,474,000
Total	$608,474,000

Interest is thus found to equal 22 percent of the bond principal. This is in sharp contrast to the cost to the users of financing the Ohio Turnpike. The $326 million turnpike revenue bond issue sold in 1952 at a 3¼ percent coupon, matures in 1992, and according to the Official Statement (15, p. 16) interest and principal requirements would be as follows, assuming advance retirements from revenues during the years 1957-1992:

Bond principal	$326,000,000
Interest, 1956-92	245,246,000
Total	$571,246,000

For this issue, interest will equal 75 percent of bond principal. Actually, the first retirement of turnpike bonds occurred in 1961, rather than 1957, so that the estimated cost may well prove to be conservative.

The debt service on major thoroughfare construction bonds in 1960 totaled $41.2 million, and during that year the proceeds of the pledged $0.01 motor fuel tax, and the highway use tax were $30.7 million, and $17.6 million, respectively, and in addition, the State had built a reserve fund by the end of the year of $41.5 million. Thus, the State at present has ample security to meet all debt requirements. Ohio's accelerated program has moved it to the vanguard among States in meeting highway needs envisioned by the Federal-aid Interstate program. According to records of the Bureau of Public Roads, as of May 31, 1962, Ohio had obligated 65 percent of its fiscal 1963 Federal Interstate funds, and also 71 percent of 1963 ABC funds, to rank among the top 4 States in this respect.

Road-User Tax Bonds in Michigan.—Michigan, like Ohio, has a constitutional prohibition against borrowing but, unlike Ohio, has chosen to use limited obligation bonds without submitting the question to the electorate. During the early 1920's, the State

TABLE 20

OHIO MAJOR THOROUGHFARE CONSTRUCTION BOND ISSUES

Year Sold	Issue	Par Value ($ × 10^6)	Coupon	Net Interest Cost	Maturities
1954	Series A	30	1.0 -6.0	1.381	1956-64
1955	Series B	52	2.0 -6.0	2.308	1956-72
1956	Series C	50	3.0 -3.5	3.0932	1956-72
	Series D	25	3.0 -6.0	3.1106	
1957	Series E	32	2.5 -6.0	2.906	
	Series F	32	3.6 -6.0	3.754	1957-72
	Series G	31	3.0 -6.0	3.324	
	Series H	30	3.0 -6.0	3.345	
1958	Series I	32	2.0 -6.0	2.559	
	Series J	32	2.0 -6.0	2.673	
	Series K	31	2.5 -6.0	3.881	1958-72
	Series L	30	3.25 -6.0	3.373	
1959	Series M	31	3.0 -6.0	3.537	1960-72
1961	Series N	32	2.5 -5.0	2.92	1962-72
	Series O	30	2.5 -6.0	2.88	1962-72

issued $50 million of general obligation highway bonds under a constitutional amendment[26] ratified in 1919, but over a span of nearly 30 years, the State did not borrow for highway purposes, except for small amounts of toll bridge revenue bonds issued during the late 1930's by the Michigan State Bridge Commission.

In 1945, the State entered into a contract with Wayne County and the city of Detroit to finance jointly construction of the John C. Lodge and the Edsel Ford Expressways within the city of Detroit. The three participating units contributed a total of $5 million annually which, together with Federal-aid funds, had reached an aggregate of $42 million by the end of 1950. However, at that rate of progress it had become evident that an additional 15 years would be required to complete the projects, and the 1950 legislature accordingly enacted a statute[27] authorizing the State to enter into a contract with any county, city, or village, for the construction of limited-access highways to be financed with proceeds of bonds secured by a pledge of the road-user tax revenues accruing to each of the participants from the State (motor vehicle) highway fund. The legality of these proposed bonds was challenged in the courts, and the Michigan Supreme Court held them not to be in contravention of the constitutional prohibition on borrowing.[28] The court, in explaining the special fund doctrine, quoted the following from a California decision[29]:

> The overwhelming weight of judicial opinion in this country is to the effect that bonds, ...issued by states, cities, counties,...if such particular bonds or obligations are secured by and payable only from the revenues to be realized from a particular utility or property, acquired with the proceeds of the bonds or obligations, do not constitute debts of the particular state, ...within the definitions of "debts" as used in the constitutional provisions of the states having limitations as to the incurring of indebtedness.

This describes, in most succinct terms, the distinctive features of nonguaranteed bonds.

Following this decision, the State sold late in 1951 the first of a series of limited-access highway revenue bonds to provide additional financing for the Lodge-Ford expressways. Later, bonds were issued under the 1950 statute for the construction of a number of other expressway projects, such as the Detroit-Toledo and Grand Rapids expressways, and by 1957 when the last of this series was issued, the State had sold a total of $203 million of bonds, out of an authorized total of $300 million. The 1950 Act limited the annual expenditure by the State from its share of highway funds to $3,500,000. Later Acts raised this limit to $12 million, although the maximum annual pledge as of September 30, 1961, was $9,953,935.

The net interest cost of the limited-access bonds ranged from a low of 2.032 percent on $20 million sold in December 1952, to a high of 3.3772 percent on $17 million sold in January 1957.

Under the 1950 Act, as amended, the State could issue an additional $97 million of bonds, and pledge an additional $2,046,065 of State highway funds annually. It appears doubtful, however, that any additional debt will be created under the provisions of this statute because of the limiting feature of the State's pledge.

In 1955, Public Act 87 authorized the issuance of highway construction bonds to expedite financing and construction of necessary highways, and also increased the gasoline tax by $0.015 per gallon and imposed some additional fees on commercial vehicles. Under this authorization, bonds in the amount of $25,000,000 were sold in September 1956 at a net interest cost of 3.042 percent to provide the State's share of cost of 184 miles of Interstate highways and 36 miles of trunkline highways. The bonds were secured by a second lien against the State Highway Department's total allocations from the Motor Vehicle Highway Fund. No additional bonds may be issued under the provisions of Act 87, as bonding provisions of this act have been repealed.

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[26] Michigan Constitution, Art. X, §10.
[27] Public Act 22, 1950 Extra Session, amending Act 205, Public Acts of Michigan, 1941.
[28] Ziegler v. Witherspoon, 49 N.W.2d 318.
[29] California Toll Bridge Authority v. Wentworth, 212 Cal. 298, 298 P. 485.

Faced with the need for additional borrowing authority to accelerate highway construction, the 1957 legislature by amending Act 51 of the 1951 Public Acts[30], broadened the basis for bond financing and at the same time provided certain limits on the bond interest rates and maturities of future sales.

Under Section 18(b) of this Act, the State Highway Commissioner, subject to approval by the State Administrative Board, may issue limited obligations to pay all or any portion of the cost of construction or reconstruction of highways, including limited-access highways, which he is authorized to construct either with or without participation by other governmental units. In authorizing each issue, the Administrative Board must, by resolution, describe the contemplated project and estimate the cost thereof, as well as stipulate the amount, maximum interest rate, and maturity dates of the bonds.

Under Section 18(d) of Act 51, as amended, the Commissioner may enter into contracts with counties, cities, and villages to finance highway construction on a participating basis, by which each of the contracting parties may make an irrevocable pledge of its annual share of Motor Vehicle Highway Fund receipts for periods not in excess of 30 years. Bonds may be issued by any governmental unit that is a party to the contract, subject only to the limitation that the annual pledges for these bonds, or any other bonds paid from the same funds, cannot exceed 50 percent of the participants' annual share of Motor Vehicle Highway Fund receipts. The State's limitation applies after first deducting the pledges for bonds issued under the 1950 and 1955 statutes.

Bonds issued under either Section 18 (b) or 18 (d) shall be serial bonds, with 25-year maximum maturities; bear interest at not to exceed 5 percent; and be redeemable before maturity.

Between 1958, when the first bonds were issued under Act 51, as amended, and December 31, 1961, the State issued a total of $363 million of trunk line highway bonds under Section 18 (b) and Expressway Bonds under Section 18(d) at net interest cost ranging from 3.307 percent for $100 million sold in May 1958 to 4.2861 percent for $50 million sold in July 1959.

Thus, in summary, the State of Michigan has issued a total of $591 million of road-user tax revenue bonds between 1951 and 1961. Of this total, the State is responsible for debt service on $514,190,000 and $76,810,000 is the responsibility of local units of government (16, p. 23). Based on its share of fiscal 1961 receipts, the State has utilized nearly two-thirds of its annual funds available for debt pledge computed as follows on the basis of fiscal 1961 receipts (in millions of dollars):

Motor vehicle highway fund receipts (State share)	99.7
Pledges for Act 205 and Act 87 bonds	11.5
Balance of funds	88.2
50% available for §§ 18(b) and 18(d) bonds	44.1
Pledges for §§ 18(b) and 18(d) bonds	24.6
Balance available for pledge	19.5

Michigan's accomplishment under its bond financing program has been impressive in recent years. In 1957, the State launched a $1.25 billion 5-year construction program, covering the fiscal years 1958-62 to be financed by an estimated $505 million in Federal aid, $330 million in current State funds, and $415 million in bonds. By the end of the fourth year of the program, the State (17, p.16) could announce, with justifiable pride:

> During the past four years, Michigan has moved from 35th to first place among all states in the construction of Interstate Highways, leading the nation for the calendar year of 1960, and for the first six months of 1961, in the amount of Interstate construction placed under contract. Michigan currently ranks second in the nation in the amount of toll-free Interstate Highways open to traffic and built to standards adequate for 1975 traffic. At the end of fiscal 1961, Michigan had 372 miles of such highways open for travel.

Although Michigan has been highly successful in managing its highway bond program, it is probable that a pledge of the State's credit would have resulted in reduced interest costs. According to the State Auditor's 1961 report (16), the average interest rate on

[30] Public Act 262, 1957 Laws, amending Act 51, 1951 Laws of Michigan.

$355 million of general obligation bonds for veteran's bonuses and hospital buildings sold by the State during the years 1947-54 ranged from 1.44 to 1.84 percent. The average rate for expressway bonds has been 2.84 percent; for highway construction (Act 87), bonds 3.04 percent; and for Trunkline highway bonds, 3.74 percent.

Nonetheless, the interest cost of highway bonds has been far lower than the toll revenue bonds sold by the Mackinac Bridge Authority or the International Bridge Authority of Michigan. Bonds of the former, in amount of $99,800,000, were sold in 1954 at a net interest cost of 4.349 percent, whereas those of the latter, in aggregate amount of $16,250,000, sold in 1960 at 5.0 and 6.0 percent net interest cost.

Alabama Highway Authority.—As discussed earlier, Alabama issued $25 million of general obligation bonds in 1952 to match Federal-aid funds. This issue had been required to take up the slack in tax revenues as a result of the State's reducing registration tag fees in 1952 to $3, one of the lowest rates in the Nation. Faced with the need for additional capital funds, the legislature in 1955 increased the motor-fuel tax from $0.06 to $0.07 per gallon and created the Alabama Highway Authority[31]. The enabling statute authorized $50 million of bonds, and subsequently in 1959, the legislature authorized an additional $60 million[32]. The proceeds were used to continue a large road-building program and to match Federal funds.

Between 1955 and 1961, the Authority sold $110 million of bonds in eight separate sales, ranging in amounts from $6 to $20 million, and at net interest costs from 2.903 percent on the 1955 sale to 3.83 percent on a 1960 sale. All issued are callable; were issued at par or at a slight premium, mature serially over a 20-year period, and carry an A rating.

Security for the bonds is a pledge of the following portions of the State gasoline tax.

1. Remainder of $0.02 of gas tax (after amount required to service general obligation highway bonds) pledged first for service of 1955 Act bonds, with remainder for 1959 Act bonds.
2. Two-thirds of $0.01 of gas tax pledged first to the 1955 Act bonds, with remainder for 1959 Act bonds.
3. One-third of $0.01 of gas tax all to the 1959 Act bonds.

The Authority is one of the "financing" type, inasmuch as it is merely a vehicle by which the bonds are issued. Its membership consists of the Director of Finance, the Highway Director, Attorney General, State Treasurer, and Executive Secretary to the Governor. Except for small amounts charged for travel expenses, legal services, and bond issue expenses, the proceeds of the bond sales are transferred to the Highway Department as required.

By use of the authority device, the State has avoided the need for a constitutional amendment to authorize additional borrowing and has carried out a 7-year improvement program by means of limited obligation bonds. However, indications are that the State may have overextended its resources by reducing taxes and by using bond financing as a substitute for tax revenue in financing current highway needs, rather than as an auxiliary means of financing an accelerated "catch up" program.

Pennsylvania State Highway And Bridge Authority.—Although Pennsylvania adopted constitutional amendments in the 1920's and 1930's authorizing highway borrowing, the amendatory procedure in that State has been complicated by two factors. First, the constitution requires action of two consecutive legislatures before an amendment can be submitted to the electorate. Second, a particular section of the constitution may not be amended more often than once in five years. Undoubtedly, these factors have had an important bearing on the decision by the legislature to create special authorities such as the Turnpike Commission, the State Highway and Bridge Authority, and others with power to issue bonds not subject to constitutional restriction.

The Pennsylvania State Highway and Bridge Authority was organized in 1949 as a public corporation and the enabling legislation was written in such a way that, although legally an independent agency, the Authority has no actual existence outside the Depart-

[31] Act 43, §§9 and 10, Laws of Alabama, Special Session 1955.
[32] Act 45, Laws of Alabama, Special Session 1959.

ment of Highways. Its function is solely to provide a legal means for borrowing money on the security of a portion of State highway-user revenues.

The enabling legislation gave the Authority the power to borrow $40,000,000. The Act provided that the Authority has no power to pledge the full faith and credit of the State but only its own resources.

Under the Act, the Highway and Bridge Authority can undertake any type of highway project, but not until plans and specifications have been "submitted to and approved by the Department of Highways." Further provisions enable the Authority to cooperate with the Department of Highways in the use of its equipment, personnel, and other facilities. In practice, the Authority employs no personnel save legal counsel and all its work is done by the Department of Highways.

The following procedures are necessary to assure compliance with the legal and constitutional provisions involved in the establishment of the Authority: All highway projects financed with funds borrowed by the Authority are designed, contracted for, and constructed under the supervision of the Department of Highways acting as agent of the Authority. The Authority and the Department of Highways, before the construction of the project, sign an agreement whereby the Authority leases the facility to the Department for a specified rental. The rentals are to be derived from the highway user taxes and other State moneys deposited in the Motor License Fund, and are applied to principal and interest on the Authority's bonds. In fact, the rentals will equal the debt service requirements plus the administrative costs of the agency.

Subsequent legislation raised the borrowing power of the Authority to $80 million in 1951 and to $120 million in 1955. The 1961 legislature added an additional $300 million borrowing authority, under which bonds can be issued at a rate not to exceed $50 million per year. This latest increment is designated to finance an accelerated interstate system construction program.

As of the end of 1961, the Authority had issued a total of $120 million of bonds at net interest costs from 1.2534 percent for $15 million sold in 1949 to 3.5545 percent for $10 million issued in 1959.

The Authority is evidently destined to play a major part in the State's highway-financing program. On November 30, 1961, construction contracts had been awarded for the Authority in the aggregate amount of $125 million, and the Authority had financed or shared in financing numerous major projects, such as the Penn Lincoln Parkway in the Pittsburgh area and the Schuylkill Expressway into Philadelphia. Rental had been fixed on 97 completed projects at a total annual rate of $10 million at the end of 1961 (18).

Florida Limited Obligations Secured by Tolls and Road-User Taxes.—Financing by means of limited obligations secured by a pledge of tolls and road-user taxes has been discussed in connection with Connecticut bonds. A variation of this method is also used by Florida. The constitution of Florida prohibits the issuance of State bonds (with the usual exceptions for wars and emergencies). However, State funds are used to service a large volume of highway debt through various boards and commissions and, in addition, several authorities have been created to finance specific toll projects. At the end of 1960, $293,812,000 of highway debt was being serviced by State agencies—none of it a direct obligation of the State.

In general, debt management is vested in five agencies: the Florida State Board of Administration, the State Road Department, the Florida Development Commission, the Jacksonville Expressway Authority, and the Florida State Turnpike Authority. (The last mentioned is discussed later, in the section on revenue bond financing.)

State Board of Administration.—The State Board of Administration (whose members are the Governor, State Treasurer, and State Comptroller) acts as the fiscal agent for the State, administers all county highway debt incurred before 1931, with the power to refund same, and receives, beginning in 1943 and for 50 years thereafter, the annual proceeds of $0.02 per gallon motor fuel tax as a fund to service the county debt. The share of this fund that accrues to the benefit of each county is determined by a formula that gives equal weight to (a) area, (b) population, and (c) the counties' contributions to the cost of State road construction before 1931. The remaining county road indebtedness chargeable to this fund was $27,451,000 as of June 30, 1960, and 39 of the 67 counties are now free of this class of indebtedness. Out of each county's share, surplus funds not required for debt service are allotted 80 percent to the State Road Department and 20 percent to the county. These surplus funds must be used for highway purposes within the county, but may be pledged and applied for debt service on new bond issues.

State Road Department. —The State Road Department has entered into "lease-purchase" agreements with a number of counties, cities, special districts, and toll authorities whereby it acquires title to various road and bridge projects on the State system by payment of an annual rental generally equal to debt service requirements on the lessor's bonds issued to finance the projects. For payment of these rentals, it pledges all or a portion of its "80 percent surplus" funds accruing for use in the respective counties.

The Department presently has agreements with lessors in 10 counties, covering 17 facilities on which the debt outstanding at the end of 1960 totaled $29,877,000. Two of the leases are with toll authorities: the Ocean Highway and Port Authority (formerly known as the Fernandina Port Authority) operating a toll road-ferry project in Duval and Nassau Counties, and the Santa Rosa Island Authority operating a toll bridge in Escambia County. Outstanding debt for these two facilities totaled $5,559,000 at the end of 1960, carrying coupon rates of 3 to 3¼ percent.

The Department supplies debt service funds to the Board of Administration which applies them as provided under terms of the lease-purchase agreements. The Department's remittance to the Board consists of a part of the "80 percent surplus" gasoline tax funds allotted to the respective counties, in which the leased facilities are located, together with tolls from the two toll facilities.

Florida Development Commission. —The Development Commission is composed of nine members, one from each of the eight congressional districts, and one at large. The Commission was created in 1955 as a successor to the Florida State Improvement Commission. It is empowered by law, on application of any county, to construct roads or bridges connecting State highways, and to issue revenue bonds paid from and secured by a lien on the Road Department's 80 percent surplus gas tax, under lease-purchase agreements. A 1959 law permitted issuance of certificates of indebtedness to be secured by a lien on the counties' 20 percent surplus tax.

As of the end of 1960, the Commission had $66,637,000 of county road revenue bonds outstanding on behalf of 40 counties, secured by a pledge of surplus gas tax funds.

The Commission has also issued revenue bonds to finance construction of the Lower Tampa Bay Bridge, a toll facility. There is no pledge of surplus gas tax revenues for this project, but the Road Department provides for maintenance and repair costs under lease-purchase agreement, and the bridge tolls, after deducting operating costs, are pledged for debt service. Callable revenue bonds having a par value of $21,250,000 were issued in 1951, bearing a coupon rate of 3.75 percent, and maturing in 1981. They carry a Moody's rating of Baa. At the end of 1960, $12,348,000 of these bonds remained outstanding, the remainder having been called and retired from earnings.

The Commission has also financed toll projects in five counties from proceeds of bonds that are secured, under lease-purchase agreements, by a pledge of tolls and 80 percent surplus gas tax funds. In three of the counties, bond proceeds were applied to construct a series of projects, both toll and toll free. In 1953, $6,000,000 of bonds were sold at a net cost of 3.555 percent to finance the Palma Sola and Cortez toll bridges, and three free bridges at or near Bradenton in Manatee County. A $2,200,000 bond issue was sold in 1956 at 3.698 percent net interest cost to finance the St. Lucie River, Jensen River, and Indian River toll bridges and other free bridges in Martin County. In 1959, the Commission sold $25,000,000 at 4.104 net cost to finance a number of road projects in Dade County, including the 36th Street Expressway, a toll road in Miami.

In Pinellas and Santa Rosa Counties, bond funds were applied only for toll projects. A $16,800,000 issue was sold in 1960 at 4.84 percent net interest to finance a series of causeways and bridges in Pineallas County in the vicinity of St. Petersburg; and in 1958, a $2,000,000 issue was sold at 4.4316 percent net interest to construct the Navarre Bridge in Santa Rosa County.

Jacksonville Expressway Authority. —The Authority was created in 1955 for the purpose of financing and completing a system of limited-access routes through the city of

Jacksonville. The Authority consists of three citizens of Duval County appointed by the Governor, and two ex-officio members: the Chairman of the Board of Duval County Commissioners, and a member of the State Road Department from the district that includes Duval County.

The Jacksonville Expressway System was begun in 1950 when the Florida State Improvement Commission sold $28 million of bonds which, together with $13.8 million to be provided from Road Department and Federal-aid funds, was expected to complete the system. In addition to an expressway system, the program provided for two toll bridges across the St. Johns River (the John E. Mathews and Fuller Warren Bridges).

In 1957, the Authority sold $70 million of bonds to retire the 1950 issue and to finance completion of the system, including a third toll bridge across Trout River. These bonds were sold at a net interest cost of 4.322 percent and consisted of a $60 million term issue maturing in 1992, and $10 million maturing serially to 1976. At the end of 1960, $68,826,000 was outstanding.

Under a lease-purchase agreement, the Department will operate the System and will pay the Authority as rental for, and purchase of, said System the following amounts:

1. All gross tolls from operation of the three toll bridges.
2. All 80 percent surplus gasoline tax funds accruing to the State for use in Duval County, subject to a prior lien for service of Ocean Highway and Port Authority bonds.

Thus, under the aegis of several State agencies, Florida has financed a large volume of highway work throughout the State, from the proceeds of limited obligation or State-assumed bonds, for which gasoline tax revenues have been pledged for debt service. To service the $228.5 million of highway debt outstanding at the end of 1960 (excluding Florida Turnpike debt, and pre-1931 county debt) required an allotment of $12.9 million of motor-fuel tax revenues. As Table 8 shows, this is about 11 percent of available 1960 revenues—well below the median payment. Undoubtedly, the State will continue to make use of this borrowing authority.

Revenue Bond Financing

As discussed previously, the highway revenue bond device (usually employed in conjunction with creation of an authority) gained widespread usage during the period of this study. Reaching a peak in 1954 when slightly over $1.8 billion of such bonds were issued, the sale of revenue bonds declined in the late 1950's following enactment in 1956 of an accelerated Federal-aid highway program. Since 1960, however, interest in toll road financing has revived and several States (notably Delaware, Florida, Kentucky, Maryland, Massachusetts, and Oklahoma) have successfully floated revenue bond issues to finance new toll road sections, whereas Virginia and other States have recently marketed large toll bridge and tunnel bond issues. Because of the financing features of these newer issues, several of them are examined here in some depth.

Massachusetts Turnpike Authority.—This authority was created by chapter 354 of the Acts of 1952 to finance and build toll roads within Massachusetts. In 1954, the authority sold $239 million of turnpike revenue bonds to finance the "initial turnpike" which would extend from an intersection with Route 128 in the environs of Boston westwardly 123 miles to the New York State line. The bonds were sold as 40-year terms, bearing a coupon rate of 3.3 percent, at a net interest cost of 3.356 percent. Construction began in January 1955, and the road was opened to traffic 28 months later in May 1957. Since that time, the turnpike has shown a steadily improving earnings-to-debt ratio, although the legislature saw fit, shortly after the turnpike was opened, to grant refunds for the tax paid on motor fuel consumed on the turnpike as an encouragement for greater patronage.

In 1958, the Authority was authorized to acquire the existing 2-lane Sumner Tunnel between Boston and East Boston, and to construct an adjacent new two-lane tunnel. Accordingly, in 1959 the Authority sold $52,800,000 of tunnel revenue bonds as 40-year, $4\frac{3}{4}$ percent term bonds, at a net interest cost of 4.84 percent. Under terms of the enabling act, this is a closed indentured project, and all funds relative thereto must be held and administered separately from those of the "initial turnpike."

Meanwhile, studies continued to be made of the feasibility of extending the "initial turnpike" from its terminus at Route 128, near Boston, into the center of the city in the vicinity of the South Station rail terminal, a distance of about 12 miles. Base on traffic and engineering studies made in 1958 and 1960, the Authority attempted unsuccessfully to obtain financing for this project. In 1962, however, an acceptable bond-financing plan was devised, and the Authority in February was successful in selling a $180 million revenue bond issue to finance the Boston extension. Several novel features account for the success of this financing plan, and bear examination.

Although indentured as a distinct project, the Boston extension will be linked with the "initial turnpike" in several respects. The new bond issue consists of $100 million of Series A bonds with a coupon rate of 4.75 percent, and $80 million of Series B bonds with a 4 percent coupon. The bonds were sold with a 40-year term maturity, at a combined net interest cost of 4.48 percent. A unique feature of the Series B bonds is that they will bear two different rates of interest at different periods of time. So long as any of the $239 million of bonds to finance the "initial turnpike" are outstanding, the new Series B bonds will bear a 4 percent interest rate.

As soon as the 1954 issue is retired, the 4 percent Series B bonds will be refunded with 5 percent bonds, plus a retroactive premium of 1 percent for each year that has elapsed since issue of the Series B bonds, making them, in effect, 5 percent bonds throughout their life. If the Series B bonds are refunded at any time before January 1, 1972, the Authority must pay an additional call penalty of 10 percent, or in other words purchase the Series B bonds at 110 percent of par. For each year that refunding of the Series B bonds is deferred beyond 1972, the call penalty increases by ½ percent, to a maximum of 12½ percent.

Series A bonds are also callable after January 1, 1972, at 106 percent of par, and this same call penalty applies to the Series B refunding bonds if retired 5 years after issuance. Revenues of the "initial turnpike," after retirement of the 1954 bonds, shall be applied toward retirement of the Boston extension bonds. To hasten retirement of the 1954 issue, net revenues of the Boston extension will be applied toward their redemption.

The financing plan outlined here is not only highly complex but also proves to be costly. According to Table 21, the Authority (and hence the public via the toll road user) will have paid a total of nearly $327 million to finance a project having an initial capital cost of $152 million. All the data in Table 21 are derived from the Authority's Official Statement (19) issued to prospective buyers of the Series A and B bonds.

Of course, some of the added costs of financing this project are inherent in any program of bond financing, but it is interesting and perhaps informative to speculate on the differential in cost of financing this project with general obligation of the State rather than toll revenue bonds.

Massachusetts is particularly well suited for this type of comparison, because the State has managed a well-planned program of general obligation highway bond financing for several years. Between 1950 and 1960 the State sold $590 million of highway bonds, the proceeds of which were used to finance such major projects as Route 128 (the circumferential highway around Boston), the Boston Central Artery, and many other expressway projects throughout the State. These general obligation bonds have found a ready market, and the State has managed the sales wisely, by the device of advance appropriation of capital funds, replenished from time to time from the proceeds of bond issues. This has afforded the State an opportunity to select a time to sell its bonds when bond market conditions are advantageous.

Assuming that the State could have financed the Boston turnpike extension with guaranteed bonds, and accepting the $152 million construction cost as a base, the following postulates can be made:

1. Construction bonds totaling $152 million, would be issued at par over a 3-year construction period in three approximately equal annual installments.
2. Interest would be computed at 3.1 percent, the rate at which other Massachusetts highway bonds were selling in 1960-62.
3. Maturities would be scheduled as equal annual serial retirements over a 20-year period, again typical of guaranteed bonds.

TABLE 21

COST OF FINANCING MASSACHUSETTS TURNPIKE EXTENSION

Factor	Amount ($)
Cost to build extension:	
Construction	95,883,000
Right-of-way	33,000,000
Engineering	9,350,000
Administration	1,617,000
Maintenance, toll, and other equipment	2,150,000
Contingencies	5,000,000
Subtotal	147,000,000
Improvements	5,000,000
Total	152,000,000
Source of funds:	
Par value of Series A and B bonds sold for extension	180,000,000
Less discount on bonds sold	-4,300,000
Less capitalized interest to March 1, 1966	-31,800,000
Plus investment earnings on construction funds	8,100,000
Total	152,000,000
Cost to motorist to amortize investment:	
Interest paid on Series A and B bonds until retirement of original 1954 turnpike bonds—assumed to be on July 1, 1976 (March 1, 1966—July 1, 1976)	81,487,500
Cost of refunding Series B bonds, if redeemed on July 1, 1976 at 112% call premium plus 1% per year for 14 years—(based on consulting engineer's estimate)	21,467,000
Interest on Series A and B refunding bonds until retired (based on retirement of Series A bonds by 1980 and Series B refunding bonds by 1982)	31,820,500
Call premium on Series A and B refunding	12,088,000
Retirement of Series A and B refunding (excluding amount of Series B refunding bonds shown as cost in item 2)	180,000,000
Total	326,863,000

Computed on the preceding factors, the cost of financing with general obligation bonds (interest plus redemption) would be $203,615,000 over the life of the issue. This would be a savings of 38 percent of the $326,863,000 probable cost of revenue bond financing.

Excluding the $152 million construction cost from both figures leaves $52 million as the added cost of financing with guaranteed bonds, compared with $175 million for revenue bonds. On this basis of comparision, over 70 percent of the financing costs of the revenue bond issue could be saved by the use of guaranteed bonds.

Financing this project with general obligation bonds would have been feasible, even though tolls were to be imposed. The experience in Connecticut and other States has shown that the levy of tolls has not precluded the use of the guaranteed or limited obligation bond as a means of raising the necessary capital, and of holding the financing costs to a minimum.

Florida State Turnpike Authority.—The Florida legislature by a 1953 Act (Ch. 28128) created the Turnpike Authority with powers to finance and construct such turnpike projects as might be designated by the legislature. The first such project so stipulated was a toll road from Miami to Ft. Pierce, a distance of about 110 miles.

In 1955, the Authority sold $74 million of $3\frac{1}{4}$ percent revenue bonds to finance project No. 1 (the Sunshine State Parkway). The bonds were to mature in 1995, were callable, and were sold at a net interest cost of 3.32 percent. The bonds are secured solely by tolls, and no direct or contingent pledge of State funds is involved. By November 1, 1961, $10,183,000 of bonds had been called for redemption, of which approximately two-thirds had been retired from revenues, and the remainder from surplus bond proceeds and interest income. Under terms of the enabling act, the Authority may in its discretion designate the turnpike as part of the State road system when it becomes debt-free, and the State Road Department shall then maintain sufficient tolls to defray the cost of maintenance and operation.

Subsequent enactments authorized extension of the turnpike northerly to Jacksonville, and from the Miami terminus westward to Fort Myers and Tampa. Late in 1961, the Authority sold $157 million of bonds to refund the 1955 series, and to provide funds to finance construction of project No. 2, extending the turnpike from Ft. Pierce to Orlando and Wildwood, a distance of approximately 158 miles. These bonds were sold as 40-year terms, at a coupon rate of 4.75 percent, and were purchased at 95.75 percent of par, or a 4.86 percent net interest cost.

To obtain a maximum feasibility ratio for this project (ratio of net earnings to debt service requirements), agreements have been made with the State Road Department to defer construction until 1972 of any parallel or competing routes within the general north-south corridor that would adversely affect the traffic and revenues of turnpike projects 1 and 2. Although the northern 40 miles of turnpike project No. 1 is located on Interstate 95, (which extends along the east coast of Florida), project No. 2 is not, veering inland instead to a terminus in the central area of the State. The State, however, plans to defer construction of I-95 between Daytona Beach and Ft. Pierce (competing with turnpike project No. 2), as well as between Ft. Lauderdale and West Palm Beach (competing with turnpike project No. 1) until 1972. The Authority's traffic consultants estimate that completion of these two sections of I-95 will reduce turnpike revenues by about 36 percent (20, p. 65). However, the consultants assume completion by 1964 of I-75 from the Florida-Georgia line to Wildwood, and I-4 between Daytona Beach and Orlando, both of which will channel traffic into the turnpike system (20, p. 43).

Unlike Massachusetts, where the debt underlying the first turnpike was left undisturbed at the time the extension was financed, the Florida Turnpike Authority chose to indenture both of its projects under a single bond issue. As a result, the $3\frac{1}{4}$ percent bonds issued for project No. 1 were refunded in 1961 with proceeds of $4\frac{3}{4}$ percent bonds. At the time of refunding, $63,817,000 of the 1955 bond issue was outstanding. Had this issue been amortized in accordance with the original schedule (21, p. 18), final maturity would have occurred in 1993, and the remaining cost to the Authority would have been $103,447,000 including redemption of the bonds, interest at $3\frac{1}{4}$ percent, and small amounts of redemption premiums. However, to refund these bonds, the Authority was required to capitalize a total of $67,142,621 to cover one semiannual interest payment on the 1955 bonds, and a redemption (call) premium of $3\frac{1}{2}$ percent, in addition to the par value of the bonds to be refunded. Based on the 1961 official statement (20, p. 70), the cost to the Authority to amortize $67 million of bonds at $4\frac{3}{4}$ percent interest plus redemption premiums will be $137,021,000 or an added financing expense of $33,574,000 for project No. 1. The financial transactions involved in the 1961 sale of bonds are given in Table 22.

Undoubtedly the Authority would have found it difficult if not impossible to finance project No. 2 with revenue bonds had not this refunding plan been included. The pledging of over $15 million of toll revenues and reserves of project No. 1 toward construction of project No. 2 (Table 22) comprises 20 percent of the cost of project No. 2, thus reducing materially the amount of new bonds required.

The Turnpike Authority of Kentucky.—As early as 1930, Kentucky began issuing revenue bonds to finance construction of toll bridges across the Ohio River. The last of such bonds were issued in 1953 and 1954 when the State purchased a private bridge at Covington, and constructed a new facility at Shawneetown. The State pays all costs of

TABLE 22

COST OF FINANCING FLORIDA SUNSHINE STATE PARKWAY PROJECT NO. 2

Factor	Amount ($)
Cost to build project:	
Construction	54,341,000
Right-of-way	5,761,000
Maintenance and office equipment	277,000
Administration	279,000
Engineering	4,891,000
Contingencies (12.5 %)	8,151,000
Subtotal	73,700,000
Golden Glades Improvement, including $316,000 (13.2 %) for contingencies	2,698,000
Total	76,398,000
Source of funds:	
Par value of bonds sold for project	157,000,000
Plus accrued interest on bonds sold	1,325,777
Less discount on bonds sold	-6,672,500
Less redemption of 1955 bonds (including 6 months interest and call penalty on these bonds)	-67,142,621
Less capitalized interest on 1961 bonds to November 1, 1964	-22,372,500
Less payments to operating and maintenance funds	-1,500,000
Less repayments of advances from State Road Department and Arvida Corporation for preliminary engineering and construction expenditures	-1,750,000
Remainder of bond proceeds available for construction of project and Golden Glades improvement	58,888,156
Additional moneys to be used for construction funds held under 1955 Trust Agreement	7,311,000
Estimated net revenues from operation of Miami to Ft. Pierce section of turnpike	7,907,000
Estimated interest income during construction	2,280,000
Total	76,386,156
Cost to motorist if bonds are retired by 1992, in accordance with engineer's estimates:	
Interest paid on bonds through 1992	79,672,000
Call premium	1,048,000
Redemption of bonds	89,857,000[1]
Total	170,577,000

[1] That portion of total bond issue allocated to project after deducting amount applied to redemption of 1955 bonds; $157,000,000 - $67,143,000 = $89,857,000.

operating, maintenance, and repair of these bridges from other highway funds, thus permitting all toll revenues to be applied for debt service.

An Act[33] of the 1950 legislature authorized the Department of Highways to construct a system of toll roads, at such locations "as may be determined by the Department and

[33] K.R.S., §§177.390-.570.

approved by the Governor." Pursuant to this authorization, the Department in 1954 issued $38,500,000 of 3.4 percent term revenue bonds maturing in 1994 to finance construction of a 40-mile toll road from Louisville to Elizabethtown. The bonds (which are not obligations of the State) were sold at 98.35 percent of par, resulting in a net interest cost of 3.440 percent. Under terms of the indenture, bond interest and principal requirements are a charge on tolls and revenues before operating and maintenance costs and, if revenues are insufficient to meet the latter, the Department covenants to advance from other highway funds such amounts as are necessary to meet operating and maintenance costs, which advances may be repaid in future years from surplus toll revenues. The legality of such a covenant has been sustained by the Court of Appeals of Kentucky[34].

Although the 1950 Act permitted construction of additional turnpikes, none have been financed under this statute, and in 1960 the legislature created the Turnpike Authority of Kentucky[35], composed of the Governor, the Lieutenant Governor, the Commissioner of Highways, the State Highway Engineer, and the Attorney General. The statute authorizes the Authority to finance, construct, and operate turnpike projects and to lease such projects to the Department of Highways. Under this enactment, the Authority has sold $39 million of toll road revenue bonds to finance a toll road extending 43 miles from a junction with Interstate 64 east of Winchester to a point near Campton, in east-central Kentucky, and has sold $118 million of revenue bonds for a 127-mile turnpike extending westward from Elizabethtown to Princeton.

The $39 million Eastern Turnpike issue was sold in February 1961, and consists of $17,800,000 of serial bonds maturing 1965-85 in annual amounts increasing from $600,000 to $1,200,000 with interest coupon rates from 4¼ to 4¾ percent; and a $21,200,000 term issue with a 4.8 interest coupon rate, maturing in the year 2000. The issue was sold at 97 percent of par, at a net interest cost of 4.86 percent.

The $118 million issue of Western Turnpike bonds was sold in June 1961 at a net interest cost of 4.928 percent. The issue consists of $20,000,000 of serial bonds maturing in amounts from $900,000 in 1967 to $1,200,000 in 1985, with coupon rates from 4¼ to 4.7 percent, and a $98,000,000 term issue due in 2000 at a 4.85 percent coupon rate.

Both the Eastern and Western turnpike bonds are callable as a whole in 1971 at 105 percent of par, or in part, beginning in 1966, at 103 percent of par. The terms of the lease agreement (22, 23) between the Authority and the Department of Highways are rather novel, and contain the following provisions:

1. The Department shall pay the costs of maintaining, repairing, and operating the turnpike for the entire period of years until the final maturity of the bonds.
2. The Department shall pay to the Authority the sum of $5,000,000 per biennium beginning July 1, 1962, and ending June 30, 2000, to meet the principal and interest requirements of the Eastern Turnpike bonds, and $14,450,000 each biennium beginning July 1, 1964, and ending June 30, 2000, for similar requirements of the Western Turnpike bonds. These payments are also to cover administrative costs of the Authority.
3. The lease shall be renewed each biennium at the option of the Department, and shall be automatic unless the Department by written notice to the Authority before the last working day in April elects not to renew.
4. At such time as the lease is not in effect, the Department shall set aside and pay over to the Authority all tolls and other revenues of the toll roads, including five-sevenths of all motor-fuel taxes collected by the Department on gasoline and other motor fuels consumed on the toll roads.
5. While the lease is in effect, the Department may use all tolls and other revenues of the toll roads, including the motor-fuel taxes, for such highway purposes as are authorized by law.
6. At any time the lease is not renewed or the Department shall fail to perform its obligations in full, the Department's option to renew the lease for all future bienniums shall be forfeited.

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[34] Guthrie v. Curlin, 263 S.W.2d 240.
[35] Ch. 173, Kentucky Acts of 1960 (§§175.410 to 175.990 K.R.S.).

It would appear to be to the Department's advantage to renew its options so long as the tolls and computed fuel tax earnings are in excess of the biennial lease payments. Even in the event that revenues fall below the lease payments, however, it is doubtful that the Department would elect to terminate the lease because of the implications of possible default. In the event the lease were to be terminated, the indenture provides that the Authority may adjust tolls to produce sufficient funds for debt service, but failing in this, the covenant merely provides that the Authority will adjust tolls to provide the maximum amount of revenues obtainable.

A more fundamental reason for including the renewable lease option, however, stems from an unsuccessful attempt in 1954 to create a highway authority to finance construction of free highways, with bonds to be secured by yearly rentals from the State Road Fund. The Act provided that, as security for the rentals, the lease agreement would contain a pledge of the current resources of the Department of Highways for each biennium[36] for the full term of the lease (not to exceed 40 years). The Court of Appeals[37] declared the Act unconstitutional on the grounds that the nonrenewable lease created an irrevocable obligation, and hence a debt subject to constitutional prohibitions.

Although the Authority's bonds are classed as revenue bonds for purposes of this discussion, it is obvious that so long as the lease is in effect, the issues are in reality limited obligations, and become revenue bonds only in the event that the lease expires.

In January 1962 the Authority sold an additional $29 million of bonds to finance a 33-mile, two-lane toll road extending the eastern turnpike from Campton to Salyersville. This issue comprises $10 million of serial 4 and $4\frac{1}{4}$ percent bonds maturing 1967-85, and $19 million of 4.30 percent term bonds, maturing in 2000. This issue was purchased by negotiation at 97 percent of par.

Thus, the Authority now has outstanding a total of $186 million of bonds to finance construction of 203 miles of toll roads within Kentucky, none of which is located on the Interstate System.

Table 23 gives the financing aspects of the eastern and western Kentucky turnpikes

TABLE 23

COST OF FINANCING EASTERN AND WESTERN KENTUCKY TURNPIKES

Factor	Eastern Turnpike ($)	Western Turnpike ($)
Project cost:		
Construction	27,633,745	75,238,438
Right-of-way	1,726,000	6,572,143
Engineering	2,665,630	6,752,516
Administration and legal	250,000	507,200
Toll collection facilities	245,000	482,000
Contingencies	2,267,625	6,229,653
Total	34,788,000	95,781,950
Source of funds to build project:		
Par value of bonds sold	39,000,000	118,000,000
Less discount on sale	-1,170,000	-4,130,000
Less capitalized interest	-6,092,000	-25,438,050
Less authority administrative cost	- 200,000	- 150,000
Plus investment earnings	+ 750,000	+4,000,000
Plus State highway fund contributions	+2,500,000	+3,500,000
Total	34,788,000	95,781,950
Cost to motorist to amortize investment:		
Interest requirements	40,811,120	127,051,061
Call premium	148,900	1,080,550
Redemption of bonds	39,000,000	118,000,000
Total	79,960,020	246,131,611

[36] Ch. 39, Kentucky Acts of 1954.

[37] Curlin v. Wetherby, 275 S.W.2d 934.

(excluding the 1962 sale). The cost of constructing these two projects will be $130.6 million for which the user will pay a total of $326 million in interest and amortization charges. Data for this table are derived from schedules contained in the Authority's Official Statement (22, 23).

Here again, a comparison of the cost of financing these projects with general obligation bonds is of interest. Kentucky voters at the November 1956 election approved an Act[38] authorizing $100 million of general obligation bonds to provide funds to match Federal funds for construction and reconstruction of highways, tunnels, and bridges. This was the first such authorization in Kentucky's history. In 1957, the Court of Appeals validated the bonds and held that no single bond could be sold at more than 3 percent, and that the bonds could not be sold at less than par, nor in blocks of less than $5 million. They must be retired within 30 years.

Under this authorization, the State issued $35 million in 1957, $35 million in 1958, and the remaining $30 million in 1960. All the bonds were issued with serial maturities, and final redemption is scheduled for 1986. Carrying coupon rates of 2.9 and 3 percent, the bonds were sold at net interest costs ranging from 2.94 to 3 percent.

A second authorization of $90 million, as provided by a 1960 Act[39], was approved at the November 1960 election. The interest rate limitation was removed from this authorization, and accordingly, the first sale of $15 million of bonds in 1961 carried 3.60 and 3¾ percent coupon rates and was sold at a net interest cost of 3.60 percent.

If the State were to have financed the construction cost of the turnpike with general obligation bonds, the total debt service could have been held to $204.8 million, or less than two-thirds of the cost of the present method of bond financing. This would be based, of course, on the assumption that general obligation bonds could have been sold as needed over a three-year period, with increments of $45 million in 1961, $45 million in 1962, and the remaining $40 million in 1963; and that they could have been marketed as 30-year serial bonds at a net interest cost of 3.6 percent, the rate carried by the actual 1961 bond issue. Although these are assumptions, they are not inconsistent with the State's experience in marketing general obligation bonds and would therefore appear reasonable.

Northeastern Expressway and Delaware Turnpike.—In what was perhaps the first such joint action on record, the States of Delaware and Maryland simultaneously sold toll road revenue bonds in February 1962 to finance a joint toll road project linking the Delaware Memorial Bridge with the metropolitan environs of Baltimore. Specifically, the project comprises a controlled-access toll highway. It extends approximately 11 miles laterally across the State of Delaware from the westernly approaches of the Delaware Memorial Bridge to the Delaware-Maryland line. The project then continues within Maryland approximately 42 miles to the Whitemarsh Boulevard interchange, near Baltimore, where a 6-mile, toll-free section will link the project to the approaches of the Baltimore Harbor (Patapsco) Tunnel. The Delaware section will be known as the Delaware Turnpike, the Maryland section as the Northeastern Expressway.

Construction of this highway as a toll project had been proposed for some time. The Maryland legislature[40] in 1955 authorized the State Roads Commission to construct a toll road in this corridor, and the Delaware legislature[41] followed suit in the same year, and again in 1961. The location of the project followed Interstate 95; in fact, State and Federal funds had been expended on some sections at the time the toll road proposal was adopted. For this reason, it was necessary to obtain Congressional approval for repayment of Federal funds on the included sections before the project could be built as a toll facility. Accordingly, legislation was included in the Federal Highway Act[42] of 1960 authorizing repayment by the States of some $1,400,000 of Federal funds that had been expended on the Delaware and Maryland sections (24, p. 119).

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[38] Ch. 3, Kentucky Acts of 1956, 2nd Extraordinary Session.

[39] Ch. 106, Kentucky Acts of 1960 (Regular Session).

[40] §§141 to 162, Art. 89B, Annotated Code of Maryland, 1957 Ed.

[41] Ch. 176, Vol. 53, Laws of Delaware. A 1955 Act permitted refinancing of the Delaware Memorial Bridge to permit construction of a new highway to the Maryland line from bridge revenues.

[42] P.L. 86-657, 86th Congress, H.R. 10495, July 14, 1960.

The reason advanced by the States for withdrawing this project from the Federal-aid program was that traffic demands were so great as to warrant prompt construction of the highway, and that the availability of Federal Interstate funds would not permit completion short of 8 to 10 years.

The two States agreed to seek concurrent toll financing to insure that traffic and earnings on each section could take mutual advantage of this simultaneous completion of the sections.

On February 21, 1962, the two States were successful in selling $102 million of revenue bonds—$74 million by Maryland and $28 million by Delaware. Both issues carry a $4\frac{1}{8}$ percent coupon rate, are dated January 1, 1962, are callable at 104 percent of par after January 1, 1972, and mature January 1, 2002. They were sold at $97\frac{1}{2}$ percent of par, at a net interest cost of 4.1875 percent.

As with the other turnpike issues under study, it is interesting to compare the cost of financing these projects with revenue bonds versus the customary type of borrowing used by these States.

Delaware.—This State had traditionally financed major capital projects from proceeds of general obligation bonds. During the 1950-60 period, the State issued $91,225,000 of guaranteed bonds to finance highway improvements. The only exceptions have been the Delaware Memorial Bridge, which was financed in 1948 by proceeds of a revenue bond issue, and a few county road bonds that were assumed by the State and now have been largely retired. Recent highway general obligations have carried interest and maturity features as given in Table 24.

All these issues have had 20-year serial maturities, and the average coupon rate has been 3.13 percent, although each of the last three sales has carried a lower rate than the preceding issue. It might be fairly assumed, however, that guaranteed bonds to finance the Delaware Turnpike could have been marketed at 3.20 percent. The cost of the project as estimated by the consulting engineers will be $23,957,250, including reimbursement of State and Federal funds (25). Assuming that all project costs were funded with general obligation bonds to the par value of $24 million, the cost of amortizing such bonds at 3.20 percent interest for 20 years would be $32,064,000. This compares with $55,474,000 for the revenue bond issue, excluding any redemption premium, as estimated in the official statement (25, p. 28). A savings of as much as 42 percent could thus have been realized in the cost of financing this project.

Maryland.—Although the Maryland legislature can authorize issuance of general obligation bonds, the practice in recent years in that State has been to issue limited obligations highway bonds secured by road-user tax revenues. The legislature[43] in 1953 directed the State Roads Commission to carry out a 12-year highway improvement

TABLE 24

DELAWARE GENERAL OBLIGATION HIGHWAY BONDS

Year Sold	Issue	Par Value ($1,000)	Interest (%) Coupon	Interest (%) Cost	Maturity
1959	Highway Improvement - 1957, Series D	1,500	3.0	2.957	1960-79
	Highway Improvement - 1959, Series A	6,700	3.3	3.293	1960-79
1960	Highway Improvement - 1959, Series B	7,300	3.25	3.24	1961-80
1961	Highway Improvement - 1961, Series A	5,000	3.20	3.12	1962-81
1962	Highway Improvement - 1961, Series B	10,000	2.90	2.83	1963-82

[43] Act 657, 1953 Acts of the Maryland General Assembly.

program, and authorized the issuance of $330 million of State Highway Construction bonds during the period July 1, 1954, to June 30, 1968. Security for these bonds is a pledge of proceeds of the 2 percent excise tax on motor vehicle titles, and the Commission's 50 percent share of motor-fuel tax revenue.

By the end of 1961, the Roads Commission had issued $220 million of these bonds. Features of the 1958-61 sales are given in Table 25. The average net interest cost for these recent issues is 3.44 percent. A coupon rate of 3½ percent is therefore indicated as reasonable for this type of bond.

According to the Official Statement of the Roads Commission, the cost of the Maryland toll road is estimated to be $64,200,000 (26, p. 7). Because the Commission has scheduled a two-year construction program, it is reasonable to assume that limited obligation bonds in two annual installments of $32 million could have provided the financing. Following the State's pattern of 15-year maturities, the State could have amortized a $64 million limited obligation bond issue with interest at 3½ percent for a total cost of $81,920,000. This compares with $146,419,000 as the estimated cost of debt service for the $74 million revenue bond issue (26, p. 27). In this case the savings would have amounted to about 44 percent. Moreover, if constructed as a free road, the State could then have claimed Federal reimbursement up to 90 percent of the value of the bond issue as it matured, as could have Delaware.

Virginia Toll Authorities.—Highway construction in Virginia has traditionally been on a "pay-as-you-go" basis. The State has issued no general or limited obligation bonds to finance highways since the mid-1920's. However, during the period of this study, Virginia incurred $403,801,000 of highway toll revenue debt, of which $75,150,000 financed the Richmond-Petersburg Turnpike, and the remainder financed bridge, ferry, and tunnel projects in the reaches and estuaries of Cheseapeake Bay. Bond financing has been used by four agencies: the State Highway Commission, the Elizabeth River Tunnel Commission, the Richmond-Petersburg Turnpike Authority, and the Chesapeake Bay Bridge and Tunnel Commission.

State Highway Commission.—Pursuant to the State revenue bond act[44], the State Highway Commission sold $19 million of revenue bonds in 1949 to acquire the privately-owned properties of the Chesapeake Ferry Company, and the James River Bridge System, and to construct a bridge across the York River. In 1954, the Commission sold $95 million of revenue bonds under an indenture that combined the resources of the previous facilities with those to be derived from construction of a Rappahannock River Bridge and a combination bridge and tunnel project across Hampton Roads. This issue sold at a net interest cost of 3.063 percent and matures in 1994. Part of the proceeds were used to retire the remainder of the 1949 series bond.

TABLE 25

MARYLAND ROADS COMMISSION BOND SALES, 1958-61

Year Sold	Issues (series)	Par Value ($1,000)	Interest (%) Coupon	Interest (%) Cost	Maturity
1958	L	25,000	2.4-5.0	3.099	1959-73
1959	M	25,000	3⅜-5.0	4.0202	1960-74
1960	N	20,000	3.1-5.0	3.51	1961-75
1961	O	12,500	2¾-5.0	3.29	1962-76
1961	P	15,000	3.0-5.0	3.40	1962-76
1961	Q	12,500	2.7-5.0	3.31	1962-76

[44] Virginia Code, §§33-227 to 33-255, inclusive.

Elizabeth River Tunnel Commission.—This commission was created[45] in 1942 as the governing body of the Elizabeth River Tunnel District, comprising the cities of Norfolk and Portsmouth, and Norfolk County. In 1950, the Commission sold $23 million of revenue bonds to finance construction of a bridge and tunnel connecting Norfolk and Portsmouth. These bonds carried a coupon rate of 3½ percent and were to mature in 1980. In addition to providing the crossing facility, the Commission also established its own bus service transporting passengers over the bridge and tunnel. In 1955, three years after the project was opened to traffic, the competing Norfolk County ferries discontinued operations, thus increasing patronage of the tunnel and the Commission-owned buses. Although tolls were levied on users of the tunnel from its opening, no tolls were levied for use of the bridge. Under a unique agreement with the city of Norfolk, the city agreed to pay the Commission, based on treadle counts on the bridge ramps, a rate of $0.05 per axle for the first 2,250,000 axle counts, diminishing as the count went higher, to $0.0005 per axle over 16,000,000 counts, in lieu of a direct user toll levy.

In 1960, the Commission sold $41,700,000 of revenue bonds to finance construction of a second tunnel across the Elizabeth River, together with connecting highways, and to retire some $15.7 million principal amount remaining of the 1950 bond issue. The 1960 sale carried a coupon rate of 4½ percent and matures as a term issue in the year 2000. The net interest cost was 4.55 percent. Also from the proceeds of these bonds, the Commission paid $2,211,236 to the city of Portsmouth and to Norfolk County (as owners of the Norfolk County ferries) for loss of income due to construction of the bridge and first tunnel, and an additional amount of $573,386 to the cities of Norfolk and Portsmouth for loss of taxable income and incidental costs and damages to utilities due to such construction.

A new agreement was drawn in 1960 between the Commission and the city of Norfolk whereby in lieu of charging tolls on the bridge, the city will pay the Commission annually, for a 20-year period, $197,936 plus approximately 53 percent of the Commission's cost of maintaining, repairing, and operating the bridge each year.

Richmond-Petersburg Turnpike Authority.—The legislature in 1954 created[46] this Authority to finance and operate a toll road between and through the cities of Richmond and Petersburg. The Act contains the restrictive proviso that no competing project that would substantially reduce traffic may be constructed within 25 miles of the turnpike until bonds have been retired. In 1955, $69 million of revenue bonds were sold as 40-year terms at a net interest cost of 3.52 percent. Additional funds were found to be necessary to complete construction, and in 1958, a final increment of $6,150,000 of bonds were sold at a net cost of 4.67 percent. This 35-mile toll road was opened to traffic in 1958.

Chesapeake Bay Bridge and Tunnel Commission.—One of the most complex highway financing and construction projects on record was brought to fruition in 1960 with the sale by the Commission in August of $200 million of revenue bonds to finance a bridge-tunnel crossing of lower Chesapeake Bay which, together with approach roads, will be approximately 23 miles long.

Organized in 1954, the Chesapeake Bay Ferry Commission was authorized[47] to acquire and operate a ferry service within a District comprising four counties and seven cities and towns that surround the mouth of Chesapeake Bay. In 1956, the Commission sold $20 million of toll revenue bonds and applied the proceeds to acquire and construct ferry properties. These bonds were sold as 30-year terms, at a net interest cost of 4.404 percent. In the same year, the Commission's functions were extended[48] to permit financing of the bridge-tunnel crossing from the proceeds of toll revenue bonds.

In seeking a means of financing this project which will link for the first time the eastern shore of Virginia on the Delmarva peninsula with the remainder of the State, the Commission and their underwriting syndicate devised a plan whereby primary and

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[45] Ch. 130, Acts of Virginia of 1942, as amended.
[46] Ch. 705, 1954 Laws of Virginia.
[47] Ch. 693, 1954 Laws of Virginia.
[48] Ch. 462 and 714, 1956 Laws of Virginia.

subordinate lien bonds would be sold. Accordingly, the $200 million revenue bond issue consists of $70 million of $4\frac{7}{8}$ percent Series A First Pledge Revenue Bonds, $30 million of $5\frac{1}{2}$ percent Series B Second Pledge Revenue Bonds, and $100 million of $5\frac{3}{4}$ percent Series C Third Pledge Revenue Bonds, all due July 1, 2000. The issue was sold at 96.25 percent of par at a net interest cost of 5.61766 percent. With respect to payment of interest and principal, the Series A bonds have priority over the Series B bonds, and the latter have priority over the Series C bonds.

Despite the junior nature of the lien on the Series B and C bonds, the issue was promptly sold. The fact that interest was capitalized for a period of $4\frac{1}{2}$ years (i.e., bonds proceeds were set aside in a reserve for that purpose) undoubtedly was a favorable factor in marketing the bonds, as was the high tax-exempt interest rate on the Series B and C bonds.

The financing of this project, as well as of the Massachusetts Turnpike Extension described previously, has been hailed in financial circles as a brilliant solution to a most difficult financing problem, which undoubtedly it was. However, as in Massachusetts, the users of the facility will bear a heavy financing burden. The cost of constructing the bridge-tunnel project is estimated to be $139,200,000 for which the

TABLE 26

COST OF FINANCING CHESAPEAKE BAY BRIDGE AND TUNNEL

Factor	Amount ($)
Cost of project:	
Construction	122,333,800
Right-of-way	1,000,000
Engineering	7,625,000
Administration	2,120,000
Contingencies	6,121,200
Total	139,200,000
Source of funds to build project:	
Par value of bonds sold	200,000,000
Less discount	-6,700,000
Less capitalized interest for $4\frac{1}{2}$ years	-48,405,600
Plus estimated investment earnings	+8,355,600
Plus income from ferry operations (three years)	+3,750,000
Less redemption of 1956 bonds	-17,800,000
Total	139,200,000
Cost to motorist to amortize investment:	
Interest requirements[1]	283,760,794
Redemption of bonds	200,000,000
Total	483,760,794

[1]Excluding capitalized interest; assuming redemption of $100,000,000 of Series A and B bonds between 1970 and 1999 according to amortization schedule on page 25 of bond prospectus leaving $100,000,000 of Series C bonds to be redeemed at maturity (July 1, 2000).

user must pay in bond interest and redemption charges a scheduled $483,761,000 (Table 26). In other words, for every $1.00 in initial cost, the users must provide $3.48 to discharge the obligation.

Summary

In this study, it has been impossible, of course, to review all of the bond financing programs of the States. However, a representative selection has been made to permit comparison of the features, significance, and costs of guaranteed and nonguaranteed highway bond programs.

Table 27 summarizes the amortization costs of a number of these bond issue programs. It serves two purposes: (a) it illustrates the variety in the type and selection of bond-financing programs, and (b) it compares the differential in financing costs with particular reference to States that have financed both with toll revenue bonds and with general or limited obligations.

The ratios of financing to capital costs, given in Table 27, are derived by comparing the capital costs (i.e., right-of-way, engineering, construction, and other roadway costs) paid from bond proceeds, with the costs to final maturity of debt service on the bond issues; i.e., bond interest, bond discounts, call penalities, etc.

TABLE 27

COMPARATIVE COSTS OF SELECTED STATE HIGHWAY BOND FINANCING PROGRAMS

Description of Bond Issue	Toll or Free Facilities	Years of Issue	Scheduled Redemption Dates	Capital Costs Funded[1] ($1,000)	Added Financing Costs[2] ($1,000)	Ratio of Financing to Capital Costs
General obligation:						
Connecticut highway system	Free	1959-61	1961-87	102,420	48,985	0.48
Greenwich-Killingly expressway (Conn.)	Toll	1957-58	1963-97	112,000	117,932	1.05
Delaware highway improvement	Free	1959-62	1960-82	30,500	10,010	0.33
Kentucky highway	Free	1957-61	1959-90	115,000	49,434	0.43
Louisiana long-range highway	Free	1959-60	1960-84	60,000	29,431	0.49
Massachusetts highway improvement loan	Free	1957-60	1958-80	189,000	66,344	0.35
New Jersey Highway Authority, Garden State Parkway	Toll	1953-54	1955-87	285,000	216,991	0.76
New York highway construction	Free	1958-59	1959-79	90,000	25,350	0.28
New York Thruway Authority	Toll	1953-60	1958-95	500,000	380,552	0.76
Limited obligation:						
Alabama Highway Authority	Free	1955-61	1962-81	110,000	44,650	0.41
Greenwich-Killingly expressway (Conn.)	Toll	1954-59	1962-97	347,500	315,233	0.91
Jacksonville Expressway Authority (Fla.)	Both	1957	1961-92	46,300	46,616	1.01
Maryland State highway construction	Free	1958-61	1959-76	110,000	49,073	0.45
Michigan trunk line and expressway	Free	1956-61	1959-86	363,000	195,575	0.54
Ohio major thoroughfare	Free	1954-61	1956-72	500,000	108,474	0.22
Pennsylvania State Highway and Bridge Authority	Free	1949-61	1953-80	120,000	30,809	0.26
Toll revenue:						
Delaware turnpike	Toll	1962	1966-2001	23,957	31,517	1.32
Florida Turnpike Authority (Proj. 2)	Toll	1961	1967-92	76,398	94,179	1.23
Kentucky Turnpike Authority	Toll	1961	1965-2000	130,570	195,522	1.50
Maryland northeastern expressway	Toll	1962	1966-2001	64,200	82,219	1.28
Massachusetts Turnpike Authority (Boston extension)	Toll	1962	1976-82	152,000	174,863	1.15
New Jersey Highway Authority, Garden State Parkway	Toll	1954-56	1961-88	45,000	35,838	0.80
New York Thruway Authority	Toll	1954-59	1964-96	400,000	339,251	0.85
Ohio Turnpike Authority	Toll	1952	1957-92	283,356	291,031	1.03
Chesapeake Bay Bridge and Tunnel Commission bonds (Va.)	Toll	1960	1970-2000	139,200	344,561	2.48

[1]Project costs (i.e., right-of-way, engineering, and construction) paid from bond proceeds; for most free road facilities, amount shown is par value of bond issues; for most toll facilities, bond proceeds used to meet interest payments are excluded, as are bond discounts. [2]Includes total bond interest to final maturity, bond discounts, and redemption (call) premiums on bonds expected to be retired in advance of maturity. [3]Redemption dates are those contemplated by bond consultants at time of sale.

All but two of the revenue bond issues carry a ratio in excess of 1.0, and this despite the assumption that these term bond issues will be redeemed in advance of maturity. General and limited obligation bonds have ratios as low as 0.33 and 0.22, respectively, among those selected, and in only two cases do the ratios equal or exceed 1.0--in each case, for toll facilities. The effects of both higher interest rates, and longer maturities of toll revenue bonds are apparent in these comparisons.

Figure 11 compares the bond-financing programs of five States (Delaware, Kentucky, Maryland, Massachusetts, and Ohio) among those that have chosen to issue both revenue bonds and general or limited obligations for highways.

For each State, the first bar shows the amount of capital costs funded with general or limited obligations, as the case may be, with an extension of the bar to show the added costs of bond financing. The second bar shows similar facts for the revenue bond issues. The third bar shows the cost of funding with general or limited bonds a capital cost equivalent to that of the toll road project. The difference in the height of the second and third bars is thus a measure of the added cost of revenue bond financing. Obviously, the differential is a function of both interest rates and length of maturity schedules.

Although such comparisons are hypothetical, the bond issues are not; and the fact that these State could and did use general or limited bond financing during or near the same period that revenue bonds were sold, lends more than a superficial validity to the comparisons. Although the interest and other financing costs might have been greater or lesser under actual market conditions, the range in savings from 65 to 78 percent is an impressive indicator of the differential attributable to the selection of the borrowing device.

CONCLUSIONS

This study has not attempted to debate the merits of "pay-as-you-go" versus credit financing of highways. Others (27) have probed this area in depth, and the previous study (2), of which this is a sequel, reviewed the case for highway bond financing. The present study, rather, sheds some light on the significance of the type of bond program selected, and measures its cost to the public.

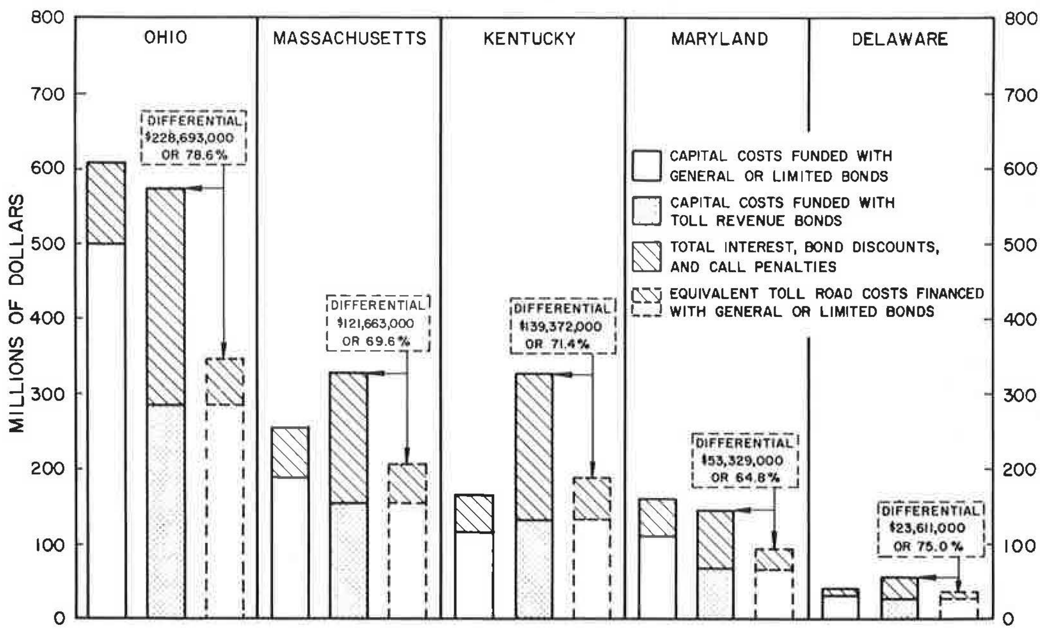

Figure 11. Cost differential of selected toll and free bond-financing programs.

It can be firmly concluded that, if borrowing is justified to finance major accelerated highway programs, the public interest is best served by selecting general obligation bonds. The cost of borrowing to the highway user (who, being almost everyone, surely represents the public interest) will be held to a minimum, and by means of the amendatory or referendum process he is given the opportunity in most States to express his decision as to the merits of an accelerated bond-financed highway program versus the two alternatives of a slower program financed from current revenues or of one that could be speeded by means of increased taxes.

When this solution is unfeasible, a clear case can be made for the use of limited obligation bonds, with or without the authority device, for purposes of financing a toll-free highway program. With adequate pledge of road-user tax revenues as security for the bond issue either directly or by means of a lease-purchase contract in the event an authority is established, the costs of borrowing can be held to levels that compare favorably with those of general obligation bonds.

In conjunction with either a general or limited bond-financing program, the judicious use of short-term note financing may be warranted. Notes issued in anticipation of Federal-aid reimbursements, or preliminary to later highway bond issues, can provide a means of program acceleration through credit financing at a minimum of cost.

Revenue bond financing is peculiarly well adapted for interstate or international crossing facilities where joint financing and ownership make it necessary to establish a commission or authority to coordinate the project. However, the toll road authority device, with its concomitant use of revenue bonds, has been demonstrated to be a costly excursion in the area of highway finance. There has been, unfortunately, a widespread impression that the only high-class road is a toll road and that the only way to obtain high-class roads promptly is by the use of toll revenue bonds. It is thus forgotten that construction of the Interstate System and a large mileage of similar high-type roads is being financed in many States, and by the Federal Government, from tax revenues without benefit of borrowing of any type; and that in many other States it is being accelerated by the use of credit financing without resort to the toll revenue bond. Revenue bond financing should thus be viewed in its proper perspective: it is merely one of several alternative methods of borrowing highway capital funds that must be repaid from future income.

Proponents of the toll facility concept, however, seem at times to find no satisfactory alternatives in sight. According to Lindman (28):

> State and local officials, confronted with ever worsening traffic congestion in metropolitan areas, may well decide to build their Interstate System highways immediately as toll facilities rather that wait for long-term Federal aid financing. They may have other high-cost metropolitan highways for which toll financing will prove to be the only feasible solution.

Dearing (29) states:

> ...the true capital costs of the tollway, even though financed at a higher interest rate, may prove to be lower than those of a similar facility financed under the so-called pay-as-you-go basis.

According to Funk (30), Chairman-Director of the State Roads Commission, "Toll financing of Maryland's Northeastern Expressway is enabling the State to open the road in November, 1963, a full ten years ahead of the date it could be completed as a free road."

The ability of a State to develop rapidly an adequate system of highways (in other words, to accelerate its highway program) may well rest on the decision to raise road-user tax rates (or to reallocate the revenues from existing taxes) or to employ bond financing. The choice is not solely one of "pay-as-you-go" and stagnation versus toll roads and progress; rather, if the decision is made to utilize bond financing, the real concern should be the selection of the borrowing device that most economically serves the public interest.

Too often the explanation is heard, in justification of toll revenue bond financing, that "this will not cost the taxpayer a cent." Dearing (29), for example, says:

> The contention that the cost of revenue-bond financing is high points to an apparent disadvantage inherent in this method of providing highway facilities. Nevertheless, (the) additional cost of providing roads through revenue-bond financing is not borne by the taxpayers, nor even indirectly by the State, but only by those individuals who voluntarily choose to use the toll roads.

The implication here is that, somehow, the users of a toll facility are not taxpayers or, even more subtly, that to a large extent they may not be taxpayers of the home State. Undeniably some toll facilities are so located as to attract large proportionate volumes of out-of-State traffic (such as the Delaware Memorial Bridge connecting the States of Delaware and New Jersey), but this would not be true of, say, the San Francisco-Oakland Bay Bridge.

Thus, the burden of financing such projects cannot be dismissed as being a problem for the nonresident motorist. It may become a domestic problem as well. It is thus essential that the methods of financing revenue-producing facilities be examined with great care, so as to select that which best meets the public interest.

The toll road user may be surprised to learn that he is not considered to be a taxpayer. But if he is not, then neither is the user of free roads financed with general or limited obligation bonds. Because the user in either case provides the revenue from which the debt is amortized, and such revenue may be collected in the first instance as "toll" or in the second as a levy on his motor-fuel purchases, the distinction is merely one of degree. The payment of a gasoline tax or a toll for the use of highways is in either instance assessed in proportion to highway use. In fact, the toll road user is assessed for free roads whether he uses them or not.

The levy of tolls should not be confused with the use of toll revenue bonds. There is merit in the contention that corridor States, in particular, must provide high-class highway service, but that a large percentage of the users are nonresidents who would otherwise make little or no contribution to the cost of the roads they use. New Hampshire, faced with this problem, constructed a 14-mile toll road that collects revenue largely from Interstate vehicles, but New Hampshire financed this road by means of general obligation bonds at a net interest cost of only 1.6 percent. Both New Jersey and New York also financed major toll road projects by means of general obligation bonds, and although this choice may have been dictated by necessity to insure marketability of the bond issues, it nevertheless resulted in a savings in financing costs and indicates an awareness of the advantages of the guaranteed bond.

Although levying tolls on its costly expressway project, Connecticut has also avoided using revenue bonds and secured the needed capital both from guaranteed bonds and from limited obligations secured by tolls and gasoline tax revenues.

The contention can be dispelled that bond financing of toll-free highways can neither win public acceptance nor provide the priority routes when needed. The magnitude of toll-free borrowing within the past decade speaks for itself. The experience in Michigan in financing specific expressway projects or of the Pennsylvania State Highway and Bridge Authority among others attest to the fact that the pressures for balancing sectional benefits at the expense of priority needs can be overcome.

Bond financing is not a panacea, but where it is justified, the exercise of sound judgment and financial acumen must lead to selection of the borrowing procedure best designed to meet the needs at the most economical cost to the public; namely, the highway user.

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Special Assessment Financing of Major Highway Improvements

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Special assessments are an accepted, established, and legal method of obtaining funds for public improvements. The questions arise as to the place of special assessments in plans for the financing of modern highways — when and for what purposes they should be used, and how they should be levied. This method can be used when the improvement to be financed creates benefits enhancing the value of specific properties, when these benefits are definitely measurable and can be allocated to the specific properties, and when the proceeds of the assessments are wholly applied to construction costs. It can be used for almost any type of facility.

The "how" of levying special assessments involves many alternatives. The financing may be from certificates imposing a liability only on each tract or parcel involved, or it may be guaranteed by the full faith and credit of the governments concerned. If the former, excessive costs of financing may be incurred; if the latter, the financing is likely to be sound and economical. Special assessments, soundly used, are feasible and should be employed to meet the costs of modern highway development.

• SPECIAL ASSESSMENTS are based on the premise that a new public improvement enhances the value of adjacent property and that hence the cost of the project should be recovered in whole or in part by charges against the properties benefited. By the end of the 1920's the use of special assessments was widespread and, to a considerable degree, excessive and unwarranted. With the depression years of the 1930's wholesale default of special assessment bonds occurred. This, coupled with extensive aids for public improvements through WPA and other major relief grants, caused the practical discontinuance of the special assessment method of finance. With the 1940's a renaissance of this system developed until at present (1962) special assessments play a significant role in financing highways and other public improvements. But this development is largely a return by communities to their previous procedures. Therefore, except in those places having historical experience with special assessment, public authorities and particularly those at the State and county level are unaware of the fact that substantial revenues for highway and other purposes can be obtained through special assessments. The purpose of this article is, therefore, to show that this is being done and how the benefits of special assessment finance can be obtained.

Parkways, major thoroughfares, through streets connecting a downtown business area with outlying territory, access roads, off-street parking, downtown business district rehabilitation — all can be financed through special assessment. This method of public finance at present is not being used to the extent characteristic of former years — and it well could and probably should be.

Up to the early 1930's, the common practice was to finance public improvements, including major street developments in whole or in part, through special assessments — even in the building of courthouses, fire stations, and other public buildings.

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In the boom days of the 1920's, wildcat subdividing was rampant. Highways, sewer, and water systems were extended in all directions and largely financed through special assessments, but the optimistic hopes of the 1920's collapsed in the depression years of the 1930's. Properties were saddled with special assessments, often in excess of their value. The result was that wholesale delinquency occurred. Table 1 shows this condition.

In San Diego County, of $13,868,000 bonds outstanding, $8,563,000 were in default.

In Cleveland, of $17,373,589 of special assessments due in 1929, $10,731,901 were delinquent in 1931 (2).

In one county in southeastern Michigan (3), of the dozens of special assessment districts shortly after 1930, one was considered to have an excellent special assessment collection record. Its levies were only 92 percent delinquent! The others were 100 percent.

These happenings, plus misuse of the special assessment authority, caused the method to fall into disrepute. Also, the fact that civic improvements were constructed through WPA and other emergency grants resulted in there being little resort to special assessment finance during the 1930's

With the 1940's, municipalities returned to using special assessment method of financing extensively and are getting large amounts from this source to pay the costs of public improvements, including highways.

Table 2 shows to some degree the role special assessment can play. These figures are sufficient to show substantial revenues are being derived for highway purposes from special assessments. Many other examples can be given. In fact, this is a common and accepted way of financing streets in whole or in part in American cities.

Of the 876 cities of over 10,000 population reporting the use of special assessments in response to the questionnaire sent out in 1959 by the International City Manager Association, 719 (or 80%) finance street paving by special assessments. A total of 211 (24%), also use this method for repaving.

That large sums for public improvements can be obtained from special assessments is of major importance. Public demands for facilities and services outstrip the funds available for governmental units. Billions will be needed to meet future highway demands. More billions will be required for education, public health, conservation, and many other purposes. Sound public finance, therefore, demands that thorough and careful consideration must be given to exploring various means available to get funds for these undertakings. Special assessments can be a legal and equitable source of revenue for financing many public undertakings.

SPECIAL ASSESSMENT THEORY

Because this is intended as a practical rather than a theoretical discussion, the theory and legal basis for special assessments is mentioned only briefly.

Special assessments are based on the principle stated by Justinian — that the burden should be borne by those who derive

TABLE 1

SPECIAL ASSESSMENT TAX DELINQUENCY LOS ANGELES COUNTY, 1936[1]

Percent	No. of Districts	Percent	No. of Districts
90 to 99	9	50 to 59	9
80 to 89	11	40 to 49	15
70 to 79	20	30 to 39	16
60 to 69	15	Under 30	25

[1] Source: (1).

TABLE 2

SPECIAL ASSESSMENTS FOR HIGHWAYS

City	Date	Assessment ($)
New York	1950-1958	84,506,000
Milwaukee	1950-1957	18,005,000
Detroit	1949-1958	21,722,000
Los Angeles	1955-1959	18,147,000

the benefit. This principle was embodied in early English law, was carried over to the colonies, and by 1800 was an accepted method of financing public improvements in the young American States. When the legality of the method was questioned, the courts were hard put to justify the legality of this procedure. The position was first taken that special assessments could be imposed through the use of eminent domain or the police power, but it subsequently shifted and evolved the unique doctrine that special assessments were legal as a manifestation of the taxing power, although they were not taxes — and this theory is now universally accepted. Thus, special assessment finance is a method legally approved as a means for defraying the costs of public improvements. The following (3) is a good definition of these assessments:

> Taxation by Special Assessment is a compulsory charge upon real estate within a pre-determined district, made under express legislative authority, for defraying in whole or in part the expense of a permanent public improvement, therein enhancing the present value of such real estate, and laid by some reasonable rule of uniformity based upon, in the ratio of, and limited by, such enhanced value.

The applications of this rule are widespread. The 1957 Census of Local Governments lists well over 100 different types of special assessments, even to such an extreme as a district empowered to levy an assessment per bushel of oysters to finance construction of dikes to protect the oyster beds. Highways, water, sewer and drainage improvements are quite commonly financed through assessments.

SPECIAL ASSESSMENT AND HIGHWAYS

That the cost either in whole or in part of a new access road, curbs, sidewalks, and water and sewer, can be met by a special assessment charge against the abutting property is quite generally known. But that this method can also be used in connection with parkways, major thoroughfares, through streets leading to downtown areas, off-street parking, and rehabilitation of central business districts is not generally realized. However, the use of special assessments for financing such improvements has long been established. This is of particular significance in connection with modern highway development. Among many specific cases which could be cited are the following.

The Arroyo-Seco Parkway between Los Angeles and Pasadena was financed through special assessment.

Milwaukee and Detroit have used special assessments in connection with the construction of arterials.

New York City since 1909 has met the cost of building major thoroughfares 200 ft or more wide across entire boroughs out of special assessments.

The Kilbourn Avenue development in Milwaukee consisted of creating a broad avenue from Lake Michigan some 2 miles to the courthouse. Associated with the project was the clearing of several blocks of ramshackle buildings and a conversion of the property to an open area approach to the courthouse and for a setting for other buildings. A large share of the cost was met by special assessments.

Milwaukee has also used special assessments to defray in part its share of the cost of a major highway development primarily financed out of State and Federal funds. A section of Capitol Drive was improved at a cost of $284,803. The city's share was $55,410, of which $22,052 was raised through special assessments.

Similar examples as to the use of special assessments for financing the improvement of major thoroughfares could be given for Chicago, Minneapolis, and a number of other places. The fact that a substantial part of the cost of the improvement of major thoroughfares can be met through special assessments should be of major importance in connection with the need for creating improved highway facilities in cities.

Mention was made as to other improvements allied with highways which can be and are being financed through special assessments. The practice of providing off-street parking facilities through special assessments is well established. Milwaukee and Los Angeles — and undoubtedly many other cities — pay the entire costs of acquiring downtown parking facilities through special assessments against surrounding business properties. Both these cities have established formulas and procedures for allocating the assessments.

Special assessments can also be used for downtown rehabilitation. Royal Oak, Mich., is making the following improvements:

1. Widening and redesigning major streets leading to the central district.
2. The creation of 3,404 free parking spaces.
3. The closing of certain sections of the streets and installation of flower beds, pools, fountains, and other landscaping effects as well as conveniences for the shopper.

Another and rather new use of special assessments having some connection with highways is the creation of "green belts." Detroit has a procedure under which, if residential property is located across a highway from a railroad track, factory, or other use thought unsightly, through special assessments property can be acquired and a "green belt" created screening the unesthetic use.

Other applications of the special assessment principle in relation to modern highway development are being proposed. One is that special assessments can properly be levied against lateral streets having access to throughways at interchanges. Another is to finance service roads along throughways through this method. Both proposals would seem to have considerable merit.

BASIC SPECIAL ASSESSMENT PROCEDURE

This material is sufficient to show that special assessments can be used in connection with modern highway programs. And with the demands for facilities increasing, coupled with the problem of getting funds for this and other major public activities, it would seem that highway authorities should give serious consideration to using special assessment finance to a greater degree. This gives rise to the question as to how highway administrators can proceed to avail themselves of this method of financing.

Every special assessment project is governed by laws and methods peculiar to it. Consequently, hundreds and perhaps thousands of variations in types of procedures exist. But all are governed by the following underlying principles:

1. Although usually imposed under the taxing power, the right to levy them is not an inherent power of government such as the taxing power, the police power, eminent domain, and others. Special assessments, therefore, can be imposed only under specific laws authorizing the use of this method.

2. The laws granting the public assessment right must be strictly construed and all assessments levied in exact compliance with such laws.

3. The first step is the initiation of the special assessment project. Usually this is on petition of property owners, although it may be by a city, county, or local government. Sometimes the legislature by law specifies that an improvement is to be financed through special assessments. The principle giving property owners the right to initiate a special assessment is one of the elements that distinguishes a special assessment from a property tax.

4. Unless otherwise specified by legislative act, the proposal after initiation is referred to a board which does the following things:

   a. Establishes the special assessment district boundaries.
   b. Estimates the cost of the project.
   c. Determines the amount of benefits to be charged property owners as special assessments, and decides on the method of allocating the assessments.

5. Unless otherwise specified by legislative act, property owners must be notified of a public hearing concerning the project. Adequate notification is mandatory and special assessments are invalid unless the property owners affected have been given adequate notice. But what the courts consider adequate notice is most highly controversial and even after hundreds of years has not been settled. This matter of notice is a fundamental element which distinguishes a special assessment from a property tax.

6. A public hearing is usually held. The original plans and specifications may be modified at such a hearing. A special assessment project theoretically can be under-

taken only with the approval of those affected. (However, in Minnesota under the Elwell Law, a public hearing is not held.)

7. The board then confirms the project as approved at the hearing and notifies the property owners as to the scope and character of the operation.

8. If no appeal is taken, the actions of the board are carried on.

9. The contract is awarded and the work is carried on. The contractor is paid through obligations which are charged against the property benefited in the amount assessed against each property by the board.

10. In connection with this step, the board makes up a special assessment roll showing the amount charged against each property. Property owners have the right of appeal and frequently hearings are held in connection with the spreading of the assessments.

11. Property owners are given the opportunity of paying the entire amount of the assessment immediately. Bonds or other evidences of indebtedness are issued in the amount unpaid. These bonds are payable in installments over a period of five to thirty years, with ten years being most common.

12. When the costs of improvement have been paid, the special assessment project is terminated. This element, that special assessments are used solely to pay the costs of a public improvement and ceases when the object is accomplished with no ensuing or continuing charges for that project, is another way in which special assessments differ from taxes.

These are the principles governing the special assessment activity when a capital investment is involved. Special assessments can also be levied to meet annual recurring costs such as highway maintenance and lighting. When once established, these become automatic reoccurring charges.

The manner in which these principles are applied differs greatly among the various cities. Exception to the rule is more common than adherence.

Two examples illustrate typical procedures. The first is a standard California procedure as used in Pomona:

<u>Steps Under Improvement Act of 1911</u>

Request for petition from engineering department
4 weeks — Petition returned to engineering department
2 weeks — Council accepts petition and orders city engineer to proceed
2 weeks — Survey information obtained for design of project
4 weeks — Design completed
2 weeks — Assessment district formed, estimate cost calculated
4 weeks — Resolution of intention
5 weeks — Resolution hearing
5 weeks — Open bids, award contract
12 weeks — Construction completed
2 weeks — Assessment of costs
4 weeks — Assessment hearing
4 weeks — Data bond
4 weeks — Bond printed
(Records and work completed in 54 weeks)

In this procedure, although the city initiates the action, a petition signed by the property owner is required before a project is authorized.

The second example is the procedure used in Minnesota under the Elwell Law:

<u>Elwell Project Steps</u>

1. First resolution.—Designates lands to be acquired and/or improvements to be made. Orders city engineer to make survey, plats, and estimates. Specifies duration of assessment (no time interval specified).

2. Second resolution.—City Council adopts plats and estimates. Appoints commissioners. States limits of city portion (three days after publication of second resolution).

3. City clerk's notification.—Notifies commissioners of appointment. Administers oath of office (no time interval).

4. Commissioner's notice.—Notice that plats and surveys are on file in city clerk's office, published two times. Designates place and time to view premises (at least ten days).

5. Viewing.—Commissioners view premises at time and place designated in Step 4. During this period the commissioners, with the assistance of the city engineer's department and the city clerk's office, determine the awards, damages, benefits, and assessments. Report filed with city clerk (no time interval specified).

6. Commissioner's estimate.—Estimate of project including cost of procedure. Estimate shows city's portion, assessed portion, and the portion that would have been assessed against parcels of land that have been forfeited to the State for nonpayment of taxes (no time interval specified).

7. Assessment rolls published.—Designates time and place for public hearing. City clerk serves notice on each property owner at least two weeks before public hearing. At this time property owners may file objections (at least three weeks).

Minneapolis which uses special assessments extensively has a little different procedure:

Condemnation Procedure Under City Charter—Minneapolis, Ch. 10, §§ 1-4, 6, and 7

Initiation.—Under resolution, city council appoints a committee on location and description. Committee (a) examines and proposes suitable land, (b) presents a plat of proposed acquisition, (c) includes in report any other appropriate information relative to the proceeding; and (d) files report and plat with city clerk.

Committee report filed.

Notices of filing of committee reports published twice in official newspaper.

Report presented to city council one week after last notice.

City council acts on report.—May act on committee report at same or subsequent meeting. May hear evidence or refer to a committee. May adopt committee report and plat in resolution— (a) designates land to be condemned; (b) files directing plat and committee report; and (c) appoints five commissioners.

Condemnation committee appointed.—Notification published twice that project plans are on file.

Property viewed and report prepared.—Ten days after first publication commission views property, prepares report, and submits to city council.

Report laid over for minimum of one week.—Council confirms, annuls, or refers back report. Property owner within ten days may appeal to district court. Commission views premises again, considers evidence, and prepares revised report.

Council confirms or annuls the proceedings.—Under this law, the project is initiated entirely by the city. After the assessments have been imposed, the property owner may file objections.

NATURE OF BENEFITS

Special attention is called to the preceding material dealing with the assessing of benefits. The benefits must be reasonably measurable and the assessment must not exceed the benefits. In the past, a common assumption was that a benefit occurred equal to the cost of the major public improvement; hence, the practice was to charge such cost against supposedly benefited property owners.

This arose from the concept and principle that the local road or street is a property appurtenance that should be financed by the property owners. The construction of local roads and streets can be done by local contract directly between the property owners and the highway builders. Construction by special assessment differs from this in only one major manner — property owners in an area recognize the need for an improved highway facility and believe the cost will be a recoverable investment because of an enhanced value to their properties.

Unfortunately, the practice developed quite extensively of assuming that almost any highway improvement automatically created benefits equal to the cost. The result was that assessments sometimes exceeded the value of the properties. But since 1930 this condition has become virtually nonexistent.

With respect to major highways, a commonly-accepted theory is that the benefit extends beyond the limits of the abutting properties. Zones or districts are set up and a portion of the cost of a major highway improvement is charged in the form of a special assessment against the entire district. When 12th Street in Chicago was widened at a land cost of $3, 259, 708 for 2½ mi, properties within an area of a little over 5 sq mi were considered benefited, and $1, 490, 490 of the entire cost was recovered through special assessment charges in that area. Similarly, when Michigan Avenue was widened ⅝ mi at a cost of $13, 762, 302, special assessment charges of $5, 926, 702 were imposed on an area of 2½ sq mi (4).

The theory is that the improved highway facility enhances the value of properties whose occupants are capable of using such facilities.

The fact that a modern highway may result in appreciation of values to areas warrants particular consideration. The principle that benefit charges may be imposed on areas made more accessible through such a development is well established and sustained by the courts.

In Omaha, where a special assessment was levied against property ¾ mi from a boulevard, the court found that remote property could receive an assessable benefit[1].

It has been held in Arkansas, Connecticut, Nebraska, and Kentucky that the building of a bridge or a viaduct creates a benefit that may be assessed against the surrounding area[2].

A business district may be assessed for a portion of the cost of a street improvement which carries vehicular traffic into the business district on a more direct route[3].

The Arroyo-Seco Parkway (where the cost was assessed against large areas in Los Angeles and Pasadena), the 12th Street improvement in Chicago, and the Kilbourn Avenue development in Milwaukee are examples of places where costs were met by special assessments spread over fairly large territories. Reference has also been made to the policy in New York of charging part of the cost of the major thoroughfare against the the borough and the entire city.

The development most analogous to a major cross-country highway improvement is the Moffat Tunnel. To finance this tunnel under the Continental Divide, a special asessment district 145 mi long was created. Benefits were assessed against the entire city of Denver, three other entire counties, and parts of five additional counties.

The lack of major through or arterial highway facilities may stifle or hamper normal growth of an area. Under such conditions, when a new adequate highway facility is provided a rapid rise in the property values in the area tributary to the new throughway may develop. Under such conditions special assessments may possibly be used legitimately to recover a part of the cost of the improvement.

METHODS OF SPREADING ASSESSMENTS

When an improvement creates special benefits, great latitude is allowed in determining the way in which the assessments may be allocated to or spread among the various parcels. Furthermore, so long as the method is not arbitrary, a special assessment is not invalid even if inequities result. The special assessment district may also be of any size. As to the method, the U. S. Supreme Court[4] has stated:

> The state, in its discretion, may levy such assessments in proportion to position, frontage, area, market value or to benefits estimated by commissioners.

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[1] Hart v. City of Omaha, 74 Neb. 836 (1905), 195 N.W. 546.
[2] Mullins v. Little Rock, 131 Ark. 59, 198 S.W. 262; State ex. rel. Sulkeley v. Williams, 68 Conn. 131, 35 Atl. 24, 421, affirmed in 170 U.S. 304, 42 L.Ed. 1047, 18 Sup. Ct. 617; Springfield v. Hayden 216 Ky. 483, 388, S.W. 337.
[3] Re Aurora Ave., 180 Wash. 523, 41 P.2d 143, 96 A.L.R. 1374.
[4] Houck v. Little River Drainage Dist., 239 U.S. 254, 265 (1913).

As to the fact that inequities may occur:

> Assume that the only theory of these assessments for local improvements upon which they can stand, is that they are imposed on account of the benefits received, and that no land ought in justice to be assessed for a greater sum than the benefits received, yet it is plain that the fact of the amount of benefits is not susceptible of that accurate determination which appertains to a demonstration in geometry.
>
> It may be that the front foot rule is not the best that might be devised for the assessment of street improvements in cities upon abutting property, but for the present it is the only one we have;... It is perhaps impossible to frame any general rule that would produce exact uniformity and do equal justice in all cases. This arises from the fact that a rule to be valid must be general, and the further conceded fact, that in the application of all general rules there will be cases of individual hardship.

As to the size of the district:

> Fixing the tax district or, in other words, defining the territory within which the special assessment shall be made is exclusively a legislative prerogative.... How small it may be had never been determined.... The taxing district may embrace an entire city.

Metropolitan sewerage districts commonly embrace a central city and outlying areas. The Moffat Tunnel special assessment district includes all or part of eleven counties. The consequence is that many methods are used for spreading special assessments.

The following are the main methods used for allocating special assessment benefits to properties:

Front Foot Against Abutting Property

The cost is apportioned on the basis of the footage fronting on the improvement. Sidewalks, curbs and gutters, and alley improvement charges may be said to be universally spread on that basis. Highway construction and reconstruction, sanitary sewers, and sometimes storm sewers commonly use this method, although frequently in combination with other systems. Street maintenance and highway lighting are usually financed by a front foot charge.

Sliding-Scale Front Foot Area Basis

When the benefits resulting from an improvement are considered to benefit an area rather than just the strip of the property abutting, the front foot method is used for all properties within the area. The basis is a sliding scale with the assessment per front foot decreasing progressively, sometimes geometrically, with the distance each street is from the improvement. Some cities have well-established formulas for spreading such assessments.

The sliding scale method of apportioning benefits is subject to criticism. If adequate access is provided to the improvement, properties several blocks away may have a benefit equal to or in excess of those in direct proximity to the development.

Square Foot Basis

The amount assessed is simply apportioned on the basis of the area of such parcel. This may be a flat uniform amount per square foot for each property in the area or

[5] Harrisburg v. McCormick, 129 Pa. St. 213, 18 Atl. 135.

decreasing unit per square foot may be used according to the proximity of the property to the improvement. This method is also frequently applied to business properties, particularly industrial sites. In rural areas the acre instead of the square foot becomes the unit.

Ad Valorem Basis

The assessment is spread in proportion to the value of each property. Usually the assessed value is the basis. Assessments may be laid against land owner, land and buildings, buildings only, although rarely, and against all taxable property including personal property. The use of the ad valorem method is more extensive than generally realized.

Building Site Basis

A rather new development consists of using the number of building sites benefited by an improvement and charging an equal amount to each site, irrespective of its frontage or sides. This plan was developed to meet the situation caused by the modern subdivision development with its curving streets and odd-shaped lots.

Personal Property Basis

In some rare instances a public improvement has been made to benefit a particular type of industry. The original costs and maintenance are recovered by charges against the commodity produced, such as per ton of coal or per bushel of oysters. This method is an extremely uncommon and minor part of special assessment finance.

METHODS OF FINANCING

Although there are probably hundreds of ways of financing special assessment projects, basically they fall into the following six types:

Revolving Fund Method

Under the revolving fund method a municipality sets up a specific fund for special assessment work. The city meets the expenses of the undertaking out of this fund. No bonds or other evidences of indebtedness are issued. When the work is done the city charges against each property benefited the proportionate share of the benefits. These amounts when collected are paid back into the revolving fund.

City General Bond—Sinking Fund Method

The city itself directly pays the contractor for the work done. General city sinking fund bonds are issued equal to the amount of the cost and from these the city derives the needed revenue for the payment to the contractor. A sinking fund is set up against these bonds, and special assessment charges levied against the benefited properties are paid into this sinking fund.

In neither of the first two methods are public improvements financed by special assessment bonds resting directly on an obligation of benefited properties or a district, although the amounts advanced out of general municipal sources are recovered from special assessments.

"Full Faith and Credit" Bond Method

Under this system special assessment bonds are issued which are a specific obligation against benefited properties — whether against individual properties or a district. The municipality underwrites such bonds by guaranteeing payment of any delinquencies out of other municipal resources.

Reserve Fund Method

The municipality sets up a special reserve fund and in the event of delinquency pays bondholders out of this fund. The city then enforces the collection of delinquent assessments and pays the proceeds into the reserve fund.

General Assessment Bond Method

The cost of the work is met through bonds issued against the benefited properties. These may be against either all the real estate within the district or each property benefited. The contractor is given these bonds in payment for his services. In case of delinquency it becomes the responsibility of the bondholder to enforce collection. The city or county may initially act as the collecting agent but in case of default the responsibility for collection is thrown on the bondholder.

Assessment Certificate or Assessment Bill Method

The contractor gets a special receipt, a bill, or a certificate against the property benefited for the amount of his services. The certificates may be drawn so as to be a liability against all the property in a benefited area, against groups of property in the area, or against individual specific properties. Under this method the work is considered to be of a contract nature directly between the property owner and the contractor. Though formerly a very common system and still prevalent, this method is not now used extensively.

MERITS OF FINANCING METHODS

The method of financing has an effect on the cost of public improvements financed by special assessments. Under the first four plans, the municipality through one device or another guarantees or underwrites full payment of bonds. Furthermore, the contractor is assured full and prompt payment for his services.

Under the last two, the contractor must face the probability that a portion of the bonds may become delinquent. A standard practice, therefore, is for him to increase his price by an amount adequate to cover these delinquent items. Also, under the general bond or certificate plans, sometimes the contractor does not receive his payments even in that form until after the completion of the job. This necessitates his adding to his price the carrying charges during construction. Also, special assessment bonds or certificates not underwritten in some manner by the full credit of the community bear higher interest rates than for obligations where such guarantee is present. This is shown by Table 3.

Of the 91 cities using full faith and credit finance, 56 (61%) sold bonds with an interest rate of less than 5 percent compared with 18 (22%) of the 83 cities using unguaranteed obligations. Inasmuch as the maximum legal rate in many places is 6 percent, it is possible that some of the 6 percent bonds were discounted.

SPECIAL ASSESSMENT DISTRICT

Special assessment districts can and do carry on almost all types of governmental activities. Under statutory authority a special assessment district is created as a

TABLE 3

INTEREST RATES ON SPECIAL ASSESSMENT OBLIGATIONS

Type of Obligation	Number of Cities												
	Total	8%	7%	6½%	6%	5½%	5%	4½%	4%	3½%	3%	2½%	2%
Full faith	91	-	2	1	22	1	9	2	17	12	12	9	4
General	83	1	5	1	40	2	14	3	5	5	5	1	1
Certificate	17	-	-	1	11	-	3	-	1	1	-	-	-

separate and distinct entity. These districts have the authority to determine and levy special assessments, fix and collect charges for services, and may incur indebtedness without review by other authorities. These autonomous districts have their own headquarters (sometimes in the homes of one of their officers), keep their own records, and prepare their own financial reports, if any. Commonly, they are not required to report their activities to any central accounting authority such as the State or accounting auditing department, although there are exceptions. However, cities and counties that use special assessments usually have separate departments for such work. Although these departments keep records generally of the financial status of the special assessment districts under their jurisdiction, commonly this is on a project by project basis without any general annual summation of special assessment activities. Because they operate independently, special assessment data are often hard to come by.

For example, California is known to have at least 2,982 special assessment districts created under 183 different statutory authorizations of which 45 had been repealed, leaving 138 laws authorizing the creation of a particular type of district. In San Diego City in 1959, there were 125 separate assessment roles for paving, sewer, walks and lights; in addition, San Diego County had 84 special assessment districts, besides many local districts.

The California situation is considerably more confused than most States, but to a considerable degree, the same conditions are found generally.

OVERLAPPING DISTRICTS

The possible multiplicity of districts can create a serious problem — that of overlapping assessments. A property may be within the boundaries of a number of special assessment districts. Figure 1 shows overlapping special assessments for park purposes in Minneapolis. Also, special assessments for highways, sewers, and other public purposes may be laid against these same areas. The result is that the pyramiding of assessments may result in the aggregate of creating levies that are excessive. Though this was an all too frequent occurrence in the past, modern practice has largely alleviated this condition.

SPECIAL ASSESSMENT DELINQUENCY

Special assessment financing has an inherent danger in that anticipated benefits may not develop and hence the assessments may become delinquent. Optimism as to future city growth may cause overdevelopment. Real estate promoters may be willing to gamble one or two special assessment payments to get the improvements in and to have the opportunity of enhancing the value of their properties. Special assessments are akin to installment buying; as in the purchase of commodities, payments may be associated with the degree of general economic prosperity.

In the 1920's tremendous growth occurred in many cities, coupled with a major demand for improved roads and streets. Overexpansion and overdevelopment occurred. With the depression and, even previously, wholesale delinquency of special assessment bonds developed.

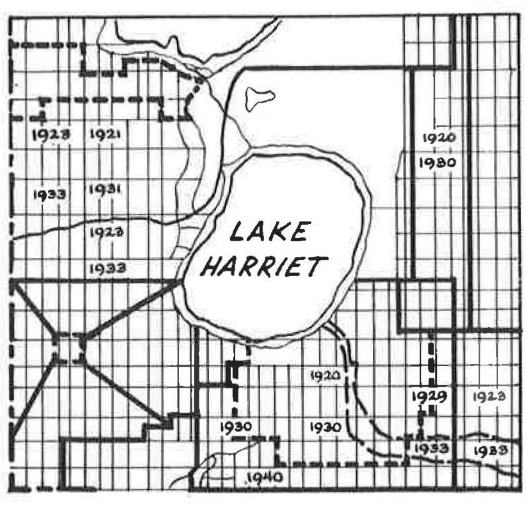

Figure 1. Overlapping park districts in Minneapolis (year indicating overlapping district).

ADVANTAGES AND DISADVANTAGES OF SPECIAL ASSESSMENT FINANCING

Whether special assessments are justifiable is a debatable question. Some of the positions taken are as follows.

Proponents of special assessments give these reasons:

1. With debt and tax limitation, revenues from general taxation for needed improvements sometimes cannot be obtained.

2. The amount collected from general property taxes should remain relatively stable. Loading the cost of an expensive public improvement on the regular tax bill may cause an erratic fluctuation in such levies, felt by all taxpayers within the municipality; whereas a special assessment localizes the impact to benefited properties and does not affect the public as a whole.

3. Special assessments are levied against religious, educational, charitable, and other types of property which are exempt from property taxations.

4. The cost of a public improvement such as a street or sewer may be much greater in one section of the city than another and property owners generally should not be required to pay out of their general taxes the extra cost of such improvements. For example, in Los Angeles the construction of street and sewer facilities in an adjacent semimountainous area costs many times that of providing comparable facilities in the level sections, and the owners of properties in those areas should not be called on to subsidize the expensive construction in the other areas. Similarly, in another city, streets are being constructed across an area of marshy land, again entailing extra-heavy construction costs.

5. The sound use of special assessments makes possible the development of a city plan in an orderly manner.

6. When special assessment obligations are full faith and credit bonds, funds for construction can be made available at lower interest rates than if the work was undertaken under private contract.

7. A number of subdivisions in the same area may be in the process of development simultaneously. Though each subdivider may be required to finance the costs of improvements within his area, economies are effected by consolidating under municipal authority as one project what would otherwise be a number of separate enterprises.

8. Financing by general taxation might result in an intolerable tax burden because property taxes are already as great as many can or will stand.

9. A special assessment imposes no real burden on the property owner because the benefit equals or exceeds the cost and payments are spread over an extended period.

10. There can be no intelligently planned improvement that will not result in some local benefit, and it should follow that there should always be some local assessment.

11. Special assessments are the essence of democracy in that generally they originate at the request or with the approval of those on whom the charges will fall.

12. Special assessments constitute an established part of the public finance structure and comprise an established institution essential to the financial operations of many municipalities.

13. Groups of property owners independently cannot often get together and finance and construct needed improvements in their areas.

14. Roads and sewers serving properties comprise parts of a general system, and though theoretically they might be built directly by property owners, this could result in haphazard developments. Special assessments insure against this.

Among the points considered to be disadvantages of the special assessment system are the following:

1. Improvements, such as pavements and sewers, are essentially public in character; therefore, the costs should be met out of general taxes.

2. When the principle of benefit taxation is accepted, there is no logical place to stop.

3. The degree of benefit is speculative.

4. Methods of equitably apportioning benefits to particular properties are not based generally on sound principles and levies are made by guesswork of some rule-of-thumb device.

5. Special assessment levies are commonly made by local boards lacking the proper and necessary administrative abilities.

6. Unless rigidly controlled by an overall city planning, public works, engineering, or other continuing authoritative department of an established governmental unit, extension of facilities beyond the reasonable and legitimate needs may take place.

7. Costs will be definitely inflated under improper use of special assessment financing.

8. If improvements enhance the value of properties, enhanced value will be reflected in an increase in taxable values and the cost of the improvement will automatically in time be recovered through the resultant greater taxes from these properties.

9. The use of the special assessment procedure may cause unnecessary delays.

10. Although benefits to the property may arise, the owners may not be in a position to realize on them.

11. The property owner is deprived of his rights because he does not have adequate information nor the technical ability to appraise the feasibility of the improvement.

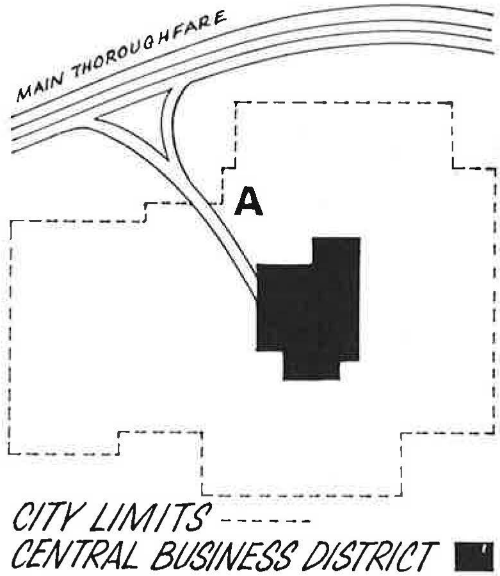

Figure 2. Application of special assessments in financing connecting routes.

ILLUSTRATIONS OF SPECIAL ASSESSMENT USE

Figures 1 and 2 show the use of special assessments. Figure 1 shows how special assessments can overlay the "pyramiding" of the charges. Figure 2 shows the application of special assessments in financing connecting routes. Connecting highway A can be financed in part by a special assessment against the central business district.

Part of a main thoroughfare cost can be met through special assessments, as in New York. There a through highway such as a main road traversing part of the city is financed by charging the cost of the central 60 ft against contiguous property, the next 20 ft on each side of the central portion against the borough, and the outside 50-ft strips of the right-of-way against the city as a whole.

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Selection of a County Distribution Formula for State Road Assistance In Mississippi

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This paper describes the method employed by the Mississippi highway finance study staff to determine the formula recommended by it to the legislature for distributing State assistance for road purposes to the counties. The 20-yr annual average total cost of county roads in each county was accepted as a measure of need. Although need per se was rejected as a basis for distributing State assistance, a distribution formula based on other factors but one which, on the average, most nearly would equate proportionwise road cost (needs) and State assistance, was considered desirable.

Five factors most frequently used by States for distributing motor fuel taxes to local units of government were tested, singly and in all possible combinations. They ranked from best to worst as follows: (a) road mileage, (b) area, (c) equal division, (d) population, and (e) motor vehicle registrations. Moreover, combinations of factors do not appear to secure better results by compensating extremes. The single factor of road mileage was found superior under Mississippi conditions to any other factor or combination of factors.

The superiority of the mileage formula was further verified by distributing various amounts of assumed State assistance and analyzing the results. Another statistical measure used in this connection was the sum of deficits of counties having deficits, smallness of deficit sums being indicative of formula efficiency.

•THIS PAPER is concerned primarily with the method employed by the Mississippi highway finance study staff to determine the formula recommended by it to the legislature for distributing State assistance for road purposes among the counties. Adoption of a proper distribution formula for such State assistance is a prerequisite to a necessary reallocation of highway responsibilities and/or highway revenues between the State and its local units of governments if an adequate system of highways in the State is to be realized.

The highway finance study (1), from which this paper is extracted for the most part, was made by the University of Mississippi for the Legislative Highway Planning Committee as a companion study to an engineering evaluation made by the Automotive Safety Foundation (2). This connection is important inasmuch as the approach to the problem of distributing State assistance among the counties was made within the framework of the engineering study. The latter provides 20-yr cost estimates for the upgrading and maintenance of Mississippi's network of roads and streets to acceptable standards. (The study provides three alternate programs with regard to the time period

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necessary to bring all highways, roads, and streets up to adequate standards. The programs are for 10-yr, 15-yr, and 20-yr catch-up periods, respectively. Only the financing of the 20-yr catch-up period was developed by the finance study staff.)

Program costs were developed in detail for the State highway system, the county road systems, and municipal street systems under each of three different assumptions as to the mileages to be included in each system. The assumptions were designated as A, B, and C, respectively. Under assumption A, the currently-designated State highway system is to be developed as proposed, and existing routes paralleling both the Interstate system and the proposed major thoroughfares are to be continued as a part of the State system. The ultimate mileage in the State system under this assumption would be 12,111 miles. Under assumption B, certain categories of highways would be transferred from the State system to the counties and municipalities. These categories would include (a) the parallel routes just mentioned, (b) designated but non-State-maintained highways, and (c) State highways with discontinuous system or maintenance responsibility. The ultimate mileage in the State system under this assumption would be 8,466 miles. Under assumption C, the State highway system would be further reduced in size to a recommended 6,500 miles.

To the estimated program costs, the highway finance study staff added estimated costs of debt service (principal and interest) on outstanding highway, road, and street debt. All costs were stated in terms of annual averages. The staff also made estimates of all revenues that will be available under current law to finance the highway, road, and street needs previously outlined. These likewise were reduced to annual averages.

THE PROBLEM

For the purpose of emphasizing the overall view and pointing the direction of needed adjustments among the State, counties, and municipalities, each of these levels of government is considered as a single administrative unit. That is, all State Highway Department revenues are considered available for expenditure on State highways on a needs basis without regard to highway districts; all road revenues of all the counties collectively are considered to be available for expenditure on county roads on a needs basis without regard to county lines; and all street revenues of all municipalities collectively are considered to be available for expenditure on a needs basis regardless of the municipalities within which the streets are located. These assumptions do not accord with the facts but they do serve a useful purpose.

Table 1 gives the projected annual average highway costs and highway revenues from current sources for each level of government under each assumption (A, B, and C) as to mileage responsibility. These data identify clearly and unmistakably the major highway finance problem in Mississippi; i.e., the existing imbalance between the highway responsibilities of the different units of government and the revenues available to the latter for meeting these responsibilities. As serious as the overall deficiency in highway revenues admittedly is, the misallocation of available funds relative to needs is even more so. Additional revenue is not the only answer. Revenues and responsibilities of the different governmental units must be brought more nearly into balance.

Under assumption A (Col. 1, Table 1), under the present assignment of responsibilities and revenues, the State highway system will require $82.9 million annually but will receive only $61.3 million, leaving an annual average deficit of $21.6 million. On the other hand, counties as a group will require $42.8 million and will receive $59.7 million, leaving a statistical surplus of $17.0 million. (When discussing the surplus or deficit relationship of revenue to cost for counties collectively or for municipalities collectively or for all units of government combined, the qualifying term "statistical" is used to refer to the algebraic sum of surpluses and deficits of all counties, or of all municipalities or of all units, respectively.

Of particular significance in this connection is the fact that only 21 percent of estimated county road revenues is from locally levied taxes. (Even this figure overstates the local contribution because it includes an indeterminable amount of homestead exemption reimbursement payments made by the State to the counties.) The municipalities as a group will require $14.0 million and will receive $13.5 million, leaving a statistical deficit of $0.6 million. All units combined will require $139.7 million and

TABLE 1

PROJECTED HIGHWAY COSTS[1] AND HIGHWAY REVENUES[2] FROM CURRENT SOURCES, MISSISSIPPI: 1963-1982 ANNUAL AVERAGES[3, 4]

System and Item	Automotive Safety Foundation Assumption[5] ($ × 10^3)		
	A	B	C
All units:			
Cost	139,724	139,724	139,724
Revenue	134,491	134,491	134,491
Deficit	-5,233	-5,233	-5,233
State:			
Cost	82,908	71,096	63,964
Revenue	61,287	61,287	61,287
Deficit	-21,621	-9,809	-2,677
County:			
Cost	42,767	52,355	58,547
Revenue	59,741	59,741	59,741
Surplus	16,974	7,386	1,194
Municipal:			
Cost	14,049	16,273	17,213
Revenue	13,463	13,463	13,463
Deficit	-586	-2,810	-3,750

[1] 20-yr program costs plus debt service on highway debt outstanding as of June 30, 1961, for State and as of September 30, 1959, for counties and municipalities.
[2] Net of collection expense.
[3] Detail figures shown may not add to totals due to rounding.
[4] Source: Table 99 (1).
[5] Program costs under A, B, and C based on State highway system of 12,111, 8,466, and 6,500 miles, respectively.

will receive $134.5 million, leaving a statistical deficit of only $5.2 million. The amounts for all units combined remain the same under assumptions A, B, and C.

Under assumption B, a considerably improved relationship would be achieved between assigned responsibilities for providing highway services and revenues available under current law. Under this assumption, the annual average cost of the shortened State highway system would decline to $71.1 million, and the State deficit would be reduced to $9.8 million. The counties would find the cost of their road responsibilities increased to $52.4 million and their statistical surplus reduced to $7.4 million. The municipalities would find the cost of their street responsibilities increased to $16.3 million with a corresponding increase in their statistical deficit to $2.8 million.

Under assumption C, the annual average deficit of the State would decline to $2.7 million. The counties as a group would just about break even with a statistical surplus of $1.2 million. The municipalities as a group would find their annual average statistical shortage of street revenues increased to $3.7 million.

These data suggest that much can be done toward financing the modern highway program recommended for Mississippi without any increase in taxes. To accomplish this, however, a substantial reassignment of highway responsibilities and/or highway revenues will be required among the State, counties, and municipalities to bring about a better balance between responsibilities and revenues. The most obvious interlevel shift is between the State and the counties. But economic as well as political difficulties would be involved in such shifting, because when individual county statistics are studied, it becomes apparent that not all counties share proportionately in the statistical surpluses of $17.0 million, $7.4 million, and $1.2 million found under assumptions A, B, and C, respectively.

Indeed, not all counties will have a surplus. Even under assumption A, the most favorable from the counties' standpoint, 17 counties will have estimated deficits totaling $0.7 million. Under assumption B, 47 counties will have an estimated combined deficit of $4.6 million. Under assumption C, 56 counties are found to have estimated deficits totaling $8.9 million. It appears clear that a different method of allocating State assistance (which constitutes approximately 80 percent of estimated county road revenues) among the counties is a prerequisite to any reassignment of responsibilities and/or revenues among the State, counties, and municipalities.

SELECTION OF FORMULA

If all counties made the same relative effort tax-wise and managed their road affairs equally well, a strong case could be made for the proposition that the most efficient and equitable distribution of State assistance would be strictly on a needs basis. However, not all counties make the same relative tax effort nor manage their road affairs equally well. Moreover, needs would be difficult to measure in a politically acceptable manner through the years. Therefore, a distribution formula that on the average most nearly equates proportion-wise total road costs and State assistance was accepted as a desirable goal. Such a formula, though basically reflecting needs, would not penalize individual counties that may have exerted extra efforts in their road programs or may have been favored by the current distribution formula.

In seeking such a formula, the five factors most frequently used by States for distributing motor fuel taxes to local rural units of government were tested singly and in all possible combinations. These factors (Table G-106, 3) were (a) motor vehicle registrations (used by 14 States), (b) miles of road (13 States), (c) area (12 States), (d) population (12 States), and (e) equal division (11 States). There are 31 possible combinations of these factors.

Other factors used less extensively are sales of motor fuel (used by 3 States), assessed valuation (3 States), vehicle-miles (2 States), needs (2 States), and other factors (8 States). The number of factors used by individual States range from 1 to 5. They are used in various combinations and an individual State may use more than one formula. The data are as of January 1, 1959.

Mississippi values used for the three factors that will vary with time were motor vehicle registrations (estimated number in 1972); miles of road (ultimate mileage as furnished by Automotive Safety Foundation); and population (average of 1960 and estimated 1970).

Technical Procedures

The testing method was as follows. It was assumed that a total amount of State assistance equal to the annual average total cost of all county roads in the State was to be distributed. The amount which each county would receive under each formula was stated as a percentage of its road cost, and the percent of surplus or deficit it would experience was computed. (Thus, a county that would receive 115 percent of its road cost would have a 15 percent surplus, whereas a county which would receive 85 percent of its road cost would have a 15 percent deficit.) The average deviation of these percentage surpluses and deficits was computed for each formula. The formula giving the smallest average deviation would, on the average, most nearly equate proportion-wise road costs and any given amount of State assistance. This procedure was carried through for costs under assumptions A, B, and C.

The results given in Table 2 point clearly and persuasively to road mileage as being superior to any other factor or combination of factors. The single factors rank from best to worst as follows: (a) road mileage, (b) area, (c) equal division, (d) population, and (e) motor vehicle registrations. Moreover, combinations of factors do not appear

TABLE 2

TEST OF DISTRIBUTION FORMULAS[1]
(average deviation of surpluses and deficits as percent of road cost)

Distribution Formula[2]	Automotive Safety Foundation Assumption[3]		
	A	B	C
R	63	65	66
A	20	19	21
P	53	54	55
M[4]	8	9	9
E	25	25	27
RA	33	34	35
RP	57	59	59
RM	32	33	33
RE	33	34	35
AP	28	28	29
AM[5]	12	12	13
AE	20	19	21
PM	27	28	27
PE	28	29	30
ME[5]	14	14	15
RAP	38	39	39
RAM	22	23	24
RAE	25	26	27
RPM	38	39	40
RPE	38	38	39
RME	23	23	24
APM[6]	19	20	20
APE	22	23	24
AME[5]	14	14	15
PME[6]	19	20	21
RAPM	29	29	30
RAPE	29	30	31
RAME[6]	19	20	21
RPME	28	29	29
APME[6]	17	18	19
RAPME	24	24	26

[1] Source: Table 131 (1).
[2] R = registrations; A = area; P = population; M = road mileage; E = equal division.
[3] Program costs under A, B, and C based on State highway system of 12,111, 8,466, and 6,500 miles, respectively.
[4] Recommended.
[5] Runners-up.
[6] Also further tested.

TABLE 3

AVERAGE DEVIATIONS OF COUNTY SURPLUSES AND DEFICITS AS PERCENTAGES OF ROAD COSTS UNDER VARIOUS ASSUMPTIONS AS TO AMOUNT OF STATE ASSISTANCE AND DISTRIBUTION FORMULA[1]

Automotive Safety Foundation Assumption[2]	Amount of State Assistance ($1,000)	Average Deviation of Surpluses and Deficits as Percent of Road Costs When State Assistance Distributed by							
		Mileage	Mileage and Area	Mileage and Equal	Mileage, Area and Equal	Mileage, Area and Population	Mileage, Equal and Population	Mileage, Area, Equal and Registration	Mileage, Area, Equal and Population
A	45,371	36	38	41	41	39	41	40	40
	41,061	27	29	31	31	34	35	34	34
	38,909	23	26	27	28	32	32	32	31
	36,756	20	23	24	25	31	31	30	29
	34,604	19	21	23	23	30	30	29	28
	32,451	19	21	21	22	31	31	29	28
	30,299	20	22	21	22	32	31	30	29
B	45,371	17	20	21	21	28	29	28	27
	41,061	17	19	20	20	29	29	28	27
	38,909	18	20	20	21	30	29	28	27
C	45,371	16	20	20	21	29	29	28	27
	47,523	15	20	20	21	29	29	28	26
	49,676	16	20	20	21	29	29	28	26

[1] Source: Mississippi Highway Finance Study Staff.
[2] Program costs under A, B, and C based on State highway system of 12,111, 8,466 and 6,500 mi, respectively.

to secure better results by compensating extreme values. The influence of the better factors can be discerned in the various combinations.

Despite the persuasiveness of the preceding evidence, it was not accepted as being conclusive. From the 31 formulas, the eight having the lowest average deviations, as previously described, were selected for further examination and analysis:

1. Mileage.
2. Mileage and area.
3. Mileage and equal division.
4. Mileage, area, and equal division.
5. Mileage, area, and population.
6. Mileage, equal division, and population.
7. Mileage, area, equal division, and registrations.
8. Mileage, area, equal division, and population.

Each formula was tested pragmatically to determine how the various counties would fare if the formula were used to distribute State road assistance. The testing was done by distributing varying amounts of assumed State assistance under each assumption as to allocation of highway responsibility. The test amounts distributed were determined on the basis of various assumptions as to the division to be made between the State and the counties of estimated road revenues available under current law from State-levied taxes and Federal aid. (Some adjustments not pertinent to the present discussion were made in the average amount of estimated road revenues available under current law from State-levied taxes and Federal aid. Then, a series of assumed changes from current law in the State-county assignment of these revenues was made. Under assumptions A and B, the estimated sum assignable to the counties under current law was reduced successively, first by the truck and bus privilege (license) tax and then by $0.0025 decrements of gasoline tax, until the balance remaining plus local revenue was roughly equal to the estimated all-county road cost. Under assumption C, two increments of $0.0025 of gasoline tax were added to the estimated sum assignable to counties under current law.)

(The use of such a range of amounts of State assistance was dictated in large part by the fact that these same data also were used in reconciling the conflicting claims of the counties and the State to the road revenues available from State-levied taxes and Federal aid.)

Altogether 104 sets of assumptions as to (a) highway responsibility (i.e., assumption A, B, or C), (b) the amount of State assistance, and (c) distribution formula were tested. Under each assumption the following values were computed for each county: (a) the amount of State assistance it would receive, (b) the amount of its total road revenues including local sources, (c) the amount of its road surplus or deficit, and (d) the road surplus or deficit as a percent of its total road cost. Frequency distributions of the last were made and carefully analyzed; their average deviations are given in Table 3.

TABLE 4

STATISTICAL SURPLUS OR DEFICIT[1] AND SUMS OF DEFICITS[2] COMPARED: ESTIMATED COUNTY AVERAGES (1963-1982) UNDER VARIOUS ASSUMPTIONS AS TO ASSIGNMENT OF RESPONSIBILITY, AMOUNT OF STATE ASSISTANCE, AND ALLOCATION FORMULA[3] ($ × 10^3)

Automotive Safety Foundation Assumption[4]	Amount of State Assistance	Statistical Surplus or Deficit (-)[1]	Sum of Deficits[2] When State Aid Distributed by							
			Mileage	Mileage and Area	Mileage and Equal	Mileage, Area and Equal	Mileage, Area and Population	Mileage, Equal and Population	Mileage, Area, Equal and Registration	Mileage, Area, Equal and Population
A	45,371	15,752	-72	-64	-102	-81	-809	-772	-582	-491
	41,061	11,442	-261	-412	-350	-407	-1,853	-1,829	-1,610	-1,441
	38,909	9,290	-527	-828	-721	-842	-2,580	-2,526	-2,257	-2,087
	36,756	7,137	-1,035	-1,359	-1,344	-1,433	-3,430	-3,370	-3,083	-2,822
	34,604	4,985	-1,828	-2,098	-2,149	-2,240	-4,433	-4,367	-4,051	-3,735
	32,451	2,832	-2,930	-3,170	-3,127	-3,210	-5,582	-5,486	-5,184	-4,862
	30,299	680	-4,254	-4,511	-4,315	-4,434	-6,870	-6,751	-6,461	-6,163
B	45,371	6,164	-1,633	-2,008	-2,019	-2,071	-4,674	-4,736	-4,295	-3,948
	41,061	1,854	-3,709	-4,092	-4,116	-4,245	-7,097	-7,027	-6,654	-6,266
	38,909	-298	-5,130	-5,466	-5,444	-5,616	-8,442	-8,275	-7,946	-7,574
C	45,371	-28	-5,016	-5,818	-5,707	-5,975	-8,852	-8,763	-8,411	-8,015
	47,523	2,124	-3,655	-4,619	-4,391	-4,700	-7,659	-7,533	-7,128	-6,709
	49,676	4,277	-2,541	-3,484	-3,290	-3,583	-6,504	-6,353	-5,945	-5,526

[1]Algebraic sum of surpluses and deficits of all counties. [2]Sum of deficits of counties having deficits. [3]Source: Table 132 (1).
[4]Progam costs under A, B, and C based on State highway system of 12,111, 8,466, and 6,500 mi, respectively.

TABLE 5

STATISTICAL SURPLUS OR DEFICIT[1] AND NUMBER OF COUNTIES HAVING DEFICITS UNDER VARIOUS ASSUMPTIONS AS TO AMOUNT OF STATE ASSISTANCE AND DISTRIBUTION FORMULA[2]

Automotive Safety Foundation Assumption[3]	Amount of State Assistance ($1,000)	Statistical Surplus or Deficit (-)[1] ($1,000)	Number of Counties Having Deficits When State Assistance Distributed by							
			Mileage	Mileage and Area	Mileage and Equal	Mileage, Area and Equal	Mileage, Area and Population	Mileage, Equal and Population	Mileage, Area, Equal and Registration	Mileage, Area, Equal and Population
A	45,371	15,752	2	4	2	3	19	18	17	14
	41,061	11,442	7	13	9	12	30	27	26	25
	38,909	9,290	15	19	17	19	36	33	30	29
	36,756	7,137	24	24	26	25	40	41	38	34
	34,604	4,985	38	33	32	34	50	46	45	43
	32,451	2,832	47	50	38	38	55	51	52	51
	30,299	680	56	55	50	52	58	57	57	57
B	45,371	6,164	29	34	28	30	48	48	43	42
	41,061	1,854	51	48	47	50	57	51	53	51
	38,909	-298	60	58	52	52	61	57	57	56
C	45,371	-28	54	49	52	50	57	54	55	56
	47,523	2,124	48	44	43	45	52	51	53	51
	49,676	4,277	39	42	38	39	49	50	48	49

[1]Algebraic sum of surpluses and deficits of all counties. [2]Source: Highway Finance Study Staff.
[3]Program costs under A, B, and C based on State highway system of 12,111, 8,466, and 6,500 mi, respectively.

TABLE 6

STATISTICAL SURPLUS OR DEFICIT[1] AND AVERAGE DEFICITS OF COUNTIES HAVING DEFICITS UNDER VARIOUS ASSUMPTIONS AS TO AMOUNT OF STATE ASSISTANCE AND DISTRIBUTION FORMULA[2] ($ × 10^3)

Automotive Safety Foundation Assumption[3]	Amount of State Assistance	Statistical Surplus or Deficit (-)[1]	Average Deficit of Counties Having Deficits When State Assistance Distributed by							
			Mileage	Mileage and Area	Mileage and Equal	Mileage, Area and Equal	Mileage, Area and Population	Mileage, Equal and Population	Mileage, Area, Equal and Registration	Mileage, Area, Equal and Population
A	45,371	15,752	36	16	51	27	43	43	34	35
	41,061	11,442	37	32	39	34	62	68	62	58
	38,909	9,290	35	44	42	44	72	77	75	72
	36,756	7,137	43	57	52	57	86	82	81	83
	34,604	4,985	48	64	67	66	89	95	90	87
	32,451	2,832	62	63	82	84	101	108	100	95
	30,299	680	76	82	86	85	118	118	113	108
B	45,371	6,164	56	59	72	69	97	99	100	94
	41,061	1,854	73	85	88	85	125	138	126	123
	38,909	-298	86	94	105	108	138	145	139	135
C	45,371	-28	93	119	110	120	155	162	153	143
	47,523	2,124	76	105	102	104	147	148	134	132
	49,676	4,277	65	83	87	92	133	127	124	113

[1]Algebraic sum of surpluses and deficits of all counties. [2]Source: Computed from Tables 4 and 5.
[3]Program costs under A, B, and C based on State highway system of 12,111, 8,466, and 6,500 mi, respectively.

In computing surplus or deficit, estimated total road revenue (State assistance plus local sources) was used. Also, the total statistical surplus or deficit for all counties combined and the total of deficits for those counties having deficits were computed and analyzed (Table 4). Tables 5 and 6 give, respectively, the number of counties having a deficit and the average deficit of deficit counties under each assumption.

CONCLUSION

On the basis of the previous analysis, it was concluded that only the first four of the eight formulas merit any consideration and that, on balance, the single factor of road mileage is the best. (The detailed results of the first four formulas were presented in the report to the committee. Any one of the four would be far superior to the currently-used formula; and one of the other three might prove to be politically more acceptable than road mileage alone.) Selection of this factor does not deny that the mileage formula may appear to be particularly unfortunate to a very limited number of counties. But if the objective is to provide the most completely developed statewide system of county roads possible with a given amount of State assistance, the mileage formula is superior to all other tested formulas.

Moreover, if all State assistance to counties were distributed on the basis of road mileage, a considerable reduction could be made in the amount of such assistance without impairing in any way the overall program of county road development. For example, under assumption A average State assistance could be reduced by $6.5 million (i.e., by the truck and bus privilege tax and $0.0025 of motor fuel tax) without increasing the number of counties that would have a deficit under existing distribution formulas or the total deficits of such counties. The particular counties involved, however, would be different. This is not to suggest that $6.5 million is the proper amount of reduction in State assistance to counties, but it is illustrative of the advantages to be derived from use of a better allocation formula.

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Model for Funds Allocation for Urban Highway Systems Capacity Improvements

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•MOST AGENCIES, in considering the allocation of funds for highway and street improvements among possible alternatives, make somewhat arbitrary decisions based on sufficiency ratings, engineering judgment, or some other empirical criterion. These methods for allocating funds do not consider the effect of particular improvements on the system as a whole, nor do they consider the effect on the total system costs of congestion on particular links. The objective of this paper is to introduce a feasible method of allocating funds for highway improvements in a manner that will yield a minimum total cost for the entire system, considering the total costs of operating vehicles (time, accident, and operating costs) on all links of the network, plus the total costs for making improvements to various links throughout the system.

This report is divided into three sections: use of the model, formulation of the model, and some related models. An Appendix presents the mathematical development of an efficient solution technique for the model developed, together with a solution of an example problem.

USE OF THE MODEL

Figure 1 is a flow diagram of the transportation planning in process, similar to that described by Hansen (1), illustrating how the proposed model could be used in this process. As this diagram suggests, the model performs the equivalent functions of current assignment techniques including adjustment of link travel times as volumes approach link capacities and the evaluation and adjustment of transportation network improvement plans.

The basic input data are the same as those typically required for current techniques:

1. Estimates of future zone-to-zone trip interchanges.
2. Geometry of the existing network of major arterials and express highways (to represent the network as a system of nodes and links).
3. General physical description of all existing links of the system in sufficient detail to determine practical and possible capacities and all operating costs (time, fuel, accident costs, etc.) under conditions of both free-flow and congestion.
4. Location and design characteristics of all alternative new facilities in sufficient detail to estimate items 2 and 3 for these new links or links to be considered for improvement to higher standards.
5. Cost estimates of all alternative improvements to be tested.

The precise form in which these data are required will become clear in the next section where the model is developed.

A single run of the model on a computer will simultaneously (a) assign zone-to-zone movements to the highway network according to minimum cost (largely, time costs) paths; (b) adjust costs upward as volumes exceed practical capacity; (c) adjust minimum

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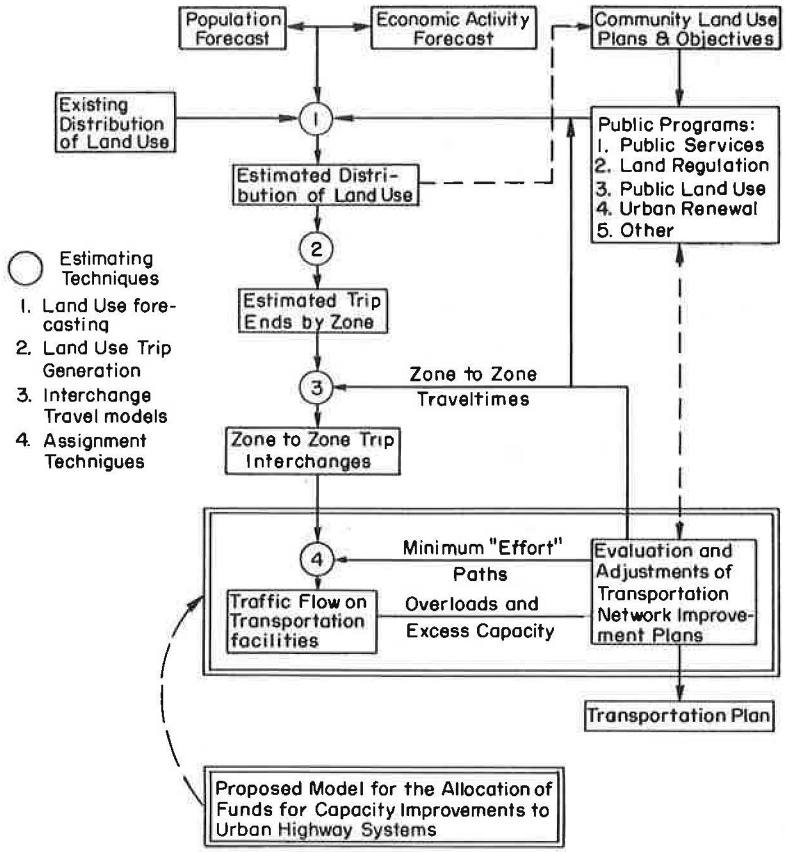

Figure 1. Transportation planning process (double-outlined boxes contain parts of process replaced by model).

cost paths as link costs are adjusted, and alter assignments accordingly; and (d) introduce new links to the system and/or increase the capacity of existing links in a manner that yields the minimum total cost system. This last operation, the addition of new capacities to the system, is done in the model by selecting, from predetermined improvements to be evaluated, those improvements that are most economical--considering the total circulation pattern and the effect that the new improvements will have on this pattern. The amount of new construction that the model will select can be limited by a budget constraint if it is desired.

Output of the model includes (a) traffic flows on all existing and proposed links, (b) capacity increases proposed for existing links and capacities of proposed new links, (c) total funds required for all new construction, (d) vehicle-operating costs for each link and for the total system, taking into account the level of congestion on each link, (e) the marginal costs for the entire system of decisions made (before operation of the model) not to allow capacity improvements to links that are congested, and (f) the marginal cost of budget limitations; i. e., the rate of return that could be realized, considering total system costs, if additional funds were available for construction. The marginal cost of budget limitations would be zero, of course, if operation of the model revealed that the budget was sufficient or even excessive. In the latter case, the model would not allocate all available funds for construction, but would indicate the most economical level of expenditures.

This model is adaptable for use in short-range planning or for small urban areas without comprehensive transportation planning studies, as well as for use in the major metropolitan studies. On a small scale, the model could be used to program the widening of arterials and the installation of traffic control devices, or to determine such items as the system cost of decisions not to widen arterials in residential areas.

There are manifold advantages to the use of this model that cannot be realized with other current techniques, such as the following. The model can be used to determine the optimum level of public expenditures for the urban highway system. It can indicate whether budgeted funds are insufficient or excessive, and under each condition, how much money should be allocated to various improvements to yield the most economical system considering all measurable transportation costs. Also, the model can be used to determine the total system cost of decisions not to improve certain links. This may aid in the objective evaluation of controversial street widening in residential areas, and other problems of this nature. Current methods such as the benefit-cost ratio analysis only consider the effects of an improvement on one link of the system.

The assignment function of this model contains an advantage over all currently used assignment techniques which is significant enough in itself to warrant the adoption of the model. Current methods either (a) do not adjust link travel times as the volume-capacity ratio increases; or (b) adjust travel times after an assignment has been made (it is necessary then to rerun the assignment program using the new travel times, and if sufficient accuracy is desired, to continue this adjustment and reassignment until a balance is achieved); or (c) simultaneously make assignments and adjust travel times as volumes on links increase; however, assignments from particular nodes are never altered to agree with adjusted travel times after they are first assigned to the network—thus, only the assignments from the nodes considered last can be expected to be in agreement with the final adjusted travel times. In contrast, this linear programing method, in one run on the computer, assigns traffic and adjusts travel times in such a way that the final output is an assignment that is in complete balance with adjusted travel times.

There are many additional advantages that can be expected from a model that assigns traffic and programs funds for improvements all in one operation. Time and cost savings will be realized. The model could be easily used to compare alternative types of expressway systems; e.g., radial-circumferential vs grid networks. Also, it should prove interesting to compare the results that would be obtained from short-range planning in several increments vs the results from one long-range planning period. Such an analysis could indicate the optimum length of the planning period.

The use of this model by highway planning agencies is, at present, dependent not only on the availability of computers but also on the availability of personnel qualified to program models of this type on computers. Programs are widely available for solving linear programing problems using the simplex method and its variations. Small networks could be solved using these programs, but a more efficient program is needed to handle large networks on most available computers. The authors have used a solution technique developed by Charnes (2) which is very efficient for linear programing problems that have the peculiar mathematical structure of this model. This technique is amenable to computer programing; therefore, with the hope of expediting the use of this model, the authors have included the mathematical development of the method and a detailed solution of an example problem in the Appendix.

FORMULATION OF THE MODEL

In defining the objective of transportation planning, the Chicago Area Transportation Study (3, Ch. 2) listed six criteria to be strived for in the development of plans:

1. Greater speed.
2. Increased safety.
3. Lower operating costs.
4. Economy in new construction.
5. Minimizing disruption.
6. Promoting better land development.

The report discusses these criteria and contains an excellent statement of the goals of transportation planning and their relationships to comprehensive community planning goals.

Because these criteria cannot all be optimized (some conflict with others), it becomes desirable to express these goals in terms of a single criterion. The single objective chosen by CATS (3, p. 15) was "to provide that transportation system for the region which will cost least to build and use"; that is,

> to plan a system the sum of whose measurable costs for all travelers and taxpayers in the region will be at a minimum. Ideally, every cost should be included, and cost should be used in a general way to cover many indeterminate and non-measurable elements. But this form of universal social accounting is not presently possible—every cost cannot be measured. Therefore, total costs are defined here as construction and travel costs, the latter including time, accident, and other user costs.

Using the preceding as the best single criterion, it is not difficult to translate items 1 through 4 into common economic terms and compare proposed plans. The last two items are more difficult to measure, and hence cannot readily be optimized in any planning model. Careful analysis of any proposed new construction (the inputs to the model discussed here) is necessary to determine how well these last two criteria are met. However, to the extent that the effects of proposed improvements can be quantified with respect to these criteria, they should be added to construction costs and included in the inputs to the model. Otherwise, they must be evaluated with the best planning judgment. Only highway improvements that foster the desired land use planning goals and cause a minimum of disruption to the community should be considered as possible alternative improvements and therefore as inputs to the model. Hence, close cooperation between transportation and city planners is necessary in the determination of inputs to the model so that the final transportation plan will meet the last two criteria listed.

The type of planning model suggested by the preceding statement of the transportation planning objective is an optimization model whose objective function takes the following general form:

Minimize: User costs + Construction costs

in which both terms are defined in the broadest possible way. If such a model is to be readily solvable by machine methods, it should be reducible to linear programing form; i.e., it should have a linear objective function to be minimized, subject to the appropriate linear constraints on the solution.

Several difficulties arose in writing the objective function and the constraints in linear form. These difficulties and their resolution are discussed before the formal statement of the linear programing problem is made.

User costs per vehicle for a link of a given length are not constant but increase as volume on the link increases, particularly when the volume exceeds practical capacity. Therefore, the model would give an inaccurate solution if the objective function stated user costs on the links as a linear function of volume on the links. User costs per vehicle are approximately constant under free-flowing operation (volumes up to practical capacity), but increase rapidly with increasing congestion (volumes between practical and possible capacity). A good approximation of this relationship can be made using a piecewise linear function (Fig. 2)—one constant user cost per vehicle associated with free-flow conditions and another higher user cost per vehicle assigned to all vehicles that increase the volume beyond practical capacity. In the model this is accomplished by using two links (called branches of a link, to avoid confusion) to represent each link of the real network. One branch is assigned free-flow user costs and a capacity equal to practical capacity of the real link. The second branch is assigned much higher user costs (chosen so as to best fit the true relationship of average user cost per vehicle for all vehicles on the link vs volume under conditions of congestion for the real link) and a capacity equal to the difference between possible and practical capacity of the real link.

Using this technique to approximate the nonlinear relationship between volume and user costs, the average user cost per vehicle at any level of congestion is the sum of the user costs on the two branches divided by the total number of vehicles on the two branches. At first glance it may seem that this technique is unrealistic because, when volume exceeds practical capacity, vehicles will have different user costs attached to them depending on which branch they happen to be assigned to. However, this presents no difficulty, because the model yields the optimum solution considering the total user costs on all links.

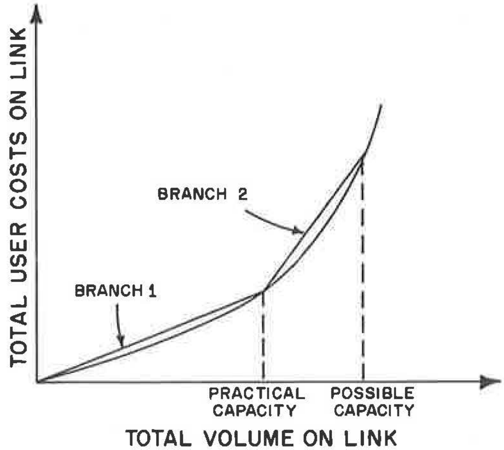

Figure 2. Piecewise linear approximation of volume vs user costs curve.

At optimum (i.e., under the final assignment), no vehicle could find a lesser cost path, except, if it were initially assigned to a high-cost branch, by exchanging branches with a vehicle on the low-cost branch of the same link. (It may be possible for a particular vehicle to displace another vehicle on the low-cost branch of a different link that is operating beyond practical capacity, and thus find a seemingly lower cost path. However, the model recognizes that such a solution would increase the cost to the displaced vehicle at least as much as the amount saved by the vehicle that displaced it and that, therefore, the overall solution is not improved. In addition, the model recognizes that neither vehicle will have actually lowered its cost in terms of average user costs per vehicle on the links. All the preceding claims of the model can be verified by mathematical proof or by the use of simple examples.) If this is done, the total system cost, the average and total link user cost, and the link assignment pattern are all unchanged. Thus, it is not of interest to know to which branch of a link a vehicle is assigned, and the only meaningful cost in the final solution is in terms of the average user cost on the links.

Thus, the model assigns traffic to the low cost branch until practical capacity of the link is reached. If the optimum solution, considering entire system costs, indicates further use of this link, the model assigns the additional traffic to the high-cost branch until possible capacity is reached. At this point, no more traffic can use the link unless it is being considered for possible improvement to higher standards (determined before operation of the model), and unless total system costs indicate that is the most economical decision to be made.

Treating an improvement to a link of the system (or the addition of a new link) as a capacity increase allows some of the vehicles to travel at a lower cost (if such is the case) and also increases the maximum number of vehicles that may use the link. By viewing improvements in this manner, the model adds the unit cost of operating a vehicle to the unit cost of providing the additional capacity to handle another vehicle.

If the total costs of an improvement are converted to daily costs over the useful life of the improvement, and then divided by the added daily capacity, the result is the cost of providing the additional capacity for one vehicle trip over the link. The cost of providing additional capacity for vehicles to use a link does not increase linearly as the amount of capacity added increases. The cost of highway and street improvements takes the form of step functions. That is, a street-widening project might add a given volume to the capacity of the original facility, the installation of a signal would add perhaps a different volume, and so on, depending on the specific type of improvement. For this reason, the unit cost of adding capacity to a particular link would not be constant but would vary with the type of improvement contemplated (Fig. 3).

The use of a constant unit cost for increasing the capacity of links or adding new links will result in values that show the relative demand (from a cost viewpoint) for improvement on the various links. Thus, a solution that indicated the addition of a very small number of vehicles to the capacity of a particular arterial would not be

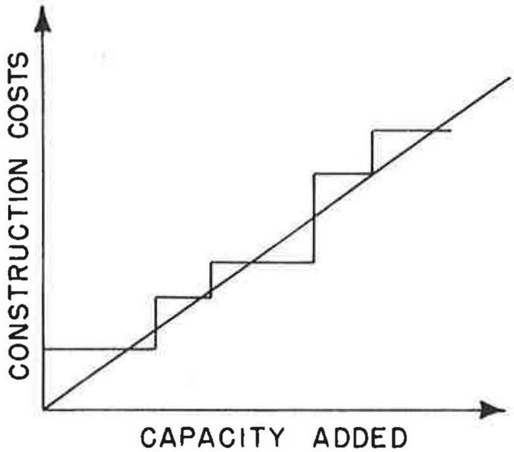

Figure 3. Linear approximation of unit cost of adding capacity.

significant, whereas the solution that indicated the addition of several hundred vehicles to the capacity of a link definitely points out a critical link—one whose improvement will contribute greatly to the efficiency of the entire system.

The preceding discussion indicates the form that the objective function must take. Also indicated is the nature of one of the necessary sets of constraints (the capacity restrictions) and the nature of one optional constraint (the budget limitation on the amount of funds that may be allocated for improvements to the network). Two additional sets of constraints are necessary due to the structure of the model.

Due to the manner in which the problem of the nonlinearity of user costs was handled (the representation of each link by one branch for free-flow conditions and one branch for congested-flow conditions), it is necessary to introduce a constraint that insures that, when the capacity of a link is increased, the ratio of practical to possible capacity will remain the same. This follows from the definitions of practical and possible capacities. If this constraint was not included, the model could, for example, double the practical capacity of a link by carrying out an indicated improvement without adding any incremental capacity (possible minus practical capacity). Therefore, another set of constraints is required, one for each link to be considered for improvement.

The final set of constraints required, aside from the non-negativity conditions on all the variables, is the Kirchhoff node equations, so called because of the analogy to electrical network equations. These state that there must be a balance of flow at each node; i.e., the flow into a node must equal the flow out of the node, considering traffic originating at a node as input and traffic with destination at a node as output. Due to the structure of the model, one of these equations is required for each node for each copy (a copy is the distribution from a node of origin). For example, if a network has ten nodes and five nodes with traffic originating from them, then $10 \times 5 = 50$ Kirchhoff node equations are required.

The formal statement of the preceding discussion takes the following form as a linear programing problem:

$$\text{Min } f(X, C') = \sum_i \sum_j \sum_k U_{jk} (X_{ijk+} + X_{ijk-}) + \sum_j r_j C'_{j1}$$

subject to

$$\sum_j \sum_k e_{hijk} (X_{ijk+} - X_{ijk-}) = E_{hi} \qquad h = 1, \ldots, n; \quad i = 1, \ldots, m$$

$$\sum_i (X_{ijk+} + X_{ijk-}) - C'_{jk} \leq C_{jk} \qquad j = 1, \ldots, L; \quad k = 1, 2$$

$$\sum_j r_j C'_{j1} \leq F$$

$$C_{j1} C'_{j2} - C_{j2} C'_{j1} = 0 \qquad J = 1, \ldots, L$$

$$X_{ijk+}, X_{ijk-}, C'_{jk} \geq 0$$

in which

X_{ijk+} = number of vehicles per day on k^{th} branch of j^{th} link for distribution from the i^{th} originating node in arbitrarily chosen positive direction of branch. X_{ijk-} is volume in opposite direction.

U_{jk} = user cost per vehicle on k^{th} branch, j^{th} link.

r_j = cost of improvement per day per vehicle of capacity added to j^{th} link.

C_{jk} = existing two-way daily capacity of k^{th} branch, j^{th} link.

C'_{jk} = daily capacity added to k^{th} branch, j^{th} link.

e_{hijk} = incidence number at h^{th} node, for flow from i^{th} originating node, for k^{th} branch of j^{th} link. Convention adopted here for incidence numbers is

+ 1 for input to node; i.e., if arbitrarily chosen positive direction of a link is toward node.
- 1 for output from node.
0 if link is not connected to node.

E_{hi} = number of vehicles per day originating (minus) or terminating (plus) at h^{th} node for flow from i^{th} originating node.

F = total funds available for improvements to the network on a daily basis.

The first set of constraints is the Kirchhoff node equation stating that the total traffic flow into each node must equal the total flow out.

The second set of constraints states that the total traffic minus the added capacity cannot exceed the existing capacity of each branch.

The third constraint states that the total amount spent for capacity improvements cannot exceed the amount of funds available.

The fourth set of constraints states that the improvements in capacity must be made so that the ratio of practical to possible capacity remains the same for each link.

The dual of this problem can be written as

$$\text{Max } f(B, D, G) = \sum_h \sum_i B_{hi} E_{hi} - FD - \sum_j \sum_k C_{jk} G_{jk}$$

subject to

$$(\text{sign of } X_{ijk}) \sum_h e_{hijk} B_{hi} - G_{jk} \le U_{jk} \qquad i = 1, \ldots, m;\; j = 1, \ldots, L;\; k = 1, 2$$

$$G_{j1} - C_{j2} D_j - r_j D \le r_j \qquad j = 1, \ldots, L$$

$$G_{j2} + C_{j1} D_j \le 0 \qquad j = 1, \ldots, L$$

$$G_{jk},\ D \le 0$$

B_{hi}, D_j may be positive, negative, or zero

in which

E_{hi}, F, C_{jk}, X_{ijk+}, X_{ijk-}, e_{hijk}, U_{jk} and r_j are as defined for the primal problem.

The interpretation of the dual appears to be of little utility; however, two of the dual variables, whose values will be known when the primal problem is solved, are of considerable interest:

G_{jk} = total change in system cost per unit increase in capacity of k^{th} branch, j^{th} link.

D = total change in system cost per unit increase in F, budget limitation.

As already noted these values will be either negative or zero, and therefore will indicate the unit savings that would have been realized, if capacities could be increased on links not considered for improvement or if additional funds were available for improvements.

The structure of the general problem and the relationship between the primal and the dual are given in Table 1.

TABLE 1
GENERAL FORM OF PRIMAL AND DUAL TABLEAU FOR CAPACITY IMPROVEMENT MODEL

Interpretation of Primal Constraint		$X_{111+}\ X_{111-} \cdots X_{1L2+}\ X_{1L2-}$	$\cdots$	$X_{m11+}\ X_{m11-} \cdots X_{mL2+}\ X_{mL2-}$	$C'_{11}\ C'_{12} \cdots C'_{L1}\ C'_{L2}$	
Balance of Input and Output of Traffic at each Node	B_{11}	$e_{1111}\ -e_{1111} \cdots e_{11L2}\ -e_{11L2}$				$=E_{11}$
	B_{12}	$e_{1211}\ -e_{1211} \cdots e_{12L2}\ -e_{12L2}$				$=E_{12}$
	$\vdots$	$\vdots \quad \vdots \quad \vdots \quad \vdots$				$\vdots$
	B_{1n}	$e_{1n11}\ -e_{1n11}\ \ e_{1nL2}\ -e_{1nL2}$				$=E_{1n}$
	$\vdots$		$\ddots$			$\vdots$
	B_{m1}			$e_{m111}\ -e_{m111} \cdots e_{m1L2}\ -e_{m1L2}$		$=E_{m1}$
	B_{m}			$e_{m211}\ -e_{m211} \cdots e_{m2L2}\ -e_{m2L2}$		$=E_{m2}$
	$\vdots$			$\vdots \quad \vdots \quad \vdots \quad \vdots$		$\vdots$
	B_{mn}			$e_{mn11}\ -e_{mn11} \cdots e_{mnL2}\ -e_{mnL2}$		$=E_{mn}$
Funds Constraint	D				$-r_1 \cdots -r_L$	$\geq -F$
Rentention of Capacity Ratio (Pass.: Pract.) for each Link	D_1				$-C_{12}\ C_{11}$	$= 0$
	$\vdots$				$\ddots$	
	D_L				$-C_{L2}\ C_{L1}$	$= 0$
Capacity Constraint for each Branch of each Link	G_{11}	$-1\ \ -1$	$\cdots$	$-1\ \ -1$	$+1$	$\geq -C_{11}$
	$\vdots$	$\ddots$	$\cdots$	$\ddots$	$\ddots$	$\vdots$
	G_{L2}	$-1\ \ -1$	$\cdots$	$-1\ \ -1$	$+1$	$\geq -C_{L2}$
		$\wedge\ U_{11}\ \ \wedge\ U_{11} \cdots \wedge\ U_{L2}\ \ \wedge\ U_{L2}$	$\cdots$	$\wedge\ U_{11}\ \ \wedge\ U_{11} \cdots \wedge\ U_{L2}\ \ \wedge\ U_{L2}$	$\wedge\ r_1\ \ \wedge\ 0 \cdots \wedge\ r_L\ \ \wedge\ 0$	

SOME RELATED MODELS

At least three other writers have suggested the use of linear programing models to determine the optimum allocation of funds for highway improvements. Each author has considered different aspects of the general problem, and therefore has attacked the problem in a different manner. The first two of these models are mentioned only briefly, because they have already appeared in the literature. The work of the third author, however, is contained in an unpublished thesis; therefore, it should be helpful to discuss this model in more detail.

Garrison (4) considered the problem of the shipment of commodities between urban centers over a regional or National highway network. Assumed given are existing capacities between all pairs of cities, shipment costs on all links, current levels of production and demand for commodities at all nodes (cities), unit costs of adding capacities to all links, and quantitative measures of the impact of capacity improvements on production and demand at all nodes. Solution of the model determines the optimum allocation of funds for improvements to the highway system. The model also indicates the total growth in production and demand that is expected to occur in each city as a result of the added capacities of the links. Unlike the model presented in this paper, Garrison's model does not, as written, handle such difficulties as the nonlinearity of shipment costs, the fact that commodities are transshipped through several nodes in the real world, or the fact that the solution may be constrained by budget limitations. However, these difficulties could be dealt with in the same manner as in the urban model presented in this paper.

Quandt (5) also considered the problem of the shipment of commodities between centers of production and consumption and the allocation of funds for highway improvements. Several linear programing formulations are presented, each dealing with the problem under different assumptions. In general, this work differs from Garrison's in that transshipment through several cities is possible, and the case where budget constraints are introduced is considered. However, Quandt does not deal with increases in production or demand, nor with the problem of nonlinearity of shipment costs versus volume on links.

Plaza (6) also deals with interurban travel and the allocation of funds for highway improvements. However, he is not concerned with the determination of commodity flows between cities. As in the preceding urban model, node-to-node traffic is assumed known. In fact, the actual volumes on links are assumed to have been determined by an assignment model. Unlike the urban model, however, Plaza's formulation ignores capacity restrictions and concentrates on the determination of the optimum allocation of funds to improve links to higher standards in order to reduce maintenance costs and user costs. This model has application to interurban highways where traffic volumes never exceed practical capacity but where geometric design features and roadway surface conditions are the chief factors affecting user costs. The model has particular utility in the determination of the timing of improvements to higher-type surfaces in developing regions.

It is not possible to discuss here all the many variations of this problem that were treated by Plaza. Only the linear programing formulation covering the most general case of the problem is presented.

The general problem is

$$\text{Min} \sum_i t_i^q \left[K_i - d_i^q \sum_k x_i^k \right]$$

subject to

$$\sum_i \left[\sum_{k=1}^{k} r_i^k x_i^k + a_i^k x_i^k \right] + B_o^k \leq B^k$$

$$\sum_{k=1}^{q} x_i^k \leq G_i$$

$$x_i^k \geq 0$$

in which

t_i^q = total number of vehicles using i^{th} link in q^{th} year.

q = number of years to accomplish program.

K_i = $u_i^q S_i + U_i^q G_i$ = cost of travel over i^{th} link in q^{th} year, if no improvement were made.

u_i^q = time plus operating costs during q^{th} year of travel over unimproved sections of i^{th} link, per vehicle mile.

S_i = length of previously improved sections in i^{th} link, in miles.

G_i = length of unimproved sections in i^{th} link, in miles.

d_i^q = difference of travel costs per mile during q^{th} year over unimproved and improved sections of i^{th} link. $d_i^q = U_i^q - u_i^q$

x_i^k = length of i^{th} link improved during k^{th} year of program (these are variables to be determined by solution of problem).

r_i^k = $b_i^k - c_i^k$ = difference in costs of maintenance of a miles of i^{th} link after and before improvement at k^{th} year.

a_i^k = cost of improvement per mile of i^{th} link, k^{th} year.

B^k = budget for maintenance and improvements on whole network during k^{th} year.

$$B_0^k = \sum_i (b_i^k S_i + c_i^k G_i) = \text{budget at } k^{th} \text{ year, if no improvements at all are made.}$$

The preceding objective function is the total travel costs over the network after the improvements have been made.

The first set of constraints states that the sum of all increases in maintenance costs due to improvements plus the sum of all costs of improvements cannot exceed the budget in any year.

The second set of constraints states that the total length of improvements over the years, to any link, cannot exceed the original length of unimproved section on that link.

The following are some of the many particular cases of this problem considered and successfully solved by Plaza:

1. The budget limitation only applies to the cost of improvements.
2. Cost of improvements per mile for each section is expected to remain constant throughout the period of the program.
3. Budget constraints are unspecified; the optimum level of expenditure for each year is to be determined.
4. Scarcity of materials required for certain improvements.
5. Geographic distribution of the improvements is desired to avoid excessive concentration of improvements in particular areas.
6. Decentralization of the budget among several local agencies.
7. Changes in the pattern of movements between cities due to improvements in the system.

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Appendix

DEVELOPMENT OF A COMPUTATIONAL TECHNIQUE

The linear programing problem in the second section requires nm + 3L + 1 constraint equations, in which n is the number of nodes in the network, m is the number of copies (nodes that originate traffic), and L is the number of links. The analysis of relatively large street systems by simplex routines would exceed the capacity of most electronic computers. Therefore, a computational technique that takes advantage of the special structure of the proposed model would be very useful. The structure of the model is shown in Figure 4.

The M_i's (matrices of incidence numbers, e_{hijk}'s for the i^{th} copy) together with their respective restraint vectors b_i's) represent individual linear programing problems of which the first m are unconstrained network problems for the distribution of traffic from each copy. The capacity improvement copy M_{m+1} b_{m+1} represents the linear programing problem for the capacity ratio and fund constraints. The N_i's are matrices of structural coefficients (1 or 0) that couple the various copies to the link capacity constraints (C's). Y_i is the solution vector of flows (or capacity increments for i = m+1)

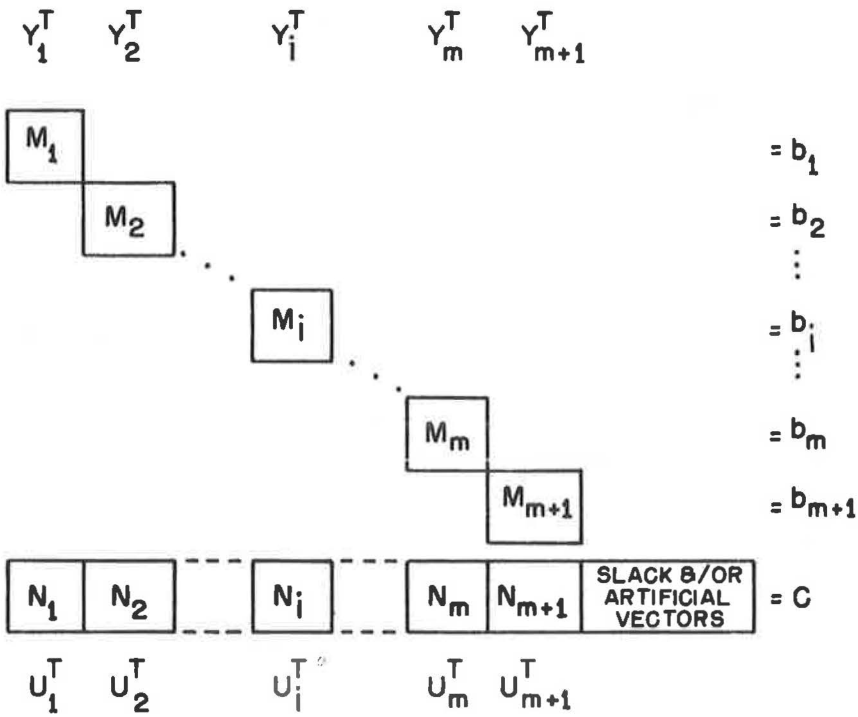

Figure 4. Model schema.

for the i^{th} copy, and b_i is the vector of stipulations for the i^{th} copy.

The form of this problem is the same as that of the mixing routine for coupling models, developed by Charnes (2). This method essentially solves two different linear programing problems: the network problem for each copy and the mixing problem. The mixing problem uses a convex combination (mixture) of extreme point solutions from each copy to obtain (by iteration) the optimum solution for the entire system.

The mixing problem is stated as follows:

$$\text{Minimize} \sum_i \sum_q U_i^T p_{iq} R_{iq}$$

subject to

$$\sum_i \sum_q N_i p_{iq} R_{iq} = C$$

$$\sum_q R_{iq} = 1$$

$$R_{iq} \geq 0$$

in which

U_i = vector of costs (U_{jk}) for i^{th} copy.

R_{iq} = fraction of q^{th} extreme point (p_{iq}) from i^{th} copy that is included in mixing problem.

p_{iq} = q^{th} extreme point (solution vector) from i^{th} copy.

U_{jk}, N_i, and C are as previously defined.

The vector of coefficients in the mixing problem associated with R_{iq} is

$$P_{iq} = \left[H_{iq}^T \mid d_i^T \right]$$

in which

$H_{iq} = N_i \, p_{iq}$

d_i^T = unit vector with a 1 in i^{th} column.

$U_{iq} = U_i^T p_{iq}$ = solution cost for iq^{th} extreme point.

Because each network copy has only n-1 constraint equations, the capacity improvement copy has only L+1 equations and the mixing problem has only m+2L equations (even with all branches constrained, which is never the case for an actual street system), the mixing routine enables quite large networks to be programed for electronic computer solution.

EXAMPLE

The problem chosen to illustrate this method is shown in Figure 5 and Table 2. It is a somewhat simplified (for the purpose of hand computations) representation of an existing city street network. The link operating costs (cents per vehicle) are equivalent to the average vehicle operating costs per mile times the length of the link plus a time cost of traversing the link and an estimate of the accident costs on the link. The practical and possible capacities of the streets were determined from a physical description of the width, control of access, adjacent land use, and other pertinent data.

The capacity figures used are 24-hr, two-directional ones. If the relationship between peak-hour and 24-hr volumes is kept in mind, either peak-hour or 24-hr volumes may be used.

The node origins and destinations (Table 2) are based on data from an actual traffic origin and destination study. Traffic was assigned from the originating node to the various destinations for each copy by the uncapacitated network minimum cost path method. From Table 3, which gives the total assignment from all three copies, it is evident that only two links in the system (links 5 and 9) have assignments over practical capacity. Only those links close to or over capacity are likely to be critical ones. Thus it is possible to simplify the required computations tremendously by assuming that only links 5 and 9 are capacitated and to solve the coupling problem with the remaining links as uncapacitated ones. If, however, in the optimal solution (with this assumption) other links have assignments greater than their actual practical capacity, the problem would have to be reworked—with these links now considered as capacitated ones. Because it is of interest to determine the "cost" of making the political or policy decision not to improve a particular street in a system, it was assumed that the capacity of link 9 could not be improved. The result of this decision can be evaluated by the dual variables associated with link 9 in the final solution.

To have amounts that are easier to work with by hand-computing techniques, the origin and destination amounts in the computations are in hundreds of vehicles and the costs, therefore, in dollars per 100 vehicles. The incidence matrix (M_4) for the capacity improvement copy is given in Table 4. S_F is the fund slack vector; C'_{51} and C'_{52} (as previously defined) are the daily capacities added to branches 51 and 52; U_j is the cost of adding one vehicle of daily capacity to link j (calculated as explained in the second section); and b_4 is the stipulations vector.

The $50 budget stipulation is the total daily funds for improvements to the system.

An initial solution for the mixing problem was composed of one extreme point from each of the four copies plus four slack and artificial vectors required to satisfy the capacity constraints.[1] For the three network copies, these were obtained by multiplying

[1] A slightly different solution for this type of problem is given elsewhere (7).

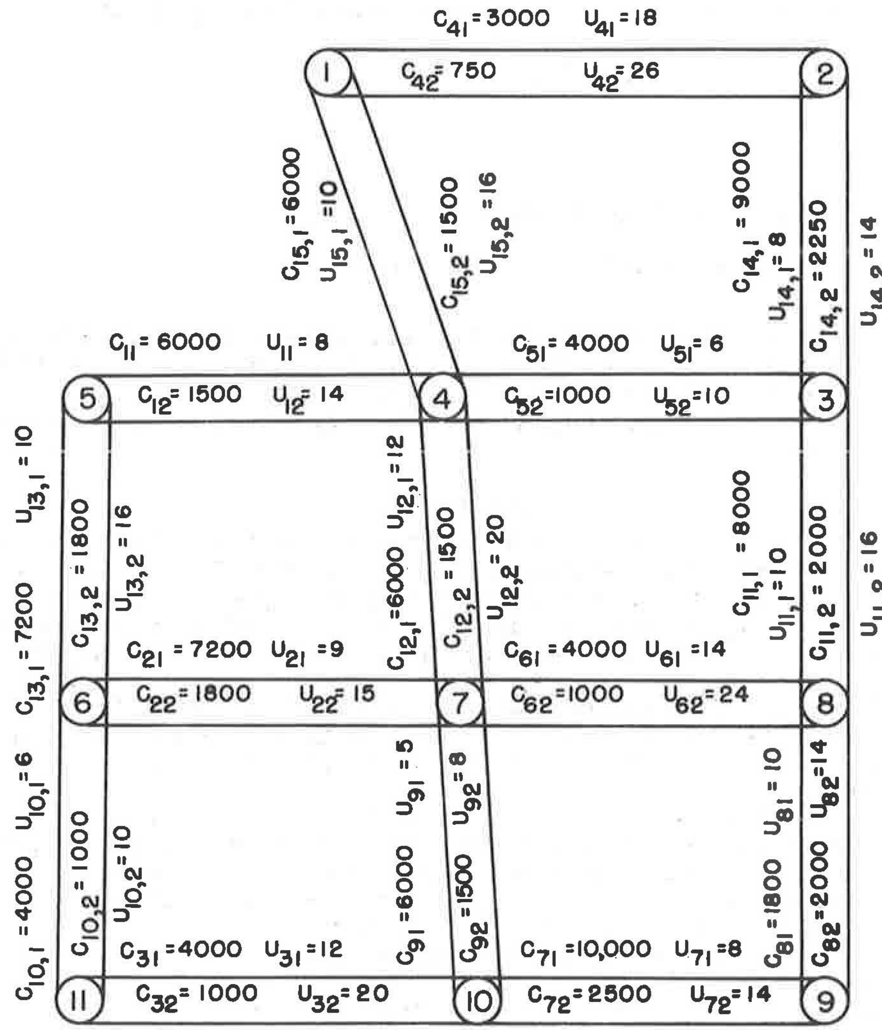

Figure 5. Operating costs per vehicle (U_{jk}) and capacity (C_{jk}) of each branch of each link for example problem.

TABLE 2

ZONE-TO-ZONE MOVEMENTS[a]

Zone (node)	Copy 1	Copy 2	Copy 3
1	500	3,000	500
2	-8,000	1,000	500
3	0	1,000	3,000
4	1,000	500	500
5	0	1,000	500
6	500	1,000	-10,000
7	1,000	2,000	2,000
8	500	0	1,000
9	2,500	-10,000	500
10	1,500	0	500
11	500	500	500

[a]Negative sign = traffic originates at node; positive number = traffic that has destination at node.

TABLE 3

CAPACITIES AND INITIAL TRAFFIC ASSIGNMENT TO NETWORK LINKS[a]

Link	Capacity of Branch 1 of j^{th} Link, C_{j1}	Capacity of Branch 2 of j^{th} Link, C_{j2}	Total Traffic Assigned[b]
1	6,000	1,500	5,500
2	7,200	1,800	6,500
3	4,000	1,000	500
4	3,000	750	500
5	4,000	1,000	8,000
6	4,000	1,000	1,000
7	10,000	2,500	8,500
8	8,000	2,000	4,500
9	6,000	1,500	10,500
10	4,000	1,000	1,000
11	8,000	2,000	5,000
12	6,000	1,500	6,000
13	7,200	1,800	7,000
14	9,000	2,250	9,000
15	6,000	1,500	3,500

[a]Positive directions of links chosen in obviously expected direction of traffic distribution for each copy, but this is arbitrary choice.

[b]From all copies assigned by uncapacitated minimum cost path solution.

TABLE 4

SIMPLEX TABLEAU (M_4) FOR CAPACITY IMPROVEMENT COPY

r_j	5	0	0	
	C'_{51}	C'_{52}	S_F	b_4
	5	0	1	50
	-10	40	0	0

the corresponding N_i (incident matrix) times the uncapacitated solution, $H_{iq} = N_i p_{iq}$, and attaching a unit vector with a 1 in the i^{th} row. Thus, $P_{11}^T = (H_{11}, 1, 0, 0, 0) = (45, 0, 15, 0, 1, 0, 0, 0)$; (Table 5).

The extreme point from the fourth (capacity improvement) copy was computed by solving M_4 (the fourth incidence matrix) using the regular simplex method.

At this point the computational procedure is outlined as an algorithm:

1. A basic feasible optimal solution is obtained from each copy, and costs associated with each solution are computed. The uncapacitated minimum cost network or the simplex method (copy 4) gives the copy solutions. Solution costs are given by

$$U_{iq} = U_i^T p_{iq}$$

2. Mixing problem vectors are obtained from the first extreme points (p_{i1}) of the individual copies by using

$$p_{i1} = (H_{i1}^T \mid d_i^T = \left[(N_i p_{i1})^T \mid d_i^T\right]$$

3. A basis (B) for the mixing problem is obtained by adding slack and artificial vectors to satisfy the stipulations.
4. The initial basis is inverted so that the modified simplex method can be used (by iteration) to obtain an optimum solution.

TABLE 5

INITIAL BASIS FOR MIXING ROUTINE AND STIPULATION VECTOR P_0

V	2095	2555	1850	0	K	0	K	0	
Basis	P_{11}	P_{21}	P_{31}	P_{41}	A_{51}	S_{52}	A_{91}	S_{92}	P_0
	45	0	35	0	-1	0	0	0	40
	0	0	0	0	0	1	0	0	10
	15	75	15	0	0	0	-1	0	60
	0	0	0	0	0	0	0	1	15
	1	0	0	0	0	0	0	0	1
	0	1	0	0	0	0	0	0	1
	0	0	1	0	0	0	0	0	1
	0	0	0	1	0	0	0	0	1

5. The P_0' column for the first tableau (inverted first basis) is calculated from

$$P_0' = B^{-1}\left[C\,|\,1,\ 1,\ 1,\ 1\right]^T$$

For this problem (Table 6), $P_0' = B^{-1}\left[C_{51},\ C_{52},\ C_{91},\ C_{92},\ 1,\ 1,\ 1,\ 1\right]^T$

6. The vector of costs for the first basis vectors is V_B, of which the first m-components are the costs of the copy solutions. (For this example the artificial vectors were assigned a finite, but very large, "K" cost and the slack vectors have a zero cost.) The w^T row is obtained from

$$w^T = V_B^T B^{-1}.$$

7. The mixing problem solution is tested for optimality by computing a new (q^{th}) optimal solution from one of the copies (in the case of the first check, copy 1 was used) using the regular network algorithm (or the simplex method in the case of copy 4), but with new "dummy" costs. The dummy costs (J) are obtained from

$$J^T = U_i^T - W^T N_i$$

in which

W^T = portion of w^T row associated with capacitated links (here, the first four elements).

J = vector of dummy link costs used to calculate a new optimum from one of the copies.

The cost of this new optimal copy solution (p_{iq}) is obtained from

$$U_{iq} = U_i^T p_{iq}$$

8. As in step 2, the new optimal copy solution is transformed into a mixing problem vector, P_{iq}.

9. Next, entry into the basis is tested for by computing (similarly to the regular simplex method)

$$Z_{iq} - U_{iq} = w^T P_{iq} - U_{iq}$$

If $Z_{iq} - U_{iq} > 0$, the vector can improve the mixing problem solution and, therefore, enters the basis (one proceeds to step 10).

If $Z_{iq} - U_{iq} \leq 0$, the vector will not improve the mixing problem solution. Therefore, step 7 is returned to and repeated with the next copy. When no vector from any copy wants to come into the mixing problem basis, the mixing routine is optimal. Therefore, for optimality,

$$\underset{q}{\text{maximum}}\ w^T P_{iq} - U_{iq} \leq 0$$

for each $i = 1, \ldots, m+1$.

10. The new mixing problem vector (from step 8) is premultiplied by the current inverted basis, B^{-1}, to yield $B^{-1}P_{iq}$.

11. The vector to be removed is determined by dividing the P'_0 elements by the corresponding positive elements of $B^{-1}P_{iq}$. The minimum ratio of P'_0 elements to $B^{-1}P_{iq}$ element signifies the vector to be removed.

12. By row reduction, $B^{-1}P_{iq}$ is transformed into a unit vector with a 1 in the row having the minimum ratio (from step 11). This same row reduction is also performed on the complete inverted basis, including the w^T row. The result is the complete next-stage tableau.

13. Step 7 is returned to the new optimum solution calculated from the same copy that was being analyzed in steps 10 through 12. This is continued until at step 9 an optimum is indicated.

Table 5 is the initial mixing problem basis. Table 6 gives the inverse of this basis, along with the cost vector V_B, P_{12} (calculated from copy 1, p_{iq}, using dummy costs determined as outlined in step 7), and $B^{-1}P_{12}$. This table shows that P_{12} will improve the solution ($Z_{12} - U_{12} = 60k - 195$) and that S_{52} is the vector to be removed from the basis.

The upper half of Table 7 gives the result (stage 2) of bringing P_{12} into and of removing S_{52} from the basis. Iteration continued (following the outlined algorithm) until

TABLE 6

INVERSE OF INITIAL BASIS AND FIRST ITERATION (MODIFIED SIMPLEX TABLEAU) OF MIXING ROUTINE TESTING FOR OPTIMALITY

P_{12}	V_B	BASIS									P'_0	$B^{-1}P_{12}$	RATIO
0	2095	P_{11}					1				1	1	1
30	2555	P_{21}						1			1	0	
0	1850	P_{31}							1		1	0	
0	0	P_{41}								1	1	0	
1	K	A_{51}	-1				45		35		40	45	8/9
0	0	S_{52}		1							10	30	1/3
0	K	A_{91}			-1		15	75	15		45	15	3
0	0	S_{92}				1					15	0	
U_{12} = 2290		W	-K	0	-K	0	2095 +60K	2555 +75K	1850 +50K	0	6500 +85K	-195 +60K	

TABLE 7

TABLEAUX FOR 2ND AND 16TH (FINAL) ITERATIONS

P_{13}	V_B	B_2^{-1}									P_0'	$B^{-1}P_{13}$	RATIO
0	2095	P_{11}		$-1/30$			1				$2/3$	1	$2/3$
0	2555	P_{21}						1			1		
0	1850	P_{31}							1		1		
0	0	P_{41}								1	1		
1	K	A_{51}	-1	$-3/2$			45		35		25	45	$5/9$
0	2290	P_{12}		$1/30$							$1/3$		
0	K	A_{91}		$-1/2$	-1		15	75	15		40	15	$8/3$
0	0	S_{92}				1					15		
2460		W	-K	$13/2$ -2K	-K	0	2095 +60K	2555 +75K	1850 +50K	0	6565 +65K	-365 -60K	

P_{44}	P_{34}	P_{27}	$P_{1,10}$	V_B	B_{16}^{-1}									P_0'	$B^{-1}P_{1,10}$	$B^{-1}P_{27}$	$B^{-1}P_{34}$	$B^{-1}P_{44}$
-10	35	0	30	2230	P_{15}	$-1/10$	$-1/10$			3		$7/2$	$-5/4$	$1/4$	0	0	0	0
$-5/2$	0	0	0	2555	P_{21}			$1/20$	$11/300$		$-11/4$	$-3/4$		$1/20$	0	1	0	0
0	15	75	0	1850	P_{31}		$-1/35$					1	$-1/14$	$-9/14$	0	0	1	0
0	0	0	0	2170	P_{13}	$1/10$	$1/10$			-2		$7/2$	$5/4$	$3/4$	1	0	0	0
0	0	0	1	50									1	1	0	0	0	1
0	0	1	0	1990	P_{32}		$1/35$						$1/4$	$5/14$	0	0	0	0
0	1	0	0	2635	P_{25}			$-1/20$	$-1/20$		$15/4$	$3/4$		$3/4$	0	0	0	0
1	0	0	0	2780	P_{22}				$1/75$					$1/5$	0	0	0	0
50	1850	2555	2170		W	-6	-2	-4	-1	2350	2855	2120	-15	6795	Z-U= 0	Z-U= 0	Z-U= 0	Z-U= 0

an optimum solution was indicated at stage 16. The lower half of Table 7 shows the 16th stage.

The elements of P_0' in this final stage indicate the proportion (R_{iq}) of the various copy solutions that are combined to yield the optimum solution for the entire system. Taking these P_0' elements times their corresponding vector of flows and summing gives the total traffic flow on all links of the system (Fig. 6) for the optimal mixing problem solution.

Although the mixing routine always yields a feasible optimal solution, the results are not always basic feasible optimal. Therefore, the regular network evaluation procedure was used to compute the node evaluations (G's and w's) for the three copy solutions and to obtain a basic feasible optimal solution (2, p. 637). The evaluation procedure usually produces a basic feasible solution with only one or two iterations from the mixing routine results. In this example, the mixing model results were basic; therefore, no iterations were necessary.

The optimal solution of this example (Fig. 6) shows that the traffic flow on link 9 is at the maximum allowable capacity (assuming that the capacity of link 9 could not be increased). Also, the practical capacity of link 5 was increased from 4,000 to 5,000 vehicles, and the difference between practical and possible capacities increased from 1,000 to 1,250 vehicles. This increase in capacity expended all available funds. Because the flows on all other links are below their practical capacities, the system does not have to be re-evaluated when the assumption that these links are uncapacitated is relaxed and they become capacitated links.

The G^*_{jk} associated with the capacity constraints on link 9, $G^*_{91} = -4$ and $G^*_{92} = -1$ (Table 7), are the evaluations of the functional for a unit change in the capacity constraints C_{91} and C_{92}. Thus, these dual evaluators give the decrease to the total system cost if a vehicle unit of capacity could be added to link 9. Similarly, $G^*_{51} = -6$ and $G^*_{52} = -2$ give the savings that would be realized in the system cost if the capacity of link 5 could be increased by one unit.

The savings to the system for an additional unit of investment in capacity increase (-D) can also be obtained from the w row. The eighth value divided by the total funds is -15/50 = 30 percent.

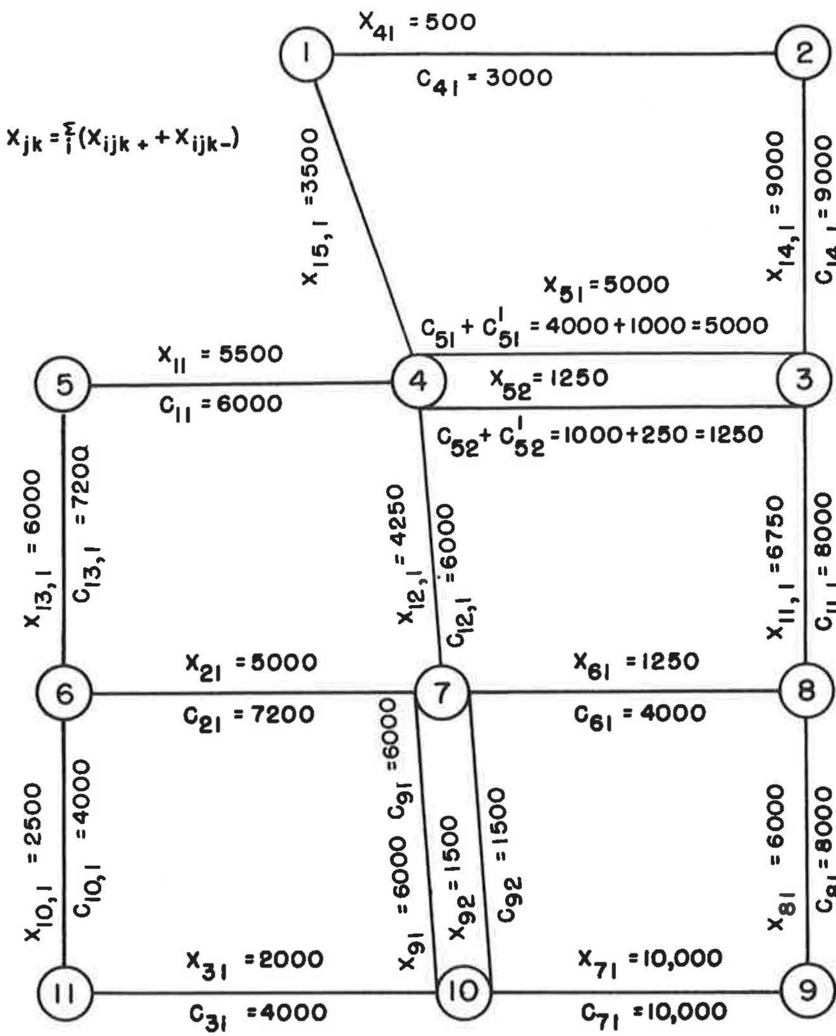

Figure 6. Optimum solution for example problem (from mixing routine) showing total traffic (X_{jk}) on links, original capacities (C_{jk}), and capacity increases (C'_{jk}).

By looking at the dual problem constraints,

$$G_{j1} - C_{j2}D_j - r_jD \le r_j$$

$$G_{j2} + C_{j1}D_j \le 0$$

$$G_{51} - C_{52}D_5 - 5D \le 5$$

$$G_{52} + C_{51}D_5 \le 0$$

Because at the optimum there was no slack, the equalities hold; therefore,

$$6 - 1{,}000\ D_5 - 5D = 5$$
$$2 + 4{,}000\ D_5 = 0;$$
$$D_5 = 2/4{,}000,$$

Substituting,

$$6 - 1{,}000\ (-2/4{,}000) - 5D = 5$$

Thus, D = 3/10 or 30 percent, which agrees with the value obtained from the final tableau.

This means that a unit increase in F (funds) would result in a 30 percent return in terms of the savings to the system.

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The Place of Subsidies in an Optimum Transportation System

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In the free enterprise world of economic theory, four distinct grounds for socially desirable subsidies are generally enumerated: (a) economies of scale, (b) indivisibilities, (c) "second best" considerations, and (d) social considerations. Many students of transportation economics have presented arguments that would seem to justify general transportation subsidies or subsidies to particular components of transportation on grounds other than these four commonly accepted ones. Four of these arguments are presented.

This paper demonstrates through use of some simple mathematical models that these common and seemingly plausible arguments do not provide an economic foundation for a general policy of transportation subsidy; describes the basic economic conditions generally regarded as justifying subsidy; and summarizes the limited available evidence concerning the presence of these subsidy justifying characteristics in transportation activities.

•THE EFFECTS of highway improvements pervade the economy in a different manner than do, say, the effects of new steel mills. Perhaps for this reason, many noneconomists (particularly those engaged in the use or development of highways) tend to regard highway investments not only as quantitatively but also as qualitatively unique. Similarly, when dealing with a wide variety of problems, economists find it convenient to ignore the condition that the production and distribution of goods and services normally entail the employment of resources to overcome the friction of space. Perhaps for this reason, the opinion seems common among economists that different tools of analysis and different standards of valuation are required to deal with problems—the economics of transportation and of international trade, in particular—in which space must necessarily play a central role.

One upshot of this putative uniqueness of the role of transportation is a wide variety of special economic arguments purporting to show why various types of transportation or transportation in general is deserving of subsidy. Two matters should be clarified at the outset: what a "subsidy" is and what a "special economic argument" for subsidy is.

Dictionaries define "subsidy" along the lines of "a payment out of general tax revenues to support an activity deemed advantageous to the public." This definition is too narrow. The label "subsidy" has been attached to a wide variety of situations in which no direct payment from tax revenues is involved. For example, some argue that apple growers subsidize bee keepers because no payment is made for the nectar bees convert into honey. Some claim that non-user contributions to highway trust funds would constitute subsidies to highway users; others maintain that paying for highway improvements entirely through user taxes subsidizes the many non-users who benefit from these improvements. Inasmuch as the license fee a private passenger vehicle operator pays is independent of the number of miles he drives, it can be contended that the 3,000-mile per year driver subsidizes his 30,000-mile per year counterpart.

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Some of the special arguments discussed here are arguments for subsidies in the narrow dictionary sense; that is, arguments for payments out of general tax revenues. Others are arguments for subsidies in a broader sense of the term, subsidies that involve payments from one specific population group to another rather than from general tax revenues.

In the last analysis, payment of a subsidy of either variety is justified and justifiable only on grounds of social desirability; that is, on grounds that its payment is deemed a good thing. Some subsidies are justified largely or entirely on humanitarian, equity, or national defense grounds. Unemployment compensation is paid because most feel that it is not nice to let people starve. Many argue that public transportation subsidies are necessary to enable people who cannot afford cars or are unable to drive to get to and from work. The basic argument for veterans' benefits seems to be that the services rendered by veterans are deemed to have been of higher value to society than the price initially paid for them. The American merchant marine (among a great many other activities) has successfully petitioned for subsidy on grounds that ships are needed in time of war.

Whether a subsidy is justified on humanitarian, equity, or defense grounds is a matter for politicians, not economists, to decide. About all an economist acting in his role as economist can do is put the costs involved in perspective. He can, for example, point out the number of nuclear submarines that could be provided with the funds presently spent on merchant marine subsidies.

In addition to humanitarian, equity, or defense justifications, however, proponents frequently claim purely economic justifications for the subsidies they favor. That is, they claim, in effect, that the market value of the subsidy's anticipated benefits will exceed its dollar costs. Although most economists have rather jaundiced views about subsidies, they do typically agree that a subsidy to an activity would have a benefit-cost ratio of greater than one under certain conditions. The argument runs about as follows: It would be economically desirable to increase the output of a commodity if the cost of the additional resources required to do so is less than the price consumers would be willing to pay for these additional units. More succinctly, it would be economically desirable (economically efficient, to employ the commonly-used term) to increase the output of any commodity as long as its additional, incremental, or marginal production costs are less than its market price. Expanding output would be economically efficient in the sense that doing so would enable making at least one person in the economy better off, without at the same time making any one else worse off.

Also, the key here is not average production costs; it is, rather, additional, incremental, or marginal production costs. The key to achieving economic efficiency is to set marginal cost equal to price even if doing so requires operating at a loss and hence requires a subsidy. A "marginal cost equals price" output policy would require operating at a loss if the production process in question was characterized by economies of scale, by a decline in average production costs with an increase in output. Under such circumstances, marginal production costs would necessarily be less than average production costs.

The economic efficiency argument for subsidy is a perfectly general one. If the existence of unexploited scale economies (or some other possibilities) is proved in any line of economic activity, most economists will agree that a subsidy is justified in principle. However, the economic efficiency argument is rarely adduced by petitioners for public doles. Much more common are arguments purporting to show why the petitioning activity is more or less unique in providing economic benefits that would be lost in the absence of a subsidy. A number of such special arguments for transportation subsidies—arguments that do not fall under the general "economic efficiency" heading—have been put forth. Four of the most common of these special arguments are really not sound. An analysis of these is followed by a presentation of the limited available information on the extent to which it may be possible to justify transportation subsidies on general economic efficiency grounds.

The four common special subsidy arguments discussed are those for (a) urban mass transportation subsidies that rest on the alleged superior efficiency of these modes of travel; (b) highway subsidies that rest on the existence of "non-user benefits," particularly benefits to the owners of land near improved highways; (c) subsidies to transportation and public utilities, which are common in the economics profession although perhaps not outside it (Hotelling paradox); and (d) private passenger vehicle operators' willingness to subsidize existing or improved mass transit facilities inasmuch as a shift from private to public conveyances would reduce highway congestion and thereby benefit the remaining highway users.

As an example of efficiency arguments for mass transportation subsidies (1 p. 116),

> The automobile is already obsolete as the primary means of transportation and communication within our major metropolitan areas—based on current auto sales and the glut of city streets which in themselves already occupy one third of our central business districts (such as in Los Angeles). How much more of our most valuable land can we sacrifice to such necessary but unproductive uses? A new, more efficient, less costly and less space-consuming means of mass transport must be brought into operation. If we continue with the hopelessly inefficient system of transport, we will move toward the point of the "immovable glut" and to increase in private as well as public costs of transport.

Or (2, p. 53),

> If transportation modes were selected on the basis of sound economic decisions, then the whole problem of urban transportation could be much [more?] objectively approached and analyzed by traffic engineers, traffic companies, and others.
>
> People don't behave according to sound economic decisions in the selection of transportation modes. There are conveniences and psychological values that cause many people to use automobiles when it can be simply demonstrated that such usages are [not?] most economical.

These arguments seem to boil down to the contention that socially undesirable waste is entailed in using a high dollar cost transport system when one involving lower dollar costs could be substituted. Although this argument is really quite silly, the frequency with which it is made and the apparent discomfort of private transportation proponents on hearing it make it desirable to spend some time attacking it. Its silliness can perhaps be most easily seen by applying the same line of reasoning to a different problem.

A recent Bureau of Labor Statistics study (3) determined the amount required to provide a "modest but adequate" living for a hypothetical four-person family "according to standards prevailing in large cities in the United States in recent years." The food and beverage component of this budget ranged between $1,514 and $1,889 a year. If the most "efficient" diet is defined as that entailing the lowest dollar outlay, the Bureau of Labor Statistics' conception of a "modest but adequate" diet entails gross inefficiency. Stigler and others (4, 5) have shown that about $100 a year would suffice to provide a balanced diet (one containing neither too much nor too little protein, carbohydrates, vitamins, etc.) for a 160-lb man of average metabolism and activity. Yet even though they cost more, few bemoan the preference for steak, french fries, and asparagus instead of the primary constituents of an efficient diet—wheat flour, evaporated milk, spinach, cabbage, and dried navy beans. If the Spartan "efficiency" concept is deemed applicable to transportation, consistency would seem to demand that it also be applied to diets and other consumption activities. After all, why berate people for letting "conveniences and psychological values" interfere with "sound economic decisions in the selection of transportation modes" when the same condemnation is not applied to their dietary preferences?

Restricting attention to land values, the "non-user benefits" argument for highway subsidies seems to say the following: land values have been shown to increase in the vicinity of improved highways, sometimes by dramatic amounts. Because benefited landowners need not use the improved highways involved to reap their benefits, a class of non-user beneficiaries clearly exists. To measure total highway benefits, it is therefore necessary to add benefits received by landowners to those received by highway "efficiency" or "benefit-maximizing" tax should be in the case under discussion depends, of course, on the value motor vehicle occupants place on their travel time. If this time is valued at $1.55 an hour as suggested by the American Association of State Highway Officials (8, p. 126), the tax for the trip ought to be about $0.26 at a traffic level of 700 vehicles per hour. Assuming an average gasoline consumption rate of 15 mi per gallon, a gasoline tax of about $0.0775 per gallon would be required. At $5.00 an hour, on the other hand, the required tax would be $0.25 per gallon.

Thus, putting the costs of highway congestion into proper perspective reduces the apparent conflict between the long-run and short-run maximization of highway benefits. Of course, nothing has yet been said about the relationship between "benefit-maximizing" or "efficient" highway-user taxes on the one hand, and the total cost of providing highways on the other. Unfortunately, no general statements can be made on this subject. However, if a severe but plausible condition holds, it can be demonstrated that an "optimum" highway system would require benefit-maximizing tolls that would just suffice to cover total highway costs. An optimum highway system is one that would maximize the present value of net highway-derived benefits. Establishing such an optimum highway system would require two steps: (a) charging benefit-maximizing tolls that force each individual driver to take fully into account the costs that his trips impose on other drivers; and (b) increasing capital expenditures on highways to the point where, for the corresponding optimum traffic level, the annual congestion cost savings provided by an increment in capital expenditures just equals the annual capital charge on that increment.

The condition under which a highway system that is optimum in this sense would generate tolls just sufficient to cover its capital and maintenance costs is, simply enough, that there be neither economies nor diseconomies of scale in highway construction, maintenance, and use. That is, an optimum highway system would just pay for itself if (a) the cost of building and maintaining one four-lane highway is the same as that of two two-lane highways having equivalent characteristics; and (b) the time and money costs incurred by each individual driver would not change if both the traffic on a highway and its capital and maintenance costs were increased by the same proportion. If economies of scale exist in highway construction, maintenance, or use, maximizing the net highway benefits would require highway subsidies. But these are, after all, the basic conditions under which an economist would agree that a subsidy would be warranted to any line of economic activity.

Just as with the "efficiency" argument which was given such short shrift, the final special subsidy argument also relates to the benefits of mass transportation subsidies. As an example (9, p. 62) of the "bribery" argument for subsidy,

> To make people pay what it costs is self-defeating for the reason that one of the broad social justifications of a new investment in rapid transit facilities is to reduce the urban traffic dilemma by inducing people to give up the use of private motor vehicles or to remain on public transportation if they are becoming discouraged by poor service.

This and similar "bribery" propositions say, in effect, that anything that reduces the number of automobile trips taken on the roads connecting here and there will reduce congestion on these roads, thereby benefiting the remaining auto drivers. In particular, the substitution of trips by subway or bus for trips by auto will be encouraged by improvements in existing subway or bus service or by the introduction of new service if none is presently available. Because they benefit from the resulting reduction in congestion, the remaining auto travelers ought to be willing to pay part of the costs of improving public transportation service. That is, they ought to be willing to subsidize, to bribe people to shift from auto trips to subway or bus trips.

As with the "efficiency" argument for subsidies, it is instructive to attempt to generalize the bribery argument. The consumers of a commodity are not the only beneficiaries of a reduction in its price. Those who consume substitute products also benefit. For example, a reduction in the price of apples will cause some people to substitute apples for oranges in their diets. Such substitutions benefit orange consumers because they serve to reduce the demand for and hence the price of oranges.

This suggests a couple of intriguing possibilities. For example, it would be possible for a representative group of orange consumers to use some of the money they presently spend for oranges to subsidize apple producers. This would lower apple prices and would induce orange consumers to shift to apples. Alternatively, they could use some of this money to bribe present orange consumers to shift to apples. Clearly, either alternative would serve to lower the price of oranges. Would it not therefore be in the interest of orange consumers to follow one or another of these alternatives?

Perhaps not surprisingly, the answer is "No." To see why, it is useful to consider the bribery proposition in somewhat greater detail. Once more, if some orange consumers bribed other orange consumers to shift to apples, the remaining orange consumers would benefit. In addition, by substituting apples for oranges, the bribed consumers would increase the demand for and hence the price of apples. Apple producers therefore ought also to be willing to contribute part of the necessary bribe. Orange producers and apple consumers, however, would clearly oppose the substitution of apples for oranges. The former would suffer a reduction in the prices they received; the latter, an increase in the prices they pay. Both groups ought therefore to be willing to contribute counterbribes to discourage the shift.

Clearly, these two groups of potential subsidy payments tend to cancel each other out. Indeed, they would precisely cancel each other if the markets for oranges and apples are competitive. More exactly, if both orange and apple markets are in competitive equilibrium, the dollar gains to orange consumers and apple producers resulting from a small shift from orange to apple consumption would be precisely offset by equal dollar losses to orange producers and apple consumers.

At least some of the same considerations apply to the markets for auto and public transit trips. Although congestion would be reduced if auto drivers bribed (either directly or by contributing to an improvement in public transportation service) some of their number to shift to public conveyances, those who presently use public conveyances would likely suffer from such shifts. The public conveyances would become more crowded. The number and duration of stops might increase. Present users of public conveyances would therefore likely be willing to offer counterbribes to keep such shifts from taking place. The possibility exists, then, that these two sets of bribes would also cancel each other out.

However, there is at least one peculiarity of the public-private transportation case that makes it seem intuitively plausible that the orange-apple analogy might not apply. Even if the conveyance on which he travels is publicly owned, the individual must himself supply a valuable asset—his time—if he makes a trip. Individuals do differ substantially in the values they place on their time. That the occupant of one vehicle values his time at $50 an hour and the occupant of another at $0.10 might well seem to open the way to mutually beneficial and socially desirable bribes, even if both private and public transportation are "competitive."

As it turns out, however, this peculiarity is not a vital one. Just as argued in the case of the Hotelling paradox, if a highway, or more generally, a transportation system is of optimum size (that is, if it is designed to maximize long-run net benefits) and if there are no economies of scale in either construction or use of the system, the toll system that would maximize benefits would be one that required each member of each user class to pay exactly the costs his trips impose on others. In particular, under such circumstances, it would not be desirable from the viewpoint of either society or auto drivers to have each auto driver pay more than the cost he imposes on other travelers in order to encourage still more people to travel by bus or subway.

Again, the logic supporting these contentions is not overly complicated. However, time does not permit developing it here. The argument, however, can be made intuitively more plausible by putting it in a broader context. Individual tastes in various commodities—furniture, clothing, housing, and autos, for example—do differ. This being the case, if no cost penalty is involved, society as a whole would seem better off if a variety of choices was available in these product groups than if alternatives were few in number. The more alternatives available, the more likely it is that each consumer will be able to find a combination of specifications that conforms closely to his tastes. So, too, with transportation routes. Tastes do differ. Most importantly, the rates at which individuals would be willing to exchange dollars for time do vary considerably. Thus, again, if no cost penality is involved, the availability of routes possessing a wide variety of toll and time combinations would clearly give each traveler a better chance of finding a personally optimum travel mode than if no choice was available. However, the fact that tastes differ does not in itself justify subsidizing either a particular product or those who buy it.

In nothing said so far has it been proved or even contended that transportation subsidies are undesirable. Rather, plausible reasons have been offered for the contention that, if transportation subsidies are to be proven economically desirable, essentially the same arguments must be used as those which would provide economic justification for a subsidy to any other line of economic activity. In conclusion a brief summary of the small amount of information available on the extent to which transportation activities possess these general subsidy-justifying characteristics is offered.

Once more, economic efficiency requires setting price equal to marginal cost. If scale economies exist, marginal costs will be less than average costs. If marginal costs are less than average costs, setting prices equal to marginal costs would require operating at a loss and hence would require a subsidy. In discussing empirical evidence of scale economies in transportation, it is useful to distinguish between the long-run costs of providing transportation capacity and the short-run costs of utilizing that capacity. As for the long-run problem, there seems to be no information on whether scale economies exist in the construction of such special rights-of-way as railroad and subway tracks. The only study providing information on scale economies in highway construction appears to be an unpublished analysis by a University of London economist, Michael Beesley, of optimum investment timing on Great Britain's only superhighway, the London-Birmingham Motorway. He is reported to have concluded that increasing the size of the road in question by 50 percent from four to six lanes would have increased its capital cost by only about 35 percent. Without seeing the study, why this should be the case can only be speculated on. Economies of scale may exist in the construction of roadways, interchanges, and bridges. In addition, scale economies in the provision of rights-of-way quite probably exist. A 50 percent increase in the number of lanes would presumably increase the amount of land required for this purpose by almost exactly 50 percent. However, the land required for medians and shoulders increases little, if at all, with increases in road width.

Economies of scale in highway use also appear to exist, although perhaps only for relatively small traffic flows. The "Highway Capacity Manual" (8, pp. 38, 46-47) indicates that the "practical capacities" of straight, level, two- and four-lane roads with 12-ft lanes are 450 and 1,000 vehicles per lane per hour, respectively. Above four lanes, however, scale economies in highway use seem to disappear. A six-lane highway is also regarded as having a "practical capacity" of 1,000 vehicles per lane per hour and, probably due to the effects of increased weaving from lane to lane, the capacity of an eight-lane highway seems to be somewhat less than 1,000 vehicles per lane.

In brief, there is some evidence that economies of scale exist in the construction of highways or at least in the construction of limited-access highways. Economies of scale also appear to exist in highway use. However, these latter economies appear to end well below the levels at which urban traffic arteries are used. If scale economies in highway construction and use do exist, they presumably apply with equal force to all highway users—public or private; truck, bus, or auto.

In addition, there is at least one factor that suggests economies of scale to be greater in public than in private transportation. Although there may be no scale economies in the costs to a transit company of providing bus or subway trips, there do definitely appear to be scale economies from the standpoint of the individual user. The time costs to users of public transportation facilities are really of two sorts: time en route and waiting (or walking) time at one or both ends and perhaps in the middle of the trip. Once a rider is aboard a bus or subway car, an increase in the number of passengers very likely increases his time en route by increasing both the number and duration of stops. At the same time, however, an increase in the demand for trips on a route can also be expected to result in increased service frequency, and therefore reduced waiting time. For example, if service is scheduled on a route every 15 min, and if an individual rider does not know the schedule, he can expect on the average to wait $7\frac{1}{2}$ min for his bus to come. If service is increased to a 10-min interval, his expected wait is cut to 5 min. Furthermore, as density increases still further, skip stop or express service may become possible, thereby actually reducing time in transit.

Another possible subsidy-justifying attribute of economic activity is indivisibilities. It is common in economic theory to assume that changes can be made in very small steps; that the cost of producing an additional unit of a commodity differs by only a very small amount from the cost of producing the unit that preceded it. In the real world, however, this assumption is frequently inapplicable. Choices often have to be made on an all-or-nothing basis. Such choices definitely exist in transportation. Either a road is built from here to there or it is not. If a subway is to be built, it must necessarily have at least two tracks.

All-or-nothing choices are of particular importance in dealing with urban mass transit facilities. As the "efficiency" proponents of these facilities are so fond of pointing out, a single subway track can carry as many passengers as 12 or 24 or 32 or some other such large number of highway lanes. If the choice is between no subway at all or a subway so large that it does not generate sufficient efficiency tolls to cover its capital costs, benefit maximization may dictate the latter alternative. That is, benefit maximization may dictate subsidy even though true economies of scale are not present.

Having recognized this possibility, however, it is perhaps worth pointing out that transportation facilities are by no means as lumpy as commonly supposed. Although engineering standards generally call for 12-ft lanes, there is no divine law saying that the capacity of a highway can be expanded only by adding 24-ft increments to its width. Capacity also depends on the widths of lanes, and on signal, sight distance, and gradient characteristics. At least in planning a highway, improvements in these characteristics can be made in quite small steps. Similarly, once two rails have been laid, it is by no means essential to duplicate them completely if the capacity of a rail or subway line is to be increased. By improving signaling and control devices and by installing sidings, capacity can be increased in small increments.

All that has been said so far has implicitly assumed that it is possible to talk about the demand for trips per time period without specifying the time period involved; that is, once a transportation network and benefit-maximizing tolls for its use are established, the demand for trips will be the same regardless of the hour of day or day of week being considered. Such is, of course, anything but the case. Trips per hour on transportation facilities vary considerably through the day. Indeed, there is considerable reason to argue that the financial crisis currently besetting most urban mass transportation systems stems not so much from the loss of patrons per se but rather from the loss of off-peak patrons. The demand for service during morning and afternoon rush hours appears to have declined little, if at all, on many transit systems. The reduction in demand has primarily entailed a shift from public to private transportation by former off-peak riders.

The costs of providing peak and off-peak service differ considerably. Public transit systems must acquire vehicles and the crews to man them only to have them remain idle for all but a few hours a day. It seems only reasonable to regard the costs of these idle facilities and men as costs attributable exclusively to the provision of peak load capacity.

Similarly, from the long-run point of view, highway construction requirements would almost certainly be considerably smaller than at present if traffic was distributed evenly throughout the day. It might well have been possible, for example, to have constructed Lake Shore Drive in Chicago as a six- or even four-lane facility had it not been necessary to provide for morning and afternoon rush hour traffic. It therefore seems quite reasonable to regard the costs of the additional two (or four) lanes as costs attributable to these peak load periods.

Looked at from the short-run viewpoint, the costs an individual driver imposes on the remaining drivers clearly depend on how many other drivers there are. The more drivers, the greater these costs are. Indeed, the difference between the private and the social costs of a trip approaches infinity as traffic on a highway approaches the "capacity" level.

As already argued, each component of an optimum transportation system would just pay for itself if the system entailed no scale economies and if marginal cost prices were actually charged. The validity of this contention is in no way affected by the fact that the demand for transportation varies through the day. All this characteristic implies is that an optimum pricing system for transportation services would entail tolls that vary with time of day. The greater the demand for the service, the greater these optimum tolls would be.

This point deserves emphasis. An optimum pricing system for urban transportation facilities would entail prices that vary directly with the demand for the services provided by the system. Such a toll system would almost certainly serve to diminish peak traffic loads. In the short-run, high peak-hour tolls would likely serve to shift to off-peak hours many of whatever non-work trips presently take place during peak hours. Furthermore, high peak-hour tolls would likely provide a considerably greater incentive than presently exists for employers to stagger work hours.

Once more, varying tolls on urban transportation facilities through the day would seem highly desirable. Various systems for doing this have been proposed. These range from highly complex mechanical and electronic systems to variable taxes on parking facilities in highly congested areas. All these proposals present substantial—perhaps insuperable—financial, legal, or political obstacles. The possibility must therefore be faced that it may not prove feasible to establish marginal cost prices for some or all forms of metropolitan transportation.

Economists are generally in agreement that, if it is impossible to establish marginal cost prices in one line of economic activity, it no longer follows that marginal cost prices are desirable in all other lines of economic activity. In particular, if it proves impossible to establish marginal cost pricing procedures for the use of highways by private vehicles, it may well prove desirable to provide public transportation subsidies even if no scale economies are involved in these facilities. Unfortunately, the cost and demand data necessary to determine whether subsidies would be desirable under such circumstances are not presently available.

To summarize, whether a particular activity or group is worthy of subsidy is, in the last analysis, a matter for politicians, not economists, to decide. Subsidies may be deemed desirable for humanitarian, equity, or national defense reasons. In discussing arguments for subsidy based on such considerations, about all an economist can do is attempt to supply some perspective on the costs involved.

However, many advocates allege purely economic justifications for the subsidies they favor. Economists do not deny that subsidies can, under certain circumstances, be justified on purely economic grounds. However, subsidy justifications that an economist would accept on such grounds are rarely advanced by subsidy proponents. Rather, they typically adduce one or another special argument as to why the benefits of a subsidy to their favored activity or group would exceed its costs. After discussion of four of the most common special economic justifications for subsidies to transportation activities, they were found to be without merit as special justifications. This paper has concluded with a brief discussion of the extent to which the general economic justifications for subsidy apply to transportation activities. The basic conclusion to be drawn is that there is really not enough information on the subject at present to make any firm statements at all.

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The Problem of Nonuser Revenues

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Nonuser revenues are distinguished by two classes (a) nonvehicular taxes levied to collect for highway use, and (b) nonvehicular taxes unrelated to highway use. The first serves an economic function, but it is difficult to justify the existence of the second on economic grounds. This conclusion is based on an analysis of highway taxation as an aspect of highway planning, in relation to the optimum distribution of traffic among all modes of transit and in relation to the general process of economic growth.

The first class of nonuser sources is analyzed for the extent to which it satisfies the criteria used in rejecting the second. Existing allocation procedures, including especially the relative-use method and the earnings-credit solution, are discussed for their economic implications. It is concluded that (a) economic efficiency could be furthered by planning highways with regard to the tax revenues expected to arise from them, and (b) a modification of the relative-use method might provide the basis for such planning insofar as traffic volume is concerned. A comparison is made with expenditures and highway use on existing highway systems.

•THE PROBLEM of nonuser revenues has beset almost every mode of transportation. Railroads were the beneficiaries of western land grants, air transport today functions with the help of subsidies of various kinds, and inland waterways are notoriously maintained from general tax revenues. Economists condemn the waterway situation. They usually assail the airline subsidies, and they applaud the fact that railroads by the beginning of the 1940's had more than repaid the Federal government for the value of land grants in the form of reduced rates on Federal traffic (1, pp. 105-109). All this is more than a simple penchant for operating in the black and avoiding operations in the red. Red ink and black ink have their significance for transportation just as they do for manufacturing. This is not true of many government functions, but it happens to be true of transportation, with only minor exceptions.

The exceptions are found in certain non-economic functions ascribed to highways. Some writers have noted a political responsibility of government to provide rights-of-way for all who wish to travel. Others emphasize aesthetic considerations. (Social costs as well as social gains attend highway location, including noise, fumes, smog, and accidents involving pedestrians and nonvehicular property.) To the extent that these matters are relevant, society-wide financing is called for. Otherwise, transportation in general and highway transportation in particular is an economic process to be judged by economic standards.

National defense is often cited as a traditional non-economic function and hence, it is argued that travel by military vehicles should be paid for from nonuser revenues. It is true that national defense should properly be supported by general tax revenues. But it is just as true that military travel is a user activity. To keep the record straight, revenues for defense had best be assigned to the Department of Defense and from there to highway agencies as user revenues. Similar observations apply to the postal service, fire and police services, and other government uses of the highways.

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The orientation of the present paper is economic. That is, the nonuser revenue problem is analyzed for the effects of highway finance on the efficiency of the economy in providing greater consumer satisfactions and increased productivity. In taking an economic orientation, the present paper is in the tradition of most highway studies dealing with the user-nonuser problem. So far, it appears that economic considerations are the only ones implicit in such frequently used methods of user-nonuser allocations as the relative-use method and the earnings-credit method. Economic criteria appear to be the only goals lying behind the interest in economic impact of highways. Thus, the present paper deals with the same objectives as most highway finance studies, but the conclusions are different.

ECONOMIC FUNCTION OF TRANSPORTATION

The history of economic growth testifies to the importance of improved transportation. At the earliest stages, in which today's underdeveloped countries find themselves, there is little transportation. Each community is a relatively independent economic unit. As long as pack-horse transportation sets the cost of moving goods, there are very few goods sufficiently valuable to be carried overland. A second stage in economic progress occurs with the growth of improved, and hence low-cost, transportation. More goods can stand the cost of shipment, markets are broadened, and more production can take place at the same location. Specialization, and later mass production, is made possible by trade which, in turn, is made possible by transportation.

As long as the costs of transportation are covered in the final sale price of goods transported, a test of the social desirability of transportation is readily available. The test consists in asking simply whether any given commodity can be obtained more cheaply by manufacture at home or by shipment in from elsewhere, provided that the cost of shipment is included as a cost to the buyer of the commodity. The cost of transportation is a cost of production in the truest economic sense. Transportation consumes material resources, labor, capital, etc., just as manufacturing does. Unless the cost of transportation plus manufacture elsewhere is less than the cost of home manufacture by itself, the inputs required for transportation are better used for some other purposes. Reorganizations in the location and method of production occur as a result of improved transportation. But only when there is full cost coverage of transportation expenses by users is there a way of being sure that such reorganizations result in overall productivity gains.

When the same logic is applied to highway transportation, if the users of the highways do not want to pay for the highways, this means that the highways are not worth the money they cost. If consumers are not willing to pay a price that covers all transport charges, including the cost of the highway itself, this is evidence that they prefer to get substitute products locally or to make other uses of their money. In this case, what is to be gained by hauling the goods to them out of general tax revenue? Similar observations can be made on the subject of passenger travel.

The trouble is that these ancient tenets of economics are sometimes obscured by the effects of highways on land values. The condition of a highway can mean economic life or death to a roadside establishment or it can determine the location of a suburban real estate development. Numerous studies of economic impact furnish all the evidence needed on these facts and then some. But they do not usually recall another proposition from classical economics—location is the one fixed attribute of land that can be neither created nor destroyed. As a result, land is the recipient of an unearned surplus called economic rent. Pure rent is unearned in the sense that nothing need be done to get it. The farmer who finds that his property will be better served by a highway improvement is in the same position as the farmer who finds that his property contains oil. Neither needs to turn a hand to realize his bonanza. (A different way of looking at the change in land values of property attached to land is to recognize them as capitalized gains or losses in commercial opportunities resulting from the change in transport benefits or costs and the servicing of transport at the location in question.)

This irritates everyone and the immediate thought is to tax the unearned increment. God put the oil there, but men built the highways. So, when it comes to highway finance, it is sometimes thought obvious who should get the tax revenue.

The real point is not so much whether the increased property values from highway improvement are taxed; even the unearned increment may be taxed. The point is that such taxes should not be used for the support of highways. If any revenues other than those from highway users are diverted to highways, more will be being spent for highway transportation than the transportation function itself warrants, as judged by those who use it and indirectly by society in its paying for products transported.

The distinction between highway user revenue and general tax revenue is founded on a distinction between transportation and traditional government functions. The latter are characterized by collective consumption, whereas transportation is a case of individual consumption. Thus, public health and justice are received by all members of the community even though these government services may be rendered only to a few. The few cannot appropriate to themselves alone the government services rendered to them. Like the enjoyment of public gardens, public goods may be received by many without being diminished by those who first receive them. The distinction between public and private goods is made rigorously by Samuelson (2, 3).

In contrast, a highway (or a set of railroad tracks) provides a fixed, divisible, and separately received unit of output, the trip opportunity. A trip made by one vehicle is of no advantage to another vehicle, except, of course, by market happenstance when an economic relationship exists between the products transported. In this last case, indirect effects become direct effects through the market mechanism if highway costs are covered by users. The main point is the absence of extramarket relationships among highway users and other members of society. Economic benefits of transportation are individually received by users and can be taxed accordingly.

The result of this situation is that highway planning is economically the same as private investment planning. Both are dealing with the establishment of a plant, the product of which can be sold on a quid pro basis; i.e., according to units consumed. Both depend on the receipt of revenues equal at least to total costs over the expected lifetime of the plant. As a by-product of the conclusion favoring sole reliance on user finance, a criterion for highway planning is discovered—a traffic volume should be planned for that will yield enough user revenue to cover the cost of the plant over its lifetime, plus all other costs of operation and maintenance.

There is the additional question of effects on other roads, consisting largely of diversion of traffic, but also perhaps congestion on feeder routes. The question is whether expected traffic effects elsewhere in the highway network should enter as benefits and costs in the planning of a highway improvement. Two kinds of considerations are illustrated for traffic diversion.

First, each highway could be treated as a separate economic unit in competition with all other highways. If traffic (and hence "tax earnings") are reduced on alternate routes, this might reflect increased quality of service and hence obsolescence of the older routes. In such a case, the useful lives of highways in general should be calculated with a view to recovering costs before they become obsolete (which is presumably a shorter period of time than their physical life expectancy). If there is no difference in quality, the use of the same (user) standards in planning the new highway as were used for the design of the old, would lead to the introduction of the new highway only when traffic density reached too high a level on the old.

Second, the highway network would be treated as a whole. This approach would be justified on the ground that highway planning should be designed to make use of highways over their entire physical lifetime. If so, the loss of "tax earnings" on the reduced-traffic highways would be charged as a cost against the proposed new highway.

Whatever the choice between these two alternatives when dealing with highways, it is clear that long-run productivity becomes a sufficiently important consideration to favor the first alternative when considering the effects of a proposed highway on other modes of transport.

In analyzing prospective future traffic volume, it is appropriate to consider the value of elapsed time to travelers, safety, and vehicle wear-and-tear. The effects on local industrial development and tourist traffic are both relevant considerations. But the reason for considering these is to determine user demand; i.e., the relationship between user charges and traffic volume. User demand then gives a basic (subject, of course, to the errors of forecasting) for calculating expected future revenues against which costs of the highway plant are to be compared.

In principle, this is not the same thing as making recommendations about the tax structure on already existing highways. The difference comes from the fact that a highway, like a private manufacturing plant, is a fixed investment expected to last for a long time. Economic rationality requires that planning for each must be based on expected revenues from each. But after investments have actually been made, the only strictly relevant cost considerations are for operation and maintenance.

Notwithstanding the difference in long- and short-term economic considerations, highway planning and finance might establish the tax structure for highways after they are constructed if bond financing and trust funding requires the establishment of a retirement schedule that dictates tax policy. Moreover, for administrative reasons, tax policies are not likely to be changed frequently. Finally, as a result of equity considerations, it is customary to tax vehicles in accordance with highway plant costs for which they are responsible. This appears to be the rationale behind the incremental cost approach and is equally relevant for other methods of plant costing.

USERS AND NONUSERS

The concept of highway user must be broad enough to include special uses for access, parking, and other purposes. Many analysts refer to access traffic as nonuser traffic because nonvehicular taxes are employed in financing it. This is an unfortunate custom. Previous discussion suggests the importance of maintaining the distinction between those who occupy highways and those who do not. The term "user" is employed to refer to highway occupants and "nonuser" to refer to nonoccupants. The question of what taxes users pay is another matter.

The next step in working toward a tax structure is to define a unit of highway use. The trip opportunity was used in previous discussion to indicate the separable output of a given highway. It is also a measure of highway capacity. The greater the capacity, the larger the number of trips that can be made on a highway between any two points by the same class of vehicle, say automobiles, under defined operating conditions. The operating conditions can be defined in as complicated a way as desired, to include, for example, a distribution of speeds around some norm rather than a single uniform operating speed. An example of the use of the trip-opportunity concept can be found in Beckmann, McGuire, and Winston (4). The orientation in Beckmann et al. is for optimization in the use of existing highway plant, in contrast to the emphasis of the present paper on highway planning.

When different classes of vehicles simultaneously travel over the same highway, the larger vehicles with lower horsepower-to-gross weight ratios will, of course, reduce trip opportunities of others more than in proportion to their numbers. This effect can be represented by the concept of effective space occupance. The number of automobile trips eliminated by a trip of one four-axle semitrailer might be five, for example, on a given highway. Obvious adjustments of effective space occupance would be required for different highways, operating conditions, and vehicle classes.

The main reason for bringing space occupance in at this point is to deal with local traffic. In the problem of access, residential access is encountered on all rural and urban roads except for limited-access freeways. It is well known that a vehicle gaining access or egress is consuming trip opportunities that might be used by other vehicles. A certain amount of space occupance can therefore be assigned to the access function.

In the most extreme case of rural secondary roads, the space occupance of local residents is considerable. Farmers affect traffic flows with their livestock crossings, tractors on the roads and slow-speed hauling with wagons. A space-occupance measure must allocate a high proportional consumption of trip opportunities to such uses.

Similar observations apply in urban business districts. Traffic-flow effects from adjacent property bear on elapsed time, safety, and driver strain. Local business parking, frequent cross-streets, and traffic controls due to schools and local pedestrians shift a larger user burden to the shoulders of local groups.

It would seem worth the trouble to develop space-occupance factors for access and other local highway uses even if all through traffic were lumped in the same space-occupance category. There are important space-occupance differences between vehicle classes, as already noted. Whether these are taken into account depends on how fine a study is conducted and whether the vehicular tax structure is being judged.

Space occupance is a unit pertaining to geometric capacity of the highway and as such might be employed in distinguishing geometric costs among vehicular classes. This, however, is not the point of the present discussion. Nor is there any intention to claim space occupance as the only unit of use. When pavement thickness is involved, the axle load is presumably a better unit of use. The present discussion is limited to geometric use. Primary interest here is in the relation of vehicular to nonvehicular taxes.

CAPACITY BY HIGHWAY LEVEL

The most important part of the difference usually assigned to vehicular and nonvehicular taxes arises from differences in highway cost per vehicle-mile. Vehicle mileage is sometimes distinguished by vehicle classes, but not for the purpose of making vehicular-nonvehicular tax responsibility calculations in the relative-use or earnings-credit methods. The effect, therefore, is analogous to that where space-occupance factors are not distinguished by vehicle classes in making space-occupance calculations.

The difference in vehicle-mile costs with level of highway design is given in Table 1 for all roads and street systems in the United States according to Bureau of Public Roads calculations. The costs are total costs including maintenance, administration, and capital costs. Capital costs are in 1956 prices without consideration of interest accruals. Maintenance and administration costs and vehicle-miles of travel are estimated for 1975. By this last date, the Interstate program is expected to be completed and travel on the various highway systems adjusted to it. For the same reason, this table gives intrinsic differences in travel cost between systems and hence levels of design.

The inverse relationship between cost per mile and cost per vehicle-mile is readily apparent on the rural systems. The continuity is broken only by the "other State" classification among the rural systems. There is no break in the continuity among the urban systems. Indeed, the urban systems show a remarkable similarity of costs per vehicle-mile except for the last class (other local highways).

An equality of highway costs per vehicle-mile on all systems would mean (with some approximation) that vehicular taxes could be relied on to finance all highways because revenues from vehicular taxes vary roughly in proportion to vehicle-miles. This is administratively convenient, but it does not take account of space-occupance costs of local users. The latter complicate the problem by requiring a nonvehicular tax in whatever degree there are such local space-occupance effects.

Returning to the rural systems, there appear to be two principal explanations for the high cost per vehicle-mile or low traffic density on lower level highways: (a) it may be that lower level systems are used to capacity when account is taken of the high space occupance of farm uses, or (b) it may be that lower level highways are overdesigned as compared with the uses that are made of them. Undoubtedly, minimum safe operating conditions and performance standards would have something to do with capacity design and hence any final judgment on the second point would have to take these considerations into account.

Table 2 gives the same data as Table 1 (plus miles of system) for the four subclasses of highways in the Bureau's last rural group (other roads and streets). The inverse relation between level of highway and cost of travel also characterizes this group, except at the lowest level, unsurfaced roads. If overdesign is the problem on low traffic density roads, the example provided by the unsurfaced type may be highly relevant.

TAX STRUCTURE

A tax structure that taxes users on different highway systems differently must identify the users and associate a tax with them. This is a tall order, though some suggestions

TABLE 1

ANNUAL HIGHWAY COST OF HIGHWAY TRAVEL, CONTINENTAL UNITED STATES, 1975[1]

Highway System	Rural Cost		Urban Cost	
	Level of Design ($ per mi)	Cost of Travel ($ per veh-mi)	Level of Design ($ per mi)	Cost of Travel ($ per veh-mi)
Interstate	19,165	0.00415	73,798	0.00370
Other Federal-aid primary	9,634	0.00756	32,633	0.00497
Federal-aid secondary:				
State	4,444	0.01254	16,147	0.00499
Local	2,401	0.01620	9,568	0.00505
Other State	5,464	0.01871	16,031	0.00499
Other local	1,134	0.02567	5,614	0.00997

[1] Table III G-1 (5).

TABLE 2

ANNUAL COST OF HIGHWAY TRAVEL ON OTHER LOCAL ROADS AND STREETS, RURAL, CONTINENTAL UNITED STATES, 1975[1]

Highway Class	Thousands of Miles in System	Level of Design ($ per mi)	Cost of Travel ($ per veh-mi)
High	149	4,941	0.01380
Intermediate	348	1,837	0.03118
Low	1,261	877	0.05000
Unsurfaced	522	203	0.02200
Total	2,280	1,134	0.02567

[1] Table III G-1 (5).

have already been made to deal with it. In particular, space-occupance factors might be developed for access and egress traffic and for various other urban and rural interferences. Property taxes can probably be used to cover associated revenue responsibility, though it is important to note that such taxes would be for highway space occupance and should be separated from general tax revenues.

Another, and very important part of the problem consists in identifying travel itself with appropriate tax source. A variety of methods are used for doing this (5). Almost all the methods rely on a philosophic foundation made most explicit in the relative-use method. Approximations of various kinds are employed in other methods, but a satisfactory comparison of the ideas in this paper with their counterparts in current practice can be made by dealing only with the relative-use method.

The best way to present the issues is to summarize the basic principles of the relative-use method. The classic work on this method is by St. Clair (6). These are already familiar to many.

The relative-use method divides each individual trip into three components: access, neighborhood, and through (Fig. 1). The access component is generally defined as that part of a trip from origin to the nearest street intersection and from the nearest street

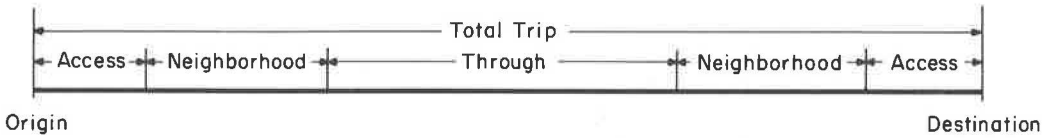

Figure 1. Relative-use travel allocation concepts.

intersection to destination. Thus, there is an access component at both ends of a trip. The average access component will be one-half block long in municipal areas and longer in rural areas.

The neighborhood component is more difficult to define. It is generally defined as an average radius that must be traveled to reach a collection of facilities, including schools, churches, and local businesses considered to constitute a neighborhood, but subtracting out the access components at both ends of this radius. Again, the length of trip considered as the neighborhood component will vary with the density of population. There is a neighborhood component at both ends of all trips long enough to include them. Numerical values for the length of the neighborhood component are given elsewhere (5, p. 115).

Finally, the through component is defined as all the rest of the trip exclusive of access and neighborhood travel. It is possible for short trips to include no through component.

From origin-and-destination studies, it is possible to get total vehicle-miles in each category on each mile of road, each highway, and each highway system. (The practical problems of doing this are considerable, but for present purposes, it is best to pass over these problems and concentrate on general principles.)

Tax responsibility is then assigned according to relative proportions of access, neighborhood, and through vehicle-miles on each highway system. Various taxes, discussed later, are selected to represent payments by the access, neighborhood, and through travel components.

The effect of the foregoing procedure is to deal with differences in the level of cost per vehicle-mile on each system by changing the proportion of the cost of each system covered by the different tax groups. If the taxes selected actually represent responsibility for use, the result will be to charge users for what they get. No one will object to high costs per vehicle-mile if these costs are paid by persons who consume the vehicle-miles. But if the proportions do not represent use, the effect of the system is to finance one man's travel at another man's expense.

The use of absolute rather than relative measures of highway use would reduce the danger of paying for one highway system at the expense of another. Planning could take account of separately measured demand for each highway use.

EVALUATION AND APPLICATION

The discussion that follows applies the principles developed earlier in the present paper to an evaluation of the relative-use method and to the design of a tax structure that corresponds to highway usage. Similarities and differences with the relative-use method are not to be stressed for their own sake. The purpose is mainly to show how the broad user concept developed herein takes care of what is often referred to as "the nonuser revenue problem," or its legitimate parts.

The access component of travel is traditionally associated with special local assessments of abutting property owners and therefore is usually considered to be the responsibility of the local units of government levying these assessments. This is the same identification of tax with user as previously made in the present paper, but there are certain difficulties with charging access users according to relative vehicle mileage. Access travelers have, in fact, already paid vehicle taxes for their vehicle-miles of travel. They did this in paying the same vehicular taxes that through travelers paid. The only extra charge to which they are economically subject as users is the previously-mentioned space occupance arising from the act of access itself. There is no reason to think that vehicle-miles of access measure this aspect of use.

It is true, as noted in Table 1, that costs of highway per vehicle-mile are higher on local roads than on primary highways. But this fact would suggest that all travelers on local roads pay more for a vehicle-mile of travel on them—through travelers as well as access travelers. A way of making vehicular taxes higher on secondary systems than on primary systems has yet to be found.

Similar observations apply to the proportion of vehicle-miles in neighborhood travel. The issue is not whether local travel can be identified with a local tax source. Perhaps it can, though the definitions applicable for neighborhood travel are more arbitrary than for accèss travel. The question is what measure of use is attached to the neighborhood component. A vehicle-mile of travel is a vehicle-mile of travel, and there is no obvious reason why neighborhood vehicle-miles should be charged more than through vehicle-miles. What is actually sought is the special costs that arise from the cluster of establishments that account for local businesses, social organizations, etc. If this is the case, the space-occupance concept would seem to give a direct approach to the problem.

In the neighborhood case, it is probably more difficult than in any other to pinpoint a tax that should be used for all of the direct services of streets. Further study might well lead to the conclusion that, as a practical matter, general tax revenues must be employed, not because of any indirect benefits of the community, but because many aspects of community life other than travel itself constitute road and street use. Any revenues for neighborhood highway use should be separated from other general revenues in a highway fund so as to maintain the distinctions explained earlier.

When, as, and if full calculations are made of the revenues arising from trips and from space occupance of all kinds that interfere with trips, there is still the real possibility that the revenues will not cover the costs on secondary roads and streets. It would be remarkable if they did, in view of the figures in Table 1. Public policy would then face the two alternatives: (a) to tax all users on lower level highway systems at a higher rate than they are now paying, or (b) to reduce the design level of sparsely used systems.

The first alternative would be particularly difficult because of the problems of identifying all users of secondary roads and separating them for taxation. It could be argued that a very rough approximation might be realized by simply determining vehicular-nonvehicular proportions in accordance with space-occupance principles and making no other changes in existing patterns of finance. This approach might be rationalized with the thesis that most vehicle operators account for mileage on each system in about the same proportions as the average distribution of vehicle-mileage. If so and if all user revenues were put in the same kitty, the same users would be financing their use of the secondary highways from their operations on the primary. This thesis probably does not come close at all to describing the situation. More important from an economic standpoint, highway users should be made aware of the costs per vehicle-mile on the lower level systems for what this might imply about reorganization of their own activities.

If a direct approach to the question of who uses the lower level systems were made, using origin-and-destination data or otherwise, it is conceivable that relationships predictable in the statistical sense might be discovered between trip length and vehicle mileage by highway system. To whatever extent valid relationships are found, some thought might be given to taxing commercial vehicles according to probable mileage on each system, or for those who want to keep records, according to actual mileage by system. Higher rates on low-level systems combined with the usually poorer capacity conditions would work to further reduce the problem of heavy vehicles on such systems. For private passenger cars, statistical classifications of trip length might have sufficient significance by occupational and income groups of their owners to justify graduated registration fees. These are primarily research suggestions at the present time, designed for the case where the marked difference in cost per vehicle-mile is expected to continue between highway systems.

Adjustment of the highway plant itself would, of course, reduce the need for adjustment of revenues. Downward adjustment of capacity and design on low traffic density highways would be the easiest method of dealing with intersystem differences in cost per vehicle-mile, provided that due recognition can be given to space occupance and safety. The relatively favorable cost per vehicle-mile of unsurfaced roads was given in Table 2. It is true, of course, that unsurfaced roads cause more wear and tear on vehicles. But it is also true that the vehicle costs are incurred by the users of the low density roads. This is the very result sought in the design of an intersystem tax structure.

A final caution is that capacity limits on lower level highways might be reached before traffic density is brought into adjustment with user revenues. Vehicular earnings are roughly proportional to vehicle-miles, but geometric use (whether vehicular or otherwise) is by space occupance. There is no guarantee that reducing the level of secondary road design can be made to solve the whole problem.

SUMMARY

The discussion extended from a consideration of user-nonuser distinctions to the design of a tax structure dealing with what is commonly considered the nonuser revenue problem. The major conclusion was that only user taxes can be justified on economic grounds; however, the word "user" is defined broadly to include all those who directly affect the number of trips on a highway, not only the travelers themselves.

The result of this approach was to establish a basis for taxing nonvehicular sources, but according to their effects on trip opportunities of vehicles, as measured by space occupance. A comparison of the qualitative differences of the space-occupance approach and the relative-use method showed that the heart of the nonuser revenue problem lies in the definition of the units by which nonvehicular responsibility is measured. Some research suggestions were made for resolving interhighway cost differences without throwing more of the burden on nonvehicular tax sources than would be indicated by a space-occupance analysis. Deeper study will doubtless reveal other means of implementing a space-occupance approach.

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AASHO Road Test Findings Applied to State Highway Cost Allocation Studies

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Results of the pavement experiments on the AASHO Road Test have been applied in allocating cost responsibility to motor vehicle users in comprehensive studies of highway finance in Kansas and South Dakota. The Road Test formulas were used in apportioning pavement costs among vehicle classes in the incremental solution of the allocation problem. The incremental solution, with other allocation solutions and tax data, guided the formulation of recommendations on user taxation.

The Road Test equations were used as a model for predicting performance under traffic of typical pavement structure designs. These designs reflected local conditions and costs in several areas of each State. Pavement costs reported in highway needs studies were then allocated to users in proportion to their influence on pavement performance. The pavement allocation was a relatively small part of the total user responsibility, but for the heavier trucks it was a very significant part.

The incremental solution tended to assign greater responsibility to light vehicles and less to heavy trucks compared with the cost-function solution or the average of the vehicle-mile and ton-mile solutions. In formulating recommendations, the incremental solution was particularly useful because it reflected the influence of vehicle type and axle configuration. The Road Test equations assign less responsibility to tandem axle units than to single axles of similar weight.

•THE AASHO Road Test has commanded the attention of the highway fraternity for several years. The areas of study and experiment touched on many technical aspects of highway management. One aspect, which has been foremost in the minds of planners and administrators, is the influence of the pavement experiments on vehicle size and weight and on allocation of cost responsibility among classes and weights of vehicles. The AASHO Highway Transport Committee (1) in its "Statement of Fundamental Principles, Project Elements, and Specific Directions," emphasized the importance of the Road Test in developing bases for taxation and guidance on economics of vehicle size and weight.

During 1962, comprehensive studies of highway finance on all road systems—State, county, and municipal—were made in Kansas and South Dakota. These were undertaken in conjunction with highway needs studies and included the allocation of responsibility for costs in the estimates of 20-year needs. Agreements for the conduct of the studies specified that an incremental analysis would be made using the results of the AASHO Road Test, as they apply to local conditions. Results of these studies have been published in reports presented to the South Dakota Highway Commission (2) and the Legislative Council and the State Highway Commission of Kansas (3).

The problem of highway cost allocation, or distribution of responsibility, divides naturally into two phases. The first phase is the assignment of gross responsibility between the general public, commonly referred to as the nonuser, and the motor vehicle users. In reality, these two categories are not exclusive but, from the taxation

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viewpoint, they constitute sources of revenue which require distinct tax structures. The "earnings-credit" method was used to allocate total highway program costs into shares to be borne by the general public and the motor vehicle users. By this method, approximately 70 percent of the total program was assigned to the motor vehicles (user responsibility amounts to 73.2% in Kansas and 69.0% in South Dakota) a result which is generally consistent with solutions based on 20-year needs in other States—for Mississippi, 68 percent user responsibility (4); for Missouri, 60 percent (5); for Ohio, 69 percent (6).

USER COST ALLOCATION

The portion of program responsibility assigned to the highway user must be further allocated to vehicle-type and weight classes so that a comparison can be made between the tax structure and responsibility. Four solutions of the cost allocation were made in each study to provide maximum guidance for recommendations on user taxation, realizing that all such solutions must be tempered by peculiar local conditions, precedents, and other factors. These four allocations were the incremental, the cost function, the vehicle-mile, and the ton-mile methods. Because of its sound, logical basis, the incremental analysis was assumed to provide one of the most valid solutions. At the same time, it was recognized that certain arbitrary decisions were necessary in all methods and that more experience was available on the other methods because they have had wider applications.

In the two studies, procedures and decisions were kept uniform. Needs data were reported on the same format in each State; the similarity of terrain and construction practices further aided uniformity (7, 8). Adequate traffic data were available but differences in form, arising in part from the different registration fee bases, made it necessary to devise separate traffic analysis procedures for each State. These differences in traffic data are carried over to the presentation of results related to gross vehicle weights since Kansas reported maximum gross weight for each registration fee group and South Dakota reported the owners statement of gross vehicle weight and related it to chassis weight.

Throughout the study, guidance was derived from procedures used in the Federal Highway Cost Allocation Study (9, 10, 11). Several conferences were held with personnel of the U. S. Bureau of Public Roads and every effort was made to keep the State study procedures consistent with those used by the Bureau.

Cost-Function, Vehicle-Mile, and Ton-Mile Solutions

The cost-function solution distributes costs in categories according to several measures of use. All items of cost are considered and a decision is made as to the measure of use that would be most likely to influence the magnitude of the cost item. In these studies, the selected measures of use were numbers of vehicles, axle-miles of travel, and ton-miles of travel. Each distinct item of cost was assigned to one of these functions or proportioned between two of them.

The vehicle-mile and ton-mile solutions allocate all cost according to the respective measures of highway use. Neither is generally regarded as an adequate solution of the user cost allocation problem, but both do establish limits of total responsibility for each class. An allocation based on a compromise or proportioning between the two provides a useful reference point when evaluating other solutions. In these studies, equal weight was given to each of these methods and the results were presented as a single compromise solution.

Incremental Solution

The underlying concept of the incremental method of cost allocation is that each vehicle should participate in all increments of costs incurred in building a road adequate for that vehicle. Increments of costs made necessary by larger or heavier vehicles should be borne by these vehicles only. All vehicles participate in the first increment of costs, but the lighter vehicles are not required to contribute to the successively higher increments. In theory, this assigns responsibility according to the costs of providing highway facilities which each vehicle has occasioned. In practice, much depends on the judgment of the analyst in selecting methods of incrementing costs, of allocating costs within increments, and in assigning gross costs to the several categories which are analyzed by the various methods. For example, in the treatment of pavements, a critical decision is necessary on what minimum thickness of surface will be incremented. In comprehensive State studies there may be many miles of secondary roads with surfacing at or near this cutoff. Similarly, decisions are necessary on which types of work changed structural characteristics and which merely rehabilitated them.

Four categories of costs were established for distribution in the incremental analysis: pavement, structures, grading and drainage, and miscellaneous. Each category was treated differently in the analysis so that a total assignment of costs by four methods was necessary.

The cost category for which the AASHO Road Test pavement experiment results were used included all costs for base and surface on reconstruction or new construction where the surface type was classed as high or intermediate in the needs study. These classes include all rigid pavements as well as all flexible surfaces greater than one inch in thickness on a prepared base. Design engineers in each State prepared typical designs for these surface types. Typical designs and associated cost estimates were prepared for each system classification and highway district so that the analysis would reflect the influence of soil conditions, material availability, and traffic composition.

Results of the Road Test indicate clearly that, although rigid and flexible pavement performance could be described by the same general formulas, different parameters were necessary to describe the behavior under traffic. It was, therefore, necessary to analyze both types of pavement separately and sum the responsibility by vehicle types. Needs data indicated the class of pavement, either high or intermediate, and State construction practice provided the basis for proportioning needed mileage at each class to rigid and flexible types. Traffic data, including traffic counts, loadometer surveys, vehicle registration records, and truck-use questionnaires, were obtained and processed to determine the frequency of application of axle loads in six increments of weight as related to vehicle type and weight. Frequency distributions were developed for each basic pavement design and for each highway district and road system.

Analysis of the pavement designs, using Road Test equations, established the proportion of the pavement structure that should be attributed to each of the increments of axle weight. The proportion of effective pavement structure in each increment was assumed to be directly proportional to construction costs and was distributed to each vehicle type according to the frequency of occurrence of that weight. Responsibility of each vehicle type was then summed and the total cost responsibility for each vehicle of a given type was redistributed according to frequency of occurrence of axle loads in the gross weight groups of the vehicle type.

The second group of costs consisted of those associated with construction of new bridges either on the same or on new locations, less the general public's share of these costs. All structure costs were incremented in proportion to the cost of providing bridges carrying H5, H10, H15, H20, and H20-S16 design loadings, conforming to AASHO bridge specifications. Several typical spans and structural types were investigated and weighted average costs were developed. Loadometer data were used to develop frequency of occurrence of gross operating weights for each vehicle type. Table 1 gives the assignment of vehicle-operating weights to increments. Allocation of costs within the increments was made in proportion to vehicle-miles of travel. The AASHO Road Test bridge experiments were not a factor in the incremental analysis of structure costs.

The third group of costs included grading and drainage costs on widening, reconstruction, and new construction projects, again excluding the general public's share. The basis for incrementing these costs was the assumed effect of vehicle size on pavement and shoulder width. Only vehicles having observed operating weights of more than 10,000 lb shared grading and drainage costs associated with provision of the outside ½ ft of surface and 2 ft of shoulder. Analysis of typical design cross-sections

TABLE 1

INCREMENTS OF STRUCTURE COSTS

Increment	AASHO Design Loading	Vehicle-Operating Weight (lb)	
		Single Unit	Combination
First	H5	0 - 10,000	--
Second	H10	10,000 - 20,000	0 - 27,000
Third	H15	20,000 - 30,000	27,000 - 40,000
Fourth	H20	30,000 - 40,000	40,000 - 54,000
Fifth	H20-S16	Over 40,000	Over 54,000

showed that approximately 9 percent of the total grading and drainage quantities were required because of this added width. Therefore, a percentage of these costs was allocated to vehicles having observed operating weights over 10,000 lb. The remaining 91 percent of the costs were distributed to all vehicles in proportion to travel.

All other costs making up the total motor vehicle user responsibility fall into the fourth category which does not lend itself to incremental treatment. These costs include such items as right-of-way, gravel and light bituminous surfaces, resurfacing, structure reconditioning, maintenance, and administration of highway and motor vehicle regulatory activities. These costs were distributed to all vehicles in proportion to vehicle-miles of travel.

USE OF ROAD TEST EQUATIONS

The equations derived from the pavement experiments of the AASHO Road Test (12) describe the relationship between the number of applications of uniform axle loads and pavement performance of change in serviceability. The model of pavement performance which was selected as most appropriate for expressing results of the experiment is the general form:

$$p = c_0 - (c_0 - c_1)(W/\rho)^{\beta} \tag{1}$$

in which

- p = serviceability trend value;
- c_0 = initial serviceability index;
- c_1 = serviceability index at which a test section was considered out of test;
- W = accumulated axle load applications at time p is observed; and
- ρ and β = functions of design and load.

By defining a function of serviceability,

$$G = \log(c_0 - p) - \log(c_0 - c_1) \tag{2}$$

the basic model is expressed as

$$G/\beta = \log W - \log \rho \tag{3}$$

In applying these equations, it was necessary to convert to mixed traffic having a wide range of axle loads and axle configurations. Also, the concept of serviceability had to be related to levels of tolerability on public highways. On the Road Test, pavement sections remained in the test until they reached a serviceability trend value of 1.5, measured on a scale of 5.0 points. Initial serviceability, the level before traffic started, averaged 4.5 for rigid pavements and 4.2 for flexible pavements (12). For the Kansas and South Dakota studies, it was decided that 2.0 points better described the minimum conditions that could be considered tolerable. It was assumed that average initial serviceability would be the same as that measured on the Road Test. Because this assumption may not be entirely tenable, it might be better to say that during their useful life, a decline in serviceability of 2.2 to 2.5 points was assumed.

Procedures developed by the U. S. Bureau of Public Roads were used in solving the equations for mixed traffic conditions (13). Though this method uses the "equivalent applications approach" to mixed traffic, which has some acknowledged theoretical deficiency (14), it is felt that the quality of the solution is consistent with the precision of the data on traffic and the generalized nature of the typical designs and costs. In the analysis of loadometer data for this procedure, axle load frequency distributions were developed for each type of vehicle using single axle equivalents for tandem axles. Equivalency factors of 0.54 for flexible pavements and 0.62 for rigid pavements were used. Frequency was expressed in terms of proportion of single axles and equivalent tandem axles falling in six weight groups: 0 to 3 kips, 3 to 7 kips, 7 to 12 kips, 12 to 16 kips, 16 to 20 kips, and over 20 kips. For each axle weight group, the summation of frequency of occurrence times numbers of the appropriate vehicle type was accumulated and reduced to a series of C-factors or proportional parts for use in the incremental analysis of each typical design.

The Road Test equations were solved and tabulated for each 0.05-in. variation in thickness in the working range of effective depth D. This range is from 1 to 7 in. for flexible pavements and 4 to 10 in. for rigid pavements. As used in the Road Test equations, the effective thickness is given for rigid pavements by

$$D = D_1 \tag{4}$$

and for flexible pavements by

$$D = 0.44\, D_1 + 0.14\, D_2 + 0.11\, D_3 \tag{5}$$

in which

D_1 = surface thickness,
D_2 = base thickness, and
D_3 = subbase thickness.

It was not intended to increment below the lower limit of the working range but in the analysis it was never necessary to apply this criterion.

The Road Test equation solutions gave the number of applications, R, of a 3-kip axle which had the same influence of pavement performance as one axle in each heavier axle weight group, an equivalence that varies with D. Also they were solved for the ratio of the number of applications of a 3-kip axle load to reach the selected tolerable serviceability index over the number of applications to reach an index of 1.5 during the pavement experiment. The logarithm of this ratio is the term G. Although only values for the 3-kip axle load were used in the incremental solution, it was necessary to evaluate the term for each load in solving for R. Table 2 gives the ranges of values for these functions, within the working ranges of D. Values for $R_{22.2}$ (the R factor for axle loads over 20 kips) were required infrequently and were not developed for the entire range of D.

To facilitate the solution for increments of pavement thickness, a value K was calculated for each design, which was a function of pavement thickness, change in serviceability, and traffic for the initial D, as follows:

$$K = A_1 \log(D + 1) + G/\beta_3 - \log \Sigma\, CR \tag{6}$$

in which

A_1 = constant determined by pavement type and by use of unweighted (seasonally) traffic data equal to 9.36 for flexible pavements and 7.35 for rigid pavements (12).

Traffic is expressed as the summation of products of C and R for each axle weight group. In successive trials, D was re-evaluated using K and revised values for G/β_3 and Σ CR.

For each lesser increment, a trial D was selected; C for the highest axle load group of the preceding increment was added to the next lower C, R values for trial D were determined, summation of C times R was re-evaluated, and a calculated D was deter-

TABLE 2

TYPICAL FACTORS DEVELOPED FROM ROAD TEST EQUATIONS

Effective Pavement Structure (in.)	$\text{Log}(W/\rho)$[1]	R_7[2]	R_{12}	R_{16}	R_{20}
(a) Flexible Pavements					
1.00	-0.14939	21.497	205.18	732.81	2003.1
2.00	-0.20985	23.635	200.65	676.45	1803.0
3.00	-0.21942	26.312	235.14	761.96	1941.7
4.00	-0.22142	27.198	261.56	874.90	2218.1
5.00	-0.22199	27.471	273.48	948.88	2470.1
6.00	-0.22219	27.573	278.57	986.17	2629.0
7.00	-0.22227	27.613	280.73	1003.70	2713.4
(b) Rigid Pavements					
4.00	-0.07871	23.813	202.84	677.45	1781.0
5.00	-0.07908	24.387	216.60	703.92	1810.3
6.00	-0.07915	24.536	225.95	745.19	1883.7
7.00	-0.07917	24.576	229.64	775.43	1980.8
8.00	-0.07918	24.584	230.91	789.80	2053.0
9.00	-0.07918	24.583	231.33	795.62	2090.0
10.00	-0.07918	24.586	231.50	798.15	2108.8

[1] Logarithm to base 10 of ratio of number of axle load applications, W, necessary to cause a given loss in serviceability over number of applications, ρ, causing a loss in serviceability which would remove a test section from road test experiment, also referred to as G/β.

[2] Ratio R_x is number of applications of a 3-kip axle load divided by the number of applications of an axle load x kips causing the same loss in serviceability.

mined. Successive trials were run until the assume D equaled the calculated D. Differences in D-values determined for successive axle weight groups established the increments of pavement thickness that were allocated only to axles heavier than those used in calculating the lesser value.

SIGNIFICANCE OF ROAD TEST EQUATIONS IN INCREMENTAL ANALYSIS

A comparatively small portion of the total user responsibility was allocated by the incremental analysis of pavements using AASHO Road Test equations. For example, in Kansas 17 percent of costs were included in the pavement category and 61 percent in the miscellaneous category which was allocated equally to all classes of vehicles in proportion to travel. In South Dakota, a similar relationship prevailed with 23 percent of responsibility in pavement costs, an amount that is influenced by a high proportion of user responsibility for the State highway system where most high and intermediate-type pavements occurred. The structure, and grading and drainage cost categories each represented a smaller proportion than pavements of the total user responsibility.

For heavier vehicles, the pavement allocation has a much greater effect on responsibility. This could, of course, be inferred from the fact that vehicle size, weight, and travel are the variables which influence the incremental solution. For combination vehicles, approximately 40 percent of responsibility was derived from the pavement analysis. Table 3 and Figure 1 show the composition of the responsibility assigned to the several vehicle classes in Kansas.

Passenger cars and small trucks in the two-axle four-tire class accounted for 88 percent of the total vehicle-miles of travel and were allocated 78 percent of the total highway user responsibility by the incremental solution in Kansas. The distribution of

TABLE 3

COMPOSITION OF USER RESPONSIBILITY BY VEHICLE CLASS INCREMENTAL SOLUTION, KANSAS

Vehicle Class	Derivation of User Responsibility (%)				
	Pavement[1]	Bridges	Grading & Drainage	Misc.	Total
Passenger cars	12	8	11	69	100
Single-unit trucks and buses:					
2 axles - 4 tires	12	8	11	69	100
2 axles - 6 tires	24	15	13	48	100
3 axles	29	30	10	31	100
Combination trucks:					
3 axles	39	21	10	30	100
4 axles	40	28	8	24	100
5 or more axles	39	33	7	21	100
Total	17	11	11	61	100

[1] Based on AASHO Road Test results.

total costs assigned to each of the four incremental cost categories is shown in Table 4. Figure 2 shows total cost responsibility and travel by vehicle class.

Tables 3 and 4 show the relatively great influence that the Road Test equations have in the allocations to heavier types of vehicles. The influences of vehicle type and axle configuration is particularly apparent in Table 2 in the percentage of responsibility derived from structure costs and pavement costs. Both of these cost categories depend on travel and operating weight for the allocation. For the two heavier classes of single-unit trucks, the increase in average operating weight is apparent in the twofold increase

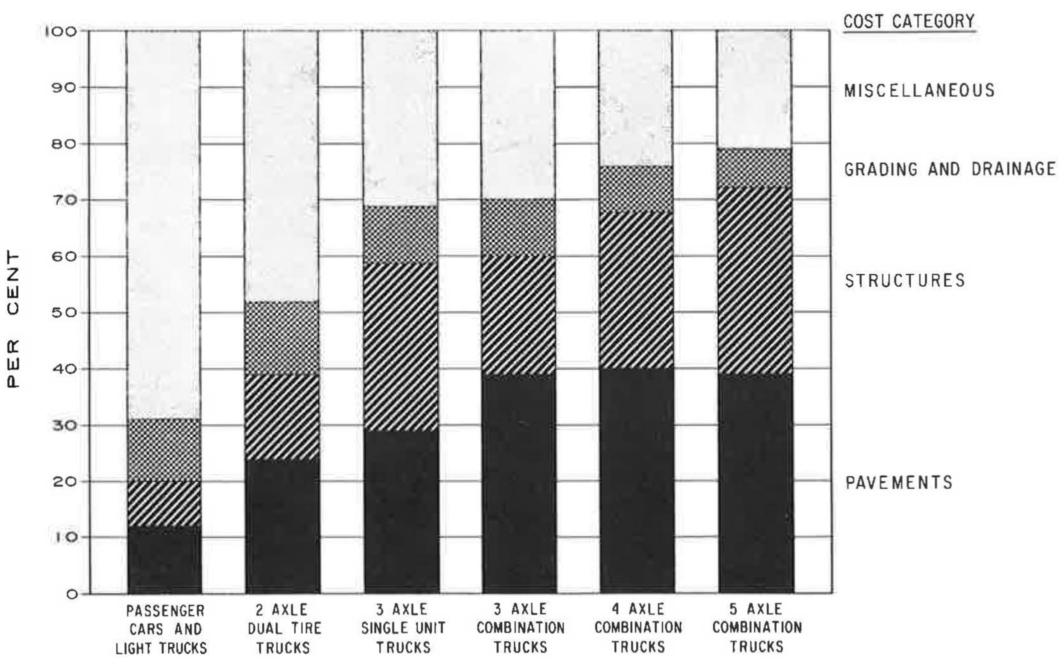

Figure 1. Composition of user cost responsibility, Kansas.

TABLE 4

TOTAL RESPONSIBILITY OF ALL VEHICLES BY CLASS INCREMENTAL SOLUTION, KANSAS

Vehicle Class	Cost Categories (%)				
	Pavement[1]	Bridges	Grading & Drainage	Misc.[2]	All Costs
Passenger cars	49.7	47.2	70.8	77.8	68.8
Single-unit trucks and buses:					
2 axles - 4 tires	6.7	6.6	9.6	10.4	9.2
2 axles - 6 tires	10.7	10.0	8.8	6.0	7.6
3 axles	1.7	2.6	0.9	0.5	1.0
Combination trucks:					
3 axles	6.1	4.9	2.4	1.3	2.6
4 axles	13.8	14.6	4.3	2.3	5.9
5 or more axles	11.3	14.1	3.2	1.7	4.9
Total	100.0	100.0	100.0	100.0	100.0

[1]Based on AASHO Road Test results.
[2]Distribution identical to distribution of total travel by vehicle type.

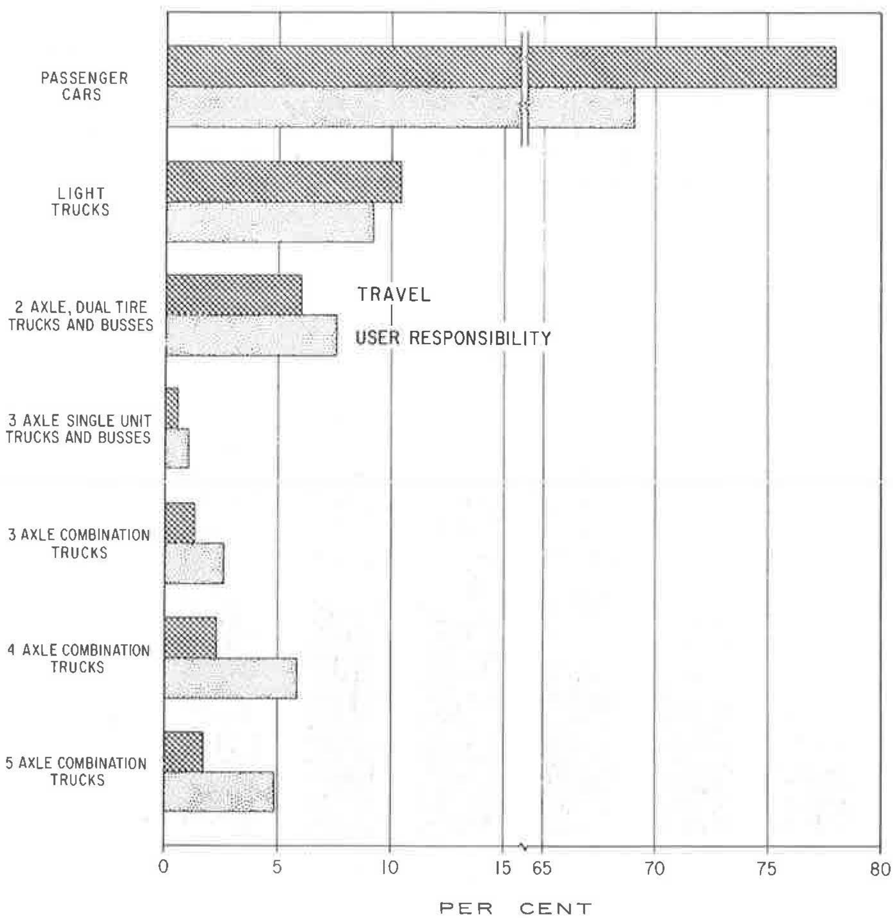

Figure 2. Total user responsibility and travel, Kansas.

in proportion of responsibility in the bridge category. For the same vehicles, pavement responsibility is increased by a factor of 1.2, reflecting the low equivalent single-axle load that replaces the total load on the tandem axles of the three-axle single-unit trucks. The relatively uniform proportion of responsibility for pavements of all combination trucks reflects this same influence. South Dakota results conform to these characteristics, but the effects are less apparent because of sharp fluctuations in reported travel for different vehicle types and weights.

USE OF INCREMENTAL SOLUTION IN FORMULATING RECOMMENDATIONS

Because of the sound basis in logic of the incremental method and because of its inherent ability to reflect the effect of vehicle type on highway costs, the incremental solution strongly influences decisions on user taxation recommendations. Other factors influencing realistic recommendations include allocations by the cost-function, vehicle-mile, and ton-mile methods; the highway user tax structure of the State; the current rates of taxation in the State; and the rates and bases for taxation in other States, particularly those in the same general region. Ideally, the recommended user taxes should

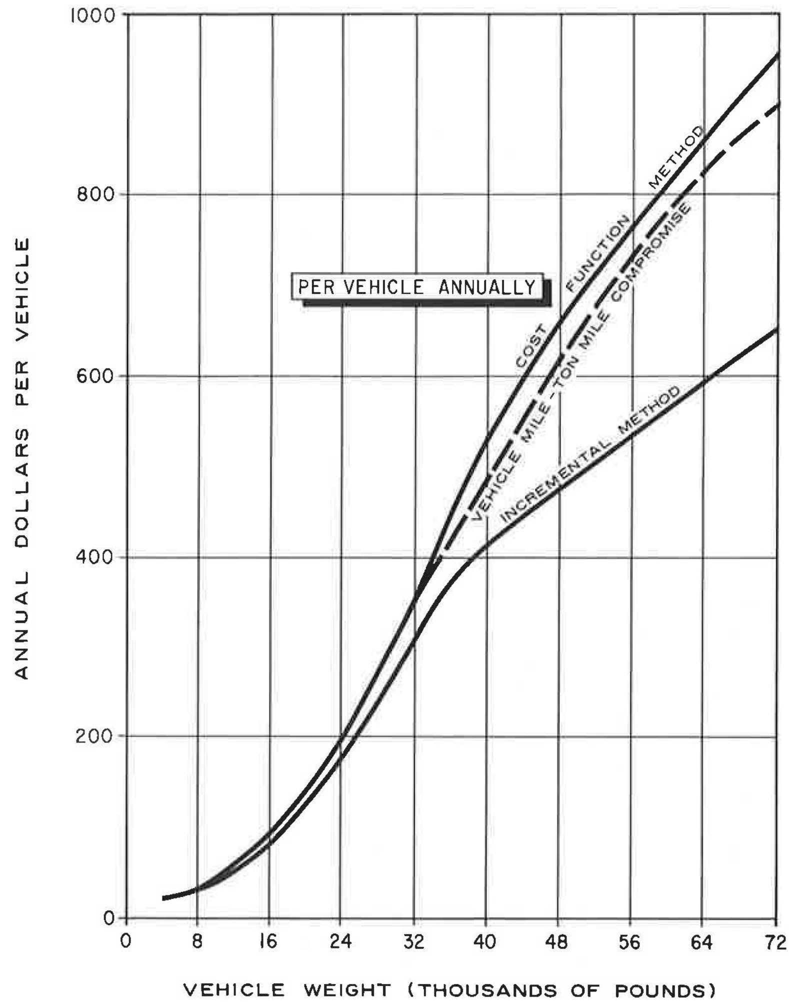

Figure 3. Average cost responsibility per vehicle annually, Kansas.

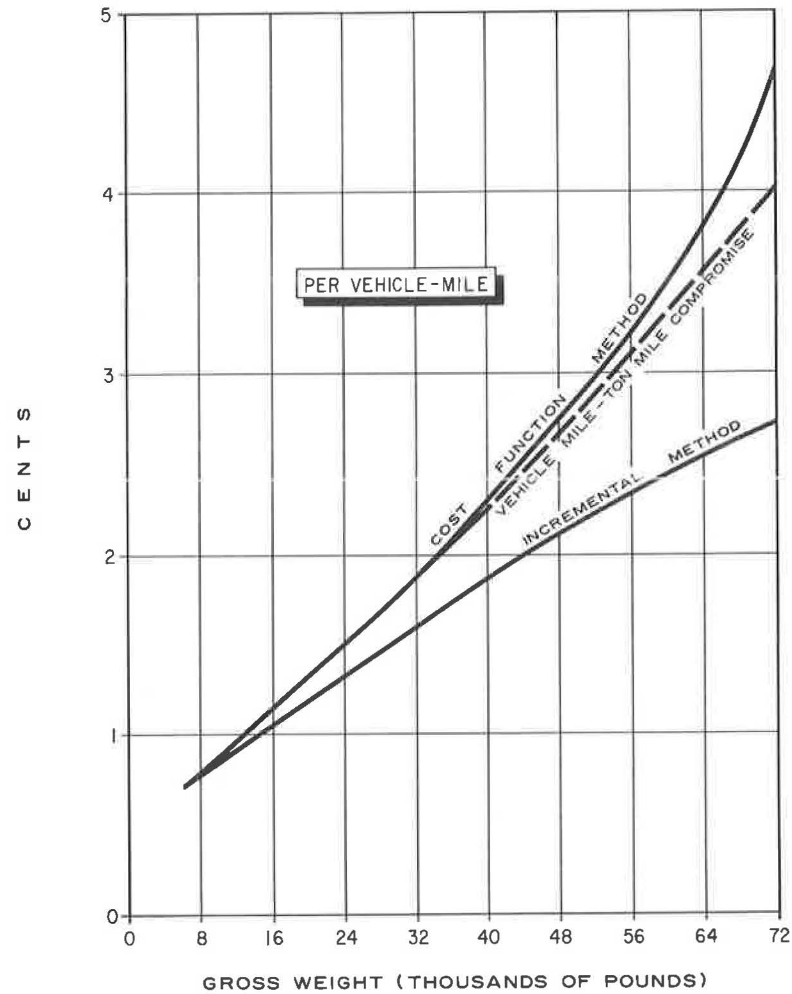

Figure 4. Average cost responsibility per vehicle-mile, Kansas.

provide the needed revenues, assess these revenues in relation to responsibility, and follow a tenable political course. Responsibility varies with type and weight groups of vehicles and with variations of use within the group, making a balance between annual taxes and use-related taxes necessary for equity.

The cost-function allocation and the average of the vehicle-mile and ton-mile allocations were quite similar and the general relationship to the incremental solution was the same in each State. The incremental solution allocated relatively greater responsibility to passenger cars, about the same responsibility to light trucks, and relatively lesser responsibility to heavy trucks with the proportional difference increasing as the weight of the vehicles increased. Figures 3, 4, and 5 show the relationship between the cost function and incremental allocations by gross vehicle weight without regard to type. These curves are for trucks and buses only, and show the average annual responsibility per vehicle and the average responsibility per vehicle-mile and per ton-mile over the period from 1963 to 1982 (2, 3). Table 5 gives the same data by vehicle type and includes the responsibility for passenger cars.

Solutions of allocation assigned total responsibility to each class of vehicles. These totals were reduced to per vehicle, per vehicle-mile, and per ton-mile to facilitate appraisal and presentation. The per-vehicle-mile and per-ton-mile responsibilities

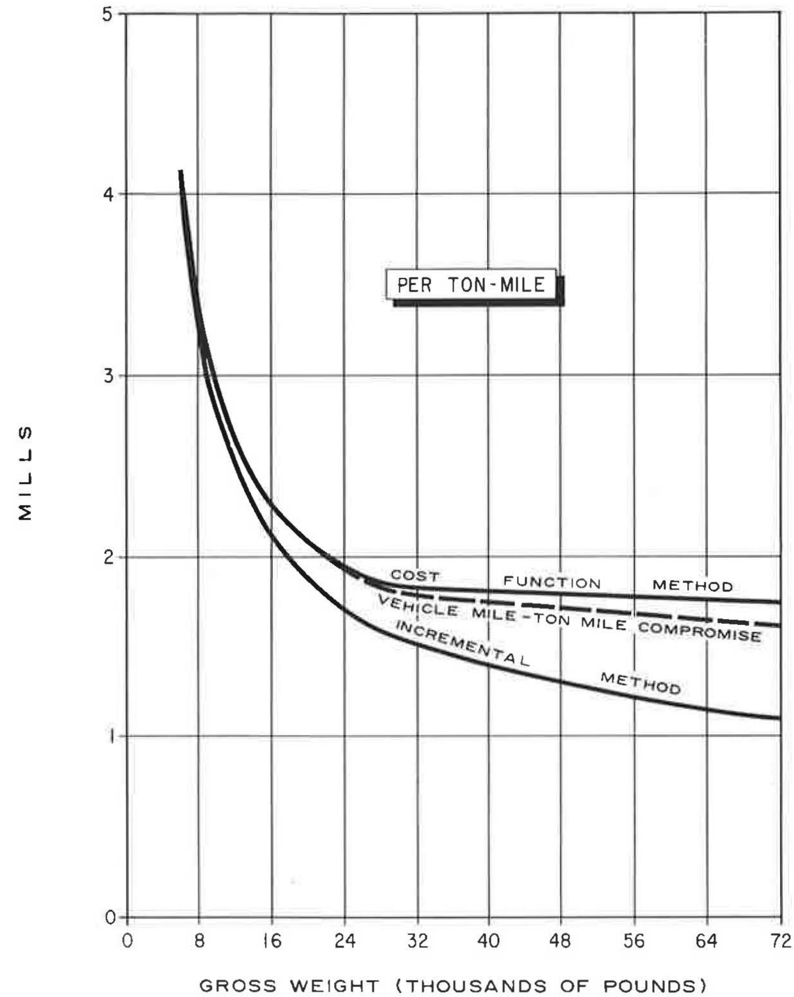

Figure 5. Average cost responsibility per ton-mile, Kansas.

TABLE 5

AVERAGE COST RESPONSIBILITY BY CLASS OF VEHICLE, KANSAS

Vehicle Type	Annual Cost ($)					
	Per Vehicle		Per Vehicle-Mile		Per Ton-Mile	
	Incre-mental	Cost Function	Incre-mental	Cost Function	Incre-mental	Cost Function
Passenger cars	86	77	0.008	0.007	0.0042	0.0037
Single-unit trucks and buses:						
2 axle - 4 tire	53	54	0.008	0.008	0.0032	0.0032
2 axle - 6 tire	105	118	0.011	0.013	0.0019	0.0021
3 axle	310	401	0.017	0.022	0.0014	0.0018
Combinations:						
3 axle	437	546	0.019	0.024	0.0014	0.0018
4 axle	661	963	0.023	0.034	0.0012	0.0018
5 axle or more	547	888	0.026	0.043	0.0011	0.0018

were particularly useful in recognizing trends when average travel and average operating weights varied erratically.

SUMMARY

The AASHO Road Test has provided significant progress in the evaluation of cost responsibility for pavements. It is of particular value in determining relative influence of vehicle type and axle configuration on costs of the pavement structure. However, pavement costs represent a comparatively small part of the total cost responsibility which is normally assigned to motor vehicle users. The magnitude of this portion and the handling of other aspects of the incremental solution are dependent on subjective decisions. Also, there are other analyses and comparisons which must influence the judgment of engineers, administrators, and legislators in proposing and enacting tax rates and tax structures.

The equations derived from the Road Test pavement experiment provide a rigorous though somewhat cumbersome method of allocating pavement responsibility. The quality of the solution is, of course, related to the quality of traffic, pavement design, and cost data to a very large degree and to a lesser degree on method selected to evaluate mixed traffic. In the studies that provided the background for this paper, both data and method were considered entirely adequate for a valid solution.

Results of the incremental analysis, when compared with other allocations, indicate a greater responsibility for passenger cars and proportionally increasing lower responsibility for trucks as weight increases. The tendency for the incremental responsibility to diverge from the responsibility by other methods as vehicle size and weight increases is attributed to the influence of vehicle type and axle configuration in the bridge and pavement categories of the incremental solution.

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Applications of Earnings-Credit and Relative-Use Methods of Highway Cost Allocation

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In the final report on the Highway Cost Allocation Study, the Federal-aid highway program cost responsibilities were allocated between highway users and other beneficiaries on the basis of an averaging of the cost responsibilities as found in the relative-use and earnings-credit procedures. Neither procedure is new, but the added information then available made possible much more thoroughgoing and sophisticated analyses than could be made at the time of their previous application. Although these analyses were oriented primarily toward the Federal-aid portion of the total highway program, the improved techniques developed could also be applied to similar analyses covering all road and street systems at either the National or the State level. This paper sets forth the reasons for the development of the new techniques, explains the modifications made (showing how they differ from the procedures previously used), and indicates how they may be applied in other studies.

• ONE REQUIREMENT of the Highway Cost Allocation Study requested by Section 210 of the Highway Revenue Act of 1956 was "to make available to Congress information on the basis of which it may determine . . . an equitable distribution of the tax burden among the various classes of persons using the Federal-aid highways or otherwise deriving benefits from such highways." The Congress thus requested information concerning a problem that has plagued highway tax and finance researchers for many years, and one that will probably continue to be a subject of research and discussion for many more.

It is almost universally accepted among specialists in the field of highway finance that the tax burden of supporting highways, roads, and streets should, first, be allocated between the users and nonusers, and, second, among the various classes of users. It has been customary to attempt to allocate highway cost responsibility on the basis of estimates of either benefits received or costs caused, although other bases, such as ability to pay, or some combination of bases have been tried on occasion, or at least considered. The fact that benefits received from highways frequently accrue indirectly to ultimate beneficiaries complicates the benefit-allocation analyses considerably, but it does not change the underlying concepts.

Some authorities on government and finance, though recognizing the propriety of allocating highway costs among the various classes of highway users, are convinced that nonusers should not be required to support any part of the cost of the principal road systems. It is recognized that in this complex problem, as in others of public concern, theory alone is not always right or sufficient for practical application; and that considerations of general fiscal policy, as distinguished from highway finance taken alone,

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may at times invalidate carefully worked out solutions of the allocation problem.

Other public finance theorists and practitioners would completely reject the establishment of any relationship between highway disbursements and the taxation of highway users in any form at any level. Their reasons for this attitude vary. Thus, one authority believes that centralized control should be exercised over all areas of public expenditure, and that no single area should be "untouchable" and exempt from control by having a portion of governmental receipts earmarked for it. Another objects to the allocation of such a large proportion of a jurisdiction's resources to a single function of government, while others — education and health are most frequently cited — go vainly begging for funds. A third, and he would represent a good proportion of modern economic theorists, would object because he believes that, to conserve and ration economic resources, highway financing should be approached from a pricing rather than a taxing standpoint. As Zettel said in a panel discussion of perplexing financial problems facing the State highway departments held during the 47th Annual Meeting of the American Association of State Highway Officials in October 1961:

> . . . there are some economists now who believe that the raising of the money from highway users should be entirely unrelated to highway costs. They would ration highway space, they would set prices high enough to make demand clear the market. These . . . argue that highways are badly underpriced.

Another group of economists would almost completely reject the fundamental concept that the provision of highways is a governmental function. They would treat the highway function as a public utility, to be supported wholly by charges to be levied against those who benefited from the highway network.

However, nearly all the States and the Federal Government have now embraced the philosophy of levying taxes on motor vehicles and their use and earmarking the proceeds for the support of the highway function. They have in effect voted down all the other philosophies just listed, largely because the tax-paying public has demanded more and better highways, and has clearly indicated its willingness to pay for them through imposts related in one way or another to highway use.

The Highway Revenue Act of 1956 adopted this philosophy of earmarking the proceeds of highway-user taxation for the Federal support of the highway function, thereby reversing the long-standing policy of supporting Federal aid for highways from general revenues.

COST ALLOCATION STUDY PROCEDURES

In carrying out the mandate of the Highway Revenue Act of 1956 concerning the allocation of the costs of Federal-aid highways between motor-vehicle users and others, the Highway Cost Allocation Study staff (1, p. 6) decided on the following procedure:

> First, to identify and evaluate any specific costs that may not be allocable to motor-vehicle users; second, to work out a general allocation between motor-vehicle users and others by the use of methods that have been in previous Federal and/or State studies of the problems of Highway cost allocation.

For the allocation of highway costs between motor vehicle users and others, the staff chose the "relative-use" and "earnings-credit" methods, the basic concepts of which are generally well known among those who have critically studied problems relating to highway taxation.

Recognizing that highway cost allocation is far from being an exact science, the staff of the Highway Cost Allocation Study considered that a compromise between the conflicting findings of the two studies would probably be more readily accepted than those of either alone. Accordingly, a compromise of the findings of the relative-use and earnings-credit studies was developed and presented in the final report.

This paper is primarily concerned with describing how the relative-use and earnings-credit allocations were made. Special attention is devoted to the improved techniques applied. Although these analyses were oriented primarily toward the Federal-aid portion of the total highway program, the modified techniques employed could also be applied to similar analyses covering all road and street systems at either National or State levels. Examples of actual State-level application are cited.

SOME FUNDAMENTAL CONCEPTS

There is little room for disagreement with the position taken in the Final Report of the Highway Cost Allocation Study (1, pp. 6-7) that no adequate method of measuring the nonvehicular benefits derived from highways has been developed; and, that, in consequence, no way of comparing vehicular and nonvehicular benefits is now available. However, neither the relative-use nor the earnings-credit approach involves the direct analysis of benefits, with the result that the need for direct comparisons of the two types of benefits does not arise.

The relative-use study attempts to assign cost responsibility for each road and street system to users and nonusers in proportion to the extent to which each system renders through-traffic service, community or neighborhood service, or access service. The prosecution and findings of the study are, of course, influenced materially by the definitions and measurements adopted as representative of the three components of total traffic. Variations in defining the three components can vary the final results by a considerable degree. The division of highway service into categories of through-traffic, neighborhood, and land service suggests a parallel allocation of tax responsibility to the motor-vehicle user, to the community, and to land.

The earnings-credit method of cost allocation is based on a pragmatic rather than a theoretical approach to the problem. It combines concepts of the relative-use and standard-cost methods of allocation. Under the standard-cost concept, which was used in a 1951 highway finance study in Ohio, each primary rural and urban road system would be allocated user taxes at a unit rate — per vehicle-mile or ton-mile of travel over it — sufficient to meet its full costs.

Those portions of the costs of other systems not covered by this procedure would need to be met from the property taxes and other general revenues. A description of the standard-cost approach has been given by Simpson (2, pp. 81-87).

The earnings-credit study attempts to assign cost responsibility for each of the several highway and street systems by mediating or averaging such cost allocations between two somewhat inconsistent concepts: (a) each road and street system should receive an allocation of road-user tax revenues at a rate, per vehicle-mile of travel on it, adequate to support the primary or top rural and urban highway systems; and (b) each road and street system should receive an allocation of nonuser tax revenues at a rate, per mile of road or street on it, adequate to support the bottom or lowest-density road or street systems.

RELATIVE-USE STUDY

The principle of taxation according to benefit received underlies not only the practice of road-user taxation but also that of property taxation levied for the support of highways. Measurement of the cost responsibility of nonuser beneficiaries is complicated by the fact that benefits accruing to nonusers are now, in large part, transfers of benefits realized in the first instance by highway users; thus, charges paid by commercial users initially are transferred through the prices charged for their services.

St. Clair (3) postulates that cost responsibility for each road and street system may be allocated between users and nonusers by some measure of the relative amount of service each system renders to abutting property owners, to communities, and to motorists.

Before the 1950's, researchers and investigators were seriously handicapped in their efforts to make highway cost allocation analyses by the lack of usable data. This lack has been, to a substantial degree, reduced by the increasing amount of data made available from the highway planning studies conducted by various State highway departments. As a result of the ever-growing reservoir of factual information, the researchers and investigators have been able to apply scientific study procedures to the cost allocation analyses instead of using the subjective approach.

Among the "scientific" approaches which have become applicable with the increasing availability of certain basic data, is the relative-use method, which St. Clair (3, pp. 3-4) describes as follows:

> A procedure which has been called the theory of relative use would allocate highway tax responsibility in accordance with the extent to which different classes of highways render different kinds of service. The service of direct access to land, although it is the predominant function of local roads and residential streets, is provided to some degree by all classes of highways except controlled-access facilities. Similarly, there is some through traffic even on unimportant roads and quiet streets. There is an intermediate service, that of providing access to neighborhoods, which is the primary function of roads and streets of intermediate traffic importance. This division of highway service into categories of land service, local or neighborhood service, and through-traffic service, immediately suggests the parallel allocation of tax responsibility to the land, the community or general tax base, and the motor-vehicle user.
>
> * * *
>
> Tax responsibility for the support of a given unit road section would, under the relative-use theory, be allocated as follows: to the land, the annual cost of a road facility adequate to support the existing volume of land-service traffic; to the community or general tax base, the annual cost of a facility adequate to support the existing volume of land-service plus community-service traffic, less the increment of cost assignable to the land; and to the motor-vehicle user, the annual cost of a facility adequate to support the total volume of traffic in the section, less the increments of cost assignable to the land and the community. Application of this procedure to a representative sample of all road and street sections in a given State would lead to an evaluation of the respective total highway tax responsibilities of the land, the community, and the highway user.

St. Clair also points out that this general approach to cost allocation was used by the Federal Coordinator of Transportation (4) as an alternate to the added-expenditure method; and subsequently by the Board of Investigation and Research (5), in its public aids study. Other students of the problem have accepted the relative-use thoory in principle, but have simplified its application by allocating tax support in accordance with the predominant type of use to which a given road is put.

In the years that have passed since St. Clair published his report, he and others have done a considerable amount of work toward providing more scientific tools and materials for the relative-use analysis. These efforts included pilot "road-service" studies conducted in Oregon and Washington, which were essentially roadside-interview origin-destination studies made to determine the character of service rendered by selected unit rural road sections. Attempts were also made to apply information obtained for statewide highway physical needs studies toward improving the relative-use analysis techniques.

Application of New Data

The motor-vehicle-use studies that have been conducted on a statewide basis by more than one-half of the State highway departments with Public Roads cooperation since 1951 appear to offer possibilities for the development of a more practical and yet scientific method for making the relative-use analysis than any attempted or suggested previously. These studies provide data on number of trips, purpose of trip, trip length, highway systems used, place of origin, and place of destination. However, the tabulations customarily prepared from these studies are not in the detail necessary for the relative-use analysis. Therefore, recourse must be made to a special trip-by-trip analysis of the original interview forms to obtain the required information. Consequently, during the summer and fall of 1960 the Highway Economics Branch of the Bureau of Public Roads attempted to develop and apply procedures utilizing this data source.

Because in the relative-use analysis mileage of access, neighborhood, and through travel measures each type of service rendered by each road system it became necessary, first, to establish definitions of these terms to which the data available from the motor vehicle use studies could be adapted. It was also equally necessary to define what is meant by a neighborhood in terms of a plane of reference that is consistent with the findings of these studies.

For the study made by the Bureau of Public Roads, information about individual motor-vehicle trips was obtained from a sample of the questionnaires collected in studies conducted by four States: Colorado, Delaware, Kansas, and Tennessee. A comparison with some other data provides one indication that this very small, and perhaps not overly representative, sample provides an acceptable basis for a National relative-use study. Table 1 and Figure 1 show the trip-length distribution for passenger cars from three sets of sample estimates. The first set is that obtained from the four-State subsample. The second set is that obtained by combining the results of motor-vehicle studies conducted in 19 States. The third set is based on the preliminary results of a National automobile-use study conducted independently for the Bureau of Public Roads by the Bureau of the Census.

TABLE 1

PERCENTAGE DISTRIBUTION OF VEHICLE-MILES OF PASSENGER CARS BY TRIP-LENGTH GROUPINGS FOR THREE SETS OF SAMPLE ESTIMATES

One-Way Trip-Length (mi)	Passenger Car Vehicle-Mile Distribution (%)					
	Relative-Use Analysis[1]		Motor-Vehicle-Use Studies[2]		National Auto-Use Survey[3]	
	Actual	Cumulative	Actual	Cumulative	Actual	Cumulative
Under 5.0	12.2	12.2	13.2	13.2	12.3	12.3
5.0 - 9.9	12.2	24.4	15.4	28.6	16.8	29.1
10.0 - 14.9	10.4	34.8	11.2	39.8	14.1	43.2
15.0 - 19.9	9.1	43.9	8.2	48.0	8.4	51.6
20.0 - 29.9	12.3	56.2	10.4	58.4	13.2	64.8
30.0 - 39.9	10.5	66.7	6.5	64.9	7.3	72.1
40.0 - 49.9	8.8	75.5	4.3	69.2	4.1	76.2
50.0 - 99.9	16.4	91.9	10.8	80.0	10.5	86.7
100.0 and over	8.1	100.0	20.0	100.0	13.3	100.0
Total	100.0	-	100.0	-	100.0	-

[1]Based on motor-vehicle-use studies in Colorado, Delaware, Kansas, and Tennessee, excluding travel on toll roads.
[2]Based on motor-vehicle-use studies conducted in 19 States during 1951-56, including travel on toll roads.
[3]Preliminary tabulations from survey conducted for Bureau of Public Roads by the Bureau of the Census during fall of 1959; data obtained chiefly from travel logs kept by respondents, with travel on toll roads included.

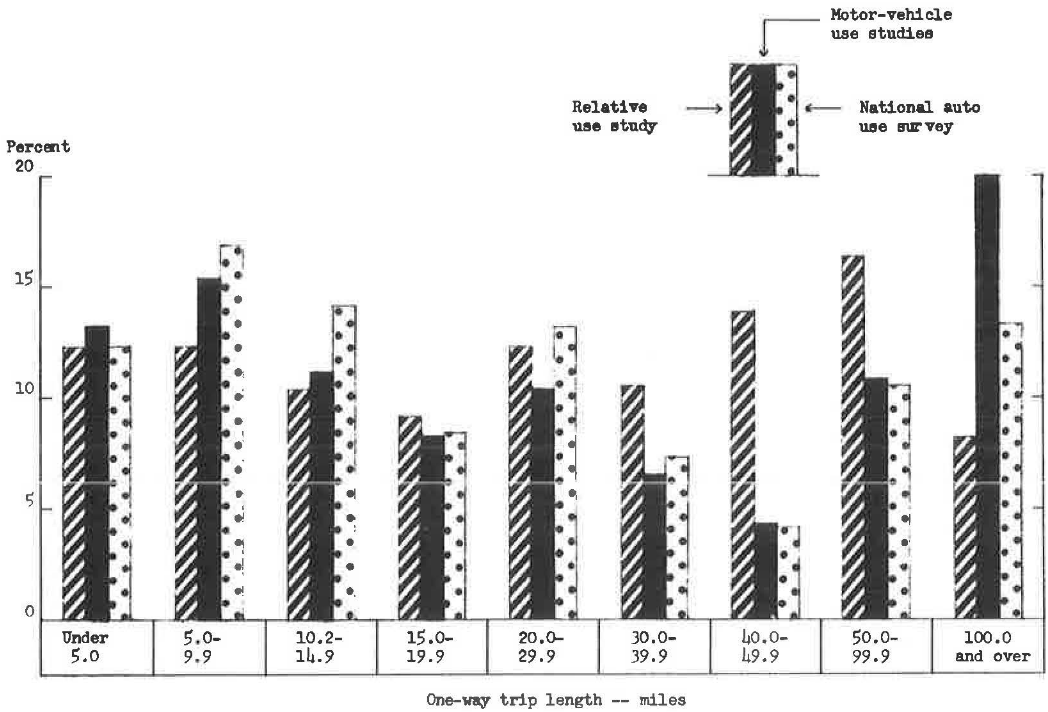

Figure 1. Percentage distribution of vehicle-miles of passenger cars by trip-length groupings for three sets of sample estimates.

The three distributions agree fairly well. At worst, the data for the relative-use analysis underestimate to a small extent the proportion of shorter trips. This possible bias would tend to cause an underestimate, on the National level, of the magnitude of nonuser cost responsibility because of the corresponding overrepresentation of the through-traffic component. On the other hand, it may result in a reasonably accurate forecast of the passenger car trip-length distribution at a time when better roads may be expected to encourage a greater proportion of longer trips.

Table 2 gives by States the total number of interview forms (cases) entering into the analysis for the relative-use study, the corresponding number of trips, and the total number of road system segments used on these trips.

TABLE 2

NUMBER OF CASES, TRIPS, AND ROAD SYSTEM SEGMENTS ANALYZED FOR RELATIVE-USE STUDY

State	Number of Cases	Number of Trips	Number of Road System Segments[1]
Colorado	121	1,044	2,084
Delaware	80	497	1,270
Kansas	177	1,457	2,825
Tennessee	189	2,006	4,242
Total	567	5,004	10,421

[1] Each highway system used on a trip was counted once only for that trip no matter how many times trip route included sections of system.

Access and Neighborhood Segments

Before analysis of any reported trip could be undertaken, it was necessary to define what constituted the "access" portion of a trip, and what constituted the "neighborhood" portion. Any remainder of a trip then constituted the "through travel" portion.

Access Segments. — In the paper previously cited (3), the access portion of a trip was defined as the sum of the distance in the direction of travel along the road or street serving the point of origin of the

TABLE 3

NUMBER OF SAMPLE LENGTHS AND AVERAGE BLOCK LENGTH

1950 Population	City	Uptown		CBD	
		No. of Sample Lengths	Avg. Block Length (mi)	No. of Sample Lengths	Avg. Block Length (mi)
100, 000 or more	Wichita, Kans.	157	0. 08	59	0. 08
	Kansas City, Mo. - Kans.	230	0. 08	104	0. 07
	Wilmington, Del.	88	0. 06	47	0. 06
	Dallas, Texas	97	0. 08	56	0. 06
	San Diego, Calif.	91	0. 07	65	0. 06
25, 000 to 100, 000	Muncie, Ind.	54	0. 06	26	0. 06
	Fayetteville, N. C.	21	0. 08	25	0. 09
	Lancaster, Pa.	32	0. 06	34	0. 06
	Boulder, Colo.	38	0. 08	32	0. 08
5, 000 to 25, 000	Americus, Ga.	19	0. 09	5	0. 07
	Aberdeen, S. Dak.	44	0. 07	20	0. 07
	Gardner, Mass.	24	0. 09	-[1]	-[1]

[1] Not determinable; measurements taken in every area.

trip to the first intersection, and the distance from the last intersection to the destination. This definition was applied without modification to reported trips beginning or ending in unincorporated areas, inasmuch as trip beginnings and trip ends could be accurately located on county culture maps prepared by the State highway departments.

Available information was not sufficient to pinpoint an origin or destination on a map of urban streets. A standardized access distance, therefore, had to be adopted to make analysis possible. Samples of the block lengths of a few cities of various sizes— size being equated to 1950 population— were map-measured to yield estimates of the average block length in each city-size group. In all except one case, a separate average was calculated for block lengths in the central business district (CBD) and in the remainder of the city. Each measurement was of several blocks in a straight line to reduce the relative error for a single block. Table 3 gives the results.

No well-defined trends could be discerned among the sample cities. Therefore, a uniform standard length of 0. 08 mi was adopted; this block length lay between the two extremes of 0. 06 and 0. 09 mi.

The access segment within cities was always taken as one-half the standard block length, or 0. 04 mi.

Neighborhood Components. —Two basic approaches were considered in defining a neighborhood. St. Clair (3) defines a neighborhood as an area of such size as to generate a prescribed number of trip ends (origins and destinations) per day. Available data were not sufficiently detailed to permit the ready establishment according to this approach of standardized neighborhoods for areas of varying population density and land use. A sociologically-oriented definition of neighborhood was, therefore, considered and adopted. Under this approach, neighborhoods are recognized, among other criteria, by the presence of certain facilities and services, such as elementary schools, churches, and local businesses; by a general homogeneity of development; and by the absence of physical barriers that would impede or prevent the normal flow of neighborhood traffic.

The approach adopted also avoids one area of criticism of the St. Clair hypothesis— the determination of neighborhood size strictly on the basis of the number of trip ends generated. It has been contended with merit that to delimit neighborhoods on this basis is neither practical nor correct in theory, although it is granted that for purposes of allocation by the relative-use method the "neighborhood" definition adopted does not need to be in agreement with generally-recognized "community" concepts. It is pointed out, however, that a single block in a downtown business zone, an industrial area, or a

TABLE 4

DISTRIBUTION OF TRIPS MADE FOR FAMILY-NECESSITOUS PURPOSES CLASSIFIED BY STATE, POPULATION GROUP OF RESIDENCE, AND BY TRIP LENGTH

State	Population Group	Trip Distribution for Trip Length of													Total No. of Trips
		0.1 - 0.9 mi	1.0 - 1.9 mi	2.0 - 2.9 mi	3.0 - 3.9 mi	4.0 - 4.9 mi	5.0 - 5.9 mi	6.0 - 6.9 mi	7.0 - 7.9 mi	8.0 - 8.9 mi	9.0 - 9.9 mi	10.0 - 14.9 mi	15.0 - 19.9 mi	20.0 mi and over	
Kansas	Incorporated places of:														
	100, 000 and over	74	58	48	27	9	7	6	1	2	1	2	-	1	236
	25, 000 - 99, 999	67	38	32	16	13	3	2	1	1	2	2	2	-	179
	5, 000 - 24, 999	78	77	19	7	7	2	3	-	2	-	6	-	6	213
	1 - 4, 999	97	19	13	4	4	6	2	-	2	1	11	-	13	171
	Unincorporated areas	44	24	38	21	21	18	15	11	4	2	18	33	15	263
Delaware	Incorporated places of:														
	100, 000 and over	26	50	20	22	6	1	-	-	-	4[a]	-	-	-	129
	25, 000 - 99, 999[b]	-	-	-	-	-	-	-	-	-	-	-	-	-	0
	5, 000 - 24, 999	110	62	4	4	2	4		10	2	10[a]	-	-	-	208
	1 - 4, 999	168	8	2	4	16	4	12	-	-	56[a]	-	-	-	270
	Unincorporated suburban areas	10	16	22	6	28	6	14	-	-	4[a]	-	-	-	107
	Unincorporated nonsuburban areas	24	56	60	78	72	73	50	26	28	170[a]	-	-	-	637

[a]9.0 mi or greater.
[b]No place of this size in State.

dense apartment area might easily generate more trip ends per day than would a thousand square miles in a sparsely settled rural area, which is typical of at least 17 States west of the Mississippi River.

The motor-vehicle-use studies offered a means of at least partially employing the sociological concept of a neighborhood. It is a matter of general knowledge that trips to transact family business (such as medical, dental, or shopping trips) as well as trips to school and church are very frequently made to neighborhood destinations, although the present counter tendency for the cruising radius of the family car to increase is recognized. Any samples of trips made for such purposes, such as described in motor-vehicle-use study questionnaires, would be expected to show a pronounced clustering about a value that could be taken as the neighborhood radius, especially if the analyses were made separately for each population group.

The trip lengths for a sample of the interview forms from the Kansas and Delaware studies were analyzed to discover any clustering tendency. The results are given in Table 4.

For incorporated places, by far the most frequent family business trips were those of less than 2. 0 mi. Within this group, when trips were arrayed in increments of 0. 1 mi each, trips tended to cluster around 1. 0 mi. No pronounced variation in the modal trip length with size of incorporated place could be established.

No consistent tendency to cluster could be discerned for trips made by residents of unincorporated areas on family business. Because no positive basis could be found for a unique definition of a standard neighborhood in unincorporated areas, a uniform definition of 1. 0 mi was adopted for the original analysis for the standard neighborhood around all points of origin and destination, with one exception. That exception is for points within the CBD of a place of 5, 000 or more people. Because of the narrow and congested character of CBD's, a distance of 0. 5 mi was used to define the neighborhood area around points of origin and destination within them.

"Through-Travel" Components. —The "through" portion of a trip is the mileage remaining after the access and neighborhood components have been subtracted. For purposes of the original analysis, through travel was divided into two types, A and B.

Inasmuch as the data available did not permit an exact classification, the classification was made arbitrarily on a graduated trip-radius basis, depending on the type of area in which the trip occurred. Thus, those portions of through travel occurring within 3 mi of the point of origin or destination in unincorporated areas were classified as "through travel, type A," and those portions beyond that point were classified as "through travel, type B." Similarly, a radius of 5 mi was used for medium-sized urban places, and one of 7 mi for the larger metropolitan areas. Although this breakdown was carried throughout the analysis, it was dropped in the final stage when the travel percentages were applied against the dollar program requirements; here the two subtypes of through travel were combined.

Assignment of Trip Mileages

With the adoption of these definitions, it was possible to assign trip mileages to appropriate highway systems and to proper service components. Trip routes that were reported on the motor-vehicle-use study interview schedules for the four States noted earlier were traced on highway maps. Construction of the Interstate System was not far advanced when data for the latest of the motor-vehicle-use studies were collected in 1958. Therefore, the highways that most closely paralleled the routes of the projected Interstate System were designated as comprising that system for the purpose of the relative-use analysis.

The procedure outlined next was adopted for assigning the travel to the correct system and to the proper components of access, neighborhood, and through traffic. The information was entered on coding forms, a sample of which is appended to this paper. To simplify the coding procedures, a separate line was used to record each system-segment of a trip as it was encountered. Thus, if county highways were used on two different portions of a given trip, a separate entry was made for each portion.

"Through travel, type B" is not recorded on the form. It was calculated by subtracting the sum of the mileages shown under "access" (cols. 30-32), "neighborhood (cols. 33-36), and "through travel, type A" (cols. 37-41) from the system-segment total (cols. 25-29). All travel was recorded on one-hundredths of a mile to provide for exact recording of the "access" portions of the trips.

The detail of this procedure was as follows:

1. For a given trip, the highway systems and the mileage traveled on each system were listed in the sequence they were encountered on the trip. Any system might be listed more than once if the trip entered and left that system more than once.
2. The appropriate length of access mileage was credited to the proper system at both origin and destination ends of the trip. This was determined by map measurement for any origin or destination located in an unincorporated, nonsuburban area. Elsewhere, the standardized distance of 0.04 mi was assigned.
3. If any of the listed mileage then remained unassigned, net neighborhood mileage was assigned to the system or systems with the mileages listed immediately following the access mileage, both at the origin and destination end of the trip. Net neighborhood mileage equaled the standard neighborhood radius of 1.0 mi (except for 0.5 mi in CBD's) minus the assigned access mileage. In some cases the trip was so short as to require assignment of all the mileage to the access components.
4. After deduction of the access and neighborhood components, any remaining trip mileage was assigned to the through-traffic component (subdivided between types A and B in the original analysis) and credited to the proper system or systems.

Results

This analysis technique for the trip data in the motor-vehicle-use study sample was applied separately to two vehicle groupings: (a) passenger cars, and (b) trucks and combinations. The distributions of sample mileages by systems were converted to percentage distributions and weighted by the total vehicle-miles of traffic on the system. Two sets of weight bases were used, the nationwide travel estimates for 1957 and the nationwide travel forecasts for 1975. However, Tables 5 and 6 present the unweighted sample distributions as more amenable to weighting with different system and total

TABLE 5

ESTIMATED PERCENTAGE DISTRIBUTION OF TRAVEL BY PASSENGER CARS AND TRUCKS AND COMBINATIONS BY HIGHWAY SYSTEM AND BY RELATIVE-USE CLASSIFICATION COMPONENTS, SOCIOLOGICAL CRITERIA: 1957

Highway System	Area	Distribution of Travel (%)				
		Access	Neighborhood	Access + Neighborhood	Through	Total
(a) Passenger Cars						
Interstate	Rural	1.38	3.05	4.43	95.57	100.00
	Urban	0.52	14.96	15.48	84.52	100.00
Other Federal-aid primary	Rural	0.75	3.40	4.15	95.85	100.00
	Urban	0.69	23.89	24.58	75.42	100.00
Federal-aid secondary	Rural	1.98	8.49	10.47	89.53	100.00
	Urban	0.67	32.17	32.84	67.16	100.00
Non-Federal-aid	Rural	16.62	20.32	36.94	63.06	100.00
	Urban	5.06	63.46	68.52	31.48	100.00
(b) Trucks and Combinations						
Interstate	Rural	0.60	1.11	1.71	98.29	100.00
	Urban	0.24	5.49	5.73	94.27	100.00
Other Federal-aid primary	Rural	0.82	2.20	3.02	96.98	100.00
	Urban	0.40	13.66	14.06	85.94	100.00
Federal-aid secondary	Rural	2.46	8.50	10.96	89.04	100.00
	Urban	0.78	23.86	24.64	75.36	100.00
Non-Federal-aid	Rural	14.97	20.02	34.99	65.01	100.00
	Urban	3.79	53.88	57.67	42.33	100.00

TABLE 6

FORECAST PERCENTAGE DISTRIBUTION OF TRAVEL BY PASSENGER CARS AND TRUCKS AND COMBINATIONS BY HIGHWAY SYSTEM AND BY RELATIVE-USE CLASSIFICATION COMPONENTS, SOCIOLOGICAL CRITERIA: 1975

Highway System	Area	Distribution of Travel (%)				
		Access	Neighborhood	Access + Neighborhood	Through	Total
(a) Passenger Cars						
Interstate	Rural	0.40	2.38	2.78	97.22	100.00
	Urban	0.33	12.48	12.81	87.19	100.00
Other Federal-aid primary	Rural	0.75	3.40	4.15	95.85	100.00
	Urban	0.69	23.89	24.58	75.42	100.00
Federal-aid Secondary	Rural	1.98	8.49	10.47	89.53	100.00
	Urban	0.67	32.17	32.84	67.16	100.00
Non-Federal-aid	Rural	16.62	20.32	36.94	63.06	100.00
	Urban	5.06	63.46	68.52	31.48	100.00
(b) Trucks and Combinations						
Interstate	Rural	0.17	0.97	1.14	98.86	100.00
	Urban	0.21	5.04	5.25	94.75	100.00
Other Federal-aid primary	Rural	0.82	2.20	3.02	96.98	100.00
	Urban	0.40	13.66	14.06	85.94	100.00
Federal-aid secondary	Rural	2.46	8.50	10.96	89.04	100.00
	Urban	0.78	23.86	24.64	75.36	100.00
Non-Federal-aid	Rural	14.97	20.02	34.99	65.01	100.00
	Urban	3.79	53.88	57.67	42.33	100.00

travel estimates, such as would be found in different States. This will result in more reasonable composite estimates by other users of these data.

Effects of Future System Changes

The expenditure of Federal funds for the improvement of the Interstate System is directed toward the achievement of a condition where nearly the entire system is improved to a controlled-access status. It is, therefore, reasonable to take the attitude that the allocation of cost responsibility should be based on the end-of-program status for which the funds are to be spent, rather than on the status at an intermediate year. The estimated access, neighborhood, and through-traffic components of travel on the several systems in 1975 are given in Table 6.

The access changes on systems below the Interstate are assumed to be negligible, as these lower systems are expected to render much the same kinds of service in the future as they do now. The estimated changes in the service characteristics of the Interstate System were based on certain known or highly predictable changes that will occur, among which the following are the most prominent:

1. Access service on the Interstate System will be rendered only by frontage roads. The volume of access service will, therefore, be contingent on the expected mileage of frontage roads.
2. Neighborhood service on the Interstate System will be rendered by both frontage roads and interchanges.
3. An expected reduction of neighborhood service on the Interstate System will be chiefly accomplished by the elimination of short trips. All those that are shorter than the spacing between interchanges may be presumed to be eliminated; and a part of those that are longer will be discouraged by the effort of getting on and off the controlled-access highway, although it is impossible to estimate the latter with any degree of accuracy. The amount of reduction in neighborhood travel will, therefore, be contingent on the average spacing of interchanges, which will probably average between 4 and 5 mi in rural areas and slightly over 1 mi in urban areas. Consequently, for the end-of-program analysis all rural trips under 5 mi and all urban trips under 2 mi were eliminated from the Interstate System.

Modification Based on Recalculation of Travel Radii

The draft of the final report on the Highway Cost Allocation Study underwent extensive and critical scrutiny before the report was submitted to the Congress. Some of the reviewers of the draft expressed dissatisfaction with the values used for the neighborhood distances or radii (0.5 mi in CBD and 1 mi elsewhere) used in the single relative-use analysis included in the draft report, the procedure already described in this paper. The reviewers inquired what the effect on the percentage findings of the relative-use analysis would be if reasonable but significant changes were made in the specifications for the size of neighborhood area.

When the original analysis was made, it had been considered that lack of necessary data would bar the use of a neighborhood concept based on the number of trips terminating within specified areas, the procedure advocated by St. Clair (3). To answer the questions raised by the reviewers it was decided to attempt an alternative analysis conforming generally to St. Clair's procedure in spite of the lack of important segments in the basic data required for such an analysis.

The St. Clair thesis was that the size of the neighborhood area should be made to vary inversely with the density of population and business aggregation — from very small in the CBD's of large cities to very large in areas of low density of dwellings or other traffic-generating establishments. He suggested that to tie the neighborhood definition in with the generation of motor vehicle traffic, a neighborhood area might be defined as an area generating a fixed number; say, 5,000 or 10,000 trip origins or destinations per day.

To test his hypothesis, St. Clair made extensive analyses of origin-destination data obtained some years ago for the Baltimore Transportation Study. The results of his analysis of various zones in downtown Baltimore and its suburbs indicated that if a neighborhood were to be defined in terms of 10,000 trip ends per day the radius of a circular area would vary from approximately 0.12 mi in the center of the city to 1.8 mi or more in the outlying suburbs. Expressed in terms of "square" areas the variation would be from about 0.2 to 3.2 mi or more on a side of such an area, or, expressed in terms of average-sized city blocks, from 2 to 30 blocks or more on a side.

The data applied in the first analysis made for the Highway Cost Allocation Study were reexamined under this concept, and "neighborhood" and "through travel" (types A and B combined) components were reallocated on this general basis. Access travel was not affected. The result was a range in neighborhood-area radii considerably more modest for urban areas than would have been indicated by the Baltimore data analyzed by St. Clair, but which was still generally in line with the traffic-generation concept. The redefined radii for the various classes of incorporated and unincorporated areas adopted for the analysis are given in Table 7.

The changes in definition of the neighborhood radius were such as to reduce the size of the neighborhood component of a trip in urban areas and to enlarge it in rural areas. The resulting changes in allocation of highway costs between motor-vehicle-user taxes and other revenue sources were substantial but were not of such magnitude as to indicate fundamental disagreement with the previous analysis. The unweighted sample percentages from this analysis are given in Tables 8 and 9 for 1957 and 1975. These may be compared with those resulting from the previous analysis (Tables 5 and 6).

Suggestions on Application of Relative-Use Procedures

In applying these percentages in a relative-use analysis for a given State where a motor-vehicle-use study had not been made or where the individual interview forms were not available, the proper procedure would be to determine the vehicle-type composition of present and projected travel for the rural and urban portion of each highway system separately, then multiply each travel figure by the appropriate percentage in Tables 5 and 6 or Tables 8 and 9, depending on the neighborhood definition adopted. The resulting values should be summed to make a composite travel table, and a new composite percentage distribution should then be calculated. These latter percentages can be applied against the appropriate program dollars to obtain the individual assignments of dollar responsibility.

Certain shortcomings which must be made up for by some means are reflected in Tables 5 and 6. Unfortunately, the motor-vehicle-use study samples were too small to provide stable samples for the various classes of trucks and combinations separately. Furthermore, motorcycle and bus operations were not included in these studies nor in Tables 5 and 6. The adjustment to separate light trucks from heavy trucks and combinations should not be unduly difficult to make if separate travel figures are available for such vehicle types, and if it can be assumed that the travel patterns of passenger cars and light trucks are essentially similar.

Estimating the characteristics of bus travel is a different matter. Bus operations are usually divided into three broad groupings: (a) intercity; (b) transit, including sightseeing and certain miscellaneous operations; and (c) school and nonrevenue. Estimates by rural and urban system segments of travel by these groupings of vehicles during one year were made by the individual States for the Public Roads

TABLE 7

REDEFINITION OF NEIGHBORHOOD RADII FOR RELATIVE-USE ANALYSIS

Location of Trip Origin or Destination	Neighborhood Radius (mi)
Unincorporated, nonurbanized areas:	
Sparse rural[1]	3.00
Medium rural[2]	2.00
Dense rural[3]	1.00
Urbanized areas:	
Central city, downtown[4]	0.25
Central city, remainder	0.50
Outside central city	0.50
Incorporated places with population of 5,000 and over, not in urbanized area:	
Downtown	0.50
Remainder	0.50
Incorporated places with population of 4,999 or less, not in urbanized area	1.00

[1] Less than 2 dwelling units per square mile.
[2] From 2 to 40 dwelling units per square mile.
[3] More than 40 dwelling units per square mile.
[4] Including CBD, industrial, waterfront, and financial areas.

TABLE 8

ESTIMATED PERCENTAGE DISTRIBUTION OF TRAVEL BY PASSENGER CARS AND TRUCKS AND COMBINATIONS BY HIGHWAY SYSTEM AND BY RELATIVE-USE CLASSIFICATION COMPONENTS, TRIP TERMINI CRITERIA: 1957

Highway System	Area	Distribution of Travel (%)				
		Access	Neighborhood	Access + Neighborhood	Through	Total
(a) Passenger Cars						
Interstate	Rural	1.38	4.33	5.71	94.29	100.00
	Urban	0.52	8.79	9.31	90.69	100.00
Other Federal-aid primary	Rural	0.75	4.72	5.47	94.53	100.00
	Urban	0.69	11.67	12.36	87.64	100.00
Federal-aid secondary	Rural	1.98	13.79	15.77	84.23	100.00
	Urban	0.67	13.11	13.78	86.22	100.00
Non-Federal-aid	Rural	16.62	34.58	51.20	48.80	100.00
	Urban	5.06	50.21	55.27	44.73	100.00
(b) Trucks and Combinations						
Interstate	Rural	0.60	1.85	2.45	97.55	100.00
	Urban	0.24	3.57	3.81	96.19	100.00
Other Federal-aid primary	Rural	0.82	3.03	3.85	96.15	100.00
	Urban	0.40	5.90	6.30	93.70	100.00
Federal-aid secondary	Rural	2.46	13.37	15.83	84.17	100.00
	Urban	0.78	13.96	14.74	85.26	100.00
Non-Federal-aid	Rural	14.97	35.69	50.66	49.34	100.00
	Urban	3.79	39.54	43.33	56.67	100.00

TABLE 9

FORECAST PERCENTAGE DISTRIBUTION OF TRAVEL BY PASSENGER CARS AND TRUCKS AND COMBINATIONS BY HIGHWAY SYSTEM AND BY RELATIVE-USE CLASSIFICATION COMPONENTS, TRIP TERMINI CRITERIA: 1975

Highway System	Area	Distribution of Travel (%)				
		Access	Neighborhood	Access + Neighborhood	Through	Total
(a) Passenger Cars						
Interstate	Rural	0.40	3.19	3.59	96.41	100.00
	Urban	0.33	5.04	5.37	94.63	100.00
Other Federal-aid primary	Rural	0.75	4.72	5.47	94.53	100.00
	Urban	0.69	11.67	12.36	87.64	100.00
Federal-aid secondary	Rural	1.98	13.79	15.77	84.23	100.00
	Urban	0.67	13.11	13.78	86.22	100.00
Non-Federal-aid	Rural	16.62	34.58	51.20	48.80	100.00
	Urban	5.06	50.21	55.27	44.73	100.00
(b) Trucks and Combinations						
Interstate	Rural	0.17	1.85	2.02	97.98	100.00
	Urban	0.21	2.94	3.15	96.85	100.00
Other Federal-aid primary	Rural	0.82	3.03	3.85	96.15	100.00
	Urban	0.40	5.90	6.30	93.70	100.00
Federal-aid secondary	Rural	2.46	13.37	15.83	84.17	100.00
	Urban	0.78	13.96	14.74	85.26	100.00
Non-Federal-aid	Rural	14.97	35.69	50.66	49.34	100.00
	Urban	3.79	39.54	43.33	56.67	100.00

Highway Cost Allocation Study, and should be available as a guide to further estimating. Accurate determination of the access, neighborhood, and through components of bus travel is probably out of the question because buses render all types of travel at the same time depending on the origin and destination of their passengers. Consequently, it might, perhaps, be assumed with impunity that for want of a better base all travel of intercity buses can be assigned to the "through" category, and that of transit, school, and nonrevenue buses to the "neighborhood" category.

Motorcycle operations were estimated to account for less than 0.2 percent of travel on all systems in 1957, according to Table 7 (6). Considering this fact and the extreme lightness of these vehicles, even when loaded, it may be entirely reasonable to omit them from the cost-allocation calculation. If it is desired to include them, it might be safe to assume that their travel characteristics are essentially the same as those of passenger cars.

EARNINGS-CREDIT ANALYSIS

In 1951, Simpson (2, p. 78) stated that all the three classical theories of public finance have been drawn on for the financial support of the highway function: benefit, ability to pay, and cost. He cited the use of special assessments in the financing of city streets as an example of direct "benefit" taxation; the support of highways by general taxation as an example of taxation on the basis of some assumed measure of ability to pay; and the financing of main highways through taxes on motor vehicle users graduated somehow in relation to costs incurred as an example of taxation on the basis of cost. Except for residual allocations, Simpson rejected all but the cost principle in his analyses.

In his discussion of highway tax theory, Simpson (2, p. 76) described the then new proposal by St. Clair for an "earnings-credit" analysis as an application of "predominant use at both ends [i.e., primary highways and land-services roads] so to speak," with an averaging of the results. He summarily dismisses this method, along with others, as a "benefit" approach, and applies in its place the "standard-cost" approach, which he describes as an attempt to allocate "the cost of providing highway facilities for motor traffic" according to a measure of "a 'reasonable cost' that is properly chargeable to motor traffic." He justifies his approach (2, pp. 81-82) as being in line with the application of the reasonable cost concept as applied by the Interstate Commerce Commission, other regulatory bodies, and the courts to railroads and public utilities for nearly a century.

To many, the differentiation noted by Simpson between the earnings-credit "top-drawer" calculation, which he designated a benefit approach, and his own standard-cost method, which he described as a cost approach, seems rather illusory because of the great similarity between the calculations involved in both instances, even though Simpson made his cost allocation on the basis of ton-mile units, whereas vehicle-mile units are customarily, but not necessarily, used in the earnings-credit analysis. A brief description of the standard-cost approach will clarify the situation.

Standard-Cost Approach

Drawing on the utility analogy, Simpson attempted to begin the distribution of joint highway costs by determining the costs chargeable to highway users and treating the remainder as "residual costs" assignable to other groups. He contended that the costs assignable to general property, governmental functions, and "neighborhood and community services" were "practically unascertainable." But, he also contended, the cost of providing services to motor vehicle traffic can be ascertained with a reasonable degree of accuracy, providing certain assumptions are made.

The "standard-cost" approach consists of assigning "reasonable costs" of providing "highway facilities for motor traffic." The development of the so-called "reasonable-cost" concept was, then, the key item in the Ohio Study. The "reasonable cost" assignment used was the cost per ton-mile of the rural portions of the State A and B systems. This cost per ton-mile was applied to the ton-miles of travel for all roads and streets as the highway-user share of total costs. The difference between this share and the total cost was considered as the nonusers' contribution. In discussing the assignment of costs, Simpson (2, p. 81) says:

> But when we undertake to ascertain the cost of providing "highway facilities for motor traffic," we are immediately confronted by the fact that there are highway facilities which are not provided primarily for motor traffic, which have little relation to the volume of motor traffic on them, and which would, in fact, be there if there were no motor traffic. These are the local rural roads and residential access streets in the cities, upon which the costs, if assigned entirely to motor transportation, would be excessive and unreasonable. Any assignment of costs, whether per vehicle-mile, per ton-mile, or other measure, on a Statewide mileage basis must necessarily include these lightly traveled roads and streets.

Simpson used his standard-cost technique to accomplish three ends: (a) to determine the costs to be assigned to motor vehicle users, (b) to determine a residual cost to be assigned to others, and (c) to allocate the users' share among the various types and classes of vehicles.

Earnings-Credit Approach

It has already been mentioned that the earnings-credit method of cost allocation is based on a pragmatic rather than a theoretical approach to the problem. Simpson (2, p. 76) describes it as a method of overcoming some of the obvious shortcomings of the "predominant-use" modification of the "relative-use" analysis, in which predominant-use concepts are applied to both the primary and local highway systems, and the results averaged. This is an oversimplification, but it dramatically and succinctly describes what actually takes place in the usual earnings-credit analysis without giving the fundamental reasons.

The earnings-credit method may properly be considered as a variant of the "standard-cost" and "relative-use" approaches in which certain somewhat inconsistent concepts of the two methods are applied to combine some of the best features of both. It is based on a merger of or compromise between two concepts:

1. That the user component of tax support on all highway systems should be based on the average cost per vehicle-mile of primary highways, or better. This is the so-called "top-drawer" solution.
2. That there should be a nonuser component of highway tax support on all systems based on the average cost, per mile, of tertiary or access roads and streets. This is known as the "bottom-drawer" solution.

The first concept recognizes that the user has tax responsibilities chiefly for the support of the primary highways and also to a lesser, yet substantial degree, for all other roads and streets. In an orderly array of highway program costs, the costs per vehicle-mile of travel will increase substantially as the traffic importance of the highway system decreases. The costs per mile, however, act in reverse order, with the unit costs decreasing as the traffic importance of the system decreases. Therefore, a cost-per-vehicle-mile rate which will pay for the primary system can be considered as a reasonable contribution toward the support of all other highway and street systems. This, of course, results in a very substantial allocation of costs for all roads and streets to the user.

The second concept recognizes the fact that the tertiary or access road and street costs constitute a tax responsibility of the abutting property and the community which are the chief beneficiaries of such improvements. It also recognizes another principle — communities derive benefits, possibly intangible but nonetheless substantial, from the primary and secondary systems. Cognizance of this principle is expressed by assigning the cost per mile of the lowest system to all systems as a nonuser contribution.

This concept called the "bottom-drawer" solution results in a distribution of costs which materially lessens the user-cost responsibility.

To smooth out the rather variable assignments of costs arrived at by the application of the two concepts, a compromise of the cost assignments is arrived at by averaging the costs per vehicle-mile obtained from the two solutions. This modifies the user share obtained from the "top-drawer" solution to some extent and ordinarily raises it above that obtained from the "bottom-drawer" solution.

In the original work on the "earnings-credit" approach, a modification was introduced which took account of the lower level of costs per vehicle-mile on urban systems. In commenting on this modification, St. Clair (3, pp. 12-13) states:

> Certain of these principles and provisos need to be amplified by further discussion. The indicated modification providing that motor-vehicle tax earnings shall be credited at a lower rate to urban streets than to rural roads appears to be inconsistent with the earnings-credit principle, if the latter is to be taken as the guiding concept of the solution. This modification obviously works to the disadvantage of the cities and to the advantage of the rural roads, and particularly of the local rural units. It may be remarked at this point that the proposed method of analysis does not attempt to set up a completely logical theory, but rather to bring about a compromise among several concepts, none of which appears able to stand alone.
>
> With respect to the rural-urban modification, it may be remarked that the cities are a more productive source of taxable wealth than the rural areas, and that this wealth is in large part derived from industrial and commercial relations with the surrounding countryside. Furthermore, as a practical matter, the cities in most States will fare much better under the proposed solution, even with the rural-urban modification, than they do at the present time.
>
> A study. . . will reveal the fact that costs per vehicle-mile on city streets are likely to be remarkably low; and this is particularly true of those arterial streets which form the connecting links of the State primary system. If the earnings-credit solution were applied, so to speak, across the board, the rate of motor-vehicle taxation per vehicle-mile would have to be set at a point below the cost per vehicle-mile of the primary urban system, and this would result in a ratio of motor-vehicle to non-motor-vehicle tax responsibility so low as to prove unacceptable to most students of the subject, as well as to the general public.

Availability of Data

To perform an earnings-credit analysis, it is necessary to have available detailed needs, costs, and travel data for all road and street systems. The highway needs, costs, and travel data for all systems were prepared and submitted by the several State highway departments in connection with the Section 210 Study. Such data contemplated a 15-year improvement program (1956-71), and the needs were based on design criteria that were assumed adequate to accommodate types and volumes of traffic anticipated for the year 1975. There was, therefore, an array of needs, costs, and travel data much more complete and detailed than had hitherto been available for any earnings-credit study concerned with all roads and streets.

Conduct of Study

In making previous earnings-credit analyses for individual States, certain standard procedures were followed which had been more or less predetermined. It was observed rather early in the Highway Cost Allocation Study that some of those procedures would have to be modified in order to be applicable to an analysis involving all roads and streets of the Nation. These procedures and reasons for the modification are given next.

The highway systems, their needs, estimated travel and mileage usually included in a typical analysis at the State level are approximately as follows:

System	Rural	Urban
State primary	x	x
State secondary	x	x
County and other local rural roads	x	-
City streets:		
Arterials	-	x
Local	-	x

The rural and urban portions of the State primary systems constituted the road systems used for the top-drawer solution; and county roads and local city streets constituted the respective rural and urban road systems for the bottom-drawer solution. It has always been recognized that the arbitrary grouping of needs under the legally constituted road systems, although implementing the presentation of the assembled data, and very satisfactory for administrative purposes, did not represent as refined a presentation of the data as would be desirable. There is usually a considerable mileage of the county road system in an average State which will be expected to carry a substantially greater volume of traffic than many portions of the rural State secondary system and, possibly, a few sections of the State primary system. The same is generally true with regard to arterial and local streets in comparison with the urban portions of the State systems. Therefore, the grouping of all county and local rural road costs under the county system, and assigning to that system the key index of the bottom-drawer solution, results in some sections of road with a high-type design criterion being assigned to a system supposedly concerned only with a land-access function. Similar situations also exist among other systems.

This situation became very apparent in the data assembled in connection with the Highway Cost Allocation Section 210 Study. Projections of travel by road systems and surface types to 1975 showed that about 496, 000 miles of county and local rural roads, and 333, 000 miles of city streets were designed with intermediate- or high-surface types. The anticipated average daily traffic (ADT) on these roads and streets ranged from 161 to 981 on the rural portion and from 191 to 3, 221 on urban. Obviously, the function of such roads and streets is expected to be above that which could be considered access.

The detail of data available as already noted made it possible to array the mileage of various surface types of a road system into what appeared to be the most logical order for the earnings-credit analysis. The original data submitted by the States showed the needs, by surface types (unsurfaced, low, intermediate, and high) for 12 separate systems. These were as follows:

System	System Number	
	Rural	Urban
Interstate	1	2
Other Federal-aid primary	3	4
Federal-aid secondary:		
State	5	6
Local	7	8
Other State highways	9	10
Local roads	11	--
Local streets	--	12

TABLE 10

DISTRIBUTION OF ROAD SEGMENTS, MILEAGE, AND TRAVEL TO TOP, SECONDARY, AND BOTTOM GROUPS OF EARNINGS-CREDIT ANALYSIS

Group	Highway System	Surface Type	Miles on System[1]	Percent	Cost[2] per Mile ($)	1975 Travel on System: Vehicle-Miles (millions)	Percent	Cost per Vehicle-Mile ($)	ADT
Top	Interstate	High	36,427	1.17	25,470	232,605	20.39	0.00399	17,495
	Other FA primary	High	196,265	6.33	12,020	367,797	32.23	0.00641	5,134
		Intermediate	23,189	0.75	6,840	4,199	0.37	0.03775	496
	Subtotal		255,881	8.25	13,460	604,601	52.99	0.00570	6,473
Secondary	FAS	High	203,725	6.57	6,540	153,861	13.48	0.00866	2,069
		Intermediate	297,420	9.59	2,290	27,277	2.39	0.02493	251
	Other State highways	High	36,495	1.18	10,750	36,292	3.18	0.01081	2,724
		Intermediate	39,411	1.27	2,650	3,972	0.35	0.02633	276
	Other local roads and streets	High	322,581	10.40	6,720	257,519	22.57	0.00842	2,187
	Subtotal		899,632	29.01	5,200	478,921	41.97	0.00977	1,458
Bottom	FAS	Low	128,904	4.16	1,770	2,732	0.24	0.08338	58
	Other State highways	Low	4,978	0.16	2,430	180	0.01	0.06722	99
	Other local roads and streets	Intermediate	506,922	16.35	2,470	31,591	2.77	0.03963	171
		Low	1,304,603	42.07	0,930	23,012	2.02	0.05269	48
	Subtotal		1,945,407	62.74	1,390	57,515	5.04	0.04702	81
Total			3,100,920	100.00	3,490	1,141,037	100.00	0.00949	1,008

[1]Estimated in service at completion of program, excluding toll-facility mileage or the 2,102-mi expansion of Interstate System.
[2]Estimated annual cost of investment in right-of-way and construction and estimated maintenance and administration costs, all at last half of 1956 price level and at 0 percent interest rate.

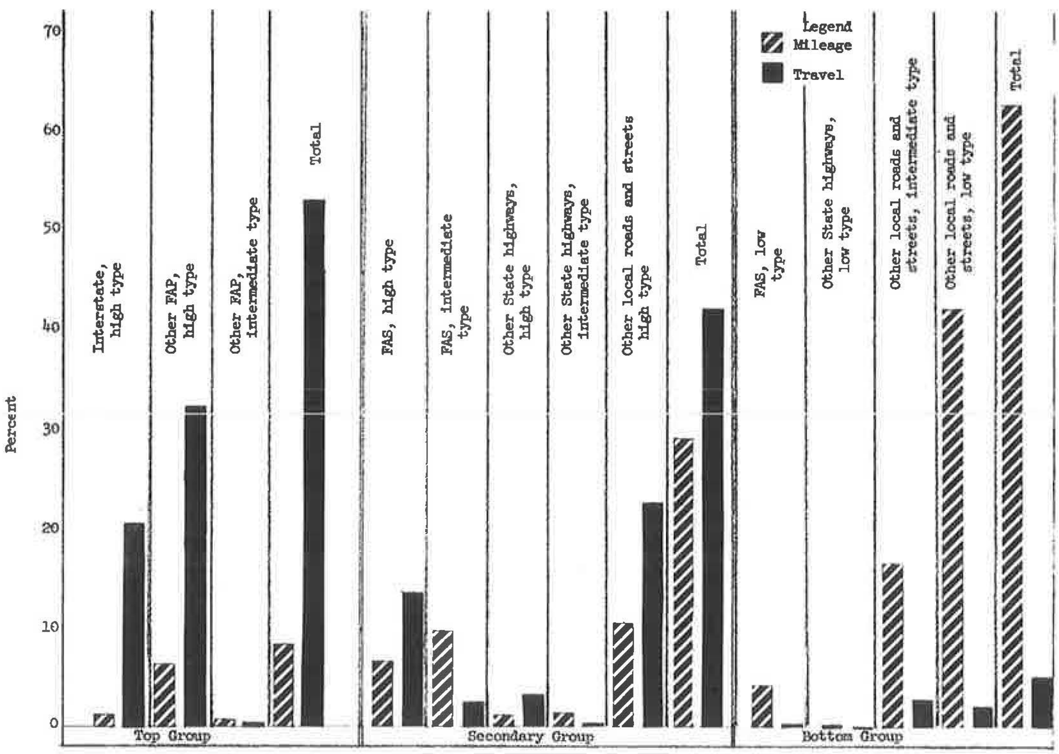

Figure 2. Percent distribution of mileage and travel for all roads and streets by earnings-credit study distribution, 1975.

In the usual conduct of an earnings-credit analysis the Interstate and other Federal-aid primary systems would be combined to form the top-drawer systems, with the local roads and urban streets forming the bottom-drawer systems. However, the available data made it possible to segment the systems in a more realistic pattern. The resulting array for each road system segment is included in Table 10 and Figure 2.

The road systems in the top grouping comprise only 8.3 percent of the total mileage but are expected to accommodate 53.0 percent of the estimated total travel in 1975. These systems are expected to have an ADT of about 6,500 at that time; this system is composed of all Federal-aid primary (FA) highways, including the Interstate routes.

The segments of road systems in the secondary groups contain 29.0 percent of the total mileage and are expected to carry 42.0 percent of the total travel in 1975 and to have an ADT of 1,458. About 80 percent of the Federal-aid secondary (FAS) mileage is on this system.

The bottom groups, consisting of 62.7 percent of the total mileages, are expected to carry only 5.0 percent of the total traffic and have an ADT of 81 by 1975. About 20 percent of the FAS mileage is on this system.

Table 10 and Figure 2 show that a rather orderly array of road types by traffic volume groups was obtained, and that the three groups appear to line up fairly well with the three travel components of the traffic stream; namely, through, neighborhood, and access.

Figure 3 shows costs per mile and costs per vehicle-mile for the three highway

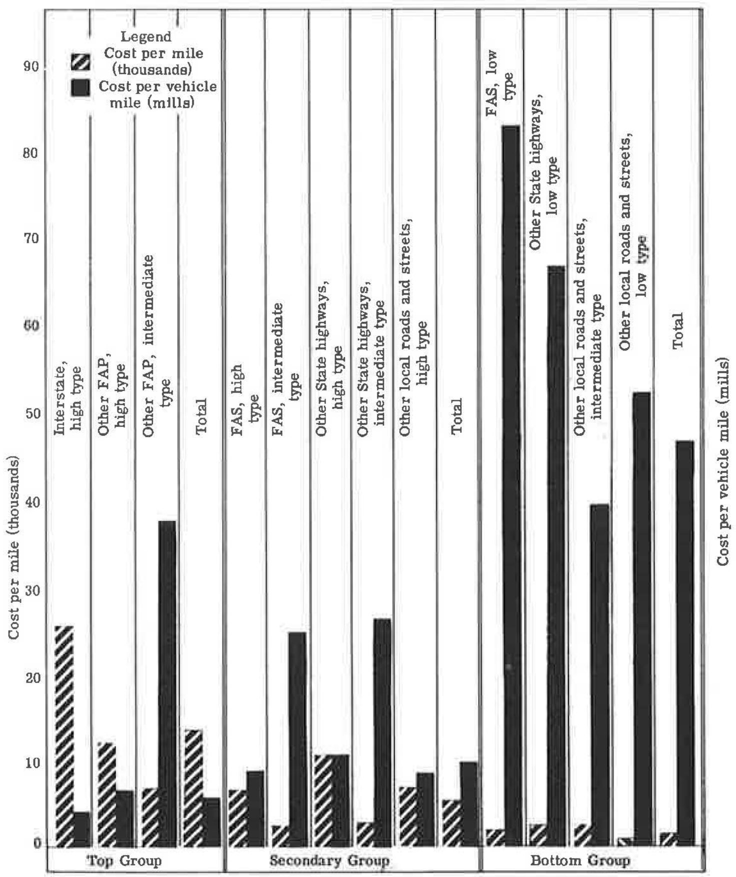

Figure 3. Cost per mile and costs per vehicle-mile for all roads and streets by earnings-credit study distribution.

groups. The top group, although having the highest average annual cost per mile ($13,460) has the lowest cost per vehicle-mile ($0.00570).

As the earnings-credit analysis for the Highway Cost Allocation Study was concerned only with equity of taxes imposed at the Federal level and earmarked for the highway trust fund, program costs in which there was no Federal participation could not be considered. Therefore, the costs of maintenance, operation, administration, and highway police incurred by the States for Federal-aid highways were not included. Also, because the study was concerned with only capital costs, a large mileage of road which would be unsurfaced at the end of the program period (1971) was eliminated from the analysis as, obviously, no capital costs would be incurred. The roads thus eliminated totaled about 633,000 miles, having an anticipated 1975 ADT of 25.

"Average annual program costs" is the term applied to the annual expenditures of a given year of a scheduled program. These costs are ordinarily used by a State in making an earnings-credit solution. Such costs include captial outlay, maintenance, operation, administration, policing, and interest on debt. As noted previously, only capital costs were considered in this analysis. The use of average annual capital program costs has one very serious deficiency in that such costs overstate the actual cost requirements of the high-type improvements while understating the costs of the low-type improvements. This results from the high initial costs of major improvements and the low initial costs of the minor improvements. Such methodology does not take into account the longer average lives of the high-type improvements. Use of the annual-cost method appeared to be dictated by this problem. Annual costs can be described as the amortization of the capital expenditures over the given life of the investment at a given rate of interest. This, of course, equalized to a certain degree the program cost differences in the high-type and lower-type improvements.

The last major modification adopted for the analysis was the use of predicted travel for the year 1975. Ordinarily, the estimated travel at the midyear of the program is employed, along with a fixed average annual program cost. Thus, the costs per vehicle-mile remain constant. In using annual costs, however, the computed vehicle-mile costs vary from year to year due to the changes in the volume of travel. It was necessary, then, to decide which year should be taken to provide traffic volumes that would be suitable for the solution. The decision to use 1975 travel was based on the thinking that if annual costs are used, the travel should reflect the cost per vehicle-mile of a completed program, rather than one partially completed.

The computations involved in establishing the annual capital costs consist of multiplying the given investment item by the recovery factor that will provide for its replacement, at a given rate of interest, at the end of its investment life. The given rate of interest runs the gamut from 0 to 7 percent, depending on the individual researcher, with the majority using a 6 percent interest rate. Such calculations are employed in determining economic costs in engineering economy studies of alternate highway investments. This study was concerned only with the financing of the Federal-aid systems which for all practical purposes are being financed on a current-revenue basis. It seemed that the inclusion of an interest charge was not relevant to the work at hand and yet such charges are an integral part of the computations of annual costs. A decision to compute annual costs at three different interest rates (0.0, 2.5, and 5.0%) was made. The computation at 0.0 percent tends to favor the high-type systems in terms of cost per vehicle-mile, and because of the high recovery factor of investments in such facilities, the 5.0 percent rate tends to disfavor them. A rate of 2.5 percent probably comes nearest to representing a normal credit-financing situation.

When highway expenditures and estimated costs per vehicle-mile are plotted against average daily traffic, there is usually a tendency for the values for the urban systems to be at a lower level than the values for the rural systems. Although such values, when plotted, appear to mingle randomly, the values of functionally comparable rural and urban systems definitely show this tendency. Such data were available from earnings-credit studies recently completed in Missouri and Iowa (7, p. 189; 8, p. C-3). The values are shown in Table 11 and Figure 4.

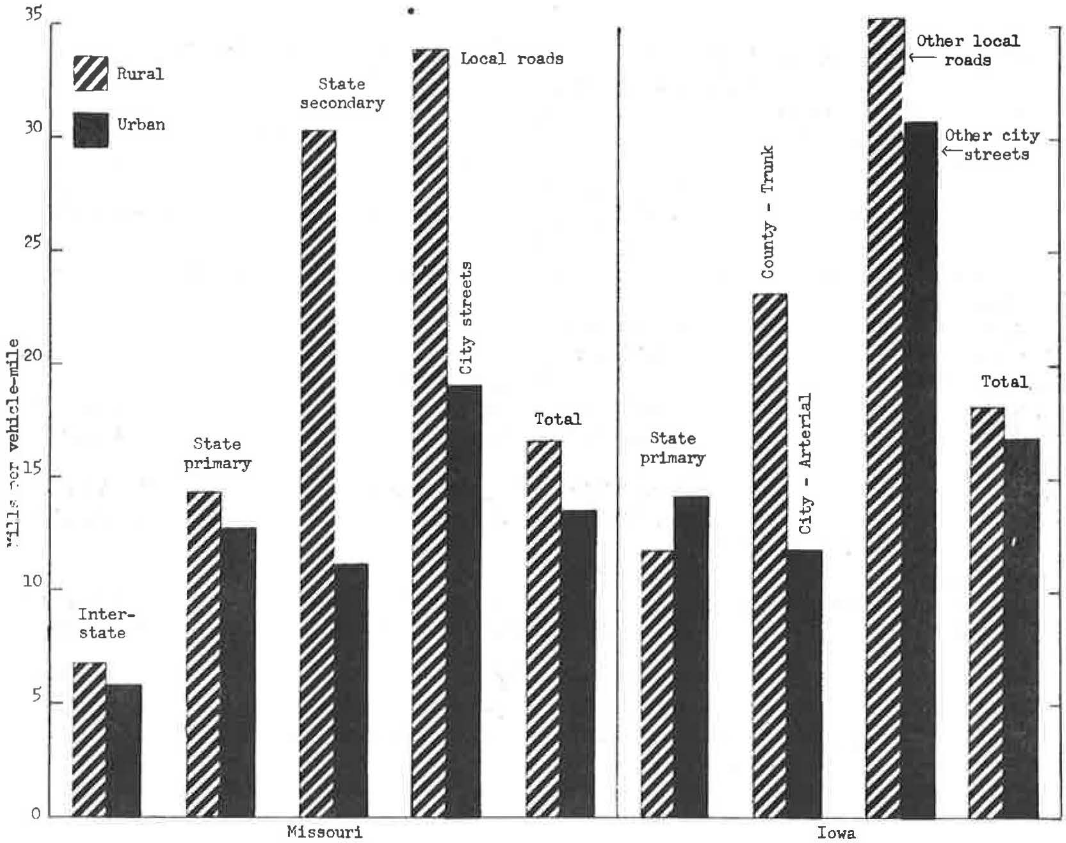

Figure 4. Cost per vehicle-mile of various road systems in Missouri and Iowa.

Critique of Earnings-Credit Analysis

In spite of its somewhat tenuous theoretical basis, the earnings-credit analysis has proven to be a most acceptable and useful tool for those who must attempt to allocate highway costs between users and others. Consequently, it has been utilized by other Federal investigators besides the staff of the Highway Cost Allocation Study, and in numerous State studies. Unfortunately, the findings of some of the State studies exhibited certain rather serious aberrations, probably traceable largely to shortcomings of the basic data available and the highway classification scheme used. There is reason to believe, however, that if adequate data are available, if a realistic classification of highways is adopted, and if certain other pitfalls can be avoided the earnings-credit analysis will produce consistent and useful results. In the paragraphs that follow, some of the major problem areas are considered for the benefit of those who may undertake earnings-credit analyses in the future.

Findings Affected by Program Costs.—The findings of the relative-use analysis are not affected by program costs because the determinations of cost responsibility are based entirely on the magnitude and characteristics of motor-vehicle travel. On the other hand, program-cost data are a part of the foundation on which the entire structure of the earnings-credit analysis rests. Consequently, errors or inconsistencies in the program-cost information utilized in the earnings-credit analysis can have a greatly adverse effect on the reasonableness of the results. Even the application of a different

TABLE 11

AVERAGE ANNUAL PROGRAM COST PER VEHICLE-MILE FOR SELECTED SYSTEMS IN MISSOURI AND IOWA

Missouri[1]		Iowa[2]	
System	Cost per Vehicle-Mile ($)	System	Cost per Vehicle-Mile ($)
Interstate:			
Rural	0.0066284		
Urban	0.0058016		
State primary:		State primary:	
Rural	0.0144739	Rural	0.0118406
Urban	0.0126879	Urban	0.0142687
State secondary:			
Rural	0.0302915	County-trunk	0.0230602
Urban	0.0112034	City-arterial	0.0119393
County, township and special road district	0.0339879		
Arterials, collectors, and local streets	0.0190042	County-Federal and local	0.0353528
		City-Access	0.0307590
Total:		Total:	
Rural	0.0165105	Rural	0.0180721
Urban	0.0135251	Urban	0.0166816

[1] Source: Table XIII-3, p. 189 (7).
[2] Source: Table C-1, p. C-3, (8).

interest-rate or rate-of-return factor can have a pronounced effect, as was amply demonstrated in the analysis made for the Highway Cost Allocation Study; for example, the discussion and accompanying tables, pp. 141-145 (1).

It is essential, then, that due consideration be given to the quality and reasonableness of the program-cost or annual-expenditure data available before an earnings-credit calculation is attempted. The desirability of including interest or rate-of-return factors in the analysis should also be given careful attention. The inclusion of such factors is proper and sometimes necessary, but their possible effects on the findings should be thoroughly understood.

Effects of Highway Classification. —The findings of the earnings-credit analysis are especially susceptible to aberrations in the highway classification scheme used. Thus, inclusion of extensive mileages of low traffic importance in the primary system will tend to increase the proportional responsibility of motor-vehicle users, whereas the inclusion of high-density roads and streets in the tertiary system will tend to increase the per-mile costs of access roads and streets developed in the bottom-drawer analysis. A less drastic but nonetheless apparent effect will result from the inclusion in the intermediate grouping of roads or streets that belong either in the primary category or in the land-access category.

In several States that have undertaken earnings-credit analyses such classification problems arose and, where it was not possible to rectify the situation, the findings of the analysis were considerably affected, even to rendering them questionable in some aspects. The modification in the highway classification adopted for the Highway Cost Allocation Study analysis was an ingenious approach to this problem, and is one that should be available in most States (1, pp. 135-136). It is worthy of adoption wherever possible.

Modified Compromise Solution. —Some objection has been raised to the usual type of compromise solution developed for the earnings-credit analyses. Another that has been proposed would attempt to overcome most of these criticisms by retaining the user

TABLE 12

HIGHWAY COST ALLOCATION STUDY: EARNINGS-CREDIT ANALYSIS—CAPITAL COSTS, ALL SYSTEMS, RURAL AND URBAN
(Modified Compromise Solution)

Highway System	Surface Type	User Share, Top-Drawer Solution[a]		Nonuser Share, Bottom-Drawer[b]	Total Allocations (million $)	Avg. Annual Capital Costs (million $)	Allocations/Costs (million $)		Adjustments (million $)	Net from Other Sources (million $)
		Dollars/Mile	Total Dollars (million $)	Total Dollars (million $)			Excesses	Deficits		
Interstate	All			22.7						
Other FAP	All			137.0						
	Subtotal	15,533	3,979.7	159.7	4,139.4	3,979.7	159.7	-	-159.7	-
FA secondary	High	4,971	1,012.7	126.9						
	Intermediate	603	179.5	185.4						
	Low	139	18.2	81.3						
	Subtotal	1,916	1,210.4	393.6	1,604.0	1,991.1	-	387.1	+285.6	101.5
All FA		5,846	5,190.1	553.3	5,743.4	5,970.8	-	227.4	+125.9	101.5
Other State highways	High									
	Intermediate									
	Low									
	Subtotal	3,234	266.2	51.3	317.5	547.4	-	229.9	+229.9	-
Local roads and streets	High									
	Intermediate									
	Low									
	Subtotal	783	2,086.7	1,660.1	3,746.8	3,391.0	355.8	-	-355.8	-
All non-FA		857	2,352.9	1,711.4	4,064.3	3,938.4	125.9	-	-125.9	-
All roads and streets		2,076	7,543.0	2,264.7	9,807.7	9,909.2	-	101.5	-	101.5

[a]$0.006582118 for all surface types.
[b]$623.181 for all surface types

share at the top-drawer solution level and the nonuser share at the bottom-drawer solution level, and would undertake to make all of the necessary adjustments in the allocation for secondary roads and streets. This is shown in Table 12 in which this type of analysis has been applied to the capital costs of all systems, both rural and urban, determined for the Highway Cost Allocation Study. The total program costs and the costs by systems are those shown in Table III-g-3, p. 137 (1). The modified compromise is worked out in the last four columns at the right-hand side of the table.

The nature of the information available in Table III-G-3 imposed certain limitations on this analysis. Thus, it had to be assumed that the so-called "primary" system — to be supported entirely from user earnings — would be composed of the Interstate and other Federal-aid primary highways as given in the table. The user cost of fully supporting the capital outlay program for this system was determined to be $0. 00658+ per vehicle-mile. This earnings rate was applied to all systems as set up in the table and produced the "dollars per mile" and the "total dollars" of earnings shown.

The amount per route-mile necessary to support the local roads and streets was calculated by dividing the total capital costs for the intermediate-type and low-type segments of "other local roads and streets," and was found to be $623. 18. The "total dollars" column indicates, by systems, the gross expected from this source.

The amounts shown in the "total allocations" column are, for each system, the sum of the calculated motor-vehicle earnings at the $0. 00658 rate and the nonuser share calculated by multiplying the route miles on the system by the $623. 18 rate per mile. When these figures are compared with those shown in the "average annual capital costs" column it can be observed that total allocations exceed the annual capital costs for two of the system groups for which subtotals are shown, and annual capital requirements exceed total allocations for the other two. Also, total annual requirements exceed total allocations by $101. 5 million.

In making the "adjustments" shown in the next-to-last column of Table 12, the following assumptions were made:

1. All primary systems would be under direct supervision and control of the State highway department.

2. Part of the roads on the Federal-aid secondary system would be under State control, and others would be under the control of counties or local units.

3. "Other State highways" would be under direct control of the State highway department.

4. All so-called local roads and streets would be under the control of counties or local governments.

5. The user share, to be collected through imposts on motor vehicle users, would be collected by the Federal and State governments.

6. The nonuser's share, to be collected at the rate of $623. 18 per route-mile of all roads and streets, would be collected entirely by counties and/or local jurisdictions.

These assumptions are reflected in the adjustments made. It was assumed that the State highway departments would spend the State motor-vehicle-user revenues and Federal aids received to defray the total annual costs of the primary system, and to the extent justified by "earnings" (including Federal aid), on the other State highways and Federal-aid secondary highways under State jurisdiction. On the other hand the counties and local units would be expected to apply the funds collected from their own revenue sources to meet the non-motor-vehicle-user share of the requirements of local roads and streets (the entire cost), and would also spend these revenues at the predetermined mileage rate on secondary roads and streets under their jurisdiction.

This would mean, in effect, that the State highway departments would forego all nonuser "earnings" on the primary system and on other State highways, allowing the counties and local units who collect them to apply these funds where deficits would be found to exist on roads and streets under their control. It would also be assumed that the States would retain and apply to "other State highways" and secondary roads under their jurisdiction incomes from motor-vehicle-user taxes sufficient to overcome the deficits between motor-vehicle-user taxes earned on those highways and the amounts required for annual capital costs.

At the levels of earnings and capital requirements given in Table 12, the result would be complete financing of all systems (as there classified) except for the Federal-aid secondary. For these roads and streets, it was found that even after allocating all excesses of both user-tax earnings and nonuser collections, a net annual deficiency of \$101.5 million would still remain. Funds to meet these deficiencies would need to be drawn from sources not included in this table, such as the general revenue funds of the governmental agencies responsible for the roads and streets in question. Just what agencies these would be cannot be determined precisely from the data available for this analysis because no separation was made between Federal-aid secondary highways administered by the State highway departments and those administered by other jurisdictions.

It is obvious that this particular analysis will work satisfactorily only when the allocations produced by the top- and bottom-drawer calculations do not produce quite enough revenue to finance the entire program.

When it is calculated that the totals of responsibility, as determined in the top-drawer solution, and of access responsibility, as determined in the bottom-drawer solution, exceed the total amount needed, the compromise can, probably, be made best as was done for the Highway Cost Allocation Study.

Treatment of Federal Aid in State Studies. — The proper treatment of Federal highway aid has always presented a major problem in State studies of highway cost allocation. Before passage of the 1956 Federal highway legislation, when aid for highways was paid from the general revenues of the Federal Government, and when the levels of aid payments were much lower than they now are, it was customary (but not universal practice) to deduct an amount equal to expected Federal aid from the program costs of the road systems affected before undertaking any allocation of costs between users and others. Since enactment of the 1956 legislation, however, the proper treatment of Federal aid in State analyses has become a very controversial matter, with eminent authorities lined up on either side of the issue.

The principal arguments for inclusion of Federal aid in the State analysis appear to be that (a) inasmuch as such aid is now paid from the proceeds of motor-vehicle-user taxation, account should be taken of this contribution in calculating the allocation to highway users at the State level; and (b) the level of Federal aid received on a very small portion of the primary system (the Interstate highways) is so high that to omit this segment in the earnings-credit analysis will result in understating the level of user contributions required. On the other hand, the staff of the Highway Cost Allocation Study (1, p. 18) took the following position:

> In the conduct of an earnings-credit study (or, indeed, any study of the highway cost allocation problem) in an individual State the customary practice is to deduct anticipated Federal-aid funds from the data on program costs, so that only the net costs to the State and its civil subdivisions will be involved in the solution. Only in the conduct of an earnings-credit study on a nationwide basis is it feasible to take account of the entire package of highway costs.

During the six years that have elapsed since passage of the 1956 Act, the authors of this paper have rendered technical assistance on highway cost allocation studies made in several States. It has been their observation that to omit Federal aid from the initial determination of vehicle-user responsibility results in levels of such responsibility that are entirely unrealistic (too low) in most instances. Therefore, they have recommended that Federal aid be left in for the calculation of the burdens to be allocated between users and others. The allocation of costs among various classes of vehicles also includes Federal aid but the vehicles are given credit for the Federal taxes paid by each type, which, in effect, offsets the Federal aid involved.

CONCLUSION

Highway economists, especially those concerned with taxation and finance, are sometimes inclined to be pessimistic about the outlook for developing theoretically sound and foolproof methods for the allocation of highway costs between users and others, not to mention the allocation of such costs among the various groups of users. They are even inclined to feel, sometimes, that no significant progress in either theory or methodology has been made in recent years, and that further penetrating studies of the questions involved would be of little avail. Even such a competent and well-regarded authority as Zettel took this position in the panel discussion, previously referred to, before the Committee on Highway Finance held during the October 1961 meeting of the American Association of State Highway Officials, when he said:

> It seems to me that there is not much point in making anymore studies of the kind that have been made in the States, or in the Section 210 Study, until we can find some way of getting authoritative agreement on what . . . we are trying to do in the area of highway financing and taxation. I have hopes that the National Tax Association's Subcommittee on Federal Excise Taxation may develop something along these lines, dealing with both excises and highway-user taxes.
>
> At the present time, it is almost ridiculous to carry allocation of costs of highways between users and nonusers to a second decimal point when we can't even agree whether $20 billion worth of automotive excises are general taxes or highway-user taxes. If we don't agree on this, our attempts to get arithmetical accuracy in cost allocations are pretty much nonsense.

The authors of this paper are not as pessimistic as Zettel seems to be. Although they agree that there seems at present to be no single correct or even best answer to some of the fundamental questions of highway cost allocation, and recognize that there is room for argument about the treatment of certain excise taxes, they are convinced that satisfactory empirical approaches to solution of the problem can be made as has been done at both Federal and State levels in recent years. After all, the problems of fund-raising for highways that face legislative bodies and executives at Federal and State levels cannot be deferred until the public finance theorists can agree on some of the more esoteric points involved in such analyses. The authors of this paper believe that the additional data now available in all the States, and accordingly to the Federal Government, make it possible to do a much more theoretically sound and practically satisfying job of allocating highway costs than has been possible at any time in the past.

Also, the relative-use and earnings-credit analyses offer two of the best available means of allocating highway costs between users and others. Until better and more practical methods are available, the authors will continue to recommend that those who have the responsibility of undertaking cost allocation studies at the State level utilize at least two methods of cost allocation between users and others, and that careful consideration be given to using these two methods. Additional methods could also be used if the local circumstances appear to warrant it.

It has been observed that past studies have sometimes failed to be most effective because they have presented several allocation bases without recommending any particular one or a means of combining their results. It is recognized that when the investigators find no special virtue in any one method of allocation they would hesitate to recommend it over others. Consequently, the mediation approach adopted by the staff of the Highway Cost Allocation Study has much to recommend it under such circumstances. A procedure adopted for mediation between the relative-use and the earnings-credit findings is described elsewhere (1, pp. 146-147).

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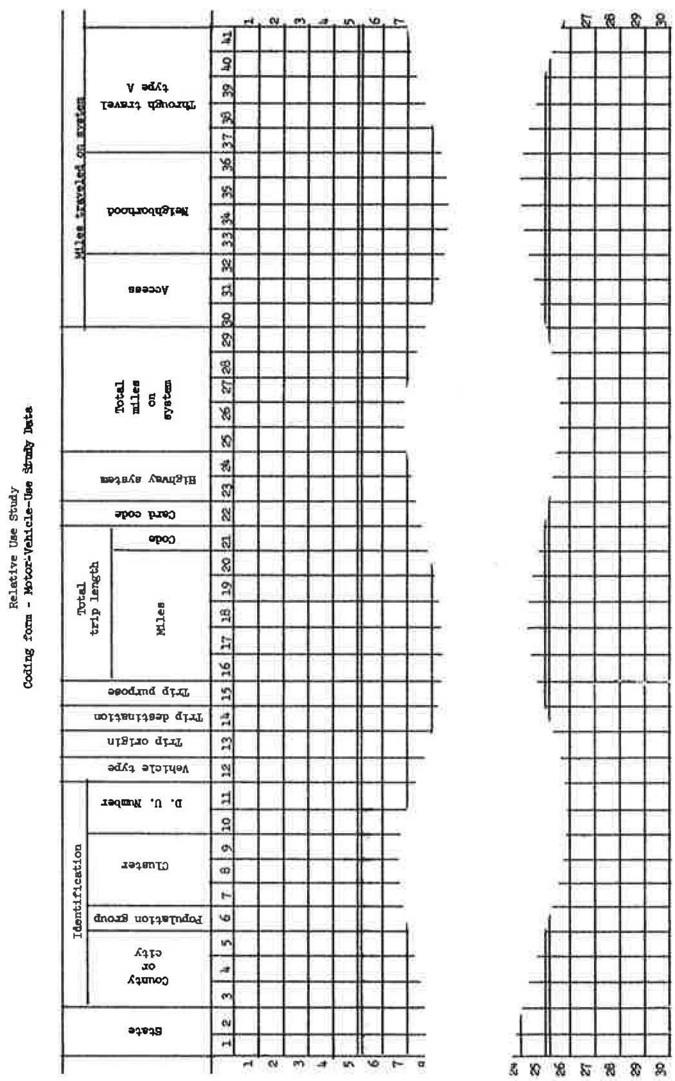
Appendix



Nonuser Benefits from Highways

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The paper evaluates the concept of nonuser benefits. It presents evidence obtained from economic impact studies of such benefits in the nature of advantages to land-use patterns and to land values and other indirect beneficiaries of highway improvements. It describes these various fields on which highway benefits impinge and focuses on some specific areas of benefit such as land values and industrial and commercial development.

The scope of the economic impact studies is described as well as the shortcomings of this approach wherever relevant, especially in relation to the quantification of such indirect benefits. Some of the theoretical means proposed by various researchers to quantify and account for these benefits are delineated.

•THE LITERATURE of highway research abounds with the concept of benefit measurement. This concept follows the tradition that, at its very least, a public works facility should indicate an order of "benefit" to the community at large. For this reason, legislatures apportion part of their tax funds to the provision of social overhead items for the community. The assumption is made, implicitly or explicitly, that investment in social overhead furnishes immediate benefits to a community at large and provides the means for increasing the stream of future benefits to the community.

Yet, the placing of any particular public works improvement (e.g., highways) results in a change in the traditional relationship of people to commodities and services and affects their demands for particular items because of time-distance factors, cost factors, and spatial rearrangements in general. As one commentator (1) has stated,

> ...the contribution of social overhead to increase productivity is widely acknowledged, but its exact importance is hard to assess.... Nevertheless, the marginal contribution of good schools, an efficient road and highway system, reliable water supply and utilities and even recreational facilities may be decisive in the improvement of productivity. Though not precise, the evidence to this effect is sufficiently convincing to entrepreneurs to cause them to give these factors substantial weight in selecting localities for investment.

Through the years, in public works research, it has become conventional to separate user benefits from nonuser benefits. The rationale is that an individual should financially support public facilities according to the benefit that he receives from them; this has been interpreted by many to mean according to his use of such facilities.

Yet, in addition to benefit enjoyment by those who use a facility, there are advantages that accrue to particular types of business and parcels of land only because of their location near the facility. Thus, the advantage that accrues to such economic entities appears at least to be different in nature and locale from the advantage that accrues to the user of the highway facility.

In attempting to evaluate these separate means of identifying and measuring benefits, one needs to be aware of the pitfalls of double-counting benefits and measurement of transfers of economic activity, suggested by some researchers. Others find a suffi-

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cient difference in type and magnitude of such benefits, thus reinforcing their belief that these nonuser benefits are proper objects of taxation, in an effort to recoup for the community any undue advantage accruing to such beneficiaries. These theories and others are discussed later.

Nonuser benefits from highway improvements as used in this paper encompass various broad elements of social and economic life, as well as some fairly restricted ones. At the very least, advantages or disadvantages that flow to an individual or a community from a highway improvement might include drainage, view, and amenity changes of various sorts. At the other extreme, they could include such items as the benefits accruing to industry, commerce, and residence, in rural and urban areas. In addition, they might include benefits to specific groups such as landowners, or separable benefits such as to public utilities and to outdoor advertisers for the use of highway right-of-way.

TYPES OF IMPACT RESEARCH

The Bureau of Public Roads has recently had the occasion to analyze the concept of nonuser benefits and to summarize the research materials on this subject in the Highway Cost Allocation Study (2, 3) which the Bureau recently submitted to the U.S. Congress. One of its objectives was the identification and measurement of these nonuser benefits.

The attempt to define and quantify "nonuser benefits" led into many byways of research activity. Thus, it was obvious that some representation of highway effects on urban and rural communities would be required. It was likewise obvious that in a mobile and dynamic system like that in the United States, the benefit that could be related to highways alone, apart from its integral relationship with other activities, would be difficult to assess.

One recognizes that it might be possible to evaluate the benefits accruing to the Nation as a whole from highway construction at one point in time. Thus, a detailed snapshot grid of input-output data could indicate the effects of highway construction expenditures on the primary and derivative purchases of labor, materials, and capital equipment by all supplying industries. Such an estimate would not deal, however, with the dynamic results that might occur from each of these purchases in stimulating relocation of activities, in changing space demands, or in any way altering the straight-line linkage patterns already in existence in the basic framework. In such a construction-induced multiplier, a dollar of investment on highway transportation would not be different from a dollar of investment on any other form of investment activity.

Although on the surface there appear to be no essential differences in the results emanating from ordinary investment expenditures versus highway expenditures, such an estimate would not indicate what would happen to the local structure of economic activity. The Corporation for Economic and Industrial Research (CEIR) of Arlington, Va., made some preliminary estimates of this nature which would indicate the magnitude of the investment multiplier associated with the expenditure of an assumed amount of highway construction funds per year in the United States as a whole.

This research firm estimated the effect of the investment in highways of an assumed $4 billion per year in 1947 prices. Material and service requirements were generated directly and indirectly throughout the economy so as to multiply the original expenditures between two and three times the original investment. A rough computation of annual business generated for each of 192 industries shows annual volumes of $400 million for structural metal products down to $100,000 for motion picture products (in 1947 prices). The major impact is, of course, in steel, cement, aggregates, and petroleum products (4, pp. 37-40, Appendix B).

In addition to such effect on material requirements throughout the economy, there are all sorts of investments that occur through the reorganization of economic facilities and the increased efficiencies that occur. Better accessibility, time and distance savings, and many other factors, of course, inspire such new investment, and each such increment has its own ramifications throughout the economy. These ramifications are familiar in terms of what has happened along Mass. 128, Dallas Expressway, the California freeways, and various other facilities. Furthermore, these estimates would give no indication of the upgrading of land use and, hence, values that accompany the placement of highway facilities.

To obtain representative coverage of the United States on the local effects of highway improvements, research efforts by State highway departments through their universities were accelerated in a program of economic impact research. Because of the emphasis on controlled-access facilities in recent years, as in the Interstate System, there were a number of studies that had been completed in Texas, California, and other States in which these types of facilities were already in existence. In order not to omit the rural aspects of highway impact, a number of studies of this nature were sponsored.

The spread of economic impact research can be seen in two bibliographies on this subject prepared by the Virginia Council of Highway Investigation and Research (5, 6) for 1956 and 1961. The 1956 bibliography on economic impact research listed only 90 references, of which 30 were legal and right-of-way items. The bulk of the remaining references was concerned with work completed in the State of California and especially with bypasses. The similar bibliography prepared during 1961 consisted of 451 items, with some 300 authors identified by name.

In the urban areas, impact has been evaluated in cities like San Antonio and Dallas, Texas; Minneapolis, Minn.; Oakland, Calif.; and Richmond, Va.; rural trading centers have also been represented.

Beginning with the 1920's, the interest in highway impact was noted in rural areas. More recently, perhaps a decade ago, a number of studies were undertaken of individual highway facilities. These studies were associated with a variety of highway problems, including right-of-way acquisition, public hearings, route location, cost allocation, design, public relations, and similar aspects of highway work. Today, there are over 100 completed economic impact studies that have been sponsored by State highway departments and the Bureau of Public Roads and an additional 40 that are in progress. Almost every State is represented in this research.

In only a few instances are the State highway departments themselves, with their own personnel, engaged in the complex research involved. In several cases, special consultants have been retained by the State highway departments. In the vast majority of cases, universities have carried on this work. In several instances, the Bureau of Public Roads itself sponsored inquiries on particular phases of nationwide scope.

Description of Studies

The studies on which much of Part VI (dealing with nonvehicular benefits) of the Highway Cost Allocation Study was based depended on various kinds of research approaches. In general, the methodology encompasses a "before and after" technique—an analysis of some period before a highway improvement compared with a period after the completion of the improvement. Evaluation (7) of the data compiled indicates the trend of economic events associated with these highway improvements.

Because of differences in periods of road construction and research projects, results are not exactly comparable in time. Little study experience is available for sections of the Interstate System because of the recency of much of this construction. However, wherever possible, data have been developed for highways of a similar type (that is, of the limited-access variety) as well as for more conventional types of facilities. Consequently, in the material presented in this report there is a substantial dependence on highway experience in such States as Massachusetts, California, and New York as well as other States that have had significant experience with limited-access facilities which have been studied and recorded. Many of these research efforts involve such facilities as the Boston Circumferential Highway, the Connecticut Turnpike, the Atlanta Expressway, the Edens Expressway in the Chicago metropolitan area, the California freeways, the Lexington, Ky., Belt Line, the Watterson Expressway in Louisville, the Dallas Expressway. Highways of conventional design (in terms of access control) and secondary roads constitute the subjects for study in a number of instances. Bypass studies are also strongly emphasized. The studies were made in urban areas, small communities, and rural areas. A number of the more recent studies are concerned with regional influences of highway transportation. In studies such as the Boston Inner Loop Study, attempts were made to assess all the regional influences so that the net effects can be approximated.

To the degree that these studies isolate the impact of highway improvements on economic activity, they provide a measure of the manner in which the improvements influence a community's economic structure. The procedures used in answering questions posed by these studies range from the collection and analysis of field data to various deductive and mathematical approaches. Various methods have been used in quantifying data.

These studies generally attempt to filter out the highway influence. This has been accomplished, at least to a limited extent, through a device generally used in other sciences, namely, the "study" and "control" area or "study" and "control" influence zones. Admittedly, such a technique, by itself, omits the wide ramifications traceable to a highway improvement or to an entire highway network. It does, however, furnish information on the economic influence generated by the highway for the area under study. This method is, of course, most useful in smaller communities, least subject to outside influences.

The subject matter in these studies varies widely. Most of it has been concerned with the highway influence on land use (physical use as well as the economic activity which reflects the use) and the influences on the land values near a particular highway facility. Included with these are the advantages accruing to public utilities from the use of highway right-of-way, the impact of the highway influence on various public services, and other community influences. As previously indicated, economic impact research has resulted in representative studies of various kinds of highway facilities, so that the influence of modern-type, limited-access facilities and bypass routes can be distinguished from the conventional, urban highways or farm-to-market roads.

It is perhaps fortunate that the nature of these studies varies widely. In addition to the subjects enumerated, some studies contain an analysis of general economic effects. Some concentrate on retail and industrial aspects, others on recreation, others on tax bases, special assessments, public utilities, still others on residence. Aspects of small communities have been stressed in several instances. The impact of highway improvements on agriculture is dealt with in special studies.

Information Analyzed

In any analysis of change, as in the economic impact studies, the mixture of possibilities in commercial, industrial, and personal reorganization is very great. In some instances, the net benefit to a community from the highway improvement is clear. In other cases, it has been necessary to standardize some important items such as the study areas, zones, time periods, and historical growth patterns in order to approximate the impact. In still other situations, the highway influence is not entirely clear.

For the purposes of the Highway Cost Allocation Study, the advantages and detriments of highway improvement to all groups other than motor vehicle users were analyzed as a widely diffused bundle of effects which permeate the entire economic and social system, and come to rest in particular urban, rural, and other communities. The expenditure of funds for highway improvements serves as an infusion of highway investment into the economy which reverberates throughout all industries, their labor forces, their spending patterns, etc.

The very nature of highway improvement, however, serves to reorganize local activity. These improvements have a tendency to cluster development about them. They aid in channeling economic growth along specific locations and, in addition, they make it possible to reduce industrial costs (through transportation savings) and thus aid in the more efficient distribution of economic resources.

In dealing with local communities, however, it is extremely difficult to ferret out what some have called the "net" benefits to an area derived from the highway improvements. Communities blessed with an abundance of natural resources, skilled labor, etc., have better opportunities to attract economic growth immediately into their areas. Other communities, of course, do not have such opportunities to the same extent. It is only in very special cases that improvements in transportation can furnish equal advantage to all areas. As Garrison (8) has remarked:

> The very nature of specialization and the geographic system means a differentiation of benefits among places, and therefore it is very important to keep in mind the fact that benefits from transportation improvements are almost always differentiated geographically as well as in more obvious ways. By more obvious ways, we refer to differentiation among industries, among kinds of highway users, among kinds of transportation, and the other things.

It is precisely this approach to analyzing the different kinds of benefits or detriments that accrue to differentiated geographic entities from highway improvements that was taken in this analysis.

It would only be fair to say that no valid assumptions can be made that a particular type of highway improvement will lead inevitably to a particular set of consequences. No assurance can be given, for example, that widening a two-lane highway to a four-lane facility will result in traffic flows of some given amount, or land value increases of some given amount. All results are dependent on the economic and social activities served by the highway and whether these are responsive to the particular highway improvement. The nature of the impact is determined by both the type of transportation systems developed and the existing complex of cultural interrelationships associated with transportation demand (8).

Because transportation is conditioned by the arrangement of land uses, and because the arrangement of land uses, in turn, is conditioned by the nature and quality of transportation service, the studies cited make available knowledge of the structure of the dependence and interrelationship of various individual and business uses by different kinds of highway improvements. These studies provide clues to the highway benefits derived by households and business and industrial firms. These benefits arise from the increased use of lower cost transportation as well as from possibilities for the more efficient operation of vehicles, firms, and households. Thus, both vehicular and nonvehicular benefits occur. Nonvehicular benefits are associated with the influence of highway improvements when other conditions are ripe for such effects.

CONCEPTS OF NONUSER BENEFITS

There were a number of theoretical attempts to measure the "net" nonuser benefits from highway improvements. In the normal pattern, some activities in an area are declining, whereas other activities are gaining as the result of competitive forces alone. Grafted atop these usual variations are changes introduced through the advantages given to one area over another by a highway improvement. It is necessary to separate or "net" the gains attributable to the highway; the "control" area mechanism affords one means to accomplish this task.

A major problem to be faced in this endeavor is that of the redistribution of economic activity or the transfer of activity that may be stimulated by the new advantageous locations abutting the highway. Although this activity might have come to rest elsewhere but for the new highway, belief in a dynamic system impels one, however, to reason that a portion of the new activity was stimulated by the highway investment; it might never have resulted elsewhere.

Various researchers have reasoned that it is more appropriate to count the benefits accruing from a highway improvement through an identification of the amount of highway use. The savings attributable to the users would, they feel, provide the entire economic benefit to an area. This dichotomy between user and nonuser benefits has led some commentators to suggest that this is a double entry type of arrangement. Various user benefits have been identified, such as reduced operating costs, reductions in the strains of congested driving, reduction in accident costs and time savings; at the other end of the spectrum have been the nonuser benefits. The latter have been identified through the impact studies. These two are difficult to separate inasmuch as both types of benefits are linked one to the other. Zettel (9) and others have pointed out that the principal benefits accruing to the so-called nonuser interests come by way of motor vehicle use.

These observers believe that reductions in motor vehicle transportation cost may be reflected or capitalized in an increase in the value of land to be served by the highway improvement. Also, the expectation of transport savings may induce investments at the terminal points or interchanges of a major highway facility. These researchers believe that any attempt to add these together may result in "double counting" of benefits.

Northwestern University's Transportation Center (10), in a framework study conducted for the U.S. Bureau of Public Roads, examined the increase in highway use attributable to a new highway facility. They believed that the increased accessibility to land attributable to the highway can be valued in user savings which are capitalized in land. They proceeded to adjust some early data developed by Wheeler (11) in connection with the Floating Bridge in the State of Washington and obtained results that they feel reasonably approximate user savings. This led to the reference that, if all data were treated in this fashion, it would be possible to prove that the measurement of quantitative benefit of use and of nonuse (land values) would tend to be the same.

Though no one would deny that many of the benefits from highway improvements reach the public via motor vehicle use, the mere adding up of benefits, even if possible, would not give a true indication of the total benefit. The total amount of nonuser benefits would tend to be greater than any amount that could be calculated by user savings because of the "multiplier" effect on the flow of highway benefits to the user which proliferates into all elements of the economic and social systems. In addition to these effects, one would also have to value the "separable" benefits accruing to public utilities, outdoor advertisers, etc.

Inasmuch as the benefits of highway construction tend to extend in all directions, some researchers have suggested that some part of highway investment should be supported by taxation for general fund purposes rather than by taxation based on highway use alone.

Peterson (12) and others (10) believe that a highway investment is, in essence, like any other kind of investment that has economy-wide ramifications. There is a major difference, however, between the impact of highway improvements and other forms of investment. Because transportation is so significant in personal, commercial, and industrial lives, any alteration of this element of space and location will tend to affect the ordering of economic and social activities.

Other researchers are concerned with locating the highway benefit through the use of a commercial or pricing approach or marginal cost pricing (13, 14) or measurement of welfare (15) in order to recoup the outlay for highway investment in whole or in part.

There is one current concept that is fairly close to the belief that nonusers should support highways. Hennes (16) of the University of Washington has labeled this the "motivation" approach. He finds that highway improvements are often made because of pressures from realtors, developers, etc., who stand to gain, and should, therefore, be taxed for the social contribution to their private gain. Following this approach leads into the thought that highway planning needs to be coordinated with comprehensive master planning of land use because highways tend to create regrouping of economic and social activities.

As previously expressed, not all indirect benefits can be accounted for by savings in transportation. A number of researchers, Garrison, Tinbergen, Bos and Koyck, and others, have found that transportation savings induce other changes that induce increases in output above the magnitude of the savings.

Starting from the criterion that the only net benefit to the society that accrues from highway investment is one that contributes a social dividend, Garrison has pointed to the element of reorganization benefits. These concern a new arrangement of resources that imply a certain efficient allocation.

In analytical papers developed in 1957 by Tinbergen (17, 18) of Harvard University and one year later by Bos and Koyck (19), an input-output analysis was prepared. This procedure set up a static model in terms of present costs, prices, and volumes of production. A road improvement program was stipulated. This reduced some transportation costs and the effect of this was traced to the total output. This "before" and "after" change is assumed to be a yardstick of the value of the road to the economy. There were two assumptions made by Tinbergen as to degree of elasticity and two by Bos and Koyck as to costs and prices. Tinbergen's analyses gave a multiplier of 1.9 and 3.8;

thus, the increase in National income would be 1.9 or 3.8 times the reduction in transportation costs; Bos and Koyck calculated benefit values of 10.52 and 1.52. Thus, traditional methods highly underestimate the value of a new road.

Also, in the Northwestern University study, attention was directed to the "benefit on existing highway use" and transportation savings resulting from the substitution of transportation-intensive methods of output. These user savings did not take account of economies of scale that may result from larger plants or reduced unit production costs. Mohring and Williamson (20) tried to deal with this and found a savings because of reduction in trucking costs of 88.7 percent as an "existing use benefit" and of 11.3 percent as "reorganization benefits." The Northwestern researchers point out that the phenomenon of induced investment is characteristic of all types of investment and is not necessarily associated with highway investment alone. In addition, Harwitz attempted to define a multiregional programing model in the Northwestern study in order to delineate impact between regions. The data and theory problems here made it rather difficult to implement this model.

All the model formulations described here dealt with truck use and were not concerned with the bulk of highway transport, which is passenger transportation.

These input-output model analyses have demonstrated a benefit to society over and above the savings in transportation costs, indicating that an element of nonuser benefit exists which is not reached by the user analyses. One commentator (21, p. 60) using this type of analysis in a slightly different field has stated:

> ...conceptually, although not empirically, one of the simplest ways to describe a community's economic activities is to show the local inter-industry relations in some given historical period. Such a "snapshot" picture can be used to determine, for a particular period, the impact of any given transaction upon each sector in the local economy; it can be used to describe how the benefits or injury of any transaction are distributed among the various local industries; it can be used to assess the relative importance of each sector to community welfare.

The input-output approach is certainly a systematic means of determining dollar impact on sectors of the economy. It is, however, not easily translatable into the size, nature, and location of the specific activities and their relevance to highway transportation. It is a means of finding the effect of investment expenditures either by Government or private industry on the material, service, and labor inputs of each industry so that total direct and indirect effects of such expenditures can be accounted for. Any activity which is different in nature from what had preceded the establishment of the basic input-output chart would be ignored in this analysis. Through the input-output system of accounts one could trace the changes stimulated by highway investment. Despite the limitations of this method, it is possible to work out the full incidence of the investment in the community at large. Spatially, however, the locations of incidence would have to be placed through other analytical means.

The usual input-output analysis of this type does not concern itself, of course, with the land value phenomenon. The latter is considered a transfer and hence is not included in the activity measures. To the extent, however, that changes in income to individuals occur, whether they be through land sales or any other way in a locality, they affect consumption expenditures in an area and may redirect other investments in the area.

The most discouraging feature of the use of input-output accounting is that local data are not available in proper form and they are expensive to collect; even the National data are more than a decade behind present times. Thus, the 1947 U.S. Bureau of Labor Statistics National chart of interindustry relationships, which has built in it 1947 price, productivity, and technological constraints, is being used by some as representative of present-day National and local economic structures.

Although a 1958 chart is being developed by the U.S. Department of Commerce, it is questionable whether these National coefficients would be relevant on a lower level of application than regional analysis. In the case of local product accounting, considerable advances are being made to the State level, at least.

Research in local use (22, 23) of many of the social accounting systems is still in its infancy. The major advantage of these systems is that they place data in an understandable and interrelated fashion for quantification.

ECONOMIC IMPACT FINDINGS

The various model analyses indicate what might be involved in a rigorous delineation of the benefits to nonusers. Although these hypothetical models provide some understanding of the analytical elements to be weighed in the consideration of nonuser benefits if interpreted as a net social dividend, they lack empirical verification.

What is immediately evident in any study of highway effects is the extent of resource rearrangements that occur near highways. In the following pages, some of the major findings with reference to the industrial, commercial, and land value effects of highway construction have been summarized. There are many other findings that can be alluded to only very generally in this paper, especially those regarding the social effects of highway improvements.

Such subjects as the importance of highways to farm life, residential development, and public services were discussed at the 1962 Highway Research Board Annual Meeting. A considerable amount of material was presented on two important subjects, based in the main on research conducted for the Highway Cost Allocation Study: social effects of highways (24) and statistical evaluation of the influence of highways on rural land values (25). These may be considered as companion pieces to this paper in their specialized areas.

General Effects—Urban and Rural

The findings from the over 100 economic impact studies which will be specified in the following pages detail the highway influences on investment, output, and the general scale effects on industry, commerce, and residences. In this summary, it is difficult to cite more than a few instances of the magnetic force that highway improvements have become for industry and commerce. These are available in the individual impact studies.

Allusion has already been made to the tendency that highway improvements have to direct investment into nearby locations. This channeling of investment into highway locations apparently occurs because there are situations awaiting a "triggering" by an outside agent in order to effectuate a shift; for example, from vacant to industrial land. Highways often provide this triggering and, because of the complex linkages between industries, the effect of the original investment is multiplied.

In a dynamic society, resource allocation is constantly shifting in response to changing demands. To the extent that highway improvements lead to efficient satisfaction of basic demands—through the more intensive uses of present resources and shifts between present resource combinations—highways contribute a net increment to society as a whole. The beneficial effects on production and output associated with the increased efficiencies of highway locations have been experienced by enterprises of varying types and sizes.

Many of the larger modern plants locating within highway proximity are able to achieve efficient ouput because of internal economies in the use of land, labor, and materials. Savings in resource combination can often be realized best at a decentralized location near a modern highway where adequate space is available for large-scale operations.

The possible effect of transportation betterment on the scale or size of an establishment's operations may also be apparent from consideration of production costs. If the price of even one variable input rises, the marginal cost of the product at each output will rise. This will serve to reduce sales and output, and thus the scale of the enterprise will be diminished. At the other extreme, the lowering of transportation costs and the rearrangement of resource use, as previously described, tend to lower costs, and to increase the size of the enterprise. The magnitude of this size or scale effect depends mainly on the degree of importance of the input being considered, and its relationship to the transportation factor.

Smaller enterprises, as well as large-scale operations, often realize substantial increases in efficiency as a result of highway improvements. Benefits accruing to small enterprises include such highway-associated savings as faster deliveries and more efficient storage and warehousing.

Many of the economies provided by highways are, of course, external to the plant itself—whether the establishment is large or small. Savings in storage and warehousing, in marketing, and in recruiting labor, though external or primarily external to the plant, all tend to increase plant efficiency. These advantages are often maximized in industrial parks and suburban shopping centers—developments which are, of course, particularly oriented to highway transportation. Establishments in industrial parks, for example, are often able to realize the economies already mentioned, to benefit from easy access to the services of other firms in highway locations, and to participate in downtown-type, face-to-face contacts in parklike surroundings. Thus, highway improvements are associated with changes in investment, output, and in the effect on scale of operation.

Just as highway improvements tend to make possible a different size or scale of individual plant and commercial center than that which previously existed, highways also provide expanded opportunities for farm investment and output. Among the general effects of the improved accessibility to farming areas provided by modern-type highways are the tendency for farm land near highway locations to become ripe for conversion to higher uses, economies in farm operations, in marketing and in obtaining labor and supplies, and improved opportunities for off-farm employment and nonwork associations.

These economies in highway transportation, which are, of course, external to the farm, may have a number of different consequences. Transportation betterment may, for example, tend to reduce the artificial competitive advantage of farm lands near market areas by lowering the total costs of farms at some distance from the market. Improved transportation may also help improve the character or tone of a rural community or it may open up opportunities for social, educational, or cultural activities that may have been too remote before the existence of a highway improvement.

Efficiencies in highway transportation may also foster the current trend to larger farm enterprises, particularly if there is a reorganization of farm lands as a result of acquiring highway right-of-way. This movement to larger farms is, of course, dependent on a number of causes, including modern highway transportation (26).

> Transportation reduces the cost of goods—through the encouragement it lends to large-scale production. Large-scale production may exist which is not dependent upon cheap transportation. But in many instances large-scale production means that either raw materials or finished products must be transported long distances.

Highway Benefits to Industry

A considerable amount of evidence exists to substantiate that highways have played an important role in the development of nearby land for industrial use.

The outward expansion of industry from congested central business districts to suburban locations is an innovation resulting from many factors. The increase in the use of trucks and concomitant lessening of dependence on rail transportation is a major cause of the shift of industrial location in suburban areas near large sources of labor. Another factor which stimulated suburban industrial development has been the increased building of industrial parks which afforded a manufacturer more space at less cost while affording him closer proximity to his customers and suppliers, ample parking for employees, and less congestion.

Only a few of the many cases which tend to illustrate the encouragement a modern highway can apparently give to new industrial investment are mentioned here: Mass. 128 near Boston, a circumferential highway, often referred to as the "miracle" highway, resulted in opening up vast areas for industrial development. The plants located along Mass. 128 represent an enormous amount of investment. By the fall of 1958 over 200 companies were in operation along the facility and, in addition, many other plants and industrial parks were under construction.

The demand for land for industrial use along Mass. 128 appeared to have a dynamic effect on land use and land values. For example, in Needham, formerly poor land within the complex of the New England industrial center was developed for industrial use; the resultant increase in the assessable tax base amounted to $5.6 million, and $300,000 annually was realized in additional annual taxes. If this same land were developed residentially, the increase in the tax base would have been about $3½ million and new taxes would have totaled only $187,000. Of course, this net difference depends on the value of the services required in each instance.

In Waltham, almost unusable land was converted to industrial use for plants costing $22 million and paying about $400,000 in taxes. Acreage prices responded to heavy demand for land after development and rose from $1,000 to $1,500 an acre to about $8,000 an acre.

Two recent Kentucky studies (27, 28) evaluated the economic effects of two highway facilities (one a limited-access highway and the other a free-access belt line) on adjacent properties. The free-access highway was found to have a more positive influence in connection with the conversion of land to a higher use than did the expressway. Since completion of the Belt Line in 1953 the demand for land along the facility for industrial use has continued unabated. Whereas no commercial or industrial activity existed in the area before construction of the Belt Line, 40 percent of the area within 500 ft of the facility was later developed for commercial or industrial use.

A recent comparative study of the present and proposed Belt Line routes west of the Twin Cities in Minnesota revealed that warehousing and manufacturing development are associated to a great extent with highways and railways. Retail and service establishments, on the other hand, tend to associate themselves with residential density as well as with highway traffic. It was found, for example, that 89 percent of the warehousing and manufacturing enterprises (with 74 percent of the acreage) were within 1,000 ft of a major highway. This association of belt lines and distribution facilities has also been encountered around the Capital Beltway in Washington, the Baltimore Belt (29) and other circumferential highways because of the accessibility of large metropolitan areas from such facilities.

Another modern highway facility which has attracted a tremendous amount of new industrial growth is the New York Thruway (30, 31). Many leading industrial companies have constructed multimillion dollar manufacturing complexes within its range of influence. An executive of one of these companies claimed that the Thruway afforded a number of advantages, including better transportation for employees, proximity to intercity and interstate truck lines, advertising benefits, and facilitation of establishment of satellite plants.

The influence of the Eastshore Freeway on industrial development in the San Francisco-Oakland area has been great. A survey (32) of an area encompassing only 9 percent of the available land in Alameda County suitable for industrial development revealed that in only 7 years (1951-57) this area accounted for over two-fifths of the county's expenditures for new industrial development and 30 percent of the total of new plants built. When executives of the firms locating adjacent to the Eastshore Freeway were asked what motivated them to locate where they did the answers most frequently given were (a) the area offered a central location with respect to markets, and (b) access to the Eastshore Freeway.

Highway Influence on Investment

Modern highways, though not encouraging industrial investment in the absence of other favorable factors, have in several instances, been able to attract industrial development into nearby areas. For example, industrial investment along Mass. 128 during a recent year amounted to almost two-fifths of all new investment in the Boston Metropolitan Area. In Indiana, almost one-half of the 354 new industrial plants established during the past three years are located within a 45-mi band straddling the Indiana Turnpike; and during a recent period in Alameda County, Calif., over 40 percent of the industrial development occurred within an area most subject to highway influence comprising less than 10 percent of the county's industrial acreage.

In addition to assisting the development of new or vacant areas, highway improvements ordinarily improve the productive efficiency of established industrial areas. Redevelopment projects in a number of cities demonstrate the importance of modern highway facilities in preserving or rejuvenating industrial facilities.

The need for adequate highway transportation in established industrial centers is particularly important because of the increasing decentralization of many market areas and of industrial activities generally. In Detroit (33) for example, the number of "in-city" manufacturing establishments increased by 47 percent during a recent eight-year period, whereas in the region outside of Detroit the increase was some 220 percent. This general decentralization of industry results from such factors as (a) the need for space for expansion; (b) easier access to markets, supplies, and labor; (c) desire to improve public relations; and (d) savings in storage and inventory.

Highways of modern design obviously facilitate access to markets and supplies. Many firms at freeway sites on the fringe of metropolitan areas are able to serve the central city, a large suburban area, and a large hinterland as well. For instance, companies located along the Santa Ana Freeway in California have found that it takes less time to get to the city's center from their new outlying locations than from their former in-town sites. Location close to markets is especially important to industries (e.g., bakeries) whose finished product is perishable, whereas material-oriented industries (e.g., food preserving or cotton ginning and baling) seek improved accessibility to supplies.

Public relations advantages are also a factor in the increasing popularity of highway locations away from population centers. Many businessmen value sites near highways of modern design because of the opportunity it affords to be seen by the traveling public. In addition, decentralized locations often result in savings in storage and inventory costs because of the ability to serve a wider area from a single point.

Industrial Parks

Decentralization of industry has resulted in the development of industrial districts or industrial parks which characteristically place an important reliance on highway transportation. There were over 800 of these industrial parks in 1958, ranging in size from 17 to 1,700 acres (34, 35). Industrial parks, which are primarily a post-World War II development, tend to maximize the advantages of decentralized locations by careful control of the use made of land and by facilitating the exchange of services between neighboring firms.

Case studies verify the importance of highway factors in industrial location consideration. Of 68 industrial location cases recently studied (36), location factors related to highways were considered to be dominant in 23 cases.

Benefits of Highways to Commercial Activities

The motor vehicle and technological changes have had far-reaching effects on American retailing patterns and shopping habits. During the past half-century, trading areas have undergone tremendous expansion, from a few miles in the beginning of the century to 30 to 150 mi presently. Although the number of retailers increased by less than one-third during the past 20 years, retail trade volume quadrupled and population increased by almost 50 percent during this same period.

The trend toward large retailing operations with limited storage facilities has resulted in increased dependence on large outlying warehouses with rapid and flexible transportation connections with selling outlets. Thus, the motor truck has proven to be an integral part in this distributive process while functioning in the added service of home delivery.

According to census data, metropolitan areas have in recent years been outgrowing the central cities. One of the outcroppings of this growth as described by both Garrison (8) and Horwood (37) has been the rapid development of suburban shopping centers, regional, community, and neighborhood. Because most of the patrons of these shopping centers are auto-borne, these business complexes are extremely dependent on good highways. This is particularly true in connection with regional shopping centers which depend on trading areas of over 100, 000 people in heavily-settled residential areas.

Almost all choice locations for these centers are located on, or adjacent to, expressways. In fact, many of the larger downtown department stores have found it more profitable to open branches in regional shopping centers. A survey shows that branches of large department and specialty stores in 50 large cities increased from 350 to 644 between 1952 and 1956. Only 50 of the 644 branches are in city locations and 594 are located in shopping centers or other suburban places. Only 9 or 10 percent of the 90 branches opened in 1956 are in cities.

An analysis of profits of seven branch stores in shopping centers by the National Retail Dry Goods Association revealed that none of the branches experienced a loss and that the branches showed net profit margins that were higher than those of the downtown stores.

Conventional highways and expressways and freeways differ as to the measure of protection they afford established business in cities and towns along the highways. Conventional highways, when built, immediately open up new sites for businesses that have an opportunity of intercepting business from motorists using that highway. The limited-access facility, on the other hand, does not afford opportunities for establishing highway-oriented enterprises. Motorists using limited-access highways are obliged to transact business with establishments in regular trading areas or along frontage roads. The claim is made that limited-access highways therefore make for more cohesive business areas while affording higher standards of construction and service.

Suburban Shopping Center Development

The well-being of the central business district has undoubtedly been affected, in many instances, by the development of suburban shopping centers. These shopping centers have mushroomed in both number and activities during the same period that many central business districts have experienced a relative decline in retail trade activity. It is not at all clear, however, that the growth of suburban shopping centers has taken place at the expense of retail trade activities in central business districts, because there are differences in the kinds of merchandise handled in central business districts and suburban shopping centers.

Until recently shopping centers have evolved piecemeal and on an unplanned basis, primarily as a result of business establishments locating themselves near intersections of major streets or highways or at other points of easy access. Today, planned shopping centers have developed and the number has increased dramatically, some 2, 500 having been constructed since World War II. These planned shopping centers, though differing in size, composition, and area served, are alike in the emphasis they give to serving auto-borne customers. Special attention to easy access by highway and customer parking is a fundamental characteristic of these centers.

Central Business Districts

Although highway transportation has been generally advantageous to central business district development in the past (by permitting increased specialization, expanded markets, etc.), current highway influences may be of uncertain advantage to central business districts. Some observers feel that the mushrooming of suburban shopping centers spells difficulty for certain kinds of downtown business enterprises. This concern appears to result from the decline in certain activities in the central business districts of many large American cities, though in many instances this is simply a relative decline; that is, a slower rate of increase in central business district activities than in surrounding areas.

Retail Trade

The relative decline in central business district activity is especially apparent in retail trade activities, one of the most important functions of the central business district. During a recent six-year period, the percentage increase in retail sales occurring in 168 major metropolitan areas amounted to over 30 percent (in current dollars), whereas the increase for the central business districts of these metropolitan areas amounted to less than 2 percent (38). For a few areas, this decline in retail trade activity is absolute, an actual decrease in retail trade activity. Retail trade activity decreases are more pronounced in central business districts of cities with a million or more population.

Office Space

Although central business district activity in many major metropolitan areas has ceased to grow, absolute gains in particular areas or in particular phases of retail trade have also occurred. More important, retail trade losses in downtown locations are being replaced, at least to some extent, by other activities—notably, office space. In some cities, increases in office space in central business districts appear to be sufficient to more than offset any losses in retail trade activities. A survey (36) of 60 cities each with at least 100,000 population shows that relative gains in office space during the past 10 years have been greater in large cities than in smaller cities, amounting to 1 to 2 percent in a city of 3 million. New York City provides a dramatic example of the post-war office boom, adding 42 million square feet or about 1,000 acres of floor space.

Some types of office space activities (for example, insurance offices) appear to be undergoing an outward shift, at least in some cities. Examination of the location decisions made by 69 insurance companies during the past 12 years shows that 68 percent of the new insurance establishments were located in outlying areas, whereas 32 percent have settled in the predominantly commercial area near the city center The suburban shift of insurance activities is also apparent in terms of employees; in 1946, 4 percent of all headquarters and regional office employees were located in outlying areas compared with 30 percent in 1958.

Unlike insurance offices, banking continues to be a strong central business district activity Although the number of banks is growing rapidly in outlying areas, central business districts account for the major part (about 80 percent) of bank deposits, the primary measure of banking activity.

The location of public utility companies also sheds some light on the role of the central business district and the influence that highway transport is having in urban areas. About 92 percent of all utility company headquarters offices are located in central business districts; in the 1946 to 1958 period, approximately 75 percent of the floor space added for public utility offices was established in or near central business districts. Though there has been some transfer of establishments from the central business district to outlying locations, employees and floor space added through growth in the central business district have offset any loss of public utility activities.

There is some tendency though, for public utility companies to decentralize a portion of their functions, particularly in larger cities. The factors that encourage the decentralization of utility company activities are similar to those influencing decentralization of other activities: sites with easy access in urban areas, traffic and parking problems in central business district locations, etc.

Location of Commercial Enterprise

Like shopping centers, individual business establishments ordinarily seek locations where their markets can be served as effectively as possible. These location decisions are often influenced by highway considerations. A survey of business firms in Chicago, Hartford, and Pittsburgh, for example, revealed that of the 10 dominant location criteria, five were directly related to highways. Among the more important of these location criteria are access and exposure to highway networks (3, Tables IV-9 and IV-10).

Bypasses

Information concerning 90 bypassed communities in 22 different States reveals that, generally, business activity either benefited or was unaffected in areas where bypasses caused traffic to be directed from the main business thoroughfares (3, Tables IV-1 through IV-6).

A variety of indicators was used to measure highway influence in bypassed areas, including retail trade volume, number of businesses, retail employment, sales taxes, business starts and stops, land value and land use changes.

Fifty of the 76 bypassed areas for which retail trade information was available showed a larger increase (or smaller decrease) in business than occurred in comparable areas without bypasses. Even in the case of service stations, which are highly highway oriented, gains were recorded which were greater than those for the control group in about one-half of the 46 instances where information was available.

Many of the studies found that bypass routes were beneficial to business activity primarily because they aided in the elimination of non-buying through traffic, thus making for less congestion and better parking conditions for local shoppers. Local bypassed businesses are also aided by the fact that most of the modern bypass highways are of the limited-access type which precludes ribbon development of businesses. Thus, the through traveler must shop in the bypassed area nearest the bypass route if a purchase is to be made.

Findings from these bypass studies also pointed out that through travelers do not purchase as much from highway-oriented businesses as one might suppose. A study of commercial development along US 41 between Chicago and Milwaukee, for example, showed that even along this heavily-traveled route most of the business was done with local customers who lived or worked within five miles of the facility.

Urban Land Values

Highway improvements generally have a tendency to increase the alternative uses of nearby land and alter the time-distance factor, thus affecting land values. Improved accessibility to land through improved highways may enlarge the amount of land available for productive use and for uses to which the land would not have been put in the absence of the new road facility.

Land value increases are more or less expectational in nature. That is, gains in land values do not always wait for physical developments to occur. Rather, such impact on values begins to assert itself almost as soon as it becomes known that a highway project has been approved. There are a number of studies that reveal that land values generally increased at a faster rate than the values of the improvements on the land.

Certain broad findings were adduced from approximately 60 land value studies conducted over the past 20 years. For example, the value of land adjacent to a major highway improvement increased faster than land farther from the highway. This undoubtedly was a reflection of the relocation of activity closer to the new highway facility.

A study of effects of the Gulf Freeway found that land in two zones near the freeway increased 667 percent and 242 percent of former average values, whereas land in two control zones not influenced by the freeway increased in value by 80 and 203 percent. Along the Dallas Expressway the value of land near the facility increased four times faster than did similar land farther away from the expressway.

The dramatic changes in the values of land influenced by the 427-mi New York Thruway have been well documented. The value of land at certain strategic locations along the Thruway increased sharply over relatively short periods of time (2, pp. 75-78).

Industrial Land Values

Where a highway improvement effects changes in the use of land in the area of influence, such changes in land use are generally accompanied by very significant changes in land values. Not only does the present use of the land determine land values but future use also has a bearing on the price of land. For example, a shift from agricultural to industrial land use (or an expectation of such use) generally produces increases in land values. An analysis of industrial land values in 7 studies conducted in California, Texas, and Georgia indicated annual increases in industrial properties of from 7 to 117 percent on a constant dollar basis.

A study of the economic effects of the Lexington, Ky., Northern Belt Line found that no commercial or industrial development existed in the area. Several years after opening of the facility, 40 percent of the area within 500 ft of the Belt line was being used for commercial or industrial purposes. During the period of development land prices jumped from $500 an acre to $10,000 an acre. Smaller commercial parcels of less than 25,000 sq ft sold for over $20,000 an acre.

The Lexington Northern Belt Line also had the effect of retarding the conversion of nearby land to residential use. When the commercial potential of the belt line became apparent, nearby land which was earmarked for residential development was converted instead, to commercial and industrial use with attendant increases in land values therefore.

In Alameda, Calif., a shift to industrial use of land (from agricultural use) near the Eastshore Freeway resulted in acreage prices rising from $500 to $10,000 (in current dollars) between 1941 and 1953. Land along a frontage road of the Santa Ana Freeway sold for $55,000 an acre, the land to be used for industrial development.

Commercial Land Values

A number of studies made in connection with highway effects on commercial land values indicate that highway improvements have had a generally favorable effect on nearby commercial properties. A summarization of results of highway influence on commercial land values from 11 studies in California, Georgia, Kentucky, and Texas bears out this conclusion. In North Sacramento, commercial property prices rose by about 40 percent in current values after opening of a bypass route. In Texas, the Dallas Central Expressway in most cases had a beneficial effect on business volumes, and commercial property values rose rapidly. Downtown commercial properties in Houston, served by the Gulf Freeway, experienced value increments much faster than similar properties located elsewhere in the city. The San Antonio Expressway exerted a similar influence on San Antonio commercial property values.

Residential Land Value

One effect that can be reasonably expected of highway improvements is a shortening of travel time to work or business and to social, cultural, and educational activities. A lessening of such travel time may very well serve to enhance affected residential properties and hence increase the value of residential land.

From studies made in a number of States it was found that, generally, residential properties adjacent to modern highway facilities had more rapid increases in value than did similar properties farther away from the facility. At least, such was the case along Park-Presidio Boulevard in California and US 50 in Lawrenceville, Ill.

There are, to be sure, cases in which immediate gains from highway improvements do not manifest themselves. The Louisville Watterson Expressway, with its heavy traffic, resulted in land close to the highway becoming less valuable. However, land a short distance away from the facility enjoyed value increments mainly because of better access and the absence of nuisances created by the highway. In Needham, Mass., the values of older homes near Mass. 128 did not increase in value nearly as much as did homes further removed from the highway.

Summary of Percentage Changes in Land Values

Among these studies of the impact of highways on land values, the changes in urban property values are impressive (3). These percentage changes in land values by themselves do not tell the entire story, because no comparison with unaffected or less affected areas (control areas) is afforded. They do, however, give the order of magnitude and the spread of property value changes as found in these impact studies. For instance, out of 56 studies in 19 States it was possible to identify 183 separate study segments that lent themselves to systematic analysis.

The median values (in constant dollars) of these annual percentage changes, classified according to kinds of land and proximity to highways, indicates that the greatest annual changes in land values are associated with industrial land or unimproved land. All types of land had a median annual percentage change of 8.8 percent (Table 1).

Comparison with control area data affords a more realistic impression of the highway influence. There were 44 study segments which gave the changes in value of land and improvements as a total. The ratios of the percentage changes were distributed according to Table 2.

TABLE 1

MEDIAN ANNUAL PERCENTAGE CHANGE

Kind of Land[1]	Median Annual Percentage Change[2]
Industrial	17.5
Commercial	10.3
Residential	8.5
Unimproved	12.5
Total classified	9.3
Unclassified	5.8
Total	8.8

[1]After improvement.
[2]Constant dollars.

TABLE 2

PERCENTAGE CHANGE RATIO DISTRIBUTION

Ratio[1]	Number of Study Segments
0.0 - 0.5	3
0.5 - 1.0	9
1.0 - 2.0	9
2.0 - 4.0	14
4.0 - 8.0	5
8.0 - 38.0	4
Total	44

[1]Study area to control area.

From the table it is plain that a part of the increase in land values shown by the percentage-change tabulations is accounted for by nationwide or areawide trends. For example, out of the 44 study segments giving values of land and improvements in 12 (27%), the ratios to percentage change in the control area were 1.00 or less. On the whole, however, this table shows a substantial advantage to the study area. Of the 44 study segments, 32 (73%) show ratios of more than 1.00; 9 (20%) have ratios of more than 4.00; and 4 (9%) have ratios of more than 8.00.

Rural Land Values

Changes in rural land values are equally impressive. There does not seem to be any doubt that, other things being equal, farms situated on paved roads are worth more than those situated on gravel roads; and that those situated on gravel roads are worth more than those situated on earth roads. These differentials appear to be directly associated with the differences in all-weather travelability and in operating costs and time costs in driving to and from the market town.

In 1958 and 1959, the Department of Agriculture conducted a survey involving 11,452 agricultural land sales throughout the United States. Actual sales data were gathered for farms on dirt, gravel, and paved roads, classified according to distance from the nearest trading center and by type of farming area. Local reporters familiar with farm market values were asked to estimate what the farm would have sold for had it been situated on a different type of road. The following brief summary will suffice here:

1. Farm properties on dirt roads sold for average prices per acre ranging from $34 (spring wheat) to $115 (central cotton); had these properties been situated on hard-surfaced roads the prices per acre would have ranged from 5 to 31 percent higher.

2. Farm properties on gravel roads sold for average prices per acre ranging from $45 (spring wheat) to $280 (eastern corn belt); had they been situated on dirt roads the discount would have ranged from 2 to 23 percent; for location on hard-surfaced roads the premium would have ranged from 0 to 20 percent.

Comment on Rural Land Values

Although the associations indicated between type of road surface and land values do not necessarily indicate a causal relationship, there is close relationship between these two variables. It is probable that more productive lands justify and ordinarily receive better roads. Therefore, higher prices for farm land along better roads should be attributed only partly to the highway. There is, however, a strong association between rural land value increases and highway improvements. It is no doubt, also, quite significant that farmers themselves consider road improvements to add to the value of their land, confirming the results of studies of market sales of farm real estate. This subject was extensively treated by Longley (25).

Conclusions on Quantification of Benefits

The economic impact studies originated for a variety of reasons, including the need of impact data for land acquisition purposes, highway planning, public hearings, and public relations. Because of this conglomerate set of uses, data collected in economic impact studies are not always of the same type nor of the same depth or sophistication. The designs of the various studies differ considerably.

A major purpose of the impact studies encouraged or sponsored by the Highway Cost Allocation Study was to obtain a representative overview of impact on various segments of the population. Therefore, many of the studies dealt with one geographic section or one specific subject of interest. Because the economic impact studies were usually concerned with a strip or zone analysis, the data tend to give some conception of the benefit differential to highway-abutting areas, but do not provide data for overall quantification. The studies gathered information on a variety of subjects dealing with tax losses, central business districts, special assessments, industry location, and many others, and it was not possible to obtain complete coverage of each subject.

Analysis of the land value results furnishes similar limiting factors. Many of the land studies have been concerned with only one particular time, in a static approach to the subject, or in an attempt to study short-run dynamics of land values. Both of these methods are subject to the criticism that no means have been developed to determine whether successive impacts of additional highway improvements tend to affect land value increments, or whether land increments reflect transfers in use of land between different segments of a community.

Nevertheless, the findings of land value studies indicate at least what the short-run results might be that should be given consideration in highway planning.

Various attempts to add up the results of impact data collected in the pattern described in order to obtain a figure of nonuser benefit have not been successful although frequency distributions of the results of the land value and bypass studies were attempted, and they tend to furnish a consistent picture.

Recognition of these limitations led the Bureau of Public Roads (3, pp. 5-6) to state in House Document No. 72, in its discussion of land value changes to state:

> Over 50 studies of land values along major highway improvements in urban, suburban, and small town centers have been made at various times during the past two decades, almost 30 of which have tabulations of land-value data that lend themselves to systematic evaluation. The studies have varied as to time, type of highway improvement, community, methods of deriving land values, and the unit of land studied. Some studies used assessments for obtaining comparative data; others depended upon appraisals. Most of

> the studies used actual market sales and a simple comparison of land prices "before" and "after" the highway improvement. A few limited studies dealt with parcels of land while those in metropolitan areas dealt with bands, zones, and sections of land adjacent to the highway compared with those more distant from the highways. Many of the communities for which land-value data were gathered were in varying stages of historical growth and development.

Development of overall nonuser benefit figures can, however, be associated with the model analyses described in the early part of this paper. It would be necessary to indulge in an involved input-output or other model analysis to develop the community effects of an investment program. As Isard (39) has stated, in a somewhat different context:

> The most difficult economies to estimate are, of course, the positive welfare effects. However, it is possible that certain indirect effects of alternative size complexes upon community or regional growth can be compared by some sort of regional multiplier approach, perhaps utilizing input-output concepts.

In the light of current knowledge, however, no definite methodology has yet been established to clearly quantify nonuser benefits.

Nevertheless, evidence abounds that highways have brought about extensive reorganization of land uses, particularly in urbanized areas. The outward growth of metropolitan areas, the rise of the suburbs, and the decline, relative or absolute, of central cities have been well documented.

The economic impact studies do not lend themselves to any precise quantification of nonuser benefit on a national, regional, area, or other extended basis; they are generally concerned with the effects of individual highway projects with the exception of some nationwide studies sponsored by the Bureau of Public Roads. They do, however, provide an indication of the powerful changes that can be wrought by the highway in economic and social life. Such generalized indications provide the basis, when added to the theoretical formulations already described, of finding a nonuser benefit from highway improvement over and above the savings in transportation costs.

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General Discussion

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• THE PAPERS that have been presented deal primarily with the related questions of indirect benefits, nonuser contributions, and highway subsidy. They represent an attempt to evaluate what might be called the "social" component in highway finance. Inasmuch as social value is an exceedingly difficult concept to define and measure, the differences in approach and contradictions in conclusions that have been presented might be expected.

The division of highway costs between users and nonusers is based on the fact that highway use and development create diverse indirect benefits which accrue to persons other than the direct users of the highway plant. As a matter of equity, it is maintained that these indirect benefits justify a general tax contribution toward the highway program. According to Steele and Todd, this practice is "almost universally accepted by specialists in the field." Steele and Todd review and evaluate the data and techniques employed in allocating costs among users and nonusers, and conclude that it is now "possible to do a much more theoretically sound and practically satisfying job of allocating highway costs than has been possible at any time in the past." Their analysis represents an important step in the direction of developing a standardized approach to the user-nonuser allocation.

However, within the past few years a number of economists have questioned the validity of the allocation of highway cost between users and nonusers. Thus Tybout, in a stimulating reorientation, defines highway use as space occupance and concludes that "only user-taxes can be justified on economic grounds." Adopting a more restricted pricing approach, Mohring states that the economic justification for general tax contributions must be found in situations where marginal cost is below average cost. This purely theoretical case for the use of general tax contributions has not as yet had an important impact on highway finance. It clearly is not the rationale of the traditional nonuser share which is based on the existence of indirect benefits.

Although indirect benefits to others than users are generally cited in justification of a nonuser share, the actual techniques employed—relative-use and earnings-credit—appear to have no direct or close relationship to indirect benefits. The implication of these techniques is that indirect benefits are relatively greater on lightly-traveled access routes than on primary highways. Measurements to give weight to this hypothesis have never been made, and in view of Goldstein's well-documented analysis, it is doubtful that this hypothesis can be supported. Of course, it might be possible to define indirect benefits to include only increases in land value associated with access facilities. Here the problem (emphasized by Mohring) is encountered that increases in land value may represent a capitalization of user savings and should not, therefore, play a separate role in highway finance. This does not mean that landowners and other indirect beneficiaries should take their gains and go scot-free. According to Tybout, "Even the unearned increment may be taxed. The point is that such taxes should not be used for the support of highways." The traditional allocation of highway cost to nonusers may lead to the creation of a highway subsidy disguised in the name of equity, for what is paid by nonusers represents a reduction in the amount paid by users. If a subsidy is created in this manner neither equity nor economic efficiency will be served.

Zettel and others have noted that the usual allocation of cost between users and nonusers has been developed to solve the administrative problem of recovering through uniform user taxes the differentially-higher unit costs on secondary roads. Thus, property taxes and other sources of revenue closely associated with the local highway user have been employed. That is, there has been a close identification between tax and user. Tybout emphasizes this point and suggests that nonuser sources be employed, not in the light of indirect benefits, but because access uses are more expensive per unit of travel than through or primary uses. A clear implication of Tybout's discussion is that the calculation of a nonuser share on the Interstate Highway System could be justified only to the extent that local traffic on the Interstate System requires or utilizes more units of capacity than the through traffic. Following through on Tybout's approach, it would appear that any nonuser revenue sources utilized to finance the Interstate System should be assessed and collected at the State or local level where local users may be reached. Tybout's analysis is implicitly damaging to the case for a nonuser share at the Federal level.

Mohring's paper fortifies these conclusions. He suggests that highway services be priced according to a marginal cost. Because the most important component of marginal cost is time loss due to congestion, user rates would vary in relation to traffic density or demand. An interesting feature of Mohring's analysis is the proof that optimal highway operations in the absence of scale economies would yield sufficient user revenue to defray highway cost. To provide highway services at rates below marginal cost would lead to a subsidized user tax structure.

Mohring gives scant attention to indirect benefits assuming perhaps that such benefits are received by users in the first instance and subsequently passed along to indirect beneficiaries. But an easy dismissal of indirect benefits seems inappropriate. Goldstein's paper cites an impressive array of "net" indirect benefits. His paper suggests that horizons in considering highways should be broadly social rather than narrowly economic. Goldstein describes highways as "social overhead" and classifies them along with schools, water supply, recreation, and other activities that are sometimes heavily subsidized. On the other hand, Tybout states that highway services are private goods. Though Goldstein does not suggest that highways be subsidized with general revenues, his analysis logically raises the question. Mohring, who deals extensively with subsidies in relation to the mass transit problem, does find a justification for subsidy in what he describes as noneconomic "social considerations." That is, "aesthetic, national defense, or other reasons entirely unrelated to economic value." But the indirect benefits cited by Goldstein are, more often than not, economic in character, not aesthetic or ethical. It is doubtful that transportation subsidies historically have been based on noneconomic grounds, although they may have been based in part on decreasing cost, a situation which Mohring takes into account. It seems that transport subsidies have been granted because the economic benefits to society—indirect benefits—far exceeded the direct economic benefits to private users as reflected in the market place. Mohring's classification of subsidy-justifying conditions seems to omit the most important economic factor of all—indirect benefits. Only under some rather extraordinary theoretical conditions does the market adequately measure all relevant indirect benefits. The market place is a powerful institution for the measurement of value, but it is not perfect; it overlooks many indirect benefits and costs.

The existence of significant indirect benefits frequently calls for public subsidies designed to encourage expansion of what is socially and economically a good thing. Subsidies to schools are, in part at least, justified on the basis of economic values, especially anticipated increases in productivity in excess of those accruing to the individual. Why not subsidized highways, especially in the light of Goldstein's findings? It might be argued that indirect benefits are associated in equal amounts in both private and public investments. That is, indirect benefits cancel out and to subsidize public works would "rig" the economy in favor of the public sector. This is the import of Mohring's apples-oranges analogy. The canceling out assumption, however, does not sit well. For it is likely that the areas in which the public has taken an interest are precisely the areas in which indirect benefits are greatest, and transportation is one of these areas. More efforts along the lines of Goldstein's paper may shed some light on these questions. Relatively narrow market approaches to highway planning and finance are difficult to justify, at least at this stage.

In attempting to reach a conclusion regarding the desirability of highway subsidy, it might be asked whether the private demand of highway users is of sufficient intensity to provide, through direct user payments, the quantity and type of facilities required to meet society's needs. In short, will the private economy provide "social overhead?" If the answer is affirmative, the traditional nonuser share amounts to a superfluous subsidy. If the answer is in the negative, an appropriate subsidy in the form of a non-user share would be in order.

It is possible that in some of the less developed areas of the Nation, traffic stimulation through the use of subsidies may increase productivity and therefore be economically desirable. However, in general, this situation does not exist in the United States. Although a different situation existed historically, current highway development reflects primarily a response to the direct demand of motorists. Modern highway policy is not consciously geared, as it was in the early 1900's, to the positive stimulation of traffic. One might question the validity of an infant industry rationale for the nonuser share. Thus, Goldstein's excellent analysis of indirect benefits with an emphasis on "social overhead" may not adversely affect the conclusions reached by Mohring and Tybout relative to highway subsidy.

The space-occupance approach to the determination of user tax rates was introduced by Troxel and others a number of years ago. Tybout's suggestion that space occupance be employed for the allocation of geometric costs merits serious consideration. It is consistent with the marginal cost standard described by Mohring and seems to provide a more rational basis for the allocation of geometric costs than either vehicle-miles or axle-miles. After all, the limiting or relevant economic factor is highway capacity. The development of space-occupance factors for various highway uses and for vehicle classes would add significantly to the highway analyst's box of tools. The "Highway Capacity Manual" represents a good start in this direction.

Although the papers presented suggest many areas for further research, the chief implication for current analysis relates to the possibility of reorienting the cost allocation between users and nonusers. Elimination of this costly and time-consuming allocation would not preclude the employment of nonuser revenues, would not diminish equity, and might improve economic efficiency. There are many indirect benefits that will accrue as a result of the new highway program. It is reasonable to suppose that some groups will insist that these surpluses warrant general fund contributions toward the highway program. Extreme care should be taken before making such transfers. Equity may still be served by taxing obvious windfalls for other public purposes.