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II. Productivity in Selected Service Sectors

4 Measurement and Analysis of Productivity in Transportation Industries

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4.1 The Interest in Transportation Productivity

Recently, a great deal of interest has been expressed in measuring and improving productivity in the transportation industries. In addition to all the conventional reasons for wishing to know more about the productivity of any industry, an additional concern in the case of transportation is that several transportation modes, notably the railroads and urban mass transit, have been declining rapidly. Many analysts have argued that the decline of these modes is undesirable—because, for example, it imposes hardships on employees and certain groups of passengers and shippers who are particularly dependent on the service these modes provide; or, more recently, because these modes appear to generate less pollution and use less energy than their competitors.

It is, of course, less than fully obvious that a high rate of productivity growth will necessarily reverse the decline of these, or any other, industries. The evidence, though, suggests that productivity and growth are positively related, as shown in figure 4.1. Needless to say, one can debate cause and effect in this relationship; besides, it is not always that close: two of the more notoriously declining or stagnant industries of the U.S. postwar economy—railroads and coal mines—were also by many conventional measures good productivity performers.

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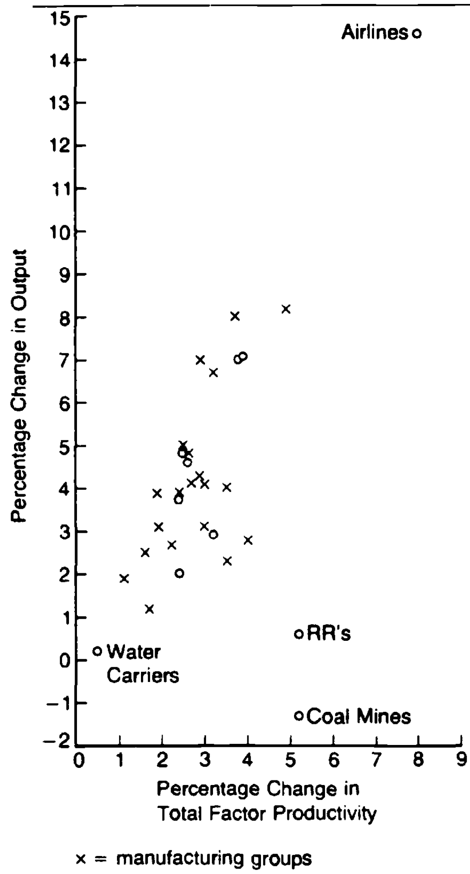


Source: Kendrick (1973), p. 106

Fig. 4.1 Relationship between Annual Rates of Change in Output and in Total Factor Productivity, Thirty-Two Industry Groups: 1948–66

Productivity improvement probably is perhaps best viewed as a helpful, perhaps sometimes necessary, but not a sufficient condition for an industry to develop a favorable growth record. Certainly, productivity improvement does help an industry to keep pace with other industries, all else being equal. Moreover, few would argue with the proposition that if productivity could be improved in some of the troubled transportation industries, the odds would at least improve, even if ever so slightly, that these modes could be once again revived.

Interest in measuring and improving transportation productivity is also generated by the circumstance that many of the transportation industries are closely regulated and often subsidized by government.

The extensive public involvement in the industry has a variety of motivations, too many to list here. But whatever the motives, regulation often involves the government in decisions about the industry where information on productivity is deemed vital or at least helpful. Such decisions include the appropriate fares and rates for transportation services, valuation of transportation capital, and compensation for labor.

It is also now apparent that a common unintended consequence of public involvement may be the weakening of industry incentives to improve productivity. This possibility is perhaps most pertinent where public operating subsidies exist. Operating subsidies are common among transit firms and local service airlines, and are being implemented for northeastern railroads.

Even without direct subsidies, motivation for productivity improvement may be undermined by public regulation. One famous example is the ICC regulation on calculation of the cost of service in rate making. An unintended consequence was apparently to make it unprofitable for the railroads to use what was, under normal circumstances, the most efficient type of flat cars for piggyback service (Gellman 1971).

These concerns, new and old, have stimulated several recent analyses of productivity trends in transportation industries. Several problems in measuring productivity have been identified recurrently in these efforts. While the problems are usually not unique to transportation, they are perhaps particularly common and difficult in this sector. No insurmountable conceptual barriers may exist to finding solutions, but substantial difficulties in the accurate measurement and analysis of productivity trends are posed.

To illustrate these problems, we shall first describe some of the most difficult and common of them as encountered when measuring transportation productivity. Then we will review some recent attempts to estimate productivity trends in the trucking and railroad industries. Finally, we will present some new research on the productivity record of the urban mass transit industry from 1948 to 1970.

4.2 Problems in Measuring Transportation Productivity

In essence, measuring productivity change really involves manipulating and comparing four basic quantities: (1) rate of growth of output (Y'); rate of growth of labor inputs (L'); (3) rate of growth of capital (K'); and (4) rate of growth of intermediate goods used (I'). Using these four quantities, a standard formula for measuring change in what has come to be called total factor productivity is

$$A' = Y' - [\alpha\ (L')] - [\beta\ (K')] - [(1-\alpha-\beta)\ (I')],$$

where

A' = total factor productivity change;

α = the "weight" attached to the labor contribution to output (e.g., the labor exponent in a Cobb-Douglas production function); and

β = the "weight" attached to the capital contribution to output.

Obviously, the fundamental problems of productivity measurement are developing acceptable measures of the four basic rates of growth and determining the weights (e.g., α, β, and $1-\alpha-\beta$) to be attached to the different factor inputs. For a variety of reasons, these measurement and weighting problems almost always involve a certain number of assumptions and judgments. However, additional difficulties can be encountered in transportation because the sector is often of particular public interest, which commonly leads in turn to government regulation, subsidy, and other public involvement in the industry.

By way of illustration, a conventional method employed by governments for achieving social goals in transport is to keep rates low on those transport activities that are deemed most essential to promoting these objectives. Of course, if low enough, such rates may generate losses, which if not subsidized from public funds, must be made up from other activities conducted by the transport enterprise. One commonly used method of recouping is to charge high rates in so-called monopoly markets served by the carrier. Often these monopolies prove transient or nonexistent; a temptation may then emerge for the regulators to "remedy" the situation by artificially creating monopolies through various restrictions, e.g., on entry or competitor's prices.

Such policies can make it difficult to derive a meaningful measure of industry output. In most industries a single index of output is usually calculated by using relative prices to weight different types of service or outputs. In a market economy relative prices should reflect the relative value which customers place on these services and, where the industry is competitive, the relative cost of producing them. But when public policies deliberately keep some prices below and some above costs, relative prices may lose these qualities. Under these regulatory "distortions," relative price weights may mainly reflect circumstances that are largely irrelevant to normal output measurement, such as changes in the policies of regulators or in the mix of subsidized and unsubsidized outputs.

This problem is well illustrated in estimating postwar railroad productivity growth. Railroads produced both freight and passenger services, and the tariffs charged were heavily regulated and cross-subsidized. Usually passenger tariffs were far below costs and the services were continued only because the regulators so decreed, against the wishes of management and often in the absence of much market demand. At the same time, "monopoly" tariffs placed on freight to compensate for the passenger losses were in large measure forced down by truck or barge competition, so that rates charged for different types of freight services increasingly tended to reflect real demand and cost characteristics. Since passenger services declined rapidly while freight services did not, an index of railroad output constructed with passenger and freight outputs weighted by relative prices makes the postwar decline in output look less precipitous than, in some senses, it was. Productivity estimates based on such an output index would correspondingly exaggerate the growth in railroad productivity.

Even if public transport goals are advanced without distorting relative prices, say by direct government subsidy, a problem may remain of properly valuing the special "outputs" thereby achieved. For example, in recent years the transit industry has received public subsidies in order to preserve mobility and reduce air pollution, among other goals. But the worth of additional mobility in an urban area or for a small town has never been assessed very objectively. And while some attempts have been made to estimate the value of less polluted air, the estimates done to date are probably best described as rough approximations (National Academy of Sciences, Committee on the Costs and Benefits of Automobile Emission Control, 1974).

In sum, the "social" character of some transport activities may make it difficult even to define a quantitative measure of "true" output for the industry. Even if that problem can be finessed or ignored, the conventional solution of using market prices or values to construct an aggregate index of total output is not feasible or meaningful if prices are highly regulated and cross-subsidization is prevalent.

This lack of good market information permeates and complicates almost all aspects of transport productivity measurement. For example, a pervasive, special difficulty in measuring transportation output is differentiating between terminal and line-haul operations. Although both operations are essential for completing most shipments, they involve two distinct types of service, normally performed by different parts of a transportation organization or even by different organizations. To handle joint production problems of this type when measuring output and productivity, two approaches are commonly used: (1) establish that the relative proportions of the two activities are more or less constant; or (2) "unbundle" the two activities and estimate their value or costs separately.

Unfortunately, there is no reason to believe that the mix of these two functions will be the same for different transport modes or has remained constant over time within a particular mode. The extent and cost of terminal operations (which includes local pickup and delivery of freight or passengers and sorting for assignment to the appropriate vehicle) depend in the first instance on the number of shipments or passengers handled and to a lesser extent on cubage and weight; these costs are usually not overly sensitive to the distances traveled. The cost of line-haul transportation, on the other hand, is dependent on the distance moved and to a lesser extent the weight of the shipment. Obviously, shipments come in different sizes and weights; even more pronouncedly, passenger trip and shipment distances vary widely.

Most conventionally available physical measures of transportation output tend to capture changes in one of these activities and not the other. For example, if the basic measure of output is the number of shipments or passengers, it will not reflect shifts in amounts of line-haul services provided when these are caused by changes in the average distance moved or the size of shipment. On the other hand, if output is measured by the number of ton-miles transported, it will not reflect shifts in amounts of terminal services required as caused by changes in the number of shipments or of passengers carried.

In short, several measures of output may be needed to accurately reflect all the relevant dimensions of transportation output. How to combine or weight these different measures so as to create one composite index of total output is usually not obvious. Of course, if separate prices were assessed for the different services, terminal and line-haul, then fairly conventional product value weighting schemes could be followed. The difficulty is that in most, though not all, transportation operations the service charge or tariff is "bundled" and a separate market valuation for the different activities is not available. Furthermore, even if separate charges were assessed, as they are in a few instances, rate regulation would often mitigate their usefulness.

Measuring transportation output, as for most industries, can also be confounded by the problem of controlling for differences in the quality of service rendered. Important components of quality include the average speed of the journey; the frequency and convenience of scheduled services; the reliability of estimated pickup, delivery, and travel times; vibration; temperature variation and its control; noise levels; physical protection against product damage; etc.

These service qualities have been changing rapidly in recent years for many modes. The availability of new technologies, such as the jet airplane or containerized freight, is one reason. Another has been the rise in per capita income. With higher incomes, passengers have generally demanded faster, more convenient, and more comfortable transportation service. Higher incomes have also meant an increase in the share of traffic in highly manufactured goods relative to basic materials.

Because these highly manufactured goods are generally more valuable, shippers have tried to reduce inventory costs by making smaller and more frequent shipments and by using faster, more convenient, more reliable, and less damage-prone services.

The quality of service has not increased, however, on all modes. For example, the average quality of service provided by railroads has probably declined in recent years. Moreover, some service changes which at first glance may appear to be clear improvements may not be unambiguously so in all dimensions. For example, the introduction of jet airplanes improved service by making air travel faster, but it may have also degraded service at some medium and lower density airports by making operation of larger planes relatively more economical and thus decreasing flight frequency.

If transport outputs were sold in freely competitive, unregulated markets, quality differences could be measured by simply using as output weights the rates charged for services of different quality. Actually, intermodal competition, in spite of attempts to suppress it through regulation, is probably sufficient to make existing rates at least somewhat indicative of the valuations placed on some service differentials. But the corrections so derived are probably rough approximations at best.

Complications also arise in determining the factor inputs required for delivering transport services. One of the more common of these difficulties is that in many modes the firms providing the transportation services do not own outright some of the capital they use. Some important capital inputs (e.g., highways, airports, airways, ports, and waterways) conventionally are provided and owned by government. In addition, among privately owned transport firms there has been a decided move in recent years away from outright ownership and toward various kinds of leasing arrangements. The reasons for this shift are many, the most important being tax advantages and the greater availability of financing under leasing as compared with ownership (due, for example, to better subordination of existing debt, etc.).

Unfortunately, conventional measures of capital stock or capital inputs, especially at an industry level, will not always accurately capture these changes. Specifically, an implicit ownership assumption is often made in the capital goods series so that only those capital inputs actually owned by the enterprise rendering the service will be incorporated into the capital measures. Usually, these omissions can be corrected, but only at the expense of doing somewhat more in-depth analysis of the particular industry and its practices. Even then, it may be difficult to measure with any precision the changes in these practices over time.

Probably the most difficult of these problems is evaluating highway inputs with any accuracy. Complexities inherently arise when determining the amount of public investment in highways that properly should be assigned to different highway modes. Without much question, motor carrier, bus, and transit productivity have benefited from postwar highway investments. Furthermore, the total amount of capital employed in these industries may have risen more rapidly than indexes based on rolling stock alone would suggest. Thus conventional measures of the increased capital employed in an industry might understate the actual situation. The exact dimensions of this understatement, though, can be very difficult to determine.

Factor inputs, once measured, must be weighted, of course, to construct a productivity index. Factor weights attached to labor and capital in productivity measures are usually determined by the national income shares attributed to labor and property. Such weights should be reasonably satisfactory as long as wage and profit shares do indeed reflect normal market influences. Clearly, though, such an assumption is at least questionable in highly regulated industries.

Regulated transportation, for example, has generally had a relatively poor record of profitability and accordingly relatively low weights attached to capital inputs. To what extent this is due entirely to regulation is at least debatable. To some extent, though, low profitability in several transport industries almost surely reflects various attempts at cross-subsidization and particularly the failure of the transport enterprises to realize high monopoly profits needed to pay for losses on social activities. Regulation may also diminish profitability by introducing a long "regulatory lag" between an increase in costs and the realization of a compensatory tariff rate increase—a particularly troublesome problem, of course, in an inflationary economy. Finally, regulation may inhibit the ability of an enterprise to attract good managerial talent or may divert such talent away from the pursuit of operating economies and into legal and political problems.

Whatever the cause, the low rate of return to capital in many regulated transportation industries leads some productivity analysts to assign very low weights to capital inputs in these industries. Other analysts argue that the weight given to capital ought to reflect the higher rate of return in other, unregulated sectors since this higher rate represents the social opportunity cost of transportation capital. While the proper weights in these circumstances are not always readily obvious, it is clear that changes in the weights can make a great deal of difference to the calculation of total factor productivity (as shown more fully in the next section).

4.3 Recent Analyses of Trucking and Railroad Productivity

Obviously, caution would appear advisable in interpreting any single transport industry productivity measure. Indeed, there is probably no substitute for a detailed knowledge of an industry in interpreting and understanding the various productivity measures normally available. The usefulness of any particular series, moreover, is likely to depend rather crucially on the application: certain measures serve certain purposes rather better than others.

Moreover, rarely are productivity measures likely to be so precise and unambiguous as to provide clear-cut quantitative guides to many of the public and private policy decisions which productivity measures are expected to aid. In short, rough or approximate answers may be possible in some instances, but highly precise or definitive answers are not.[1] A review of work done on different modes, as discussed below, confirms this.

4.3.1 Intercity Trucking

Several estimates of postwar productivity trends in U.S. intercity trucking have been made by the Bureau of Labor Statistics and by John W. Kendrick; these are summarized in table 4.1. Both the BLS and Kendrick independently estimate that while output in intercity trucking has been growing at the rate of 6 to 8% per year in the postwar period, labor productivity (output per man-hour) has been growing at the rate of only about 3% per year. The BLS also estimates that among the general freight carriers of the intercity trucking industry, postwar output and labor productivity have been increasing by only 4.9 and 2.1% per year, respectively, rates much lower than those for the industry as a whole. Capital and total factor productivity growth was not estimated because of the lack of data on capital stocks and depreciation. Both the BLS and Kendrick use ton-miles as the basic measure of output, apparently corrected, at least in the case of the BLS estimates, for changes in the composition of commodities carried.

Daryl Wyckoff has suggested that fundamental problems may be created for these estimates because the ratio of less-than-truckload (LTL) to full-truckload shipments, the average shipment size, and the average length of haul have all been changing over time.[2] From the standpoint of productivity measurement, the importance of these shifts

1. As one student on the subject has summarized the situation: "At best, a productivity measure (or a group of productivity measures) may serve as guides to better understanding of the achievements and frustrations of the industry—they certainly can never be taken as final truth." D. Daryl Wyckoff, "Issues of Productivity: State of the Art and Proposed Measures of Regular Common Carrier Motor-Carrier Productivity," *Traffic World*, 18 December 1972.

2. D. Daryl Wyckoff, "Issues of Productivity," *Traffic World*, 18 September; 6 and 13 November; 18 and 25 December 1972; and 26 February 1973. D. Daryl Wyckoff, *Organizational Formality and Performance in the Motor Carrier Industry* Lexington, Mass.: D. C. Heath, 1974). Many of the same observations were also made by Darwin D. Daicofe, "Analyzing Productivity Trends in Intercity Trucking," *Monthly Labor Review* 97 (1974):41–45.

Table 4.1 Previous Estimates of Postwar Output and Labor Productivity Trends in Intercity Trucking

Type of Trucking	Source	Period	Estimated Average Annual Percentage Growth in: Output	Labor Productivity
Intercity common carriers, class I and II	Kendrick[a]	1948–66	8.4	3.1
Intercity common carriers, class I and II	Bureau of Labor Statistics[b]	1954–72	6.0	2.7
Intercity common carriers of *General Freight*, class I and II	Bureau of Labor Statistics[c]	1954–72	4.9	2.1

[a]*Kendrick (1973), pp. 193, 335.*
[b]Carnes (1974).
[c]Carnes (1974, p. 55).

(in LTL freight, shipment size, and distance) is to create a corresponding shift in the mix of terminal and line-haul services required by the typical common carrier. For example, if the ratio of LTL and non-truckload shipments is increasing or average shipment size and length of haul are decreasing, then an output measure based on ton-miles alone (even corrected for changes in commodity composition) will almost certainly understate output growth and therefore, all else being equal, productivity gain as well.

Such shifts may explain, in part, the disparity between the estimates of productivity growth in the trucking industry as a whole and productivity growth among general freight carriers. In the industry as a whole LTL shipment tonnage declined from about 25% of total tonnage in 1950 to 12% in 1970.[3] Over the same period the average length of haul has increased slightly from about 235 to 264 miles.[4] *Ceteris paribus*, such trends decrease the amount of terminal services required relative to line-haul services; as a result, ton-miles measures, like those used by

3. Calculated from data in Transportation Association of America, *Transportation Facts and Trends*, 11th ed. (Washington: Transportation Association of America, 1974), pp. 10, 11.

4. Data for class I carriers only from the American Trucking Association, *American Trucking Trends, 1975* (Washington: American Trucking Association, 1975), p. 32.

the BLS and Kendrick, could possibly overstate output and productivity growth in the industry as a whole.

On the other hand, general freight carriers apparently experienced trends in shipment size different from the industry as a whole. For example, Wyckoff argues that the ratio of LTL to non–LTL shipments for general freight carriers increased from 1958 to 1970.[5] To the extent this is true, a ton-mile metric would tend to underestimate postwar growth in output, and thus productivity, among general freight carriers.

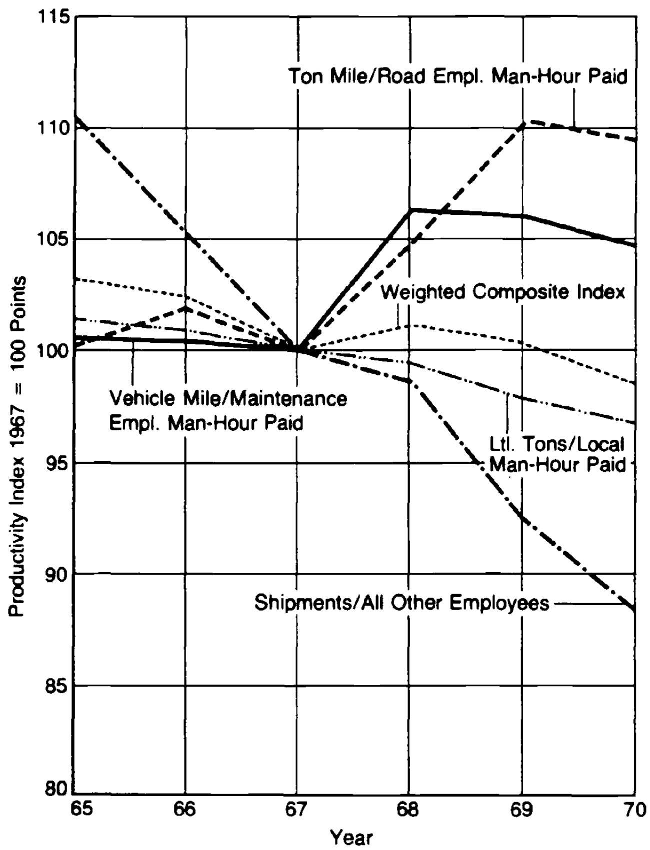
Wyckoff also finds that individual elements of general motor carrier operations displayed different productivity trends over recent years. As shown in figure 4.2, line-haul operations and maintenance both improved in productivity, and handling of less-than-truckload (LTL) shipments and the administrative costs of handling individual shipments seem to have declined. To the extent that general freight carriers have become increasingly involved in these slow or negative-productivity-growth activities, their overall productivity record as measured by ton-miles would, of course, be held back.

More generally, any productivity decline in the handling of LTL shipments would only heighten skepticism about the adequacy of conventional estimates of postwar trucking productivity growth that abstract from changes in shipment size and composition. Because a ton-mile metric may exaggerate output growth when average shipment size and length of haul are increasing, intercity trucking output and labor productivity may not have increased quite as rapidly as suggested by the 8.4 to 6.0% and 3.1 to 2.7% per year estimates in table 4.1. Similarly, because ton-miles may understate output growth when shipment size is decreasing, general freight carrier output and labor productivity may have increased more rapidly than the 4.9 and 2.1% per year estimates would indicate.

4.3.2 Railroads

Railroads have always represented something of a puzzle for productivity analysts in that, to a greater extent than almost any other industry —the only possible exception being coal mining—railroading represents

5. Wyckoff reports data from the U.S. Interstate Commerce Commission which show that the ratio of LTL to non–LTL shipments *increased* from 1958 to 1970. However, according to Wyckoff's data LTL to non–LTL shipments *decreased* fairly steadily from 1958 to 1964 and from 1965 to 1970; the increase between 1958 and 1970 is due almost entirely to an extremely large upward shift between 1964 and 1965. The size of this shift suggests that the 1958–64 and 1965–70 data are not consistent and that better evidence of the trend in LTL general freight shipments is needed. See D. Daryl Wyckoff, "Issues of Productivity: Measures of Productivity—What Is Being Measured and For What Purpose?" *Traffic World*, 18 September 1972.



Source: D. Daryl Wyckoff, "Issues of Productivity: State of the Art and Proposed Measures of Regular Common Motor-Carrier Productivity," *Traffic World*, 18 December 1972.

Fig. 4.2 Comparison of Productivity of Individual Elements of General Commodities Motor Carrier Operations

a case of an industry experiencing relatively high productivity gains while at the same time declining, or stagnating, in terms of output growth. This situation is aptly illustrated by referring back to figure 4.1 wherein it is shown that railroading, at least as measured by conventional productivity indices, lies well off of the relationship between percentage change in output and percentage change in productivity during the postwar period.

It seems highly likely that this deviation may be at least partly a result of methods used to measure railroad productivity. Specifically, research undertaken recently by the Task Force on Railroad Productivity suggests that postwar productivity growth in railroads may have been less than conventionally estimated earlier. Whereas previous estimates (again by the Bureau of Labor Statistics and John Kendrick) were in the range of 5%, the task force estimated rail productivity growth as probably lying somewhere between 1 and 2% (U.S. Bureau of Labor Statistics 1971; Kendrick 1973; Task Force on Railroad Productivity 1973).

Some of the differences in these estimates, as might be expected, are simply explained by the use of different concepts. The BLS focuses exclusively on estimating labor productivity and, in contrast to Kendrick, did not attempt to measure total factor productivity. Since the railroads have been substituting capital for labor rather more rapidly than industry in general, the rate of growth for total factor productivity in the industry is substantially less than that for labor productivity. However, the task force's research suggests that, even if one confines attention to labor productivity alone (which, of course, is a quite legitimate and useful measure for many purposes), simple labor productivity in the rail industry may have grown at an average rate of only 3 to 4% per year during the postwar years, substantially lower than the 5% estimated by the BLS. Nevertheless, even 3 to 4% is as great or greater than the growth of labor productivity computed for the entire private domestic economy, which is placed between 2.0 and 3.0% per year during the postwar period (Kendrick 1973, p. 41).

But the largest part of the difference between the estimates by the BLS and Kendrick and those by the task force stem from the differences in the measures of inputs and outputs. For example, unlike the task force, Kendrick does not adjust his estimates of capital inputs to count capital which is leased by the railroads. Since leasing arrangements are becoming more common, especially for railroad rolling stock, the task force estimates a higher rate of growth of capital inputs, and thus a lower rate of growth in capital and total factor productivity, than Kendrick.

More importantly, the Kendrick results are very sensitive to the weights used for combining capital and labor inputs when doing the calculations to determine total factor productivity. Kendrick follows the usual procedures for determining weights by basing these on the relative shares of labor and property in the national income originating in the industry. As noted, though, the property share of capital in national income depends upon profitability, and since the rate of profit in the highly regulated railroad industry is by most measures rather low, the relative level of capital inputs could be understated for many purposes by following this convention. Specifically, Kendrick accords to capital inputs a weighting of roughly 0.1, while labor is weighted at 0.9; any shift of ten percentile points in this weighting away from labor and to capital would reduce total productivity estimates by about three-tenths of a percentage point. For example, with a 25–75 weighting, the estimate of annual postwar total productivity growth drops by about one-half a percentage point.

As in trucking, rail productivity estimates are commonly based on ton-miles as the basic measure of output, and the mix of railroad traffic has been changing. Specifically, railroads have lost much of their short-haul, small-shipment, and high-value traffic, which generally requires more factor input per ton to carry and which incurs more terminal outlay per ton-mile. Thus, if one uses tonnage weighted by revenue (to control for changes in the commodity mix) rather than ton-miles as the major measure of output,[6] another half a percentage point or so per year of productivity growth is shaved from the standard rail estimates.

The standard productivity estimates also use relative prices, instead of relative costs, as weights in combining the rail freight and rail passenger outputs into a single index. As noted earlier, public regulators long required that passenger service be cross-subsidized by freight service, and thus the relative prices did not reflect the relative amounts of resources required to produce the services or, presumably, their relative value to society. A shift from prices to costs in weighting passenger output explains another half a percent per year difference between the standard and task force estimates of rail productivity growth.

Railroad productivity measures might also be usefully adjusted for changes in the quality of services. The prevailing view among those acquainted with the transportation industry is that the quality of railroad services, especially speed and service reliability, has been deteriorating over the postwar years, just as the conventional view is that there has been an improvement in the quality of trucking services. Accordingly, if one could develop reasonably adequate measures of service qualities for these highly regulated industries, the probability would be that the railroad productivity estimates would be scaled downward, while the trucking estimates probably would be adjusted upward.

4.3.3 Truck-Rail Comparisons

In sum, many alternatives have been suggested for measurement of productivity change in the motor-carrier and railroad industry. Each of these measures probably embodies some useful information. Clearly, though, none of the measures in and of itself is likely to be accepted as

6. The Task Force did not actually weight tonnage by revenue to control for the effect of systematic changes in the composition of rail freight traffic. Instead they used the analogous procedure of deflating total freight revenues by an ICC-computed index of rail rates which abstracts from changes in freight composition. See Task Force on Railroad Productivity (1973).

the definitive measure of productivity change for all purposes within the industry.

The measures are nevertheless suggestive. In particular, on the basis of the comparisons and reviews of the various measures thus far done, it would appear that the conventional measures of productivity, as reported by the BLS or Kendrick, probably tend to substantially overestimate the general rate of productivity improvement in the railroad industry, to slightly overestimate productivity improvement for the intercity trucking industry as a whole, and to underestimate productivity improvement for general freight trucking. If true, this would make it at least somewhat easier to explain why the motor-carrier industry has grown so rapidly relative to rail in the postwar years since, after revision, it may well be true that the motor-carrier industry experienced a rate of productivity improvement comparable to that of the railroad industry. In short, the seeming paradox that the growth records of these highly competitive industries being the reverse of their productivity records may be more a measurement aberration than a reflection of industry reality.

4.4 Productivity in Urban Mass Transit, 1948–70

Urban mass transit, probably to an even greater extent than railroading and trucking, has been an industry of intense public concern. The productivity record of the industry has come under particular scrutiny as the industry has drifted toward increasing governmental control and ownership. The advent of federal operating subsidies for local transit operations has heightened this interest since a major apparent worry, at least as expressed by subsidy opponents, is that the subsidies may induce "inefficiency" in the industry's use of resources. There is no reason to believe, moreover, that measures of productivity in transit will be any less ambiguous than those for the other transportation industries.

Transit includes four modes: motor bus, trolley bus, light rail transit (more commonly known as streetcars or trolleys), and heavy rail transit (such as subways). The size and character of the transit industry have been changing rapidly since World War II. According to estimates by the American Transit Association (since 1974 the American Public Transit Association), the number of revenue passengers carried dropped drastically in the postwar years. As the data in table 4.2 show, the decline in passengers was sharpest in the years immediately following the war for light rail transit and (after 1952) trolley bus modes.

The factor inputs consumed by the industry, as shown in table 4.3, have also declined. The index of capital inputs is based on estimates

Table 4.2 **Millions of Transit Revenue Passengers Carried per Year, 1948–70**

Year	Heavy Rail	Light Rail	Trolley Bus	Motor Bus	All Modes
1948	2473	4740	1206	8893	17,312
1949	2203	3480	1286	8300	15,269
1950	2113	2790	1261	7681	13,845
1951	2041	2171	1231	7438	12,881
1952	1982	1714	1201	7125	12,022
1953	1903	1403	1137	6593	11,036
1954	1767	1053	993	6045	9,858
1955	1741	845	869	5734	9,184
1956	1748	625	814	5568	8,755
1957	1706	491	703	5438	8,338
1958	1635	415	593	5135	7,778
1959	1647	378	517	5108	7,650
1960	1670	335	447	5069	7,521
1961	1680	323	405	4834	7,242
1962	1704	284	361	4773	7,122
1963	1661	238	264	4752	6,915
1964	1698	213	214	4729	6,854
1965	1678	204	186	4730	6,798
1966	1584	211	174	4702	6,671
1967	1632	196	155	4633	6,616
1968	1627	187	152.2	4524.5	6,490
1969	1656.3	183.4	135.2	4335.3	6,310.3
1970	1573	172	127	4158	6,032

SOURCE: American Transit Association, *Transit Fact Book*, annual (Washington: American Transit Association, various years).

of industry capital stocks and depreciation recently developed by Jack Faucett Associates, Inc. Since buses, trolley buses, and streetcars use public highways, a portion of highway costs is included in the capital measure.[7] The labor input index is calculated from American Transit Association's (ATA) annual estimates of the industry's average employment adjusted by Bureau of Labor Statistics (BLS) figures on changes in the average number of hours worked per week by unionized local transit operating employees. The index on intermediate goods

7. Faucett Associates apportioned highway stock and depreciation costs among the various highway modes according to the formulas proposed by a 1965 government study on allocating highway costs. See Jack Faucett Associates, *Capital Stock Measures for Transportation*, report no. JACKFAU-71-04-6, prepared for the U.S. Department of Transportation, Office of the Secretary (Washington: U.S. Department of Transportation, 1974).

consumed is based on ATA annual estimates of industry expenditures for fuel and maintenance materials adjusted by BLS data on changes in the wholesale prices of fuels and transportation equipment. Finally, total factor inputs are calculated by weighting the labor, capital, and intermediate goods inputs by their relative prices in the base year, 1958.[8]

As the industry has declined, public ownership, which is usually accompanied by public subsidization, has become more important and common. Even before 1950, publicly owned firms may have carried nearly as many passengers as privately owned firms; although most firms were privately owned in 1950, the publicly owned firms included the principal properties in several large metropolitan areas where the industry's ridership is concentrated—such as New York, Chicago, Boston, and San Francisco.[9] By 1971 public ownership had become much more common, especially among large firms, and the ATA estimated that, although publicly owned firms were still only 14% of all firms, they carried 84% of all the revenue passengers (American Transit Association 1972, p. 3).

Estimates of postwar productivity in the U.S. transit industry have been previously made by Kendrick. His estimates are for privately owned firms only. Since data on transit capital stocks were not readily available at the time he did his work, Kendrick estimated labor productivity and not total factor productivity. His results, shown in table 4.4, indicate that transit productivity increased at a very slow rate in the 1940s and early 1950s and declined at an average rate of 2 to 4% per year during the late 1950s and early 1960s. Over the entire postwar period studied, from 1948 to 1966, he estimates that transit labor productivity declined at an average annual rate of 0.9%. This 0.9% annual decline in transit productivity is striking when compared to Kendrick's estimate that labor productivity in the entire private business sector increased by 3.0% per year during the postwar period (Kendrick 1973, p. 41).

Similar results were obtained by B. M. Deakin and T. Seward in a study of total factor productivity for the postwar period in the British transit and taxi industries. Their estimates, also shown in table 4.4, indicate that transit and taxi productivity declined rapidly during the mid 1950s and mid 1960s and was relatively stagnant in the intervening years. Over the entire period studied, from 1954 to 1965, they report that total factor productivity in the British taxi and transit industry declined at an average annual rate of 1.65%.

8. The opportunity cost of capital in 1958 was assumed to be 6% per year. Both the capital and total factor index were relatively insensitive to changing the cost of capital to either 4 or 10% per year.

9. These four metropolitan areas alone accounted for 50 to 55% of all transit ridership in the United States in 1970.

Table 4.3 **Inputs Used by the Transit Industry, 1948–70 (1958=100.0)**

Year	Labor Inputs[a]	Capital Inputs[b]	Intermediate Goods (Operating and Maintenance Materials)[c]	Total Inputs[d]
1948	171.0	153.5	146.8	160.7
1949	165.8	127.9	135.5	145.8
1950	156.9	124.9	131.1	140.0
1951	149.9	122.3	127.2	135.3
1952	143.3	119.6	122.2	130.6
1953	138.9	116.0	116.7	126.4
1954	129.8	112.6	112.7	120.4
1955	122.1	109.3	102.9	114.4
1956	114.4	106.2	101.6	109.4
1957	108.3	103.1	98.9	105.0
1958	100.0	100.0	100.0	100.0
1959	96.4	96.9	97.9	96.8
1960	94.6	93.4	98.4	94.5
1961	91.5	90.6	99.2	91.9
1962	89.9	87.7	95.6	89.5
1963	88.8	84.5	95.1	87.5
1964	86.9	81.8	95.5	85.5
1965	87.0	79.5	90.5	84.0
1966	86.4	77.9	92.8	83.3
1967	87.5	76.3	98.0	83.6
1968	86.0	75.4	101.8	82.9
1969	84.3	76.3	n.a.[f]	n.a.[f]
1970	82.6	76.0	105.6	82.1
Average annual percentage change, 1948–70[e]	−3.48	−2.97	−1.63	−3.15

[a]Calculated from American Transit Association estimates of the industry's average employment adjusted by the Bureau of Labor Statistics' estimates of changes in the average number of hours worked per week by unionized local transit operating employees. See American Transit Association, *Transit Fact Book*, annual (Washington: American Transit Association, various years); and U.S. Bureau of Labor Statistics, *Union Wages and Hours: Local-Transit Operating Employees*, annual (Washington: Government Printing Office, various years).

[b]Calculated from data in Jack Faucett Associates, Inc., *Capital Stock Measures for Transportation*, report no. JACKFAU-71-04-6, prepared for the U.S. Dept. of Transportation, Office of the Secretary (Washington: U.S. Department of Transportation, 1974).

[c]Calculated from American Transit Association estimates of industry expenditures on operating and maintenance materials adjusted by Bureau of Labor Statistics' estimates of the wholesale price indices for fuels and related products (05) and transportation equipment (14), respectively. See American Transit Association,

Table 4.4 **Previous Estimates of Postwar Productivity Trends in the U.S. Transit Industry and the British Transit and Taxi Industry**

Year	Kendrick's Estimates of Labor Productivity in Privately Owned Firms in the U.S. Transit Industry[a]	Deakin and Seward's Estimates of Total Factor Productivity in the British Taxi and Transit Industries[b]
1948	105.3	
1949	102.0	
1950	105.5	
1951	99.9	
1952	107.3	115.6
1953	106.9	114.9
1954	104.2	113.2
1955	111.6	111.8
1956	111.3	109.0
1957	112.6	103.8
1958	100.0	100.0
1959	93.8	103.2
1960	98.6	105.0
1961	99.3	104.6
1962	100.0	102.0
1963	95.0	98.3
1964	92.4	95.5
1965	88.0	88.8
1966	88.2	
Average annual percentage change[c]	−0.93	−1.65

[a]Kendrick (1973), p. 334.
[b]Deakin and Seward (1969), p. 227.
[c]Calculated from a least-squares fit of an exponential curve.

Transit Fact Book; and U.S. Bureau of Labor Statistics, *Handbook of Labor Statistics, 1972* (Washington: Government Printing Office, 1972).
[d]Weighted by 1958 relative prices for capital and labor.
[e]Calculated from a least-squares fit of an exponential curve.
[f]Not available.

While these pioneer attempts at measuring productivity in the transit industry represent a remarkable effort, given the available data, they may be misleading in some important respects, mainly because they use revenue passengers carried or revenue passenger-miles as the basic measure of transit output. Among other deficiencies, these two output measures may not adequately track basic trends in the quality of service rendered. Determining whether the quality of transit has improved or deteriorated is difficult. Many dimensions of transit service have been changing in the postwar period and, while quality has clearly improved in some respects, it has declined in others.

For example, declines have occurred on many routes because the frequency of vehicles has been reduced and service has sometimes been completely eliminated during late evening hours or on weekends. This reduction in service frequencies and service hours may force travelers to wait at stops longer or to travel at less convenient times. Quality may also be deemed to have declined because of the increases in crime on vehicles or near stops and stations—although, obviously, it is not likely that the responsibility for any such quality decline rests with the industry.

The quality of transit service has also increased in several ways during the postwar period, and these gains probably outweigh the declines. The installation of air conditioning, for example, has improved services to passengers. A more important quality improvement has been a reduction in crowding in vehicles, allowing a higher percentage of passengers to get a seat (often even in the peak hours); this reduction in crowding has mainly resulted from transit officials not reducing the frequency of service on routes as rapidly as patronage has declined.

Quality has also improved in that the average speeds at which transit vehicles travel on a given type of route appear to have increased. This seems true notwithstanding the fact that industry-wide *average* transit vehicle speeds probably declined in the postwar period, largely because transit patronage has increasingly been concentrated on those routes which generally operate at slower speeds (i.e. in the cores of the larger and more congested metropolitan areas). Conversely, ridership and service have dropped sharply during the off-peak times and on suburban routes where vehicle speeds are relatively high. On any given type of route or service, however, average vehicle speeds have probably been increasing, because of both improvements in general traffic speeds on urban arterials and the introduction of more express services by transit lines.

Service rendered per passenger has also improved because the average length of transit trips very probably increased in the postwar period. The average length of intraurban work, shopping, and recreational trips by all modes increased greatly during the postwar period as residential and employment locations dispersed. While time-series data on transit passenger trip lengths alone are not generally available in the U.S., it seems likely that transit shared in this general trend toward longer urban journeys and, if so, passengers carried (or passenger trips) as an output measure will understate the growth in output in recent years.

These various dimensions of quality changes are most inadequately or not at all reflected when revenue passengers is used as the output metric. Some are perhaps captured when revenue passenger-miles is the output measure (as in Deakin and Seward's analysis of British taxi and transit productivity). Revenue passenger miles will reflect changes in average trip length as well as in the number of transit trips taken. Unfortunately, passenger-mile data are not generally available for the U.S. industry.

Series are available, however, on the number of vehicle-miles operated, and for some purposes it may be a more appropriate measure of output than revenue passengers. Vehicle-miles would capture at least some of the reduction in crowding in transit during the postwar period as well as much or most of the increase in trip lengths. It would not reflect, on the other hand, the deterioration in schedules, the increase in crime, or improvements in amenities such as air conditioning.

As a comparison of tables 4.2 and 4.5 shows, the number of vehicle-miles operated on each transit mode declined much less rapidly than the number of revenue passengers carried. The increase in vehicle-miles operated per passenger carried may of course reflect consumer preference or demand for longer trips and less crowding, but it may represent other trends as well. In particular, maintaining the number of vehicle-miles may have been perceived as important to achieving certain public or social objectives. As widespread public regulation and subsidy of the industry suggest, other dimensions of transit output besides passengers carried may be important to society. Perhaps the most important of these other dimensions is the maintenance of some "minimum" network and schedule of transit service for the local community. A common provision of franchises granted by local governments to private transit firms almost always has been that the firms provide certain minimum levels of service, even when and where service at the normal fare was less profitable, for example during evenings and weekends or to less densely populated parts of a city. As the fortunes of the transit industry have declined, a key motivation for local public takeover and subsidy of transit in many cities was concern about preserving at least some of this service, especially services to downtown retail areas or for those residents who do not have ready access to automobiles because they are too old or too young to drive, physically disabled, or too poor to own a car.

Table 4.5 **Millions of Vehicle-Miles Operated by Transit Mode, 1948–70**

Year	Heavy Rail	Light Rail	Trolley Bus	Motor Bus	All Modes
1948	458.1	699.3	178.0	1975.7	3311.1
1949	460.0	555.4	200.0	1968.2	3183.6
1950	443.4	463.1	205.7	1895.4	3007.6
1951	424.0	387.6	208.8	1893.0	2913.4
1952	400.4	321.2	215.2	1877.7	2814.5
1953	391.1	373.7	211.7	1819.0	2695.5
1954	375.6	215.8	196.7	1760.7	2548.8
1955	382.8	178.3	176.5	1709.9	2447.5
1956	387.1	132.9	165.7	1680.9	2366.6
1957	388.0	106.6	146.5	1648.4	2289.5
1958	386.5	89.9	131.0	1593.6	2201.0
1959	388.7	81.3	112.4	1576.5	2158.9
1960	390.9	74.8	100.7	1576.4	2142.8
1961	385.1	69.4	92.9	1529.7	2077.1
1962	386.7	61.5	84.0	1515.2	2047.4
1963	387.3	48.9	62.4	1523.1	2021.7
1964	395.8	42.9	49.2	1527.9	2015.8
1965	395.3	41.6	43.0	1528.3	2008.2
1966	378.9	42.9	40.1	1521.7	1983.6
1967	396.5	37.8	36.5	1526.0	1996.8
1968	406.8	37.5	36.2	1508.2	1988.7
1969	416.6	36.0	35.8	1478.3	1966.7
1970	407.1	33.7	33.0	1409.3	1883.1

SOURCE: American Transit Association, *Transit Fact Book*, annual (Washington: American Transit Association, various years).

If the number of vehicle-miles declined more slowly than patronage because of publicly mandated social policy (rather than passenger willingness to pay for the retained or mandated services), then a transit output index based on vehicle-miles alone could possibly exaggerate the output, and its quality, *rendered to passengers*. Such an output index should perhaps best be viewed as an upper bound for any estimate of postwar growth in services provided to passengers, just as an output index based on revenue passengers (like Kendrick's) points to a lower bound.

For these same reasons, however, vehicle-miles might be an appropriate, albeit crude, index of the social outputs which transit produces *in addition* to its services to passengers. Since the stability of vehicle-mileage is a product of both passenger demands for improved services and publicly mandated policies to maintain minimum levels of service despite declining patronage, vehicle-miles will reflect to at least some extent both the passenger and social outputs. It might even be an underestimate of the combined social and passenger services produced because it does not adjust for all of the improvements in passenger service quality.

The degree of meaning attached to any such index depends, of course, on whether maintaining transit vehicle-mileage provides significant public benefits. It should be noted that some considerable doubt exists as to whether maintaining unprofitable transit service is necessarily an effective means to advance the social objectives which proponents of transit subsidy often claim (see, for example, Meyer, Kain, and Wohl 1965, chap. 13; Gómez-Ibáñez 1975). Nevertheless, the fact that transit subsidies are enacted by legislatures does suggest that maintenance of transit services is deemed a public benefit by much of the electorate.

The choice between revenue passengers and vehicle-miles does make a significant difference when estimating transit output trends. Table 4.6 shows two indexes of transit output from 1948 to 1970, one based on passengers and the other on vehicle-miles. Output as measured by revenue passengers declines at an average annual rate of 4.94% whereas output measured in vehicle-miles declines at only 3.44% per year.

Since productivity is measured by the relation between outputs and inputs, the choice between revenue passengers and vehicle-miles will affect estimates of the postwar trends in transit productivity. The productivity estimates in table 4.7 show that if output is measured in revenue passengers carried, total factor productivity appears to have declined at an average annual rate of 1.40% per year from 1948 to 1970. This estimate is slightly more negative but otherwise quite comparable to that of Kendrick for the private sector only of the industry between 1948 to 1966. However, if output is measured in vehicle-miles operated, the average annual rate of total factor productivity decline drops by 1.29 percentage points to only 0.11%.

Moreover, if vehicle-miles are used to measure output, any productivity decline that does take place is in the years immediately after World War II and not, as Kendrick suggests, in the late 1950s and the 1960s. Indeed, with vehicle-miles as the measure, the postwar productivity record separates into two distinct periods: (1) the decade from 1948 to 1958 when total factor productivity declined at a rate of about 0.8% per year; and (2) the years from 1958 to 1968 when productivity seemingly improved at a rough rate of 0.7% annually.

When deriving these comprehensive measures of output and productivity for the entire transit industry, the outputs of the different component modes (motor and trolley buses and light and heavy rail transit) have been weighted by the relative prices of the modes. These prices may or may not well reflect differences in factor inputs required or market values placed on the services. On the whole, in a regulated and subsidized industry, relative costs are probably more appropriate weights than relative prices, especially if some modes are more heavily subsidized than others. As explained earlier, where public policy keeps the price of some outputs below costs, relative costs are at least as likely as relative prices to reflect the relative value which society places on the outputs or the relative resources which are necessary for producing them. Specifically, systematic subsidy of a service would suggest that society envisages some special social goals or outputs of value (at least equal to costs) thereby being achieved.

Table 4.6 **Effect on Output Estimates of Using Vehicle-Miles instead of Revenue Passengers as the Basic Measure of Output (1958=100.0)**

Year	Index of Output Based on Revenue Passengers	Index of Output Based on Vehicle-Miles
1948	228.6	171.8
1949	200.4	161.2
1950	181.4	150.1
1951	168.1	143.0
1952	156.5	136.1
1953	143.4	129.2
1954	127.7	120.4
1955	118.8	114.5
1956	112.9	109.1
1957	98.0	104.6
1958	100.0	100.0
1959	98.3	97.6
1960	96.5	96.5
1961	92.9	93.4
1962	91.3	91.7
1963	88.5	89.9
1964	87.7	89.2
1965	86.9	88.7
1966	85.3	87.5
1967	84.6	88.0
1968	83.0	87.7
1969	80.6	86.9
1970	77.1	83.2
Average annual percentage change, 1948–70[a]	−4.42	−3.23

NOTE: The outputs of the different modes are weighted by the modes' relative prices in 1958.
[a]Calculated from a least-squares fit of an exponential curve.

Table 4.7 **Effect on Productivity Estimates of Using Vehicle-Miles instead of Revenue Passengers as the Basic Measure of Output (1958=100.0)**

	Labor Productivity		Capital Productivity		Total Factor Productivity	
Year	Passengers Measure Output	Vehicle-Miles Measure Output	Passengers Measure Output	Vehicle-Miles Measure Output	Passengers Measure Output	Vehicle-Miles Measure Output
1948	133.7	100.5	148.9	111.9	142.3	106.9
1949	120.9	97.2	156.7	126.0	137.4	110.6
1950	115.6	95.2	145.2	120.2	129.6	107.2
1951	112.1	95.4	137.4	116.9	124.2	105.7
1952	109.2	95.0	130.9	113.8	119.8	104.2
1953	103.2	93.0	123.6	111.4	113.4	102.2
1954	98.4	92.8	113.4	106.9	106.1	100.0
1955	97.3	93.8	108.7	104.8	103.8	100.1
1956	98.7	95.4	106.3	102.7	103.2	99.7
1957	90.5	96.6	95.1	101.5	93.3	99.6
1958	100.0	100.0	100.0	100.0	100.0	100.0
1959	102.0	101.2	101.4	100.7	101.5	100.8
1960	102.0	102.0	103.3	103.3	102.1	102.1
1961	101.5	102.1	102.5	103.1	101.1	101.6
1962	101.6	102.0	104.1	104.6	102.0	102.6
1963	99.7	95.6	104.7	100.5	101.1	97.0
1964	100.9	102.6	107.2	109.0	102.6	104.3
1965	99.9	102.0	109.3	111.6	103.5	105.6

Table 4.7 (continued)

Year	Labor Productivity		Capital Productivity		Total Factor Productivity	
	Passengers Measure Output	Vehicle-Miles Measure Output	Passengers Measure Output	Vehicle-Miles Measure Output	Passengers Measure Output	Vehicle-Miles Measure Output
1966	98.7	101.3	109.5	112.3	102.4	105.0
1967	96.7	100.6	110.9	115.3	101.2	105.3
1968	96.5	102.0	110.1	116.3	100.1	105.8
1969	95.6	103.1	105.6	113.9	n.a.[b]	n.a.[a]
1970	93.3	100.7	101.4	109.5	93.9	101.3
Average annual percentage change, 1948–70[b]	−0.93	+0.35	−1.45	−0.14	−1.40	−0.11

NOTE: The outputs of the different modes are weighted by the modes' relative prices in 1958.
[a]Not available.
[b]Calculated from a least-squares fit of an exponential curve.

Within the transit industry, heavy and light rail transit service tends to be more heavily subsidized than trolley bus and, especially, motor bus. Although the situation varied from firm to firm, in the industry as a whole during 1958, the base year for our estimates, the revenues collected on each mode were only about sufficient to cover operating expenses. The two rail transit modes, though, have relatively high directly identifiable capital costs and thus may have been subsidized more (i.e., a bigger gap is created between fares and total factor input requirements for these modes). On the other hand, the trolley and the motor bus may have been the beneficiaries of equal but disguised capital inputs through their use of public highways. A firm determination of the extent and incidence of subsidy to various classes of highway users has been a matter of some contention in highway circles and would require an analysis well beyond the scope of the present study to settle. Jack Faucett Associates, quite heroically, attempted such an allocation when measuring highway inputs in their transit industry capital estimates. Nevertheless, the issue is probably best regarded as still open.

It would seem highly improbable, though, that any "highway subsidy" bestowed on trolleys, and especially buses, could be substantial, given that the highways are shared by so many modes and the costs are prorated or spread over a very large volume of traffic, particularly in urban areas. Furthermore, quite a bit of evidence suggests that urban arterials of the type commonly used by transit are actually sources of subsidy (via user taxation) for covering the costs of less intensively utilized roads in rural areas (Meyer, Kain, and Wohl 1965, chap. 4). On balance, therefore, it may not be too misleading to ignore the possibility of unrecouped or unrecognized highway costs for trolley and bus, but we admit this is a subjective judgment and debatable.

To better gauge the possibility of differential modal subsidies, table 4.8 shows estimates of average revenues and two estimates of average costs per revenue passenger trip and per vehicle-mile on the different modes in 1958. Two cost estimates are given because with the available data it is difficult to know exactly how to allocate industry costs, especially capital costs, among the modes. In our view, the most reasonable estimate assumes that heavy rail transit is responsible for most of the rail capital costs reported by Faucett Associates. Our "less likely estimate" assigns more of the capital costs to light rail transit and trolley buses.[10]

10. Unfortunately, Faucett did not make separate estimates of stocks and depreciation for the four basic modes but only for the bus mode and for the three "rail" modes (heavy and light rail and trolley bus) together. For both bus and "rail" modes Faucett made separate estimates of costs associated with equipment and with structures and way. For years before 1968 separate estimates of capital

Because the different transit modes declined at different rates during the postwar period, a shift from price to cost-based weights can make a difference in estimates of postwar trends of industry output and thus productivity. The impact, moreover, is very sensitive to the particular cost estimates used. Tables 4.9 and 4.10 show output estimates measured in revenue passengers and vehicle-miles using three different weighting schemes. The data show that a shift from weights based on relative prices to weights based on what seems to be the most likely estimate of relative costs alters the estimated postwar average annual percentage decline in revenue passengers from 4.42 to 4.24 and the annual percentage decline in vehicle-miles from 3.23 to 2.43. This occurs because the most likely estimates of relative costs strongly weight heavy rail transit output, and heavy rail transit has not declined as rapidly as other modes. However, the data in tables 4.9 and 4.10 also show that a shift from price-based weights to weights based on a less likely (but not totally indefensible) estimate of relative costs increases the estimated annual rate of decline. The "less likely" relative cost estimates weight light rail output more strongly than heavy rail transit output, and light rail transit declined relatively rapidly, especially in the years immediately after World War II.

A shift to weights based on relative costs also changes, of course, the estimates of productivity. Tables 4.11 and 4.12 show estimates of labor, capital, and total factor productivity using weights based on relative prices and on the more and less likely estimates of relative costs. The data show that a shift from weights based on relative prices to weights based on the most likely estimates of relative costs makes the trend in transit productivity look slightly more favorable. For example, if output

stocks for the four basic modes were made by the American Transit Association (ATA). However, the derivation of the ATA estimates was never documented, and they must be considered less reliable than those by Faucett. See Jack Faucett Associates, *Capital Stock Measures for Transportation* and American Transit Association, "Gross Investment of the Transit Industry as of December 31, 1940–1967, Segregated as to Mode of Service," unpublished, 1968.

For the "most likely" estimate of the relative costs of transit modes, Faucett's estimates of "rail" capital costs (both for structures and equipment) were allocated among the heavy rail, light rail, and trolley bus in proportion to the 1958 ATA estimates of the stocks of these three modes. For the "less likely" estimate of relative costs, Faucett's estimates of "rail" structure costs were allocated among the three modes on the basis of the number of line-miles each mode served, assuming that a light rail line-mile and a trolley bus line-mile were only one-fourth and one-tenth as expensive, respectively, as a heavy rail line-mile; Faucett's estimates of "rail" equipment costs were allocated on the basis of vehicles owned, assuming that a light rail vehicle and a trolley bus vehicle were only two-thirds and one-sixth as expensive, respectively, as heavy rail vehicle.

Table 4.8 **Indexes of Revenue and Cost per Vehicle-Mile and per Revenue Passenger for Transit Modes in 1958 (motor bus=100.0)**

Mode	Relative Revenue[a]	Relative Cost[b]: Using the Most Likely Allocation of Capital Costs	Relative Cost[b]: Using a Less Likely Allocation of Capital Costs
	Per vehicle-mile operated		
Heavy rail	124.8	425.2	330.1
Light Rail	199.5	354.0	656.3
Trolley bus	142.5	159.0	232.3
Motor bus	100.0	100.0	100.0
	Per revenue passenger carried		
Heavy rail	95.0	323.9	251.4
Light rail	139.2	247.1	458.1
Trolley bus	101.5	113.2	105.3
Motor bus	100.0	100.0	100.0

[a]Calculated from data in American Transit Association, *Transit Fact Book, 1959* (Washington: American Transit Association, 1959).

[b]See footnote 10 for a description of the two methods of allocating capital costs among the modes.

NOTE: These estimates of the relative costs of heavy rail, light rail, trolley bus, and motor bus trips do not necessarily indicate the relative efficiency or effectiveness of the four transit modes. One mode's average cost may be higher than another's because that mode tends to provide better quality service or operates in localities where factor prices are higher. For example, heavy rail transit costs may be higher because this mode generally serves longer passenger trips and is more heavily concentrated in the largest cities, where wages are higher.

is measured in revenue passengers, the shift from price-based weights to weights based on most likely estimates of relative costs alters the estimated average change in total factor productivity from —1.40 to —1.21% per year. Similarly, if output is measured in vehicle-miles, the shift from weights based on prices to those based on most likely costs alters the estimated average change in total factor productivity from —0.11 to +0.63% per year. However, a shift from price-based weights to weights based on the less likely estimates of relative costs makes the postwar trend in productivity look much less favorable, whether output is measured in revenue passengers or vehicle-miles.

Table 4.13 summarizes what seem to be the best estimates of the industry's productivity trends from 1948 to 1970. In broad outline, the postwar productivity record of the transit industry can be placed as lying somewhere between ±1% per year. Estimates lying outside that

Table 4.9 **Revenue Passenger Output Indexes Calculated Using Relative Costs and Relative Prices as Weights (1958=100.0)**

Year	Weights Based on Relative Prices	Weights Based on Most Likely Estimate of Relative Costs	Weights Based on Less Likely Estimates of Relative Costs
1948	228.6	222.6	320.1
1949	200.4	196.1	262.9
1950	181.4	178.0	229.7
1951	168.1	152.8	202.4
1952	156.5	154.6	181.0
1953	143.4	141.9	162.3
1954	127.7	126.7	139.8
1955	118.8	118.1	127.1
1956	112.9	112.6	116.9
1957	98.0	107.2	98.8
1958	100.0	100.0	100.0
1959	98.3	98.4	97.6
1960	96.5	96.7	95.2
1961	92.9	93.1	92.4
1962	91.3	91.6	90.3
1963	88.5	88.9	86.2
1964	87.7	88.1	85.2
1965	86.9	87.4	84.0
1966	85.3	85.8	82.0
1967	84.6	85.1	81.6
1968	83.0	83.4	80.2
1969	80.6	81.1	78.9
1970	77.1	77.5	75.2
Average annual percentage change, 1948–70[a]	−4.42	−4.24	−5.85

[a]Calculated using a least-squares fit of an exponential equation.

range could be justified, though, under certain circumstances, especially beyond the lower bound.

Exactly which estimate one might prefer within the range of ±1% will depend to some considerable extent upon one's purposes and assumptions. If the emphasis is upon output as reflected in market prices paid by passengers, then a relatively negative productivity record can be justified. On the other hand, if one chooses instead to stress the social goals ostensibly achieved through transit operations (which seems to be the emphasis increasingly favored by the governments which subsidize such operations), then a more favorable productivity record

Table 4.10 **Vehicle-Mile Output Indexes Calculated Using Relative Costs and Relative Prices as Weights (1958=100.0)**

Year	Weights Based on Relative Prices	Weights Based on Most Likely Estimate of Relative Costs	Weights Based on Less Likely Estimate of Relative Costs
1948	171.8	150.4	225.6
1949	161.2	144.6	201.8
1950	150.1	136.6	182.7
1951	143.0	132.4	167.9
1952	136.1	127.9	154.3
1953	129.2	122.4	143.4
1954	120.4	115.8	129.5
1955	114.5	111.2	121.0
1956	109.1	107.5	112.0
1957	104.6	104.0	105.5
1958	100.0	100.0	100.0
1959	97.6	98.1	97.1
1960	96.5	97.4	95.4
1961	93.4	94.3	92.2
1962	91.7	93.0	90.1
1963	89.9	91.9	86.8
1964	89.2	91.6	85.8
1965	88.7	91.2	85.2
1966	87.5	90.1	83.6
1967	88.0	90.7	84.2
1968	87.7	90.4	84.5
1969	86.9	89.4	84.3
1970	83.2	85.6	81.1
Average annual percentage change, 1948–70[a]	−3.23	−2.43	−4.37

[a]Calculated using a least-squares fit of an exponential equation.

can be demonstrated. However, even using the most favorable estimate (of +0.63% per year), transit's productivity record still has fallen far short of the average annual total factor productivity increase of 2 to 3% in the private domestic economy as a whole.

4.5 Some Implications

To recapitulate, recent research suggests some dramatic changes in the estimates of productivity trends in several transportation industries. A comparison of these old and new estimates appears in table 4.14.

Table 4.11 **Productivity Estimates Using Revenue Passengers as Output Measure**

	Labor Productivity			Capital Productivity			Total Factor Productivity		
		Output Weighted by Estimates of Relative Costs			Output Weighted by Estimates of Relative Costs			Output Weighted by Estimates of Relative Costs	
Year	Output Weighted by Relative Prices	Most Likely	Less Likely	Output Weighted by Relative Prices	Most Likely	Less Likely	Output Weighted by Relative Prices	Most Likely	Less Likely
1948	133.7	130.2	187.2	148.9	145.0	208.5	142.3	138.5	199.2
1949	120.9	118.3	158.6	156.7	153.3	205.6	137.4	134.5	180.3
1950	115.6	113.4	146.4	145.2	142.5	183.9	129.6	127.1	164.1
1951	112.1	101.9	135.0	137.4	124.9	165.5	124.2	112.9	149.6
1952	109.2	107.9	126.3	130.9	129.3	151.3	119.8	118.4	138.6
1953	103.2	102.2	116.8	123.6	122.3	139.9	113.4	112.3	128.4
1954	98.4	97.6	107.9	113.4	112.5	124.2	106.1	105.2	116.1
1955	97.3	96.7	104.1	108.7	108.1	116.3	103.8	103.2	111.1
1956	98.7	98.4	102.2	106.3	106.0	101.1	103.2	102.9	106.9
1957	90.5	99.0	91.2	95.1	104.0	95.8	93.3	102.1	94.1
1958	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1959	102.0	102.1	101.2	101.4	101.5	100.7	101.5	101.7	100.8
1960	102.0	102.2	100.6	103.3	103.5	101.9	102.1	102.3	100.7
1961	101.5	101.7	101.0	102.5	102.8	102.0	101.1	101.3	100.5
1962	101.6	101.9	100.4	104.1	104.4	103.0	102.0	102.3	100.9
1963	99.7	100.1	97.1	104.7	105.2	102.0	101.1	101.6	98.5
1964	100.9	101.4	98.0	107.2	107.7	104.2	102.6	103.0	99.6
1965	99.9	100.5	96.6	109.3	109.9	105.7	103.5	104.0	100.0

Table 4.11 (continued)

Year	Labor Productivity			Capital Productivity			Total Factor Productivity		
	Output Weighted by Relative Prices	Output Weighted by Estimates of Relative Costs		Output Weighted by Relative Prices	Output Weighted by Estimates of Relative Costs		Output Weighted by Relative Prices	Output Weighted by Estimates of Relative Costs	
		Most Likely	Less Likely		Most Likely	Less Likely		Most Likely	Less Likely
1966	98.7	99.3	94.9	109.5	110.1	105.3	102.4	103.0	98.4
1967	96.7	97.3	93.3	110.9	111.5	106.9	101.2	101.8	97.6
1968	96.5	97.0	93.3	110.1	110.6	106.4	100.1	100.6	96.7
1969	95.6	96.2	93.6	105.6	106.3	103.4	n.a.[b]	n.a.[b]	n.a.[b]
1970	93.3	93.8	91.0	101.4	102.0	98.9	93.9	94.4	91.6
Avg. annual percentage change, 1948–70[a]	−0.93	−0.75	−2.37	−1.45	−1.27	−2.86	−1.40	−1.21	−2.92

[a]Calculated from a least-squares fit of an exponential curve.
[b]Not available.

Table 4.12 Productivity Estimates Using Vehicle-Miles as Output Measure

	Labor Productivity			Capital Productivity			Total Factor Productivity		
		Output Weighted by Estimates of Relative Costs			Output Weighted by Estimates of Relative Costs			Output Weighted by Estimates of Relative Costs	
Year	Output Weighted by Relative Prices	Most Likely	Less Likely	Output Weighted by Relative Prices	Most Likely	Less Likely	Output Weighted by Relative Prices	Most Likely	Less Likely
1948	100.5	88.0	131.9	111.9	98.0	147.0	106.9	93.6	140.4
1949	97.2	87.2	121.7	126.0	113.1	157.8	110.6	99.2	138.4
1950	95.2	87.1	116.4	120.2	109.4	146.3	107.2	97.6	130.5
1951	95.4	88.3	112.0	116.9	108.3	137.3	105.7	97.9	124.1
1952	95.0	89.3	107.7	113.8	106.9	129.0	104.2	97.9	118.1
1953	93.0	88.1	103.2	111.4	105.5	123.6	102.2	96.8	113.4
1954	92.8	89.2	99.9	106.9	102.8	115.0	100.0	96.2	107.6
1955	93.8	91.1	99.1	104.8	101.7	110.7	100.1	97.2	105.8
1956	95.4	94.0	97.9	102.7	101.2	105.5	99.7	98.3	102.4
1957	96.6	96.0	97.4	101.5	100.9	102.3	99.6	99.0	100.5
1958	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1959	101.2	101.8	100.7	100.7	101.2	100.2	100.8	101.3	100.3
1960	102.0	103.0	100.8	103.3	104.3	102.1	102.1	103.1	101.0
1961	102.1	103.1	100.8	103.1	104.1	101.8	101.6	102.6	100.3
1962	102.0	103.4	100.2	104.6	106.0	102.7	102.6	103.9	100.7
1963	95.6	103.5	97.7	100.5	108.8	102.7	97.0	105.0	99.2
1964	102.6	105.4	98.7	109.0	112.0	104.9	104.3	107.1	100.4
1965	102.0	104.8	97.9	111.6	114.7	107.2	105.6	108.6	101.4

Table 4.12 (continued)

Year	Labor Productivity			Capital Productivity			Total Factor Productivity		
	Output Weighted by Relative Prices	Output Weighted by Estimates of Relative Costs		Output Weighted by Relative Prices	Output Weighted by Estimates of Relative Costs		Output Weighted by Relative Prices	Output Weighted by Estimates of Relative Costs	
		Most Likely	Less Likely		Most Likely	Less Likely		Most Likely	Less Likely
1966	101.3	104.3	96.8	112.3	115.7	107.3	105.0	108.2	100.4
1967	100.6	103.7	96.2	115.3	118.9	110.4	105.3	108.5	100.7
1968	102.0	105.1	98.3	116.3	119.9	112.1	105.8	109.0	101.9
1969	103.1	106.0	100.0	113.9	117.2	110.5	n.a.[a]	n.a.[a]	n.a.[a]
1970	100.7	103.6	98.2	109.5	112.6	106.7	101.3	104.3	98.8
Avg. annual percentage change, 1948–70[b]	+0.35	+1.05	−0.89	−0.14	+0.54	−1.40	−0.11	+0.63	−1.40

[a]Not available.
[b]Calculated from a least-squares fit of an exponential curve.

Table 4.13 **Final Transit Productivity Estimates**

Basic Measure of Output Used	Average Annual Rate of Productivity Change, 1948–70		
	Total Factor Productivity	Labor Productivity	Capital Productivity
Revenue passengers	−1.21	−0.75	−1.27
Vehicle-miles	+0.63	+1.05	+0.54

NOTE: Output weighted by the most likely estimates of the relative costs of the modes.

Given these results, it is difficult to escape the conclusion that, at least in transportation, productivity measurement is an art in which interpretation and understanding is enhanced by knowledge of the industry involved and, equally important, careful consideration of the purpose for which any estimate might be used. In transportation, moreover, it is crucial to understand the social characteristics of the output and the effect of public involvement on prices and returns to factors, especially capital. A particularly difficult "joint-production" problem also complicates output and productivity measurement in most transport undertakings, specifically the common practice of jointly providing terminal and line-haul services. Difficulties are also introduced, as in many industries, by changes in the quality of service provided and in the form of ownership or financing employed for capital inputs. The normal remedy for most of these complications involves weighting by market prices. Unfortunately, in highly regulated transport industries market data may lose much of its conventional meaning and therefore usefulness in such applications.

Some troublesome implications are also suggested for comparisons made of productivity trends among a large number of industries. In order to generate the required data series, large-scale comparative studies must rely on simple, standard conventions for estimating the output and input trends in each industry. These conventions generate data series which are, at least in some narrow sense, consistent. But given that the interpretations are so sensitive to purpose and the particular characteristics of an industry, the question arises of whether the resulting estimates can be meaningfully compared across time and industry sector.

By way of amelioration, it is tempting to argue that measuring productivity in transportation is more difficult than in other sectors. We suspect, though, that while other industries may not share the particular

Table 4.14 "Conventional" and Adjusted Estimates of the Postwar Output and Productivity Changes in Selected Transportation Industries

Industry	Average Annual Percentage Change[a] in Output		Average Annual Percentage Change[a] in			
			Total Factor Productivity		Labor Productivity	
	"Conventional" Estimate	Adjusted Estimate	"Conventional" Estimate	Adjusted Estimate	"Conventional" Estimate	Adjusted Estimate
Intercity trucking						
All class I and II carriers	6.0,[b] 8.4[c]	< 6.0, 8.4[d]			2.7,[b] 3.1[c]	< 2.7, 3.1[d]
General freight carriers only	4.9[b]	> 4.9[d]			2.1[b]	> 2.1[d]
Railroad	0.4,[e] 0.3[c]	– 0.7[f]	5.0[e]	1.8 to 0.8[f]	4.9,[c] 6.0[e]	3.7[f]
Urban Mass Transit	– 4.8,[c] – 2.6[g]	– 4.2 to – 2.4[h]	– 1.6[g]	– 1.2 to + .6[h]	– 0.9[c]	– .7 to + 1.0[h]

[a]Annual changes calculated from a least-squares fit of an exponential curve.
[b]Estimates from 1954 to 1972 in Carnes (1974).
[c]Estimates for 1948 to 1966 from data in Kendrick (1973), pp. 329, 334, and 335.
[d]See the discussion of Daryl Wyckoff's work in section 4.3.
[e]Estimates for 1948 to 1970 from data at U.S. Bureau of Labor Statistics, *Indexes of Output Per Man-Hour, Selected Industries*, bulletin no. 1827 (Washington: Government Printing Office, 1974), pp. 89, 90, and 93.
[f]Estimates for 1947 to 1970 from Task Force on Railroad Productivity (1973), pp. 75 and 78.
[g]Estimates for the British taxi and transit industries between 1952 and 1965 from data in Deakin and Seward (1969), p. 227.
[h]See Section 4.4.

characteristics which complicate measurement in transportation, they may well have their own special attributes and complications that are at least equally confusing and obfuscating.

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