Toward Practicality in Defining and Measuring Railroad Productivity

HARVEY A. LEVINE

ABSTRACT

The standard definition of productivity as being the relationship between the factors of production and physical output (goods or services or both) is accepted and the various and commonly used measures in the railroad industry are critically evaluated. Problems range from the credibility of data to the difficulty in separating changes in ton-miles due to productivity versus shifts in traffic consist. The conclusion is reached that there are many indicators of railroad productivity but no reliable overall standard acceptable for all purposes. Thus the adoption of productivity measurements is a function of the use of those measurements. For instance, relatively simple productivity measurements are available as a basis for making capital investment decisions. On the other hand, highly sensitive uses of railroad productivity changes, such as adjusting the rail cost adjustment factor or increasing labor wages, demand precise productivity measurements, which are currently not available. Given the problems of calculating railroad productivity (e.g., assets that float throughout the country and are used by railroad competitors, long-lived assets, a multitude of output factors, and the inability to properly calculate the value of capital stock) it is unlikely that an overall railroad productivity measure can be developed that would satisfy the standards of precision, reliability, and general application.

The author's first and short-lived approach to addressing the issue of defining and measuring railroad productivity was to act as the reluctant draftee in presenting a summary of a literature search. After all, productivity has been studied thoroughly and a uniform method of measuring productivity in general, and railroad productivity in particular, has never been universally accepted. Second, he led a public session on productivity, sponsored by the Interstate Commerce Commission, some 12 years ago and the results of that conference were inconclusive. And finally, in a current ICC proceeding (Ex Parte No. 290, Sub.-4), he is on record as stating that railroad productivity cannot be properly measured. Still, given the elevation of productivity as a key ingredient to America's future, and more to the point, as the possible linchpin to the survival of this country's railroads as private entities, a revisit, and a fresh approach, appears in order.

The approach here was to spend a minimal amount of time in defining productivity (a textbook definition will suffice) so as to focus on the problems of measuring productivity relative to potential uses of productivity measures. Such an approach would steer away from the traditional conclusion that a precise productivity standard is beyond expectation; rather, it would relate various uses of productivity standards to different levels of productivity measures, and in some cases, productivity indicators. Thus, some of the major problems in measuring productivity have been identified, potential uses of productivity adjustments in the railroad industry are examined, and the conclusion is reached that the proper measure of productivity largely depends on the use of the adopted standard.

DEFINITIONS AND MEASUREMENT CONCEPTS

Although the term "productivity" may be an often misunderstood term, its definition is clear in economics literature. Simply put, productivity is the relationship between input factors (labor, capital, and other expense items) and output (goods or services or both). When this relationship is measured over time, and later relationships are higher than earlier relationships, productivity is believed to have increased. A literature search has revealed three basic types of productivity measures as follows:

1. Single-factor productivity: The measure of output related to a single measure of input (e.g., output to labor or output to capital). A popular measure of single-factor productivity in the railroad industry is ton-miles to hours of labor.
2. Total-factor productivity: The measure of output related to the two major input factors--labor and capital. Thus, the substitution of, say, automation for manpower is accounted for in this measurement.
3. Total productivity: The measure of output to all input variables, including the so-called "intermediate purchases," such as materials and supplies.

No matter which of the productivity measurements is used, it is emphasized that all of these factors (labor, capital, and intermediate purchases) affect productivity. Thus, even a single-factor measure, such as ton-miles per labor hour, does not alone really measure labor productivity because a change in the output (ton-miles) may have been caused by changes in capital and intermediate inputs.

PROBLEMS OF MEASURING RAILROAD PRODUCTIVITY

Although there are a host of problems associated with the measurement of productivity (including the assignment of weights to the inputs and the measurement of intermediate purchases), this paper focuses on primary issues associated with the labor and capital inputs, and the seemingly ubiquitous output measure of ton-miles.

Input Factors

Labor

For years analysts have divided ton-mile output by labor input to measure railroad productivity. This method has obvious flaws (all productivity gains cannot be assumed to be caused by labor only) and has been highly criticized, but rarely on the basis of the quality of the labor input measure.

Indexes of labor productivity and compensation per hour, unit labor costs, and related measures for broad economic sectors are published by the Bureau of Labor Statistics (BLS). These measures, which show changes in the relationship between output and employment or employee hours, provide information about productivity, prices, wages, employment, and economic growth. These indexes are prepared for the following sectors of the U.S. economy:

1. Quarterly and annual measures:
   a. Business sector,
   b. Nonfinancial corporations,
   c. Nonfarm business sector, and
   d. Manufacturing (total, durable, and nondurable);
2. Annual measures:
   a. Agriculture;
   b. Mining;
   c. Transportation;
   d. Communications;
   e. Utilities;
   f. Wholesale and retail trade;
   g. Finance, insurance, and real estate; and
   h. Government enterprises.

The BLS has also developed a multifactor productivity program that measures output per unit of labor and capital input. However, only data for the private nonfarm business and manufacturing sectors are available at this time--nothing yet for total transportation or for railroads. Therefore, the only available BLS "productivity" data applicable to railroads are those indexes that show input only. As will be discussed later, the BLS has a railroad capital stock measure, but it has not yet been integrated into a productivity index.

The BLS annual labor publication Productivity Measures for Selected Industries provides a prime example of productivity data that actually measure only output per unit of labor input. Because of the sharp decline in railroad employment, especially over the past 5 years, the output gains reflected by the BLS indexes are undoubtedly overblown as productivity indicators. For example, the BLS index for railroad transportation, as shown in Table 1, produces productivity gains from 1977 to 1983, ranging from 30.3 percent for output per employee (all workers) to 40.7 percent for output per employee hour (production workers). It is patently obvious to those familiar with the railroad industry that employees did not work 30 to 40 percent harder, or faster, in 1983 than they did in 1977; simply stated, innovation and capital investment produced productivity gains that BLS attributes to rail labor.

Aside from the serious deficiency related to the use of labor only, another problem associated with its use as a single input factor is the selection of the proper divisor. For example, is the number of employees or man hours the more appropriate measure? If the latter were to be used, would man hours worked or man hours paid for be the better choice? In the railroad industry, merely identifying "freight service employees" is no simple task--some employee classifications straddle both freight and passenger operations. In fact, this problem is so pervasive that statisticians frequently calculate the employment (or man-hour) base on the basis of the ratio of freight operating expenses to total operating expenses. Although this concept may provide a simple estimate of productivity, it obviously falls far short of depicting precise productivity measures--and the same can be said of all productivity measures that use railroad labor as an input component. This fact has been recognized in a number of studies by pundits in the field of transportation economic research. For example, a 1973 study on railroad productivity by a federal task force (1) found serious deficiencies in the use of labor as the input segment of a single-factor productivity equation. The study cited these three basic flaws:

1. Rail labor inputs have declined more rapidly than capital inputs,
2. The railroad industry has increasingly employed relatively more outside labor services, and
3. Man hours understate the growth of inputs needed to produce output and to maintain the rail plant at given standards.

TABLE 1 BLS Railroad Productivity Measures

	Output per Employee Hour (%)		Output per Employee (%)	
Year	All Workers	Production Workers	All Workers	Production Workers
1977	100.0	100.0	100.0	100.0
1978	104.5	104.7	104.5	104.6
1979	104.7	104.8	105.4	105.5
1980	107.3	108.4	105.5	106.2
1981	111.7	113.5	109.0	110.1
1982	115.9	119.4	110.2	112.6
1983	136.6	140.7	130.3	133.2

Capital

Obtaining a true measure of a capital input and translating that into a unit of capital service is a similar and equally perplexing problem. A fixed capital input should be a measure of the quantity of capital services utilized in providing transportation services. The quantities of each type of fixed capital should then be weighted by the implicit cost per unit of capital services. However, it is quite difficult to do this: capital is generally owned by the company using it and imputations are necessary to calculate the value of the input of capital services and the implicit unit costs (rental values) of these services in the absence of market transactions. In concept, capital services are the machine hours or service hours provided by various types of equipment and structures. In practice, it is difficult, if not impossible, to obtain detailed measures of equipment hours. (Instead, it is usually assumed that the flow of capital services over time is more or less proportionate to the stock of capital held.)

A measure of the stock of capital should reflect the reductions in the flow of services due to increasing down time for repairs and maintenance, as well as the decline in efficiency due to the wear and tear of prolonged use. These estimates of capital stock should be consistent for a long period of time, measurable (obtainable), and detailed enough to provide an informative picture for a particular industry.

The most ideal data for estimating a constant-dollar capital stock input would be gross value of investment for land, structures, and equipment by year purchased, along with estimates of the average lives and the age distribution of the assets. (Data on age distribution are necessary to help determine the efficiency loss that occurs as equipment ages.)

The estimation of railroad capital inputs is a more complex problem. Difficulties arise because the capital inputs of land, structures, and equipment are diverse (they tend to have long lives) and because much of the investment is made over a period of years. This makes it harder to obtain an accurate valuation for a base year.

Reports on capital inputs for railroads contain only the total gross book value with no distribution of assets by age grouping. A dollar value for land owned by railroads is also difficult to achieve because its value depends more on its location than on its time of acquisition.

BLS and the Department of Commerce provide similar series of capital stock measures by using what they consider to be reliable data for total investment in road and equipment of Class I and Class II railroads. These series were broken down into plant and equipment shares according to the relative shares of annual expenditures for additions and betterments to road and equipment and property. The primary source of the data was the ICC, specifically, Transport Statistics and Statistics of Railways in the United States; other data came from the American Railway Car Institute. Because of data limitations, it was possible to include only the equipment portion of leased property.

These measures do not explicitly take changes in technology into account. Changes in the productive capability of assets are reflected only to the extent that they are reflected in the real cost of the assets. More important, these are capital stock measures, not productivity measures, and they are estimates, not actual data. Nonetheless, the BLS and Bureau of Economic Analysis (BEA) measures complete the first step in the quest to find out how much a unit of capital contributes to a unit of output.

But after surrogate capital stock estimates are obtained, these data then need to be transformed into estimates of capital services to make them useful in creating a capital productivity and total productivity index. Otherwise, the dreaded "output per unit of capital expenditure" is obtained, and not true capital productivity. BLS and other organizations are still in the early research stages of the measurement of capital productivity.

Output: The Ton-Mile Problem

Determining the appropriate output measure or measures is a major problem that has generally been overlooked in the railroad industry. This is because the overwhelming number of cases focusing on productivity adopt the ton-mile as the single-factor output of railroad freight productivity. The attributes of the ton-mile measure are that it is readily available as a statistical measure (railroads report it to the ICC), it appears to be a homogeneous standard among carriers, and it represents the two major elements of ratemaking--weight and distance. However, in terms of productivity, the issue regarding the ton-mile factor is, Do railroads produce solely ton-miles? The answer, of course, is a resounding no.

Railroads, and thus railroad labor and capital, provide a capacity for transportation that includes the right-of-way (track, tunnels, bridges, etc.), locomotive power, hauling capacity (cars), and related facilities (repair shops, terminals, transloading equipment, etc.). Thus, some railroad employees produce outputs that may be best described as measures--among others, number of cars handled, train miles, couplers repaired, and tons of rail laid. In a 1973 study of railroad productivity, Paul H. Banner of the Southern Railway System adopted four measures of railroad productivity, with the following weights (2):

Output Measure	Weight (%)
Car loads	38.6
Car miles	31.2
Train miles	18.1
Overhead	12.1

Banner concluded that over the period of time he studied, when the preceding output measures are used instead of ton-miles, a far different productivity result is produced.

Aside from the problem that ton-miles is not necessarily the proper measure of railroad output, the ton-mile suffers from two other major deficiencies. First, it can be affected by changes other than fluctuations in productivity. For instance, if a railroad gains coal traffic at the expense of losing some business of a much lighter (but possibly more profitable) commodity, can productivity be said to have increased simply because ton-miles accelerate? After all, the shift in traffic consist requires no additional labor or capital input. Thus, in using ton-miles as the railroad output, shifts in traffic must be excluded from the measurement if productivity changes are to be estimated with some degree of accuracy; this task is no simple endeavor. For example, between 1972 and 1982 railroad ton-miles per employee increased by 45 percent, whereas total tonnage declined by 12.4 percent. Rhetorically speaking, is the increase in ton-miles per employee largely due to a shift toward coal traffic (up to 40 percent during this period), an increase in labor productivity, an increase in capital productivity, a combination of factors, and so forth? Shifts in the proportional tonnages of commodities carried over various distances, whether of the magnitude of the 10-year gain in coal traffic or a less dramatic shift, result in changes in both unit costs and input-output ratios. When shifts to heavier products occur, the railroads generate more output per unit of input, but this is not because of an increase in productivity.

Second, the ton-mile measure is not always a homogeneous standard because one ton-mile can be far different than another; in fact, the rates for shorter distances are generally higher on a unit basis than those for longer distances, and this is why commodities have different ratings even though they may have the same densities. Thus, although the ton-mile measure provides knowledge as to overall railroad output, it is extremely limited in its use as part of the productivity equation.

PROPOSED USES OF RAILROAD PRODUCTIVITY MEASURES

Given than no single acceptable measure of railroad productivity exists, or is likely to be developed, the issue of measuring productivity is best examined within the context of proposed uses. After all, the required level of precision for any standard depends largely on its proposed application. Listed in the following sections are a number of potential uses of railroad productivity measures and a brief discussion of the need for precision.

Investment Criteria

Part of many investment decisions is the degree to which productivity is increased and cost savings ensue. In this case, rather simplistic measures of productivity can be adopted because the input variable is often limited to a single capital asset (e.g., a locomotive, freight car, or repair facility). For example, the productivity of a single freight car may be measured by its added weight, longer life, or greater use. Such productivity indicators (not measurements) as ton-mile per freight car mile or per freight car hour may be legitimate factors in the investment decision. Of course, in some other instances, both labor and capital are involved and the needed productivity indicator becomes more complex.

General Indicators

Both Congress and the ICC tend to treat the railroad industry differently if the industry is thought to be unproductive (inefficient) as opposed to productive. The National Transportation Policy, established as the preamble to the Transportation Act of 1940, and the more recent Staggers Rail Act of 1980 focus on the public policy need to encourage "honest and efficient" railroads; in essence, shippers are best served when railroad inefficiency is minimized. Consequently, under regulation railroad mergers are more likely where efficiencies exist, railroad rate increases are less likely where inefficiencies exist, and railroad abandonments are more likely where lines are of light density and unprofitable (unproductive).

A number of productivity indicators may be used for the foregoing purposes without acceptance of any single productivity measure. For instance, by using the simplistic data presented in Table 2, it can be generally concluded that the railroad industry has become increasingly more productive over the past 10 years. An increasing number of ton-miles have been produced in the face of declining employment, less miles of route, and relatively less equipment. Although the indicators in Table 2 are far from productivity measures, when used in concert with other indicators, they form a picture of greater productivity, but at an undefinable level of precision. Still, they are useful for examining general public policy and regulatory perspective.

Wage Adjustments

Another area in which so-called productivity gains are used is in support of demands for increased wages and wage supplements. Although labor should certainly benefit from true productivity gains, along with management, investors, shippers, and the general public, there is no justification for basing wage and fringe benefit increases on imprecise output data that are merely masquerading as productivity measures. As long ago as 1962 the President's Council of Economic Advisors addressed some aspects of productivity in a study entitled Guideposts for Noninflationary Wage and Price Behavior. As stated by Burton N. Behling, an economist with the Association of American Railroads, in January 1964:

> Productivity is a guide rather than a rule for appraising wage and price behavior for several reasons. First, there are a number of problems involved in measuring productivity change, and a number of alternative measures are available. Second, there is nothing immutable in fact or in justice about the distribution of the total product between labor and non-labor incomes. Third, the pattern of wages and prices among industries is and should be responsive to forces other than changes in productivity.

Economic theory supports the notion that labor is generally entitled to wage increases where it increases its marginal productivity rate, but to use an imprecise measure as the standard for wage increases can only accelerate a major problem associated with railroad costs, that is, that in 1984, the average railroad employee earned about $43,000 annually ($34,000 in wages and $9,000 in fringe benefits), whereas the industry's chief competitor, the trucking industry, paid its employees an average wage of $26,000. Obviously, historic railroad wage increases based on ill-defined productivity in-

TABLE 2 Single-Factor Productivity Indicators in Freight Service

	Freight Revenue Ton-Miles per							
Year	Employee[a] (000,000s)	Employee Hour	Avg Route Miles Operated in Freight Service (000,000s)	Active Locomotive (000,000s)	Serviceable Freight Car (000s)	Freight Car Mile (000s)	Freight Train Mile (000s)	Freight Train Hour (000s)
1967	1.4	579	3.4	42.1	457	24.3	1.7	34.9
1968	1.4	590	3.5	43.2	490	24.7	1.7	35.4
1969	1.5	611	3.6	44.6	512	25.3	1.8	35.7
1970	1.5	616	3.7	44.1	511	25.6	1.8	36.1
1971	1.5	605	3.6	41.9	494	25.3	1.7	35.2
1972	1.5	637	3.7	42.0	527	25.6	1.7	34.4
1973	1.7	696	4.1	44.6	575	27.2	1.8	35.4
1974	1.7	695	4.1	43.5	581	27.7	1.8	36.0
1975	1.6	676	3.7	40.4	533	27.3	1.9	37.5
1976	1.7	712	4.1	42.3	577	27.8	1.9	37.7
1977	1.8	738	4.2	43.3	609	28.7	1.9	38.3
1978	1.9	777	4.5	44.6	640	29.5	2.0	38.5
1979	2.0	792	5.0	N.A.	N.A.	31.0	2.1	35.8
1980	2.1	862	5.1	N.A.	N.A.	31.4	2.1	39.0
1981	2.2	906	5.1	N.A.	N.A.	32.5	2.2	42.5
1982	2.2	927	4.6	N.A.	N.A.	33.3	2.3	49.5
1983	2.6	1,073	4.9	N.A.	N.A.	34.0	2.4	48.6

Note: Data are based on the consist of Class I railroads for each respective year, excluding the National Rail Passenger Corporation (Amtrak) and the Long Island Railroad, from various reports of Class I railroads to the ICC.

[a] Freight service employment estimated based on proportion of freight to total operating expenses.

creases have been detrimental to the industry and are inappropriate for future adjustments.

GENERAL RATE INCREASES

In the era before the Staggers Rail Act, the only recourse available to the railroad industry for recovering cost increases was lengthy and costly general rate increase proceedings. As part of the testimony submitted in each proceeding, the railroads were required to develop statistics pertaining to productivity and unit labor costs. In a separate schedule (Schedule G), the railroads were required to calculate the ratio of revenue ton-miles to freight-service hours as a measure of productivity and the ratio of freight labor costs to revenue ton-miles as a measure of unit labor costs. The computations in Schedule G did not succeed in accurately portraying productivity trends in the railroad industry. On the contrary, the computations were an open invitation to confusion and misinterpretation, for two primary reasons. First, the time span covered by the data required by Schedule G was far too brief to reveal meaningful productivity changes. The computations only permitted comparisons of revenue ton-miles per freight service hour in the pro forma year with the base year and in the base year with the previous year. Because the railroad industry is particularly prone to severe year-to-year fluctuations in traffic and employment levels evolving from aberrations in the activities of industries that account for large portions of rail traffic, short-term productivity gains just do not mean much.

Second, as has been said repeatedly, ton-mile output based on a single-factor labor input is not a meaningful productivity indicator. Misinterpretation of the Schedule G data, which was usually self-serving, came in the form of allegations that cost justifications presented by the railroads did not take into account productivity gains that had allegedly reduced the amount of labor and other inputs employed by the railroads. Other protestants argued that the railroads should be required to improve their profits only through productivity gains, not rate increases. Also, in connection with general rate proceedings, the Council of Wage and Price Stability (COWPS) included an analysis of the Schedule G data in its deliberations on the validity of railroad rate increase proposals.

AMERICAN ASSOCIATION OF RAILROADS (AAR) COST INDEX

Section 203 of the Staggers Rail Act of 1980 brought an end to the lengthy general rate proceedings by creating a statutory mechanism to enable railroads to adjust their rates to keep pace with the effects of inflation on railroad costs and to do so without extended regulatory delay. The ICC implemented this statutory mandate in Ex Parte No. 290 (Sub No. 2) by adopting the AAR index as the method of measuring the effects of inflation on railroad costs. It decided at that time not to require a so-called "productivity adjustment" to the changes in costs determined through use of the index. The commission's decision was sustained by the Court of Appeals. However, the commission is again considering whether a productivity adjustment is appropriate and, if so, how to measure productivity.

The railroads' position on this issue is that the proposed adjustment to the AAR index should again be rejected for the following reasons. In the first place, no accurate, reliable index of current changes in rail productivity exists for such a precise adjustment. But even if an accurate index did exist, a productivity adjustment to the AAR cost index would be inappropriate because to the extent that productivity gains are realized by the railroad industry, they are, to a significant extent, already passed on to consumers by competitive pricing in the marketplace. This issue is still in limbo. The commission issued a Notice for Proposed Rulemaking (NPR) on September 27, 1985, asking for comments with replies due in March 1986.

CONCLUSIONS

There are three major conclusions that have ensued from the research undertaken in support of this presentation. First, it is not overwhelmingly important to develop a single, comprehensive method defining or measuring railroad productivity. This is because such a measurement cannot be expected to be universally accepted; it has limited application, and its nonexistence should not undermine the goal of increasing productivity. In essence, there are enough indicators of railroad productivity available to serve as support for capital investment and other managerial decisions so that a single overall measure (given all its definitional problems and related foibles) is not required. Second, productivity measures should not be used to adjust such sensitive areas as wage rates and the rail cost adjustment factor. In the case of wage rates, the lack of an adequate productivity measure coupled with the economic fact that competition is the best standard for determining labor wages make a productivity adjustment inappropriate. In the case of the rail cost adjustment factor, a productivity adjustment is akin to double-accounting in that productivity increases are already passed on to consumers in the form of lower rates in the competitive market. And finally, various measures of productivity can be adopted, depending on the ensuing application. For instance, for a simple analysis of railroad productivity in general, ton-miles, tons, carloads, and so on, related to a host of input variables can be used to show that over the recent past, railroads have produced more output with less labor, track, fuel, fixed facilities, and other input factors.

The task at hand is not to define and measure productivity but rather to shatter the institutional barriers that limit its realization. Much has already been accomplished with the passage of the Staggers Rail Act of 1980, and railroad management has moved forward to exercise its newly found market freedom. Now railroad labor must join forces with management and eliminate antiquated work rules and related procedures. As within the U.S. economy, the viability of the railroad industry is largely dependent on increasing productivity in a highly competitive marketplace.

REFERENCES

1. Improving Railroad Productivity. Task Force on Railroad Productivity, National Commission on Productivity and Council of Economic Advisors, Washington, D.C., Nov. 1973.
2. P.H. Banner. The Measure of Productivity in Rail Transportation. Presented at Annual Meeting of the American Society of Mechanical Engineers, Denver, Colo., Sept. 1973.

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