PRODUCTIVITY IN THE NORTH AMERICAN RAIL INDUSTRY

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INTRODUCTION

The North American rail industry has undergone substantial changes over the last 25 years. They have faced substantial competition from other modes as well as in the markets for the products they carry. There have been major changes in the public policy, affecting the decision-making environment for rail managers. There has been much interest in the implications of these changes for productivity performance, although, curiously, there has been more speculation about rail productivity trends than actual analysis.

This paper summarizes briefly the changes in policy environments of the Canadian and U.S. rail industries, and presents a number of output trends and simple performance measures over the 1970s and 1980s. The comparisons are for the two large Canadian railways (Canadian Pacific and Canadian National) and the U.S. Class I rail industry as a whole. It is generally recognized that simple performance measures, such as labour productivity (output per employee or per employee-hour), are not necessarily a guide to more comprehensive performance measures, such as total factor productivity (TFP, the growth of total output compared to the growth of total inputs). Unfortunately, few studies of TFP have been carried out in recent years. This paper reviews the results of the studies which have been undertaken.

Part 1.0 provides a capsule summary of the changing policy and managerial environment in the North American rail industry. Part 2.0 present a number of output trends and performance indicators for 1972-1989. Part 3.0 reviews estimates of total factor productivity for the U.S. and Canadian railways and comparisons between them.

1.0 POLICY DEVELOPMENTS AND PERFORMANCE TRENDS FOR NORTH AMERICAN RAILWAYS

1.1 Some Salient Characteristics of the North American Rail Industry

The North American railways differ from those in most other countries in primarily being freight carriers. Except for a couple corridors, rail passenger service is but a (high cost) remnant of what once existed. Most rail passenger service in both countries is provided by a separate government corporation contracting for use of track owned by freight railways. The industry is also distinctive in its reliance on private ownership of railway companies. The notable exception is the Canadian National (CN), but it operates independently with a mandate to pursue a profit; essentially it behaves like a private carrier. The large land area of the two countries is reflected in relatively long average hauls. Average load per train is higher than for most countries as well, about 2500 revenue tonnes per train on average, with many trains pulling in excess of 10,000 tonnes payload.

1.2 Public Policy Changes and Their Effects

The North American rail industry has undergone major changes in public policy regimes. Railways in both Canada and the United States evolved under close regulations over the decades. As alternative modes of transport emerged (inland water transport and motor carriers), they also tended to be regulated to prevent competition.

Canada. The first significant policy we discuss was Canada's *National Transportation Act, 1967,* which deregulated railway pricing. Although some maximum and minimum rate limits were specified, they were essentially unconstraining. Nevertheless, the Canadian policy change was not complete deregulation. While it gave dramatic new freedoms in most markets, significant portions of rail operations were still restricted. In particular, the largest commodity category, export grain, continued to move under statutory rates set at 1897 levels. This continued until the Western Grain Transportation Act, 1983, but even then the rates changed little (but the WGTA provided for financial compensation for the railways' losses). Given the uneconomic nature of the operation, the whole grain transportation system is regulated. Freight car allocation and shipments are controlled by the Canadian Wheat Board, which controls farm quotas and shipment scheduling. Further, the railways face many obstacles in abandoning light density lines. In brief, after 1967, the Canadian railways had extensive freedoms for pricing and service delivery on most of their operations, but mixed in with extensive controls or interference with their ability to rationalize large blocks of uneconomic services. This pricing freedom stimulated significant changes in rail management behaviour and performance. Railways become more market- and profit-oriented. Pricing and service became active market tools, and the railways' performance improved significantly. (Heaver and Nelson, 1977). Canadian rail productivity growth outstripped that in the U.S. (Caves, Christensen, Swanson and Tretheway-CCST, 1982).

The *National Transportation Act, 1987* brought further changes to the Canadian railways, including additional flexibility in rate making and other policies intended to stimulate more competition. Confidential contracts were permitted, and joint quotations of rates by the two railways (collusion) was prohibited. Controversial pro-competitive measures were introduced, including legislation to allow access to "captive" shippers by allowing off-line carriers to bid to pickup or deliver traffic on another railway's line.

U.S. The U.S. rail industry continued under tight regulatory controls until the late 1970s. Productivity was lagging and the rail industry was in poor financial health.

Partially influenced by the performance of the Canadian railways following their (partial) deregulation, and facing the prospect of wholesale financial collapse of the U.S. rail industry, regulations began to be relaxed in the late 1970s, culminating in the Staggers Rail Act, 1980. The Staggers Act was a more extensive deregulation than in Canada. Railways were granted pricing freedom,[1] and significant (though not complete) freedom to shed uneconomic operations and rail lines. Substantial track was abandoned or transferred to local short line operators. The U.S. rail industry substantially improved its performance following Staggers. Financial health has improved as well, although not to the same extent as the gains in productivity (that is, there is substantial competition within and from outside the rail industry such that many of the productivity gains have been passed on to customers as lower prices; some comments later).

Recently, there has been substantial interest in measuring the productivity gains of the U.S. rail industry. These arose in connection with some of the residual regulatory restrictions which still face the industry, specifically, the ICC proposal (now adopted) to deduct productivity gains from the allowable rate increases for regulated rates (ICC Ex Parte 290).[2] There is also growing interest in rail productivity measurement in Canada, as there are fears that Canadian rail productivity may be falling behind that of the U.S., and thus hampering the ability of Canadian railways to compete for east-west movements in North America. Unfortunately, there are very limited data from which to estimate comprehensive productivity measures for the Canadian railways. This study reports a few partial performance measures as well as comments on the few studies of total factor productivity.[3]

2.0 SELECTED TRENDS AND PARTIAL PRODUCTIVITY MEASURES FOR CANADIAN AND U.S. CLASS I RAILWAYS

2.1 General Trends

Exhibit 1 presents one indicator of North American rail activity: an index of the growth in revenue tonne-kms (RTK), shown for Canadian Pacific (CP) and CN along with the aggregate figures for the U.S. Class I rail industry. There is an upward trend albeit with some fluctuations. The fluctuations in traffic appear larger in the 1980s. The only noticeable differences among the railroads are CP's avoidance of the downturn in traffic affecting other railroads in 1982, and the sharp drop in Canadian rail traffic in 1989 in contrast to the continued growth in traffic in the U.S.

An index of total employees for CP, CN and the U.S. Class I carriers is shown in **Exhibit 2**. All three show a steady downward trend, with what appears to be a major shift downward in the early 1980s. In the eight years prior to 1980, U.S. rail employment fell at an annual rate of 1.7%. In the eight years following the Staggers Act, employment fell by 8.3% per year. In Canada, the drop in employment accelerated as well after 1980, from -2.3% to -4.3% per year for CP, and from -1.5%

Exhibit 1 Revenue Ton Kilometres
1972 to 1989

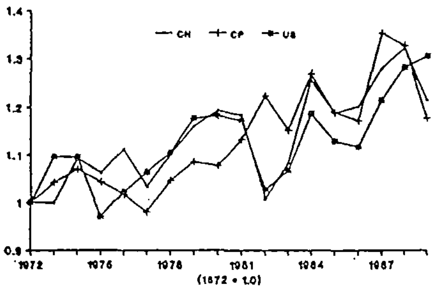


Exhibit 2 Employees
1972 to 1989

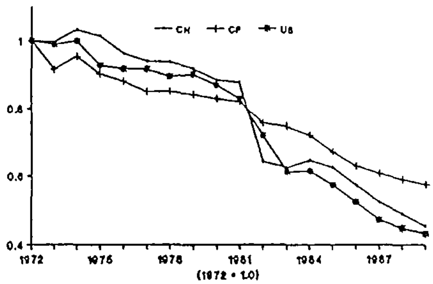


Exhibit 3 Revenue Ton Kms per Track Km
1972 to 1989

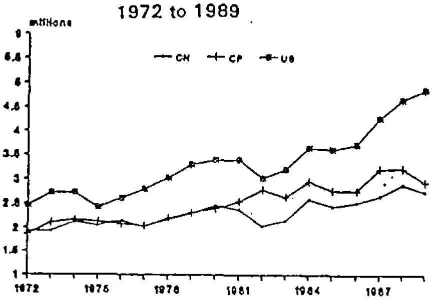


Exhibit 4 Revenue Ton Kms per Employee Hour
1972 to 1989

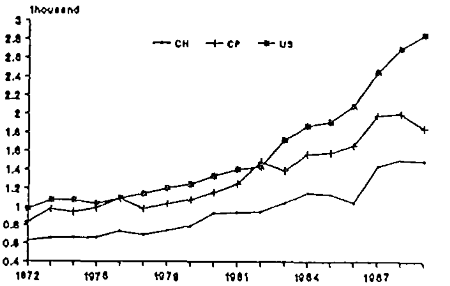


Exhibit 5 Revenues per Revenue Ton Km
1972 to 1989

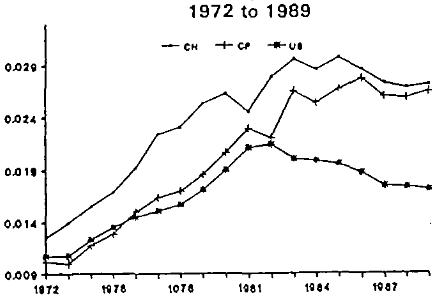
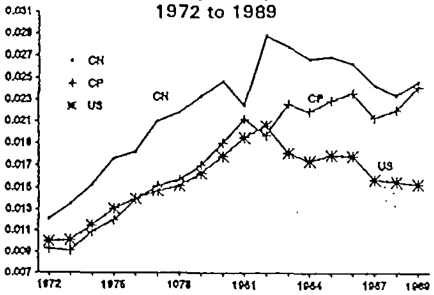


Exhibit 6 Op. Expenses per Rev. Tonne Km.
1972 to 1989



to -7.4% per year for CN.[4]

2.2 Partial Productivity Measures

It is possible to construct a great many "performance ratios" to illustrate productivity changes. **Exhibit 3** plots RTK per track kilometre, i.e., traffic density. The U.S. rail industry shows a noticeable upward trend, particularly in the 1980s, reaching an average of 5 million RTK per track km.[5]

A measure of labour productivity, RTK per employee-hour is shown in **Exhibit 4**. The Canadian and U.S. Class I railroads show very similar upward trends over the 1970s, with some indication of accelerated improvement over the 1980s, especially for the U.S. railways.[6]

2.3 Some Financial Trends

Exhibit 5 plots an index of revenue per RTK, i.e., an index of freight unit revenue. Unit revenue has fallen in real terms through the 1980s for the U.S. rail industry. This is especially striking remembering there was still noticeable inflation in the early 1980s. The Canadian railways show a decline as well in the most recent years, but they sustained unit revenue increases over the early 1980s.

Operating costs per RTK (**Exhibit 6**) also show a noticeable decline during the early 1980s for the U.S. and CN. Both CP and CN show increased costs in 1989 in contrast to the lowered cost per unit for the U.S. Operating costs per employee hour (not shown) has a steady upward trend throughout the period for CP and the U.S. industry average, and a lower rate of increase for CN in the late 1980s.

In summary, the revenue-cost trends do not show improved revenue per unit for the U.S. rail industry despite the various indications of productivity growth. The productivity gains are also indicated by declines in operating costs per RTK. However, it appears that competitive forces were sufficient to keep prices close to costs on average in the U.S., so productivity gains are being passed through on average.[7] The Canadian railways have not fared much better financially, although apparently they were able to sustain revenues to cover their higher operating cost trends compared to the U.S. during the early 1980s. However, the end of the decade shows noticeable decline in revenue/cost relationship for CP and CN.

3.0 THE CONCEPT AND MEASUREMENT OF TOTAL FACTOR PRODUCTIVITY

Simple performance ratios, such as those reported above, are suggestive but not necessarily a reliable guide to more comprehensive measures of performance. Increases in labour productivity must be compared with changes in other inputs including capital, fuel and materials. It is desirable to measure total factor productivity (TFP) to obtain more reliable performance comparisons.

3.1 The Concept of TFP

The simplest measure of TFP is a ratio of indexes of total output and total input. While total output might be represented by a crude measure such as revenue ton kilometres, combining labour, fuel, capital and materials into a single measure of input poses a major challenge. This "aggregation" problem will be discussed shortly. Another issue is that the ratio of total output to total input is a "gross" measure of productivity. It does not distinguish sources of productivity gains. For example, if economies of scale are important in an industry, then there will be productivity gains simply from market growth as distinct from productivity gains associated with new technologies and innovations. There are alternate approaches to TFP measurement which distinguish the sources of TFP (e.g., see Oum, Tretheway and Waters, 1992). The present discussion is limited to gross index number measures of productivity.

A complication in measuring productivity in transportation is that multiple outputs and inputs are involved. As is well known, the most common measure of aggregate transportation output is the tonne-kilometre (ton-mile). This reflects the volume-distance elements of transportation output, but has the recognized shortcoming of treating all tonnes and kilometres as homogeneous. Different amounts of tonnes going different kilometres entail different input requirements; thus one observes different output/input relationships across firms or markets which may simply reflect differences in traffic mix rather than revealing differences in underlying technical efficiency.

3.2 Measuring Output

Historically, scarcity of data generally has prevented extensive disaggregation when developing output and input indexes. On the output side, TFP studies generally have been able to separate freight from passenger outputs, e.g., CCST (1982). Another modification to output measures is to incorporate differences in length of haul. A significant improvement in constructing a railroad output index emerged in the recent U.S. ICC Ex Parte 290 proceedings. Caves and Christensen (1982) proposed an output index based on 50 commodity classifications, four lengths of haul and whether cars were shipper- or carrier-owned, for a total of 400 output categories. Reebie Associates (1988) reviewed this procedure and explored alternatives. They determined that it was not necessary to identify commodity type per se. They based their index on the type of equipment (rail car) and recommended an output index consisting of seven car types, three shipment weight categories, three lengths of haul, and three service types (defined as number of cars per waybill). This output index was accepted by the ICC. The weights for the output categories are the revenues reported on the waybill sample. While not devoid of controversy, it is generally agreed that this disaggregate index is a much improved measure of rail output. It reduces the extent to which shifts in traffic mix requiring fewer inputs is mistaken as productivity improvements. Such an output index has not been constructed in Canada.

3.3 Input Measurement

Disaggregation on the input side is feasible for some input categories. Generally it has been possible to subdivide some input categories such as labour. Thus it is possible to construct indexes of labour inputs based on several labour categories. Similarly, fuel and energy inputs are reported in some detail.

It is much more difficult to develop measures of capital inputs. This is a problem for all industries. Conventional accounting treatment of capital inputs can differ substantially from that indicated by economic theory. To measure capital inputs accurately, one needs to have capital stock estimates expressed in current dollars and be able to specify a measure of the flow of capital services from that stock.[8] Ideally, one would distinguish between various types of capital inputs, but disaggregation has been limited to distinguishing between way and structures capital from equipment capital.

Estimating inputs of materials and miscellaneous services also face major measurement problems. The traditional approach has been to estimate a quantity index of these inputs by deflating the expenditures by a price index thought to reflect the mix of materials and miscellaneous inputs used in producing transportation services.

The above discussion of labour, fuel and capital inputs describes techniques to construct physical measures of the quantity of inputs being used in producing transportation, a so-called physical input approach. Ultimately, it is an index constructed by physical measures of inputs, each weighted by the relative expenditures on that input. The total input index is the difference in input use by category (across firms and/or over time) weighted by their respective expenditure shares. In a simple form, the index of the growth in aggregate inputs would be:

(1) $I = \Sigma_i e_i (\Delta x_i/x_i)$

where e_i represents the share in total expenditures, and $\Delta x_i/x_i$ is the proportional change in input i between firms and/or years.[9]

Recently, a simpler approach to total input measurement has been proposed. It divides total expenditures by an input price index. If the input price index is constructed properly and if economic costs are fully and correctly measured, then this approach will produce the same measure of input quantity changes as in (1). This is called a "deflated expenditure approach" to estimating an input quantity index. Further comments below.

4.0 RECENT TFP ESTIMATES FOR CANADIAN AND U.S. RAILROADS

As noted in section 1.0, productivity comparisons between Canadian and U.S. railroads were an important influence in the move to deregulate U.S. railroads. Unfortunately, the cost and non-availability of data have constrained productivity studies in recent years. Nonetheless, a few estimates of rail TFP have now emerged. These are summarized in this section. The primary TFP estimates which have emerged are those connected with the ICC's Ex Parte 290 proceedings, although Gordon (1991) has also developed TFP estimates.

4.1 TFP Estimates for U.S. Railroads Since the Staggers Act (1980)

The TFP estimates adopted by the ICC in the Ex Parte 290 Sub-No. 4 proceedings use an index number approach to productivity measurement but, as noted earlier, the construction of both the output and input indexes differ from procedures used in previous TFP studies. Instead of using the relatively simple ton-mile and passenger-mile output index of previous studies, the much more disaggregate output quantity index discussed earlier was employed. The more comprehensive output index reduces the problem that apparent productivity gains can come about by shifting among outputs to those which require fewer inputs, which is not the same as real shifts in productivity.

In contrast to the ambitious approach to output measurement, the ICC adopted the much simpler deflated expenditure approach to input measurement. It calculates the total input quantity index simply as total accounting expenses divided by an input price index. The input price index used is the Rail Cost Adjustment Factor or RCAF. The RCAF is the regulatory-sanctioned index for rate escalation to allow for cost inflation. The deflated expenditure approach is valid in theory, providing the measure of total costs is correct as well as the input price index. However, the measure of costs being used is total rail operating expenses plus fixed charges (interest). This adopts conventional accounting treatment of capital costs. The shortcoming is that it understates the measurement of capital inputs because interest charges and book depreciation are the only capital inputs considered. (Further, the RCAF is not identical to an input price index which incorporates the true service price of capital).

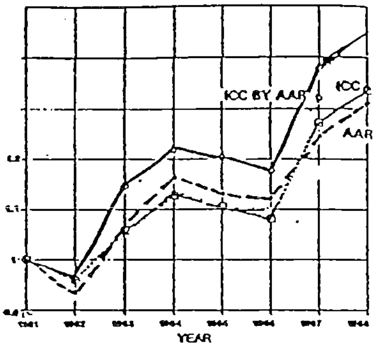
To contrast the change in input quantity measurement, we worked with the Association of American Railroads to update the capital stock estimates for the Class I rail industry using the physical input approach including the Christensen-Jorgenson framework for measuring the true economic cost of capital inputs. This is a major undertaking and the details are provided elsewhere.[10] The present paper merely summarizes the results.

The data base employed by the ICC contains differences from the AAR data base. In order to compare the two approaches to input measurement, it is necessary to employ a consistent data base. Thus three input indexes result: that calculated by the

ICC, the ICC approach applied to the AAR data base, and the direct measurement or physical input approach that we employed for the AAR. Using the same detailed output index, three TFP series result.

The three TFP indexes are graphed in **Exhibit 7**. All show a consistent pattern, but the levels and growth rates differ because of the different input indexes employed. All three show substantial productivity gains in the post-Staggers' period. The comparable (arithmetic) growth rates of the TFP measures are 5.9% (ICC by AAR), 4.5% (ICC) and 4.1% (AAR).

Exhibit 7 Alternate TFP Measures, U.S. Class I Rail Industry 1981-1988



It is not possible to make precise comparisons between these post-Staggers estimates of TFP with those of the pre-Staggers era. The post-Staggers data make use of the improved output index. But it is accurate to say that adoption of a simpler ton-mile type of output index would have shown even higher figures than above because it would not exclude the productivity gains brought about by actual shifts in traffic types.

There are a couple caveats which should be noted about these productivity measures. One cannot directly compare these productivity growth rates with those estimated for the 1960s and 1970s by Caves, Christensen, et al. The recent TFP measures do not distinguish between productivity gains resulting from economies of scale or density in contrast to pure shifts in production efficiency (as did CCST). Given the shrinkage in miles of track being operated by the rail industry since Staggers, it is likely that part of the rail productivity gains might be explained by economies of traffic density.

Another complicating factor is the state of the economy during the 1980s. Although there was a brief slowdown in the economy and reduction in rail traffic in 1982, the 1980s is basically an expansionary phase of the business cycle. An examination of past studies of productivity reveal that TFP estimates during the expansion phase of the business cycle overstate the growth rate over an entire cycle. Thus the TFP calculations in Exhibit 7 probably are an overstatement of what can be expected over a full business cycle.

Another source of TFP estimates for the U.S. rail industry are those produced by Gordon (1991). As part of a general study of transportation productivity, he reports TFP for the U.S. rail industry for 1948-1987, in groups of years. He uses some alternate output and input indexes. The ones most comparable to those used in the ICC Ex Parte 290 proceedings cited above show a 2.4% growth rate of TFP for 1969-1979, compared to a growth rate of 4.6% for 1978-1987 (Gordon, 1991, Table 14). These are broadly consistent with the other results reported above.

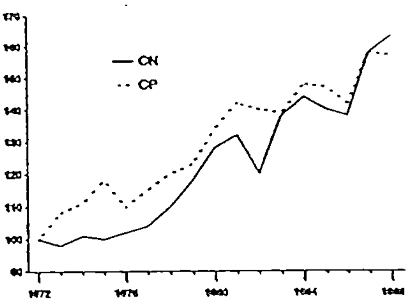
4.2 TFP Estimates for Canadian Railways

The first study of TFP for Canadian railways was carried out by Caves and Christensen (1978) with follow-up studies including CCST (1982). The latter study is particularly interesting because TFP was estimated from data incorporating railways from both countries.

Subsequent TFP estimates for Canadian railways were carried out by Cofsky and Roy (1985) as well as by Freeman, et al. (1987) for the period 1956-1981. Cofsky and Roy employed simple proxies for rail capital inputs, such as miles of track for way and structure capital, and freight and passenger car capacity for equipment capital. In contrast, Freeman et al. employed the physical input or direct measurement approach and, in fact, built on the data set originally developed by Caves, Christensen, et al. Cofsky and Roy reported TFP growth rates of 3.1 and 3.25 percent for CP and CN, respectively. However, Freeman et al. (1987), employing more detailed capital stock measures, pointed out that the proxies Cofsky and Roy had to use proved to be poor guides to capital inputs. The growth rates of TFP for CP and CN over the period 1956-1981 were 3.5 and 3.1 percent, respectively. Correcting for the larger amount of low density track in CN's capital stock (arguably a legacy of public service obligations arising from CN's origins) showed the growth rates of TFP to be very similar for the two railways.

The only TFP estimates for the Canadian railways during the 1980s were produced by Cairns (1990). He estimated TFP using the deflated expenditure approach described above. His data cover the period 1972 to 1988 and graphs of his TFP estimates are in **Exhibit 8**. His data show TFP growing over the period, fairly flat during the 1980s but jumping up in 1987-1988. Average annual TFP growth is 3.9% for CN and 3.6% for CP. His output index is based on ton-miles and therefore will differ little from that used by Freeman, et al. (1987).

Exhibit 8 TFP for CN and CP 1972-1988 (Cairns 1990)



Cairns constructed an input quantity index using the simple deflated expenditure approach like that adopted by the U.S. ICC. His input price index is based on confidential data (unlike the RCAF in the U.S., there is no equivalent published rail input price index in Canada). Therefore it is not possible to examine details of his input measure, but some comment can be made.[11]

As noted earlier, the deflated expenditure approach uses standard accounting information as a measure of total costs (to be deflated by the input price index to yield the input quantity index). Total costs are measured as total operating expenses including depreciation and fixed charges. That is, the measure of capital input expenditures consists of book depreciation and imbedded interest costs. These are not a reliable guide to economic measure of capital inputs. For both the U.S. and Canadian railways, we find that way and structure capital inputs were growing in recent years; further, the service price of capital has changed markedly, declining circa late 1970s and rising sharply in the early 1980s. The deflated expenditure approach to input measurement tends to understate the growth of capital inputs and assigns too low of a weight to the real importance of capital inputs, i.e., an accounting measure of capital expenditures is much less than a measure based on current opportunity costs of capital. As a result, the deflated expenditure approach understates total input use and thus overstates TFP. Hence, we distrust his TFP estimates for the Canadian railways. As a guess, we suspect his estimates are an overstatement of TFP growth rates if capital inputs were measured correctly. Research on this issue is underway but results will not be available until late 1992.

5.0 CONCLUSION

Although some broad trends are apparent, we cannot make strong productivity comparisons between Canadian and U.S. railroads. There are only a few TFP estimates and they are not done on an identical basis. This paper has looked at these various estimates supplemented with a few simpler performance ratios.

The broad trends do show notable productivity gains taking place during the 1980s. The trends also suggest that productivity gains in U.S. railroads are exceeding those of Canadian railways. The U.S. TFP estimates show gains whichever method of measurement is used. The only TFP estimates for CP and CN during the 1980s (Cairns, 1990) uses a simpler output index than that now employed in the U.S. This will tend to overstate productivity gains because it does not separate out gains by shifts in traffic mix to those requiring fewer inputs. Cairns (1990) does use the same approach to input estimation that is now used by the ICC. We believe that this deflated expenditure approach to input measurement understates input use in recent years (because of inaccurate treatment of capital inputs) and hence overstates productivity. Thus we think that Cairns' TFP estimates for Canadian railways probably are an overstatement. His estimates of productivity growth are lower than those being calculated for the U.S. rail industry. Therefore, although we cannot strictly compare the numerical estimates of TFP between the U.S. and Canada, it appears likely that the Canadian railways are lagging the U.S. Class I carriers in productivity gains.

What explains the difference? TFP generally is conceded to be the best approach to productivity measurement, but without further analysis it is not revealing about the causes of productivity gains. We can only speculate, and there are many possible explanations. One may be that U.S. railroads have been catching up with productivity gains realized earlier by the Canadian railways. The more intriguing possibility is that differences in the regulatory regime in the two countries may offer part of the explanation. Both countries are nominally deregulated, although various regulatory and public policy restrictions still persist. The Canadian railways face restrictions on cost-cutting and shedding assets and other inputs. It is well known that the U.S. Staggers Act gave substantial freedom to railroads to reduce services, abandon lines and take cost-cutting measures in a variety of ways. Both Canadian and U.S. railroads face similar market prospects: they are mature industries with many traffic categories growing slowly or not at all (and U.S. Class I railroads in particular have been active at shedding traffic). Productivity gains are easier in growing markets. Where traffic growth has slowed, productivity gains come about primarily by reducing input use. This requires hard decisions both by management and public policy makers. The existing statistics are not sufficient to settle this question, but further examination of the abilities and freedoms of rail management to reduce input usage looks like an important factor in rail productivity performance in North America.

Bibliography is Available Directly from the Authors

Endnotes

1. There are some residual regulations for "market dominant" traffic, although the extent of regulatory intervention is also influenced by the financial condition of the railway.

2. The specific regulatory issues are not of interest here, only the measures of productivity which arose. For a discussion of the issues, see Tretheway and Waters (1991b).

3. Portions of the balance of this paper draw from Tretheway and Waters, 1991a and 1991b.

4. The decline in employment for CN is partly explained by a transfer of some employees to VIA Rail, the national passenger rail corporation.

5. More typically, railways measure density by gross tonne kilometres, i.e., including tare weight of equipment in measuring work performed. But RTK is a more meaningful economic output measure.

6. For an analysis of labour productivity differences between Canadian and U.S. railways and their causes, see Jones, et al. (1990).

7. An analysis of this productivity pass-through is in Tretheway and Waters, 1991c.

8. An explanation of the perpetual inventory method of measuring a capital stock and its flow of services is in Appendix A of Freeman, et al. (1987).

9. This simple formula abstracts from the appropriate indexing procedure for measuring the expenditure weights, i.e., the familiar problem of choosing "before" or "after" input prices and shares. This is a choice between Paache, Laspeyres or other indexes (e.g., the Tornqvist or Divisia index).

10. The detailed procedures are outlined in Tretheway, Diewert and Waters (1988) and Tretheway and Waters (1989). A summary of results and analysis is Tretheway and Waters (1991b).

11. However, Tretheway and Waters (1991a) compared the output and input indexes (and TFP) from Freeman et al. (1987) and Cairns (1990) for the years which overlap (1972-1981). They find the output measures similar but the input measures differ: Cairns input measure shows lower input growth than in Freeman et al., which would make Cairn's TFP estimates higher than those calculated by Freeman et al.