Volume Title: Long-Term Factors in American Economic Growth

Volume Author/Editor: Stanley L. Engerman and Robert E. Gallman, eds.

Volume Publisher: University of Chicago Press

Volume ISBN: 0-226-20928-8

Volume URL: http://www.nber.org/books/enge86-1

Publication Date: 1986

Chapter Title: Growth and Productivity Change in the Canadian Railway Sector, 1871-1926

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Chapter URL: http://www.nber.org/chapters/c9694

Chapter pages in book: (p. 779 - 818)

15 Growth and Productivity Change in the Canadian Railway Sector, 1871–1926

Alan G. Green

The written history of the Canadian railway sector focuses almost exclusively on the financial problems associated with the construction of specific railways.[1] Virtually no work on the growth of the Canadian railway system has been undertaken either in terms of its dimensions, and how they changed over time, or on the efficiency of this sector. This paper redresses part of this deficiency. It does so by setting out the growth of the railway system in Canada from 1871 to 1926 in terms of the net income generated by this industry. In addition, a preliminary attempt is made at estimating productivity change for the railway system.

The time period studied is from 1871 to 1926. These years span the decades from just after Confederation (1867) to approximately the peak of economic activity in Canada during the interwar period. By 1926 the railway system, as we know it today was largely in place. This is a far cry from the system which existed in the early 1870s. At that time there were only 2,700 miles of track in operation and they were located entirely in the Central (Ontario and Quebec) and Maritime (Prince Edward Island, Nova Scotia, and New Brunswick) Provinces and only in limited areas within these regions. The 55 years included here then cover the growth of the system from its infancy to full maturity.

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Although a number of people participated in the preparation of these estimates, two deserve special mention. Leighton Reid estimated interest and dividend payments, and Peter Wylie worked on the real output and capital stock estimates. I pulled the scattered pieces together while on leave at Harvard University. Robert Fogel kindly provided the space needed to do this research. The Social Sciences and Humanities Research Council of Canada provided a fellowship to take the leave. Much of the base funding was provided by a Killiam Grant. M. C. Urquhart was the principal investigator on this grant, and his support and assistance are gratefully acknowledged. Albert Fishlow's helpful comments on the paper at Williamsburg influenced my revision.

Railways provide the economic historian with a unique opportunity to study long-term economic development. Given their size and ultimate importance, governments sought information on them virtually from the day they were introduced. It was obvious to contemporaries that here was an innovation destined to touch, in some way, the lives of all citizens and hence the government needed to be informed about this new "gadget." This interest was often translated into a special effort to collect detailed data on the number of miles of track, revenue, expenses, engines owned, etc. The sector, then, may well provide the best window we have both on the development of a particular industry (how often do we get reasonably consistent annual data series that extend back 113 years?) and on the economy as a whole.

The paper is divided into three parts. Section 15.1 sets out the procedures used to estimate net income originating in the railway industry. These estimates were derived as part of a larger project on reestimating the Canadian National Accounts from 1871 to 1926 (reported on elsewhere in this volume). As such the railway figures discussed in this paper are only one segment of the income data devised for the Transportation and Communications sector.[2] Section 15.2 of the paper presents some analysis of the growth of railways in Canada over the study period, and in Section 15.3 a preliminary investigation is made of productivity change in this sector plus a look at factor share changes.

15.1 Estimating Procedures

The estimation procedure for railway net income is quite different from that used in the commodity sectors—at least that adopted in the reestimation of the Canadian national accounts. For the goods-producing sectors much of the evidence on sectoral growth comes from the decennial census. However, census reports do not contain information on output for railways as they do for agriculture, manufacturing, and so on. The only measure of railway size available from the census reports is on labor input and, as we shall see, even this evidence is suspect.

For Canada, at least, this omission did not present an insurmountable handicap to estimating railway output. From the beginning of railway development in Canada all levels of government have been interested in the progress of this industry and have, consequently, set out to record its development. Before 1867 (Confederation) such recording was carried out by the various colonial governments. Unfortunately this was not always done systematically. The newly formed Government of Canada decided to centralize the procedure and, commencing in the year ending June 30, 1875, required every railway operating in Canada to report annually on its operations to the Department of Railways and

Canals under the recently passed Railway Statistics Act of 1875. Annual collection of railway data has continued from then to the present. These annual estimates were published by the Department of Railways and Canals from 1875 to 1918 under the title "Railway Statistics" and appear in the Sessional Papers of Canada. Beginning in 1919 they were published by the Dominion Bureau of Statistics as "Railway Statistics of Canada" annually from 1919 to 1921 and thereafter as "Statistics of Steam Railways of Canada."[3] More will be said on the coverage of these annual reports in the discussion covering the actual estimation of income for this sector. In addition to the official source, evidence was drawn from Standard and Poor's and Moody's manuals on railways.

These annual publications provided the basic data for the calculation of net income originating in the railway sector. A factor-incomes approach was used. Thus net railway income is the sum of wages and salaries, interest and dividend payments, and net savings. The latter is estimated as a residual after dividend payments have been deducted from net operating revenue. Each factor income component has its own particular set of problems. Hence each will be discussed separately.

15.1.1 Wages and Salaries

Estimates of the total wage bill for railway employees were first published in 1907 and have appeared annually ever since that date. Unfortunately this series was not homogeneous over the period of inquiry. In the early years the series included workers in railway express. It is possible to divide these two series from 1919 on, but not for earlier years. Since such partitioning was not possible before this date, the wage bill estimates are the sum of the two groups.

Besides these annual reports, information on wages paid to railway workers was collected in the decennial census beginning in 1871. Unfortunately, the census estimates did not prove to be an entirely satisfactory alternative source for this type of information. The main reason is that those who assigned the results from the census to various components in the published reports saw the railway industry divided into two distinct parts. One part was composed of those activities which dealt exclusively with the provision of railway services, that is, the movement of people and goods. The other part was associated with manufacturing activity, the repair and rebuilding of railway equipment. Another component, and one even harder to separate, consists of unskilled workers who were partly engaged in track maintenance and partly on new construction. For our purposes inclusion of the latter would be inappropriate since they were not associated with the delivery of railway services in a given year.

The discrepancy is not small. If we take the censuses of 1911 and 1921, when annual estimates of total employment compensation are

also available, the differences are as shown in table 15.1. There are two points to note. First, the absolute difference between the two series can be large. Second, the size of the difference is not stable. By 1921 it had grown to $81 million. The greater spread between the two series implies that as the system entered its slower expansion period more employees were engaged in repairing and rebuilding rolling stock, relative to operating workers, than was the case in 1911. The census estimates, for this reason (and for others to be discussed later), had to be abandoned.

The failure of the "augmented" census reports to provide reasonable estimates of the *level* of total wage payments forced us to find an alternative method. What was required, then, was to discover a reasonably constant relationship between an annual series that stretched over these earlier years and the railway wage bill. After some experimentation it was found that a fairly stable relationship existed between wages (the wage bill) and total operating expenses. For example, between 1907 and 1920 the ratio of wages and salaries to operating expenses averaged 59.1%, with only a small dispersion around this mean.

To check the stability of this ratio total annual compensation paid to United States railway employees was divided by total expenses for the system. The period chosen was from 1895 to 1910. Over these years the ratio averaged 61.0%, with only a small deviation about the mean. Interestingly, the United States ratio was within 2 percentage points of the Canadian ratio, and like the latter was trendless over the period reviewed.

It was decided then, on the basis of the stability of the wage/expense ratio, to extrapolate the wage bill for Canadian railways back from 1906 to 1875 on the basis of the total annual expenses record for the system, with one modification. Total expenses were broken down into "Maintenance of Way and Structures" and "Other Operating Expenses." The ratios of wages paid differs sharply between these two broad categories of expenses. "Maintenance of Way and Structures" exhibit a

Table 15.1 **Railway Employees' Total Compensation, Census Estimates and the Annual Reports of Railway Operation in Canada: 1911 and 1921 (Millions of Dollars)**

Year	Census (1)	Annual Reports (2)
1911	69.2	74.6
1921	167.0	247.8

Sources:
Col. 1: 1911, *Census of Canada;* 1921, *Census of Canada.*
Col. 2: *Canada Year Book of 1921* (Ottawa), p. 537.

higher ratio due, one suspects, to the amount of track maintenance, that is, replacing rails and ties, reballasting, snow removal, and so on, all of which is labor-intensive work. This breakdown then permitted us to incorporate, in the final estimates, any alterations between these two broad categories which occurred in the course of building and operating the railway system. Finally, estimates of total wages were carried back to 1871 on the basis of expenses recorded for the Grand Trunk Railway—the largest single railway operating in Canada at that time. The results of these calculations appear in table. 15.2.

15.1.2 Interest and Dividend Payments

Estimating annual costs associated with the use of capital proved to be a more difficult chore than was the procedure for obtaining a long-term series on the wage bill for Canadian railways. In setting out the procedures for estimating this component of total net income, the dis-

Table 15.2 **Annual Estimates of Total Wages and Salaries Paid to Railway Employees, 1871–1926 (Thousands of Dollars)**

Year	Amount	Year	Amount	Year	Amount
1871	7,190	1891	19,834	1911	77,520
1872	7,819	1892	20,639	1912	97,654
1873	8,538	1893	20,668	1913	119,771
1874	10,964	1894	19,851	1914	116,136
1875	8,987	1895	18,479	1915	94,159
1876	9,054	1896	19,718	1916	108,358
1877	8,669	1897	19,779	1917	135,009
1878	9,164	1898	22,058	1918	158,824
1879	9,259	1899	22,956	1919	240,377[a]
1880	9,573	1900	26,849	1920	299,875
1881	11,382	1901	28,617	1921	256,631
1882	12,673	1902	32,626	1922	240,428
1883	13,951	1903	38,436	1923	256,368
1884	14,471	1904	42,169	1924	241,359
1885	13,615	1905	45,450	1925	238,641
1886	13,725	1906	49,394	1926	254,689
1887	15,776	1907	58,719		
1888	17,443	1908	60,377		
1889	17,684	1909	63,217		
1890	18,700	1910	67,168		

Sources and methods:
1907–26: *Canada Year Book*, 1926.
1875–1906: "Annual Reports of the Department of Railways and Canals," various reports *Sessional Papers of Canada.*
1874–71: Poor's Manual—annual reports of expenses for the Grand Trunk Railway. See text for methods.

[a]Beginning with June 30, 1871, the estimates are for fiscal years until 1918. Beginning in 1919 estimates are for calendar years ending December 31.

cussion will be divided into two parts, since the method of estimating interest payments (i.e., the bond or fixed-income portion) differs substantially from that used to calculate dividend payments.

Interest Income Payments

Interest payments by Canadian railways are available from 1919 to 1926 and are recorded annually in the Dominion Bureau of Statistics publication, *Railway Statistics of Canada* from 1919 to 1921 and in *Statistics of Steam Railways of Canada: 1922 to 1926:* indeed, up to the present. Funded and floating debt payments from 1911 to 1915 can be found in the "Annual Reports of the Department of Railways and Canals," which appear in the *Sessional Papers of Canada*. The only problem with this series is that interest payments of the Canadian Pacific Railway's 4% debenture stock were excluded until 1919. However, with the introduction of the new publication they were properly recorded as part of interest payments. An adjustment for this omission was made for these years.

Before 1911 the "Annual Reports" did not calculate total interest payments (unlike the United States publications, which show total interest and dividend payments back to at least 1890). However, on very large spread sheets inserted in each "Annual Report" is shown the amount outstanding of the "Bonded" and "Floating" debt for each railroad in Canada, plus the coupon interest rate payable for the majority of these issues. This type of individual security information is available annually from 1875 to 1911.

The solution to our problem of obtaining total interest payments, then, seemed quite simple. We would multiply the outstanding security value by its own coupon rate and total across all railways. To check the validity of this approach, we calculated total interest payments using this method for 1911—a year for which we had the official total. Unfortunately the two estimates were very different. Our "calculated" total was much larger than the official estimate. In fact the difference was close to $2.5 million. On checking each of the 72 railways included in the estimation, we found that for many the difference between the calculated method and the official figures was small, and quite often the two estimates were identical. At least this was the case for the small railways. The problem centered on the large railways, such as the CPR and the Grand Trunk Railway. For example, for the CPR calculated interest exceeded the official estimate by $5.3 million. The excess of calculated over official for the Grand Trunk was about $2.0 million.

To eliminate this discrepancy, the estimation procedure was divided into two parts. For the small railways we calculated individual annual interest payments using the method described above. To this total we added interest payments for the Canadian Pacific Railway, the Grand

Trunk, the Canadian Northern, and the Canadian Northern Quebec Railway. Estimates of interest payments for these larger railways are recorded annually in Poor's *Manual of Railroads* back to the beginning of operation of each. Poor's proved to be an invaluable source of information on these larger Canadian railways. The manual recorded operating data for any Canadian railway which sought to issue securities in the United States, and did so annually from the middle of the nineteenth century. The information provided was quite extensive. It included such statistics as operating revenue and expenses, interest and dividend payments, capitalization by type of security, a history of the organization of each railway, and so on.

A number of the smaller railways did not report the coupon rate for their fixed interest securities. To solve this problem we calculated for each year an average interest rate from the lines which did report coupon rates. Table 15.3 sets out these average rates for each year from 1875 to 1916 for bonded and floating debt. They are unweighted

Table 15.3 **Average Interest Rates on Bonded and Floating Debt Paid by Canadian Railways, Annually, 1875–1916 (%)**

Year (1)	Bonded Debt (2)	Floating Debt (3)	Year (4)	Bonded Debt (5)	Floating Debt (6)
1875	6.42	7.06	1896	5.27	5.93
1876	6.42	6.25	1897	5.20	5.37
1877	6.28	7.20	1898	5.27	4.01
1878	6.28	7.06	1899	5.14	5.54
1879	6.13	7.06	1900	5.16	4.81
1880	6.20	7.27	1901	5.12	4.90
1881	5.92	6.50	1902	5.13	4.49
1882	6.06	6.29	1903	5.07	3.62
1883	5.63	6.70	1904	5.00	3.87
1884	5.72	6.30	1905	5.02	4.04
1885	5.82	6.63	1906	n.a.[a]	n.a.
1886	5.84	6.66	1907	4.95	4.04
1887	5.89	6.75	1908	4.98	4.04
1888	5.83	6.94	1909	4.95	4.04
1889	5.58	6.85	1910	4.94	4.04
1890	5.49	6.94	1911	4.86	4.04
1891	5.51	6.49	1912	4.91	4.04
1892	5.49	6.36	1913	4.92	4.04
1893	5.42	6.26	1914	4.85	4.04
1894	5.42	5.84	1915	4.89	n.a.
1895	5.40	5.74	1916	4.90	n.a.

Source: Department of Railways and Canals, "Annual Reports," *Sessional Papers of Canada*, 1875–1916.

Note: Unweighted average of reported coupon interest rates.

[a]n.a. = not available.

averages, and the number of observations varies from year to year, hence the results in terms of absolute levels for any one year must be treated cautiously.

These nominal interest rates trace out an interesting pattern over our study period. They dropped sharply from 1875 to 1915. For bonded debt the rates fell by 22% from 1875–80 to 1910–15, that is, from 6.29% to 4.90%. The full implication of this drop is seen if we compare average interest rates to price trends in general. Table 15.4 sets out these changes. For the last third of the nineteenth century, according to these results, real interest rates rose. The quality of these two data series precludes any closer judgment on the trend in real interest rates, even though the percentage changes suggest that prices fell slightly more slowly than longer-term nominal interest rates. Real interest rates dropped, however, in the opening years of the twentieth century, largely because of a reversal in the trend of prices. This changing pattern, as we will see, conforms closely to the level of railway investment over this period.

Columns 3 and 6 of table 15.3 show interest rates for floating debt, representing the rate on short-term securities. Behavior of this series parallels, over the whole period, the trend in bond debt; that is, the nominal rate falls. However, for the last decades of the nineteenth century the short-term rate is greater than the long-term rate, while after 1900 the short-term rate is below the longer-term rate. Whether these apparently divergent results are a product of the way interest rate averages were obtained or whether they signal different market prices for the two types of securities is a problem that will have to be studied elsewhere.

Table 15.4 **Index Numbers of Interest Rates Paid by Canadian Railways and GNP Implicit Price Series, Selected Years 1875–1916**

	Annual Index for Years Shown of	
Period (1)	Annual Interest Rates (1900 = 100) (2)	Annual Prices (1900 = 100) (3)
	Period A	
1875–77	123.5	109.6
1898–1900	100.7	98.0
	Period B	
1900–1902	99.5	101.7
1914–16	94.6	139.7

Sources:
Col. 2 See table 15.3.
Col. 3 M. C. Urquhart, "New Estimates of Gross National Product, Canada, 1870–1926: Some Implications for Canadian Development," in this volume, table 2.9.

Total interest income payments for the railway sector are shown in table 15.5. As in the case of wage payments, the interest income estimates were extrapolated to 1871 using the interest expense recorded by the Grand Trunk Railway during these years.

Dividend Payments

Annual payments of dividends to shareholders in Canadian railways were not reported in the "Annual Reports" before 1911, as was the case for total interest payments. The sources of total dividend payments are the same over the period 1911–26 as those set out in the previous section.

Unfortunately, for the years before 1911 the "Annual Reports" did not carry any information on dividend payments. However, in 1911 the Department of Railways and Canals reported dividends paid by various Canadian railways (table 15.6). The CPR and the GTR, according to

Table 15.5 **Interest Payments Made by Canadian Railways, Annually, 1871–1926 (Thousands of Dollars)**

Year	Amount	Year	Amount	Year	Amount
1871	3,123	1891	11,819	1911	21,581
1872	3,546	1892	12,724	1912	23,213
1873	3,684	1893	13,408	1913	25,073
1874	4,084	1894	14,620	1914	26,960
1875	4,004	1895	15,369	1915	27,765
1876	4,039	1896	15,603	1916	24,020
1877	4,129	1897	16,017	1917	43,795
1878	4,531	1898	15,968	1918	46,900
1879	4,254	1899	16,055	1919	54,697[a]
1880	4,364	1900	16,326	1920	59,270
1881	4,490	1901	16,661	1921	74,750[b]
1882	6,083	1902	16,910	1922	78,378[b]
1883	4,644	1903	16,917	1923	54,666
1884	5,005	1904	17,933	1924	59,448
1885	8,766	1905	19,161	1925	60,498
1886	8,838	1906	19,672	1926	59,241
1887	9,405	1907	20,007		
1888	9,715	1908	20,969		
1889	10,296	1909	22,012		
1890	11,139	1910	23,095		

[a]See table 15.2, note a.

[b]The sudden increase in interest rate payments in 1921 and 1922 apparently is related to the amalgamation of several lines (i.e., Grand Trunk, Canadian Northern, etc.) into the government-owned railway, the Canadian National. In 1937, under the "Canadian National Railway Capital Revision Act" interest payments were adjusted downward beginning in 1923. Since these revised figures were the ones appearing in "Steam Railway Statistics," we used them here. The figures (in thousands of dollars) recorded annually were 1923, 84,444; 1925, 91,002; 1924, 89,761; and 1926, 90,415.

Table 15.6 **Dividends Paid by Canadian Railways for the Year Ending June 30, 1911 (Dollars)**

Railway	Amount
British Yukon	96,081
Canada Southern	450,000
Canadian Pacific Railway	26,413,556[a]
Grand Trunk Railway	3,586,103
Hereford Railway	32,000

Source: Annual Report of the Department of Railways and Canals, *Sessional Papers of Canada* (1912), 13:104.

[a]This figure does not agree with the dividend figure shown in table 15.7, since the one in table 15.6 includes the 4% Consolidated Debenture stock payments which, for purposes of the National Accounts, have been moved to "Interest Payments."

those records, accounted for approximately 98% of the total dividends paid by all Canadian railways in this year.

To obtain dividend payments, then, only two railroads were used—the CPR and the GTR. The sum of dividends paid by these two companies was divided by .98 to inflate this total to include the whole system. Two problems were encountered with the GTR estimates. First, over the period from 1875 to 1911, the GTR reported all of its financial data in pounds sterling. The exchange rate used to convert these figures to Canadian dollars was £1 = $4.86⅔—the rate set under the terms of the Uniform Exchange Act, Statutes of Canada, 1871. The second problem is the way the GTR actually reported or failed to report dividends. For the years from 1899 to 1903 the published records show that no dividends were declared. However, a close check of the "surplus" account shows that in fact they were paid. Hence dividend payments are included in our estimates for these years. Poor's *Manual of Railroads* reocrds the dividend data. We also used the "Annual Reports" of the CPR.

The results of these calculations are shown in table 15.7. A word is necessary about this series since it moves around so much, especially in the early years. We should expect greater fluctuations in a dividends series than in an interest rate series since the ability, and willingness, of a company to pay dividends depends on the profitability of the company in a given year and that company's dividend policy. If the decision has been made to pay dividends at about the same level each year (i.e., adding to or drawing down from surplus), then the payout pattern would be much less volatile.

It is difficult to discern whether the CPR or the GTR had any such policy. Certainly the GTR's payout was very volatile, as one can see from the behavior of the series in 1883 and 1884. In 1883 the company, after several years of declaring low dividends, declared one of almost

Table 15.7 **Dividends Declared by Canadian Railways Annually, 1871–1926 (Thousands of Dollars)**

Year	Amount	Year	Amount	Year	Amount
1871	100	1891	2,168	1911	24,989
1872	100	1892	2,200	1912	25,140
1873	100	1893	3,001	1913	27,333
1874	100	1894	1,920	1914	30,434
1875	100	1895	1,257	1915	32,341
1876	100	1896	2,231	1916	36,452
1877	100	1897	5,006	1917	30,145
1878	100	1898	4,944	1918	30,156
1879	100	1899	6,941	1919	30,157
1880	100	1900	6,954	1920	29,943
1881	100	1901	7,088	1921	30,157
1882	100	1902	7,516	1922	30,155
1883	2,985	1903	9,378	1923	30,356
1884	1,533	1904	9,318	1924	30,512
1885	100	1905	10,841	1925	30,410
1886	1,036	1906	12,198	1926	30,449
1887	1,872	1907	15,434		
1888	906	1908	14,443		
1889	2,101	1909	16,649		
1890	2,612	1910	18,563		

Sources and methods: See text.
[a]See table 15.2.

$3.0 million. This dropped by half the next year, and by 1885 there was only a token amount paid out. The large jump in 1883 and 1884 follows the acquisition of the Grand Trunk Western by the GTR on August 11, 1882. However, more work will have to be done both on the company's annual reports to shareholders and on the detailed reports submitted by the GTR to the Department of Railways and Canals before we will know why the Grand Trunk suddenly found that it could pay out such large amounts.

Another factor which needs to be examined is the way railways charged new capital items. Railways in Canada did not use depreciation accounting on their capital stock. Rather, they "expensed" such items as rail replacements, equipment renewals, and so on, against current revenue. Hence if the company chose to add an office building, or construct new bridges in one year, then this expenditure was charged against current revenue. The result was that net operating revenue (current receipts less current expenditures) dropped sharply and the amount available to pay for dividends declined or disappeared. For example, in 1898 the Grand Trunk built a new head office. The cost is listed at $900,000. This amount was charged against revenue earned in 1898. Such decisions will obviously distort dividend payment patterns.

15.2 Income and Investment, 1871–1926

The growth of the Canadian railway sector between 1871 and 1926 is set out in table 15.8. The estimates for income originating in this sector and for railway and telegraph capital investment are in current dollars.

Before we begin a discussion of this table, a word should be said about the link between estimates of labor and capital payments set out in the previous section and the total income figures shown in table 15.8. The latter is greater than the sum of wage and interest payments by two broad items: savings, and other fixed costs. Savings are defined as the difference between net corporate income and dividends paid out. Since information on net corporate income was not available before 1911, we used net operating revenue. This creates a slight upward bias in the recorded savings figure. In addition to savings, such items as taxes paid and income from renting equipment was included in the final figure. The final result for net income originating in the railway sector is shown in columns 1, 5, and 9 of table 15.8.

15.2.1 Income (Current Dollars)

During the first years of our study, Canadian railway income averaged about $10 million a year. By 1926 this annual income flow had increased to approximately $330 million. Even allowing for price changes, this is an impressive growth record. An additional perspective on this growth is provided in table 15.9, which sets out this expansion in terms of miles of track in operation. Between 1871 and 1926 Canada added 51,584 miles of railway track to its inventory, with 36,000 miles of this addition (or 70%) coming after 1900. The railway era for Canada is clearly a twentieth-century event, unlike the United States where the main building phase was over by the early 1890s.

The data show that within this 55-year span of time there were three periods of rapid expansion: 1871–76; 1880–84; and 1905–14. Each of these periods is associated with a particular aspect of Canadian development policy. At the time of Confederation there were two railway projects planned. One was to link the Maritime Provinces to Central Canada, and the other was to join British Columbia via a Canadian route to the rest of Canada.

A railway linking the Maritimes to Central Canada was begun in 1868 and completed in 1876. This line, known as the Intercolonial Railway (ICR), started in Truro, Nova Scotia, and ran westward terminating in Rivière du Loup. The Grand Trunk Railway ran eastward to this point. Given that the ICR was built over a fairly roundabout route (to keep it away from the United States border), private interests were unwilling to finance it; hence it was built as a government enterprise. The influ-

Table 15.8 **Income, Fixed Capital Formation and Investment/Income Ratio, in the Canadian Railway Sector, Annually, 1871–1926, in Current Dollars (Thousands of Dollars)**

Year	Income = O (Thousands of $) (1)	Gross Fixed Capital Formation = I (Millions of $) (2)	I/O (2) ÷ (1) (3)	Year	Income (4)	Gross Fixed Capital Formation (5)	I/O (6)	Year	Income (7)	Gross Fixed Capital Formation (8)	I/O (9)
1871	9,413	12.4	1.32	1895	32,540	6.6	0.20	1919[a]	279,644	95.1	0.34
1872	10,483	27.0	2.58	1896	34,986	7.4	0.21	1920	315,284	115.5	0.37
1873	11,322	29.3	2.59	1897	36,220	10.7	0.30	1921	287,821	100.0	0.35
1874	14,148	25.3	1.79	1898	42,207	18.6	0.44	1922	290,013	50.5	0.17
1875	11,606	24.1	2.08	1899	44,453	15.8	0.36	1923	295,723	102.9	0.35
1876	11,528	15.3	1.33	1900	49,986	18.7	0.37	1924	275,951	83.1	0.34
1877	11,030	8.7	0.79	1901	51,185	21.7	0.42	1925	296,740	52.2	0.18
1878	12,513	6.4	0.51	1902	58,898	24.3	0.41	1926	330,480	84.3	0.26
1879	12,008	8.7	0.72	1903	67,167	33.2	0.49				
1880	15,191	14.1	0.93	1904	68,056	37.6	0.55				
1881	17,992	18.3	1.02	1905	72,029	48.3	0.67				
1882	18,482	44.0	2.39	1906	84,764	63.4	0.75				
1883	21,848	57.5	2.63	1907	102,766	103.9	1.01				
1884	21,642	72.5	3.35	1908	101,132	103.0	1.02				
1885	20,997	33.8	1.61	1909	105,225	92.9	0.88				
1886	24,739	23.7	0.96	1910	122,946	109.5	0.89				
1887	26,222	23.4	0.89	1911	138,797	125.2	0.90				
1888	28,280	20.7	0.73	1912	166,636	157.0	0.94				
1889	28,318	22.1	0.78	1913	196,932	175.4	0.89				
1890	32,099	15.3	0.48	1914	174,153	126.6	0.73				
1891	32,119	14.2	0.44	1915	155,306	97.7	0.63				
1892	34,951	12.0	0.34	1916	194,024	49.0	0.25				
1893	35,006	12.9	0.36	1917	222,984	76.0	0.34				
1894	32,457	8.8	0.27	1918	216,510	86.5	0.40				

Sources and methods:
Col. 1: See text
Col. 2: Urquhart (in this vol.), table 2.2. Figures in millions of dollars.
Col. 3: Col. 2 divided by col. 1. Similarly for cols. 6 and 9.
[a]See table 15.2.

Table 15.9 **Miles of Railway Track in Operation, Canada, 1871–1926**

Year	Miles	Year	Miles	Year	Miles
1871	2,695	1891	13,838	1911	32,559
1872	2,899	1892	14,564	1912	34,629
1873	3,613	1893	15,005	1913	38,223
1874	3,832	1894	15,627	1914	40,605
1875	4,331	1895	15,977	1915	45,833
1876	4,804	1896	16,270	1916	48,319
1877	5,218	1897	16,550	1917	50,253
1878	5,782	1898	16,870	1918	50,640
1879	6,226	1899	17,250	1919	50,691
1880	6,858	1900	17,657	1920	51,174
1881	7,194	1901	18,140	1921	51,747
1882	7,331	1902	18,714	1922	51,860
1883	8,697	1903	18,988	1923	51,936
1884	9,577	1904	19,431	1924	52,692
1885	10,273	1905	20,487	1925	54,100
1886	10,773	1906	21,353	1926	54,279
1887	11,793	1907	27,611		
1888	12,184	1908	28,695		
1889	12,585	1909	30,330		
1890	13,151	1910	31,429		

Source: Urquhart and Buckley (1968), ser. S28 and S77, pp. 528 and 532, respectively.

ence of this construction is seen in column 2 of table 15.8. Railway investment rises sharply from $12.4 million a year in 1871 to $29.3 million in 1873, remaining in the $24.0 million range until the ICR is completed in 1876. Note as well the sharp rise (col. 3) in the incremental capital/output ratio during these years of construction. It appears that excess capacity was being built into the Canadian railway system. Traffic to support this expenditure came after the railway was built.

The same sequence was followed by the other great political railroad of the period, the Canadian Pacific Railway (CPR). After years of negotiations, and not without scandal, a line running westward across the Prairies was started in 1880 and completed in 1885. Unlike the ICR, this was a privately built railroad but with substantial government subsidies. The initial subsidy was to grant the builders $25 million in cash and provide them with 25 million acres of land. The size of this undertaking can be seen in column 2 of table 15.8. Gross investment rose from an average of $7.9 million a year in 1877–79 to a peak in 1884 of $72.5 million. Within a decade the volume of investment had soared 10-fold. This massive undertaking, as in the period of the construction of the ICR, increased the investment/output ratio threefold—to levels never experienced at any other time in our period. Again the CPR was a railway built ahead of demand, although the sharp drop in this ratio

toward the end of the 1880s and into the 1890s suggests that demand was not long in coming. By the 1890s, then, Canada was linked from the Pacific to the Atlantic by an all-Canadian railway route.

The third and final stage of rapid railway extension spanned roughly the first decade and a half of this century, peaking between 1905 and the beginning of World War I. These were the years of western settlement when the frontier pushed westward beyond Manitoba into Saskatchewan and Alberta (often called the "wheat boom" period). During these years, in addition to extensive branch lines being built, two additional transcontinental lines were constructed: the Canadian Northern, started in 1903 and completed in 1915, and the Grand Trunk Pacific, started in 1903, reaching completion at the outbreak of World War I.

The opening decades of the twentieth century were years of mass railroad building. As table 15.9 shows, the number of miles of railroad in operation increased by 26,800 between 1903 and 1915, an amount 10 times greater than the size of the whole system in 1871. The investment data reflect this rapid expansion. As column 5 of table 15.8 shows, the annual flow of gross fixed capital formation in railways, having reached a low of $6.6 million in 1895, increased to an annual level of $175.4 million in 1913 and averaged better than $120 million a year from 1907 to 1915. One must question whether, at the start of this railway investment boom, net investment was even positive. Between 1894 and 1895, for example, only 350 miles of track were brought into operation (see table 15.9). Prior to the boom, then, expansion of the railway system had virtually come to a halt. Expectations about economic returns to be made in the Canadian west after 1895 obviously proved to be a powerful magnet. CPR common stock, for example, rose from $47.50 a share in 1895 to $153.50 (Innis 1971, p. 284), in 1905—a threefold increase!

One interesting difference between this period of railway expansion and that which characterized the ICR and CPR periods is the lower absolute ratio of investment to income. Although the absolute change was quite spectacular—from .20 in 1895 to 1.02 in 1908 (table 15.8)—the "capping" at a level one-third of that observed in 1885 suggests that traffic generated by these new systems filled in very quickly behind completion of the lines. A steady state of about .30 was reached midway through the First World War and this held until the mid-1920s. This point will be studied more closely in the last section where real capital stock estimates are discussed.

The pattern of income growth, as one might suspect, is somewhat different from that of investment. The reason for this is related to the incentives for building these railways in the first place. In Canada, even more than in the United States, the majority of these new lines were really development railways, that is, railways sent into wilderness re-

gions to open them for settlement. Transforming new land into productive farms takes time. Land must be broken, and "land-breaking" initial crops sown before crops for market can be planted. All of this takes time, but in the end it is moving the cash crop to market which generates traffic, and hence income growth in the railway sector.

One can see this lagged pattern quite clearly in table 15.8. Income growth from 1873 to 1880 was relatively flat, but from the latter date to 1886 it doubled. This increase was partly the reflection of better times, but it must also be due to business created by these new facilities. Even though the system was expanding slowly after 1885, nominal income grew substantially, that is, from about $28.0 million in the late 1890s to $50.0 million by 1900. As we saw earlier (table 15.4) prices actually fell during this period, so this gives a lower bound on nominal expansion. Finally, in the "wheat boom" period (1900–1914), much of the expansion in income occurred after the main phase of railway building was completed, that is, during and after World War I.

15.2.2 Physical Output

To complement the previous series (table 15.8) on nominal income growth in the railway sector, estimates of real output measured in physical terms—ton miles and passenger miles—have been derived for the period under review. These are shown in table 15.10. Official estimates of ton miles begin in 1907 and for passenger miles in 1910. Hence for the years before these dates, physical output figures had to be constructed from alternative data series.

The method used was that adopted by Fishlow (1966). This involves dividing freight and passenger receipts by the average charge for these services. Fortunately, receipts for the whole system are available back to 1875. For the years 1871–74 the ton and passenger miles derived for 1875 were extrapolated back on the trend of total expenses for the Grand Trunk Railway.

The main problem with this procedure lies in choosing the appropriate *average charges*. Freight rates proved to be more difficult than passenger tariffs. The former vary substantially on the basis of the type of good carried, that is, class of freight, and the distance goods are transported. Generally the average freight rate falls as one moves from higher-value but smaller items to lower-value, bulky goods. For example, boots and shoes are included in Class 1, while flour and lumber are included in the lowest class. Rates also varied by distance hauled, among regions, and among trunk carriers. To obtain an average freight rate we weighted the observed rates by regional mileage, the composition of freight carried, and freight shipped along the various trunks. We were fortunate in getting a basic source of freight rates from a publication submitted to the Royal Commission on Dominion-Provincial

Table 15.10 **Ton Miles, Passenger Miles, and the Weighted Total for Canadian Railways, Annually, 1871–1926 (All Figures in Millions)**

Year	Ton Miles (1)	Passenger Miles (2)	Weighted Total (1) + (2) (3)	Year	Ton Miles (4)	Passenger Miles (5)	Weighted Total (4) + (5) (6)	Year	Ton Miles (7)	Passenger Miles (8)	Weighted Total (7) + (8) (9)
1871[a]	269	200	243	1891	2,184	583	1,615	1911	16,048	2,606	11,827
1872[a]	307	228	278	1892	2,556	604	1,900	1912	19,558	2,910	14,547
1873[a]	317	236	287	1893	2,745	629	2,015	1913	23,033	3,266	17,222
1874[a]	352	261	318	1894	2,726	644	1,954	1914	22,063	3,089	16,333
1875	345	256	312	1895	2,955	566	2,133	1915	17,661	2,484	12,971
1876	360	254	321	1896	3,236	598	2,360	1916	28,195	2,727	21,701
1877	353	258	319	1897	3,529	619	2,569	1917	31,187	3,150	23,783
1878	438	255	370	1898	4,053	710	2,977	1918	31,029	3,190	23,791
1879	447	258	377	1899	4,221	741	3,114	1919[b]	27,337	3,366	20,313
1880	596	283	490	1900	5,072	885	3,728	1920	31,894	3,522	24,432
1881	778	329	631	1901	5,185	946	3,807	1921	26,662	2,961	20,476
1882	771	401	629	1902	5,999	1,130	4,421	1922	30,368	2,814	23,700
1883	969	422	768	1903	7,009	1,275	5,231	1923	34,068	3,076	26,289
1884	988	448	786	1904	7,609	1,416	5,609	1924	30,514	2,872	23,438
1885	998	422	783	1905	8,024	1,524	5,905	1925	31,965	2,911	24,818
1886	1,115	410	864	1906	9,580	1,757	7,092	1926	34,153	2,999	26,801
1887	1,366	475	1,049	1907	11,688	2,050	8,633				
1888	1,554	510	1,188	1908	12,962	2,082	9,426				
1889	1,667	530	1,260	1909	13,161	2,033	9,622				
1890	1,995	549	1,502	1910	15,712	2,467	11,619				

Sources and methods: See text.

[a]Cols. 1 and 2 for the years 1871–74 were obtained by extrapolating backward on trend of total expenses for the Grand Trunk Railway.

[b]See table 15.2

Relations (Ottawa, 1939), entitled "Railway Freight Rates in Canada" (prepared by RAC Henry and Associates). In addition, the CPR "Annual Reports" carried details, annually, on average freight and passenger rates. Passenger rates did not show the same variation as did freight rates, although there were first-class and immigrant rates.

The final problem faced in calculating an average freight rate was to determine the average haulage distance. After plotting rates per mile against distance, it became clear that the average rate flattened out after 125 miles. Hence our estimates, by class and type of carrier (regional vs. national), were based on rates for 125 miles. Although by 1911 the average freight haul had increased from earlier years, it seemed that for the whole period the 125-mile figure could be used without seriously biasing the final results.

Finally, to combine these two series the weights used were the distribution of total earnings between freight and passenger service. These weights (i.e., shares of passenger and freight revenue) were calculated for each year from 1875 to 1926 and were used to obtain the total real output shown in columns 3, 6, and 9 of table 15.10.

The actual averages for freight and passenger rates are shown in the Appendix. Although any given rate should be treated with caution, the trends in passenger and freight charges per mile reflect, one suspects, the basic changes in the system over these decades. It is worth noting how rapidly average service charges for carrying freight dropped between 1875 and 1900 and again between the turn of the century and World War I. The rise in freight rates after the end of hostilities is an interesting reversal in trend. As far as one can tell, it reflected the awakening of the government to the fact that rates had not been allowed to rise in line with labor and other input costs caused by war inflation (more on this point later).

If we take the trends in the physical output series (table 15.10) for the total period, some interesting observations about the evolution of the system emerge. First, the volume of freight traffic being handled by the turn of the century was vastly greater than in 1871. This reinforces again the earlier contention that at the time of Confederation Canada had barely entered the railway era, but that with the completion of the ICR (1876) and the CPR (1885), plus the building of new branch lines, internal and external flows of goods (and people) were greatly enhanced. Second, note that although passenger traffic grew substantially (i.e., from 200 million to 741 million passenger miles from 1871 to 1900), freight volume growth was clearly the "leading" component, growing from 269 million to 5,072 million ton miles over these three decades. If we relate these volume differences to receipts, with freight rates falling relative to passenger rates, the distribution of earnings between the two services remained fairly stable. For example, in 1875

freight earnings accounted for 63% of total earnings, while in 1900 they accounted for 67%.

Twentieth-century expansion, although not as spectacular in rate-of-growth terms, nevertheless showed that we are dealing by the 1920s with a mature railway system. At the beginning of World War I ton miles of freight carried had increased fourfold from 1900, while between 1914 and 1926 the increase was about 50%. Hence over the whole period there are three distinct phases of growth. From the 1870s to the mid-1890s the annual compound rate of growth of freight traffic was about 10% per year. From 1900 to 1914, freight traffic grew at 11% per year, while from 1914 to 1926 the rate dropped to 3.6%. If we look back over the history of the period, it is obvious that much of this growth was associated with the geographic expansion of the system: the movement into the west and the linking of the Central Provinces with the Maritimes. For the years from 1914 to 1926 this rapid geographic expansion slowed, and so did total growth. In addition, road and canal transportation modes began to offer competition for freight business formerly held almost exclusively by the railways.[4]

15.3 Productivity Change

The written history of the role of railways in Canadian development is very different from that in the United States. Railways were central to much of the American growth experience in the nineteenth century. Schumpeter claimed that the economic history of the United States in the last half of the nineteenth century might well be written solely in terms of the railroad sector.[5] Indeed, Fishlow and Fogel introduced to economic history the concept of social savings in connection with their investigation into whether railroads were really as indispensable to United States economic growth as suggested by earlier economic historians.[6]

Railways in the context of this country's development did not fare so well in the hands of earlier Canadian economic historians. Most students read the history of Canadian railways as a series of scandals, for example, that surrounding the building of the CPR, especially in the final level of subsidy given to the contractors. Or the scandal which arose in connection with the building of the Canadian Northern Railway and the suspect role of the line's promoters, Mackenzie and Mann. Finally, the eventual takeover of all railways, except the CPR, in 1919 was clear testimony to two basic features of Canadian life. First, that the country from time to time was prone to excessive speculation, especially at the turn of the century; that is, the illusion that good times apparently always lead to better times. The main effect of this speculation during the wheat boom was the building of two new transcon-

tinental railroads (in addition to the CPR) between 1903 and 1914. Again speculative investment got out of control, and the system was overbuilt, to the detriment of the economy.[7] The second contention is that some of these larger railways, like the Grand Trunk, experienced "irresponsible management" and hence made significant construction (and operations?) errors. This is hardly the stuff of which great myths are built.

In both countries recent research has modified such extreme positions.[8] Nevertheless, for Canada at least, the simple exercise of examining the growth and efficiency of the railway system has not yet been undertaken (Fishlow 1966). Before we can begin to study patterns of performance, information on the growth of the principal inputs—labor, capital, and fuel—must be acquired.

15.3.1 Growth of Labor Input

Data on the size of the railway labor force were first published in 1907, as in the case of total wages and salaries. Thus some method of estimating the growth of this input between 1871 and 1907 had to be found. Three possible approaches were available. One approach was that used by Fishlow (1965, app. C). With this method, total employment of railway workers is divided by total operating revenue to obtain an average relationship between these two magnitudes. If observation proves this to be a fairly stable relationship, then it can be used to calculate employment for earlier years, since we have gross revenue running back to 1871. Another method involves examining the relationship between employment and the number of miles of track in operation. This approach links the growth of the labor force used in the railroads to the growth of one of the principal pieces of fixed capital. Given the nature of technological innovation in this industry during the nineteenth century, estimates based on such a relationship probably are not out of line with what was indeed happening. Finally, the simplest method is to use decennial census estimates of the number of employees recorded for this industry.

There are two problems with using census estimates of employment for the railway sector. First, as in the case of wages and salaries referred to earlier, census authorities chose to assign some railway workers (such as those engaged in car repair and rebuilding) to the manufacturing sector rather than to the railway sector. Second, and more important, is the change in the method used to record workers in the census before 1901. Beginning in 1901 information was collected both on the number of gainfully occupied and on the number of wage earners attached to a particular industry. The latter total was collected from the individual industries surveyed, while the former was collected as part of the information obtained from individual households. For the censuses before 1901, only information on the gainfully occupied was

obtained. The census takers were not interested in estimating the size of the Canadian labor force but were more concerned with the general socioeconomic characteristics of the population. As a result, where an individual worked for a number of employers in the census year, he or she was asked to name a main employer. This approach may have been adequate for workers with some skill, but for laborers who worked wherever they could find employment it meant listing them under the title "Miscellaneous Unskilled Labour." Many individuals who worked for the railroads fell into this category. For example, in a country like Canada where clearing the tracks of snow was a big job, a large number of workers who were actually on the payroll of the railway companies were not assigned to this sector. It is impossible to sort out how many of the unspecified laborers actually worked in this sector at any one census date. Indeed it is even impossible to estimate the trend. Since this was undoubtedly a large component, the census records could not be used even when the workers engaged in manufacturing activity were added to the base number of those listed as gainfully occupied workers in "Steam Railways."

With some doubt about whether the census approach would render the growth of labor input accurately, we were left with the Fishlow method and the ratio of workers to miles of track in operation. The Fishlow approach was tried,[9] but unfortunately for our case it gave misleading results. The problem which emerged was with the influence of price changes on the ratio during the turbulent years 1907–26. This period covered the last years of frontier settlement, the First World War, the inflation that accompanied it, and finally the postwar adjustment, not only to the economy, but also to the railroad sector which, with the exception of the CPR, was taken over by the government and amalgamated to form the Canadian National Railway system. These were not good years in which to establish a ratio of revenue to employment that could be used to project labor growth back from 1907 to 1871.

The method adopted, then, was to divide employment in the railroad sector by track mileage in operation. One possible benefit of this approach was that it put in the ratio two real factors, rather than mixing real (employment) with nominal elements (revenue). Further, the ratio of employment to track mileage proved to be a remarkably stable ratio over the years for which we had evidence on both figures, that is, after 1907. The ratio averaged about four employees per mile of track operated. The only deviation from this average occurred during periods of extensive railroad construction, when it rose to about 5.5 employees per mile of track. This is what one would expect, since the railroads would take on extra help during the startup of new lines. Accommodation for this variation was made by incorporating the higher ratio in

our calculation of labor input during known periods of railroad expansion (e.g. during the building of the CPR). The results are shown in table 15.11.

15.3.2 Growth in Real Capital Stock

Estimates of real capital stock were never collected by the government. The only data available are on the book value of various railroad lines, investment figures, and the physical stock of certain assets. This is not a unique problem. Fishlow (1966) faced the same difficulty.

The method used to estimate real net capital stock for the Canadian railroad sector differs from that used by Fishlow. Here we adopted the "perpetual inventory" method. The "perpetual inventory" approach requires three basic pieces of information: current dollar gross fixed capital formation estimates, capital goods price indices, and data on the "average economic life" of capital goods. The sources of each of these series are set out below.

Capital Formation Series

We are fortunate to have two extant series on gross capital formation for the railroad industry. One series was completed in 1962 by Ken Buckley (1962); the other, by Statistics Canada (1978), as basic input

Table 15.11 **Employment in the Canadian Railway Sector, Annually, 1875–1926 (Thousands)**

Year	Employment	Year	Employment	Year	Employment
1875	21.62	1893	67.52	1911	141.22
1876	23.48	1894	62.51	1912	155.90
1877	26.02	1895	63.91	1913	178.65
1878	28.02	1896	65.08	1914	159.14
1879	30.86	1897	66.20	1915	124.14
1880	32.32	1898	67.48	1916	144.77
1881	36.66	1899	69.00	1917	146.18
1882	52.18	1900	75.04	1918	143.49
1883	58.06	1901	81.63	1919	158.78
1884	51.37	1902	93.57	1920	185.18
1885	48.48	1903	94.94	1921	167.63
1886	53.96	1904	102.01	1922	165.64
1887	60.92	1905	112.68	1923	178.05
1888	60.82	1906	117.44	1924	169.97
1889	63.14	1907	124.01	1925	166.03
1890	65.76	1908	106.44	1926	174.27
1891	69.19	1909	125.11		
1892	72.84	1910	123.77		

Sources and methods: See text; 1875–1918: "Railway Statistics," Annual Reports of the Department of Railway and Canals in the *Sessional Papers of Canada* until 1918; 1919–26: "Railway Statistics," Dominion Bureau of Statistics.

to its publication *Fixed Capital Flows and Stocks*. Both series are carefully constructed, and both are defined as covering railroad transport, including telegraph and cable systems. This study uses both series—Buckley for the earlier years, and the Statistics Canada figures for the more recent period. Buckley's estimates have the added advantage of beginning in 1850. Statistics Canada's figures start in 1871.

Price Indices

The availability of the Statistics Canada series entitled, "Price Indices for Capital Expenditure" allowed us to obtain real capital formation estimates back to 1871. These indices cover building and engineering construction as well as prices for machinery and equipment. To push the series back to 1850, a price index of "Iron and Its Products" and a "General Wholesale Price Index" were used."[10]

Average Economic Life

The ground rules on determining "average economic life" of railroad assets are very shaky. It was decided, therefore, that the service life estimates used by Hood and Scott (1957) were probably the most suitable. They estimated an average service life for all structures (not just railroad structures) at 50 years and for all equipment at 28 years. Ulmer (1960) found tht railroad structures accounted for 74% of total fixed reproducible assets in this industry, while machinery and equipment accounted for the other 26%. Hence average service life was calculated as follows:

$$50\ (.74) + 28\ (.26) = 45 \text{ years.}$$

Straight-line depreciation was assumed over the 45-year average service life of structures and equipment. The final estimates of net real capital stock are shown in table 15.12.

Unfortunately there are not extant alternative series against which to check our results. As a partial substitute, data were collected on the growth of physical stock in the Canadian railroad sector from 1870 to 1930. To test whether the real net capital stock provides a fair representation of the growth of this input, annual growth rates for several series (such as miles of rail in operation, number of engines in use, etc.) were collected to provide a rough comparison against which to judge our new estimates. These comparisons are shown in table 15.13. The unweighted growth rates of various physical assets shown in column 5 exhibit a very lose relationship to the growth of our estimates of real net capital stock. This is at least encouraging. During the critical period of railroad expansion, 1900–1915, 5-year average growth estimates were calculated (table 15.13, panel B). Again the correspondence is reasonably close and leads one to believe that the "perpetual in-

Table 15.12 **Real Net Capital Stock in the Canadian Railroad Sector, Annually, 1875–1926 (Millions of Dollars)**

Year	Real Capital Stock	Year	Real Capital Stock	Year	Real Capital Stock
1875	141.4	1892	448.3	1909	1,005.7
1876	154.9	1893	453.6	1910	1,133.2
1877	166.4	1894	454.4	1911	1,279.6
1878	176.3	1895	450.8	1912	1,466.7
1879	185.3	1896	450.1	1913	1,664.2
1880	191.6	1897	451.2	1914	1,792.0
1881	201.5	1898	465.7	1915	1,855.1
1882	230.6	1899	471.7	1916	1,837.3
1883	267.2	1900	478.7	1917	1,818.7
1884	309.1	1901	488.7	1918	1,801.8
1885	342.7	1902	500.6	1919	1,789.4
1886	363.2	1903	528.1	1920	1,779.8
1887	378.8	1904	560.6	1921	1,776.6
1888	393.8	1905	608.1	1922	1,740.3
1889	415.1	1906	670.1	1923	1,740.6
1890	431.0	1907	789.4	1924	1,729.8
1891	444.8	1908	901.3	1925	1,696.3

Sources and methods: See text.

Table 15.13 **Annual Growth Rates of Rails, Engines, Passenger, and Freight Cars and in the Index of Real Net Capital Stock (%)**

Years	Rails (1)	Engines (2)	Passenger Cars (3)	Freight Cars (4)	Unweighted Average Cols. 1–4 (5)	Index of Net Capital Stock (1910 = 100) (6)
			Panel A			
1875–1900	5.38	3.43	4.25	4.76	4.5	5.00
1900–1910	5.84	5.98	18.90	6.94	9.4	8.77
1910–20	5.00	3.99	4.26	6.53	4.9	4.62
1920–30	1.01	−1.00	−1.14	−0.35	—	1.50
			Panel B			
1900–1905	2.94	4.95	0.40	5.79	3.5	4.90
1905–10	8.82	7.02	14.34	8.09	9.6	13.26
1910–15	7.84	6.10	7.93	11.24	8.3	10.14

Source: Cols. 1–4: Urquhart and Buckley (1968), pp. 528–32. col. 6: see table 15.12.

ventory" method (using the two series on capital formation) provides a good approximation to the long-term growth of railroad net real capital stock. Note that the rapid growth in passenger cars from 1905 to 1910 was followed in the next quinquennium by a a rapid growth in freight cars. The passenger car spurt was in response to accelerated immigra-

tion, while the freight car growth was in response to additions to output created by the influx of new settlers.

15.3.3 Growth of Fuel

Since the conversion of fuel into mechanical power is central to the operation of railroads, it was treated as a separate input. Table 15.14 sets out the number of BTUs consumed. Again from 1907 to 1926, the "Annual Reports" record tons of fuel consumed, in coal and coal equivalents. For the years prior to 1907 the only record of fuel consumed was that reported by the Intercolonial Railroad, a government railroad that reported separately on its annual operations. The Intercolonial listed fuel used annually over the full period plus the number of engine miles run by its locomotives during a given year. The number of engine miles run was also available for the entire railway system. Thus the tonnage used on the Intercolonial was scaled up to give a figure for the entire system, using the ratio of engine miles for the system to engine miles run on the Intercolonial. This ratio was remarkably stable, at about 10:1 over the period before 1907.

To compare Canada's consumption of fuel with the United States, I derived the figures shown in the unnumbered table below. These show pounds of coal and coal equivalents consumed per locomotive mile.

Table 15.14 **Fuel Consumed in the Canadian Railroad Sector, Annually, 1875–1926 (Millions of BTUs)**

Year	Fuel	Year	Fuel	Year	Fuel
1875	5.7	1892	20.7	1909	78.9
1876	6.1	1893	21.0	1910	72.2
1877	6.3	1894	21.0	1911	78.5
1878	6.8	1895	18.9	1912	89.9
1879	7.2	1896	20.4	1913	106.9
1880	7.3	1897	19.2	1914	98.7
1881	9.7	1898	20.8	1915	79.7
1882	9.6	1899	24.3	1916	103.8
1883	14.2	1900	26.3	1917	116.9
1884	11.1	1901	27.1	1918	117.4
1885	12.2	1902	29.9	1919	111.8
1886	12.3	1903	34.9	1920	124.0
1887	15.3	1904	39.1	1921	103.8
1888	15.3	1905	42.6	1922	106.9
1889	15.8	1906	47.7	1923	117.9
1890	17.2	1907	64.7	1924	107.5
1891	21.7	1908	68.9	1925	105.4
				1926	111.3

Sources and methods: See text.

Canada		United States (Fishlow)	
1880	62	1880	65
1890	80	1890	80
1900	76	1900	100
1907	125	—	—
1910	132	1910	150
1920	152	—	—

These figures support our estimation technique, since they indicate that both countries were experiencing about the same trend in fuel consumed per locomotive mile. Increased consumption is mainly due to the shift to heavier engines over time.

15.3.4 Measures of Partial and Total Factor Productivity

Two measures of productivity change are used in assessing the performance of the railroad sector, partial and total factor productivity. These are shown in panel B of table 15.15. The ratios are derived from the indices on output and input recorded in panel A. A weighted sum of inputs is shown in line 5. The weights used for the labor, capital, and fuel are .55, .35, and .10, respectively. Fishlow used these shares

Table 15.15 **Index of Total Output, Inputs, Partial and Total Factor Productivity for the Canadian Railroad Sector, 1875–1920 (1910 = 100.00)**

	1875 (1)	1880 (2)	1890 (3)	1900 (4)	1910 (5)	1920 (6)
			A. Total Output and Inputs			
1. Real output (O)	3.59	5.33	14.80	33.29	100.00	185.90
2. Labor (L)	17.48	26.15	53.14	60.62	100.00	125.37
3. Capital (K)	12.47	16.91	38.03	42.24	100.00	163.22
4. Fuel (F)	7.89	10.11	23.82	36.43	100.00	171.75
5. Total inputs	14.35	20.41	43.62	50.77	100.00	140.00
			B. Partial and Total Factor Productivity			
6. O/L	20.56	20.40	27.85	54.91	100.00	148.28
7. O/K	28.80	31.55	38.91	78.81	100.00	118.36
8. O/M	45.52	52.76	62.12	91.38	100.00	108.24
9. TFP	25.05	26.13	33.92	65.57	100.00	132.79

Sources: See tables 15.10, 15.11, 15.12, and 15.14.

Note:

Line 5: Weights for labor, capital, and fuel are .55, .35, and .10, respectively.

Line 6: Line 1 divided by line 2.

Line 7: Line 1 divided by line 3.

Line 8: Line 1 divided by line 4.

Line 9: Line 1 divided by line 5.

[a]TFP = total factor productivity.

in his study of United States railroads (1966, p. 626). A check on factor share costs for Canadian railroads in 1910, the same year used by Fishlow to obtain his shares, reveals an almost identical share distribution and since the cost share data appear more complete for the American case, the United States ratios were adopted.

Partial Productivity

Per worker productivity (line 6) shows the most rapid advance of the three ratios. Its compound annual growth from 1875 to 1920 was 4.5%, while for capital the compound annual growth rate was 3.2%, and for fuel, the poorest performer, it was 1.9%. This rapid growth in labor productivity was not unrelated to the growth of capital, which exceeded the growth of labor; that is, 5.9 vs. 4.5, respectively. With a rise in the K/L ratio, it is not surprising that labor productivity performed as it did over this period.

This advance in labor productivity, however, was not even. In the decades preceding the opening of the West (i.e., 1875–1900), labor productivity advanced at the annual rate of 4.0%, while for the frontier period it grew at 5.1%, or a full 25% faster. The reasons this occurred are complex, but differential rates of growth of labor and capital between the two periods tell part of the story. Between 1875 and 1900, labor grew at 5.1% and capital growth was virtually identical. After 1900 the rates diverged sharply. Labor growth slowed to 3.7% while capital growth grew at 7.0%, or almost double that of labor. It is little wonder that capital productivity fell behind that of labor after the turn of the century. The geographic expansion of the system after 1900 not only brought massive changes to the size of the system but clearly changed the relationship between capital and labor, raising the capital/labor ratio sharply.

Railroad building is a capital intensive and expensive activity. One would be surprised, then, if excess capacity were not built into the system initially. The Canadian system apparently is no exception to this rule, especially before 1800. The capital/output ratio (real capital stock divided by real output was about 14.1 in 1875 (compared to a United States ratio of 10.3). By 1900 the ratio had fallen to 5.2, and it continued to fall as we entered the twentieth century. Although we cannot say by how much, part of the observed growth in worker productivity must have come from these sharply increased capital utilization rates. These observations reenforce the points made early in the discussion on investment/output ratios.

Total Factor Productivity

The measure of total factor productivity shown in line 9 of table 15.15 was derived by dividing the real output index by an index of weighted inputs (capital, labor, and fuel). It is simply the difference between the

growth of output and weighted inputs. This residual measures the contribution of the growth in output not accounted for by measured inputs. It captures the influence of technological change, economies of scale, organization of business, and the effect of human capital improvements on productivity. The measure of total factor productivity shown here should be taken only as a first approximation. I hope that other writers will refine the estimate.

Between 1875 and 1920 total factor productivity, as measured in table 15.15, grew at an annual rate of 5.8%. The annual rate varied very little between our two periods, that is, 3.9% before 1900 and 3.6% between 1900 and 1920. In terms of the contribution of total factor productivity to total growth in real output, the story is quite different. Between 1875 and 1900 the residual accounted for 56% of output growth, while for the decades after 1900 it accounted for only 42%. This result is quite different from that for the economy as a whole. In calculating TFP for the Canadian economy, Lithwick (1967, p. 53) found that it grew at 0.75% a year between 1891 and 1910, rising to 1.2% between 1910 and 1926. The residual's contribution to the growth of national output was only 22% in the first period, rising to 47% in the second. Apparently technological change was playing a larger role in the total growth of the railroad sector than it was for the economy as a whole.

Fishlow (1966) also found that growth of TFP was high in the United States railroad sector over his period of study. In examining several factors which might have increased the quality of the capital input (such as the introduction of air brakes, the adoption of automatic couplers, the effects of building on a larger scale, and greater utilization), Fishlow (1966) came to the conclusion that the most important factor was apparently the substitution of steel for iron rails. Steel rails meant the railroads could run larger and heavier trains, hence saving on capital and labor inputs.

We have little information at this stage of our inquiry on the rate of adoption of such items as air brakes, automatic couplers, and so on, but information is available on the rate of adoption, in Canada, of steel rails. The ratios in table 15.16 indicate that Canada was ahead in the adoption of steel rails from 1875 to 1890. The rate of adoption is really quite amazing, given that the first large-scale adoption of steel rails was on the Pennsylvania Railroad system in the early 1860s. Within 2 decades, then, half of all rails used in Canada were steel. The use of steel rails, it is to be remembered, only provides an opportunity to use heavier equipment. It will be interesting to see whether Canadian companies actually exploited this potential advantage. The observation of an earlier adoption of steel rails is given only as a place to begin studying the factors which led to the high productivity gains in this sector between 1875 and the early 1920s.

15.16 Percentage of Steel Rails to Total Rails, Canada and the United States 1875–1900

Year	Canada[a]	United States[b]
1875	43	—
1880	57	30
1890	95	80
1900	100	100

[a]*Historical Statistics of Canada*, p. 528.
[b]Fishlow (1966), p. 635.

Table 15.17 Productivity Comparisons for Canadian and American Railroads 1880–1910

Year	O/L (1)	O/K (2)	O/F (3)	TFP (4)
1880	80.5	107.8	135.7	95.2
1890	54.8	72.5	111.1	66.2
1900	54.6	63.7	103.7	62.1
1910	94.1	63.3	140.9	87.0

Sources and methods: The ratios were determined using the following relationships:

$$A_2/A_1 = \frac{Q_2/L_2}{Q_1/L_1}^{S_L} \quad \frac{Q_2/K_2}{Q_2/K_1}^{S_K} \quad \frac{Q_2/F_2}{Q_1/F_1}^{S_F}$$

where subscript 2 stands for Canada and 1 stands for the United States. The factor shares S_L, S_K, and S_F are an average of these values for the year 1910. (see Allen, 1979, p. 916.) U.S., A. Fishlow (1966).

15.3.5 Productivity Change in Canada and the United States

Since the measurement techniques used by Fishlow (1966) and by me in estimating productivity change (partial and total) are very similar, it seemed reasonable to compare the relative performance of the two systems where we had estimates for both countries. These comparisons are shown table 15.17. It should be emphasized that we are only looking at productivity relatives at a particular date rather than as a trend, as in the case of productivity changes in the Canadian system discussed in connection with the results shown in table 15.16.

One does not want to make too much of these estimates, but as a preliminary glimpse of the relative performance of the two systems the effort seems worthwhile. The ratios suggest, but do not prove, that Canada's railroad system was relatively less efficient at the beginning of our study than was the United States system, and it fell slightly behind the latter during the balance of the nineteenth century. According to the estimates, this condition reversed itself in the first decade of this century. Was this due to the fact that the Canadian system was

in the process of working off excess capacity, or was it due to other factors, such as added costs in running a northern railway system? These are obviously points that need to be investigated further.

Finally, the long-run evidence on productivity growth in the Canadian railroad sector gives us some perspective on the discussion earlier concerning the supposed overbuilding and ultimately the inefficiency which apparently plagued Canadian railroads after the completion of the third transcontinental railway. The reason given for the government takeover was that the supply of railroad services exceeded demand, forcing down returns and creating the potential for bankruptcy and major dislocations in the Canadian economy. The government was forced to step in and save the system from the overzealous railroad entrepreneurs. Was this really the case? The evidence seems to suggest that the answer is no.

First, there is no question that the some railroads' ability to pay fixed debt charges deteriorated sharply between 1913 and 1920. From 1912 to 1914 net operating revenue (out of which is paid all charges on fixed and floating debt, taxes, and equipment rentals) was averaging about $70 million a a year. By 1918 and 1919 net operating revenue was averaging $49 million. In current dollar cash flow terms, the fear of failure was not unfounded. However, this evidence on cash shortage was translated by earlier writers into overbuilding. The evidence we have seen implies that this is suspect. By the middle of World War I farm output from the Prairies—which had been the goal of railroad building from the beginning—had finally come on stream. For example, by 1918 the ratio of exports to GNP had climbed to 35.3%, more than double what they had been only 6 years earlier, in 1910.[11] The ratio remained at about 25% or greater until the end of our period. Most of these exports were bulky goods, grain, war materiel, and so on, virtually all of which moved by rail. As table 15.10, column 7 shows, ton miles carried, which had been running at roughly 15.7 billion in 1910, doubled by 1916 to 31.2 billion and remained around the latter level into the mid-1920s. Real output growth continued to expand at a rapid rate, at least until the end of the First World War.

Did real output grow more slowly than inputs? Regardless of the ratios used (panel B, table 15.15), none exhibit a downward trend, and we have used 1920 as the terminal year—the year that the takeover was under way. Apparently we must cast our net wider for an explanation of the failure of the system (with the exception of the CPR) to remain in private hands. The argument concerning inefficiency based on excess capacity has been substantially weakened with our new estimates. A starting place for a revision might be with the way railroads were regulated during this period. Briefly, the government regulated freight and passenger rates and held them constant during the course

of the war. However, beginning around 1917 prices of all goods rose sharply, including wages. For railroads built just prior to the outbreak of hostilities the cost burden was high, since, among other reasons, they financed construction by borrowing rather than financing through equity. With high fixed costs and rising variable costs, but fixed tariffs, profits fell and the capacity of the railroads to meet debt obligations diminished. Ultimately, bankruptcy would have occurred, in the absence of either a change in rate regulations or, as did happen, the government's taking over railroad obligations and nationalizing the system (again with the exception of the CPR). The role of regulation in the operation of the railroads needs to be investigated more thoroughly before we know the full reasons for the nationalization of the system.

15.3.6 Long-Term Change in Labor's Factor Share

The way income in the railroad sector was estimated allows us to calculate the cost shares of capital and labor. Note that labor's factor share differs slightly from that used to estimate total factor productivity. Here the share is derived from an income approach, whereas in the earlier case an input cost-share method was adopted. The latter, for example, included a direct measure of fuel costs. Since our primary concern here is with trends, this difference should not affect the discussion. Labor's share has been estimated on a 5-year period basis from 1875 to 1924. The results are shown in table 15.18. Before discussing the results, a word needs to be said about the sudden rise in labor's share during the last period (1920–24). After the end of World War I, as discussed earlier, Canadian railroads ran into financial difficulty. The result was that the sector dissaved for much of the period from 1920 to 1924. The negative savings reduced the final estimate of income and hence pushed up the ratio of wages to income.

Table 15.18 **Labor's Factor Share, Average for Quinquennial Periods, 1875–1924 for the Canadian Railway Sector**

Period (1)	Share (2)	Period (3)	Share (4)
1875–79	0.68	1900–1904	0.57
1880–84	0.68	1905–09	0.60
1885–89	0.60	1910–14	0.60
1890–94	0.57	1915–19	0.69
1895–99	0.50	1920–24	0.87[a]

Sources: Income originating, table 15.8; total wages and salaries, table 15.2

[a]If income originating in the railway sector is measured excluding saving (see text), this ratio becomes 0.73.

The ratios shown in table 15.18 suggest that the trend in labor's share was quite different between the nineteenth and the twentieth centuries. During the former, the share fell steadily, while during the first 3 decades of the century it rose. This type of break can be observed on an aggregate basis for the United States. Moses Abramovitz and Paul David (1973, table 2) show labor's share dropping steadily from 1800 to 1900 and then rising between 1900 and 1969.

The neoclassical explanation is that the bias of technical change tended to favor capital from 1875 to 1900 (taking into account the supply of investment funds and the elasticity of substitution). On the other hand, during the twentieth century the reverse is suggested. If, then, we assume, as is usually the case, that the elasticity of substitution between capital and labor is less than one and the capital/output ratio rises sharply (as was probably the case during part of the period), one might expect to find labor's share rising. Unfortunately, as we saw in table 15.8, the incremental capital/output ratio fell during the last decade of our period. It is obvious that we need to supplement the neoclassical explanation with an alternative hypothesis.

One suggested alternative would be a market-power approach.[12] The argument here is that as railroad unions became more powerful they increased labor's share of total income, that is, the railroad companies lost some of their monopsony power in the labor market. In this type of explanation it is necessary as well to understand conditions in the product market. If, as we suggested earlier, service rates on the railroad were regulated and could not be increased to offset the rise in wage rates, then labor's share would increase.

The neoclassical and market-power approaches are presented here more as interesting alternatives than as definitive explanations, although the fact that both may play a role either sequentially or simultaneously seems to be a line worth exploring. One benefit of a long-term approach in studying the phenomenon of sectoral or national growth is that it allows us to escape the strictures of believing that a single approach will suffice in what is inherently a complex process.

Appendix

Table 15.A.1 **Average Freight and Passenger Rates per Mile, Canadian Railways, Annually, 1875–1926 (Cents per Mile)**

Year	Passenger Rate	Freight Rate	Year	Passenger Rate	Freight Rate	Year	Passenger Rate	Freight Rate
1875	2.50	3.50	1891	2.45	1.40	1907	1.91	0.81
1876	2.46	3.40	1892	2.45	1.30	1908	1.92	0.72
1877	2.50	3.20	1893	2.40	1.20	1909	1.92	0.73
1878	2.50	3.00	1894	2.40	1.10	1910	1.87	0.74
1879	2.50	2.80	1895	2.35	1.00	1911	1.94	0.78
1880	2.50	2.60	1896	2.30	1.00	1912	1.94	0.76
1881	2.50	2.40	1897	2.25	0.95	1913	1.97	0.76
1882	2.50	2.30	1898	2.20	0.95	1914	2.01	0.74
1883	2.50	2.20	1899	2.15	0.95	1915	2.02	0.75
1884	2.50	2.10	1900	2.10	0.90	1916	1.95	0.65
1885	2.50	2.00	1901	2.05	0.90	1917	1.95	0.65
1886	2.50	1.90	1902	2.00	0.90	1918	2.12	0.74
1887	2.50	1.80	1903	1.95	0.90	1919	2.59	0.98
1888	2.50	1.70	1904	1.90	0.85	1920	2.94	1.07
1889	2.50	1.60	1905	1.90	0.85	1921	3.04	1.20
1890	2.50	1.50	1906	1.90	0.85	1922	2.82	1.04
						1923	2.76	0.99
						1924	2.79	1.02
						1925	2.69	1.01
						1926	2.71	1.04

Sources and methods: 1875–1910, see text; 1911–26, "Railway Statistics," Department of Railways, and Canals; after 1919, Dominion Bureau of Statistics.

Notes

1. The interested reader is referred to such standard texts as Easterbrook and Aitken (1956); Marr and Paterson (1980), chap. 10; and Pomfret (1981), pp. 99–107.
2. Similar estimates to those for the railway industry were made for the electric railways, water transport, road transport, telephone, and telegraph industries.
3. A complete description of the sources and assessment of railway statistics can be found in Urquhart and Buckley (1965), pp. 516 ff.
4. For a parallel growth pattern, although starting earlier, see Fishlow (1966), p. 628.
5. Quoted by Fishlow (1966), p. 583.
6. Fishlow (1965), esp. chap. 2, and Fogel (1964), chaps. 1–3.
7. For a discussion of this point, see Plumptre (1937).
8. For a review of whether the CPR did or did not receive excessive government subsidies, see George (1968).
9. For a full discussion on the application of the Fishlow method to the Canadian case, see A. Green (mimeographed).
10. Urquhart and Buckley (1965), ser. 40 and 165, p. 305.
11. See M. C. Urquhart's piece in this volume.

12. For a discussion of market power in explaining factor share trends, see Matthews et al. (1982), pp. 194–97.

Comment Albert Fishlow

There are three dimensions to the research reported here by Alan Green on the evolution of the Canadian railway sector from 1871 to 1926. The first is an estimate of annual income originating as a component of M. C. Urquhart's estimates of national income reported elsewhere in this volume. The second is determination of trend rates of increase in factor productivity over the same period. Last, but not least, is the use of these quantitative results to reassess generalizations about the performance of the Canadian railway sector in the early twentieth century. As is evident, this is an ambitious paper that a brief comment cannot do full justice. I shall be able to touch only lightly on these three subjects.

The principal tasks in estimating income originating are to calculate wages and salaries before 1907 and interest and dividends before 1911. Green is able to exploit the availability of relatively accurate annual data on railway operating expenses to ascertain the wage and salary totals. For interest and dividends he takes advantage of the concentration of the Canadian railway system to focus on large units like the Canadian Pacific and Grand Trunk, for which *Poor's Manual* provides detailed financial information.

His procedures are reasonable. The results for interest and dividends, in particular, are likely to be quite accurate. Residual profits are then obtained from the annual series on operating revenue. They are sensitive to variability in fixed charges and dividend policy; in particular, the decision of the Canadian government to change accounting practice in 1923 for the components of the Canadian National Railway system reallocates income between interest and residual profits.

The wages and salaries component is the largest. It is basically derived by extrapolation on the operating expense series. Despite Green's attempt to allow for differences in the relative importance of maintenance of way, the ratio of wages and salaries is a virtual constant: .566 between 1890 and 1906 with a standard deviation of only .003. Yet the actual ratio in the period 1907–13 is much more variable. The average is .598 with a standard deviation of .038. Green's lapse is to overstate the stability of the observed relationship and hence to exaggerate the reliability of the annual variations. For trend purposes the order of

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magnitudes will clearly serve, but it is of course the annual income originating that one wants.

An alternative procedure might be to start from operating expenses and seek to estimate material purchases. Train mileage is available on an annual basis and might serve as a measure of demand; some of the price indexes for materials later used to deflate capital formation might be of use. The advantage of approaching the problem from this other side would be an independent estimate that could provide some indication of the likely range of error.

The current income estimates are the easiest because of the annual aggregates already available. The physical output and input measures that occupy much of Green's efforts, and which are necessary for calculation of productivity change, are harder to come by.

For output Green utilizes freight and passenger receipts deflated by average fares estimated from rate schedules. He also might have applied a variant of the method he had earlier used for interest and dividends. By focusing on the largest lines, for which direct information was more readily available, he might have narrowed the degree of estimation considerably. At the least, such an alternative could have supplemented the series on ton miles and passenger miles actually constructed. The composite output series suffers from the defect of its weighting: the absolutes (rather than relatives) seem to be weighted by current ratios of freight and passenger revenues to total receipts. That yields an inconsistent index. Because the long-term physical trends dominate, the quantitative consequences over long intervals are not great. But readers fortunately can construct their own output indexes, either Paasche or Laspayres, because Green provides the necessary freight and passenger rates.

More serious questions arise with regard to the labor input series. Green derives his estimates by use of a constant ratio of employees to track mileage, but with an adjustment for a larger ratio during periods of construction. Once again, and even more so, he overstates the adequacy of the relationship: the correlation between employment and track in operation in the period 1907–19 when both are known is only .49 and with an elasticity of .38. This is hardly testimony in favor of "a remarkably stable ratio." Moreover, his variable adjustments seem arbitrary: in 1892 he applies a factor of 5; in 1893, 4.5; in 1894, 4. The increments in track in operation are respectively 726, 441, and 622, and estimated real investment is not very different either. It may have been that with falling revenues in 1894, employment was reduced. On the other hand, we are told that the Grand Trunk in *1891 and 1892* "had cut wages to the point where any further reductions would lead to strikes, and it had laid off men," (Currie 1957, p. 363). Green's employment cycle, and it is considerable, is apparently of his own creation.

For the estimation of labor input, other methods can be pursued. For purposes of long-term trend, for example, one might begin with the wage and salary series and deflate by an average annual wage to derive an employment total. Average remuneration in manufactures is available on a decennial basis from 1870 on. In 1910 the average railway wage was about 17% larger. Assuming the same differential earlier permits an estimate for employment in 1880, 1890, and 1900. The results differ from Green's series by about 10% in the first 2 years, and in the opposite direction. In 1890 employment was less than 60,000, and in 1880 more than 35,000. The implication is that productivity grew more rapidly between 1880 and 1890, and less rapidly in the subsequent decade, than Green's estimates suggest. For annual variation, the train mileage series seems a better indicator of the level of employment than sheer track mileage: maintenance as well as operating requirements are more dependent on intensity of use than extension. For the later period, the relationship with train mileage is quite more regular; the R^2 is .67 compared with .24 for track mileage.

To the information on labor input, Green adds estimates of fuel and capital inputs in order to calculate total factor productivity. For the former, Green uses the consumption per locomotive mile on the Intercolonial Railroad extended by the aggregate number of engine miles. Comparison with comparable United States estimates makes suspect the 1900 value, and hence the calculations of productivity increase between 1890–1900 and 1900–1910. One also would have liked some attention to later variance among different lines: fuel use depended on locomotive weight and size of trains.

Because railroads are so capital intensive, the capital input is important. There are two problems. One is an estimate of the capital stock; the other is an estimate of capital input in circumstances of deliberate construction ahead of demand. Green relies on a gross investment series published elsewhere to construct a net capital stock series. It is difficult to judge the validity of the procedures used to derive real investment in the absence of information in the proximate source. It is obviously encouraging to see a rough correspondence between rates of change of the capital stock series and of the mileage and equipment series assembled by Green. But caution is still indicated. Crude trends are undoubtedly right, but the purpose is finer calculation.

Nor do the stock series resolve the question of how to calculate capital inputs. Excess capacity built into a system will underestimate the efficiency with which current inputs are used, and overestimate productivity increases associated with technological change. For some purposes, one wants to single out the consequences of greater utilization; to do so, one might recalculate the productivity index by assuming an actual constant capital/output ratio and noting the difference. Despite Green's later interest in the question of construction ahead of

demand and the increase in output after 1910, he does not do so. Had he, he would have found that utilization of the excess capacity (so measured) between 1900 and 1920 explains about one-fourth of the recorded total productivity increase.

Green also might have related his calculated productivity results to the trend decline in real freight rates. Then he would have noted that real freight rates fell less than productivity increased in the 1890s (even after allowance for changed labor and fuel inputs) but much more in the decade between 1910 and 1920. In the former case, it opened opportunity for greater return; in the latter, railways were being relatively taxed.

This last finding is very much in the spirit of Green's revisionism of the conventional story of Canadian railway nationalization during the First World War: "The reason given for the government takeover was that the supply of railroad services exceeded demand, forcing down returns and creating the potential for bankruptcy and major dislocations in the Canadian economy. . . . Was this really the case? The evidence seems to suggest that the answer is no."

But Green may be overstating his case and misapplying the productivity results. There are three reasons.

First, the entire system was not nationalized. The Canadian Pacific, paying handsome dividends, remained in private hands. Thus it is necessary to disaggregate the physical performance of Canadian railways. When one does, it is clear that the earlier completed line of the Canadian Pacific was a prime contributor to the great increase in railroad freight carriage rather than only the two new transcontinentals. Between 1910 and 1916 the number of bushels transported on the Canadian Pacific increased from 113 million to 277 million, proportionately more rapidly than the increase in total ton mileage (Innis 1971, p. 159).

Second, rates of change may be in the right direction without speaking to absolute levels of productivity. Here Green starts out correctly to compare the United States and Canadian levels but does not fully follow through. Because Canadian transcontinental rates were influenced by United States charges, the nexus is a critical one. Despite lower levels of productivity, partially explained by lesser revenues per mile of track and more frequent empty back hauls, Canadian freight revenues per ton mile fell from 60% more than the American in 1890 to equality in 1910. That is an important part of the story of eventual nationalization. The duplication of facilities by constructing parallel trackage as occurred after 1900 certainly did not help. Private gain seemed to call for monopolizing through haulage on a single system, but the systemic effect was overinvestment.

Third, productivity calculations are physical rather than financial. Nationalization occurred because, despite extensive governmental assistance, the Canadian Northern and the Grand Trunk Pacific coud not

earn enough to meet even their fixed obligations. That is related to the cost of construction and capitalization, as well as to the expenses of operation. Green's point about regulation is obviously well taken. Keeping rates low, as was done, meant losses. But note that rates were also constrained by the competition of the profitable Canadian Pacific and could not be set arbitrarily.

Green's challenge to conventional wisdom on the nationalization issue thus is not decisive. His productivity calculations, particularly extended to absolute comparisons with the United States and disaggregated, are an important and new element in the discussion. And he is surely right to emphasize the developmental quality of Canadian railway investment.

In sum, Alan Green has left us all in his debt by his efforts. These new data, revised, extended, and used with care, permit new questions to be posed and examined. He has himself raised many, and in a fruitful and challenging way. In the last analysis, the purpose of quantitative research is not the numbers per se, but the substantive issues they illuminate.

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