Catalogue no. 15-206-X — No. 022
ISSN 1710-5269
ISBN 978-1-100-11532-0

Research Paper

The Canadian Productivity Review

The Productivity Differential Between the Canadian and U.S. Manufacturing Sectors: A Perspective Drawn from the Early 20th Century

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Statistics Canada
Micro-economic Analysis Division

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Published by authority of the Minister responsible for Statistics Canada

December 2008

Catalogue no. 15-206-X, no. 022
Frequency: Occasional

ISSN 1710-5269
ISBN 978-1-100-11532-0

Ottawa

Authors' names are listed alphabetically.

La version française de cette publication est disponible (n° 15-206-X au catalogue, n° 022).

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Abstract

Many historical comparisons of international productivity use measures of labour productivity (output per worker). Differences in labour productivity can be caused by differences in technical efficiency or differences in capital intensity. Moving to measures of total factor productivity allows international comparisons to ascertain whether differences in labour productivity arise from differences in efficiency or differences in factors utilized in the production process.

This paper examines differences in output per worker in the manufacturing sectors of Canada and the United States in 1929 and the extent to which it arises from efficiency differences. It makes corrections for differences in capital and materials intensity per worker in order to derive a measure of total factor efficiency of Canada relative to the United States, using detailed industry data. It finds that while output per worker in Canada was only about 75% of the United States productivity level, the total factor productivity measure of Canada was about the same as the United States level—that is, there was very little difference in technical efficiency in the two countries. Canada's lower output per worker was the result of the use of less capital and materials per worker than the United States.

Preface

The Canadian Productivity Review contains papers that facilitate an understanding of productivity in Canada. Most papers deal with the recent past. But an understanding of the present is often facilitated by information on the past. Accompanying papers in this series examine the relative Canada/US total factor productivity in the late 1990s and post 2000. This paper examines the relative levels of MFP in 1929.

Cross country comparisons of productivity are difficult to make because the data that are collected by different countries often comes from different sources or are derived from different methodologies. This study makes use of a set of matched industrial data taken from the 1929 Censuses of the two countries. Because of long standing interaction between the statistical establishments in Canada and the United States, the concepts and definitions in the two censuses are quite similar. Even so, one of the greatest problems in estimating cross-country MFP estimates is provided by finding usable capital stock data. This problem was resolved in this study using detailed data on the horsepower of the capital stock in the two countries and several other alternatives that were checked for internal consistency.

This paper was started when John Baldwin was still a member of the Department of Economics at Queen’s University. Support from the SSHRC for the project is gratefully acknowledged. It was first presented at a conference of economic historians at Bellagio in Italy and more recently reworked. The authors are grateful to comments received from reviewers and colleagues.

Executive summary

Many historical comparisons of international productivity use measures of labour productivity (output per worker). Differences in labour productivity can be caused by differences in technical efficiency or differences in capital intensity. Moving to measures of total factor productivity allows international comparisons to ascertain whether differences in labour productivity arise from differences in efficiency or differences in factors utilized in the production process.

This paper examines the historical development of the Canadian manufacturing sector and calculates differences in productivity between the manufacturing sectors of Canada and the United States in 1929 and the extent to which it arises from efficiency differences. It starts by examining labour productivity measures and then makes corrections for differences in capital and materials intensity per worker in order to derive a measure of total factor productivity (a measure that captures differences in technical efficiency of Canada relative to the United States) using detailed industry data for 1929.

The paper asks several questions:

1) What is the traditional view of the efficiency of the Canadian manufacturing sector in the early 20th Century?

The traditional view of the manufacturing sector is that it was a weak partner in the chain of Canadian economic development. The growth of the manufacturing sector was fostered by a development policy that involved the encouragement of western settlement, expansion of the east-west railway system and the imposition of tariffs to protect the fledgling Canadian manufacturing sector.

In what is one of the better known Canada/U.S. studies for the pre-1945 period, Dales (1966) argues that the Canadian tariff led to the development of a large portion of the manufacturing sector—secondary manufacturing—that suffered a comparative disadvantage relative to U.S. standards.[1] Dale's estimates indicate that average productivity for secondary manufacturing in Canada varied between 75% and 85% of that for total manufacturing in the United States between 1926 and 1939.

2) What was the history of development in the manufacturing sector in the early 20th century?

The growth in the manufacturing sector during the first three decades of the 20th Century followed that of the economy as a whole. Manufacturing GDP remained at around 22% of total GDP throughout the period from 1900-1926 (Green and Urquhart, 1987). Manufacturing output grew at about the same rate as the total economy, which was expanding rapidly with western settlement. The dramatic expansion in agricultural production, which occurred with the opening of the West, was accompanied by equally rapid growth in manufacturing output.

By 1929, the substantial export positions of pulp and paper, rubber products, non-ferrous metals, non-metallic minerals and wood products suggest healthy industries able to compete in world

1. Dales focused on allocative rather than technical efficiency in that he used ratios of Canada/U.S. labour productivity relative to relative wage rates to infer inefficiency.

markets. Except for wood products, these were also industries that were growing in importance when measured by employment percentages. By way of contrast, imports were important while exports were less so for iron and steel, textiles, petroleum, publishing and clothing. However, only the latter declined in terms of the share of total employment that they held during the period. In four industries, food and beverages, leather, transportation and chemicals, there was less trade and it was of a two-way nature. In this group, only leather declined in importance in terms of its percentage of employment over this period.

3) How did growth in the Canadian manufacturing sector compare to that in the United States during this period?

The early decades of the 20th Century were marked by equally rapid increases in employment in manufacturing in Canada and the United States. As of 1900, the Canadian manufacturing sector employed 6.7% as many production workers as were listed in the U.S. 1899 census (when hand trades are excluded on the U.S. side). This ratio increased to 7.3% for the respective 1910 and U.S. 1909 censuses, decreased to 5.9% in 1919 and then increased to 6.9% by 1929.

4) What were the differences in the characteristics of Canadian and U.S. manufacturing plants?

In terms of total output or employment in 1929, Canadian industries as a whole were smaller than their U.S. counterparts. On the basis of total employees, the average Canadian manufacturing industry had only 10.9% the number of employees as the average United States industry (the median only 6.5%).

The average size of plants in Canada was smaller than the United States. When measured by employees per establishment, Canadian plants averaged only 92% the average size of plants in the United States. The ratio of median plant size in the two countries is somewhat lower at 84%.

Wages and salaries per employee in manufacturing in Canada were 20% below American levels. By themselves, lower wages would have given Canadian manufacturers the incentive to use relatively more labour compared to capital. But capital costs were also higher in Canada.

5) Were the differences in factor prices reflected in factor proportions?

With lower labour and higher capital costs, manufacturers in Canada employed more labour relative to capital than did the United States manufacturing sector. The median estimates of the relative Canada/U.S. horsepower/labour, fuel/labour, and materials/labour ratios are all about the same—around 77%.

The difference between relative labour and the capital measures indicates that Canada used more labour relative to horsepower (a measure of capital input) than did the United States. Canada was therefore relatively more labour intensive in terms of its production processes.

6) What was the difference in relative efficiency of Canadian and United States manufacturing plants?

This paper examines differences in output per worker in the manufacturing sectors of Canada and the United States and the extent to which it arose from efficiency differences. It makes corrections for differences in capital and materials intensity per worker in order to derive a measure of total factor efficiency of Canada relative to the United States, using detailed industry data for 1929. It finds that while output per worker in Canada was only about 75% of that of the United States, the total factor productivity measure of Canada was about the same as that of the United States—that is, there was very little difference in technical efficiency in the two countries.

7) What do the differences between labour and total factor productivity between Canada and the United States tell us?

Ultimately, we must be interested in the reason for the differences between countries in labour productivity. Lower output per worker ratios could arise if Canada was on a lower production frontier (technical inefficiency), or because factors were being combined in different proportions because of different factor costs.

The paper finds that while output per worker in Canada was only about 75% of that of the United States, the total factor productivity measure of Canada was about the same as that of the United States—that is, there was very little difference in technical efficiency in the two countries. Canada's lower output per worker was the result of the use of less capital and materials per worker than the United States. The fact that Canada was combining more labour with all other inputs would be expected on the basis of factor (labour versus capital) prices.

The traditional literature which relies on partial labour productivity measures leaves the false impression that the Canadian manufacturing sector has always been grossly inefficient. At least in 1929, this was not the case.

1 Introduction

The traditional view of the manufacturing sector is that it was a weak partner in the chain of Canadian economic development. The growth of the manufacturing sector was fostered by a development policy that involved the encouragement of western settlement, expansion of the east-west railway system and the imposition of tariffs to protect the fledgling Canadian manufacturing sector. The manufacturing sector, rather than being regarded as the engine of growth, was seen to hold back an otherwise rapidly growing economy. Emerging from traditional accounts is the view that tariffs provided the infant manufacturing sector with protection and that it became a perpetual child that never matured, continuing instead to operate at a low level of efficiency. Dale's (1966) work on the tariff reinforced this view with the argument that the large Canadian secondary manufacturing sector, which emerged behind this wall of protection, was inefficient when compared to its United States' counterpart.[2]

As appropriate as the characterization of the Canadian manufacturing sector as an infant might have been at Confederation in 1869, it was no longer the case by 1929. The Canadian economy and its manufacturing sector had grown markedly through the first three decades of the twentieth century. It is therefore appropriate to try and quantify the extent to which Canadian industry had matured before the dramatic events of the thirties and forties. There are a number of dimensions to the concept—the manufacturing sector's ability to compete in export markets, its ability to exploit plant or firm scale economies, and its relative efficiency. In this paper, we examine the basis for the conventional view by focusing on the efficiency of Canadian manufacturing industries relative to those of the United States in 1929.

Productivity failures have been categorized as technical or allocative (Farrel, 1957). Technical efficiency measures the relationship between outputs and inputs. Allocative inefficiency measures the extent to which factors are not combined in the proportions justified by factor price ratios. This paper focuses on technical efficiency and uses a total[3] rather than a partial labour factor productivity measure, as has been the general practice.[4]

Labour productivity (LP) is a partial measure that captures the efficiency with which labour is transformed into output; total factor productivity (TFP) measures are more comprehensive measures that capture the efficiency with which multiple factors (i.e., both labour and capital) are transformed into output. TFP measures capture allocative efficiency better than do partial productivity measures.[5]

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2. The theme that Canadian industry is inefficient is not confined to economic historians. The traditional industrial organization literature (Eastman and Stykolt, 1967) argued that not only has Canadian tariff policy expanded sectors where Canada has a comparative disadvantage, but also that those industries receiving tariff protection did not operate as efficiently as they might have. The inefficiency, it was argued, existed because of smaller plant scale and shorter production runs that arose out of the small size of the Canadian market (Fullerton and Hampson, 1957; Daly et al., 1986, Economic Council of Canada, 1961).
3. Statistical agencies refer to these as *multi* factor rather than *total* factor productivity measures since many factors contribute to the production process that at the moment are unmeasured and existing measures will therefore be less than complete—they will involve multiple factor but not all factors. Nevertheless, we adopt the more common phrase used in academic circles in this document for ease of communication. Other papers in the *Canadian Productivity Review* published by Statistics Canada make use of the phrase 'multifactor productivity measure'. The two are synonymous.
4. Keay (2000) and Inwood and Keay (2006) also focus on total factor productivity.
5. In practice, TFP estimates may also capture the extent of economies of scale and other organizational differences (Hulten, 2001); but so too do simple labour productivity measures.

While the relative TFP is a more comprehensive measure of the production efficiency difference in the two countries than the relative labour productivity level, the two are not independent of one another. Within the growth accounting framework, the relative labour productivity level can be decomposed into two components: one due to the difference in TFP and the other arising from differences in the capital intensity in Canada and the United States (Baldwin, Gu and Yan, 2008):

$$\ln\left(\frac{LP^C}{LP^U}\right)=\ln\left(\frac{TFP^C}{TFP^U}\right)-\overline{s}_K\ln\left(\frac{\left(K^C/L^C\right)}{\left(K^U/L^U\right)}\right), \tag{1}$$

Where TFP and LP represent total factor and labour productivity, K and L capital and labour, $\overline{s}$ represents the average share of GDP accruing to capital and C and U are superscripts referring to Canada and the United States.

Relative Canada/U.S. total factor productivity (a measure of technical efficiency) can be the same in the two counties and relative labour productivity can be less than one when capital intensity in Canada is less than the United States. Thus, a country may have lower labour productivity not because of lower technical efficiency (as measured by total factor productivity) but because it has lower capital intensity. And the latter may arise from a response to differences in factor price ratios across countries.

In this paper, we find that the gap between Canadian and U.S. levels of efficiency in the manufacturing sector that has been inferred to exist when partial labour productivity measures are compared virtually disappears when a total factor productivity measure is used, that labour costs relative to capital costs were considerably lower in Canada than in the U.S., and that Canada employed considerably more labour relative to capital (or less capital per worker) than did the United States. Most of the differences in labour productivity arose not from differences in technical efficiency but from lower capital intensity.

The first section reviews the findings of earlier studies on the extent and reasons given for the gap in manufacturing productivity between Canada and the United States. The second section reviews the evolution of the Canadian manufacturing sector between 1900 and 1929. The third section compares certain salient characteristics of the Canadian and American economies. The fourth section contains the detailed total factor productivity estimates.

2 Canada-U.S. Productivity Comparisons

The traditional notion that Canadian industry has long been inefficient can be found both in the work that emphasizes the link between the tariff and the growth of manufacturing and in various Canada-U.S. productivity comparisons. A number of studies have compared relative productivity for the post World War II period and concluded that a substantial gap existed. Most of these studies have relied on partial labour productivity measures to infer inefficiency. Fullerton and Hampson (1957) measured relative output per worker in secondary manufacturing between Canada and the United States for 1953. Standardizing labour input by hours worked, and adjusting for price differences, they found that Canadian productivity was only 61% of the American average. For primary industries, the gap in favour of the United States was only 10%.

In a study for the Economic Council of Canada, E.C. West (1971) working with a sample of 30 industries for 1963 found that, after correcting for input and output price differences, Canada's value-added per worker was between 72% and 77% that of the U.S., depending on whether Canadian or American outputs were used to construct the price deflator. Working with a sample of 33 industries, and adjusting for output and material prices, Frank (1977) estimated the gap in value-added per worker to be 65% in 1967 and 80% of the American levels in 1974. Caves et al. (1980) using a broader sample of 84 matched Canadian/American industries, and assuming that Canadian outputs and inputs were priced up to the tariff level when making price corrections, estimated Canadian value-added per worker to be 63% of the American level in 1967.

In contrast to the post 1945 period, there are relatively few studies of productivity in the Canadian manufacturing sector in earlier periods (Maddison, 1952; Maddison, 1953; Sutton, 1953; Dales, 1966). Existing studies suggest that productivity in Canada was substantially below that of the United States in this period. The Economic Council of Canada (1965, p. 54) calculated that real GNP per capita in Canada was between 67% and 77% of the American GNP per capita between 1920 to 1960. Sutton (1953, p. 197) estimated Canadian output per employed person as only 83% that of the United States in the non-agricultural sector and 74% overall for the period 1929-1933. While these studies do not focus directly on manufacturing per se, the disadvantages for Canada as a whole have no doubt influenced the view that the Canadian economy and the manufacturing sector have long been relatively inefficient compared to their American counterparts.[6]

In what is one of the better known Canada/U.S. studies for the pre-1945 period, Dales (1966) argues that the Canadian tariff led to the development of a large portion of the manufacturing sector—secondary manufacturing—that suffered a comparative disadvantage relative to U.S. standards.[7] Our interest is with this index of relative real value-added per employee. Dale's estimates indicate that average productivity for secondary manufacturing in Canada varied between 75% and 85% of that for total manufacturing in the United States between 1926 and 1939. His figures were not corrected for relative prices. These results have been widely interpreted as indicating that Canadian secondary manufacturing was less efficient than the United States both, in the interwar, as well as in the post 1945 period.

Most of these historical studies focus on one or other variant of a partial labour productivity measure.[8] Partial productivity measures do not take into consideration other inputs (capital, fuel, materials), nor the type of substitution that is possible among inputs. Total factor productivity measures offer potentially superior estimates of relative efficiency, but at a cost—more factors must be measured, amongst which relative capital estimates provide some of the greatest measurement problems. For purposes of comparing productivity over time, partial measures may be adequate—if factor intensities, the quality of factors and plant size relative to minimum efficient scale all remain relatively unchanged. But partial factor productivity measures may be less adequate when analyzing cross-countries differences. When factor intensities or plant sizes

6. See West (1971, p. 1) for a statement that Walters (1968) concluded lower Canadian income levels were the result of generally lower efficiency in Canada.
7. Dales focused on allocative rather than technical efficiency in that he used ratios of Canada/U.S. labour productivity relative to relative wage rates to infer inefficiency.
8. An exception is the study by Maddison (1953); but it concentrates on Canada/U.K. relative productivity in 1948 and does not therefore focus on the key differences between Canada and the United States which provide the focus of this study.

differ as they do across countries, they will be quite misleading when it comes to understanding differences in technical efficiency.

The measurement problems associated with moving from partial to total factor productivity statistics have meant that even the more recent studies of Canada/U.S. productivity (Caves et al., 1980; Saunders, 1980; Bernhardt, 1981) have tended to concentrate on partial measures. Even where rough estimates of capital are provided, the Canada/U.S. total factor productivity estimates invariably receive less emphasis, usually as a secondary reference (West, 1971; Frank, 1977). More recently, better estimates of relative capital intensity have permitted more accurate estimates of relative Canada/U.S. differences in TFP levels (Baldwin, Gu and Yan, 2008).

This study is aimed at overcoming the deficiency of partial productivity measures previously used to characterize pre World War II efficiency in manufacturing by developing a total factor productivity measure for a large number (137) of matched Canadian/U.S. industries in 1929. By choosing to calculate total factor productivity measures for individual industries, we avoid the potential aggregation bias that is associated with using total economy aggregates that apply to the manufacturing sector as a whole.[9]

3 Canadian Development and the Evolution of the Manufacturing Sector: 1900 to 1929

Productivity comparisons of Canadian manufacturing have contributed to the general notion that this sector was the weak link in Canadian economic development. There have, however, been some dissenters among economic historians. Safarian (1959), writing on the Great Depression of the 1930's, states that by 1929 a very considerable development had taken place in Canadian manufacturing. In his background study to the Rowell-Sirois Commission, W.A. Mackintosh (1964) describes the sector as having become more specialized and integrated between 1900 and 1929 and credits this change to the growth in the size of the domestic market that followed the settlement of the Canadian west.

What impressed both writers was the rapid growth in the Canadian economy and a concomitant growth in Canadian manufacturing during the early part of 20th Century. During the last decades of the nineteenth century, Canadian economic growth languished. In the last two decades of the nineteenth century, Canadian population grew about 11% each decade (Urquhart and Buckley, 1965, p. 14). In the first three decades of the twentieth century, population grew by 34%, 22% and 18% respectively. GNP also grew more rapidly after 1900. M.C. Urquhart (1987, p. 32) calculates that the growth between 1870 and 1900 as 92%, and between 1900 and 1926 as 170%.

The growth in the manufacturing sector during the first three decades of the 20th Century followed that of the economy as a whole. Manufacturing GDP remained at around 22% of total GDP throughout the period from 1900-1926 (Green and Urquhart, 1987). The constancy in the share of manufacturing output indicates that this sector grew at about the same rate as the total economy. Thus, the dramatic expansion in agricultural production, which occurred with the

9. For a brief description of the bias in performing TFP analyses at the level of the aggregate economy, see Hulten (2001).

opening of the West, was apparently accompanied by equally rapid growth in manufacturing output.

Over the period of rapid expansion that lasted from 1900 to 1929, the factors that accounted for growth changed. In the first two decades, real output grew in response to western settlement on the Canadian Prairies. During the period up to the beginning of World War I, this growth was accompanied by an investment boom. Acreage seeded in wheat increased between 1891 and 1901 by 56%; by 109% and 106% in each of the next two decades, but only by 37% between 1921 and 1931 (Urquhart and Buckley, 1965, p. 362). Miles of main railway track followed the same pattern—34%, 40%, 57% and 8% over the same four decades (Urquhart, 1987, p. 28).

While there were direct spinoffs associated with the wheat boom in industries such as flour-milling, iron and steel, and transportation products, the large increase in the domestic market occasioned by rapid population growth also provided for substantial expansion in such consumer product industries as textiles, clothing and leather. This was also the period when non-ferrous metals exports grew substantially and so did the associated smelting industry.

From 1914 to 1929, the level of investment activity declined, and a major source of income growth became the export of wheat and flour—a sector in which the country enjoyed a distinct comparative advantage. Furthermore, in the period after 1914, Canada switched from being a net importer of capital to a net exporter (in the 1920's). From World War I onward, therefore, the growth in demand was met increasingly by domestic goods producers.

The relative importance of manufacturing industries changed during the first three decades of the century. The transformation can be gauged by changes in the percentage of employment accounted for by each two digit manufacturing industry (Table 1).

During the first decade of the century, iron and steel, transport equipment and the mineral group—(non-ferrous and non-metallic)—gained about 8 percentage points. The consumer goods industries—textiles, clothing, leather and food—lost about the same amount. This split reflects the role played by high levels of population-sensitive capital formation. This investment resulted in substantially increased demand for steel rails, locomotives and cement.

The decade from 1910 to 1920 not only experienced the continuing effects of prairie expansion, but also the disruptive effects of World War I. Real GNP peaked in 1914 (Urquhart, 1987, Table 9) and was about the same in 1921 as it had been in 1911 (Green and Urquhart, 1987, Table 1). The First World War therefore was a period of little real growth in total output. However, it served to stimulate growth in munitions and in foodstuffs for export. It also reduced foreign competition in some consumer products industries like textiles where disruptions in European markets and overseas transportation served to increase the protection that Canadian tariffs already provided to the fledgling Canadian manufacturing sector.

Table 1
Total employment and its distribution by 2-digit Canadian manufacturing industry, 1900 to 1929

Sector	1900	1910	1920	1929
	year			
Food and beverages	51,900	64,300	77,158	104,253
	(15.6)	(12.9)	(13.4)	(15.7)
Tobacco	7,000	9,500	9,276	9,333
	(2.1)	(1.9)	(1.6)	(1.4)
Rubber	800	1,900	15,238	17,796
	(0.2)	(0.4)	(2.6)	(2.7)
Leather	20,800	24,600	21,807	23,500
	(6.3)	(4.9)	(3.8)	(3.5)
Textiles	24,600	25,700	47,767	58,956
	(7.4)	(5.2)	(8.3)	(8.9)
Clothing	42,100	56,400	41,222	48,582
	(12.7)	(11.3)	(7.2)	(7.3)
Wood	78,700	113,700	73,032	83,778
	(23.7)	(22.8)	(12.7)	(12.6)
Paper	9,700	15,500	39,163	43,530
	(2.7)	(3.1)	(6.8)	(6.5)
Printing	12,400	17,100	29,088	35,417
	(3.7)	(3.4)	(5.1)	(5.3)
Iron and steel	35,100	65,800	85,365	90,334
	(10.6)	(13.2)	(14.8)	(13.6)
Transportation	19,100	43,300	55,084	56,118
	(5.8)	(8.7)	(9.6)	(8.4)
Non-ferrous	5,100	12,700	14,699	18,996
	(1.5)	(2.6)	(2.6)	(2.9)
Electrical	2,000	6,400	14,115	20,871
	(0.6)	(1.3)	(2.4)	(3.1)
Non-metallic	11,700	20,500	16,656	20,377
	(3.5)	(4.1)	(2.9)	(3.1)
Petroleum and coal	700	1,900	8,286	8,880
	(0.2)	(3.8)	(1.4)	(1.3)
Chemicals	4,300	10,300	16,414	16,606
	(1.3)	(2.1)	(2.9)	(2.5)
Miscellaneous	6,300	9,000	12,047	8,854
	(1.9)	(1.8)	(2.1)	(1.3)
Total	331,800	498,500	576,417	666,181

Source: 1900 and 1910: T. Rymes, 1960, « Some Comments on the Pre-Annual Census of Industry Data with respect to Manufacturing in Canada, 1870-1915 ». 1920 and 1929: M. Urquhart and K. Buckley, 1965, *Historical Statistics of Canada*, pp. 463-474.

Between 1910 and 1920, the pulp and paper industry began to emerge as an important new industry—though the 3.7 percentage point gain in relative employment in this sector was more than offset by the 10 percentage point decline in the wood sector. The manufacturing sector was becoming less dependent upon the forest sector overall. Steel products and the transportation sector expanded slightly in relative importance both because of continued prairie settlement and the artificial stimulus of war-time demand. Clothing's decline, which had started in the first decade of the century, accelerated during this period. It lost some 4 percentage points of total employment. Textiles, on the other hand, gained about 3 percentage points, as European competition was reduced by World War I.

The wartime decade also saw the emergence of several new industries. Rubber products, an industry associated with the beginning of the automobile revolution, increased its importance from 0.4 to 2.6% of total employment in manufacturing by 1920. Electrical machinery grew from 1.3% of total employment in 1910 to 2.4% in 1920. This industry was associated with the rapid growth in hydro-electric production.[10] Finally, printing and publishing increased its percentage of total employment from 3.4% to 5.1% as urbanization led to an increased demand for newspapers.

The decade of the 1920's was one of rapid growth in total and per capita income. It was a period marked by large external sales of wheat and flour as well as mineral and paper sales. These were commodities in which Canada had a comparative advantage. This decade was less influenced by the initial investment boom associated with western settlement than by the growing domestic market provided by established farmers in the west, and by the emergence of an urban-industrial society in the east. The diffusion of electricity is reflected in the rise of the electrical goods industry (line 13, Table 1), while growth in automobile production filled part of the gap in the transport industry that was created by the slowing of railroad construction. These new technologies—automobiles and electricity—increased the demand for copper, lead and zinc which, along with exports, sustained growth in the non-ferrous metal industry. Finally, the non-metallic industry expanded as the demand for cement and other building materials increased in response to a construction boom; but this time it was related to the growth of cities.

By 1929 then, the Canadian manufacturing sector was much larger than it had been in 1900; but so was the whole domestic economy. At the 2-digit level of industrial output, there was remarkably little structural change over the preceding decade. The main areas of relative expansion were in the 'new staples'—copper, lead, zinc and pulp and paper. Two-digit industry figures, though, mask changes in individual industries within some 2 digit industrial sectors. For example, transport industries shifted from railway rolling stock to automobiles, trucks and tractors. Iron and steel production adjusted to these more sophisticated demands.

The competitiveness of industries can be seen in their trade balances (export and import levels). In Table 2, the ratios presented in columns 3 and 4 measure the degree of import penetration and export importance respectively for various 2-digit industries. Imports were largest in absolute terms for textiles, iron and steel and transport equipment. For these three industries, imports as a percentage of domestic market (domestic production plus imports minus exports) were also high in 1929—33.6%, 28.9% and 24.1% respectively. The import ratio for non-ferrous metals was also high. Exports as a percentage of the domestic market was highest for pulp and paper (66.4%). Exports were also high in wood (23.2%), non-ferrous metals (66.4%), non-metallic minerals (26.9%) and rubber products (31.6%). Lower, but not unimportant, levels of export ratios were found in food and beverages (12.4%)—the result of flour exports—leather (11.7%), transport equipment (12.3%) and chemicals (13.6%).

In summary, the substantial export positions of pulp and paper, rubber products, non-ferrous metals, non-metallic minerals and wood products suggest healthy industries able to compete in world markets. Except for wood products, these were also industries that were growing in importance when measured by employment percentages during the first three decades of the twentieth century. By way of contrast, imports were important while exports were less so for iron

10. In 1910, there were 977.2 M.H.P. installed in electric turbines; by 1920, this had increased to 2515.6 M.H.P.; and by 1930, to 6125.0 M.H.P. (Urquhart and Buckley, 1965, p. 454).

and steel, textiles, petroleum, publishing and clothing. However, only the latter declined in importance during the period. In four industries, food and beverages, leather, transportation and chemicals, there was less trade and it was of a two-way nature. In this group, only leather declined in importance in terms of its percentage of employment over this period.

Table 2
The trade position of the Canadian manufacturing sector by 2-digit industries : 1929

Sector	Imports[a]	Exports[a]	Imports as a share of domestic market[b]	Exports as a share of domestic production[c]
	thousands of dollars		percent	
Food and beverages	82,509	119,601	8.9	12.4
Tobacco	1,173	-	2.6	-
Rubber	1,759	30,583	2.6	31.6
Leather	10,998	10,656	12.0	11.7
Textiles	115,221	7,552	33.6	2.2
Clothing	30,745	984	14.0	0.4
Wood	27,941	67,487	11.2	23.2
Pulp and paper	14,735	193,291	13.1	66.4
Publishing	16,540	1,375	10.6	0.9
Iron, steel and electrical	209,962	33,124	28.9	4.6
Transportation	102,947	45,774	24.1	12.3
Non-ferrous metals	75,438	112,778	56.9	66.4
Non-metallic minerals	40,614	24,335	38.1	26.9
Petroleum and coal	32,773	3,067	19.4	2.2
Chemicals	37,723	19,438	23.4	13.6
Miscellaneous	68,492	18,264	75.6	45.2
Total	869,569	688,309	21.1	17.9

a Imports and Exports are taken from the Canada Year Book, 1932. Only finished or semi-finished products are included. The imports so classified accounted for 69% of the total, the exports for 50% of the total.
b The Domestic Market is domestic production plus imports minus exports.
c Domestic production is calculated as total value of production taken from the census and reported in the *Historical Statistics of Canada*, 1965.

4 A Comparison of the U.S. and Canadian Manufacturing Sectors

In this study, the United States is chosen for two reasons as the standard of comparison against which the performance of the Canadian manufacturing industry is measured. First by the interwar period, the United States had emerged as one of the world leaders in the adoption of new technology. Second, as the Canadian economy grew during the first three decades of the twentieth century, Canadian foreign trade became increasingly dominated by its southern neighbour. By 1929, 69% of Canadian imports came from and some 44% of her exports went to the United States (Urquhart and Buckley, p. 183). It was during this period that the source of foreign competition for manufacturing was to begin switching from the U.K. to the U.S. (MacIntosh, 1964, p. 63).

The early decades of the 20th Century were marked by equally rapid increases in employment in manufacturing in Canada and the United States. As of 1900, the Canadian manufacturing sector employed 6.7% as many production workers as were listed in the U.S. 1899 census (when hand trades are excluded on the U.S. side). This ratio increased to 7.3% for the respective 1910 and U.S. 1909 censuses, decreased to 5.9% in 1919 and then increased to 6.9% by 1929.

Table 3
A comparison of Canadian and U.S. manufacturing sectors by distribution of employment at the 2-digit level, 1929

Sector	United States	Canada
	percent	
Food and beverages	10.3	15.7
Tobacco	1.4	1.4
Rubber	1.7	2.7
Leather	3.5	3.5
Textiles	12.0	8.9
Clothing	7.6	7.3
Wood	10.1	12.6
Paper	2.7	6.6
Printing	6.0	5.3
Iron and steel	18.9	13.6
Transportation	6.0	8.4
Non-ferrous	3.1	2.9
Electrical	4.9	3.1
Non-metallic	3.8	3.1
Petroleum	1.2	1.3
Chemicals	3.8	2.5
Miscellaneous	3.8	1.3

Note: The U.S. Petroleum figure does not contain coal products (coke), while the Canadian figure does so.
Source: United States: D. Creamer, S. Dobrovolsky and I. Borenstein, 1960. C*apital in Manufacturing and Mining: Its Formation and Financing,* p. 273.
Canada: M.C. Urquhart and K.A.H. Buckley. 1965. *Historical Statistics of Canada,* 196, pp. 463-474.

While the traditional view of the Canadian manufacturing sector is that it was under-developed, relying heavily on the exploitation of natural resources, the distribution of employment across 2-digit industries for Canada and the United States as presented in Table 3 suggests more similarities than differences. Tobacco, rubber, leather, clothing, printing, non-ferrous metals, non-metallic minerals, petroleum and coal had about the same percentage of total employment in the two countries. Canada had a lower percentage in textiles, iron and steel and chemicals, but more in wood, transportation, paper and food.

To provide additional evidence on the similarities and differences between the manufacturing sectors of the two countries, the relative characteristics of matched Canadian and U.S. industries are reported in Tables 4 and 5. The mean, median and number of observations for each variable are reported.

Data for comparisons were obtained from the Canadian and U.S. Census of Manufactures for 1929 (see Appendix). Data on value of production and shipments and materials are used to compare gross outputs and value added. Data on the number of workers are used to compare the relative size of labour inputs. To compare capital stock, horsepower is used. This is the sum of horsepower produced by steam engines, internal combustion engines, water wheels and turbines and electric motors using purchased power. The latter overcomes the most difficult problem that most modern studies of cross-country comparisons face—that of deriving measures of the relative size of the volume of capital from relative dollar values of book capital. In the main, variables were defined in a similar way in the two countries in the 1929 censuses. The differences, when they exist are not critical to our results.

Table 4
Select characteristics of Canadian manufacturing industries relative to their 1929 matched U.S. counterparts

	Mean	Median	Observations
	percent		number
Relative industry size			
Total employees	11	65	130
Primary horsepower	8	51	130
Number of Establishments	16	79	130
Relative plant size			
Total employees	92	84	130
Primary horsepower	78	57	130
Value of output	76	62	130
Production workers/total employees			
Canada	83	86	130
United States	85	86	130
Relative output prices			
Using Canadian production weights	106	104	127
Using U.S. production weights	108	104	127
Motive power characteristics			
Electricity cost/fuel plus electricity cost			
Canada	41	41	108
United States	47	49	130
Electric motor H.P./primary H.P.			
Canada	76	84	106
United States	65	67	130
Electric motor H.P. using purchased power/total electric motor H.P.			
Canada	92	98	106
United States	77	82	130

Source: For definitions, see Table 5 and for discussion of variables construction, see Appendix.

Considerable effort was devoted to checking the accuracy of the capital proxy. We examined the ratio of relative Canada/U.S. capital stock derived from census book values and relative horsepower for the years prior to 1929 when book value of capital and horsepower were reported in the Censuses of both countries. Relative horsepower was found to closely proxy relative book value of capital. We traced the growth of horsepower and U.S. real capital stock (Creamer et al.) for each decade from 1899 to 1929 and found they moved closely. But perhaps our best evidence is that our estimate of the median Canada/U.S. ratio of output per horsepower is 105 (with a mean of 116). Latourette (1968) obtains very similar ratios when he builds a capital stock from investment flows.[11]

In terms of total output or employment, Canadian industries as a whole were smaller than their U.S. counterparts. On the basis of total employees, the Canadian industries were on average only 10.9% the size of their southern neighbour. The median is even smaller (6.5%) indicating the distribution of relative sizes is skewed—with a small number of the larger Canadian industries suffering less of a size disadvantage. Use of horsepower indicates an even greater size disadvantage.

11. This comparison is particularly heartening since capital stock includes both machinery and structures. A potential criticism of the horsepower estimate is that it may not reflect the relative importance of the building component of total capital stock. Our investigations suggest that it does so.

The difference between the relative labour and the capital measures indicates that Canada used more labour relative to horsepower (a capital proxy) than did the United States. Canada was therefore relatively more labour intensive in terms of its production processes.

Canada also had smaller plants. When measured by average employees per establishment, a Canadian plant averaged only 92% the size of a plant in the United States. The median is somewhat lower at 84%. Because of lower capital/labour ratios, this plant–size disadvantage increases as horsepower rather than employment is used to measure plant size. Even so, the plant–size disadvantage is considerably less than the relative market–size disadvantage. And given the nature of the differences in populations covered (the U.S. excluded the smallest plants and Canada tried to cover all plants), the differences in average plant sizes was probably smaller than reported here.

Relative output prices were on average 6% to 8% higher in Canada. Two inputs also had a relative cost disadvantage—fuel and electricity at 7% and materials at 5%. This indicates that tariffs and transportation costs acted to separate the two markets.

On the other hand, wages and salaries per person in Canada were 20% below American levels. By themselves, lower wages would have given Canadian manufacturers the incentive to use relatively more labour compared to capital. But we also found capital costs to be higher in Canada. The relative quasi-rent (value-added minus wages and salaries) per unit of horsepower was 23% higher on average in Canada. This measure is conceptually similar to the procedure followed by Christensen and Jorgenson (1969) where the rate of return is computed from national accounting data on property income divided by aggregate capital stock. We conclude that capital was more expensive in Canada.

Alternately an estimate of the relative Canada/U.S. price of capital can be derived directly from the formula used by Jorgensen (1974). The price of capital $P_t = q_{t-1}r_t + q_t\delta_t - (q_t - q_{t-1})$ (see Berndt, 1976) where q_t is the acquisition price of the asset, r_t is the rate of return, δ_t is the depreciation rate. If we assume depreciation rates are the same in the two countries, use Berndt's (1976, p. 62) depreciation estimates for equipment of .135 and structures .071, and weight by Latourette's (1968, p. 39) estimates of gross Canadian capital stock in structures and equipment, an estimate of δ of .0859 is obtained. Canadian 10 year corporate bond rates for the period 1920-1929 average 1.25 times those of the U.S.[12] Finally we assume Canada/U.S. relative prices reflected tariff rates on Building and Construction materials (10.65%) and on industrial equipment (19.4%)[13] weighted by gross capital stock estimates of Latourette (1968). This yields a relative acquisition price of 1.1269. Finally assuming $q_t = q_{t-1}$, the Jorgenson formula yields a relative cost of capital of 1.23—the same as our mean estimate of relative capital cost presented in Table 5.

12. Canadian Historical Statistics, 1966, series H591, U.S. Historical Statistics, 1960, series X489.
13. D.B.S. Annual Trade Report, 1925, p. 1476.

Table 5
Relative Canada/U.S. factor prices, intensities and shares across matched manufacturing industries, 1929

	Mean	Median	Observations
	percent		number
Relative factor prices			
Materials inputs	105	104	
Employees[1]	80	80	51
Capital[2]	123	112	13
Fuel/per BTU[3]	138	128	13
Electricity/per KWH	77	72	10
Fuel plus Electricity[5]	107		52
Relative factor intensity			
Primary horsepower[4] per employee[1]	85	78	130
Fuel expenditure per employee	94	76	130
Materials expenditure per employee	88	77	130
Factor shares			
Wages and salaries			
Canada	23.7	24.0	130
United States	24.2	24.2	130
Fuel			
Canada	2.4	1.1	130
United States	2.4	1.2	130
Principal materials			
Canada	47.4	47.2	130
United States	47.9	47.6	130

1. Employees include all wage and salary earners and proprietors.
2. Relative capital cost is defined using value-added minus wages and salaries per unit of primary horsepower.
3. Fuel consists of expenditures on coal, coke, oil and its products, gas and wood.
4. Primary horsepower consists of all engines plus electric motors run by purchased power (electricity).
5. Calculated using a divisia index from relative factor prices for fuel per BTU and electricity per KWH.

With lower labour and higher capital costs, it is not surprising that there were marked differences in relative input intensity. The median estimates of the relative Canada/U.S. horsepower/labour, fuel/labour, and materials/labour ratios are all about the same—78, 76 and 77% respectively. This means that partial labour productivity indexes are inappropriate statistics from which to draw inferences about relative efficiency.

Canadian and American factor shares are remarkably similar. Wages and salaries made up 23.7% on average of sales for Canada; 24.2% in the United States; fuel 2.4% in both; and materials 47.4% and 47.9% respectively. The fact that relative Canada/U.S. factor shares were so similar in the face of different factor prices is compatible with there being a unitary elasticity of substitution between factors.

While fuel costs were 38% higher in Canada per BTU, electricity was some 23% cheaper. As would be expected, in Canada a larger percentage of total electric motors were run with purchased power, and a larger percentage of primary power (engines plus motors using such used electricity) consisted of electric motors.

5 The Measurement of Relative Canada/U.S. Total Factor Productivity as of 1929

Because of the differences in Canadian and U.S. factor intensities, we need to calculate a total factor productivity measure, not a partial labour productivity measure, if we are to draw conclusions about Canadian inefficiency. Canada may well have had lower output per worker because it used less capital, less fuel and less materials per worker. One reason for this could simply have been that Canada was technologically backward, being slow to adopt the most advanced technology. On the other hand, it may have been a response to the different relative factor costs. With lower labour and higher capital costs, Canadian manufacturers might well have been expected to adopt lower capital/labour ratios.

This study adopts for a total factor productivity measure the commonly-used translog index (Allen, Gallop and Jorgenson, 1980). It is written as:

$$\ln TFP = \ln Q_c/Q_u - \sum_{i=1}^{N} \alpha_i \ln(X_{ic}/X_{iu}) \qquad (2)$$

where

Q = output

X_i = input i-capital (K) and labour (L)[14]

α_i = the cost share of input i

C = a subscript referring to Canada

U = a subscript referring to the U.S.

In the case of constant returns to scale,[15] equation #2 reduces to:

$$\ln (TFPc/TFP_u) = \ln ((Q_c/L_c) / (Q_u/L_u)) - \sum_{i=2}^{N} \alpha_i \ \ln((K_{ic}/L_c) / (K_{iu}/L_u)) \qquad (3)$$

and $\sum_{i=2}^{N} \alpha_i = 1 - \alpha_L$

and α_L is the output elasticity of labour.

Estimates of α_i are derived from the average factor shares of the matched Canadian and U.S. industries.

14. While it has become more common in the growth literature to make use of capital and labour services, we employ simple measures of capital stock and employment for reasons related to data availability.
15. If there are economies of scale and the measure in #2 is built up from micro-production functions, the right hand side would have an additional term (-s ln RELSIZE) where s is the degree of scale economies (s=1 when there are constant returns to scale, positive when there are increasing scale economies, negative when there are decreasing returns) and RELSIZE is the ratio of average Canadian to U.S. plant size. (See Baldwin and Gorecki, 1986 for derivation of this result).

Reformulation of the TFP index as equation #1 reported earlier serves to emphasize the reason that a TFP index will differ from the average labour productivity index that has been so often used for Canada/U.S. comparisons. Relative labour productivity is equal to relative total factor productivity (the measure of technical efficiency) and a term that is the product of the average share of GDP going to capital multiplied by the relative capital/labour ratios of the two countries.

If all relative factor input ratios are equal, the second term on the right hand side of #1 vanishes and the total factor productivity measure is just the relative output per worker measure.

Dales (1966, p. 98) had previously concluded that gross output per worker in Canada was only 70 to 80% that of American output per worker between 1926 and 1933. For our sample of 130 matched U.S. industries in 1929, the median of the relative output per worker fell in this range at 77%. As indicated above, the median for relative materials per worker was 77%, for relative horsepower, 78% and for relative fuel consumption, 76%. It is clear that Canada was relatively labour intensive in general and that a total factor productivity measure will be higher than a partial labour productivity measure.

Productivity indices can be calculated using either total production or value-added (production less some inputs such as materials and/or fuel). The latter was a popular choice for production function estimation and for productivity studies for a considerable time, partially because materials were regarded as being a fixed proportion of output and partially because early econometric techniques had difficulty in rejecting this assumption. Sims (1969) outlined the assumptions necessary for the use of a value-added function as opposed to total output. But the conditions that are necessary for estimating a value-added function have been questioned by Denny and May, 1977. Moreover, the use of value-added as an output measure in productivity studies may fail to catch important differences in material usage. This is particularly important in Canada/U.S. studies since Canadian materials input usage is generally higher than in the United States. This study sidesteps the theoretical issues and uses both output measures.

The inputs used are labour (total employment of salaried workers, wage earners, piece-workers and working proprietors), capital, fuel and materials. The total factor productivity variant that uses gross sales or output employs all these inputs. The value-added measures exclude materials or materials and fuel. The measurement of capital in productivity studies always provides difficult conceptual and empirical problems. More recent studies have available fixed capital stock estimates that are built up from investment flows; or book value measures based on annual reports. Work by Baldwin and Gorecki (1986) suggest that, at least when it comes to relative empirical estimates of Canada/U.S. capital stock, there is little to choose between the two approaches. In this study, we do not have either of these two dollar measures for individual industries in 1929. But relative horsepower and relative fuel purchased do exist. Both are used alternately as proxies for relative capital stocks. Conceptually, these relatives should be good proxies because of their relationship to motive power and therefore at least to capital invested in machinery and equipment. Corroborative evidence from attempts to estimate a capital stock using dollar values of investment suggests the horsepower proxy is accurate.[16]

16. See the data appendix for a discussion of this proxy. Horsepower was defined as the sum of horsepower in waterwheels, water turbines, steam turbines, internal-combustion engines and electric motors using rented power, what is called primary horsepower.

Table 6 presents the median estimates of the various productivity measures (the Canadian level is expressed as a % of the U.S. level) that were calculated along with definitions of each measure.[17] Two (RTVP and RVA) are partial labour productivity measures. Three (TFP1, TFP2 and TFP3) are total factor productivity measures based on gross output value. Three (TFP4, TFP5, TFP6) are total factor productivity measures based on different measures of value-added. The estimates are calculated for 127 matched Canadian/U.S. manufacturing industries in 1929.[18] TFP1 separates all factors and uses horsepower as a proxy for capital. TFP2 and TFP3 combine fuel and materials; and TFP3 uses fuel while TFP2 uses horsepower as a proxy for capital. TFP6 defines value-added net of materials only and considers labour, fuel and capital as inputs. TFP4 and TFP5 define value-added net of both materials and fuel; the first uses horsepower as a proxy for capital; the second uses fuel expenditures as the proxy for capital since it sometimes argued that this is a good alternate proxy for capital (Globerman, Reis, and Vertinsky, 1994). While our preferred measures are TFP1 and TFP6, we report the others to show how robust the results are to slight variations in the definitions.

The first column of Table 6 contains the productivity measures that make no correction for different Canada/U.S. prices. While the median of the partial labour productivity measures using total output (RTVP) and value-added (RVA) is only 77% and 81% respectively, the total factor productivity measures using gross output are around 97%, the value-added measures are about 94%.[19] For the sample as a whole, it makes little difference whether horsepower or fuel is used as a proxy for capital, whether fuel is included as a separate factor or added in with raw materials.[20] Finally, it should be noted that differences across Canada and the United States in definitions of the variables used biases our estimates of relative Canada/U.S. total factor productivity downwards, thereby indicating there was even less of a difference in the two countries than these estimates suggest.[21]

The productivity estimates reported in column 1 of Table 6 may be biased if Canadian and U.S. prices differed. In order to correct for price differences, we first calculated relative output prices for the products produced in each matched Canada/U.S. industry. Two relative output price indices were then calculated and applied to Canadian/U.S. value of output series.[22] The first used Canadian quantities as weights; the second used U.S. quantities as weights. By applying these indices only to output, the resulting total factor productivity measures based on gross output will be biased downwards to the extent materials prices were also higher in Canada than the United States. When Canadian quantity weights are used, the total factor productivity measure now has a lower median ranging from about 92% for the total output variant TFP1 to

17. We excluded hand trades and miscellaneous industries (i.e. miscellaneous food, vegetables, textiles, wood, non-ferrous metals, non-metallics and chemicals) from these estimates.

18. Rather than arbitrarily remove estimates we felt were subject to measurement error, we chose to report the median rather than the mean estimate to remove the effect of outliers.

19. That the measures differ depending upon whether gross output or value-added is used should not be interpreted to mean one is biased and the other is correct. They are measured at different levels of the production process and should be expected to differ because of this. For example, if both countries employed exactly the same inputs but Canada produced 4% less gross output and value-added was 50% of gross output, then the percentage deficiency in value-added would be 8%. A 4% deficiency at the level of gross output is equivalent to an 8% deficiency at the level of value added.

20. We also experimented with total horsepower—primary plus electric motors using internally-generated power. The results were so similar they are not reported.

21. Allowing for economies of scale would further reduce the TFP difference between Canada and the United States.

22. A discussion of the price indices is included in the data appendix.

91% for the value-added variant TFP6 (column II of Table 6). When U.S. weights are used, the result is about the same (column III).

Table 6
The median of Canada/U.S. partial and total factor productivity measures for the manufacturing sector (1929) for 127 matched industries

Productivity measure	No price correction	Output price correction (Canadian weights)	Output price correction (U.S. weights)
		percent	
RTVP	77	75	74
TFP1	97	92	92
TFP2	97	93	93
TFP3	97	95	93
RVA	81	74	79
TFP4	94	86	85
TFP5	91	89	87
TFP6	94	91	90

Notes:
RTVP = relative sales (production) per employed person. Employed persons is calculated as the sum of salaried personnel, production workers, piece-workers and proprietors.
TFP1 = total factor productivity based on sales, employment, materials, fuel expenditures and horsepower as a proxy for capital. Horsepower is defined as prime-mover = total horsepower minus electric motors using internally generated power.
TFP2 = total factor productivity based on sales, employment, materials and fuel expenditures combined, and horsepower relatives.
TFP3 = total factor productivity as in TFP2 except relative fuel expenditures are used in place of horsepower to proxy relative capital.
RVA = relative value-added per employed person where value-added is sales less materials and fuel expenditures.
TFP4 = total factor productivity using value-added, employment and horsepower as the capital proxy.
TFP5 = total factor productivity as in TFP4 but using fuel expenditures instead of horsepower as the capital proxy.
TFP6 = total factor productivity using value-added defined as sales less materials but not fuel, employment, fuel and horsepower as a proxy for capital.

The median estimates of total factor productivity presented in Table 6 could conceal undue concentration of Canadian production in sectors where inefficiency existed. Therefore weighted means of TFP1 were calculated.[23] The weights chosen are Canadian and U.S. value of production. For the TFP1 estimate that makes no correction for relative prices, the weighted mean is 96% using Canadian value of production and 97% using U.S. value of production as weights. The comparable median estimate from Table 6 was 97%. For the TFP1 estimate that uses relative output prices based on Canadian quantity weights to derive the price index, the weighted mean is 94% using Canadian value of production and 92% using U.S. value of production as weights versus the comparable median estimate in Table 6 of 92%. The median and the weighted means yield essentially the same result.

Because the use of output prices alone for deflation has been challenged in the literature, two additional deflation methods were used to test the robustness of our conclusion. For a 51 industry subset of the 137 industry matched set, relative input prices could be calculated. These input prices were used to recalculate the gross output productivity measures by deflating relative materials costs and to re-estimate the value-added total productivity measures by using the double-deflation method. These results are presented in Table 7. The first column reports the median of the estimates that make no correction for relative prices for the sub-sample where input prices were available. The second column contains the estimates that also take into account

23. For these estimates, we omitted the top and bottom 5% of our sample to reduce the effect of measurement error.

differences in relative input prices.[24] The differences between the various uncorrected and price–corrected estimates are sufficiently small to suggest that taking into account input price differentials does not affect the conclusion that inefficiency in the Canadian manufacturing sector was much smaller than has traditionally been suggested. For our purposes then, we can treat the original estimates that make no correction for prices as representative of the overall difference in efficiency between the Canadian and U.S. manufacturing sectors.

Table 7
The Median of Canada/U.S. Partial and Total Factor Productivity Measures for the Manufacturing Sector (1929) for Sub-sample of 51 Matched Industries where Relative Input Prices were Available

Productivity[1] measure	No price correction	Output price correction (Canadian weights) and input price corrections
	percent	
RTVP	78	78
TFP1	97	96
TFP2	97	96
TFP3	97	96
RVA	83	75
TFP4	93	90
TFP5	91	89
TFP6	93	94

1. For definitions of productivity measures, see Table 6.

As a final check on our result, we made use of the dual formulation to derive an index of relative inefficiency using relative prices and relative costs. Following suggestions by Sims (1966), Arrow (1974) and Diewert (1976), a divisia index of relative input prices was used where the input prices were weighted by their factor's respective share of value added. The wage rate was calculated from total wages and salaries. Capital cost was calculated as the quasi-rent accruing to capital (value added minus total wage and salaries divided by horsepower). The relative input price was that used previously. The divisia index (I) is:

$$I = \Pi \frac{P_{ic}}{P_{iu}} \bullet (S_{ic} + S_{iu}) /2$$

where

P_{ic} = the Canadian input price of factor i

P_{iu} = the U.S. input price of factor i

S_{ic} = the Canadian share of factor i in value-added[25]

S_{iu} = the U.S. share of factor i in value-added.

24. We also had relative fuel prices for a subset of our matched industries. Canadian fuel and electricity prices were about 7% higher than American. When we correct for relative fuel prices, no significant change occurs—because the relative fuel price is close to the relative materials price and the share of fuel is quite small.
25. The materials share is calculated from expenditures on materials and fuel. When fuel prices are used as a separate index, no significant change occurs.

The inefficiency measure TFP7 is then calculated as:

$\ln(TFP7) = \ln(P_c/P_u) - \ln(I)$

where

Pc = Canadian product price

Pu = U.S. product price.

This method yields a median estimate of inefficiency of 104.8%—almost exactly that of the dual approach based on quantities rather than prices reported for the same sub-sample in Table 7. This alternative approach does not change the observation that Canadian industry as a whole showed little inefficiency.

6 Conclusion

The major problem with a partial productivity measure such as output per worker that is used to show the 'inefficiency' of the Canadian manufacturing sector is that it does not allow us to draw specific conclusions about the cause of the problem. Ultimately, we must be interested in the reason for the differences between countries in such a measure. Lower output per worker ratios could arise if Canada was on a lower production frontier (technical inefficiency), or because factors were being combined in different proportions because of different factor costs. It also could be that Canada was at a different point on a production frontier that exhibits economies of scale. The results reported here suggest that a major reason for Canadian output per worker being lower than in the United States was the fact that Canada was combining more labour with all other inputs. When a total factor productivity measure is calculated, the level of technical inefficiency for the manufacturing sector is only about 3% to 5%. And we believe this overestimates the difference due to the data sources (see discussion in Appendix) and because no allowance has been made for economies of scale.[26] The traditional literature that leaves the impression that the Canadian manufacturing sector has always been grossly inefficient is wrong. At least by 1929, this was not the case.

This study then suggests that the use of partial productivity measures in international productivity comparisons may lead to very misleading results. We believe that this has consequences that extend beyond comparisons that just involve Canada/U.S. comparisons. In our case, U.S. output per worker was about a third higher than Canadian, but so too was all other factor usage relative to labour. The net result, when the TFP estimate was calculated, was to revise downward the measure of inefficiency from some 23% when the estimate is derived from comparing output per worker to less than 5% when relative TFP in the two countries is compared.[27] And given the nature of imperfection on both data and formulae used for the comparison, this estimate cannot be said to be different from zero.

26. See Baldwin and Gorecki (1986) for an estimate of the impact of economies of scale on estimates of relative Canada/US TFP. Baldwin, Gaudrealt and Harchaoui (2001) report the effect of excluding scale on the standard estimates of TFP growth in Canada.
27. This is also close to the relative TFP estimate reported by Keay using a different data set.

We believe these results have applicability to cross Atlantic studies of relative productivity. Taussig (1924) quoting work by the British economist Flux (1933) found that U.S. output per worker in blast furnaces, steel works and rolling mills was twice as high in the first decade of the century compared to the United Kingdom. But so was relative U.S./U.K. horsepower/worker. Frankel (1955) observed a similar finding in Rostas (1948). For a sample of industries in the early thirties, Rostas found U.S. output/worker to be about twice that of the U.K. But so too was the mean horsepower/worker ratio. Frankel in his 1957 study uses fuel/worker to correct for capital intensity and, as Kravis (1976, p. 37) reports, explains 19% of the variation in the relative labour productivity measure by this capital/labour proxy. Both because of this previous, often neglected work and our findings, we believe that conclusions of efficiency differences based on partial productivity measures can be very misleading.

Perhaps the most important question that needs to be addressed is the extent to which capital/labour substitution affects efficiency. Our measure of relative total factor productivity sidesteps this issue. Yet there is a literature (eg. Kaldor, 1967; Diwan, 1970) which stresses that capital substitution affects labour productivity in a way that is not caught by the total factor productivity measure used. In addition, it is of importance to trace changes in Canada/U.S. efficiency prior to and after 1929.[28] While value-added per worker in Canada relative to the U.S. grew between 1900 and 1929, we need good estimates of total factor productivity over this period to see whether 1929 was the high-point or whether Canadian industry rarely lagged behind its American counterpart in the early decades of the century. Finally, the gap in our knowledge about the change that occurred between 1929 and the post World Was II era needs to be eliminated. If post 1945 studies are correct, there has been a dramatic increase subsequent to 1929 in relative Canada/U.S. capital/labour ratios with little increase in relative output per worker. But the major problem will lie in finding a measure of relative capital intensity that avoids the problem of imprecise measures of the relative price of capital equipment and structures. This study was fortunate that the 1929 Censuses of Canada and the United States collected data that allowed this issue to be addressed directly.

7 Appendix

Data: Definitions and Comparability

The data for the individual industry comparisons were obtained by developing a matched set of industries using the Canadian and U.S. Census of Manufactures for 1929. In 1929, the Canadian census listed 168 separate industries; the U.S. total was 328. In the end, after aggregating industries in both countries, we ended up with 137 industries (127 excluding all miscellaneous categories). In matching industries, we made use of product information for individual industries.

In the main, variables were defined in a similar way in the two countries. The differences, when they exist are not critical to our results. Canada defined value of production as value of products produced, while the U.S. used value shipped. However, the U.S. Census investigated whether its use of value shipped rather than produced made much of a difference, and concluded it did not (Fabricant, 1940).

28. Keay (2000) uses data on a select number of firms to begin this process.

Materials costs were defined in a similar fashion except for two minor differences. Canada excluded returnable containers and included some contract work; the United States did the reverse. Contract work is relatively unimportant except in the clothing industry. This difference biases our estimates of relative Canada/U.S. total factor productivity downwards.

In the absence of dollar value of capital stock, we resorted to horsepower as a proxy. We chose to compare primary horsepower—the sum of horsepower produced by steam engines, internal combustion engines, water wheels and turbines and electric motors using purchased power. Both countries measured horsepower similarly—as rated capacity rather than power used; however, American coverage is less than 100%. We have made no correction for this since it is likely (though not specifically admitted) that Canadian coverage was imperfect. If this is not so, the lower U.S. coverage once more biases our estimates downward.

Some effort was devoted to checking the accuracy of the capital proxy. We examined the ratio of relative Canada/U.S. capital stock derived from census book values and relative horsepower for the years prior to 1929 when both countries reported book value of capital and horsepower and found horsepower closely proxied capital. We traced the growth of horsepower and U.S. real capital stock (Creamer, Dobrovolsky and Borenstein, 1960) for each decade from 1899 to 1929 and found they moved closely. But perhaps our best evidence is that our estimate of the median Canada/U.S. ratio of output per horsepower is 1.05 (with a mean of 1.16). Latourette (1968) obtains very similar ratios when he builds a capital stock from investment flows.

Similar definitions were employed in both countries for the labour force—though measurement practice differed. In the U.S., the number of production workers was derived by dividing by 12 the sum of monthly figures—the latter being the simple sum of establishment totals for the month. In 1929, Canada did essentially the same but adjusted its measure by dividing the sum by the number of months establishments were in operation—thereby taking into account seasonal operation. This will once more bias our calculated TFP ratios against Canada.

Wage and salary costs were defined similarly in the two countries except that the United States did not include an imputation for income derived by proprietors while Canada did so. Kuznets (1941) estimate for the size of this component suggests this creates little bias.
When it comes to establishment definitions, there were some important differences. In Canada, an establishment if defined as an operating unit—basically a single plant; the United States however occasionally grouped closely-located plants. The coverage of establishments in the two countries also differed. In 1929, the United States defined an establishment as one having a value of shipments of $5,000 or more. In Canada, all establishments regardless of size were included. As a result of both differences, our estimates of relative plant size presented in Table 4 are biased downwards.

In order to correct for output price differences between the two countries in 1929, Canadian and U.S. wholesale price data were used to calculate price relatives for that year using a Tornqvist divisia index. Data on U.S. prices came from (1) the *Products of Manufacturing Industries, 1929* bulletin published as part of the 15th Census of the United States, 1930, and in some cases form (2) the *Biennial Census of Manufacturing*, 1931, which essentially reproduces the information in the Bulletin. Data on Canadian prices were compiled from several different sources. The first choice was always the individual industry studies published by the Dominion Bureau of Statistics. In some cases, we were able to use unpublished information that was not confidential to fill in gaps. As not all industries were covered by these publications, and not all industries had information that was sufficiently extensive for our purposes, it was necessary to make use of supplementary sources. These include 1) the D.B.S. publication *Prices and Price Indices* and 2) the *Canada Year Book*, 1932.

Relative Canadian and U.S. wholesale price indexes were drawn up for the 137 matched industry categories. In many cases, we were able to generate relative prices for the components of the subsectors. Two relative prices were calculated using Tornqvist Divisia indexes. The first (RPC) used Canadian quantity weights; the second (RPU) used U.S. quantities as weights. When commodity data were not available for a category, a third price (RPA) was calculated as the average of like industries—generally those within the same 2-digit category. Of the 137 sectors, detailed price information was available for 75 of our matched industries to calculate RPC or RPU. We were only able to match 51 industries for input prices.

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