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**The Industry Origins of Canada's Weaker
Labour Productivity Performance and the
Role of Structural Adjustment in the
1990s and the 2000s**

by John R. Baldwin and Michael Willox

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- ^P preliminary
- ^r revised
- X suppressed to meet the confidentiality requirements of the *Statistics Act*
- ^E use with caution
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- * significantly different from reference category ($p < 0.05$)

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Abstract

This paper examines how much of the slowdown in productivity growth observed in Canada's business sector between the 1990s (1990 to 1999) and the 2000s (2000 to 2014) was due to weaker productivity growth within industries and how much was due to structural adjustment. The analysis makes use of a decomposition method that differs from many of the standard labour productivity decomposition approaches commonly found in the literature and allows the contributions of changes in the importance of individual industries to be calculated. The approach developed here reveals that the inter-period slowdown was attributable almost entirely to weaker productivity growth within industries and that structural adjustment had a slight mitigating effect on the slowdown. Lower productivity growth within three industries—manufacturing; finance, insurance and real estate; and mining, oil and gas—accounted for much of the moderation in business-sector labour productivity growth in the 2000s.

Keywords: Labour productivity, structural adjustment

Executive summary

Canada's business-sector labour productivity growth slowed by more than a quarter in the 2000s (2000 to 2014) from the pace set in the 1990s (1990 to 1999). This paper examines the extent to which this slowdown was the result of weaker productivity growth within industries (that is, whether all industries or only a relatively small number of industries experienced a slowdown) and how much of it was due to the restructuring of the economy as labour shifted between industries characterized by different productivity levels.

In this study, productivity growth for the business sector is separated into two distinct components: a *direct productivity growth effect*¹ and the effect of the changing importance of different industries—or *structural adjustment*. The paper estimates each of these effects for individual industries, thereby allowing inferences to be made about the extent to which the performance of individual industries was responsible for the changes in aggregate performance of the business sector as a whole.

The direct productivity growth effect captures the impact of changes in an industry's labour productivity (measured as real value added per hour worked) while the relative importance of different industries is held constant. Structural adjustment captures the impact of the reallocation of labour across industries on aggregate productivity growth. The interdependencies of structural adjustment across industries, which other studies performing similar decompositions have overlooked, are incorporated here. These interdependencies are assessed using alternate counterfactuals with respect to the nature of the adjustment process.

The paper's findings are as follows:

- The inter-period slowdown was attributable almost entirely to weaker direct productivity growth in the manufacturing; finance, insurance and real estate; and mining, oil and gas sectors.
- In the 1990s, the effects of structural change reduced overall productivity growth slightly. In contrast, the contribution from structural change in the 2000s to aggregate productivity growth was modestly positive, helping to mitigate the overall slowdown that resulted from weaker direct productivity growth in some industries.
- The manufacturing sector's decline, associated with structural adjustment, had only a marginally negative impact on the business sector's productivity growth. The impact was limited because the level of productivity of the manufacturing sector was only slightly higher than the average for all industries in the business sector. By comparison, reduced productivity growth within manufacturing accounted for all of the inter-period slowdown in business-sector productivity growth.
- The finance, insurance and real estate sector also contributed negatively to aggregate productivity growth in the 2000s as a result of slower direct productivity growth, which outweighed the positive effect from structural adjustment associated with growth in that sector's relative importance and its relatively high productivity level.
- The mining, oil and gas sector's negative contribution, stemming from its direct productivity growth effect in the 2000s, was offset—to a much larger extent than in finance, insurance and real estate—by the positive impact of structural adjustment, reflecting strong growth in the relative importance of this relatively high-productivity sector.

1. The direct productivity growth effect is sometimes referred to as the within-industry productivity growth effect.

1 Introduction

During the period from 2000 to 2014 (referred to hereinafter as “the 2000s”), Canada’s business-sector labour productivity growth slowed to an average annual rate of 1.17%, from 1.61% in the 1990s (1990 to 1999). Canada’s weaker productivity performance in the 2000s contrasts with the comparatively stable performance of the U.S. business sector. Business-sector productivity growth in the United States fell slightly between the two periods, decreasing from an annual rate of 2.12% in the 1990s to 2.08% in the 2000s, a pace nearly 80% faster than that observed in Canada.

Changes in productivity have an impact on Canadians’ standard of living. Wages (after adjusting for inflation) typically grow at roughly the same pace as real labour productivity.² While other factors, such as stronger labour force participation and increasing terms of trade, also contribute to improved standards of living, productivity growth is a key driver of real gross domestic income in the long run.³

To better understand the nature of Canada’s slowdown between the 1990s and the 2000s, the different ways in which industries contribute to the growth of labour productivity in Canada’s business sector will be examined here. In this study, productivity growth for the business sector is separated into two distinct components: a *direct productivity growth effect* and the effect of the changing relative importance of different industries—or *structural adjustment*.

The first component, the direct productivity growth effect (sometimes referred to as the ‘pure,’ or ‘within-industry,’ effect), captures the impact of changes in an industry’s labour productivity (measured as real value added per hour worked) while holding the relative importance of different industries constant. This component captures the effect of the change in productivity occurring within each industry.

The second component, structural adjustment, captures the impact on aggregate productivity growth of the reallocation of labour across industries. Reallocation occurs as a result of many forces. In the 2000s, Canada faced an appreciation of its currency, particularly against the U.S. dollar, increasing competition from emerging economies, rising commodity prices, and relatively weak U.S. demand for Canadian exports. These forces benefited some industries while others were adversely affected. For example, the manufacturing sector saw its average share of labour (measured as hours worked) decline from 18.8% in the 1990s to 15.0% in the 2000s; this reflects a secular decline that intensified in the 2000s. On the other hand, the share of labour in construction, which benefited from the natural-resource and housing boom as well as from low interest rates, increased 1.2 percentage points from 8.8% to 10.0%.

Separating aggregate productivity growth into these two components allows analysts to focus on each in isolation from the other. The examination of the sources of direct productivity growth—the measure of organic growth—permits an assessment of whether the productivity slowdown was widespread—and therefore perhaps endemic—or whether it came from specific sectors and therefore might be explained by specific circumstances. At the same time, the examination of the structural adjustment component allows a determination of the extent to which the overall slowdown in productivity growth came not from the performance of specific industries but from industrial restructuring.

To that end, the approach to decomposing aggregate labour productivity developed here reveals that measuring the impact of structural adjustment within one industry cannot be done without considering the effect of the structural adjustment in other industries. The interdependencies of

2. See Baldwin et al. 2014, Chart 2.

3. Increases in the terms of trade in the 2000s offset the weakness in productivity growth during this period. See Baldwin et al. 2014, Chart 12.

structural adjustment across industries have typically been overlooked in studies that have attempted to assess industry contributions to aggregate labour productivity. In filling this gap, this study lays the groundwork for further debate on the nature of structural adjustment: how to better measure it and how to better understand its impact on aggregate labour productivity.

2 Analytical framework

Several studies, including those by Nordhaus (2001), Stiroh (2002), and Tang and Wang (2004), have decomposed aggregate labour productivity growth into a direct productivity growth effect and a structural adjustment effect. However, as de Avillez (2012) pointed out, the variation between methods provides complementary, rather than competing, stories as they tend to produce similar results in most cases. Stiroh's (2002) approach, represented in Equation (1), is chosen here to begin, for two reasons: it has been widely used in the literature; and it is relatively easy to interpret since it neatly decomposes aggregate labour productivity growth by industry into the direct productivity growth effect and structural adjustment.⁴ By comparison, the approaches followed by Nordhaus (2001), Tang and Wang (2004) and de Avillez (2012) are made more complex by the fact that they have included an interaction term, the interpretation of which is seldom agreed upon.

$$\Delta \ln \left(\frac{Y_t}{H_t} \right) = \sum_{i=1}^N \left[\bar{S}_{i,t}^{VA} \Delta \ln \left(\frac{Y_{i,t}}{H_{i,t}} \right) + \bar{S}_{i,t}^{VA} \Delta \ln \left(\frac{H_{i,t}}{H_t} \right) \right] \quad (1)$$

The left-hand side of Equation (1) is the percentage change in aggregate labour productivity growth expressed as the change in the logarithmic value ($\Delta \ln$) of real value added (Y) per hour worked (H) for a given period of time (t). On the right-hand side, the first term in square brackets represents industry i 's contribution to aggregate productivity from the direct productivity growth effect, and the second term is a measure of industry i 's contribution that comes from structural adjustment. By construction, these two terms equal aggregate productivity growth when summed across all industries. The direct productivity growth effect for industry i is calculated by multiplying the industry's weight ($\bar{S}_{i,t}^{VA}$) by the percentage change in its labour productivity ($\Delta \ln(Y_{i,t}/H_{i,t})$). The contribution from structural adjustment for industry i is calculated as the industry's weight multiplied by the percentage change in its labour share ($\Delta \ln(H_{i,t}/H_t)$), which is expressed as the growth in the ratio of industry i 's hours worked to the hours worked in the aggregate sector. Stiroh (2002) calculated industry weights as the share of industry i 's nominal value added (VA) in the aggregate sector averaged over the current and previous periods, t and $t-1$, respectively, as represented in Equation (2).

$$\bar{S}_{i,t}^{VA} = \left(\frac{VA_{i,t-1}}{VA_{t-1}} + \frac{VA_{i,t}}{VA_t} \right) / 2 \quad (2)$$

An increase (decrease) in productivity of an industry leads directly to a larger (smaller) direct productivity growth effect in absolute terms. This effect will be absolutely larger (smaller) if the industry has a relatively larger (smaller) share of nominal value-added output. This occurs when the industry has a larger (smaller) share of labour and a relatively high nominal output per worker.

The calculation of the impact of a change in the importance of an industry is more complex. If an industry's labour share increases (decreases), its contribution to aggregate productivity will also increase (decrease)—as shown in the second term in square brackets in Equation (1). As with

4. This equation provides an approximation, which results from the use of logarithmic growth rates to approximate the growth rates in question.

the direct productivity growth component, an industry's contribution from structural adjustment will be larger when the industry has a relatively larger share of nominal value-added output.

There is, however, an important difference in how the impact of a change in a particular industry's importance needs to be assessed. For the direct productivity growth effect, a change in one industry's labour productivity does not necessarily change the productivity of any other industry. Thus, the impact of one industry can be estimated independently of the effect of another industry. In this case, productivity growth among industries generally is not a zero-sum game, in which one industry's gain is another's loss.

In contrast, measuring structural adjustment requires that the labour shares for all industries sum to one (or 100%); therefore, an increase in the labour share of one industry must be offset by a decrease of the exact same magnitude in one or more other industries. Note that the second term in square brackets of Equation (1) accounts only for the structural adjustment that occurs in a single industry (industry i) when, for instance, its labour share increases. This term does not capture the decline in the labour shares of the other industries that must accompany this increase. The effect on all other industries of one industry growing in relative terms is effectively treated as zero; this causes the individual industry structural adjustment effect, when measured independently, to be incorrectly estimated. For this reason, many studies that use this decomposition refer only to the *aggregate* structural effect derived as the sum of all industry effects; they do not refer to individual *industry* structural effects.

The production of accurate single industry estimates that take into account interdependencies across industries requires the stipulation of where the labour share gains (losses) come from—a counterfactual.^{5,6} The counterfactual developed here assumes that the labour share gain (loss) for an industry comes from (is distributed to) all other industries in proportion to their hours worked at the beginning of the period—a result that would be generated by a stochastic process that presumes the labour share of all other industries has the same probability of being shifted to the industry in question, which may be referred to as a “stochastic” counterfactual.⁷ This is equivalent to assuming that, without the share change in industry i , there would have been no change in the relative share of any industry. For illustration, an alternative “gainers-versus-losers” counterfactual, in which industries that gain labour share do so directly from those that lose labour share, is described in the Appendix.

The effect of inter-industry structural adjustment using the above assumptions is measured by means of a modified version of the Stirih formula, that is:

$$\Delta \ln \left(\frac{Y_t}{H_t} \right) = \sum_{i=1}^N \left[\bar{S}_{i,t}^{VA} \Delta \ln \left(\frac{Y_{i,t}}{H_{i,t}} \right) + \bar{S}_{i,t}^{VA} \Delta \ln \left(\frac{H_{i,t}}{H_t} \right) + \sum_{j=1, j \neq i}^N \bar{S}_{j,t}^{VA} \Delta \ln \left(\frac{H_{j,t}^i}{H_t} \right) \right], \quad (3)$$

where the first term on the right-hand side in square brackets is the *direct productivity* growth effect, as in Equation (1). The second term in square brackets is the *own-industry* structural adjustment term, which is also unchanged from Equation (1). This term does not in any way capture how other industries' labour shares change in response to the change in industry i 's labour share. The third term on the right-hand side in square brackets measures the *inter-industry* structural adjustment and is the additional term—it accounts for the corresponding change in all

5. Denison (1979, Chapter 5) is one of the few that have calculated the structural effect explicitly and expressed the need for a counterfactual. More recent discussions can be found in Baldwin and Gu (2006).

6. The directionality of these changes can be estimated in some cases (see Baldwin and Rafiquzzaman [1995]). This was not attempted here.

7. Actual hours worked do not have to be shifted by workers moving from one industry to another (although this might occur). Aggregate productivity may change over time if industries all grow at differential rates; thus, the economy restructures in terms of changing the relative importance of different industries.

other industries' labour shares. The inter-industry structural adjustment term for each of the other j industries is defined as

$$\frac{H_{j,t}^i}{H_t} = \frac{H_{j,t-1}}{H_{t-1}} - \left(\frac{H_{i,t}}{H_t} - \frac{H_{i,t-1}}{H_{t-1}} \right) \frac{H_{j,t-1}}{(H_{t-1} - H_{i,t-1})}. \quad (4)$$

The sum of the inter-industry structural adjustment terms in the other j industries measures the impact of the offsetting labour share decline (increase) when the labour share of industry i increases (decreases). This sum constitutes the required changes in the labour shares of other industries that occur in response to a change in any particular industry's labour share. Inclusion of this term is required to measure the full impact of a change in the relative importance of a particular industry. Simultaneous consideration of the own-industry and inter-industry structural terms has the effect of producing a more complete measure of the total structural adjustment that should be attributed to any one industry.⁸ However, it does not change the estimate of the overall impact of structural adjustment across all industries because the individual inter-industry terms of all industries sum approximately to zero.⁹

3 The aggregate impacts of the direct labour productivity growth and structural adjustment effects in the 1990s and the 2000s

Estimates of differences in both the aggregate direct productivity growth component and the aggregate structural adjustment component between the 1990s and the 2000s reveal that the origins of the slowdown in Canada's aggregate business-sector productivity growth are associated mostly with overall direct productivity growth effects rather than with the overall impact of structural adjustment.¹⁰

In the 1990s, the changes in business-sector labour productivity came largely from the positive impact of the aggregate annual direct productivity growth component (+1.80%), which was slightly offset by the aggregate structural adjustment component (-0.18%) (Chart 1). By comparison, the average aggregate annual direct productivity growth component (+0.94%) and the aggregate structural adjustment component (+0.23%) in the 2000s were both positive. In the 1990s, the direct effect contributed all of the growth in productivity. In the 2000s, the direct term contributed just over three-quarters of the growth in productivity.

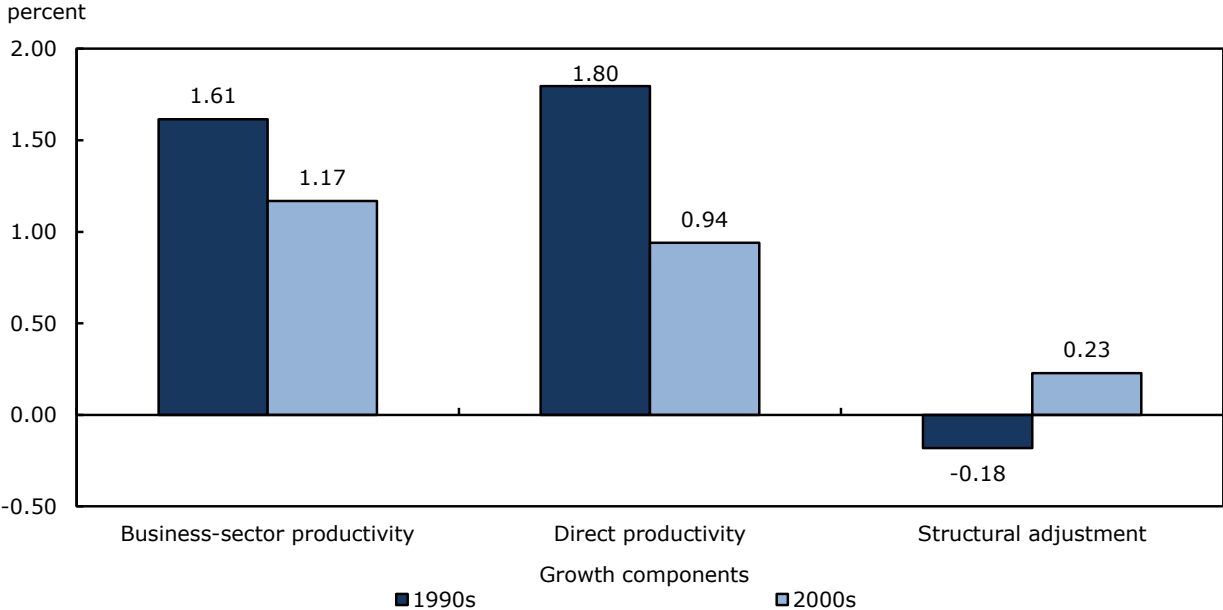
8. While the measure produced is more complete, its accuracy depends on the suitability of the counterfactual used to estimate it. In the absence of information on the nature of the replacement process, the chosen assumption was that the replacement follows a general stochastic process. The paper examined whether use of an alternate assumption affects the conclusions about the relative impact of structural changes across industries.

9. The sum is not exactly zero due to the industry weights in Equation (4), $H_{j,t-1} / (H_{t-1} - H_{i,t-1})$; these are used to reallocate the change in industry i 's labour share to all other industries. It would be more mathematically accurate to reallocate the change to all industries including industry i in proportion to their hours worked in period $t-1$. However, there is little economic rationale to an industry reallocating labour share to itself. Distributing the change in industry i 's labour share to all industries in equal proportion, regardless of industries' relative sizes, is also counterintuitive.

10. The data used here are taken from Statistics Canada's productivity accounts database, which provides an integrated set of industry accounts containing data on output and labour measured as hours worked. The data on real value added are Fisher-chain-linked indices from CANSIM table is 383-0021. This table also provides information on labour compensation and the cost of capital services. The growth rate of the sum of these two variables was used to extend nominal gross domestic product to 2014 for the business sector and individual industries.

The aggregate direct productivity growth component was reduced by half between the 1990s to the 2000s. In contrast, the impact of the aggregate structural adjustment contribution increased 0.41 percentage points. This change in the contribution of structural adjustment, turning from negative in the 1990s to positive in the 2000s, helped mitigate the overall slowdown resulting from weaker direct productivity growth in some industries.

Chart 1
Components of annual average business-sector labour productivity growth



Note: Business-sector productivity growth is the sum of direct productivity growth and structural adjustment, although the sum of the figures may not correspond to the totals shown because of rounding.

Source: Statistics Canada, authors' calculations based on data from CANSIM table 383-0021.

Taking note of the individual industry productivity growth rates and changes in labour shares provides important context for estimating the impact of individual industries on the aggregate direct effect term. Table 1 contains the changes in productivity growth at the industry level over the two periods. The largest declines between the two periods (in decreasing order) occurred in mining, oil and gas; manufacturing; and finance, insurance and real estate. Excluding smaller declines in utilities and transportation and warehousing, all other industries experienced improved productivity growth in the 2000s compared with the 1990s. The largest improvements between the two periods occurred in the industries that had the poorest performance in the 1990s (arts and entertainment, other private services and accommodation and food), which continued to perform poorly in the 2000s compared with the business sector as a whole.

Table 1
Business-sector and industry labour productivity growth

	1990s	2000s	Difference
	percent		percentage points
Business sector	1.61	1.17	-0.45
Industry¹			
Agriculture, forestry, fishing and hunting	3.18	3.84	0.66
Mining and oil and gas extraction	3.16	-2.92	-6.08
Utilities	1.44	0.20	-1.24
Construction	-0.31	0.15	0.46
Manufacturing	3.42	1.59	-1.83
Wholesale trade	2.11	3.17	1.07
Retail trade	1.96	2.22	0.25
Transport and warehousing	1.68	1.11	-0.57
Information and cultural industries	1.21	2.15	0.94
Finance, insurance, real estate and renting and leasing	2.67	1.21	-1.46
Professional, scientific and technical services	0.21	1.23	1.03
Administrative and support, waste management and remediation services	-0.21	0.31	0.52
Arts, entertainment and recreation	-1.79	0.16	1.95
Accommodation and food services	-0.84	0.70	1.54
Other private services	-0.74	1.03	1.77

1. Industry is defined by the 2-digit North American Industry Classification System (NAICS).

Note: The sum of the figures may not correspond to the totals shown because of rounding.

Source: Statistics Canada, authors' calculations based on data from CANSIM table 383-0021.

The mining, oil and gas sector, which recorded an annualized 2.92% decline in labour productivity in the 2000s, contrasts with every other industry in this regard: labour productivity in the other industries examined grew at a simple average rate of 1.36% per year during this period.¹¹ As well, the mining, oil and gas sector had the largest deceleration in labour productivity (+6.08 percentage points) from the average annual growth rate recorded in the 1990s. Labour productivity growth in mining, oil and gas was among the fastest of all industries in the 1990s, expanding at an annual pace of 3.16%; by contrast, labour productivity growth was 1.61% in the business sector during the same period. The strong productivity performance in mining, oil and gas relative to that in most other industries during the 1990s was mostly due to the decline in hours worked. Hours worked in mining, oil and gas fell 0.61% annually, while hours worked in the business sector expanded at an annual pace of 1.13%. Despite the contraction in labour, real value added in the mining, oil and gas sector grew at a rate of 2.53% per year in the 1990s, a rate moderately slower than that recorded for the business sector (+2.74%).

After the mining, oil and gas sector, the next-largest productivity slowdown was observed in manufacturing, where productivity growth decreased 1.83 percentage points, falling from 3.42% annual growth to 1.59% between the two time periods, while the finance, insurance and real estate sector recorded a decline of 1.46 percentage points.

An examination of the productivity growth rates by industry alone suggests that the mining, oil and gas sector was the key source of Canada's productivity slowdown. However, when relative size of industries is taken into account, the industry origins of the slowdown across mining, oil and gas; manufacturing; and finance, insurance and real estate converge, while the slowdown for utilities and transportation and warehousing become comparatively minor (Table 2). The increased similarity, especially between mining, oil and gas and manufacturing, reflects the fact

11. See Bradley and Sharpe (2009) and Sharpe and Waslander (2014) for an extensive discussions of the oil and gas sector's productivity performance over the 1990s and 2000s.

that nominal value added (which serves as weights) in the mining, oil and gas sector is just over half the size of that in manufacturing and roughly two-thirds as large as that in finance, insurance and real estate on average over the period from 2000 to 2014. When industry weights are taken into account, the contribution from direct productivity growth in these three industries accounted for 0.46, 0.47 and 0.23 percentage points, respectively, of the decline in business-sector productivity growth between the two periods.

Table 2
Contributions to business-sector labour productivity growth from the direct labour productivity effect

	1990s	2000s	Difference
	percentage points		
Business sector	1.80	0.94	-0.86
Industry¹			
Agriculture, forestry, fishing and hunting	0.10	0.09	-0.01
Mining and oil and gas extraction	0.15	-0.31	-0.46
Utilities	0.06	0.00	-0.06
Construction	-0.03	0.00	0.03
Manufacturing	0.76	0.29	-0.47
Wholesale trade	0.15	0.22	0.07
Retail trade	0.13	0.15	0.02
Transport and warehousing	0.09	0.06	-0.03
Information and cultural industries	0.05	0.09	0.04
Finance, insurance, real estate and renting and leasing	0.41	0.18	-0.23
Professional, scientific and technical services	0.02	0.08	0.07
Administrative and support, waste management and remediation services	-0.01	0.01	0.02
Arts, entertainment and recreation	-0.02	0.00	0.02
Accommodation and food services	-0.03	0.02	0.05
Other private services	-0.04	0.06	0.10

1. Industry is defined by the 2-digit North American Industry Classification System (NAICS).

Note: The sum of the figures may not correspond to the totals shown because of rounding.

Source: Statistics Canada, authors' calculations based on data from CANSIM table 383-0021.

4 Changes in industry labour shares in the 1990s and the 2000s

Restructuring that affected the relative importance of industries took place between the 1990s and the 2000s (Table 3). The manufacturing sector experienced the largest absolute change in labour share, falling from 18.76% to 14.99% (a 20% decline). Some of the largest proportionate changes occurred in administration and waste management (+44%) and agriculture, forestry and fishing (-39%). Other industries that experienced large absolute changes in labour shares include professional, scientific and technical services and construction. Even though the mining, oil and gas sector had a 24% gain in its labour share, increasing in absolute terms from 1.47% to 1.82%, the gain was small in relative terms.¹²

12. Other structural changes took place within the 1990s and 2000s. The labour share in wholesale trade, for example, rose sharply from 6.5% in 1990 to a peak of 7.2% in 1997. Its share remained stable near that level until 2001, after which, it fell to a low of 6.3% in 2014. The average labour share in wholesale trade was roughly 6.8% for both periods, obscuring the strong trends and associated structural adjustment within each of the two periods.

Table 3
Shares of hours worked in the business sector

	1990s	2000s	Difference
	percent		percentage points
Business sector	100.00	100.00	0.00
Industry¹			
Agriculture, forestry, fishing and hunting	5.58	3.39	-2.19
Mining and oil and gas extraction	1.47	1.82	0.35
Utilities	0.93	0.80	-0.12
Construction	8.81	10.04	1.23
Manufacturing	18.76	14.99	-3.77
Wholesale trade	6.80	6.75	-0.05
Retail trade	13.03	12.65	-0.38
Transport and warehousing	5.98	6.18	0.20
Information and cultural industries	2.18	2.38	0.21
Finance, insurance, real estate and renting and leasing	9.11	9.37	0.27
Professional, scientific and technical services	5.79	7.54	1.75
Administrative and support, waste management and remediation services	4.12	5.94	1.82
Arts, entertainment and recreation	1.36	1.78	0.42
Accommodation and food services	7.31	7.28	-0.03
Other private services	8.77	9.08	0.30

1. Industry is defined by the 2-digit North American Industry Classification System (NAICS).

Note: The sum of the figures may not correspond to the totals shown because of rounding.

Source: Statistics Canada, authors' calculations based on data from CANSIM table 383-0021.

5 The importance of total structural adjustment by industry in the 1990s and the 2000s

In this section, total structural adjustment is estimated as the sum of two terms. The first term is own-industry structural adjustment as measured by the second term on the right-hand sides of both Equation (1) and Equation (3). However, as noted in Section 2, the own-industry term for an individual industry is only a partial measure of the impact of a change in labour share of that industry on structural adjustment. Interpreting the own-industry term as an industry's impact on total structural adjustment is misleading since it is a partial derivative. What is required is the equivalent of a total derivative.¹³ It is only once the impact of interdependencies associated with labour reallocation across industries—what is referred to here as the inter-industry structural adjustment term—is subtracted from the own-industry term that the total impact of an industry-level structural adjustment can be estimated.¹⁴ A comparison of the two for select industries reveals the size of the potential error from not taking into account the interdependencies (Table 4).¹⁵

13. Stiroh (2002) reported only aggregate values for structural adjustment and did not report any at the industry level, though it has become common to do so since.

14. A variation of the counterfactual used here was also considered—where the sum of the labour share gains across industries was proportionately distributed only to the industries that lost labour share rather than to all industries. Using this counterfactual did not substantially change the findings about which three industries played the largest role or the findings on industries' relative importance in the 2000s productivity growth slowdown. For results, see the Appendix.

15. See de Avillez (2012) and Tang and Wang (2004) for examples of studies that do not take this into account.

A large adjustment is required for the manufacturing sector. The own-industry component suggests that, in the 2000s, manufacturing's structural adjustment effect subtracted almost half a percentage point from business-sector productivity growth. However, using only this component to measure the total impact of increasing manufacturing's share is misleading since the manufacturing sector's inter-industry component has the opposite sign, and at -0.41 percentage points is nearly as large. The total structural adjustment is the sum of these two terms (own-industry and inter-industry), which is close to zero (-0.01 percentage points). This suggests that total structural adjustment for the manufacturing sector subtracted almost nothing from productivity growth in the business sector and reflects the fact that the manufacturing sector's level of labour productivity in the 2000s was only moderately higher than the average for the business sector. Therefore, a large amount of structural adjustment, as occurred in manufacturing, does not necessarily translate into a large change in aggregate labour productivity.

Like the manufacturing sector, agriculture, forestry and fishing—a low-productivity industry—lost labour share in the 2000s. The large inter-industry component (+0.13 percentage points) more than offset the own-industry component (-0.08 percentage points) for this sector. The relative reallocation of labour resources away from this low-productivity industry to other industries that, on average, had higher productivity produced an overall positive contribution from total structural adjustment of 0.05 percentage points to business-sector productivity growth.

Table 4
Own-industry and inter-industry components of structural adjustment

	Own-industry			Inter-industry		
	1990s	2000s	Difference	1990s	2000s	Difference
	percentage points					
Business sector	-0.17	0.25	0.41	-0.01	-0.02	0.00
Industry¹						
Agriculture, forestry, fishing and hunting	-0.08	-0.08	0.00	0.13	0.13	0.00
Mining and oil and gas extraction	-0.08	0.38	0.45	0.02	-0.06	-0.09
Utilities	-0.06	0.00	0.05	0.01	0.00	-0.01
Construction	-0.17	0.25	0.42	0.18	-0.30	-0.48
Manufacturing	-0.32	-0.47	-0.14	0.28	0.41	0.13
Wholesale trade	0.07	-0.05	-0.12	-0.07	0.05	0.12
Retail trade	-0.02	0.00	0.02	0.04	-0.01	-0.05
Transport and warehousing	0.04	0.00	-0.04	-0.04	-0.01	0.04
Information and cultural industries	0.08	-0.02	-0.10	-0.04	0.01	0.05
Finance, insurance, real estate and renting and leasing	-0.02	0.10	0.12	0.00	-0.06	-0.06
Professional, scientific and technical services	0.18	0.06	-0.12	-0.20	-0.07	0.13
Administrative and support, waste management and remediation services	0.08	0.05	-0.03	-0.13	-0.09	0.04
Arts, entertainment and recreation	0.03	0.00	-0.02	-0.04	0.00	0.04
Accommodation and food services	0.02	-0.01	-0.02	-0.05	0.01	0.06
Other private services	0.07	0.01	-0.06	-0.11	-0.03	0.09

1. Industry is defined by the 2-digit North American Industry Classification System (NAICS).

Note: The sum of the figures may not correspond to the totals shown because of rounding.

Source: Statistics Canada, authors' calculations based on data from CANSIM table 383-0021.

The industries that gained labour share also had offsetting own-industry and inter-industry terms. For example, mining, oil and gas gained labour share and had a large positive own-industry structural term (+0.38 percentage points) in the 2000s. This gain came from comparatively lower-productivity industries, resulting in a much smaller inter-industry effect of -0.06 percentage points. The two terms summed to a positive total structural effect of 0.31 percentage points.

Finance, insurance and real estate also gained labour share over this period and had a positive own-industry structural impact (+0.10 percentage points). As was the case with mining, oil and gas, the productivity level for finance, insurance and real estate was above the average for the business sector. By assumption of stochastic shifts in labour share, one concludes that gains in this sector came largely from industries with relatively lower productivity levels. Thus, the offsetting impact of the inter-industry adjustment was comparatively small (-0.06 percentage points), and resulted in a positive total structural effect of 0.04 percentage points.

Construction, a low-productivity industry, also had gains in labour share in the 2000s. Its own-industry term was 0.25 percentage points, but its inter-industry term was -0.30 percentage points. Construction's labour-share gain came from industries that on average had higher productivity than it did. This resulted in a negative contribution from total structural adjustment of -0.06 percentage points.

These results reveal that the changes due to structural adjustment attributed to individual industries are smaller in absolute terms than those that would be obtained if only the own-industry term were calculated, though there still were positive structural effects in a small number of industries.

6 The combined impact of direct labour productivity growth and total structural adjustment from the 1990s to the 2000s

A comparison of direct productivity growth and structural adjustment effects allows an evaluation of the sources of overall productivity growth between the 1990s and the 2000s (Tables 5 and 6). Several conclusions emerge.

Table 5
Contributions to business-sector labour productivity growth from the direct labour productivity growth and total structural adjustment effects

	Direct productivity effect			Total structural adjustment		
	1990s	2000s	Difference	1990s	2000s	Difference
	percentage points					
Business sector	1.80	0.94	-0.86	-0.18	0.23	0.41
Industry¹						
Agriculture, forestry, fishing and hunting	0.10	0.09	-0.01	0.06	0.05	-0.01
Mining and oil and gas extraction	0.15	-0.31	-0.46	-0.05	0.31	0.37
Utilities	0.06	0.00	-0.06	-0.05	0.00	0.04
Construction	-0.03	0.00	0.03	0.01	-0.06	-0.07
Manufacturing	0.76	0.29	-0.47	-0.04	-0.05	-0.01
Wholesale trade	0.15	0.22	0.07	0.00	0.00	0.00
Retail trade	0.13	0.15	0.02	0.02	0.00	-0.03
Transport and warehousing	0.09	0.06	-0.03	0.00	0.00	0.00
Information and cultural industries	0.05	0.09	0.04	0.04	-0.01	-0.05
Finance, insurance, real estate and renting and leasing	0.41	0.18	-0.23	-0.01	0.04	0.06
Professional, scientific and technical services	0.02	0.08	0.07	-0.02	-0.01	0.01
Administrative and support, waste management and remediation services	-0.01	0.01	0.02	-0.05	-0.04	0.01
Arts, entertainment and recreation	-0.02	0.00	0.02	-0.02	0.00	0.02
Accommodation and food services	-0.03	0.02	0.05	-0.03	0.01	0.04
Other private services	-0.04	0.06	0.10	-0.04	-0.01	0.03

1. Industry is defined by the 2-digit North American Industry Classification System (NAICS).

Note: The sum of the figures may not correspond to the totals shown because of rounding.

Source: Statistics Canada, authors' calculations based on data from CANSIM table 383-0021.

Table 6**The change in contributions to business-sector labour productivity growth from the direct productivity effect and total structural adjustment in the 1990s and the 2000s**

	1990s	2000s	Difference
	percentage points		
Business sector	1.61	1.17	-0.45
Industry¹			
Agriculture, forestry, fishing and hunting	0.15	0.14	-0.02
Mining and oil and gas extraction	0.10	0.01	-0.09
Utilities	0.02	0.00	-0.02
Construction	-0.02	-0.06	-0.04
Manufacturing	0.72	0.24	-0.48
Wholesale trade	0.15	0.22	0.07
Retail trade	0.15	0.14	-0.01
Transport and warehousing	0.09	0.06	-0.03
Information and cultural industries	0.09	0.08	-0.01
Finance, insurance, real estate and renting and leasing	0.40	0.23	-0.17
Professional, scientific and technical services	0.00	0.07	0.07
Administrative and support, waste management and remediation services	-0.06	-0.03	0.03
Arts, entertainment and recreation	-0.03	0.00	0.03
Accommodation and food services	-0.06	0.03	0.08
Other private services	-0.08	0.04	0.13

1. Industry is defined by the 2-digit North American Industry Classification System (NAICS).

Note: The sum of the figures may not correspond to the totals shown because of rounding.

Source: Statistics Canada, authors' calculations based on data from CANSIM table 383-0021.

First, the mining, oil and gas sector's negative contribution from its direct productivity growth effect between the two periods (-0.46 percentage points) was largely offset by the positive impact on total structural adjustment (+0.37 percentage points) from the growth in the relative importance of this sector. The overall contribution of mining, oil and gas added 0.10 percentage points and 0.01 percentage points to business-sector productivity growth in the 1990s and the 2000s, respectively. The mining, oil and gas sector contributed to the productivity slowdown, but did so to a lesser extent than its direct productivity growth alone might suggest. This sector's contribution from both total structural adjustment and the direct productivity growth effect between the two periods declined 0.09 percentage points, which accounts for 20.2% of the overall inter-period decline in business-sector labour productivity growth.

Second, total structural adjustment associated with the manufacturing sector's decline had only a marginal impact, subtracting 0.01 percentage points from business-sector productivity growth. The direct productivity growth effect, however, had a substantial impact, falling from 0.76 percentage points in the 1990s to 0.29 percentage points in the 2000s. The direct productivity growth effect thus subtracted an additional 0.47 percentage points from business-sector productivity growth. The manufacturing sector's contribution from both total structural adjustment and the direct productivity growth effect between the two periods declined 0.48 percentage points, which accounts for 107.2% of the overall inter-period decline in business-sector labour productivity growth. The manufacturing sector's contribution from the direct productivity growth effect alone was 104.6%. The fact that the manufacturing sector's contribution was larger than 100% indicates that the sum of the changes in contributions between the two periods from the remaining industries was positive.

Third, another industry that contributed substantially to the productivity slowdown was the finance, insurance and real estate sector. As was the case with manufacturing, this sector's contribution to direct productivity growth slowed sharply between the two periods, falling from 0.41 percentage points in the 1990s to 0.18 percentage points in the 2000s. It differed from manufacturing,

however, in that its increasing labour share made a modest positive contribution from total structural adjustment, rising from -0.01 percentage points in the 1990s to 0.04 percentage points in the 2000s. This sector's contribution from both total structural adjustment and the direct productivity growth effect between the two periods declined 0.17 percentage points, which accounts for 38.8% of the overall inter-period decline in business-sector labour productivity growth.

The overall declines in these three industries were partially offset by stronger contributions from four service-sector industries: other private services; accommodation and food services; professional, science and technical services; and wholesale trade. The increases in these sectors' contributions were mostly attributable to stronger direct productivity growth, which raised aggregate labour productivity 0.28 percentage points more than if those industries' contributions had been unchanged.

7 Conclusion

Canada's productivity performance deteriorated from 1.61% annually in the 1990s to just 1.17% between the 1990s and the 2000s. This paper examined the extent to which this slowdown was the result of weaker productivity growth within industries and how much of it was due to the restructuring of the economy as labour shifted between industries characterized by different productivity levels. This analysis reveals the degree to which the slowdown was broadly based across several industries or was more narrowly focused on a select few.

The decline in productivity growth between the 1990s and the 2000s was not widespread. Three industries—manufacturing; mining, oil and gas; and finance, insurance and real estate—accounted for much of the decline. The contribution from direct productivity growth in these three industries subtracted 0.47, 0.46 and 0.23 percentage points, respectively, from annual business-sector productivity growth between the two periods. The overall decline, therefore, was industry-specific, and explanations for the productivity slowdown need to be sought in the events affecting these sectors.

While changes in industry structure occurred over both decades, restructuring did not contribute materially to lower aggregate productivity growth rates in either period. In the 1990s, all of the gains in business-sector labour productivity came from the aggregate annual direct productivity growth component (+1.80%), while the aggregate structural adjustment component (-0.18%) detracted slightly from growth. By comparison, annual direct productivity growth was lower (+0.94%) in the 2000s, but structural adjustment was higher and positive (+0.23%) during this period and thus attenuated the decline in overall productivity growth.

The 2000s were the period when manufacturing lost a substantial amount of labour share and when mining, oil and gas as well as construction experienced increases in their labour shares. During this time, the resource boom favoured the latter two industries, and the concomitant appreciation of the Canadian dollar, weaker U.S. demand, and increased competition from emerging economies reduced the manufacturing sector's relative performance in export markets and led to excess capacity and a decline in productivity growth in this sector.¹⁶ Changes in the importance of one industry—mining, oil and gas—accounted for most of the increase in the business sector's total structural adjustment. Declines in the importance of the manufacturing sector had virtually no impact on this component due to the fact that its average level of labour productivity in the 2000s was only moderately higher than that of the business sector. Consideration of the effect of declines in productivity growth within individual industries and the effect of changes in their relative importance reveals that manufacturing contributed significantly to the overall decline in productivity growth as a result of its internal slowdown, not on account of its decline in relative importance. The analysis also reveals that the slowdown in productivity growth experienced by mining, oil and gas was largely offset by the increase in the labour share of this sector. The productivity level of this sector—though not its growth—was well above the average. The productivity slowdown in finance, insurance and real estate can be similarly explained—although the offsetting impact of structural adjustment here was small by comparison. In this limited sense, industry restructuring matters for productivity performance; however, in the case of these two sectors, the direct effect of the slowdown in productivity growth within each mattered just as much or more.

16. See for example the study by Baldwin, Gu and Yan (2013), which attributes the decline in manufacturing to excess capacity in large exporting plants affected by the appreciation of the Canadian dollar during the 2000s.

8 Appendix

The counterfactual used in this study—the “stochastic” counterfactual—distributes labour shares in proportion to the original importance of all industries. An alternative counterfactual—the “gainers-versus-losers” counterfactual—postulates that industries gain labour share at the expense of those that lose labour share. Consideration of the gainers-versus-losers counterfactual, however, does not change the fundamental conclusions based on the stochastic counterfactual.

A comparison of the results from the two counterfactuals is presented in Appendix Table 1. Two noteworthy differences between the results are observed: (1) the choice of counterfactual had almost no impact on inter-industry estimates for the 1990s; and (2) the estimates for the gainers-versus-losers counterfactual were modestly higher in the 2000s than in the 1990s. Despite the modestly different estimates for inter-industry structural adjustment terms, the gainers-versus-losers counterfactual indicates that manufacturing followed by the mining, oil and gas and the finance, insurance and real estate sectors were the three largest contributors to the business-sector labour productivity slowdown in the period from 2000 to 2014.

Appendix Table 1
Inter-industry effects for stochastic and gainers-versus-losers counterfactuals

Industry ¹	Inter-industry structural adjustment					
	1990s			2000s		
	Stochastic	Gainers versus losers	Difference	Stochastic	Gainers versus losers	Difference
	percentage points					
Agriculture, forestry, fishing and hunting	0.13	0.04	0.10	0.13	0.20	-0.07
Mining and oil and gas extraction	0.02	-0.02	0.04	-0.05	-0.05	0.00
Utilities	0.01	-0.05	0.06	-0.01	0.10	-0.11
Construction	0.18	0.11	0.07	-0.27	-0.17	-0.10
Manufacturing	0.27	0.27	0.00	0.40	0.53	-0.13
Wholesale trade	-0.07	-0.12	0.05	0.03	0.15	-0.13
Retail trade	0.04	-0.01	0.05	-0.03	0.09	-0.12
Transport and warehousing	-0.04	-0.10	0.05	0.00	0.10	-0.09
Information and cultural industries	-0.04	-0.11	0.07	0.00	0.12	-0.12
Finance, insurance, real estate and renting and leasing	0.01	-0.04	0.04	-0.06	0.01	-0.07
Professional, scientific and technical services	-0.20	-0.24	0.04	-0.07	0.02	-0.09
Administrative and support, waste management and remediation services	-0.13	-0.16	0.02	-0.07	0.04	-0.11
Arts, entertainment and recreation	-0.04	-0.09	0.04	-0.01	0.11	-0.11
Accommodation and food services	-0.05	-0.09	0.04	0.02	0.09	-0.07
Other private services	-0.11	-0.11	0.00	-0.02	0.10	-0.12

1. Industry is defined by the 2-digit North American Industry Classification System (NAICS).

Note: The sum of the figures may not correspond to the totals shown because of rounding.

Source: Statistics Canada, authors' calculations based on data from CANSIM table 383-0021.

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