The Industry Origins of Canada's Weaker Labour Productivity Performance and the Role of Structural Adjustment in the Post-2000 Period

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ABSTRACT

This article examines how much of the slowdown in labour productivity growth observed in Canada's business sector after 2000 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 decomposition approaches commonly found in the literature and allows for the contributions of changes in the importance of individual industries to be calculated. The approach reveals that the post-2000 slowdown was attributable 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 all of the slowdown in business sector labour productivity growth in the 2000s.

During the period from 2000 to 2014 (referred to hereinafter as "the 2000s"), Canada's business sector labour productivity growth slowed to a compound annual rate of 1.00 per cent, from 1.81 per cent in the 1990s (1989 to 2000). Canada's weaker productivity performance in the 2000s contrasts with the performance of the U.S. business sector. Business sector productivity growth in the United States fell slightly between the two periods, decreasing from a compound annual rate of 2.23 per cent in the 1990s to 1.98 per cent in the 2000s, a pace nearly two times faster than that observed in Canada.[2] Changes in productivity have an

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2 The use of the 2000-2014 period obscures the slowdown in U.S. productivity growth which began in the mid-2000s. After recording compound annual growth of 3.1 per cent from 1995 to 2005, U.S. business sector labour productivity growth slowed to 1.3 per cent from 2005 to 2014.

impact on the standard of living of Canadians. Average wages (after adjusting for inflation) typically grow at roughly the same pace as labour productivity (Baldwin *et al.*, 2014, Chart 2). While other factors, such as increased labour force participation and improved terms of trade, also contribute to growth in living standards, labour productivity is the key driver of real gross domestic income growth in the long run. [3]

To better understand the nature of Canada's productivity growth 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. 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, referred to as 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 constant the relative importance of all industries. 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 share of labour (measured as hours worked in the business sector) decline from 21.1 per cent in 1989 to 18.5 per cent in 2000. The sector's secular decline intensified in the 2000s as its labour share declined every year after 2000, reaching a low of 12.1 per cent in 2014. 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 from 8.1 per cent in 2000 to 12.3 per cent in 2014, after declining for most of the 1990s.

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 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 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 adjust-

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

ment: how to better measure it and how to better understand its impact on aggregate labour productivity.

The article contains five sections. The first section provides the analytical framework for the decomposition of aggregate labour productivity growth into direct and structural adjustment effects. Section two presents the industry impacts of the direct labour productivity effect and section three presents the structural adjustment effects. In the fourth section, the combined impact of the direct and structural adjustment effects are given. The fifth and final section concludes.

Analytical Framework

Several studies, including those by Nordhaus (2001) and Stiroh (2002) for the United States, and Tang and Wang (2004) and Sharpe (2010) for Canada, have used different methodologies to decompose aggregate labour productivity growth into a direct productivity growth effect and a structural adjustment effect. As de Avillez (2012) pointed out, the variation between methods provides complementary, rather than competing, stories as they tend to produce similar results for most industries.[4] 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.[5] 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 (Balk, 2014 and Reinsdorf, 2015).

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

The left-hand side of Equation (1) is the per cent change in aggregate labour productivity growth expressed as the change in the logarithmic value (Δln) 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 in terms of nominal value added ($\overline{S}_{i,t}^{VA}$) by the per cent change in its labour productivity ($\Delta ln(Y_t/H_t)$). The contribution from structural adjustment for industry *i* is calculated as the industry's weight multiplied by the per cent 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 aver-

4 There are exceptions. Reinsdorf (2015) found large differences in the contributions to Canadian aggregate business sector labour productivity growth from mining, oil and gas, construction and manufacturing in a comparison of the Tang and Wang (2004) method-referred to as the generalized exactly additive decomposition or GEAD-and the CSLS method from Sharpe (2010). These differences were due to the role of price effects in the GEAD methodology. Total contributions from other industries were similar.

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

aged over the current and previous periods, *t* and *t-1*, respectively, as represented in Equation (2).

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

An increase (decrease) in productivity of an industry leads directly to a larger (smaller) direct productivity growth effect in absolute terms. The size of the effect is in direct proportion to its share of nominal value added, which in turn is determined by the size of its labour share and the level of its nominal value added per hour worked.

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

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 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 is not a zero-sum game, in which one industry's gain is another's loss.

In contrast, measuring structural adjustment is based on the reality that labour shares for all industries sum to one (or 100 per cent); 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; that is, a counterfactual.[6] The counterfactual 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. This can be referred to as a "stochastic" counterfactual and this counterfactual implies that, without the share change in industry *i*, there would have been no change in the relative share of any industry.[7] For illustration, an alternative "gainers-versus-losers"

6 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). The directionality of these changes can be estimated in some cases (Baldwin and Rafiquzzaman, 1995). This was not attempted here. The CSLS decomposition in de Avillez (2012) does have a counterfactual interpretation of interdependencies across industries but does not directly measure them.

counterfactual, in which industries that gain labour share do so directly from those that lose labour share in a given year, is described in Appendix A.

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

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

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 labour shares in other industries 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. It is the additional term that accounts for the corresponding change in all other industries' labour shares and is calculated as the log difference between the counterfactual labour share for industry *j* in period t and the actual labour share of industry *j* in period t-1. The counterfactual labour share term for each of the other j industries is defined as

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

where H^{i}_{j}/H_{t-1} equals the actual labour share of industry j in period t-1 ($H_{j,t-1}/H_{t-1}$) minus the proportion of the change in the labour share of industry *i* ($H_{i,t}/H_t - H_{i,t-1}/H_{t-1}$) that is reallocated to or drawn from industry *j* based on its relative size among all *j* industries ($H_{j,t-1}/(H_{t-1} - H_{i,t-1})$), which excludes industry *i*.

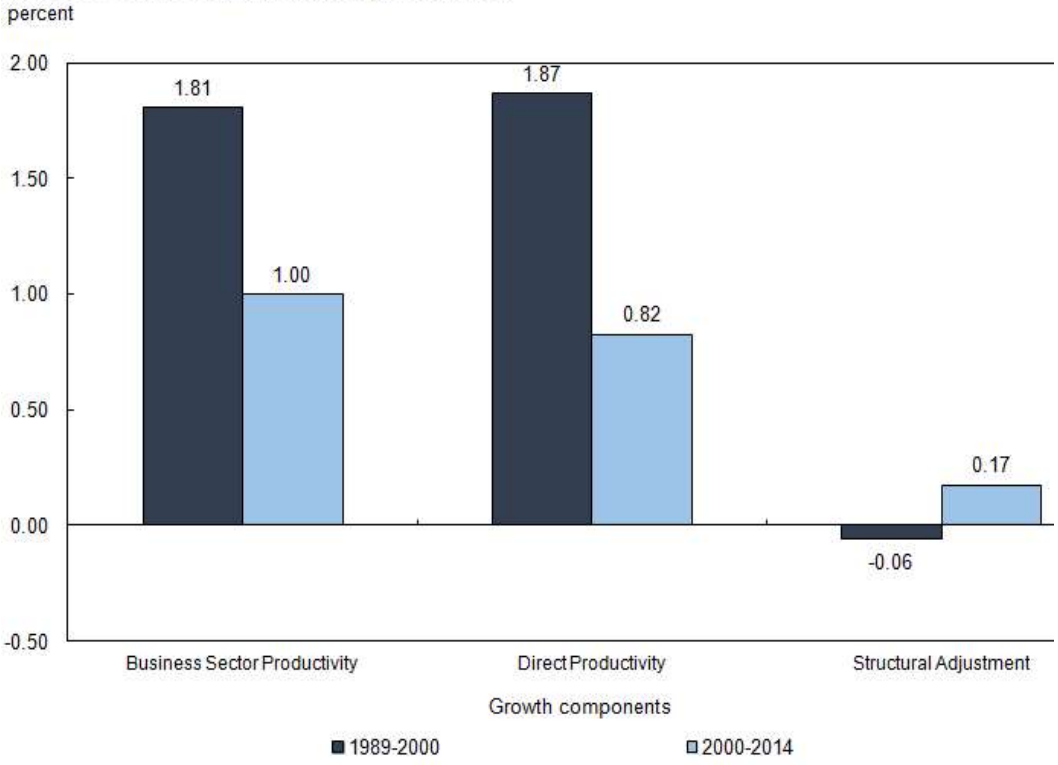
The sum of the inter-industry structural adjustment terms in the other j industries measures the impact of the offsetting labour share decline (increase) when the labour share of industry i increases (decreases). This sum constitutes the required changes in the labour shares of other industries that 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 inter-industry terms of all industries sum approximately to zero.[9]

7 Shifts in shares of hours worked come from workers moving from one industry to another and from persons joining the workforce. Aggregate productivity may change over time if hours worked in industries grow at different rates; thus, the economy restructures in terms of changing the relative importance of different industries.

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.

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 weights 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 an industry's relative size, is also counterintuitive.

Chart 1
Components of Business Sector Labour Productivity Growth in Canada, 1989-2000 and 2000-2014 (compound annual growth rates)



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.

The Industry Impacts of the Direct Labour Productivity Growth

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, business sector labour productivity growth came largely from the positive impact of the aggregate direct productivity growth component (1.87 per cent per year), which was slightly offset by the aggregate structural adjustment component (-0.06 per cent) (Chart 1). By comparison, in the 2000s the average aggregate direct productivity growth component (0.82 per cent per year) and the aggregate structural adjustment component (0.17 per cent) were both positive. In the 1990s, the direct effect contributed all of the growth in labour productivity. In the 2000s, the direct

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 real output and labour measured as hours worked. The data on real value added are Fisher-chain-linked indices from CANSIM Table 383-0021. This table includes annual data from 1961 to 2014 though only data from 1989 to 2014 were used in this study. The 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 the nominal GDP series, which currently only includes data to 2012.

Table 1

Business Sector and Industry Labour Productivity Growth in Canada, 1989-2000 and 2000-2014 (compound annual growth rate)

	1989-2000	2000-2014	Difference
	percent		percentage points
Business sector	1.81	1.00	-0.81
Industry[1]			
Agriculture, forestry, fishing and hunting	3.62	3.55	-0.08
Mining and oil and gas extraction	2.32	-2.72	-5.04
Utilities	1.42	0.13	-1.29
Construction	0.00	-0.06	-0.07
Manufacturing	3.57	1.35	-2.22
Wholesale trade	2.14	3.22	1.08
Retail trade	2.28	1.99	-0.29
Transport and warehousing	1.81	0.97	-0.83
Information and cultural industries	1.48	2.00	0.52
Finance, insurance, real estate and renting and leasing	2.35	1.36	-1.00
Professional, scientific and technical services	0.56	1.03	0.47
Administrative and support, waste management and remediation services	-0.12	0.29	0.41
Arts, entertainment and recreation	-1.50	0.07	1.57
Accommodation and food services	-0.40	0.47	0.88
Other private services	-0.44	0.92	1.35

1. Industry is defined by the 2-digit North American Industry Classification System (NAICS) 2007 code.

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.

term accounted for 82 per cent of the growth in productivity.

The aggregate direct productivity growth component fell more than a full percentage point between the 1990s to the 2000s from 1.87 per cent to 0.82 per cent. In contrast, the impact of the aggregate structural adjustment contribution increased 0.23 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.

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 shows the changes in productivity growth at the industry level over the two periods. The largest declines between the two periods (in descending order) occurred in mining, oil and gas; manufacturing; utilities; and finance, insurance and real estate. Some of the largest improvements in the 2000s occurred in the industries that had the poorest performance in the 1990s (arts and entertainment; other private services; and accommodation and food), although these industries continued to perform poorly in the 2000s compared with the business sector as a whole.

The mining, oil and gas sector recorded a compound annual 2.72 per cent decline in labour productivity in the 2000s. It was the only industry that exhibited a large decline in labour productivity in the 2000s.[11] Labour productivity in the other industries examined grew at an average rate

Table 2
Contributions to Business Sector Labour Productivity Growth from the Direct Labour Productivity Effect in 1989-2000 and 2000-2014 (percentage points per year)

	1989-2000	2000-2014	Difference
	percentage points		
Business sector	1.87	0.82	-1.04
Industry[1]			
Agriculture, forestry, fishing and hunting	0.11	0.08	-0.03
Mining and oil and gas extraction	0.10	-0.30	-0.40
Utilities	0.06	0.00	-0.06
Construction	-0.01	-0.02	-0.01
Manufacturing	0.80	0.22	-0.57
Wholesale trade	0.15	0.22	0.08
Retail trade	0.15	0.13	-0.01
Transport and warehousing	0.10	0.05	-0.05
Information and cultural industries	0.06	0.08	0.02
Finance, insurance, real estate and renting and leasing	0.37	0.21	-0.16
Professional, scientific and technical services	0.04	0.07	0.03
Administrative and support, waste management and remediation services	0.00	0.01	0.01
Arts, entertainment and recreation	-0.01	0.00	0.01
Accommodation and food services	-0.02	0.01	0.03
Other private services	-0.03	0.05	0.07

1. Industry is defined by the 2-digit North American Industry Classification System (NAICS) 2007 code.

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.

of 1.19 per cent per year during this period. As noted, the mining, oil and gas sector had the largest deceleration in labour productivity (-5.04 percentage points) from the compound annual growth rate recorded in the 1990s. Labour productivity growth in mining, oil and gas was faster than in most industries in the 1990s, expanding at an annual pace of 2.32 per cent; by contrast, labour productivity growth was 1.81 per cent in the business sector during the same period.

The strong productivity performance in mining, oil and gas during the 1990s was partly due to a modest increase in hours worked (0.37 per cent annually, while hours worked in the business sector expanded more than four times as fast at an annual pace of 1.26 per cent). Despite limited employment gains, real value added in the mining, oil and gas sector grew at a rate of 2.70 per cent per year in the 1990s, while real value added in the business sector grew at a moderately faster pace (3.06 per cent).

After the mining, oil and gas sector, the next-largest productivity slowdown was observed in manufacturing, where productivity growth decreased 2.22 percentage points, falling from 3.57 per cent annual growth to 1.35 per cent between the two time periods. The utilities and finance, insurance and real estate sectors recorded declines between the periods of 1.29 and 1.00 percentage points, respectively.

An examination of the productivity growth rates by industry alone suggests that the mining,

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.

Table 3

Shares of Hours Worked, Shares of Nominal Value Added and Labour Productivity

	Shares of hours worked			Shares of nominal value added			Labour productivity		
	1990-2000	2001-2014	Difference	1990-2000	2001-2014	Difference	1989	2000	2014
	percent		percentage points	percent		percentage points	$/hour worked (chained 2007 dollars)		
Business sector	100.00	100.00	0.00	100.00	100.00	0.00	35.78	41.92	50.04
Industry[1]									
Agriculture, forestry, fishing and hunting	5.47	3.33	-2.14	3.17	2.23	-0.95	14.49	19.82	34.89
Mining and oil and gas extraction	1.46	1.85	0.39	5.43	9.85	4.42	284.69	388.57	249.07
Utilities	0.91	0.81	-0.11	4.17	3.09	-1.08	157.76	182.08	187.60
Construction	8.74	10.18	1.43	8.15	8.86	0.70	41.41	40.14	41.04
Manufacturing	18.73	14.75	-3.99	22.70	17.58	-5.12	33.07	46.30	58.69
Wholesale trade	6.83	6.72	-0.10	6.89	7.01	0.11	30.70	37.83	60.45
Retail trade	12.97	12.68	-0.29	6.72	6.74	0.02	16.56	20.11	27.94
Transport and warehousing	6.00	6.18	0.18	5.67	5.54	-0.13	31.31	37.00	43.68
Information and cultural industries	2.20	2.38	0.17	4.30	4.17	-0.14	55.64	62.75	86.31
Finance, insurance, real estate and renting and leasing	9.09	9.40	0.31	15.32	15.25	-0.07	53.00	69.00	82.67
Professional, scientific and technical services	5.91	7.57	1.66	5.36	6.95	1.59	36.41	37.18	44.69
Administrative and support, waste management and remediation services	4.19	6.01	1.82	2.66	3.51	0.86	26.96	26.41	27.68
Arts, entertainment and recreation	1.39	1.78	0.40	0.84	0.94	0.10	29.05	24.23	24.82
Accommodation and food services	7.31	7.27	-0.04	3.25	2.77	-0.49	18.18	16.72	18.58
Other private services	8.78	9.09	0.30	5.36	5.52	0.16	27.25	25.30	29.51

1. Industry is defined by the 2-digit North American Industry Classification System (NAICS) 2007 code.

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.

oil and gas sector was the key source of Canada's productivity slowdown. However, when the relative size of industries is taken into account, the industry origins and direct contribution to 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 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 0.57, 0.40, 0.16 percentage points, respectively, of the decline of 1.04 percentage points in business sector productivity growth between the two periods.

The Importance of Labour Share and Total Structural Adjustment by Industry in the 1990s and the 2000s

Table 3 shows the restructuring that affected the relative importance of industries between the 1990s and the 2000s. The manufacturing sector experienced the largest absolute change in labour share, falling from an average of 18.7 per cent to 14.8 per cent (a 21 per cent decline). Large proportionate changes occurred in administration and waste management (43 per cent) and agriculture, forestry and fishing (-39 per cent). 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 27 per cent gain in its labour share, the increase in absolute terms from 1.46 per cent to 1.85 per cent was small compared to that of other industries.

The relationship between the changes in an industry's labour share and whether its productivity level is higher or lower than that of the business sector has important implications for structural adjustment. The intuition that underlies that relationship is presented in Sharpe and Thomson (2010) as follows: an industry that experiences an increase in labour share over a given period will exhibit a corresponding positive total structural adjustment effect if that industry's labour productivity level is above average (that is, above that of the business sector) or a negative total structural adjustment effect if its labour productivity level is below average. Conversely, an industry that experiences a decrease in labour share over a given period will exhibit a corresponding negative total structural adjustment effect if that industry's labour productivity level is above average or a positive total structural adjustment effect if its labour productivity level is below average.[12]

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 earlier, 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 added to the own-industry term that the total impact of an industry-level structural adjustment can be estimated.[14]

A comparison of the inter-industry and own-industry terms for select industries reveals the size of the potential error from not taking into

12 The CSLS decomposition methodology (Sharpe and Thomson, 2010; Reinsdorf, 2015) uses the difference between the average productivity level and a given industry's productivity level to isolate a "reallocation level effect" and a "reallocation growth effect" to adjust the calculation of industry contributions to aggregate labour productivity growth for labour share changes. The CSLS decomposition methodology implicitly captures the inter-industry effect as a part of its reallocation level effect which is similar to the total structural adjustment effect in this article. For more details, see Appendix B.

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 Appendix A.

Table 4
Own-Industry and Inter-Industry Components of Structural Adjustment in the Canadian Business Sector, 1989-2000 and 2000-2014 (annual percentage point contribution)

	Own-Industry			Inter-Industry		
	1989-2000	2000-2014	Difference	1989-2000	2000-2014	Difference
percentage points						
Business sector	-0.06	0.19	0.24	0.00	-0.01	-0.01
Industry[1]						
Agriculture, forestry, fishing and hunting	-0.09	-0.07	0.02	0.16	0.11	-0.05
Mining and oil and gas extraction	-0.03	0.37	0.39	0.01	-0.06	-0.07
Utilities	-0.06	0.00	0.06	0.01	0.00	-0.01
Construction	-0.16	0.27	0.42	0.17	-0.30	-0.47
Manufacturing	-0.26	-0.53	-0.27	0.23	0.44	0.21
Wholesale trade	0.08	-0.06	-0.13	-0.07	0.05	0.13
Retail trade	-0.02	0.01	0.04	0.06	-0.03	-0.08
Transport and warehousing	0.03	0.01	-0.03	-0.04	-0.01	0.03
Information and cultural industries	0.08	-0.02	-0.10	-0.04	0.01	0.05
Finance, insurance, real estate and renting and leasing	0.03	0.08	0.05	-0.02	-0.04	-0.03
Professional, scientific and technical services	0.18	0.05	-0.14	-0.20	-0.05	0.15
Administrative and support, waste management and remediation services	0.07	0.06	-0.02	-0.12	-0.10	0.02
Arts, entertainment and recreation	0.03	0.00	-0.02	-0.04	0.00	0.04
Accommodation and food services	0.01	0.00	-0.01	-0.02	0.00	0.02
Other private services	0.06	0.02	-0.04	-0.09	-0.03	0.05

1. Industry is defined by the 2-digit North American Industry Classification System (NAICS) 2007 code.

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.

account the interdependencies (Table 4). A large adjustment is required for the manufacturing sector. The own-industry component suggests that, in the 2000s, manufacturing's structural adjustment effect subtracted over 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 0.44 percentage points is nearly as large. The total structural adjustment is the sum of these two terms (own-industry and inter-industry), was -0.08 percentage points in the 2000s (Table 5).This suggests that total structural adjustment for the manufacturing sector subtracted very little 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.[15]

15 For a discussion of the relationship between the productivity levels of industries and structural adjustment see Appendix B.

Table 5
Contributions to Business Sector Labour Productivity Growth from the Direct Labour Productivity Growth and Total Structural Adjustment Effects, 1989-2000 and 2000-2014 (percentage points per year)

	Direct productivity effect			Total structural adjustment			Total contribution		
	1989-2000	2000-2014	Difference	1989-2000	2000-2014	Difference	1989-2000	2000-2014	Difference
percentage points									
Business sector	1.87	0.82	-1.04	-0.06	0.17	0.23	1.81	1.00	-0.81
Industry[1]									
Agriculture, forestry, fishing and hunting	0.11	0.08	-0.03	0.07	0.04	-0.03	0.17	0.12	-0.06
Mining and oil and gas extraction	0.10	-0.30	-0.40	-0.01	0.31	0.32	0.09	0.01	-0.08
Utilities	0.06	0.00	-0.06	-0.05	0.00	0.05	0.01	0.00	-0.01
Construction	-0.01	-0.02	-0.01	0.01	-0.04	-0.05	0.00	-0.06	-0.06
Manufacturing	0.80	0.22	-0.57	-0.03	-0.08	-0.06	0.77	0.14	-0.63
Wholesale trade	0.15	0.22	0.08	0.00	0.00	0.00	0.15	0.22	0.07
Retail trade	0.15	0.13	-0.01	0.03	-0.01	-0.04	0.18	0.12	-0.06
Transport and warehousing	0.10	0.05	-0.05	0.00	0.00	0.00	0.10	0.05	-0.05
Information and cultural industries	0.06	0.08	0.02	0.04	-0.01	-0.05	0.10	0.07	-0.03
Finance, insurance, real estate and renting and leasing	0.37	0.21	-0.16	0.01	0.03	0.03	0.37	0.24	-0.13
Professional, scientific and technical services	0.04	0.07	0.03	-0.02	-0.01	0.01	0.02	0.06	0.05
Administrative and support, waste management and remediation services	0.00	0.01	0.01	-0.04	-0.04	0.00	-0.05	-0.03	0.02
Arts, entertainment and recreation	-0.01	0.00	0.01	-0.02	0.00	0.02	-0.03	0.00	0.03
Accommodation and food services	-0.02	0.01	0.03	-0.01	0.00	0.01	-0.03	0.01	0.04
Other private services	-0.03	0.05	0.07	-0.03	-0.01	0.02	-0.06	0.04	0.09

1. Industry is defined by the 2-digit North American Industry Classification System (NAICS) 2007 code.

Note: The sums and differences 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.

Like the manufacturing sector, agriculture, forestry and fishing - a low-productivity level industry - lost labour share in the 2000s. The large inter-industry component (0.11 percentage points) more than offset the own-industry component (-0.07 percentage points) for this sector. The relative reallocation of labour away from this low-productivity level industry to other industries that, on average, had higher productivity produced an overall positive contribution from total structural adjustment of 0.04 percentage points to business sector productivity growth.

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 (0.37 percentage points) in the 2000s. This gain came from comparatively lower-productivity level 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 (0.08 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 (-0.04 percentage points), and resulted in a positive total structural effect of 0.03 percentage points.

Construction, a low productivity level industry, also had gains in labour share in the 2000s. Its own-industry term was 0.27 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 -0.04 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.

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 (Table 5). Several conclusions emerge.

First, the mining, oil and gas sector's negative contribution from its direct productivity growth effect between the two periods (-0.40 percentage points) was largely offset by the positive impact on total structural adjustment (0.32 percentage points) from the growth in the relative importance of this sector, as expressed by its share of labour. The overall contribution of mining, oil and gas added 0.09 percentage points in the 1990s and 0.01 percentage points to business sector productivity growth in the 2000s. 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 0.08 percentage points, which accounts for 10 per cent of the overall inter-period decline of 0.81 percentage points in business sector labour productivity growth.

Second, total structural adjustment associated with the manufacturing sector's decline had only a marginal impact, subtracting 0.06 percentage points from business sector productivity growth. The direct productivity growth effect, however, had a substantial impact, falling from 0.80 percentage points in the 1990s to 0.22 percentage points in the 2000s. The direct productivity growth effect thus subtracted an additional 0.57 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 0.63 percentage points, which accounted for 78.3 per cent 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 71.2 per cent of the decline.

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 0.37 percentage points in the 1990s to 0.21 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 0.03

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 0.13 percentage points, which accounts for 16.6 per cent of the overall inter-period decline in business sector labour productivity growth.[16]

The overall declines in these three industries were partially offset by stronger contributions from six service sector industries: other private services; wholesale trade; professional, science and technical services; arts, entertainment and recreation; and administrative and support, waste management and remediation services. The increases in these sectors' contributions were mostly attributable to stronger direct productivity growth, which raised aggregate labour productivity 0.24 percentage points more than if those industries' contributions had been unchanged.

Conclusion

Canada's productivity performance deteriorated from 1.81 per cent annually in the 1990s to just 1.00 per cent in the 2000s. This article 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. The direct effects of labour productivity growth slowdowns within three industries - manufacturing; mining, oil and gas; and finance, insurance and real estate - accounted for more than 100 per cent of the total decline. The contribution from direct productivity growth in these three industries subtracted 0.57, 0.40, and 0.16 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 (1.87 per cent), while the aggregate total structural adjustment component (-0.06 per cent) detracted slightly from growth. By comparison, annual direct productivity growth was lower (0.82 per cent) in the 2000s, but structural adjustment was higher and positive (0.17 per cent) 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.

16 Using data for comparable time periods for the 2000s as defined in Almon and Tang (2011; where the 2000s = 2000 to 2008) and also in Sharpe and Thomson (2010; where the 2000s = 2000 to 2007), the methodology used here produces similar findings related to the impact of total structural adjustment in the mining, oil and gas, manufacturing and finance, insurance and real estate sectors. Both studies as well as this one find that total structural adjustment contributed positively to aggregate labour productivity growth for the mining, oil and gas and finance, insurance and real estate sectors while it subtracted from the contribution of manufacturing – though with large differences in magnitude among the three approaches – in the correspondingly defined 2000s. However, an important caveat in making these sorts of comparisons is that revisions to historical data, especially around the 2008-2009 recession, can significantly influence findings even if the same methodology and time period were examined.

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.[17] Changes in the importance of one industry - mining, oil and gas - accounted for more than 100 per cent of the increase in the business sector's total structural adjustment in the 2000s. Declines in the importance of the manufacturing sector had only a small 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.

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Appendix A: Gains-Versus-Losers Counterfactual Versus Stochastic Counterfactual

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 in a given year. 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 the table below. 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 Contributions to Labour Productivity Growth in Canada, 1989-2000 and 2000-2014 (percentage points per year)

	Inter-Industry Structural Adjustment					
	1989-2000			2000-2014		
	Stochastic	Gainers versus Losers	Difference	Stochastic	Gainers versus Losers	Difference
Industry[1]						
Agriculture, forestry, fishing and hunting	0.16	0.17	-0.01	0.11	0.10	0.01
Mining and oil and gas extraction	0.01	0.01	0.00	-0.06	-0.05	0.00
Utilities	0.01	0.01	0.00	0.00	0.00	0.00
Construction	0.17	0.17	0.00	-0.30	-0.27	-0.03
Manufacturing	0.23	0.24	0.00	0.44	0.41	0.03
Wholesale trade	-0.07	-0.08	0.00	0.05	0.04	0.01
Retail trade	0.06	0.06	0.00	-0.03	-0.01	-0.02
Transport and warehousing	-0.04	-0.04	0.00	-0.01	0.00	-0.01
Information and cultural industries	-0.04	-0.04	0.00	0.01	0.01	0.00
Finance, insurance, real estate and renting and leasing	-0.02	-0.02	0.00	-0.04	-0.05	0.01
Professional, scientific and technical services	-0.20	-0.20	0.00	-0.05	-0.06	0.00
Administrative and support, waste management and remediation services	-0.12	-0.12	0.00	-0.10	-0.08	-0.01
Arts, entertainment and recreation	-0.04	-0.04	0.00	0.00	0.00	0.00
Accommodation and food services	-0.02	-0.02	0.00	0.00	0.02	-0.02
Other private services	-0.09	-0.08	-0.01	-0.03	-0.03	-0.01

1. Industry is defined by the 2-digit North American Industry Classification System (NAICS) 2007 code.

Note: The sums and differences 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.

Appendix B: The Relationship between Total Structural Adjustment and Relative Productivity Levels

The total structural adjustment term, including the the own-industry and inter-industry terms, can be approximated by the "reallocation level effect" term in Sharpe and Thomson (2010). Doing so demonstrates that for a given change in the labour share of an industry, whether total structural adjustment contributes positively or negatively to aggregate labour productivity growth depends on the industry's relative labour productivity level.

To see this most clearly, note that the counterfactual labour share term (Equation 4 in the article) can be written as

$$\frac{H^{i}_{j,t}}{H_t} = \frac{H_{j,t-1}}{H_{t-1}} - \left(\frac{H_{i,t}}{H_t} - \frac{H_{i,t-1}}{H_{t-1}}\right)\left(\frac{H_{j,t-1}}{H_{t-1} - H_{i,t-1}}\right)$$
$$= h_{i,t-1}\left(\frac{1-h_{i,t}}{1-h_{i,t-1}}\right)$$

where $h_{i,t} = H_{i,t}/H_t$ is the labour share of industry *i*. Let $TA_{i,t}$ denote the total structural adjustment effect for industry *i* from equation 3 in the article. Using the expression above, the total structural adjustment effect can be written as

$$TA_{i,t} = \bar{S}^{VA}_{i,t}\ \Delta\ln h_{i,t} + (1 - \bar{S}^{VA}_{i,t})\Delta\ln(1-h_{i,t})$$

where $\Delta\ln(1-h_{i,t})$ denotes $\Delta\ln\left(\frac{1-h_{i,t}}{1-h_{i,t-1}}\right)$ and $\bar{S}^{VA}_{i,t} = \frac{1}{2}(S^{VA}_{i,t-1} + S^{VA}_{i,t})$ as in Equation 2 in the article.

Since $\Delta\ln h_{i,t} \approx \frac{h_{i,t} - h_{i,t-1}}{h_{i,t-1}}$, it follows that

$$\Delta\ln(1-h_{it}) \approx \frac{-(h_{i,t} - h_{i,t-1})}{h_{i,t-1}} \frac{h_{i,t-1}}{1-h_{i,t-1}}$$
$$\approx -\Delta\ln h_{it}\ \frac{h_{i,t-1}}{1-h_{i,t-1}}$$

Using these relationships (which are just the log-difference approximations to growth rates), the total structural adjustment effect can be written as

$$TA_{i,t} = \Delta\ln h_{it}\ \frac{h_{i,t-1}}{1-h_{i,t-1}}\left(\frac{\bar{S}^{VA}_{i,t}}{h_{i,t-1}} - 1\right)$$

For simplicity, $\bar{S}^{VA}_{i,t}$ is replaced with $S^{VA}_{i,t-1}$ in the expression for $TA_{i,t}$. Then note that the value added share satisfies the identity

$$S^{VA}_{i,t-1} = \frac{A_{i,t-1}}{A_{t-1}} h_{i,t-1}$$

where $A_{i,t}$ and A_t denote the levels of labour productivity defined as nominal value added per hour worked, for industry *i* and in the aggregate business sector, respectively. Then the total structural adjustment effect can be represented as $T'A_{i,t}$.

$$T'A_{i,t} = \Delta\ln h_{it}\ \frac{h_{i,t-1}}{1-h_{i,t-1}}\left(\frac{S^{VA}_{i,t-1}}{h_{i,t-1}} - 1\right)$$
$$= \Delta\ln h_{it}\ \frac{h_{i,t-1}}{1-h_{i,t-1}}\left(\frac{A_{i,t-1}}{A_{t-1}} - 1\right)$$
$$= -\Delta\ln(1-h_{it})\ \left(\frac{A_{i,t-1}}{A_{t-1}} - 1\right)$$

This is a version of the 'reallocation level effect' as in Sharpe and Thomson (2010). The second line expresses total structural adjustment in terms of the change in the labour share of industry *i* ($\Delta\ln h_{i,t}$) while the third line expresses it in terms of the change in the labour share of the rest of the industries in the aggregate sector ($\Delta\ln(1-h_{it})$). Both forms of the expression say the same thing: if the labour share of industry *i* rises (i.e. the labour share of the rest of the economy falls), the total structural adjustment effect is positive if and only if the initial productivity level of industry *i* was above average.

Differences between the two measures, including the use of nominal rather than real value added to define labour productivity; the use of logarithmic rather than factor growth rates; and the use of $S^{VA}_{i,t-1}$ rather than $\bar{S}^{VA}_{i,t}$ are important to note. Nevertheless, conclusions about the role of total structural adjustment presented here are broadly consistent with those found in Sharpe and Thomson (2010).