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Unbalanced Industry Demand and Supply Shifts: Implications for Economic Growth in Canada and the United States

Anik Dufour, Jianmin Tang and Weimin Wang*

Industry Canada
235 Queen Street
Ottawa, Ontario
Canada K1A 0H5

Abstract

This paper estimates industry contributions to aggregate output and labour productivity growth, using a framework consistent with real GDP in the chained-Fisher index. It distinguishes between the contribution resulting from changes in an industry's real output level and the contribution resulting from changes in its real output price. This paper shows that the service sector was the major contributor to both real GDP growth and aggregate labour productivity growth in Canada and the United States over the past two decades, driven by high demand for some services in the two countries. This contribution is significantly higher than the previous estimates obtained using traditional methods that focus only on the quantity effect. By ignoring the price effect, traditional methods ignore an industry's contribution from the rising price of its output to the increase in the aggregate measures.

Keywords: industry contribution, real GDP growth, aggregate labour productivity growth
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Corresponding author: Jianmin Tang, 613-946-1621, tang.jianmin@ic.gc.ca

1. Introduction

The importance of the service sector in employment in both Canada and the United States has increased considerably in the past two decades. The hours worked share of the service sector in Canada increased from 57.4 percent in 1981 to 66.3 percent in 2000. Similarly, in the United States, it increased from 61.6 percent to 71.5 percent.[1] This trend took place despite stronger productivity growth in the goods sector relative to the service sector.[2]

Both demand and supply factors have been used to explain this general trend (e.g., Summers 1985 and OECD 2000 and 2003). For supply factors, it has been suggested that part of the employment shift could result from the labour savings achieved through relatively higher technological progress in the goods sector. The services sector acted as a sponge to absorb the saved labour. As shown in a two-sector model (Figure 1), a technological progress in the goods sector shifts the production possibility frontier outward. As a result, income grows, leading to more demand for both goods and services. If the increased demand for goods is more than met by the productivity gain due to the technological progress, less labour is required in the goods sector. The extra workers are then hired by the services sector in order to meet the rise in demand for services. This is consistent with the finding by Nordhaus (2006). Using the Industry Accounts data for the United States for the period 1948-2001, he shows that industries with higher productivity growth generally experienced declining employment and hours growth when all industries are considered, although this relationship was reversed for internationally open manufacturing industries.[3]

A relatively increase in demand for some services also plays a role in the increased importance of the service sector. The factors that have fuelled the demand are related to final demand and intermediate inputs. The final demand for services is typically income-elastic while the final demand for goods is typically income-inelastic.[4] The substitution effect – which predicts that consumers demand more goods than services as the price of

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[1] Lee and Wolpin (2006) also show that capital accumulation in the service sector was much faster than that in the goods sector.

[2] For Canada, according to Statistics Canada CANSIM table 383-0003, labour productivity in the business goods sector grew at 1.7 percent per year over the period 1981-2000 while in the business services sector it grew at 1.2 percent. For the United States, Bosworth (2005) shows that over the period 1977-2000, labour productivity in the private goods-producing industries grew on average at about 2.4 percent per year, compared to only 0.9 percent in the private services-producing industries.

[3] Triplett and Bosworth (2003) study Baumol's disease by focusing on the hypothesis that productivity improvements in services sectors are less likely than in the goods-producing sectors of the economy. They show that both the rate of labour productivity improvement in services for the period 1995-2000 and its acceleration equalled the economy wide average and claim that Baumol's disease has been cured. However, the main supporting evidence is still subject to debate. For instance, for the same period, Bosworth (2005) shows labour productivity in the private goods-producing industries grew at 2.9 percent, compared to 1.7 percent in private services-producing industries.

[4] Caves (1980) demonstrates that as real income rises, the demand for services rises faster than that for goods. More recently, Möller (2000) examines 23 industries in the United Kingdom and the United States from early 1970s to the early 1990s and finds that the estimated income elasticities are typically greater than one for the services industries and less than one for goods industries.

goods declines relatively to that of services – has been more than offset by the income effect, resulting in an increase in demand for services relative to goods.[5] At the same time, demand for business services as intermediate inputs is also increasing. With the increased international competition, firms tend to specialize and focus on core competencies by outsourcing other business activities. They also tend to use more professional services to improve the organisation of their production (e.g. module production) or their mode of supply (e.g. just-in-time delivery). Digital delivery and this mode of transferring information themselves also create demand for business services (OECD 2004).[6]

The change in industry structure and the reallocation of production resources from more productive industries to less productive industries are interesting and are consistent with the theory of unbalanced growth or the "cost disease model" that predicts that resources will be absorbed predominantly by "stagnant" industries (Baumol 1967).[7]

Using a consistent framework, this paper is to study unbalanced industry demand and supply shifts and the implications for industry contributions to real GDP growth and aggregate labour productivity growth. Real GDP per capita growth is often used as an indicator of the improvement in real income or living standards.[8] Labour productivity growth is viewed as the principal factor contributing to growth in real income. These two aggregate measures, which are regularly published by national statistical agencies, have been widely used to assess a country's overall economic performance and to develop a country's economic policies.

As an overall economic performance indicator, real GDP should reflect not only the quantity produced/consumed of each product (good or service) but also its unit value of production/consumption, with the value measured by the product's price (Nakamura, 2004). Statistical agencies in Canada, the United States and other countries have moved to measuring real GDP using the chained-Fisher index methodology.[9] This approach has the desired property—it values a real output more when its price rises and less when its price falls, since it uses output prices (updated annually) as weights in constructing real GDP. Thus in the chained-Fisher index, the movement of real GDP is sensitive to changes in output prices.

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[5] The development of a number of external forces also plays an important role in an increase in final demand for services. For example, female labour force participation is associated with an increase in demand for personal services (Fuchs 1980) and the increased demand for health care services is linked to population ageing (OECD 2000).
[6] OECD (1999) identifies five strategic business services that are essential for business processes, firm competitiveness and growth. These five services are: computer software and information processing, R&D and technical testing, marketing, business organisation (including management consultancy and labour recruitment) and human resource development. It shows that computer services exports from the U.S. were particularly strong over this period while Canada recorded healthy surpluses in both computer and R&D services.
[7] Note, however, that the "disease" hypothesis is still subject to an intensive debate (Nordhaus 2006).
[8] Although GDP is commonly used as a welfare measure, it is technically a measure of output, and thus presents production.
[9] Before the change, real GDP was constructed using the fixed-weight quantity index.

In other words, an industry can contribute to real GDP growth through two channels: an increase in real output or a rise in output price. Both channels are influenced in complex ways by changes in supply and demand conditions. For example, an increase in demand for an industry's product will mean that the industry's contribution to real GDP will increase for two reasons—an increase in output and a rise in the value of each unit of output. This can occur without any change in the industry's production technology.

This paper develops an analytical framework consistent with real GDP in the chained-Fisher index and then applies the framework to estimate industry contributions to economic growth and to aggregate labour productivity growth in Canada and the United States over the period 1981-2000. The framework distinguishes the industry contribution to real GDP growth resulting from changes in the industry output level and the contribution resulting from changes in the price of the industry's output.

Over the period 1981-2000, this paper shows that the service sector was the major contributor to both real GDP growth and aggregate labour productivity growth. For instance, it accounted for 81 percent of growth in real GDP in the business sector in Canada and 90 percent of growth in real GDP in the business sector in the United States. This is much higher than estimates using traditional methods that focus only on the quantity effect. By ignoring the price effect, traditional methods underestimate (overestimate) the contributions of industries with rising (declining) real output prices to real GDP growth and aggregate labour productivity growth.[10]

2. Industry Contribution to Real GDP Growth

This section develops a framework to measure industry contributions to real GDP growth. The framework reflects both supply and demand conditions and is consistent with real GDP in the chained-Fisher index. The framework is then used to estimate industry contributions to real GDP growth in Canada and the United States over the period 1981-2000.

2.1. A Framework for Measuring Industry Contributions to Economic Growth

This paper follows a top-down approach in which aggregate output growth is decomposed into industry components. It uses the gross output concept for industry output. This concept is widely used for studying economic growth.[11] In addition, this section normalizes all output measures by population to control for the impact of population growth. For example, GDP in this section is GDP per capita. For simplicity, this paper omits "per capita" from all output measures discussed in this section.

Define V, V^r and P^v as nominal GDP, real GDP and GDP deflator, respectively.[12] In addition, let v_i be the nominal value added of industry i. The sum of industry nominal

[10] For example, Jorgenson and Stiroh 2000; Stiroh 2002; Faruqui et al. 2003; Jorgenson 2004; Ho, Rao and Tang 2004.
[11] For example, Jorgenson, Gollop and Fraumeni (1987) and Jorgenson (2004).
[12] The GDP deflator is an implicit deflator, calculated as the ratio of nominal GDP to real GDP.

value added is equal to nominal GDP, that is, $V = \sum_i v_i$. For a given year, real GDP can be decomposed into its industry components:

$$
\begin{aligned}
V^r &= \frac{\sum_i v_i}{P^v} \\
&= \frac{\sum_i (y_i - m_i)}{P^v} \\
&= \sum_i \left(\frac{p_i^y y_i^r - p_i^m m_i^r}{P^v} \right) \\
&= \sum_i \left(\tilde{p}_i^y y_i^r - \tilde{p}_i^m m_i^r \right),
\end{aligned}
\tag{1}
$$

where y_i, y_i^r and p_i^y are the nominal gross output, the real gross output, and the gross output deflator of industry *i*;

m_i, m_i^r and p_i^m are the nominal intermediate inputs, the real intermediate inputs, and the intermediate input deflator of industry *i*; and

$\tilde{p}_i^y$ and $\tilde{p}_i^m$ are the real prices of gross output and the intermediate inputs, defined as $\tilde{p}_i^y = p_i^y / P^v$ and $\tilde{p}_i^m = p_i^m / P^v$. [13]

Equation (1) shows that real aggregate output can be expressed as the weighted sum of the gross output quantities of its constituent industries minus the weighted sum of industry intermediate input quantities. The weights are the real prices of gross outputs and intermediate inputs.

Real aggregate output growth from year *z* to year *t*, where *t* > *z*, can also be decomposed into industry growth components:

[13] $\tilde{p}_i^y$ and $\tilde{p}_i^m$ are called the real prices since the GDP deflator, P^v , can be used to measure inflation.

$$
\begin{aligned}
\dot{V}^r_{z\to t} &\equiv \frac{V^r_t - V^r_z}{V^r_z} = \frac{1}{V^r_z}\sum_i \left[\left(\tilde{p}^y_{it} y^r_{it} - \tilde{p}^y_{iz} y^r_{iz}\right) - \left(\tilde{p}^m_{it} m^r_{it} - \tilde{p}^m_{iz} m^r_{iz}\right)\right] \\
&= \frac{1}{V^r_z}\sum_i \left[\tilde{p}^y_{iz}\left(y^r_{it} - y^r_{iz}\right) + \left(\tilde{p}^y_{it} - \tilde{p}^y_{iz}\right)\left(y^r_{it} - y^r_{iz}\right) + \left(\tilde{p}^y_{it} - \tilde{p}^y_{iz}\right) y^r_{iz}\right] \\
&\quad - \frac{1}{V^r_z}\sum_i \left[\tilde{p}^m_{iz}\left(m^r_{it} - m^r_{iz}\right) + \left(\tilde{p}^m_{it} - \tilde{p}^m_{iz}\right)\left(m^r_{it} - m^r_{iz}\right) + \left(\tilde{p}^m_{it} - \tilde{p}^m_{iz}\right) m^r_{iz}\right] \\
&= \sum_i \frac{\tilde{p}^y_{iz} y^r_{iz}}{V^r_z}\left(\frac{y^r_{it} - y^r_{iz}}{y^r_{iz}} + \frac{\tilde{p}^y_{it} - \tilde{p}^y_{iz}}{\tilde{p}^y_{iz}} + \frac{y^r_{it} - y^r_{iz}}{y^r_{iz}}\frac{\tilde{p}^y_{it} - \tilde{p}^y_{iz}}{\tilde{p}^y_{iz}}\right) \\
&\quad - \sum_i \frac{\tilde{p}^m_{iz} m^r_{iz}}{V^r_z}\left(\frac{m^r_{it} - m^r_{iz}}{m^r_{iz}} + \frac{\tilde{p}^m_{it} - \tilde{p}^m_{iz}}{\tilde{p}^m_{iz}} + \frac{m^r_{it} - m^r_{iz}}{m^r_{iz}}\frac{\tilde{p}^m_{it} - \tilde{p}^m_{iz}}{\tilde{p}^m_{iz}}\right) \\
&= \sum_i \left[\frac{y_{iz}}{V_z}\left(\dot{y}^r_{z\to t} + \dot{\tilde{p}}^y_{z\to t} + \dot{y}^r_{z\to t}\dot{\tilde{p}}^y_{z\to t}\right) - \frac{m_{iz}}{V_z}\left(\dot{m}^r_{z\to t} + \dot{\tilde{p}}^m_{z\to t} + \dot{m}^r_{z\to t}\dot{\tilde{p}}^m_{z\to t}\right)\right],
\end{aligned} \tag{2}
$$

where $\dot{x}_{z\to t}$ is the growth rate of variable *x* over the period from *z* to *t*.

Equation (2) shows that each industry contributes to real GDP growth through an increase in real gross output or in real output price, which may be offset by an increase in use of intermediate inputs or a rise in real price of intermediate inputs. For each industry, the contribution associated with gross output is weighted by the ratio of the industry nominal gross output to nominal GDP at the beginning period. The weights are analogous to the "Domar weights" used to aggregate industry multifactor productivity growth calculated based on the gross output concept (Domar 1961). Similarly, an industry's offsetting effect associated with intermediate inputs is weighted by the ratio of the industry nominal intermediate inputs to nominal GDP at the beginning period.

Alternatively, the contribution of industry *i* to real GDP growth over the period from *z* to *t* can be written as

$$
\begin{aligned}
CPC_i &= \left(\frac{y_{iz}}{V_z}\dot{y}^r_{z\to t} - \frac{m_{iz}}{V_z}\dot{m}^r_{z\to t}\right) + \left(\frac{y_{iz}}{V_z}\dot{\tilde{p}}^y_{z\to t} - \frac{m_{iz}}{V_z}\dot{\tilde{p}}^m_{z\to t}\right) \\
&\quad + \left(\frac{y_{iz}}{V_z}\dot{y}^r_{z\to t}\dot{\tilde{p}}^y_{z\to t} - \frac{m_{iz}}{V_z}\dot{m}^r_{z\to t}\dot{\tilde{p}}^m_{z\to t}\right).
\end{aligned} \tag{3}
$$

The first two terms on the right-hand side are called the *pure quantity effect* and the *pure price effect* as they measure separately the contributions of growth in quantity and a rise in real price. The third term is the interaction of the first two effects associated with gross output minus the interaction of the first two effects associated with intermediate inputs. The interaction effects occur because the change in real price applies not only to the initial quantity but also to the change in quantity. However, the interaction term, which is a second-order effect, is relatively small.

The above decomposition technique has several desirable properties. First, it is consistent with real GDP in the chained-Fisher index. Besides contributing to GDP growth through a change in output quantity, an industry also contributes positively (negatively) to real GDP growth when its real output price rises (falls). Thus, it allows one to identify the sources of each industry's contribution to real GDP growth: quantity effect or price effect. Second, it is additive for any long period as it is not necessary for year t and z to be adjacent. Third, the decomposition is base-year invariant because all variables in question are either initial nominal shares or growth rates. And finally, the decomposition allows one to discuss the impact of the change in the use of intermediate inputs (outsourcing) on economic growth. For each industry, the pure quantity and price effects are net outcomes after impacts associated with the use of intermediate inputs.

These features are desirable and important for understanding industry contributions to real GDP growth. The first two properties distinguish our decomposition technique from the traditional decomposition technique used by Statistics Canada and the U.S. Bureau of Economic Analysis (BEA) to estimate industry contributions to percent change in real GDP (Chevalier 2003 for Statistics Canada; Strassner, Medeiros and Smith 2005 for the BEA).[14] The traditional decomposition technique suppresses the price effect by employing a Fisher formula that averages prices over a period. As a result, it does not isolate the price effect from the quantity effect to capture the rise or fall of the value of an output. In addition, it is additive only for a period with two consecutive years.

The change in quantity and price of a product in a competitive market is determined by a change in its demand and supply conditions. Given demand conditions, technological progress or a reduction in input cost causes a positive shift (downward) in the supply curve of an industry. This leads to an increase in output and a decrease in price. And the opposite is true when the supply curve shifts upward, say, due to a decline in production efficiency or an increase in input cost. Similarly, when consumers' tastes or income change or external forces (e.g., international trade) change, the demand for a product will change. Given supply conditions, an increase in demand (a positive upward shift in the demand curve) for an industry's output will lead to an increase in both its quantity and price. And the opposite is true for a decrease in demand.

Over a given period, an industry's output and its contribution to real GDP growth are influenced in a complex way by changes in both demand and supply conditions. If an industry in a competitive product market experiences a positive demand shift and a positive supply shift, there will necessarily be an increase in quantity, but the net effect on price will depend on the relative strength of the two shifts. If the demand shift is stronger, one will observe an increase in price; if the supply shift is stronger, one will observe a decline in price. Similarly, if the industry experiences a negative shift in both demand and supply, there will be a decline in quantity but the net effect on price will again depend on the

[14] Following an economic approach, Diewert (2002) and Reinsdorf, Diewert and Ehemann (2002) derive a similar decomposition technique as the one used by the BEA and Statistics Canada. Again, the economically-derived technique does not distinguish the price effect from the quantity effect and is not additive for a period with more than two years. For a detailed discussion, see Appendix A.

strength of one shift against the other. In the remaining two possibilities, where the shifts are in opposite directions, the effect on price can be determined but the effect on quantity depends on the relative strength of the shifts in demand and supply. Because it is difficult to untangle effects from demand and supply shifts in a given period, this paper only addresses the net shift experienced by each industry.

To facilitate a discussion of demand and supply conditions and their contributions to economic growth, this paper will assign industries to four different groups according to the signs of the pure gross output quantity effect and the pure gross output price effect: positive net demand shift, negative net demand shift, positive net supply shift, and negative net supply shift.[15] The four possible net shifts are shown in Table 1.

2.2. Industry Contribution to Economic Growth in Canada and the United States in 1981-2000

The decomposition technique, equation (2), is applied to the business sector in Canada and the United States, using a comparable data set on gross output, labour and intermediate inputs for the two countries.[16] The data set was developed under the direction of Dale Jorgenson of Harvard University to examine the sources of economic and productivity growth in the two countries. It covers 34 industries (based on the Standard Industrial Classification) in the business sector for the period 1981-2000.[17]

For simplicity, this paper groups the industries into 10 industry groups: primary; construction; manufacturing; transportation; communications; utility; trade (wholesale and retail trade); finance, insurance and real estate (FIRE); business services; and other services.[18] In addition, this paper only reports the analysis for the whole period 1981-2000 as a way to show the importance of formulating the contribution from the quantity effect as well as the price effect, although it is straightforward to apply the decomposition technique to any sub-period.

Canada

Over the period 1981-2000, all industries in Canada experienced either a net positive supply shift or a net positive demand shift, except for construction (Table 2). Five industry groups (primary, manufacturing, transportation, communications and trade) underwent net positive supply shifts, with positive pure gross output quantity effects and negative pure gross output price effects. Four industry groups (utility, FIRE, business services and other services)

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[15] This paper does not actually identify the size of supply and demand shifts, and only deals with the direction of the net shift.
[16] Nominal gross output is at producers' prices and nominal intermediate inputs are at purchasers' price.
[17] Among the 34 industries, there are 4 primary, 1 construction, 18 manufacturing and 11 services industries. For details of this database, see Ho, Rao and Tang (2004).
[18] There are two more reasons for this paper to stay at this fairly aggregated industry level. First, outputs for some services industries, especially at a detailed industry level, are difficult to measure and are more likely to be subject to measurement errors. Second, by using the aggregation, this paper hopes to minimize the problem arising from using national accounting data that adjusts prices of some products (e.g., computers) using hedonic-style methods but not the prices of others (e.g., most telecomm equipments).

underwent net positive demand shifts, with positive pure gross output quantity and positive pure gross output price effects. Construction experienced a negative supply shift, with negative pure gross output quantity effects and positive pure gross output price effects.

GDP per capita in the business sector in Canada grew 50.3 percent over the whole period 1981-2000. In terms of pure quantity effect, the single largest contribution to the growth came from output growth in trade (10.7 percentage points), followed by manufacturing (7.2 percentage points) and business services (6.9 percentage points). The pure price effects were relatively small in magnitude and they almost offset each other among the industry groups. The largest positive pure price effect occurred in other services (3.2 percentage points), followed by manufacturing and FIRE (both at 2.8 percentage points).

In terms of total industry contribution, which takes into account pure quantity effect, pure price effect and the interaction term, manufacturing was the largest contributor (12.2 percentage points), followed by FIRE (10.4 percentage points) and business services (8.2 percentage points).

The goods sector (primary, construction and manufacturing) contributed 9.5 percentage points to GDP growth over this period, compared to 40.8 percentage points for the services sector. Similarly, the industry group with a net supply shift (mainly manufacturing and trade) made a total contribution of 21.9 percentage points to GDP growth, compared to 28.2 percentage points for the industry group with net positive demand shifts (mainly FIRE, business services, and other services).

It is interesting to note that manufacturing experienced a large increase in intermediate inputs, fuelled by a large decline in intermediate input price (Table 3). The manufacturing sector had the largest gross output quantity effect, but the effect was largely offset by the quantity effect from an increase in the use of intermediate inputs. The manufacturing sector also had the largest negative gross output price effect, but the effect was more than offset by the price effect from a decline in intermediate input price.[19]

The United States

Similar trends occurred in the United States, but there were some differences. Although manufacturing in the United States underwent a positive net supply shift as in Canada, the shift was much stronger in the United States. The effect from the decline in gross output price in the United States was more than twice that in Canada, despite that the effect from the decline in intermediate input price was similar in both countries. The difference may be due to the fact that the manufacturing sector in Canada is relatively more concentrated in resource manufacturing, while in the United States it is relatively more concentrated in high-tech manufacturing. High-tech manufacturing, especially computer, communication and

[19] These phenomena may be partly explained by the fact that global supply chain has changed the Canadian manufacturing model and outsourcing for cheap intermediate inputs has become important part of Canadian manufacturing organization. For a discussion of global supply chain and a new model of industrial organization, see Sturgeon (2002) and Gereffi, Humphrey and Sturgeon (2005).

electronic equipment industries, experienced unprecedented technological progress over this period (Jorgenson 2001 and 2004).

Unlike the primary sector in Canada, which experienced a net positive supply shift, the primary sector in the United States underwent a net negative demand shift. In addition, unlike their counterparts in Canada, construction and utility in the United States underwent a small net positive and a small net negative demand shift, respectively.

GDP per capita in the business sector in the United States grew 63.8 percent over the period 1981-2000, 13.5 percentage points higher than in Canada. In terms of pure quantity effect, the single largest contribution to the growth in the United States was from manufacturing (21.2 percentage points), followed by trade (11.5 percentage points) and FIRE (7.1 percentage points). The largest positive pure price effect occurred in other services (9.2 percentage points). In terms of total industry contribution, which takes into account quantity effect, price effect and the interaction term, the largest contributor was other services (19.6 percentage points), followed by FIRE (15.4 percentage points) and business services (10.3 percentage points). Unlike Canada, where manufacturing was the largest single contributor, manufacturing in the United States made only a modest contribution to economic growth in the country, because of a large negative price effect.

Over this period, the goods and service sector contributed 6.6 percentage points and 57.2 percentage points of GDP growth in the United States, respectively. This compared to 9.5 percentage points for the goods sector and 40.8 percentage points for the services sector in Canada. Thus, the services sector was much more important to economic growth in the United States than in Canada.

The industry groups with a net positive supply shift (mainly manufacturing and trade) made a total contribution of 17.0 percentage points to GDP growth in the United States, compared to 21.9 percentage points in Canada. All these industries experienced a faster decline in real output price in the United States (Table 3). For manufacturing alone, the United States had an overall 10.4 percentage points contribution gap compared to Canada in terms of the pure price effect on aggregate GDP per capita growth.

For the industry groups with a net positive demand shift (mainly FIRE, business services, and other services), the total contribution to growth in the United States (49.3 percentage points) was much larger than in Canada (28.2 percentage points). Much of the difference was associated with a larger increase in industrial gross output prices of these industries in the United States. Over the period 1981-2000, the gross output price of other services increased 44.8 percent in the United States compared to 26.3 percent in Canada (Table 3). Similarly, the output prices of FIRE and business services also increased much faster in the United States than in Canada.

3. Industry Contribution to Aggregate Labour Productivity Growth

Demand and supply shifts influence the industrial structure in employment as well as output prices. Do those changes have any implication for industry contributions to aggregate labour productivity growth?[20]

This section develops an aggregate labour productivity decomposition technique to examine industry contributions to aggregate labour productivity growth. Like the decomposition technique for real GDP growth proposed in section 2, the decomposition technique for aggregate labour productivity growth is also consistent with real GDP in chained-Fisher index, taking into account real price effect as well as quantity effect.[21]

3.1. A Framework for Estimating Industry Contributions to Aggregate Labour Productivity Growth

Define H as total hours worked in the business sector. Labour productivity, X^r, in the business sector is then defined as real GDP per hour worked. The aggregate labour productivity can then be decomposed into its industry components.[22]

$$\begin{aligned}
X^r &= \frac{V^r}{H} = \frac{V}{P^V H} = \frac{Y-M}{P^V H} = \frac{\sum_i (y_i - m_i)}{P^V H} \\
&= \sum_i \left(\frac{p_i^y y_i^r - p_i^m m_i^r}{P^V H} \right) = \sum_i \left(\frac{p_i^y h_i x_i^y - p_i^m h_i x_i^m}{P^V H} \right) \\
&= \sum_i \frac{h_i}{H} \left(\tilde{p}_i^y x_i^y - \tilde{p}_i^m x_i^m \right) = \sum_i l_i \left(\tilde{p}_i^y x_i^y - \tilde{p}_i^m x_i^m \right) \\
&= \sum_i \left(\tilde{s}_i^y x_i^y - \tilde{s}_i^m x_i^m \right),
\end{aligned} \tag{4}$$

where h_i is total hours worked for industry *i*;

x_i^y and x_i^m are real gross output per hour worked (or gross output labour productivity) and real intermediate input per hour worked (intermediate input intensity) for industry *i*, respectively;

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[20] This paper concerns only labour productivity rather than multifactor productivity (MFP) for three reasons. First, labour productivity is directly linked to GDP per capita, commonly used as an indicator of the level of the standard of living. Second, capital input is required to estimate MFP, which is difficult to measure and often not comparable across countries (Ho, Rao and Tang 2004). Finally, and importantly, labour productivity is more tractable.

[21] An important consequence of using the chained-Fisher index is that real output is not additive. Therefore, traditional ways of computing an industry's contribution to aggregate productivity growth based on the additivity of real output (e.g., Wolff 2000 and van Ark, Inklaar and McGuckin 2002) are no longer valid.

[22] Note that real GDP is not scaled down by population for the productivity analysis.

$\tilde{s}_i^{\,y} = \tilde{p}_i^{\,y} l_i$ is the gross output relative size of industry *i*, equal to the product of the industry's labour input share ($l_i = h_i / H$) and its real gross output price ($\tilde{p}_i^{\,y}$); and

$\tilde{s}_i^{\,m} = \tilde{p}_i^{\,m} l_i$ is the intermediate input relative size of industry *i*, equal to the product of the industry's labour input share ($l_i = h_i / H$) and its real intermediate input price ($\tilde{p}_i^{\,m}$).

With this formulation, the aggregate labour productivity level equals the weighted industry gross output per hour worked minus the weighted industry intermediate inputs per hour worked. The weights are their corresponding relative sizes. The relative size of an industry, defined as the product of hours worked share and real output (or intermediate input) price, captures the effects from a change in employment share as well as a change in real output (or intermediate input) price of the industry. It indicates the importance of the industry in aggregate labour productivity. The formulation departs fundamentally from traditional methods that only consider reallocation effects from inputs (hours worked or intermediate inputs).[23] It captures not only the effect from a reallocation of hours worked across industries but also explicitly captures an industry's contribution from an increase in its real output price. Capturing the effect from a change in relative output price is consistent with aggregate labour productivity derived from real GDP in the chained-Fisher index.

Like real GDP growth, aggregate labour productivity growth between year *t* and z, where *t* > z, can be decomposed into industry growth components as:

$$\begin{aligned}
\dot{X}^{v}_{z\to t} &\equiv \frac{X^{v}_{t} - X^{v}_{z}}{X^{v}_{z}} = \frac{1}{X^{v}_{z}} \sum_i \left[\left(\tilde{s}^{y}_{it} x^{y}_{it} - \tilde{s}^{y}_{iz} x^{y}_{iz} \right) - \left(\tilde{s}^{m}_{it} x^{m}_{it} - \tilde{s}^{m}_{iz} x^{m}_{iz} \right) \right] \\
&= \frac{1}{X^{v}_{z}} \sum_i \left[\tilde{s}^{y}_{iz} \left(x^{y}_{it} - x^{y}_{iz} \right) + \left(\tilde{s}^{y}_{it} - \tilde{s}^{y}_{iz} \right)\left(x^{y}_{it} - x^{y}_{iz} \right) + \left(\tilde{s}^{y}_{it} - \tilde{s}^{y}_{iz} \right) x^{y}_{iz} \right] \\
&\quad - \frac{1}{X^{v}_{z}} \sum_i \left[\tilde{s}^{m}_{iz} \left(x^{m}_{it} - x^{m}_{iz} \right) + \left(\tilde{s}^{m}_{it} - \tilde{s}^{m}_{iz} \right)\left(x^{m}_{it} - x^{m}_{iz} \right) + \left(\tilde{s}^{m}_{it} - \tilde{s}^{m}_{iz} \right) x^{m}_{iz} \right] \\
&= \sum_i \frac{\tilde{s}^{y}_{iz} x^{y}_{iz}}{X^{v}_{z}} \left(\frac{x^{y}_{it} - x^{y}_{iz}}{x^{y}_{iz}} + \frac{\tilde{s}^{y}_{it} - \tilde{s}^{y}_{iz}}{\tilde{s}^{y}_{iz}} + \frac{x^{y}_{it} - x^{y}_{iz}}{x^{y}_{iz}} \frac{\tilde{s}^{y}_{it} - \tilde{s}^{y}_{iz}}{\tilde{s}^{y}_{iz}} \right) \\
&\quad - \sum_i \frac{\tilde{s}^{m}_{iz} x^{m}_{iz}}{X^{v}_{z}} \left(\frac{x^{m}_{it} - x^{m}_{iz}}{x^{m}_{iz}} + \frac{\tilde{s}^{m}_{it} - \tilde{s}^{m}_{iz}}{\tilde{s}^{m}_{iz}} + \frac{x^{m}_{it} - x^{m}_{iz}}{x^{m}_{iz}} \frac{\tilde{s}^{m}_{it} - \tilde{s}^{m}_{iz}}{\tilde{s}^{m}_{iz}} \right) \\
&= \sum_i \left[\frac{y_{iz}}{V_z} \left(\dot{x}^{y}_{z\to t} + \dot{\tilde{s}}^{y}_{z\to t} + \dot{x}^{y}_{z\to t} \dot{\tilde{s}}^{y}_{z\to t} \right) - \frac{m_{iz}}{V_z} \left(\dot{x}^{m}_{z\to t} + \dot{\tilde{s}}^{m}_{z\to t} + \dot{x}^{m}_{z\to t} \dot{\tilde{s}}^{m}_{z\to t} \right) \right].
\end{aligned} \tag{5}$$

With this formulation, each industry contributes to aggregate labour productivity growth through an increase in its gross output labour productivity or a rise in its relative size

[23] For example, Basu and Fernald (2002); Jorgenson and Stiroh (2000); Stiroh (2002); Faruqui et al. (2003); Jorgenson (2004); and Ho, Rao and Tang (2004).

associated with gross output, which is partly offset by an increase in intermediate input intensity and a rise in its relative size associated with intermediate inputs. Like the contributions of the industry to aggregate output growth, the contributions of the industry associated with gross output are weighted by the ratio of the industry nominal gross output to nominal GDP at the beginning period and the contributions associated with intermediate inputs are weighted by the ratio of the industry nominal intermediate inputs to nominal GDP at the beginning period. The weights are analogous to the "Domar weights" used to aggregate industry multifactor productivity growth calculated based on the gross output concept.

Alternatively, the contribution of an industry to aggregate labour productivity growth can be written as

$$\begin{aligned} CPC_i = & \left(\frac{y_{iz}}{V_z} \dot{x}^{y}_{z \to t} - \frac{m_{iz}}{V_z} \dot{x}^{m}_{z \to t} \right) + \left(\frac{y_{iz}}{V_z} \dot{\tilde{s}}^{y}_{z \to t} - \frac{m_{iz}}{V_z} \dot{\tilde{s}}^{m}_{z \to t} \right) \\ & + \left(\frac{y_{iz}}{V_z} \dot{x}^{y}_{z \to t} \dot{\tilde{s}}^{y}_{z \to t} - \frac{m_{iz}}{V_z} \dot{x}^{m}_{z \to t} \dot{\tilde{s}}^{m}_{z \to t} \right). \end{aligned} \tag{6}$$

The three terms from left to right are *the pure productivity effect*[24], *the relative size effect* and the interaction of the first two effects. The pure productivity effect captures an industry's contribution coming from the improvement in labour productivity of the industry. Similarly, the relative size effect reflects only the change in the relative size of the industry. The interaction term captures the effect of the change in relative size on the change in labour productivity. For example, an increase in hours worked share and/or relative price will apply not only to the initial labour productivity level but also to the change in labour productivity.

The developed decomposition is similar to Nordhaus (2002) but it departs in three important aspects. First, it is exact for any long period. It adds up industrial contributions for each of the components for any given number of industries that builds up the estimate for real GDP. In contrast, Nordhaus uses the approximation, $\ln[1 + \sum g(X_{it})\sigma_{i,t-1}] \approx \sum g(X_{i,t})\sigma_{i,t-1}$, which may not hold when the period in question is long or when an industry experiences high growth.[25] Secondly, unlike the decomposition developed by Nordhaus, the decomposition here is invariant to the choice of base year, that is, the value of each component does not change when the base year changes. Finally, unlike the study by Nordaus, this paper explicitly formulates an industry's contribution of a change in the real output price of the industry to aggregate labour productivity growth, which is consistent with real GDP in the chained-Fisher index.

[24] A terminology is used by Nordhaus (2002).

[25] For instance, over the period 1995-2000, output in the computer manufacturing grew (at an annual rate) 17 percent and 32 percent in Canada and the United States, respectively (Ho, Rao and Tang 2004).

3.2. Industry Contribution to Aggregate Labour Productivity Growth in Canada and the United States in 1981-2000

The decomposition technique, equation (5), is applied to aggregate labour productivity growth in the business sector in both Canada and the United States, using the same dataset as for decomposing real GDP growth.

Table 4 reports the results of decomposing aggregate labour productivity growth in Canada and the United States. In terms of the pure productivity effect, the primary and manufacturing sectors were the largest contributors to aggregate labour productivity growth in Canada. In the United States, the largest contributors were manufacturing and trade, followed by the primary sector. For all services industries except trade, FIRE and communications, the pure productivity effect was small or even negative.

In terms of the relative size effect, it was other services, business services and FIRE that had the largest contribution to aggregate labour productivity growth in the two countries. In contrast, the manufacturing and primary sector had the largest negative effect, as over this period the relative sizes of manufacturing and primary in the two economies decreased while the relative sizes of business services, FIRE and other services increased, especially in the United States.

In terms of total effect, which takes into account the pure productivity effect, the relative size effect and the interaction term, manufacturing was the largest contributor to aggregate labour productivity growth in Canada, followed by FIRE and business services. In the United States, other services sector was the largest contributor, followed by FIRE and business services. It is interesting to note that the total contribution of manufacturing in the United States was small. As discussed below, its positive pure productivity effect was mostly offset by the negative effect from a decline in its relative size, which mainly reflected declines in the share of hours and in real output price.

The goods sector contributed only 4.1 percentage points to aggregate labour productivity growth in Canada over this period, compared to 32.3 percentage points for the services sector. This compared to almost zero percentage points for the goods sector and 42.1 percentage points for the services sector in the United States. Thus, the services sector was more important to aggregate labour productivity growth in the United States than in Canada.

The industry group with a net supply shift (mainly manufacturing and trade) made a total contribution of 14.2 percentage points to aggregate labour productivity growth in Canada and 8.1 percentage points in the United States. The group, on average, experienced a smaller decline in relative size in Canada than in the United States. This translates into an overall 6.1 percentage-points gap in favour of Canada in terms of the total effect from the industry group on aggregate labour productivity growth.

For the industry group with a net positive demand shift (mainly FIRE, business services, and other services), the total contribution in the United States (37.7 percentage points) was much larger than in Canada (23.0 percentage points). Much of the difference was associated with the larger increase in the relative size of the industry group in the United States. Therefore, in contrast to the industry group with a net supply shift, the industry group with a net positive demand shift in the United States had an overall 14.7 percentage points advantage in terms of the total effect on aggregate labour productivity growth.

The decline in the importance of the primary and manufacturing sectors and the increase in the importance of FIRE, business services and other services were reflected by changes in both the shares of hours worked and the real output prices (Table 3). For Canada, the share of hours worked in the primary and manufacturing sectors decreased from 32.9 percent in 1981 to 24.9 percent in 2000. The primary gross output price declined 31.9 percent over this period, in spite of a much smaller decline in the intermediate input price (3.9 percent) over this period. Similarly, the manufacturing gross output price and intermediate input price declined 9.7 and 18.9 percent, respectively. In contrast, the share of hours worked in FIRE, business services and other services in Canada increased from 27.2 percent to 36.2 percent. The gross output price increase for this group ranged from 16.3 percent to 26.3 percent over this period, which was partly due to an increase in the intermediate input price, ranging from 13.4 percent to 26.1 percent.

The changes were more pronounced in the United States. The share of hours worked in the U.S. primary and manufacturing sectors decreased from 32.0 percent in 1981 to 20.8 percent in 2000. The primary gross output price dropped 37.1 percent, with a corresponding 20.0 percent drop in its intermediate input price. For manufacturing, the gross output price dropped 23.6 percent, with a similar drop in magnitude in the intermediate input price. In contrast, the U.S. business services and other services saw their employment shares increased from 4.2 percent and 20.1 percent to 9.5 percent and 25.8 percent. Over this period, they also saw their gross output prices increased 33.5 percent and 44.8 percent, with the change in intermediate input prices being –10.5 percent and to 12.1 percent, respectively. Although its employment share did not change much, FIRE in the United States experienced a significant increase in gross output price (36.4 percent), with a corresponding increase in intermediate input price (24.6 percent).

The industry structure change was due to unbalanced supply and demand shifts among these industries. The large decline in the importance of manufacturing in the United States in terms of relative size is because of a strong and positive supply shift in this industry, together with an increased competition from emerging economies. This industry, with its relatively strong improvement in productivity and decline in output price, required relatively less labour to meet its demand. In contrast, business services and other services, which experienced a strong increase in demand and a rise in real output price, had to employ relatively more labour to meet the increase in demand due to its stagnant labour productivity growth, as shown in Table 4.

4. Concluding Remarks

This paper has estimated industry contributions to aggregate output and labour productivity growth in Canada and the United States, by developing an analytical framework that is consistent with real GDP in the chained-Fisher index. The framework distinguishes between an industry's contribution resulting from changes in the industry output level and the contribution resulting from changes in the real price of the industry's output. This allows one further to determine whether the observed changes in the industry's output and price levels result from a net increase (decrease) in the demand for or the supply of the industry's product.

This paper demonstrates that the demand-driven industries, particularly FIRE, business services and other services, were the main contributors to real GDP growth in the business sector in the two countries over the period 1981-2000. They contributed to real GDP growth not only through real output growth but also through increases in the value of the services. On the other hand, although the supply-driven manufacturing sector, together with transportation and trade, also contributed significantly to real GDP growth through real output growth, the contribution was largely offset by a decline in its real output price.

Because of the increased hours worked share and to a lesser extent, the increased real output price, the demand-driven industries also contributed significantly to aggregate labour productivity over the sample period. In total, they accounted for more than 60 percent of aggregate labour productivity growth in Canada and almost 90 percent in the United States. This happened despite that some of those industries experienced lower labour productivity growth, which may be in part due to the strong and persistent increase in demand for their output. Interestingly, the manufacturing sector made a small contribution to aggregate labour productivity growth in the United States because its high labour productivity growth was largely offset by the decline in its relative size. Its hours worked share decreased from 24.9 percent in 1981 to 16.7 percent in 2000, and at the same time, its real output price decreased 23.6 percent over this period.

These findings are in contrast to the results based on traditional methods that focus only on the quantity effect. By ignoring the price effect, a traditional method underestimates (overestimates) the contribution of the service sector (the good sector) to aggregate measures.[26] For instance, Ho, Rao and Tang (2004), following Jorgenson, Ho and Stiroh (2003), define aggregate real GDP as a translog index over industry value added. They show that over the period 1981-2000, the service sector on average contributed 68% to real GDP growth in the Canadian business sector and 67% in the U.S. business sector. In contrast, by taking into account the price effect, the present paper demonstrates that over the same period, the service sector accounted for 81% and 90% of real GDP growth in the business sector in Canada and the Unites States, respectively.

This paper has sought to understand the direct contribution of an industry to real GDP growth and aggregate labour productivity growth, based on a growth accounting analysis. Like other growth accounting approaches, the analysis in this paper is unable to

[26] This is because service output prices on average tend to increase faster than good output prices.

deal with causality issues.   Research should be extended to examine an industry's contribution to the improvement in welfare through wealth creation and spillover effects on other industries. This is necessary for a better understanding of an industry's overall contribution (direct and indirect) to economic growth. As well, like other studies using data developed based on the Industry Accounts, the industry contribution estimates are subject to measurement errors due to the difficult nature in measuring outputs and prices of some service industries.[27]

[27] For a detailed discussion, see Triplett and Bosworth (2004).

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Appendix A

Denote Q_t and P_t as real GDP and the GDP deflator in year *t*. Similarly, denote $q_{i,t}$ and $p_{i,t}$ as real value added and the corresponding price for industry i in year *t*. The formula used by the BEA and Statistics Canada to calculate industry contributions to real GDP growth over a period with two consecutive years, $\mathrm{g(Q)}|_{t-1}^{t}$, is[28]

$$
\begin{aligned}
g(Q)\big|_{t-1}^{t} &= \mathrm{FQI}_{t-1}^{t} - 1 \\
&= \frac{\sum_i \left(p_{i,t-1} + p_{i,t}/\mathrm{FPI}_{t-1}^{t}\right)\left(q_{i,t} - q_{i,t-1}\right)}{\sum_j \left(p_{j,t-1} + p_{j,t}/\mathrm{FPI}_{t-1}^{t}\right) q_{j,t-1}} \\
&= \frac{\sum_i \left(\tilde{p}_{i,t-1} + \tilde{p}_{i,t}\right)\left(q_{i,t} - q_{i,t-1}\right)}{\sum_j \left(\tilde{p}_{j,t-1} + \tilde{p}_{j,t}\right) q_{j,t-1}},
\end{aligned}
\tag{A1}
$$

where $\mathrm{FQI}_{t-1}^{t} = Q_t / Q_{t-1}$, denoting the Fisher quantity index;

$\mathrm{FPI}_{t-1}^{t} = P_t / P_{t-1}$, denoting the Fisher price index; and

$\tilde{p}_{i,t} \equiv p_{i,t} / P_t$, denoting real output price of industry *i* in year *t*.

With the decomposition technique, the contribution of industry i to real GDP growth is

$$
\mathrm{CPC}_i\big|_{t-1}^{t} = \frac{\left(\tilde{p}_{i,t-1} + \tilde{p}_{i,t}\right)\left(q_{i,t} - q_{i,t-1}\right)}{\sum_j \left(\tilde{p}_{j,t-1} + \tilde{p}_{j,t}\right) q_{j,t-1}}. \tag{A2}
$$

The above decomposition technique (A1) is derived axiomatically. When an economic approach is based, Diewert (2002) and Reinsdorf, Diewert and Ehemann (2002) show that

$$
\begin{aligned}
g(Q)\big|_{t-1}^{t} &= \mathrm{FQI}_{t-1}^{t} - 1 \\
&= \frac{\sum_i \left(\tilde{p}_{i,t-1} + \tilde{p}_{i,t} \times \mathrm{FQI}_{t-1}^{t}\right)\left(q_{i,t} - q_{i,t-1}\right)}{\sum_j \tilde{p}_{j,t-1} q_{j,t-1} + \sum_j \tilde{p}_{j,t} q_{j,t}}.
\end{aligned}
\tag{A3}
$$

The industry contribution of industry *i* to real GDP growth is then

$$
\mathrm{CPC}_i\big|_{t-1}^{t} = \frac{\left(\tilde{p}_{i,t-1} + \tilde{p}_{i,t} \times \mathrm{FQI}_{t-1}^{t}\right)\left(q_{i,t} - q_{i,t-1}\right)}{\sum_j \tilde{p}_{j,t-1} q_{j,t-1} + \sum_j \tilde{p}_{j,t} q_{j,t}}. \tag{A4}
$$

[28] See Chevalier (2003) for Statistics Canada and Strassner, Medeiros and Smith (2005) for the BEA.

Reinsdorf, Diewert and Ehemann (2002) demonstrate that the axiomatically-derived contributions (A2) are very close numerically to the economically-derived contributions (A4).

It is interesting to note that the decomposition techniques (A1) and (A3) in evaluating industry contributions to real GDP growth do not distinguish price effect from quantity effect.

In addition, the above two decomposition techniques are valid for a period with two consecutive years. If a period has more than two years, then the industry compositions do not add up to aggregate real GDP growth. Consider a period from year *s* to year *t*, where $\forall(\mathrm{t} - \mathrm{s}) > 1$. Over the period, real GDP growth based on the official chained-Fisher index, is

$$g(Q)\,|_s^t = \frac{Q_t}{Q_s} - 1 = \mathrm{FQI}_s^{s+1} \times \mathrm{FQI}_{s+1}^{s+2} \times \cdots \times \mathrm{FQI}_{t-2}^{t-1} \times \mathrm{FQI}_{t-1}^{t} - 1. \tag{A5}$$

But, the Fisher index calculated directly for the period does not equal the one obtained by chaining:

$$\mathrm{FQI}\big|_s^t - 1 \neq \mathrm{FQI}_s^{s+1} \times \mathrm{FQI}_{s+1}^{s+2} \times \cdots \times \mathrm{FQI}_{t-2}^{t-1} \times \mathrm{FQI}_{t-1}^{t} - 1. \tag{A6}$$

Table 1: Quantity and Price Effects and Net Shifts

Net shift	Pure gross output quantity effect	Pure gross output price effect
D (+): Positive net demand shift	+	+
D (-): Negative net demand shift	-	-
S (+): Positive net supply shift	+	-
S (-): Negative net supply shift	-	+

Table 2: Industry Contributions to Real GDP Growth in the Business Sector, 1981-2000

	Gross output per capita growth (%)	Contribution (Percentage points)										
		Pure quantity effect			Pure price effect			Interaction Term			Total	Net Shift
		Gross output	Inter. inputs	Sub Total	Gross output	Inter. inputs	Sub Total	Gross output	Inter. inputs	Sub Total		
Canada												
Primary	31.4	6.9	-0.9	6.0	-7.0	0.3	-6.7	-2.2	0.0	-2.2	-2.9	S (+)
Construction	-4.7	-1.1	0.9	-0.2	0.1	0.3	0.4	0.0	0.0	0.0	0.2	S (-)
Manufacturing	46.0	38.2	-31.0	7.2	-8.1	10.9	2.8	-3.7	5.9	2.2	12.2	S (+)
Transportation	46.7	5.7	-2.1	3.6	-0.9	0.3	-0.6	-0.4	0.1	-0.3	2.7	S (+)
Communications	117.7	4.3	-0.7	3.6	-0.9	-0.3	-1.2	-1.0	-0.3	-1.3	1.2	S (+)
Utility	21.3	0.9	-1.1	-0.2	1.2	0.4	1.6	0.3	0.4	0.7	2.1	D (+)
Trade	78.6	15.6	-4.9	10.7	-0.6	-0.6	-1.2	-0.4	-0.5	-0.9	8.7	S (+)
FIRE	66.5	11.5	-5.5	6.0	3.6	-0.8	2.8	2.4	-0.7	1.7	10.4	D (+)
Business services	198.8	11.2	-4.3	6.9	0.9	-0.4	0.5	1.8	-1.1	0.7	8.2	D (+)
Other services	51.2	7.6	-4.6	3.0	3.9	-0.7	3.2	2.0	-0.6	1.4	7.5	D (+)
Total	**50.3***	**100.8**	**-54.2**	**46.6**	**-7.8**	**9.4**	**1.6**	**-1.2**	**3.2**	**2.0**	**50.3**	
Contribution from sub-group:												
Goods sector		44.0	-31.0	13.0	-15.0	11.5	-3.5	-5.9	5.9	0.0	9.5	
Service sector		56.8	-23.2	33.6	7.2	-2.1	5.1	4.7	-2.7	2.0	40.8	
Demand-driven industries		31.2	-15.5	15.7	9.6	-1.5	8.1	6.5	-2.0	4.5	28.2	D (+)
Supply-driven industries		70.7	-39.6	31.1	-17.5	10.6	-6.9	-7.7	5.2	-2.5	21.9	S (+)
The United States												
Primary	-1.0	-0.2	2.3	2.1	-7.1	1.9	-5.2	0.1	-0.5	-0.4	-3.5	D (-)
Construction	22.5	3.5	-3.6	-0.1	1.3	0.2	1.5	0.3	0.1	0.4	1.9	D (+)
Manufacturing	52.0	41.4	-20.2	21.2	-18.8	11.2	-7.6	-9.8	4.3	-5.5	8.2	S (+)
Transportation	50.5	4.5	-2.1	2.4	-1.3	0.3	-1.0	-0.6	0.1	-0.5	1.0	S (+)
Communications	61.9	3.1	-1.7	1.4	0.6	-0.1	0.5	0.3	0.0	0.3	2.1	D (+)
Utility	-15.0	-1.3	1.4	0.1	-0.8	2.2	1.4	0.1	-0.5	-0.4	1.0	D (-)
Trade	58.9	16.1	-4.6	11.5	-1.7	-0.7	-2.4	-1.0	-0.3	-1.3	7.8	S (+)
FIRE	77.1	13.8	-6.7	7.1	6.5	-1.5	5.0	5.0	-1.6	3.4	15.4	D (+)
Business services	174.5	9.4	-4.7	4.7	1.8	0.2	2.0	3.1	0.5	3.6	10.3	D (+)
Other services	58.9	13.7	-8.4	5.3	10.4	-1.2	9.2	6.1	-1.0	5.1	19.6	D (+)
Total*	**63.8***	**104.0**	**-48.3**	**55.7**	**-9.1**	**12.5**	**3.4**	**3.6**	**1.1**	**4.7**	**63.8**	
Contribution from sub-group:												
Goods sector		44.7	-21.5	23.2	-24.6	13.3	-11.3	-9.4	3.9	-5.5	6.6	
Service sector		59.3	-26.8	32.5	15.5	-0.8	14.7	13.0	-2.8	10.2	57.2	
Demand-driven industries		43.5	-25.1	18.4	20.6	-2.4	18.2	14.8	-2.0	12.8	49.3	D (+)
Supply-driven industries		62.0	-26.9	35.1	-21.8	10.8	-11.0	-11.4	4.1	-7.3	17.0	S (+)

*GDP per capita growth.

Table 3: Relative Size by Industry in Canada and the United States, 1981 and 2000

Industries	Hours Share (%)		Real Price				Relative Size			
			Gross output		Inter. inputs		Gross output		Inter. inputs	
	1981	2000	1981	2000	1981	2000	1981	2000	1981	2000
Canada										
Primary	9.1	5.5	1.000	0.681	1.000	0.961	0.091	0.038	0.091	0.053
Construction	9.7	8.8	1.000	1.003	1.000	0.977	0.097	0.088	0.097	0.086
Manufacturing	23.8	19.4	1.000	0.903	1.000	0.811	0.238	0.175	0.238	0.158
Transportation	6.8	6.8	1.000	0.929	1.000	0.954	0.068	0.063	0.068	0.065
Communications	1.5	1.1	1.000	0.765	1.000	1.361	0.015	0.009	0.015	0.015
Utility	0.9	0.8	1.000	1.266	1.000	0.620	0.009	0.010	0.009	0.005
Trade	20.9	21.4	1.000	0.972	1.000	1.096	0.209	0.208	0.209	0.235
FIRE	6.7	6.6	1.000	1.207	1.000	1.134	0.067	0.080	0.067	0.075
Business services	5.5	11.1	1.000	1.163	1.000	1.261	0.055	0.129	0.055	0.139
Other services	15.0	18.5	1.000	1.263	1.000	1.137	0.150	0.234	0.150	0.210
The United States										
Primary	7.1	4.1	1.000	0.629	1.000	0.800	0.071	0.026	0.071	0.033
Construction	6.4	7.7	1.000	1.087	1.000	0.972	0.064	0.084	0.064	0.075
Manufacturing	24.9	16.7	1.000	0.764	1.000	0.784	0.249	0.128	0.249	0.131
Transportation	3.7	4.3	1.000	0.856	1.000	0.928	0.037	0.036	0.037	0.039
Communications	1.6	1.4	1.000	1.113	1.000	1.027	0.016	0.016	0.016	0.014
Utility	0.9	0.5	1.000	0.904	1.000	0.628	0.009	0.005	0.009	0.003
Trade	24.4	23.4	1.000	0.938	1.000	1.063	0.244	0.219	0.244	0.248
FIRE	6.6	6.7	1.000	1.364	1.000	1.246	0.066	0.092	0.066	0.084
Business services	4.2	9.5	1.000	1.335	1.000	0.895	0.042	0.126	0.042	0.085
Other services	20.1	25.8	1.000	1.448	1.000	1.121	0.201	0.373	0.201	0.289

The relative size of an industry for gross output (intermediate inputs) equals the product of its hours share and its real gross output (intermediate inputs) price.

Table 4: Industry Contribution to Aggregate Labour Productivity Growth, 1981-2000

	Gross output per hour growth (%)	Contribution (Percentage Points)										
		Pure productivity effect			**Relative size effect**			**Interaction Term**			**Total**	**Net Shift**
		Gross output	**Inter. inputs**	**Sub Total**	**Gross output**	**Inter. inputs**	**Sub Total**	**Gross output**	**Inter. inputs**	**Sub Total**		
Canada												
Primary	95.8	21.1	-5.5	15.6	-12.9	3.5	-9.4	-12.4	2.3	-10.1	-3.9	S (+)
Construction	-3.9	-0.9	0.8	-0.1	-2.3	1.7	-0.6	0.1	-0.1	0.0	-0.8	S (-)
Manufacturing	62.1	51.6	-40.8	10.8	-21.8	19.5	-2.3	-13.5	13.8	0.3	8.8	S (+)
Transportation	34.5	4.2	-1.4	2.8	-1.0	0.3	-0.7	-0.3	0.1	-0.2	1.8	S (+)
Communications	161.0	5.9	-1.0	4.9	-1.5	0.0	-1.5	-2.5	0.0	-2.5	0.8	S (+)
Utility	25.1	1.1	-1.1	0.0	0.5	0.4	0.9	0.1	0.5	0.6	1.6	D (+)
Trade	58.5	11.6	-3.6	8.0	-0.1	-0.8	-0.9	-0.1	-0.4	-0.5	6.7	S (+)
FIRE	53.7	9.3	-4.6	4.7	3.2	-0.7	2.5	1.7	-0.5	1.2	8.4	D (+)
Business services	35.8	2.0	-1.2	0.8	7.5	-2.2	5.3	2.7	-1.8	0.9	7.0	D (+)
Other services	11.4	1.7	-1.9	-0.2	8.2	-2.2	6.0	0.9	-0.8	0.1	6.0	D (+)
Total	**36.4***	**107.6**	**-60.3**	**47.3**	**-20.2**	**19.5**	**-0.7**	**-23.3**	**13.1**	**-10.2**	**36.4**	
Contribution from sub-group:												
Goods sector		71.8	-45.5	26.3	-37.0	24.7	-12.3	-25.8	16.0	-9.8	4.1	
Service sector		35.8	-14.8	21.0	16.8	-5.2	11.6	2.5	-2.9	-0.4	32.3	
Demand-driven industries		14.1	-8.8	5.3	19.4	-4.7	14.7	5.4	-2.6	2.8	23.0	D (+)
Supply-driven industries		94.4	-52.3	42.1	-37.3	22.5	-14.8	-28.8	15.8	-13.0	14.2	S (+)
The United States												
Primary	49.4	9.4	-1.4	8.0	-12.2	5.2	-7.0	-6.0	0.8	-5.2	-4.3	D (-)
Construction	-11.5	-1.8	-0.2	-2.0	4.7	-1.4	3.3	-0.5	0.0	-0.5	0.7	D (+)
Manufacturing	96.0	76.4	-41.0	35.4	-38.7	24.4	-14.3	-37.2	19.4	-17.8	3.4	S (+)
Transportation	14.4	1.3	-0.5	0.8	-0.2	-0.3	-0.5	0.0	0.0	0.0	0.2	S (+)
Communications	62.9	3.1	-1.8	1.3	-0.2	0.3	0.1	-0.1	0.2	0.1	1.5	D (+)
Utility	27.7	2.4	-0.9	1.5	-4.2	3.7	-0.5	-1.2	0.5	-0.7	0.4	D (-)
Trade	44.0	12.0	-3.2	8.8	-2.8	-0.2	-3.0	-1.2	-0.1	-1.3	4.5	S (+)
FIRE	50.5	9.0	-4.8	4.2	7.0	-1.6	5.4	3.5	-1.3	2.2	11.8	D (+)
Business services	5.6	0.3	-0.6	-0.3	10.8	-2.0	8.8	0.6	-0.6	0.0	8.5	D (+)
Other services	7.5	1.8	-2.6	-0.8	19.8	-4.1	15.7	1.5	-1.1	0.4	15.2	D (+)
Total	**41.9***	**113.9**	**-57.0**	**56.9**	**-16.0**	**24.0**	**8.0**	**-40.6**	**17.8**	**-22.8**	**41.9**	
Contribution from sub-group:												
Goods sector		84.0	-42.6	41.4	-46.2	28.2	-18.0	-43.7	20.2	-23.5	-0.2	
Service sector		29.9	-14.4	15.5	30.2	-4.2	26.0	3.1	-2.4	0.7	42.1	
Demand-driven industries		12.4	-10.0	2.4	42.1	-8.8	33.3	5.0	-2.8	2.2	37.7	D (+)
Supply-driven industries		89.7	-44.7	45.0	-41.7	23.9	-17.8	-38.4	19.3	-19.1	8.1	S (+)

* GDP per hour worked growth.

Figure 1:
A Positive Supply Shock in the Goods Sector and the Movement of Labour to the Service Sector