Productivity Growth in Canada and the United States: Recent Industry Trends and Potential Explanations

Wulong Gu and Michael Willox[1]
Statistics Canada

Abstract

Labour productivity growth in Canada was weaker than that in the United States from the mid-1980s to 2010, leading to a decline in Canada's relative productivity level. This situation was mainly due to the lower multifactor productivity (MFP) growth experienced in most Canadian industries in that period. After 2010, however, the pattern reversed itself as labour productivity growth in Canada exceeded that of the United States. Higher labour productivity growth in Canada for the 2010-2014 period was due to a relatively larger capital deepening effect and relatively higher MFP growth. Both these developments were associated with stronger output growth and stronger demand in Canada. In addition, the contributions of ICT producing and ICT intensive using industries to U.S. labour productivity growth waned after 2010. For Canada, ICT producing industries contributed little to overall labour productivity before and after 2010, while ICT intensive using industries exhibited stronger productivity growth after 2010. The latter may reflect the more moderate ICT investment in Canada compared to the United States in the 1990s and early 2000s and the more gradual realization of benefits of ICT usage.

Canada's labour productivity declined relative to that of the United States from the mid-1980s to 2010. This relative decline tended to hold back growth in Canada's standard of living relative to that in the United States, as well as Canada's relative competiveness. However, in recent years, this pattern reversed itself. Since 2010, Canada experienced gains in relative labour produc-

1 Wulong Gu is Senior Advisor in the Economic Analysis Division of the Analytical Studies Branch of Statistics Canada. Michael Willox is a Senior Research Economist in the same division. This article is based on the paper prepared for the CSLS-Productivity Partnership session, "Explaining Canada's Post-2000 Productivity Performance I: Setting the Stage" at the annual meeting of the Canadian Economic Association (CEA) held at McGill University, Montréal, Québec, June 1-3, 2018. We would like to thank Jon Samuels of the U.S. Bureau of Economic Analysis and Steve Rosenthal of the U.S. Bureau of Labor Statistics for helpful discussions on the U.S. KLEMS database. We would also like to thank Romain Duval, Danny Leung, Ryan Macdonald, Andrew Sharpe, four anonymous referees and the participants at the CEA session for helpful comments. Email: wulong.gu@canada.ca, michael.willox@canada.ca

tivity growth compared to that of the United States. The reversal arises both from weaker labour productivity growth in the United States, following the financial crisis of 2008 and 2009, and from more robust labour productivity growth in Canada.

The long decline in Canada's relative labour productivity caused considerable concern in Canada, and was the source of numerous studies. Gu and Ho (2000), Faruqui *et al.* (2003), Ho, Rao and Tang (2004), and Baldwin and Gu (2007) compared industry productivity growth rates in Canada and the United States. They found that Canada's labour productivity relative to that in the United States started to decline in mid 1980s, and that the decline was mainly due to lower multifactor productivity (MFP) growth in Canada. The effect of capital deepening and the effect of changes in labour composition towards more experienced and more educated workers were similar in the two countries. They also found that ICT (information and communication technologies) service industries and high-tech manufacturing (ICT manufacturing and machinery manufacturing) were major sources of difference in relative productivity performance starting in the mid-1980s.[2] Along a similar vein, Sharpe (2003) and Baldwin and Gu (2007) traced the causes to lower innovation performance and lower investment in ICT technologies. More recently, Sharpe and Tsang (2018) and Baldwin and Willox (2016) examined recent developments for productivity growth in Canada.

This article investigates the forces that are driving the reversal after the 2008-2009 financial crisis. It provides a comparison of productivity growth in Canada and the United States over the period from 1987 to 2016, with a focus on the sources of the recent gains in Canada' relative productivity performance after 2010. To understand the sources of these differences at the industry level, industry productivity statistics published in the two countries are used.

While Statistics Canada has published MFP statistics for individual industries of the business sector since the early 1990s, those data have only become available recently in the United States. The main objective of the article is to trace the difference in aggregate labour productivity growth and its three main components into the contributions of individual industries. Those three components are: capital deepening effect, skills upgrading and MFP growth.

More comparable estimates of output, capital, labour, and intermediate input and productivity growth at the industry level for Canada and the United States have become available recently from Statistics Canada and the U.S. Bureau of Labor Statistics (BLS). The most important changes to the estimation that contribute to greater compara-

2 The ICT intensive service industries include wholesale and retail trade, finance and insurance, and communication services.

bility of the estimates come from revisions to the measurement of capital input in Canada and labour input in the United States. The revisions to Canadian data are summarized in Baldwin *et al.* (2014), which now use a method for estimating capital input that is similar to that by the U.S. BLS. Capital input and user cost of capital in both countries are estimated using a rate of return to capital that is smoothed and adjusted to industry averages when there are large and unusual movements. Similar to the estimates of labour composition and labour input from Statistics Canada, the U.S. BLS has also developed labour composition estimates at the industry level that take into account the changes in the composition of hours worked with different education levels and experience of workers. As a result, the concept and estimation of the capital and labour inputs are more comparable in the two countries than they were in the past.

This article is organized as follows. The first main section describes the data sources used for the analysis. The following session provides estimates of the sources of labour productivity growth for the Canadian and U.S. business sectors. It delves into what type of inputs make the most important contributions. The next section then examines which inputs make the largest contributions by industry and illustrates which industries make the largest contributions to business sector growth. The last section discusses the results in light of recent research and concludes.

Data Sources

Productivity measures in Canada and the United States follow the framework laid down by Jorgenson (1966), Diewert (1976), Jorgenson, Gollop and Fraumeni (1987), Jorgenson, Ho and Stiroh (2005), and Schreyer (2001). In this framework, industry-level productivity growth is estimated using detailed data on gross output and inputs, and aggregate productivity growth is estimated using industry-level data. Industry productivity accounts and aggregate productivity accounts are fully integrated; MFP growth at the aggregate level and MFP growth at the industry level are related to one another through Domar aggregation (Domar, 1961).

At both the industry and aggregate level, MFP growth is defined as output growth that is not accounted for by the growth of inputs. It measures the extent to which inputs are efficiently used in the production process. Growth in MFP is often associated with technological change, organizational change, or economies of scale.

Canadian Data

Productivity data for the business sector and individual industries in Canada are from the Canadian Productivity Accounts produced by Statistics Canada. Output for the business sector is measured as value added while the output for individual industries is gross output. Gross output and intermediate inputs are derived from Statistics Canada's supply-use tables (SUTs). Real value added is derived from SUTs using double deflation. For the post-

reference years after 2014 (for which SUTs are not yet available), real value added in the business sector is based on a measure of real value added at basic prices published by the Industry Analysis Division at Statistics Canada.

Hours worked represents the total number of hours that a person devotes to work, whether paid or unpaid. Labour input is hours worked multiplied by a labour composition index. The number of hours worked is calculated as the product of the number of jobs times average hours worked per job, which are derived from household and establishment surveys. The labour composition index estimates the effect of shifts in age (as proxy for experience), education, and class of workers (paid versus self-employed and unpaid family workers) on the total amount of labour services provided by total hours worked (Statistics Canada, 2002).

Capital service input is an estimate of the service flows derived from the stock of capital assets. The capital services measure is based on the bottom-up approach. This approach consists of three steps which involves the estimation of capital stock, the aggregation of capital stock of various asset types within each industry to estimate industry capital services with weights based on the user cost of capital, and the aggregation of capital services across industries to derive capital services in the business sector (Baldwin *et al.* 2014).

U.S. Data

Productivity data for the private business sector and individual industries in the United States is from the U.S. BLS. Output for the business sector is value added while output for individual industries is measured by sectoral output. Sectoral output of an industry differs from gross output as sectoral output nets out the transactions of intermediate inputs between production units in the industry. The BLS publishes MFP and related variables for the private business and private non-farm business sectors. More recently, it has also released the MFP data base for individual industries back to 1987. For the purpose of this article, we focus on the productivity performance of the U.S. private business sector and compare it with the Canadian business sector. The methods for constructing MFP in the U.S. private business sector are documented in Fleck et al. (2014).[3]

The main analysis of this article focuses on the period from 1987 to 2014 when the industry productivity data are available in both countries.

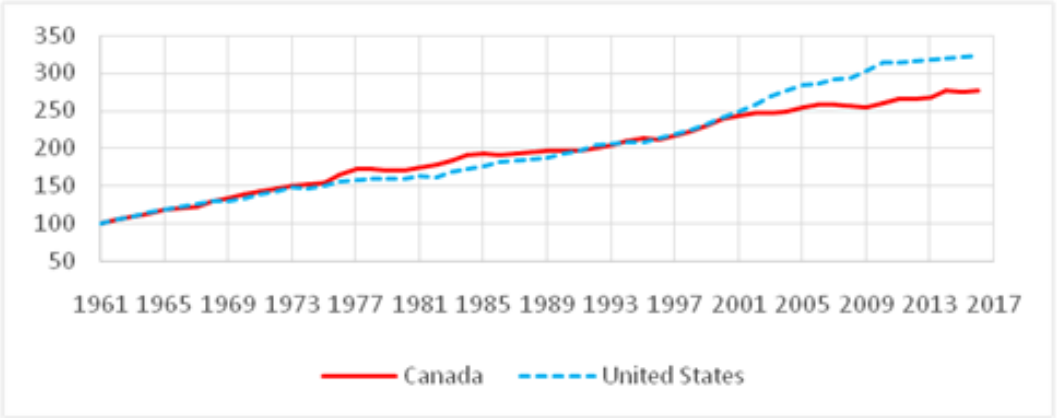
Sources of Business Sector Labour Productivity Growth

Chart 1 presents the Canada-U.S. absolute and relative labour productivity for the business sector over the period from 1961 to 2016. Canadian labour productivity growth exceeded that of the United States up to the mid-1980s. From the mid-1980s to 2010, U.S. labour

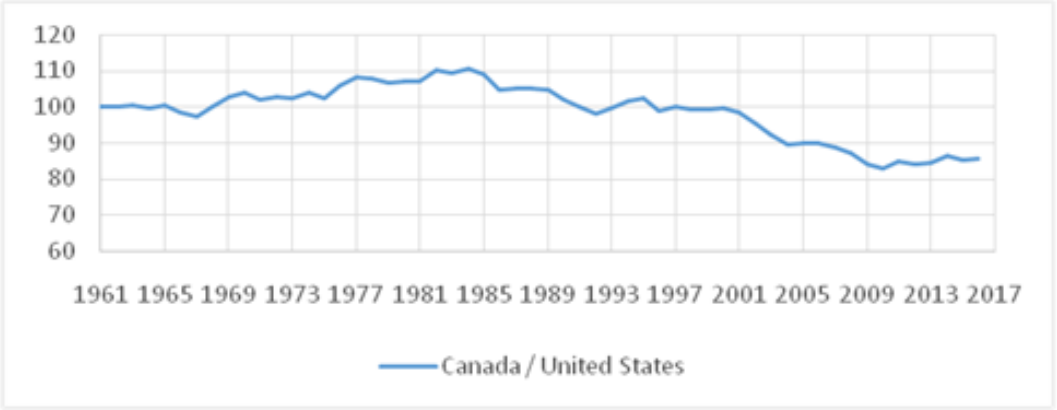
3 In the remainder of the article, the U.S. private business sector is referred to as the U.S. business sector.

Chart 1: Labour Productivity in the Business Sector, Canada and the United States, 1961-2016

Panel A: Labour productivity, Index (1961 = 100)



Panel B: Relative labour productivity of Canada compared to the United States, Index (1961 = 100 in both countries)



Sources. Statistics Canada and the Bureau of Labor Statistics.

productivity growth exceeded Canadian growth. The gap widened over that period, particularly for the period from 2000 to 2010. After 2010, Canadian labour productivity growth exceeded that of the United States.

Both Statistics Canada and the U.S. BLS decompose labour productivity growth into three components or sources of growth: capital intensity, the skill level of the labour force (due to changes in labour composition) and a residual (MFP growth). The first two components (both arising from investment, one in fixed capital such a machinery, structures and R&D, the other in education and training) were similar in the two countries after the mid-1980s. The third (the residual often referred to MFP growth that captures innovation, technological change and capacity utilization changes, and some measurement errors) was larger in the United States (Baldwin and Gu, 2007).

Table 1 summarizes labour productivity growth and its three main components in the Canadian and U.S. total business sectors. The results for the aggregate business sectors are presented for the period 1987 to 2014 as produc-

Table 1: Sources of Labour Productivity Growth in the Business Sector, Canada and the United States (average annual rate of change)

	1987-2010	2010-2014	2010-2014 less 1987-2010
Canada			
Labour productivity growth	1.30	1.53	0.24
Contribution of capital intensity	0.98	0.65	-0.33
Contribution of labour composition	0.34	0.14	-0.20
Multifactor productivity growth	-0.02	0.75	0.77
United States			
Labour productivity growth	2.33	0.50	-1.83
Contribution of capital intensity	0.98	-0.16	-1.14
Contribution of labour composition	0.30	0.17	-0.13
Multifactor productivity growth	1.05	0.49	-0.56
Canada minus the United States			
Labour productivity growth	-1.03	1.04	2.07
Contribution of capital intensity	0.00	0.81	0.81
Contribution of labour composition	0.04	-0.03	-0.07
Multifactor productivity growth	-1.07	0.26	1.33

Source: Authors' calculation using industry productivity databases from Statistics Canada and the Bureau of Labor Statistics.

tivity data at the industry level are only available over that period in both countries, and a comparison of productivity growth at the industry level is made for that period.

For the 1987-2010 period, labour productivity growth was slower in Canada than in the United States. Labour productivity rose at 1.30 per cent per year in the Canadian business sector, while it increased 2.33 per cent per year in the U. S. business sector.

The slower labour productivity growth in Canada compared with that in the United States in the period from 1987 to 2010 reflected slower MFP growth in Canada, a fact that is well documented in previous studies (e.g. Baldwin and Gu, 2007). The effects of capital deepening, skills upgrading or changes in labour composition towards more educated and more experienced workers on productivity growth were nearly identical in the two countries.

After 2010, labour productivity growth increased in Canada, from 1.30 per cent per year in the 1987-2010 period to 1.53 per cent in the 2010-2014 period. This increase after 2010 was due to higher MFP growth. The capital deepening effect and, to a lesser extent, the effect of labour composition both declined.

In contrast, for the United States, labour productivity declined after 2010. The decline in labour productivity growth from 2.33 per cent in 1987-2010 to 0.5 per cent in 2010-2014 was mostly attributed to weaker contributions from the capital deepening effect and, to a lesser extent, from weaker MFP growth. Those results have been documented in previous studies (Baily and Montalbono, 2016, Manyika, *et al.*, 2017, and Murray, 2018). The weaker effect of labour composition after 2010 also contributed to the slowdown in aggregate labour productivity growth in the United States.

As a result of the divergent trends in labour productivity growth in the two countries, labour productivity in the business sector in Canada increased at

a faster pace than in the United States for the 2010-2014 period. At the pace of 1.53 per cent per year on average in Canada over this period, was triple the 0.50 per cent average annual increase in the United States. The relatively faster growth in labour productivity in Canada over the period after 2010 was due to the relatively faster growth in capital intensity and, to lesser extent, the relatively faster growth in MFP in Canada. For the 2010-2014 period, increases in capital intensity contributed an annual average of 0.65 percentage points to labour productivity growth in Canada. By comparison, capital intensity declined in the United States, subtracting an average of 0.16 percentage points annually from U.S. labour productivity growth.

Over the same period, MFP growth was higher in Canada than in the United States. Multifactor productivity contributed an annual average of 0.75 percentage points to labour productivity growth in Canada, and it contributed an annual average of 0.49 percentage points to labour productivity growth in the United States.

The third component of labour productivity growth – the effect of skill upgrading on labour composition – was similar in the two countries after 2000. For the period from 2010 to 2014, skills upgrading contributed 0.14 percentage points annually in Canada and 0.17 percentage points in the United States.

The comparison for the business sector covering more recent years shows that labour productivity growth was also higher in Canada than that in the United States. For the period 2010 to 2017, labour productivity growth was 1.22 per year in the Canadian business sector, compared with 0.65 per year for the U.S. business sector. The relatively higher labour productivity growth in Canada for the period 2010 to 2017 reflects the high relative productivity growth in Canada for the period 2010 to 2014 (shown in Table 1) and a similar productivity growth for the period 2014 to 2017.[4] The superior labour productivity performance of Canada relative to the United States fell off significantly after 2014. The productivity growth gap was 1.04 percentage points in Canada's favour in 2010-2014, but fell to 0.57 points in 2010-2017 because of the addition of the 2014-2017 period when labour productivity growth was the same in the two countries.

4 There was a slight pickup in business sector labour productivity growth in the United States and a decline in Canada over the 2014-2017 period compared with the 2010-2014 period. As a result, labour productivity rose at a similar rate of 0.8 per cent per year in the two countries over the period 2014 to 2017.

Sources of Labour Productivity Growth Across Industries

Output in the Canadian industry productivity database is measured using gross output while it is measured using sectoral output in the United States.[5] Multifactor productivity growth based on sectoral output is higher than MFP growth based on gross output. This will bias the comparison in favour of the United States. But it will not affect its contribution to aggregate productivity growth, a property of the Domar aggregation.[6]

Labour productivity growth at the industry level is defined as gross output (or sectoral output) per hour worked. The growth in labour productivity can be decomposed into the contributions from capital deepening, labour composition change, intermediate input deepening, and MFP growth. The effect of capital deepening measures the effect of an increase in capital intensity on labour productivity growth and is estimated as the growth in the capital-labour ratio times the share of capital compensation in gross output. The effect of labour composition changes captures the effect of skills upgrading and is estimated as the change in labour composition times the share of labour compensation in gross output. The effect of intermediate input deepening captures the effect of outsourcing on labour productivity growth and is estimated as the growth in the intermediate input-to-labour ratio times the share of intermediate inputs in gross output.

Tables A1 and A2 in the Appendix [7] present the sources of labour productivity growth by industry for Canada and the United States, respectively, over the period from 1987 to 2010. The results, averaged across industries, are summarized in Chart 2.

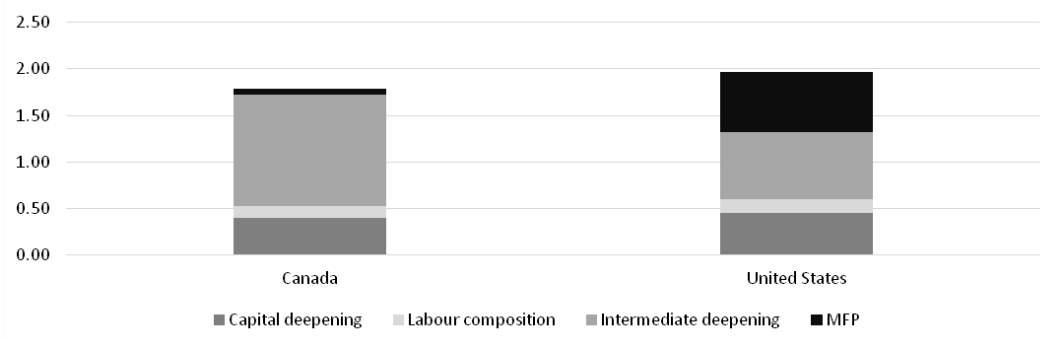
For the 1987-2010 period, in Canada and the United States, the largest contributor to labour productivity growth was intermediate input deepening across industries, reflecting the trends towards out-sourcing of intermediate inputs from domestic industries and abroad. Capital deepening was an important contributor to labour productivity growth in both countries as was the shift of workers towards higher education levels and more experience. Multifactor productivity growth was an important contributor to labour productivity growth in the United States on average, but it made a much smaller average contribution to

5 Data are comparable between Canada and the United States using 3-digit NAICS codes for the goods sector except for utilities and construction, which are defined at the 2-digit NAICS code level. Services sector industries are also defined at the 2-digit NAICS code level, except for the management of companies industry, which is included in finance and insurance. Finance and insurance also excludes the imputed rent of owner occupied dwellings. Retail trade combines NAICS codes 44 and 45. Transportation combines NAICS codes 48 and 49.

6 Multifactor productivity growth based on sectoral output is equal to MFP growth based on gross output times the ratio of nominal gross output to nominal sectoral output. The contribution of an industry to aggregate value added MFP growth is equal to industry MFP growth times the ratio of industry output to aggregate value added. Industry contributions to aggregate value added MFP growth are not affected by the choice of output used for calculating MFP growth.

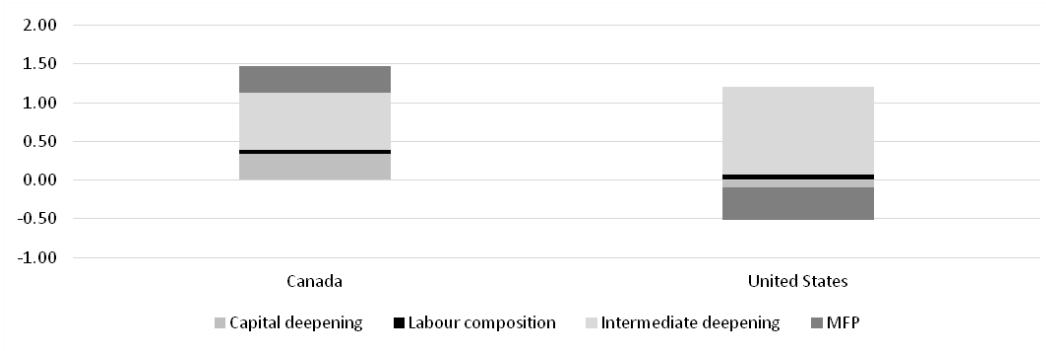
7 The Appendix is posted with this article at http://www.csls.ca/ipm/35/Gu_Willox_appendix.pdf.

Chart 2: Sources of Labour Productivity Growth in Average Canadian and U.S. Industries, 1987-2010 (average annual rate of change)



Source: Authors' calculation using industry productivity databases from Statistics Canada and the Bureau of Labor Statistics.

Chart 3: Sources of Labour Productivity Growth in Average Canadian and U.S. Industries, 2010-2014 (percentage point contribution per year)



Source: Authors' calculation using industry productivity databases from Statistics Canada and the Bureau of Labor Statistics.

labour productivity growth in Canada.

Tables A3 and A4 in Appendix present the sources of labour productivity growth by industry for Canada and the United States over the 2010-2014 period, which are summarized in Chart 3 for average industries.

For both Canada and the United States, intermediate input deepening remained the most important contributor, from a growth accounting (not causal) perspective, to labour productivity growth in the period 2010 to 2014.

The capital deepening effect and MFP growth made positive contributions to labour productivity growth on average in Canadian industries. But, the capital deepening effect and MFP growth made negative contributions to labour productivity growth in the U.S. industries after 2010. The decline in both the capital deepening effect and MFP growth in the United States after the financial crisis has been well documented (e.g., Baily *et al.*, 2016).

For the 1987-2010 period, labour productivity growth, capital deepening, intermediate input deepening and MFP are statistically significantly correlated across industries between Canada and

the United States. For both countries, the industries with a relatively high capital deepening effect and MFP growth are those industries that are either producers of information and communication goods and services (ICT) or intensive users of ICT. This suggests that similar demand, investment, technology, and innovation factors are contributing to the growth of those industries in both countries. For example, previous studies found that MFP growth is associated with investment in information and communication technologies, and offshoring (Ho, Rao and Tang, 2004).

For the period after 2010, MFP growth, capital deepening and intermediate input deepening are not correlated across industries in the two countries. The Canadian industries with relatively higher MFP growth and input deepening differ from those industries in the United States. It could be that the effect is temporary, and simply reflects the relatively larger impact of the Great Recession on the United States. It may also reflect a de-coupling of the Canadian and American economies as U.S. firms, particularly manufacturing firms, reduce their foreign direct investment in Canada. It may also point to different factors affecting industry productivity growth in the two countries. These factors include the adjustment of the industries in the two countries to emerging technologies such as digitalization, robots, internet of things or the adoption of digital technologies and associated changes in business innovation.

Industry Contributions to Aggregate Labour Productivity Growth

This section examines the industry contribution to Canada–U. S. differences in aggregate labour productivity growth and its three main components: capital deepening, labour composition and MFP growth in two periods, 1987-2010 and 2010-2014. Using the industry productivity database presented earlier, this section focuses on the industry contributions to the differences in aggregate labour productivity growth in the two countries identified in the previous section by addressing two main issues.

First, for the 1987-2010 period, aggregate labour productivity growth in the business sector was slower in Canada compared with that in the United States. The relatively slower growth in Canada's aggregate labour productivity was mainly due to the relatively slower MFP growth in Canada. This section addresses which industries contributed to the relatively slower labour productivity and MFP growth in Canada in the 1987-2010 period.

Second, for the 2010-2014 period, aggregate labour productivity growth was higher in Canada compared with that in the U.S. This situation was mainly due to the relatively stronger capital deepening effect and higher multifactor growth in Canada. This section also addresses which industries contributed to the relatively higher labour productivity and MFP growth, and higher capital deepening effect in Canada in the 2010-2014 period.

The contributions of industries to

aggregate labour productivity growth and its components are measured using the direct industry aggregation approach proposed by Domar (1961) and used by Jorgenson, Ho, Samuels, and Stiroh (2007), Fleck *et al.* (2014) and Gu (2018). In this approach, aggregate value-added labour productivity growth is the share-weighted growth of industry value-added labour productivity growth, where the weights used are calculated as the industry shares of nominal value added. The contribution of industry capital deepening, labour compositional changes and MFP growth to aggregate value-added labour productivity growth is the Domar-weighted contribution. Each industry's Domar weight is the ratio of the industry's current-dollar gross or sectoral output to aggregate current-dollar value added. The industry's contribution to aggregate MFP growth is the industry's MFP growth multiplied by its Domar weight. The contribution of industry intermediate input deepening cancels out.[8]

The sum of industry contributions may differ from aggregate value-added labour productivity growth and its three main components. The difference reflects the reallocation of capital input, labour input and value added output across industries. The difference is small except for industry contributions to aggregate labour and MFP growth for the United States over the 2010-2014 period. For that period, the reallocation of output across industries made a significant contribution to aggregate labour productivity and MFP growth in the United States. It contributed about 0.3 percentage points to aggregate labour productivity growth and contributed 0.4 percentage points to aggregate MFP growth (Table 3 and Table A10).[9]

Table 2 presents a comparison of the contribution to aggregate labour productivity growth by industry for Canada and the United States for the 1987-2010 period. Over that period, labour productivity growth in the business sector was slower in Canada than that in the United States. Most Canadian industries (21 of 38) contributed to Canada's lower labour productivity growth. Consistent with the findings from previous studies, the results show that the largest contributors to relatively slower labour productivity growth in Canada include: computer and electronic products, information and culture industries, finance and insurance, utilities, professional services, retail and wholesale trade. Those industries are mostly related to the production and use of ICT. When industries are classified into three main groups:

8 As the costs of inputs is not equal to the value of output when the exogenous rate of return is used to estimate the user cost of capital, modified Domar weights or cost weights are used for the aggregation for Canada (Gu, 2018).

9 For a rich discussion on this issue see Reinsdorf, Marshall (2015), Baldwin and Willox (2016), Balk (2014), de Avillez (2012), Nordhaus (2001), and Sharpe (2010). The estimated effects of reallocation on labour productivity and MFP growth appears to be large. A large and positive contribution of reallocation to labour productivity growth in the United States for the 2010-2014 period is also found in Remes *et al.* (2018) using the EUKLEMS database.

Table 2: Contributions to Business Sector Labour Productivity Growth by Industry in Canada and the United States, 1987-2010 (percentage points per year)

Industry	Canada	United States	Canada - U.S.
Computer and electronic products	0.05	0.52	-0.48
Information and cultural industries	0.09	0.27	-0.17
Finance and insurance	0.19	0.35	-0.16
Utilities	-0.01	0.13	-0.13
Professional service	0.04	0.14	-0.10
Retail trade	0.15	0.25	-0.09
Wholesale trade	0.20	0.26	-0.07
Chemical manufacturing	0.00	0.07	-0.06
Administration, waste management	0.01	0.06	-0.05
Plastics and rubber products	0.04	0.08	-0.05
Oil and gas extraction	-0.04	0.01	-0.04
Transportation and warehousing	0.06	0.10	-0.04
Clothing, leather and allied products	0.01	0.03	-0.02
Miscellaneous manufacturing	0.01	0.03	-0.02
Mining (exc. oil & gas extraction)	0.00	0.02	-0.02
Arts, entertainment and recreation	-0.01	0.01	-0.01
Petroleum and coal products	0.00	0.02	-0.01
Accommodation and food services	0.01	0.02	-0.01
Textile and textile products	0.00	0.01	-0.01
Wood products	0.02	0.02	-0.01
Support activities for mining, oil & gas	0.00	0.01	-0.01
Fabricated metal products	0.01	0.01	0.00
Furniture and related products	0.01	0.00	0.00
Crop and animal production	0.09	0.08	0.00
Non-metallic mineral products	0.01	0.00	0.01
Machinery	0.02	0.01	0.01
Transportation equipment	0.08	0.07	0.01
Electrical equipment	0.01	0.00	0.01
Educational services	0.00	-0.01	0.01
Food, beverage and tobacco	0.02	0.01	0.01
Forestry, fishing, and related	0.02	0.00	0.02
Paper	0.03	0.00	0.02
Other services	0.01	-0.01	0.03
Primary metal	0.05	0.02	0.03
Printing and related	0.04	0.01	0.03
Health care and social assistance	-0.02	-0.08	0.06
Construction	0.01	-0.06	0.08
Sum of industry contributions	1.23	2.46	-1.24
Reallocation	0.07	-0.13	0.21
Aggregate labour productivity	1.30	2.33	-1.03

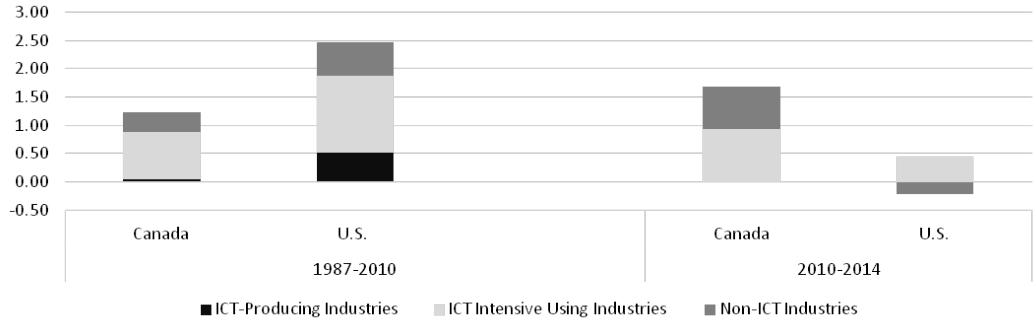
Note: Authors' calculation using industry productivity databases from Statistics Canada and the Bureau of Labor Statistics. Industries are sorted by Canada - U.S. difference.

ICT producing industries, ICT intensive using industries and non-ICT intensive using industries, shown in Chart 4, ICT producing industries and ICT intensive using industries each accounted for 0.5 percentage points of the overall lower labour productivity growth in Canada. Non-ICT intensive using industries accounted for 0.3 percentage points.[10]

Tables A5, A6 and A7 in the appendix present industry contributions to the aggregate capital deepening effect, aggregate labour compositional changes and aggregate MFP growth by industry

10 The classification of industries to ICT-producing and ICT-using industries are adopted from Jorgenson, Ho and Samuels (2010). The ICT-producing industry is defined as computer and electronic product manufacturing industry. The ICT-using industries, more specifically ICT-intensive using industries, consist of construction, machinery, wholesale and retail, transportation, information and culture, finance and insurance, and professional service. The non-ICT using industries, more specifically low-intensive ICT-using industries, are all other industries.

Chart 4: Contributions of Industry Groups to Aggregate Labour Productivity Growth, Canada and the United States, (percentage points per year)



Source: Authors' calculation using industry productivity databases from Statistics Canada and the Bureau of Labor Statistics.

for Canada and the United States for the 1987-2010 period. Chart 5 aggregates the industry contributions to capital deepening, labour composition and MFP, into contributions from three main industry groups: ICT producing industries, ICT intensive using industries and non-ICT intensive using industries.

The ICT producing and ICT intensive using industries contributed to the relatively lower aggregate capital deepening effect in Canada for the 1987-2010 period, which was partly offset by the positive contribution from higher capital deepening effect from non-ICT intensive using industries such as mining and oil and gas extraction.

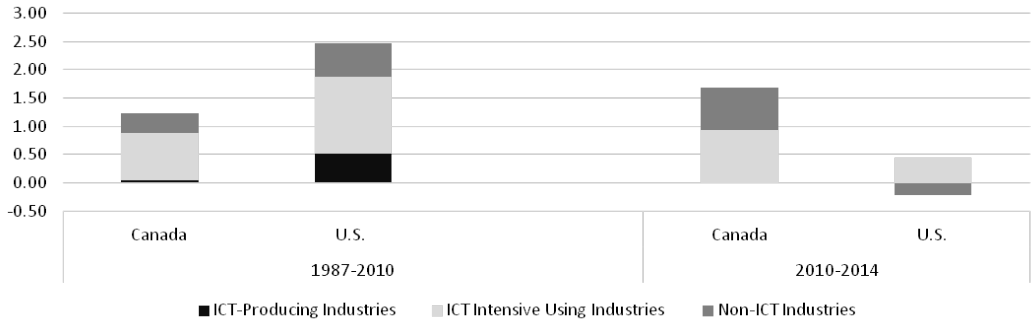
The difference in aggregate labour composition was small in the two countries during the 1987-2010 period, which was a result of positive contributions from half of the Canadian industries being offset by negative contributions from the remaining half of the industries.

Most Canadian industries contributed to the relatively lower MFP growth in Canada compared with that in the United States for the 1987-2010 period. The industries that made the largest contributions to slower MFP growth in Canada were similar to those that contributed to slower aggregate labour productivity growth. Those industries include computer and electronic products, oil and gas extraction, retail trade, transportation and warehousing, and wholesale trade. ICT producing industries and ICT intensive using industries each accounted for 0.4 percentage points of the overall lower MFP growth in Canada. Non-ICT intensive using industries accounted for 0.3 percentage points (Panel C in Chart 5).

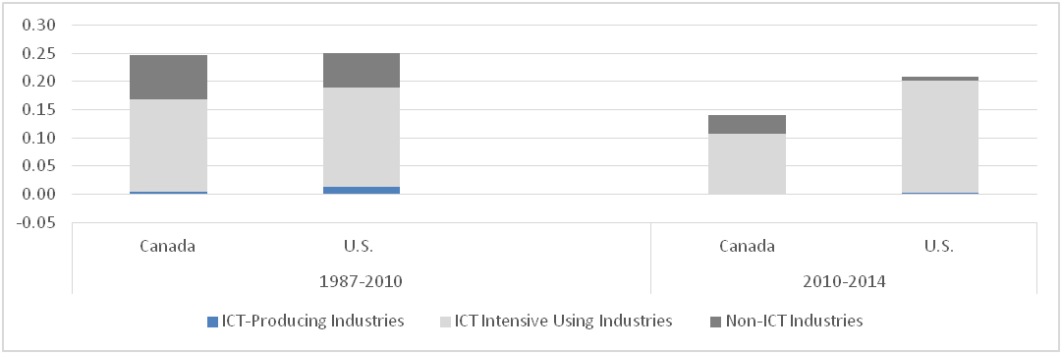
Table 3 presents industry contributions to aggregate labour productivity growth for Canada and the United States for the 2010-2014 period. Tables A8, A9 and A10 in the Appendix present industry contributions to the aggregate capital deepening effect, labour compositional changes and MFP growth. The industry contributions are aggregated into three main industry groups in charts 4 and 5: ICT producing indus-

Chart 5: Contributions of Industry Groups to Business Sector Capital Deepening, Labour Composition, and Multifactor Productivity Growth, Canada and the United States (percentage points per year)

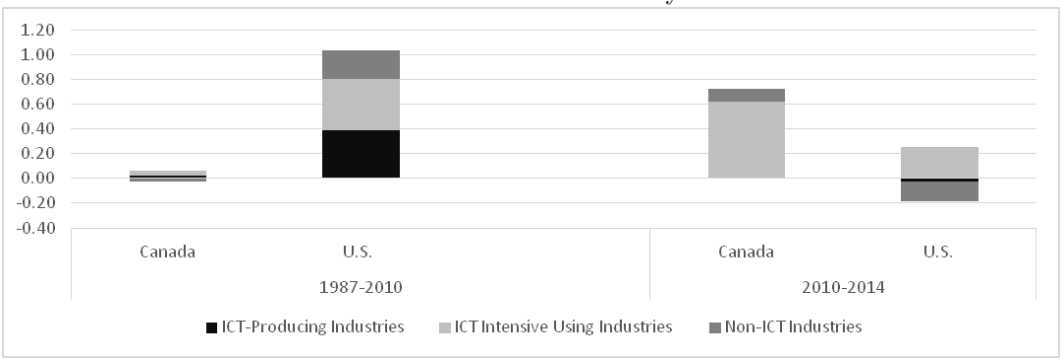
Panel A: Capital Deepening



Panel B: Labour Composition



Panel C: Multifactor Productivity Growth



Source: Authors' calculation using industry productivity databases from Statistics Canada and the Bureau of Labor Statistics.

Table 3: Contributions to Business Sector Labour Productivity Growth by Industry in Canada and the United States, 2010-2014 (percentage points per year)

Industry	Canada	United States	Canada - U.S.
Information and cultural industries	0.03	0.16	-0.14
Construction	-0.16	-0.05	-0.11
Mining (exc. oil & gas extraction)	-0.08	-0.02	-0.06
Transportation equipment	0.00	0.04	-0.04
Printing and related	-0.01	0.00	-0.01
Forestry, fishing, and related	-0.01	0.00	-0.01
Crop and animal production	-0.02	-0.01	-0.01
Textile and textile products	0.00	0.01	-0.01
Petroleum and coal products	0.00	0.01	0.00
Finance and insurance	0.24	0.24	0.00
Non-metallic mineral products	0.01	0.01	0.00
Electrical equipment	0.00	-0.01	0.01
Furniture and related products	0.01	-0.01	0.01
Arts, entertainment and recreation	0.01	0.00	0.01
Computer and electronic products	0.01	0.00	0.01
Accommodation and food services	0.03	0.02	0.02
Educational services	0.00	-0.02	0.02
Retail trade	0.07	0.05	0.02
Primary metal	0.03	0.01	0.02
Paper	0.02	-0.01	0.03
Clothing, leather and allied products	0.00	-0.03	0.03
Chemical manufacturing	0.06	0.03	0.03
Support activities for mining, oil & gas	0.04	0.01	0.03
Miscellaneous manufacturing	0.00	-0.03	0.03
Wood products	0.02	-0.03	0.05
Machinery	0.04	-0.02	0.06
Other services	0.06	-0.01	0.07
Food, beverage and tobacco	0.04	-0.03	0.07
Fabricated metal products	0.03	-0.04	0.07
Health care and social assistance	0.05	-0.03	0.07
Administration, waste management	0.07	-0.04	0.10
Utilities	0.12	0.01	0.11
Professional service	0.20	0.06	0.14
Wholesale trade	0.24	0.07	0.16
Transportation and warehousing	0.15	-0.04	0.18
Plastics and rubber products	0.03	-0.17	0.20
Oil and gas extraction	0.34	0.07	0.27
Sum of industry contributions	1.68	0.23	1.44
Reallocation	-0.15	0.27	-0.40
Aggregate labour productivity	1.53	0.50	1.04

Note: Authors' calculation using industry productivity databases from Statistics Canada and the Bureau of Labor Statistics. Industries are sorted by Canada – U.S. difference.

tries, ICT intensive using industries and non-ICT intensive using industries. For the 2010-2014 period, most Canadian industries had higher labour productivity growth (30 out of 38 industries), capital deepening effects (29 of 38), and MFP growth (29 of 38) than their United States counterparts. Canada's relatively better performance in labour productivity growth, capital deepening and MFP growth occurred in both ICT and non-ICT intensive using industries. The effect of labour composition was slightly lower in ICT intensive using industries in Canada and similar in other industries.

Potential Explanations for Canada-United States Differences in Productivity Growth

To understand the divergence in Canada-U.S. productivity performance starting in 2010, it is useful to begin with explanations for the declining labour

productivity in the two countries since the early 2000s. Previous studies have proposed reasons ranging from measurement issues to technological innovation and secular stagnation.[11]

The first explanation focuses on the mismeasurement of output, inputs and productivity in the new digital economy. It is argued that GDP and productivity is increasingly difficult to measure, as it fails to capture capital input arising from intangible capital and digital technologies and to capture the benefits of intangibles and digital technologies in output measures.[12]

A second explanation focuses on the impact of technological innovation and its diffusion. On the one hand, the ICT boom of the 1990s appears to have waned in the United States while the emerging digital technologies (mobile technology, the internet, and cloud computing) have yet to generate gains in productivity (van Ark, 2016). Brynjolfsson, Rock and Syverson (2017) argue that there are long lags before digital technologies have an impact on productivity. The rise of intangibles and its macroeconomic implications for productivity growth documented by Haskel and Westlake (2017) also lends some support to the view that digital technologies combined with investment in intangibles will have an impact on productivity growth with a lag. This explanation is sometimes referred to the Solow paradox redux (Manyika *et al.* 2017). On the other hand, it has been argued that the digital technologies are unlikely to have as big effect on productivity growth compared with previous innovations such as the internal combustion engine and electricity (Gordon, 2016).

A third explanation focuses on the rise of secular stagnation and the impact of weak demand on business investment and other productivity-enhancing business innovations after the financial crisis. The shortage of demand and investment opportunities have had a negative effect on investment and capital deepening and technical progress embodied in capital investment, key drivers of productivity growth. In an environment characterized by weak demand, businesses have less incentive to investment in capital and other innovation activities.

Other explanations for slower productivity growth in advanced economies include a decline in business dynamism and an increase in mis-allocation of capital between firms, which have acted as a drag on productivity growth.[13]

Similar to the experience in the United States and other advanced economies, labour productivity growth also slowed in Canada after 2000 before the recent pickup after 2010. For

11 See, for example Adler *et al.* (2017), Baily and Montalbano (2016), Manyika *et al.* (2017), Murray (2018), and Remes *et al.* (2018)

12 Intangible capital includes computerized information, innovative property and economic competency. See Gu, Macdonald, and Rispoli (2018)

13 Adler *et al.* (2017) provided a review and empirical evidence on the root causes of declining productivity growth in advanced economies.

the period after 2010, higher labour productivity growth in Canada than in the United States begs the question: are the three explanations for slower productivity growth in the United States less important for Canada?

The mismeasurement of productivity growth thus far has not been found to be an important explanation for slow productivity growth in either Canada or the United States. MFP growth may be under-estimated for various reasons including missing growth from new firms and products (Aghion *et al.*, 2018). Gu (2018) and Gu, Macdonald and Rispoli (2018) found that issues associated with the measurement of intangible knowledge capital had little effect on labour productivity growth estimates. They increased labour productivity growth by 0.1 or 0.2 percentage points per year, but the increase was slightly larger in the period before 2010 when intangible capital increased much faster, similar to the findings reported for the United States (Byrne, Fernald and Reinsdorf, 2016).

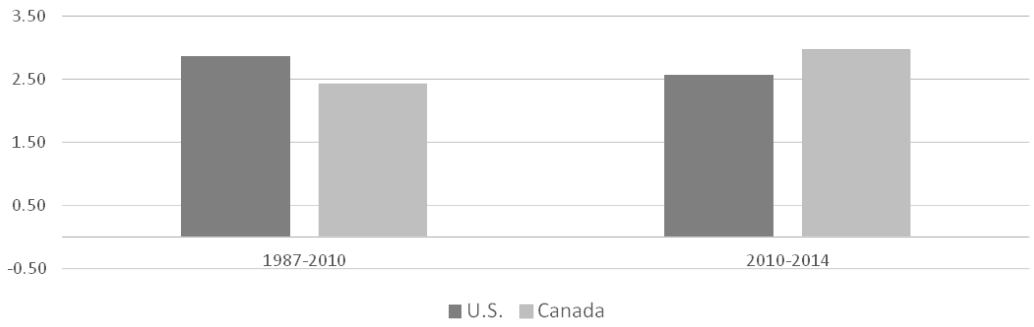
Byrne, Fernald and Reinsdorf (2016) noted that the measurement issues did not become worse over the past decade, and therefore did not account for the decline in MFP growth. It seems unlikely that the difference in measurement issues between Canada and the United States in favour of Canada would have worsened; thus contributing to the difference in MFP growth in favour of Canada.

The Solow paradox redux appears to be an important explanation for the slowdown in productivity growth in the United States as MFP growth that is commonly associated with innovation and technological progress declined in the United States after 2010. After boosting aggregate MFP growth in the United States in the late 1990s and early 2000s, productivity gains from the use and production of ICT appear to have waned in the United States (Adler *et al.* 2017). The MFP growth from ICT intensive using and ICT producing industries declined after 2010 compared with that in the 1987-2010 period (Panel C in Chart 5).

In contrast to falling MFP growth in the United States, MFP growth increased in Canada after 2010. Multifactor productivity growth in Canada was essentially zero for 1987 to 2010 period, but it posted a growth rate of 0.75 per cent year for the period from 2010 to 2014. The MFP contribution from ICT intensive using industries increased in Canada after 2010 compared with the period 1987 to 2010 (Panel C in Chart 5).

While the gains from ICT use and production appear to have waned in the United States, the gains from ICT use in Canada do not appear to have petered out. The continued strong contribution from ICT intensive using industries may reflect the fact that the ICT boom of the 1990s and the early 2000s was more modest in Canada compared with that in the United States. While U.S. industries appear to have exhausted productivity gains from ICT, Canadian industries had much lower ICT investment in the 1990s and 2000s, and therefore, continue to benefit from investment in ICT

Chart 6: Output Growth in the Business Sector, Canada and the United States (average annual rate of change)



Source: Authors' calculation using industry productivity databases from Statistics Canada and the Bureau of Labor Statistics.

in the 2000s.[14]

The last explanation for the U.S. productivity slowdown focuses on the rise of secular stagnation and the impact of the weak demand on investment and MFP growth. Output growth was faster in Canada than in the United States after the financial crisis (as shown in Chart 6).[15] Strong demand growth in Canada after 2010 has led to a large increase in industrial capacity utilization rate (as measured by ratio of actual output to potential output) in Canada. Industrial capacity utilization in Canada increased 3 percentage points from 79 per cent to 82 per cent over the 2010-2014 period. There was an additional but more modest increase of 0.23 percentage points over the 2014-2017 period.[16]

According to the U.S. Federal Reserve Board, industrial capacity utilization in the U.S. was lower in the United States over that period. It increased from 74 per cent to 79 per cent from 2010 to 2014, and then declined to 76 per cent in 2017. Is it possible that stronger demand in Canada either from international trade or the domestic economy has led to a higher capital deepening effect and higher MFP growth in Canadian industries?

Examining slower productivity growth in Canada compared with the United States after 2000, Rao and Li (2013) found that most of the post-2000 slowdown in business sector labour productivity growth was a result of weak demand growth in Canada, which impacted productivity directly by reducing economies of scale and scope and

14 The "Canada-U.S. ICT Data Base" constructed by the Centre for the Study of Living Standards (CSLS) (http://www.csls.ca/data/Summary%20with%20List%20Final%202014.pdf) shows in a variety of measures that Canada's ICT capital stock and investment per worker have been below those of the United States in most areas with the exception of computer ICT investment after 2000.

15 There are a number of explanations for stronger demand growth in Canada than that in the United States. Canada did not go through as deep a recession as the United States did during the financial crisis of 2008 and 2009, nor was the financial sector as drastically affected. The role of financial frictions in the post-global financial crisis productivity slowdown is examined by Huber (2018) and Duval, Hong and Timmer (2017).

16 Statistics Canada Table 16-10-0109-01 "Industrial capacity utilization rates."

Table 4: Regression Results on the Effects of Output Growth

	MFP growth		Capital deepening	
	1	2	3	4
Output growth	0.195**	0.166**	0.036	0.048
	(3.002)	(2.676)	(1.126)	(1.614)
Labour compositional change		-0.34		0.09
		(-0.639)		(0.349)
Labour compositional change × output growth		0.482*		0.240*
		(2.039)		(2.107)
Dummy for 2010-14	1.109**	1.028**	0.264**	0.259*
	(3.984)	(3.89)	(1.991)	(2.031)
Constant	-0.487*	-0.462*	-0.073	-0.073
	(-2.596)	(-2.605)	(-0.816)	(-0.850)
No. of Obs.	74	74	73	74
Adj. R^2	0.187	0.249	0.03	0.098

Note: One asterisk denotes statistical significance at 5% level and two asterisks denotes statistical significance at 1% level.

indirectly by affecting key productivity drivers such as investment and R&D.

Fay *et al.* (2017) found that weak aggregate demand was the main driver behind weakness in investment in the post-financial crisis period in nearly all advanced economies. Adler *et al.* (2017) found that the weak demand in the post financial crisis period explained the decline in investment rate and lower MFP growth is embodied in investment in advanced economies.

Remes *et al.* (2018) found that weak demand and uncertainty from the financial crisis lowered labour productivity growth in the United States and much of Western Europe by 0.9 percentage points per year for the 2010-2014 period compared with the 2000-2004 period.

To examine the role of weak demand on capital deepening and MFP growth, the Canada-U.S. difference in capital deepening and MFP growth was regressed on the Canada-U.S. difference in output growth across industries in the 1987-2010 and 2010-2014 periods. The change in labour composition is also included to examine the effect of skill upgrading and human capital on investment in physical capital and MFP growth. This specification is similar to the specification that expresses capital deepening and MFP growth in a country and a period as a function of output growth in a country and in a period with a set of country and period dummies included. The estimated coefficients on relative output growth can be interpreted as the association of capital deepening and MFP growth with output growth.

The results are presented in Table 4. The estimation results suggest that output growth is positively associated with MFP growth and capital deepening effects. The stronger output growth and strong demand growth in the 2010-2014 period was found to be associated with larger capital deepening effects and higher MFP growth in Canadian indus-

tries. The slower output growth and weak demand growth in the 1987-2010 period is associated with lower MFP growth and a lower capital deepening effect in Canadian industries in that period. The results are consistent with the previous findings on the role of demand on investment, innovation and productivity growth (Rao and Li, 2013, Remes *et al.* 2018, Fay *et al.* 2017)

Capeluck (2016) suggests that a weakening in demand slows the accumulation of both human and physical capital that weakens productivity growth. Weaker productivity growth, in turn, leads to a decline in cost competitiveness, reducing demand even further and resulting in a downward spiral. Finding what economic stimuli lead to a reversal is an important area for further theoretical and empirical research.

Conclusion

This article provides a comparison of productivity growth in Canada and the United States for the period after 1987 using the Canadian industry productivity database and the recently released U.S. industry productivity database from the BLS.

For the 1987-2010 period, labour productivity growth was slower in Canada compared with the United States. This situation was mainly due to the relatively slower MFP growth in Canada.

Most Canadian industries contributed to lower MFP growth in Canada between 1987 and 2010 relative to the United States. The industries that made the largest contributions are: computer and electronic products, oil and gas extraction, retail trade, transportation and warehousing, and wholesale trade. ICT producing industries and ICT intensive using industries each accounted for 0.4 percentage points of the overall lower MFP growth in Canada. Non-ICT industries accounted for 0.3 percentage points.

For the 2010-2014 period, the situation reversed itself and labour productivity growth was higher in Canada than that in the United States. Relatively faster growth in Canada's labour productivity was mainly due to the relatively higher capital deepening effect and higher MFP growth in Canada.

Most Canadian industries had higher labour productivity growth, capital deepening effects and MFP growth than their U.S. counterparts for the 2010-2014 period. Canada's better performance in capital deepening and productivity growth occurred in both ICT and non-ICT intensive using industries. While MFP growth from ICT intensive using and ICT producing industries declined in the United States after 2010, MFP contribution from ICT intensive using industries increased in Canada after 2010. This suggests that the gains from ICT use and production appear to have waned in the United States, but the gains from ICT in Canada do not appear to have petered out.

The larger capital deepening effects and higher MFP growth in Canadian industries compared with those in U.S. industries in the 2010-2014 period were found to be associated with faster output growth and stronger demand in Canada during that period. Stronger de-

mand in Canada has resulted in an increase in industrial capacity utilization in Canada. Relatively stronger demand in Canadian industries is found to be associated with higher capital deepening effects and higher MFP growth compared with those in U.S. industries.

Overall, the main sources of the relatively faster productivity growth in Canada after 2010 compared with that in the United States are found to be stronger demand and stronger productivity growth of ICT intensive using industries in Canada. The stronger demand is associated with investment in fixed capital, innovation and technological progress. A search for the determinants of productivity growth and future research on productivity should focus on the factors contributing to demand growth such as access to international markets and financial stability. It should also examine the factors that could have negative effects on demand growth such as demographic change, population aging and changes in income equality.

Research should also focus on better measurement of emerging technologies, their effect on productivity growth and economic growth and the factors that affect their adoption.

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