The Post-2001 Productivity Growth Divergence between Canada and the United States

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Abstract

The high degree of integration between the Canadian and the U.S. economies promotes sharing of technologies and innovation spillovers that are conducive to long-term productivity growth convergence. However, since 2001 labour productivity growth rates have diverged in sharp contrast to the previous four decades. A comparison of labour productivity growth decomposed into contributions by industry for both countries reveals that the information and cultural services industry has played an outsized role in the divergence, the start of which coincides with the dot-com recession of the early 2000s. Limits on foreign investment, most notably but not exclusively related to telecommunications, and strong output price growth relative to the United States are key factors for undertaking a simple counterfactual analysis to evaluate the role of competitive intensity in the information and cultural services industry. Estimates of markups and their impact on labour productivity growth suggest that limited competition has significantly reduced the productivity performance of that industry as well as the performances of others that are dependent on its services as intermediate inputs.

The economies of Canada and the United States have been intertwined throughout their history. The two countries' economic bond intensified as relations with their predominantly European roots diminished during the twentieth century and Canada-United States trade grew to be the largest merchandise trading relationship in the world[2] worth over CDN $963 billion in 2022, or about $3.4 bil-

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2 IMF Direction of Trade (DOT) Statistics was accessed Aug. 4, 2023. In 2022, Canada-United States total trade (imports plus exports) was USD 794 billion (imports from Canada = USD 438 billion and exports to Canada = USD 356 billion) compared to China-United States total imports and exports which was USD 691 billion (imports from China = USD 154 billion and exports to China = USD 154 billion).

3 Statistics Canada Table: 12-10-0119-01.

lion each day, representing nearly two thirds of Canada's total global merchandise trade.[3] Beyond sheer volume, this relationship has fostered intricate bi-national supply chains supported by elaborate telecommunications, transportation and energy infrastructure networks.

Despite their strong economic ties, the two economies have experienced episodes of economic divergence. Such episodes, however, tend to be brief. For example, as the 2009 global recession gained momentum and the U.S. economy slowed for several months before Canada's eventually followed suit. Substantive shifts in global commodity price cycles, migration patterns in labour markets, financial system shocks and other factors often lead to periods of divergence in broad-based indicators of economic performance, but they are typically brief enough to be measured in months rather than years. Divergence may be sustained for longer periods in specific markets, such as housing, which are more insulated from international trade cycles. Policies or regulations, related to immigration or agricultural production, for example, may also create sustained wedges between the two countries when they affect specific regions or industries. Nevertheless, broad indicators of national economic health, like real GDP and employment, typically show that the economic fortunes of Canada and the United States move in tandem over the long term.[4]

Yet, one fundamental measure of economic performance stands out as an exception: labour productivity growth. From 1961 to 2001, both nations experienced nearly identical annual business sector labour productivity annual growth rates of 2.3 per cent. However, the countries' labour productivity did not move in lock step with each other over that time. Business sector labour productivity growth rates in Canada were higher than in the United States from the mid-1970s to the mid-1980s. Then, starting from the mid-1980s, U.S. labour productivity growth exceeded Canada's growth until the early 1990s. The difference in the countries' average annual growth disappear over the remainder of the 1990s. While the labour productivity growth gap favouring the United States from the mid-1980s to the early 1990s was substantial enough to merit concerns that Canada's living standards were improving at a pace below its potential, its persistence was small compared to the labour productivity growth gap that appeared after the turn of the century. From 2001 to 2021, the United States observed a moderate deceleration in labour productivity growth to 2.0 per cent,

4 Using OECD data, the Pearson correlation coefficients for real GDP, employment, hours worked and real GDP per capita annual growth rates from 1970 to 2000 suggest that Canada's economy is more positively correlated with the U.S. economy than any other G7 economy on average. However, from 2001 to 2019, the United States became the second or third most correlated with Canada, with marginal differences between the top three, for the same variables. On the other hand, The United States had the second most highly correlated labour productivity growth with Canada in the pre-2001 period, nearly tied with Germany for the most correlated. In the post-2001 period (2001-2019), Canada had the lowest correlation coefficient with the United States for labour productivity growth, which was also the only coefficient that was negative. Source: OECD Dataset: Growth in GDP per capita, productivity and ULC. Note that the OECD data are for the total economy, which includes business and non-business sectors.

5 Growth rates are expressed as compound annual growth rates.

while Canada's growth rate, fell to 0.9 per cent.[5] This enduring divergence, both in magnitude and persistence, poses an intriguing question: What factors after 2001 have driven this significant and sustained gap between two otherwise closely aligned economies?

Krugman (1994) contended that while it was interesting to compare countries' economic performances, lagging productivity was not an indication of a country's failure to compete. He asserted, for example, that there was no empirical basis to claim Japanese productivity growth diminished productivity growth or living standards in the United States.[6] This argument, taken at face value, implies that Canada's lagging productivity performance could be regarded as unimportant. However, that conclusion overlooks what one might expect with two heavily integrated economies. High levels of trade and investment flows, complemented by well-established supply chains and policy coordination, facilitate technology spillovers and shared learning experiences, should push the two countries' economic performances to converge over time. In sharp contrast, Chart 1 suggests that the widening labour productivity growth gap remains on track to continue its two-decade-long trend.[7]

In addition to its longevity and severity, this economic phenomenon is also distinct because of its clear delineation with the previous four decades of productivity growth. The year 2001 is a distinct pivot point that implores the question, what changed at or near that point in time to cause such a distinct break from the past?[8] The growing gap in Canada-United States labour productivity growth since 2001 has been the subject of numerous studies examining the divergence from various perspectives.

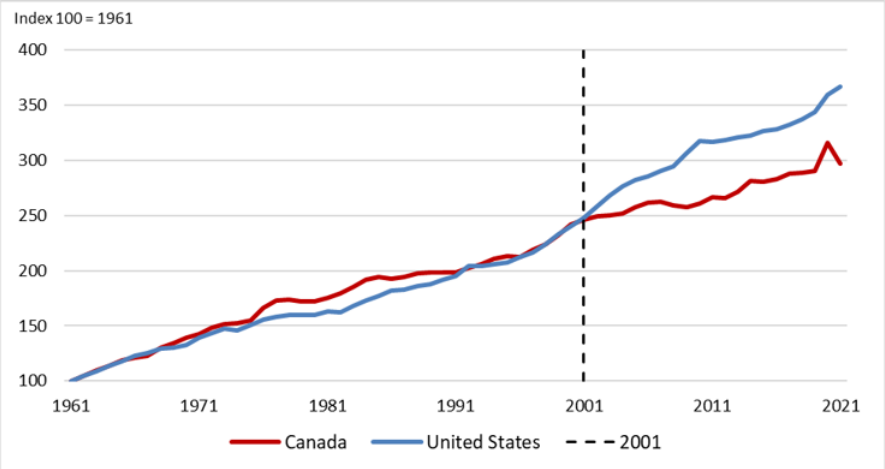
For example, Almon and Tang (2011) focus on the post-2000 output and productivity growth slowdown, attributing differences between the two countries to industrial structural changes, suggesting that shifts in industrial sectors have distinctly impacted productivity. Li *et al.* (2013) emphasize the role of differing methodologies in estimating multifactor productivity growth, highlighting that the variations in approach between Canada and the United States that may lead to contrasting interpretations of productivity trends. Gu and Willox (2018) delve into recent industry trends and potential explanations for the divergence in productivity growth, exploring factors such as technological advancements and labour market dynamics. Lastly, Tang and Wang (2020) expand the scope to include a comparison of industry productivity performance in G7 countries, offering a broader context for understanding Canada's productivity in relation to both the United States and other major

6 Dunn (1994) disputes Krugman's point, arguing that countries compete economically because they compete politically to gain power and influence, which in turn, influences countries' economic policy objectives.

7 Deviations from the longer-term trend in the productivity divergence were attributed to stronger demand in Canada relative to the United States from 2010 to 2014 in Gu and Willox (2018).

8 Structural breakpoint tests following Bai-Perron (2003) identify 2001 or 2002 as the breakpoint that signals the start of the divergence in Canada-U.S. productivity growth rate. Results are available from the authors upon request.

Chart 1: Canada and United States Business Sector Labour Productivity Growth, 1961-2021



Sources: Authors' calculations using Statistics Canada and Bureau of Labor Statistics data.
Note: Labour productivity is measured as real value added per hour worked.

economies.

In contrast to these studies, this article describes how a decline in competitive intensity that is exacerbated by a lack of international competition in a single industry (information and cultural services industry) can limit investment, innovation and technical change that negatively impact other industries.

The remainder of this article is organized as follows. Section 1 describes the data sources, Section 2 discusses the sources of labour productivity growth for the Canadian and U.S. business sectors. Section 3 illustrates which industries make the largest contributions to business sector labour productivity growth. The focus is primarily on how the information and cultural services industry stands out from other industries since 2001. Sections 4 and 5 review international indicators that affect competitive intensity and how trade liberalization influences productivity growth. A counterfactual method to evaluate what productivity growth in Canada would have looked had output price growth for the information and cultural services industry been as low as they were in the United States from 2001 to 2019 is presented in Section 6. Section 7 presents results of the analysis, which is followed by concluding remarks in Section 8.

Data Sources

Productivity measures in Canada and the United States follow the framework established by Jorgenson (1966), Diewert (1976), Jorgenson *et al.* (1987), Jorgenson *et al.* (2005), Schreyer (2001) and Oulton (2023). 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.

At both the industry and aggregate level, total factor productivity (TFP) 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 TFP is often associated with technological change, organizational change, or economies of scale. National productivity data sets consistent with the system of national accounts framework are often referred to as KLEMS, representing the five factor inputs to production, capital, labour, energy, material, and business services, where capital and labour are considered primary inputs and the remaining three are called intermediate inputs.

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 uses 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 2019 (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 Accounts Division at Statistics Canada.

Hours worked represents the total number of hours that a person devotes to work, whether paid or unpaid. 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. Note that labour input differs from hours worked since labour input incorporates changes in labour composition as well as hours worked. Labour composition accounts for the effects of changes in age (as proxy for experience), education, and class of workers (paid versus self-employed and unpaid family workers), (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; and Gu, 2018).

United States Data

Productivity data for the business sector and individual industries in the United States is from the U.S. Bureau of Labor Statistics (BLS) and the Bureau of Economic Analysis (BEA). Output for the business sector is real 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 TFP and related variables for the private business sector and the BLS and BEA jointly produce the BEA-BLS Integrated Industry-Level Production Accounts (KLEMS), which provide the industry detail used in this analysis. Historical private business sector data are

available from 1948 to 2021. The industry-level data from the integrated KLEMS database are available from 1987 to 2020. For this article, the focus is on the productivity performance of the Canadian business sector relative to the U.S. private business sector. The methods for constructing TFP in the U.S. private business sector are documented in Fleck *et al.* (2014) and Garner *et al.* (2021).

The comparability of Canadian and U.S. data is an important concern since different data collection and estimation methods may cause the labour productivity growth gap to be over or underestimated. Issues of data comparability are described in Li *et al.* (2013) though their overall conclusion is that TFP growth estimates for both countries are robust to alternative methodologies and assumptions. Since then, data comparability between the two countries has generally improved particularly with respect to measurement of capital input as noted in Gu and Willox (2018). [9]

Canada-United States Labour Productivity Growth Decompositions

Table 1 shows a decomposition of labour productivity growth into contributions from capital intensity,[10] labour composition and TFP for Canada and the United States. Capital intensity is further decomposed into contributions from information and communications (ICT) capital inputs and non-ICT capital inputs.[11] Canada experienced a discernible slowdown in labour productivity growth, with rates declining from 1.71 per cent per year during 1987-2001 to 0.92 per cent in 2001-2019, a reduction of 0.79 percentage points. Concurrently, the United States saw a more moderate decrease of 0.32 percentage points, from 2.17 per cent to 1.84 per cent over the same periods. The comparative decline in Canada is significantly attributed to a sharp drop in ICT capital intensity, which fell from 0.63 percentage point to 0.20 percentage point, a 0.42 percentage point reduction, while the United States experienced a lesser decline of 0.21 percentage points.

Additionally, Canada's TFP growth shifted from a positive 0.32 per cent growth during 1987-2001 to a negative 0.09 per cent in the subsequent period, marking a 0.41 percentage point decrease. In contrast, the United States maintained positive growth, albeit at a reduced rate, dropping by just 0.09 percentage points from 0.87 per cent to 0.78 per cent. Labour composition in Canada also diminished, contributing 0.25 per cent to productivity growth, down from 0.40 per cent (a 0.15 percentage point reduction), while the United States experienced a slight 0.05 percentage point reduction.

The 0.92 percentage point difference

9 More detailed descriptions of how each country's statistical systems have tended to converge are available in Baldwin *et al.* (2014), Gu (2018), Statistics Canada (2019), Garner *et al.* (2021) and Garner *et al.* (2018a and 2018b).

10 The terms capital intensity and capital deepening are regarded are interchangeable.

11 ICT capital inputs include computer hardware, telecommunications equipment, and computer software and databases.

Table 1: Contributions to Business Sector Labour Productivity Growth in Canada and United States

		1987-2001	2001-2019	2001-2019 less 1987-2001
		Percentage point, compound annual growth rates		
Canada	Labour productivity	1.71	0.92	-0.79
	Capital intensity	0.98	0.76	-0.22
	ICT capital intensity	0.63	0.20	-0.42
	Non-ICT capital intensity	0.35	0.56	0.21
	Labour composition	0.40	0.25	-0.16
	Total factor productivity	0.32	-0.09	-0.41
United States	Labour productivity	2.17	1.84	-0.32
	Capital intensity	1.00	0.82	-0.18
	ICT capital intensity	0.51	0.30	-0.21
	Non-ICT capital intensity	0.49	0.52	0.03
	Labour composition	0.30	0.25	-0.05
	Total factor productivity	0.87	0.78	-0.09
Canada minus the United States	Labour productivity	-0.46	-0.92	-0.46
	Capital intensity	-0.02	-0.06	-0.04
	ICT capital intensity	0.11	-0.10	-0.21
	Non-ICT capital intensity	-0.13	0.04	0.18
	Labour composition	0.10	0.00	-0.10
	Total factor productivity	-0.55	-0.87	-0.32

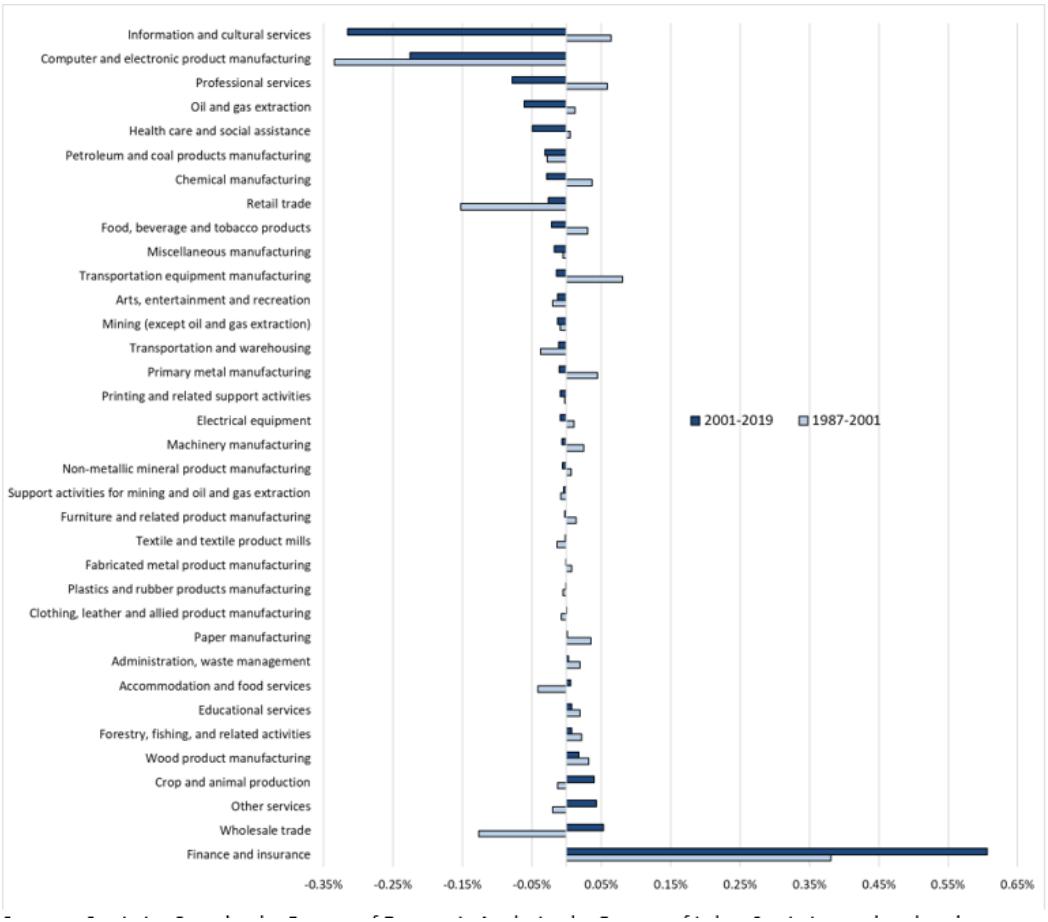
Sources: Statistics Canada, the Bureau of Economic Analysis, the Bureau of Labor Statistics, and authors' calculations.
Note: Percentage point changes represent compound annual growth rates.

in labour productivity growth between Canada and the United States for the period 2001 to 2019 was almost exclusively due to the relatively lower contributions from TFP growth in Canada and, to a lesser extent, lower capital intensity from the ICT capital. The relatively lower TFP growth in Canada accounted for 0.87 percentage points of the 0.92 percentage point difference in labour productivity growth. The relatively lower contribution of ICT capital intensity accounted for 0.10 percentage points of the difference. There was little difference in the productivity effect of labour compositional shifts towards more skilled workers in the two countries. The higher contribution from non-ICT capital intensity can be attributed to relative higher investment in engineering and building construction in Canada

For an industry perspective on the sources of the productivity divergence, detailed tables for individual industries showing annual changes in labour productivity growth for Canada and the United States over the two periods are provided in Appendix B. Additional tables in Appendix B also show each industry's contribution to business sector productivity growth. Canada's labour productivity growth gap with the United States expanded from 0.46 to 0.92 percentage points from the 1987-2001 period to the 2001 to 2019 period, an exact doubling of Canada's gap with the United States. The contributions by industry to the difference in business sector labour productivity growth between Canada and the United States for both periods are presented in Chart 2.

Several features stand out in Chart 2. First, the industries are ordered to show the industries with the largest contribution to the labour productivity growth gap after 2001 at the top. Therefore, the information and cultural services industry and computer and electronic products manu-

Chart 2: Contributions by Industry to the Pre-and Post-2001 Canada-U.S. Business Sector Labour Productivity Growth Gaps



Sources: Appendix tables 1 and 3 based on Statistics Canada, the Bureau of Economic Analysis, the Bureau of Labor Statistics, and based on authors' calculations in Appendix Tables 1 and 3.
Note: Percentage point changes represent compound annual growth rates.

facturing, with the most pronounced negative values appear in dark blue bars at the top. Those two industries contributed 0.60 percentage points of the 0.92 percentage point difference in business sector labour productivity growth between Canada and the United States (0.45 percentage points from the information and cultural services industry and 0.15 percentage points from computer and electronic products manufacturing). This comparison should be taken with a grain of salt since the sum of the industry contributions do not equal the change of 0.92 for the business sector because compound annual growth rates are not strictly additive since they are derived using a nonlinear formula. In addition, compositional or reallocation effects that represent changes in the relative sizes on industries change over time. Compositional effects for the financial and insurance industries were particularly pronounced and asymmetric across countries during the global financial crisis. This helps to account for the second outstanding feature of Chart 2, the relatively strong performance of Canada's finance and insurance industry.

Table 2: Contributions to Labour Productivity Growth, Information and Cultural Services Industry in Canada and United States

		1987-2001	2001-2019	2001-2019 less 1987-2001
		Percentage point, compound annual growth rates		
Canada	Labour productivity	2.50	1.52	-0.98
	Capital intensity	2.44	0.83	-1.61
	ICT capital intensity	2.15	0.48	-1.68
	Non-ICT capital intensity	0.28	0.35	0.07
	Labour composition	0.15	0.16	0.01
	Total factor productivity	-0.10	0.52	0.61
United States	Labour productivity	1.42	7.79	6.37
	Capital intensity	2.07	4.49	2.42
	ICT capital intensity	2.19	3.06	0.87
	Non-ICT capital intensity	-0.11	1.39	1.50
	Labour composition	0.17	0.49	0.32
	Total factor productivity	-0.83	2.81	3.64
Canada minus the United States	Labour productivity	1.08	-6.27	-7.35
	Capital intensity	0.37	-3.66	-4.03
	ICT capital intensity	-0.04	-2.58	-2.55
	Non-ICT capital intensity	0.39	-1.04	-1.43
	Labour composition	-0.02	-0.32	-0.30
	Total factor productivity	0.74	-2.29	-3.03

Sources: Statistics Canada, the Bureau of Economic Analysis, the Bureau of Labor Statistics, and authors' calculations.
Note: Percentage point changes represent compound annual growth rates.

A third noteworthy aspect of Chart 2 is related to why the information and cultural services industry is distinct from computer and electronic products. Although both industries' productivity performance after 2001 was poor, the performance of computer and electronic manufacturing was not only better than that of the information and cultural services industry, but it also marked a notable improvement from the pre-2001 period. In contrast, the information and cultural services industry's performance represents a reversal of fortunes, going from Canada's second-best performer relative its U.S. counterpart to being its biggest laggard.

Table 2 provides a decomposition of labour productivity growth for the information and cultural services industry similar to Table 1. The data reveal a more distinct divergence in the trajectories of the Canadian and U.S. information and cultural services industry's labour productivity. Canada's labour productivity growth per year contracted by 0.98 percentage points, from 2.50 per cent during 1987-2001 to 1.52 per cent in the period of 2001-2019. In stark contrast, the United States witnessed an exceptional gain of 6.37 percentage points, increasing from 1.42 per cent to 7.79 per cent over the same periods.[12]

A critical element of this divergence

12 A further break down of information and cultural services industries into subindustries is not available in the Canadian KLEMS. However, the integrated BEA-BLS KLEMS data provide information for four subindustries of information and cultural services industries, including publishing; motion picture and sound recording; broadcasting and telecommunications and data processing; internet publishing, and other information services. From 2001 to 2019, annual value added labour productivity growth was 7.3 per cent, 2.3 per cent, 8.5 per cent and 9.9 per cent, respectively. The three industries excluding motion picture and sound recording accounted for over 95 per cent of the information and cultural services industries' annual labour productivity growth over the same period. Note that the integrated labour productivity information in the BEA-BLS KLEMS represents gross output labour productivity.

is evident in the ICT capital intensity. Canada's growth in this area declined by 1.68 percentage points, from 2.15 per cent in the first period to 0.48 per cent in the second. In contrast, the United States increased from 2.19 per cent to 3.06 per cent, a rise of 0.87 percentage points, indicating a more substantial investment and utilization of ICT in the latter country.

In terms of TFP, the information and cultural services industry in both countries experienced growth, but at different magnitudes. Canada's TFP improved from -0.10 per cent to 0.52 per cent, marking a positive shift of 0.61 percentage points. The United States, however, registered a more substantial increase from 0.83 per cent to 2.81 per cent, a shift of 3.64 percentage points. These charts point towards a more significant enhancement in efficiency and innovation in the United States information and cultural services industry. Labour composition saw minor changes in both countries, with Canada experiencing a slight increase from 0.15 percentage point to 0.16 percentage point (0.01 percentage point), and the United States recording a more considerable growth from 0.17 percentage point to 0.49 percentage point (0.32 percentage points). This suggests a more substantial evolution in the skills and composition of the U.S. labour force within this sector.

The large divergence in labour productivity growth between Canada and the United States in the information and cultural services industry for the period 2001 to 2019 was due to lower contribution from capital intensity, TFP growth, and slower shifts towards more skilled workers in Canada. For the period 2001 to 2019, the growth in labour productivity in Canada's information sector was 6.27 percentage points lower than that in the United States; the lower capital intensity contribution, mostly from ICT capital in the industry in Canada accounted for 3.66 percentage points of this difference; the lower TFP growth in the sector in Canada accounted for 2.29 percentage points; and the slower shifts towards more skilled workers in Canada accounted for 0.32 percentage points of this difference.

The comparative analysis shows that Canada's lagging business sector labour productivity growth after 2001 is mostly due to weaker growth in ICT capital intensity and TFP. Moreover, the information and cultural services industry, which represents about 4.1 per cent of the business sector by nominal value added on average from 2001 to 2019, had an outsized role in expanding the productivity growth gap due to its weak ICT capital intensity and TFP growth. The industry's role in Canada's productivity divergence with the United States is made more pronounced by its shift from leading its U.S. counterpart by the widest margin (reducing the business sector labour productivity growth gap by 0.04 percentage points) of any industry before 2001 to lagging by the largest margin (increasing the business sector labour productivity growth gap by 0.45 percentage points) primarily due to weak ICT capital intensity and TFP growth.

The information and cultural services industry was not alone in experiencing weaker labour productivity growth after 2001, suggesting that a general lack of innovation and technical change and weak investment may be more pervasive dilemma

across the Canadian economy in general that is most serious in the information and cultural services industry. For example, in the computer and electronic product manufacturing industry, Canada witnessed a notable decline in both ICT capital intensity and total factor productivity (TFP) over the years. Specifically, ICT capital intensity experienced a decrement of 0.73 percentage points, from 0.96 per cent in the period 1987-2001 to 0.23 per cent in 2001-2019. Concurrently, TFP descended by 4.13 percentage points, unraveling the gains made in the earlier period.

The mining, oil, and gas extraction industry is also often noted for its weak productivity growth. Though ICT capital intensity in Canada fell only slightly by 0.02 percentage points, TFP recorded a more pronounced downturn of 2.07 percentage points. The decrease in TFP is especially significant, marking a transition from a positive growth rate to a decline over the two periods. Similar trends were posted for the transportation equipment manufacturing industry, where Canada's ICT capital intensity decreased by 0.14 percentage points, accompanied by a 2.46 percentage points decline in TFP. The United States, in contrast, saw improvements, amplifying the productivity gap between the two nations.

In contrast the finance and insurance industry in Canada experienced a decline in ICT capital intensity by 0.42 percentage points but an uptick of 0.82 percentage points in TFP. Similarly, the professional services industry in Canada also faced a reduced ICT capital intensity growth by 0.80 percentage points but marked a rebound in TFP, increasing by 0.50 percentage points. For these last two industries efficiency and innovation associated with TFP growth partly mitigated the impacts of reduced ICT capital investments.

2001: A Pivotal Year for Information and Cultural Services Industry in Canada

The information and cultural services industry outsized role in Canada's poor productivity performance extends beyond its own performance because information and cultural services (distinct from physical ICT equipment) play an important role in supporting innovation and technological change in other industries.

This hypothesis is partly supported by evidence represented in Chart 3, where it is clear to see that the price of information and cultural services industry in Canada has risen in sharp contrast to the price in the United States (an increase of 1.11 per cent per year for Canada and a decline of 0.07 per cent per year for the United States), which coincidentally begins in 2001, the starting point of productivity divergence. The sharply rising relative price of accessing and using information and cultural services represents a substantial increase in real costs to businesses that rely on those services as intermediate inputs.[13]

13 Telecommunications accounted for roughly 60 per cent of the information and cultural services industry's nominal GDP on average from 2001 to 2019.

Given the growing importance for businesses to incorporating data into production processes to monitor and reduce production costs, manage suppliers and value chains, respond to customers needs and identify opportunities to innovate and adopt new technologies, it stands to reason that the higher cost of information and cultural services would have a broad-based negative impact on most industries' total factor productivity as well as their returns on investing in ICT capital inputs. Even if the cost of ICT capital inputs were identical in Canada and the United States, the higher cost of using ICT capital inputs to transform data into actionable information for Canadian firms could reduce the rate of return on investing in ICT.

One might argue that the difference in output prices of the information and cultural services industry is not relevant if the same price trends occurred across all sectors. In that case, singling out the information and cultural services industry from the rest of the economy in Canada may not be justified. However, Chart 4 shows that since 2001, the price of the business sector output in the United States rose at a pace more than 40 per cent faster than in Canada (the dashed lines). In addition, removing the influence of the information and cultural services industry from the business sector for the US has the opposite effect as it does in Canada. In other words, the information and cultural services industry contributed to lowering price growth in the United States, while in Canada, it contributed to a negligible increase in business sector gross output prices.

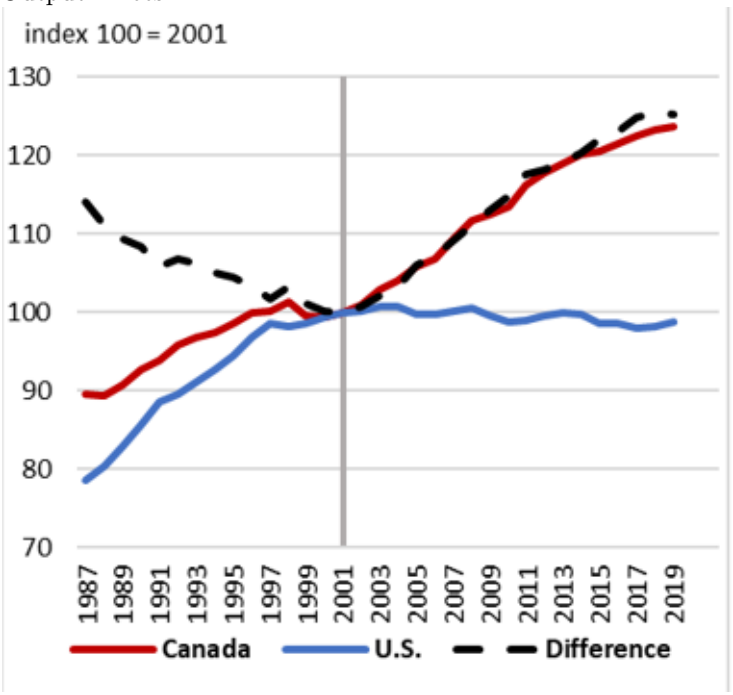
One reason the difference in prices may persist for so many years beyond the 2001 dot-com recession is because of differences in competitive intensity and the decline in competitive intensity in Canada. A lack of competitive intensity allows dominant firms to gain market power, which enables them to set higher prices without the threat of being undercut by competitors, leading to higher prices for consumers, all businesses and governments. Canadian firms in the information and cultural services industry may be more insulated from competitive pressures due to the lack of foreign rivals, which acts as a barrier to entry. A second factor that may contribute to market power is economies of scale, which represents another type of barrier to entry.

A recent report from Competition Bureau (2023) found that Canada's competitive intensity has fallen over the years, a finding that was reflected across all the indicators measured that include concentration, business dynamism and markup. Particularly, the report found that profits and markups have both risen overall since 2000, and these increases were generally greater for firms already earning higher profits and markups.

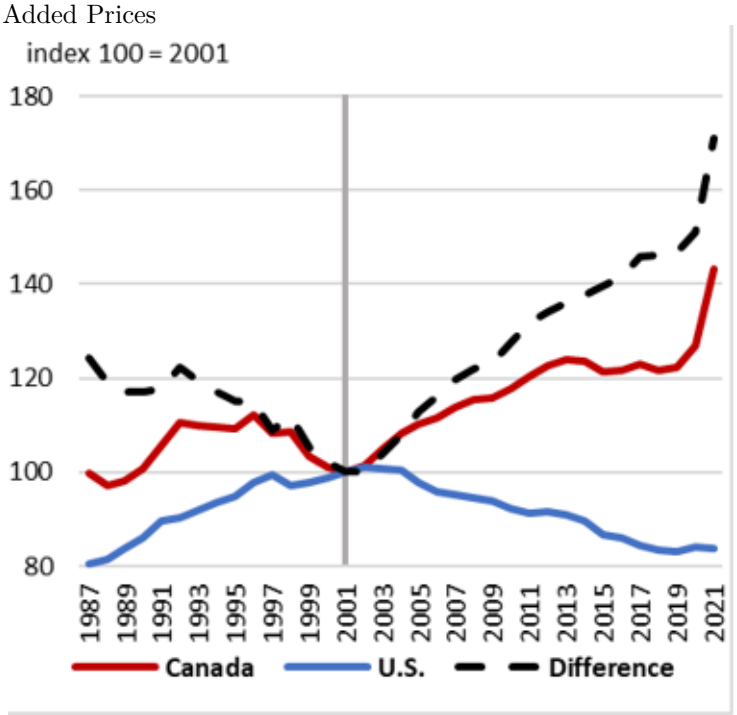
A third is related to government policies and regulations where the federal government, for example, auctions licenses for broadband spectrum to internet service providers. Auctions designed to spur competition by setting aside broadband spectrum for smaller or newer competitors may be less effective if large incumbents are able to acquire their smaller rivals. In describing the nature of broadband spectrum auctions, Middleton (2017) notes the market share of the three largest telecommunications service providers fell from 94 per cent in 2007 to 89 per cent in 2016, but also that

Chart 3: Information and Cultural Services Industry Prices in Canada and the United States

Panel A: Gross Output Prices



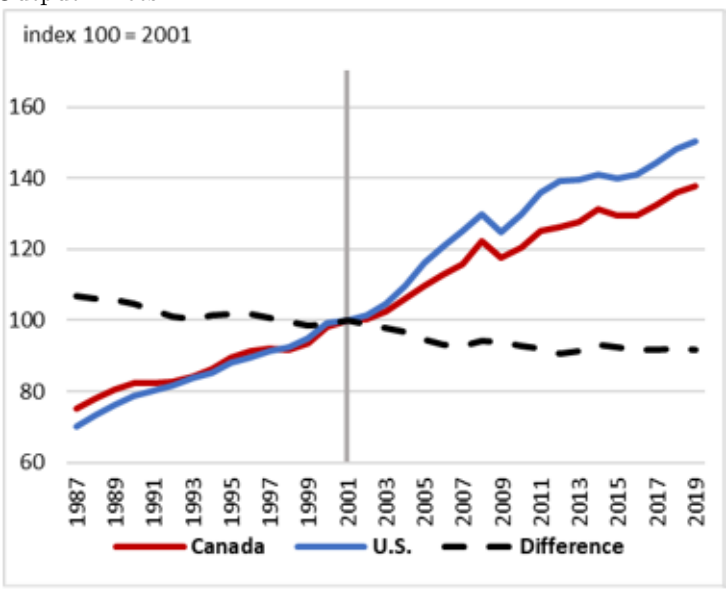
Panel B: Value Added Prices



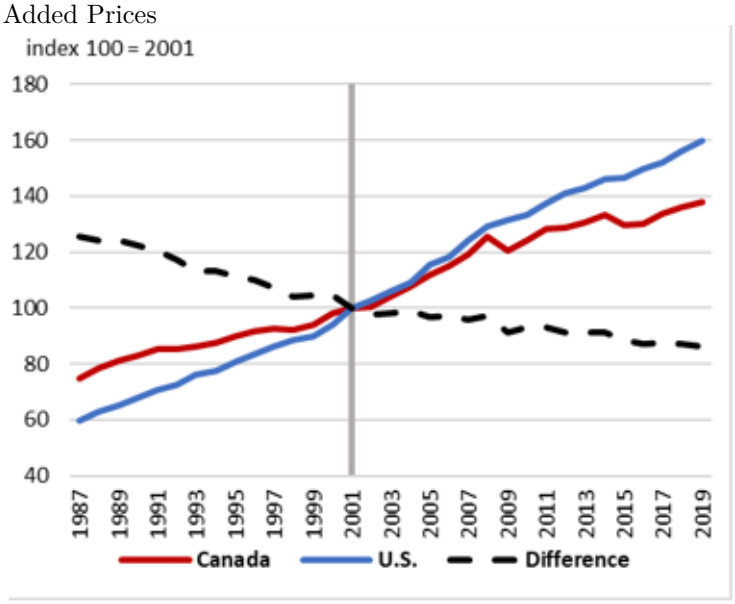
Sources: Statistics Canada, the Bureau of Economic Analysis, the Bureau of Labor Statistics, and authors' calculations.

Chart 4: Business Sector Price Developments in the Business Sector in Canada and the United States

Panel A: Gross Output Prices



Panel B: Value Added Prices



Sources: Statistics Canada, the Bureau of Economic Analysis, the Bureau of Labor Statistics, and authors' calculations.

three entrants during that period not affiliated with incumbents struggled to compete and that two of the three entrants were acquired by the three largest telecommunications service providers.

International Indicators of Market Power

The differences between output prices (levels and growth) in the Canadian and United States information and cultural services industries may be explained by a higher degree of market power in Canada compared to the United States. The OECD Services Trade Restrictiveness Index (STRI) measures obstacles to global services trade which point to Canada's telecommunication industry as an important outlier among its peers. The STRI benchmarks relative to global best practices to facilitate trade. The STRIs for each country and sector quantify restrictions on foreign entry, the movement of people, barriers to competition, regulatory transparency and other discriminatory measures that impact the ease of doing business (Grosso *et al.*, 2015).

The scoring and weighting methodology for calculation of the STRIs covers 18 sectors, five of which correspond closely as sub-industries within the information and cultural services industry. The STRIs take values between zero and one, zero representing an open market and one representing a market completely closed to foreign services providers.

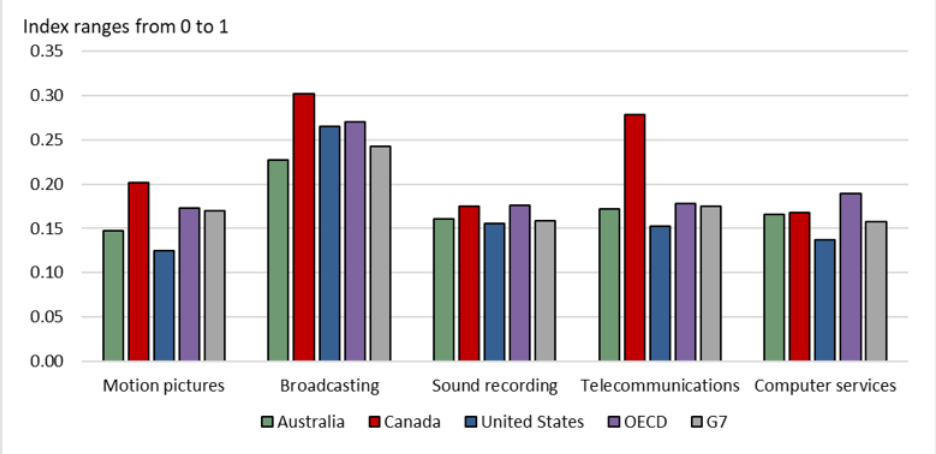
Charts 5 and 6 suggest that at least three important sub-industries within the information and cultural services industry exhibit substantially higher levels of trade restrictiveness, commonly associated with elevated markups and market power.[14] The STRI allows for comparisons between Canada and the United States as well as two broader categories, the OECD and G7 averages, as well as Australia, whose economic and geographic size, population, and natural resource-oriented economy are more similar to Canada than the United States.

The STRIs presented in Chart 5, indicate that Canada has similar levels of trade restrictions as its peers in sound recording and computer services industries. The index is relatively higher for motion pictures, particularly compared to the United States, and broadcasting. However, it is in telecommunications that Canada's trade restrictions are mostly clearly an outlier, at more than 80 per cent higher than in the United States and roughly 60 per cent higher than in Australia, the OECD and the G7.

The sub-indexes for each country and sector quantify restrictions on foreign entry, the movement of people, barriers to competition, regulatory transparency and other discriminatory measures that impact the ease of doing business. Of these five subcomponents, the index of restrictions on foreign entry, shown in Chart 6, most closely corresponds to the industry's overall STRI as it shows similar patterns for

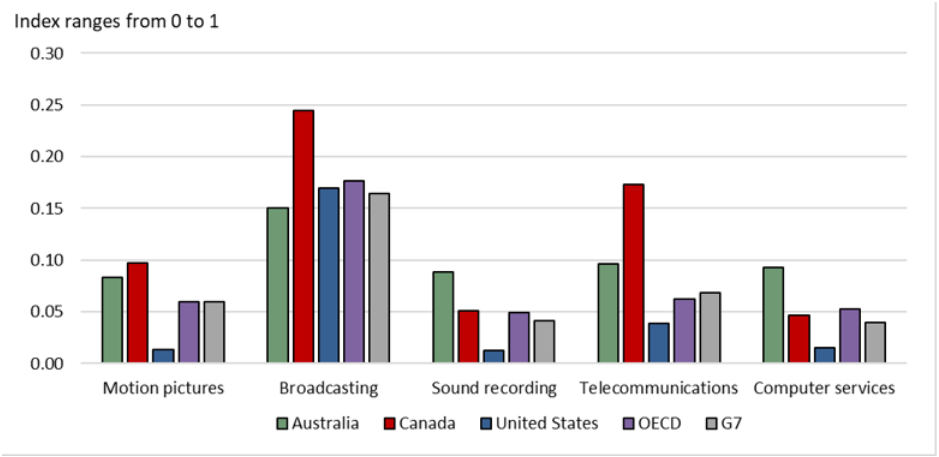
14 Some of the mostly frequently cited authors that associate trade and market power include Krugman (1979, 1980), Melitz and Ottaviano (2008), De Loecker (2011), and De Loecker and Van Biesebroeck (2016).

Chart 5: The OECD's Services Trade Restrictiveness Index (STRI)



Source: The OECD's Services Trade Restrictiveness Index (STRI) Regulatory Database accessed July 9, 2023.

Chart 6: The OECD's Restrictions on Foreign Entry Index, STRI Subcomponent



Source: The OECD Services Trade Restrictiveness Index (STRI) Regulatory Database, accessed July 9, 2023

trade restrictions when comparing Canada with its peers.[15]

The Relevance of International Competition and Market Power to the Information and Cultural Services Industry as a Driver of Canada's Productivity

Several studies have documented the essential role of investing in the production and general use of information and com-

15 Canada compares favourably with respect to the index on restriction on movement of people for each of the five information and culture sub-industries. For regulatory transparency Canada's scores are all identical to those for the United States for each of the five information and cultural sub-industries. Interpreting the indices for barriers to competition are comparatively opaque because the index reflects the existence of regulations and their flexibility, but their effectiveness is not directly measured. In addition, there is no score for barriers to competition score for Canada in computer services and sound recording.

16 For example, see Jorgenson and Stiroh (2017), Stiroh (2002), Gordon (2016) and Oliner and Sichel (2000).

munication (ICT) equipment as a driving force behind innovation and productivity growth.[16] Other studies have drawn clear connections between the importance of international trade to induce more intense competition among firms to reallocate resources from the least to the most productive firms as a critical source of aggregate productivity growth. For example, Melitz and Trefler (2012), report that tariff reductions implemented under NAFTA raised labour productivity by 13.8 per cent. Moreover, they explain that the increase in productivity growth occurs when heterogeneous firms with monopoly power transition from operating in separate economies to a more integrated economy, overall aggregate productivity increases "as market shares are reallocated from the low-productivity firms with high marginal costs to the high-productivity ones with low marginal costs."[17]

Many Canadian studies examining how the role of trade and firm turnover (Baldwin and Gu 2003, 2004, 2009; Lileeva, 2008) explain that stronger productivity growth in the manufacturing sector was due to more intense competition. In the United States, Foster *et al.* (2006) found similar evidence that more intense competition in the retail sector in the 1990s drove labour productivity growth higher.They argue that widespread use of cutting-edge information technology, that included introducing advances in inventory management and widespread use of scanners, intensified the reallocation of resources from failing low-productivity single-establishment enterprises to larger, higher-productivity national firms.

Another U.S. study (Faccio and Zingales, 2022) looking at the telecommunications industry found weak evidence that more competition and lower corporate profits lead to higher quality services for customers, higher investment in fixed capital, and higher employment and wages. Moreover, they soundly reject claims that less competition increases service quality, investment, employment, or wages.

The evidence described in this article suggests that the labour productivity growth divergence coincided with the dot-com recession in the United States shortly after the turn of the century. Enormous amounts of capital expenditure that had flowed into high-tech firms in the United States were wiped out, leaving only the strongest competitors to absorb the labour and capital resources of weaker, less competitive firms (Kraay and Ventura, 2007). This adjustment was followed by solid gains in labour productivity from ICT capital intensity growth (increasing from 2.07 per cent to 4.49 per cent average annual growth, see Table 2) among the remaining firms in information and cultural services industry and a sharp reversal of the industry's TFP growth (increasing from -0.83 per cent to 2.81 per cent).

The information and cultural services industry in Canada was not hit nearly as hard by the dot-com recession. Consequently, TFP growth was comparatively modest (increasing from 0.10 per cent to 0.52 per cent), while contributions to labour pro-

17 Page 101, in the section called "What Changes When Economies Integrate?".

ductivity growth from ICT capital intensity growth fell (decreasing from 2.15 per cent to 0.48 per cent). The difference in the direction of the contributions to labour productivity growth from TFP growth and ICT capital intensity account for three quarters of Canada's labour productivity gap with the United States for the information and cultural services industry.

Methodological Framework for Evaluating Market Power

This section presents a methodological framework to answer a simple question, what would have happened to labour productivity growth in Canada if the output price for the information and cultural services industry had grown at the same pace it did in the United States from 2001 onward? The United States was chosen for comparison, rather than another country or a group of countries, such as the OECD or G7, because the degree of economic integration makes the law of one price most likely to hold between Canada and the United States in the absence of market failures.

The empirical approach used to answer this question is a counterfactual in which the output price for the information and cultural services industry in Canada is replaced by that of the United States Because the output price in Canada is higher than in the United States, the difference can be interpreted as a measure of the industry's markup. By removing the markup to align the industry's output prices in Canada with the output price in the United States, a counterfactual is introduced to determine how a higher degree of competitive intensity in the information and cultural services industry would affect the Canada-United States labour productivity growth gap after 2001.

A well-recognized framework for understanding the relationship between markups and labour productivity growth that is amenable for analyses using aggregate KLEMS data associated with the Canadian System of National Accounts is presented in Hall (2018). A more thorough discussion of his approach can be found in the Appendix. Hall's central theoretical result is represented in equation 1 as follows:

$$\frac{\Delta \log Q}{\mu} - \sum \alpha_i \Delta \log X_i = \frac{\Delta \log A}{\mu} \quad (1)$$

The markup μ on the left-hand side of equation 1 is defined as the Canadian output price over the U.S. output price.[18] Output is represented by real gross output Q and a vector of factor inputs are expressed as X where i indexes factor inputs. The term α_i, represents the elasticity of the respective inputs. On the right-hand side, TFP is represented by A. All variables are logged and the operator Δ indicates the first difference. When the markup $\mu = 1$, the left-hand side of equation 1 is the Solow residual and TFP growth published by Statistics Canada and the U.S. BLS. In this situation, firm behaviour is consistent with assumptions embodied in

18 Equation 1 is adapted from Hall's equation 14 by rearranging terms and expressing the markup as μ^{-1} instead of one minus the Lerner index (1-λ) for simplicity as in Hall (2018).

the System of National Accounts such that markets are perfectly competitive, firms exhibit constant returns to scale, factor inputs are paid their marginal product, and the elasticity of an input is equal to the cost share of the input in total revenue.

Note that methods that econometrically derive markups ordinarily define the markup as the output price over the marginal cost. The difference is important because the definition used in this counterfactual does not imply that lowering the Canadian output price to match the price in the United States would result in perfectly competitive markets for Canada. Instead, it implies that Canadian markets would be equally competitive (or uncompetitive) as they are in the United States. In other words, the gap between Canadian and United States output prices is a markup in addition to any U.S. markup above marginal cost if Canadian and U.S. producers' marginal costs were the same. The theoretical implication of the counterfactual is therefore, not only that TFP growth should converge over the long term among well-integrated markets, but that prices and marginal costs of production should, too.

In the presence of market power, where $\mu > 1$, the Solow residual does not measure actual technical progress, $\Delta \log A$, because it does not adjust for market power. Moreover, Hall's equation shows that when market power reduces competitive intensity, permitting firms to increase output prices, the result is a proportionate reduction in real output and labour productivity growth due to lower TFP growth. That will be the case if total nominal expenditure on a product or service, such as information and cultural services, is fixed and does not vary with the price of the product.[19] A critical assumption in Hall's derivation of equation 1 is that changes in factor inputs and their prices are held constant. Relaxing this assumption would require some knowledge of how firms would reallocate factor inputs in response to changes in markups, which would require estimating a more extensive economic model rather than a simple and transparent counterfactual.

To implement a counterfactual to convey how market power in the information and cultural services industry might contribute to the Canada-United States productivity growth gap, two issues needed to be addressed. The first is related to the fact that Hall's framework is premised on gross output rather than value added output, which implies that when firms in the information and cultural services industry sell their output to other firms in the information and cultural services industry as intermediate inputs, the value added markup is not accounted for. Presumably, firms in the information and cultural services industry charge a markup to all customers regardless of whether they are individuals or other businesses regardless of their industry. An amendment to Hall's approach was made to account for higher priced intermediate inputs that drive up production costs. The increased cost of production is assumed to

19 When the cost function for producers and the utility function for consumers are Cobb-Douglas, the nominal expenditure on the product or service is fixed and does not change with input price.

be in proportion to each industries use of information and cultural outputs as a share of total gross output. The change in cost, in the long run, is passed on as higher prices of value added, even if industries other than the information and cultural services industry are perfectly competitive.

The second issue is that equation 1 does not provide any information about the level of the markup at any point in time. The difference in price information in KLEMS data for Canada and the United States is expressed as indexes, which also does not provide an initial starting value for the difference in output prices for the information and cultural services industries in the two countries.

The first issue is relatively easy to resolve. To see how large the hypothetical effect of removing the markup in the information and cultural services industry is, Hall's framework can be adapted by replacing the gross output markup with the value added measure following Basu and Fernald (1997) and Basu (2019). The adjustment accounts for the "double marginalization." Firms with sufficient market power pass their markups on to other firms driving up their intermediate input costs, which are reflected in the prices of final output. Equation 2 expresses the value added markup μ^{VA} as a function of the gross output markup.

$$\mu^{VA} = \frac{\mu\left(1 - S^{IC}\right)}{1 - \mu S^{IC}} \qquad (2)$$

Equation 2 is slightly different than it appears in Basu and Fernald (1997) and Basu (2019) because the counterfactual in this analysis assumes that only firms in the information and cultural services industry exercise significant market power. In Basu and Fernald (1997) and Basu (2019), it is assumed that firms in all industries impose the same markup. As a result, the intermediate input share of gross output includes all intermediate inputs. This is the case for the information and cultural services industry. However, for industries other than information and cultural, the share S^{IC} reflects only the value of output from the information and cultural services industries used as an intermediate input by an industry relative to the industries' value of gross output.

The second limitation is addressed by numerically solving for an initial value of the gross output markup that satisfies equation 1 by minimizing the mean squared differences in annual growth rates of real gross output for the information and cultural services industries between Canada and the United States. The solution to the minimization problem is an initial markup of 1.246, meaning that there is a 24.6 per cent markup over the U.S. price.[20]

Substituting the value added markup μ^{VA} from equation 2 into a value added, Y, expression of equation 1, rearranging terms, and assuming technological progress is Hick-neutral, Y=A(t)F(K,L), such that dividing through by hours worked

20 Alternative definitions of the markup could include normalizing gross output prices by the industries' combined input prices. Doing so produced nearly identical results for labour productivity and TFP growth for the business sector and by industry. Therefore, simple definition for the markup as the Canadian output price over the U.S. output price was chosen.

H yields an expression for labour productivity growth shown in equation 3.

$$\frac{\Delta \log(Y/H)}{\mu^{VA}} - \alpha_K \Delta \log(K/H) - \alpha_L \Delta \log(L/H) = \frac{\Delta \log A}{\mu^{VA}} \quad (3)$$

Note that X_i representing factor inputs is replaced by capital K and labour L. When they are multiplied by their respective shares in total primary costs and are divided by hours worked, their growth rates represent the contributions to labour productivity growth from capital intensity and labour composition, respectively. The last term on the right-hand side of equation 3 is the Solow residual, which in the System of National Accounts is interpreted as TFP growth, which assumes perfect competition ($\mu^{VA} = 1$). However, when the markup is greater than one, the Solow residual is less than TFP growth. To recover TFP growth, the Solow residual is multiplied by μ^{VA} to remove the influence of the markup. This adjustment contributes proportionately to labour productivity growth.

Note that the markup is defined as the difference between the output prices for information and cultural services industries in Canada and the United States. Therefore, if the output price of the information and cultural services industry in the United States exhibits a markup greater than one, the markup defined for the counterfactual is in addition to a U.S. markup.

The aggregate impact on business sector labour productivity growth is calculated by summing the industry value added markup weighted by industry shares of business sector nominal value added, S^{VA}, from 2001 to 2019 as shown in equation 4, where i indexes industries.

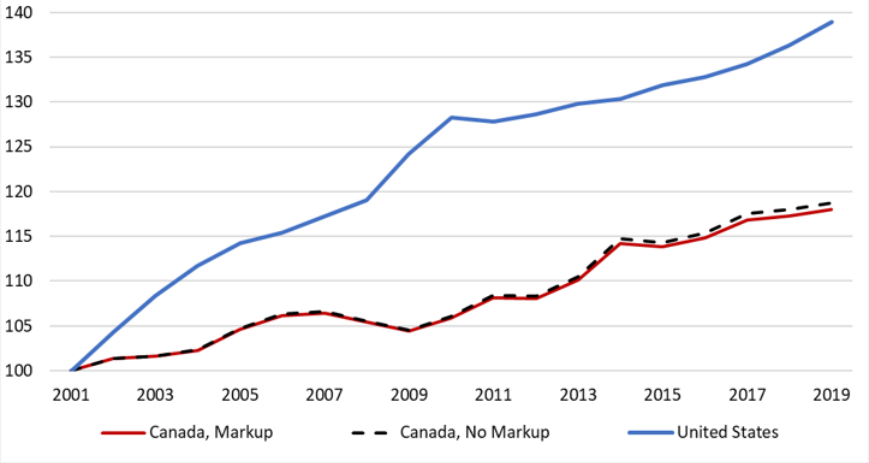
$$\Delta \log(Y/H) = \sum S_i^{VA} \left(\alpha_{K_i} \Delta \log \left(\frac{K}{H} \right)_i + \alpha_{L_i} \Delta \log \left(\frac{L}{H} \right)_i + \mu_i^{VA} \frac{\Delta \log A_i}{\mu_i^{VA}} \right) \quad (4)$$

It is important to recall that μ^{VA} for industries other than information and cultural is weighted by each industry's use of output from the information and cultural services industry as a share of gross output as described by equation 3. Therefore, the additional contribution to business sector labour productivity growth from industries varies according to their reliance on the Information and cultural services industry as a share of gross output. For example, petroleum and coal products manufacturers' use of output from the information and cultural services industry as a share of gross output was 0.1 per cent on average from 2001 to 2019. As a result, removing of the markup has a negligible effect on that industry's contribution to business sector labour productivity growth. By comparison, output from the information and cultural services industry as a share of gross output was the largest for the professional services industry at 4.4 per cent.

Advantages and Limitations of Counterfactuals

The decision to use a counterfactual to evaluate the competitive intensity of the information and cultural services in-

Chart 7: The Impact of the Markup in the Information and Cultural Services Industry on Business Sector Labour Productivity Growth



Sources: Statistics Canada, the Bureau of Economic Analysis, the Bureau of Labor Statistics, and authors' calculations.

dustry and its impact on the Canada-United States labour productivity growth gap stems primarily from the industry's contribution to the growing divergence in business sector labour productivity growth and changes in relative prices between Canada and the United States following the dot-com recession as illustrated in Charts 2 and 3. Counterfactuals also offer a simple and transparent means to explore policy-relevant "what-if" scenarios. This approach is particularly beneficial in contexts where traditional modeling and empirical validations pose significant challenges, enabling a detailed dissection of complex economic relationships.

For example, De Ridder *et al.* (2022) show that the absence of firm-level pricing data introduced a downward bias that produced markups one third as large as their true value. Deflating revenue with aggregate industry or national price deflators could mitigate the problem slightly but would still fail to capture firm heterogeneity. Along the same vein, Doraszelski and Jaumandreu (2020) found that popular control function methods such as in Ackerberg *et al.* (2015) used to correct for measurement errors in input variables and to isolate the influence of productivity shocks in the estimation of TFP are only free of bias when researchers observe markups. Observing measurement errors and productivity shocks is an equally relevant limitation for estimating markups.

Notwithstanding their limitations, statistical methods to estimate markups have some relative strengths that may warrant future areas for research. For example, Hall's (2018) approach "purges" changes in factor prices so that changes in markups have no impact on marginal rates of factor substitution. Although this assumption is amenable to the counterfactual employed here, Basu and Fernald (2002) demonstrate how markups can influence factor input prices and reallocation and, therefore, labour productivity growth. Consequently, incorporating the complex relationship between output elasticities with factor shares

and markups with Hall's (2018) framework may be more suitably handled with an econometric model. Overall, combining both counterfactual and econometric approaches in future analyses may offer a balanced and holistic perspective.

Empirical Results

The overall impact of eliminating the markup, measured as the difference in Canada-United States output prices for the information and cultural services industries, had a relatively small effect on annual business sector labour productivity growth when compared to the size of the Canada-United States labour productivity growth gap. In Chart 7, Canada's business sector labour productivity growth with the markup removed is represented by the dashed black line. It is only slightly higher than growth reported in KLEMS for Canada, which includes the markup represented by the solid red line. The counterfactual Canadian business sector labour productivity growth closes the gap with the United States by 3.7 per cent.

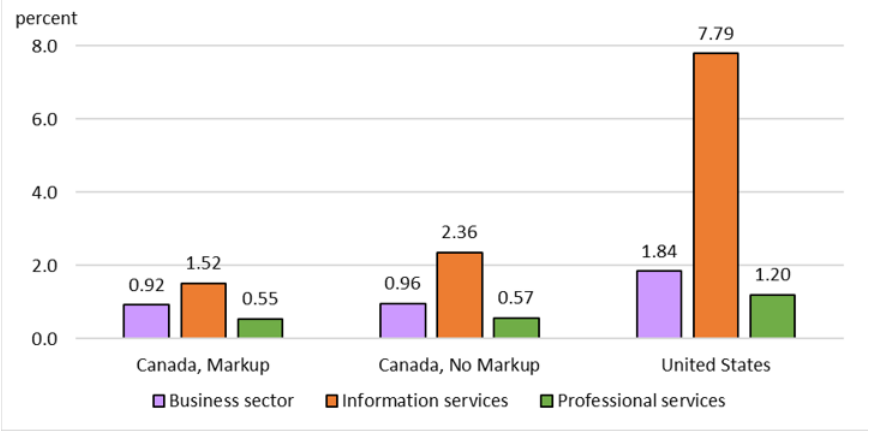
Part of the reason the markup for the information and cultural services industry has a limited impact on the business sector labour productivity growth rates is due to the relatively small use of the industry's services as intermediate inputs by other industries. In addition, substitution and income effects of removing the markup are not included in the counterfactual, consistent with Hall (2018). Chart 8 shows that eliminating the markup for the information and cultural services industry, where the benefit of more intense competition is the largest, has a substantial impact, raising labour productivity growth by about 56 per cent, or 0.84 percentage points. Despite this gain, it only reduces the labour productivity growth gap by 13.5 per cent due to the strong gains recorded by the industry in the United States.

The markup has even less influence in other industries. Even among industries that are proportionately the largest users of information and cultural services, like the professional services industry, eliminating the markup would only raise labour productivity growth by 0.02 percentage points and reduce the labour productivity growth gap by 2.2 per cent for that industry.

The counterfactual presented in this analysis provides an estimate of the effect of market power and limited competition on output prices and output. The relatively lower competitive intensity in Canada compared with that in the United States also affects investment, innovation, and technical progress. As shown in Table 2, the information and cultural services industry in Canada had lower contributions from capital intensity and TFP growth, and a slowdown in the shift towards more skilled workers compared to the U.S. since 2001. Previous studies conclude that market power and limited competition lowers investment, reduce innovation and technical progress. (Fernald and Inklaar, 2022; Goldin *et al.*, 2020; Goodridge and Haskel, 2023; Andrews, 2016). Therefore, much of the difference in labour productivity growth between Canada and the United States could be due to greater market power in Canada compared with that in the United States.

Additional analysis may find that market power in the information and cultural ser-

Chart 8: Labour Productivity Growth, 2001-2019



Sources: Statistics Canada, the Bureau of Economic Analysis, the Bureau of Labor Statistics, and authors' calculations.
Note: Percent changes represent compound annual growth rates.

vices industry has a much larger negative impact on aggregate business sector productivity growth than what simple counterfactual analyses can reveal. For example, removing the markup, defined as the difference between output prices in Canada and the U.S., only represents an improvement in competitive intensity that matches that of the same industry in the United States.

If the markup in the U.S. information and cultural services industry were 1.15, as Baqaee and Farhi (2020) find for the aggregate U.S. economy, the size of the adjustment to TFP growth required to achieve perfect competition (i.e., where price equals marginal cost) would result in an additional 15 per cent increase in TFP and labour productivity growth in the information and cultural services industry. In this case, the change in growth would filter through to the rest of the Canadian economy in proportion to the information and cultural services industry's share of gross output by industry and would have reduced the labour productivity growth gap by 2019 by 5.9 per cent rather than the 3.7 per cent estimate, which reflects no adjustment for a U.S. markup. Using an estimated markup for the aggregate U.S. economy of 1.25 from Edmond *et al.* (2023) and 1.60 from De Loecker and Eeckhout (2018) would close the gap by 7.5 per cent and 15.9 per cent, respectively.

Additional analysis could also measure how market power leads to the misallocation of resources, which also negatively impacts TFP growth. In a U.S. study, Baqaee and Farhi (2020) find that eliminating the misallocation resulting from markups would raise TFP by about 15 per cent from 1997 to 2015. A more complex economic model could capture the extent to which TFP growth would increase as industries invest more in ICT inputs to take advantage of the lower cost of using them.

Overall, the counterfactual results presented in this article may be regarded as confirming that market power in the information and cultural services industry has had a negative impact on labour productivity growth and, consequently, the living standards of Canadians. In addition,

they represent a minimalist or partial estimate of the potential for mitigating market power to reduce the Canada-United States labour productivity growth gap.

Conclusion

Since 2001, labour productivity growth rates in Canada and the United States have diverged in sharp contrast to the previous four decades. The analysis in this paper underscores the significance of the information and cultural services industry for this great divergence since the dot-com recession, which may have set it on different competitive paths within each country. The difference in the economic performance of the information service industries in Canada and the United States is distinctly related to the timing of the dot-com recession when observing output price growth after 2001. The sharp increase in output prices for the information and cultural services industry in Canada compared to the United States where they fell slightly combined with weak foreign competition in Canada, suggest the price difference may have been due to an increase in market power in Canada.

To evaluate the role of market power a counterfactual analysis describing the price divergence as a relative markup indicates that had prices for the information and cultural services industry in Canada followed the same trajectory as in the United States the information and cultural services industry would have experienced a substantial increase in labour productivity growth from 2001 to 2019. However, that increase would have done little to reduce the Canada-United States labour productivity growth gap for the information and cultural services industries and even less for the business sector overall.

The counterfactual result in this paper may be regarded as confirming that market power in the information and cultural services industry has had a negative impact on labour productivity growth and the living standards of Canadians. It represents a minimalist or partial estimate of the potential for mitigating market power to reduce the Canada-United States labour productivity growth gap. Since 2001, the information and cultural services industry in Canada has had lower capital intensity contribution, lower TFP growth and slower shifts towards more skilled workers. Reducing market power has the potential to increase investment, technical progress, and innovation, and to narrow the Canada-United States labour productivity growth gap in the information service sector and the aggregate business sector.

The information and cultural services industry was not alone in experiencing weaker labour productivity growth after 2001, suggesting that a general lack of innovation and technical change and weak investment may be more pervasive dilemma across the Canadian economy in general that is most serious in the information and cultural services industry. For example, in the computer and electronic product manufacturing industry, professional service, and oil and gas sector, Canada had much slower labour productivity growth than the United States after 2001.

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Appendix: Hall's Framework on the Relationship between Mark-up and Productivity Growth

Hall's 2018 study, "Using Empirical Marginal Cost to Measure Market Power in the US Economy," establishes a theoretical framework to show how market power influences total factor productivity (TFP) growth and output growth. Hall's approach is ideal for implementing in a counterfactual because of its simple derivation of a markup as price over marginal cost using KLEMS data. In his framework, summarized in part below, marginal cost is the ratio of the change in cost not associated with changes in input prices to the change in output not associated with productivity change.[21] In time-series data, a natural measure of marginal cost is the change in cost divided by the change in output. More precisely, the numerator is the change in cost not associated with changes in factor prices and the denominator is the change in output not associated with the change in Hicks-neutral productivity. Cost is expressed as follows:

$$c = \sum w_i x_i \tag{5}$$

and the change in cost is:

$$dc = \sum x_i dw_i + \sum w_i dx_i \tag{6}$$

The first summation is the component associated with changes in factor prices, while the second is the desired component purged of effects from changing factor prices.

The technology is represented by

$$y = Af(x) \tag{7}$$

so output growth is given as

$$dy = Adf(x) + f(x)dA = Adf(x) + y\frac{dA}{A}. \tag{8}$$

21 A good discussion the strengths and weaknesses of Hall (2018) can be found in Basu (2019).

The desired component purged of effects from changing productivity is:

$$Adf(x) = dy - y\frac{dA}{A} \tag{9}$$

Marginal cost is the ratio of adjusted cost change to adjusted output change,

$$mc = \frac{\sum w_i dx_i}{dy - y\frac{dA}{A}} \tag{10}$$

The Lerner index is

$$L = \frac{p - mc}{p} = 1 - \frac{\sum w_i dx_i}{p\left(dy - y\frac{dA}{A}\right)} \tag{11}$$

So

$$1 - L = \frac{\sum w_i dx_i}{p\left(dy - y\frac{dA}{A}\right)} \tag{12}$$

Now let:

$$\alpha_i = \frac{w_i x_i}{py} \tag{13}$$

be the share of factor i in revenue, py. The equation can then be written as:

$$(1 - L)\left(dy + y\frac{dA}{A}\right) = y\sum \alpha_i \frac{dx_i}{x_i} \tag{14}$$

Dividing by y and rearranging yields a useful result,

$$(1 - L)\frac{dy}{y} - \sum \alpha_i \frac{dx_i}{x_i} = (1 - L)\frac{dA}{A}. \tag{15}$$

Equation 13 can be written in discrete time as follows:

$$\begin{aligned}(1 - L)\Delta \log y - \sum \alpha_i \Delta \log x_i \\ = (1 - L)\Delta \log A\end{aligned} \tag{16}$$

This formulation is useful because the left-hand side is the Solow residual when L = 0. However, when L > 0, the Solow residual does not measure actual technical progress because it does not adjust for market power. Note that there is no adjustment to factor inputs x_i. This reflects Hall's assumption that markups do not influence the marginal rate of technical substitution such that any change in factor prices associated with changes in the markup impact capital and labour equally, leaving their shares α_i unchanged. This simplifying assumption makes the framework in Hall (2018) ideal for counterfactual analyses. However, Basu (2019) highlights important limitations related to this and other assumptions in Hall's framework that a more sophisticated economic model should address.

Appendix Table 1: Contributions to Business Sector Labour Productivity Growth by Industry in Canada and the United States, 1987-2001

	Canada	United States	Canada less United States
	Percentage point change, compound annual growth rates		
Business sector	1.71	2.17	-0.46
Crop and animal production	0.06	0.08	-0.01
Forestry, fishing, and related activities	0.01	-0.01	0.02
Oil and gas extraction	0.04	0.03	0.01
Mining (except oil and gas extraction)	0.03	0.04	-0.01
Support activities for mining and oil and gas extraction	0.00	0.01	-0.01
Food, beverage and tobacco products	0.04	0.01	0.03
Textile and textile product mills	0.01	0.02	-0.01
Clothing, leather and allied product manufacturing	0.01	0.02	-0.01
Wood product manufacturing	0.02	-0.01	0.03
Paper manufacturing	0.04	0.00	0.04
Printing and related support activities	0.00	0.00	0.00
Petroleum and coal products manufacturing	0.01	0.04	-0.03
Chemical manufacturing	0.09	0.05	0.04
Plastics and rubber products manufacturing	0.02	0.03	-0.01
Non-metallic mineral product manufacturing	0.01	0.01	0.01
Primary metal manufacturing	0.06	0.02	0.04
Fabricated metal product manufacturing	0.02	0.01	0.01
Machinery manufacturing	0.03	0.01	0.02
Computer and electronic product manufacturing	0.16	0.49	-0.33
Electrical equipment	0.02	0.01	0.01
Transportation equipment manufacturing	0.10	0.02	0.08
Furniture and related product manufacturing	0.02	0.00	0.01
Miscellaneous manufacturing	0.02	0.02	0.00
Wholesale trade	0.17	0.30	-0.13
Retail trade	0.18	0.33	-0.15
Transportation and warehousing	0.06	0.10	-0.04
Information and cultural industries	0.12	0.05	0.06
Finance and insurance	0.33	-0.05	0.38
Professional services	0.07	0.01	0.06
Administration, waste management	0.01	-0.01	0.02
Educational services	0.03	0.01	0.02
Health care and social assistance	-0.03	-0.04	0.01
Arts, entertainment and recreation	-0.01	0.01	-0.02
Accommodation and food services	0.02	0.06	-0.04
Other services	0.02	0.03	-0.02

Sources: Statistics Canada, the Bureau of Economic Analysis, the Bureau of Labor Statistics, and authors' calculations.
Note: Percentage point changes represent compound annual growth rates.

Appendix Table 2: Business Sector Labour Productivity Growth by Industry in Canada and the United States, 1987-2001

	Canada	United States	Canada less United States
	percent change, compound annual growth rates		
Business sector	1.71	2.17	-0.46
Crop and animal production	3.87	5.08	-1.21
Forestry, fishing, and related activities	1.54	-2.56	4.09
Oil and gas extraction	1.82	2.59	-0.77
Mining (except oil and gas extraction)	2.26	7.92	-5.66
Support activities for mining and oil and gas extraction	1.38	7.75	-6.37
Food, beverage and tobacco products	1.58	0.45	1.13
Textile and textile product mills	1.71	3.89	-2.18
Clothing, leather and allied product manufacturing	2.73	3.90	-1.18
Wood product manufacturing	2.47	-2.48	4.96
Paper manufacturing	2.75	0.43	2.31
Printing and related support activities	0.20	0.62	-0.42
Petroleum and coal products manufacturing	2.16	7.26	-5.10
Chemical manufacturing	4.15	2.41	1.74
Plastics and rubber products manufacturing	2.70	3.34	-0.64
Non-metallic mineral product manufacturing	2.18	1.22	0.95
Primary metal manufacturing	5.20	2.16	3.04
Fabricated metal product manufacturing	1.60	0.80	0.80
Machinery manufacturing	2.53	0.37	2.16
Computer and electronic product manufacturing	8.45	20.51	-12.06
Electrical equipment	3.97	1.65	2.31
Transportation equipment manufacturing	4.59	1.21	3.39
Furniture and related product manufacturing	3.56	0.65	2.91
Miscellaneous manufacturing	3.82	3.83	-0.01
Wholesale trade	2.55	4.28	-1.73
Retail trade	2.33	3.88	-1.54
Transportation and warehousing	1.17	2.58	-1.41
Information and cultural industries	2.50	0.96	1.54
Finance and insurance	1.82	-0.24	2.06
Professional services	0.97	0.08	0.88
Administration, waste management	0.40	-0.43	0.83
Educational services	4.98	0.99	3.99
Health care and social assistance	-0.69	-0.64	-0.05
Arts, entertainment and recreation	-1.32	0.93	-2.25
Accommodation and food services	0.50	1.97	-1.46
Other services	0.58	1.18	-0.60

Sources: Statistics Canada, the Bureau of Economic Analysis, the Bureau of Labor Statistics, and authors' calculations.
Note: Percentage point changes represent compound annual growth rates.

Appendix Table 3: Contributions to Business Sector Labour Productivity Growth by Industry in Canada and the United States, 2001-2019

	Canada	United States	Canada less United States
	Percentage point change, compound annual growth rates		
Business sector	0.92	1.84	-0.92
Crop and animal production	0.06	0.02	0.04
Forestry, fishing, and related activities	0.01	0.00	0.01
Oil and gas extraction	-0.03	0.03	-0.06
Mining (except oil and gas extraction)	-0.02	0.00	-0.01
Support activities for mining and oil and gas extraction	0.00	0.00	0.00
Food, beverage and tobacco products	-0.02	0.00	-0.02
Textile and textile product mills	0.00	0.01	0.00
Clothing, leather and allied product manufacturing	0.01	0.00	0.00
Wood product manufacturing	0.03	0.01	0.02
Paper manufacturing	0.01	0.01	0.00
Printing and related support activities	0.01	0.02	-0.01
Petroleum and coal products manufacturing	-0.03	0.00	-0.03
Chemical manufacturing	0.00	0.03	-0.03
Plastics and rubber products manufacturing	0.01	0.01	0.00
Non-metallic mineral product manufacturing	0.00	0.01	-0.01
Primary metal manufacturing	0.01	0.02	-0.01
Fabricated metal product manufacturing	0.01	0.01	0.00
Machinery manufacturing	0.02	0.02	-0.01
Computer and electronic product manufacturing	0.01	0.24	-0.23
Electrical equipment	0.00	0.01	-0.01
Transportation equipment manufacturing	0.03	0.04	-0.01
Furniture and related product manufacturing	0.00	0.00	0.00
Miscellaneous manufacturing	0.00	0.02	-0.02
Wholesale trade	0.17	0.11	0.05
Retail trade	0.11	0.13	-0.03
Transportation and warehousing	0.03	0.04	-0.01
Information and cultural industries	0.08	0.39	-0.32
Finance and insurance	0.30	-0.31	0.61
Professional services	0.05	0.13	-0.08
Administration, waste management	0.02	0.01	0.00
Educational services	0.01	0.00	0.01
Health care and social assistance	-0.03	0.02	-0.05
Arts, entertainment and recreation	0.00	0.02	-0.01
Accommodation and food services	0.01	0.01	0.01
Other services	0.03	-0.02	0.04

Sources: Statistics Canada, the Bureau of Economic Analysis, the Bureau of Labor Statistics, and authors' calculations.
Note: Percentage point changes represent compound annual growth rates.

Appendix Table 4: Business Sector Labour Productivity Growth by Industry in Canada and the United States, 2001-2019

	Canada	United States	Canada less United States
	percent change, compound annual growth rates		
Business sector	0.92	1.84	-0.92
Crop and animal production	4.87	2.40	2.47
Forestry, fishing, and related activities	1.44	-0.07	1.51
Oil and gas extraction	-0.90	3.64	-4.54
Mining (except oil and gas extraction)	-2.31	-1.19	-1.13
Support activities for mining and oil and gas extraction	-0.45	0.74	-1.19
Food, beverage and tobacco products	-1.05	-0.03	-1.02
Textile and textile product mills	1.53	1.91	-0.38
Clothing, leather and allied product manufacturing	1.92	2.21	-0.29
Wood product manufacturing	3.19	2.76	0.43
Paper manufacturing	1.13	1.61	-0.49
Printing and related support activities	1.42	3.36	-1.94
Petroleum and coal products manufacturing	-3.54	0.46	-4.00
Chemical manufacturing	-0.09	1.27	-1.36
Plastics and rubber products manufacturing	1.25	1.53	-0.28
Non-metallic mineral product manufacturing	0.26	1.49	-1.24
Primary metal manufacturing	0.86	3.94	-3.08
Fabricated metal product manufacturing	0.64	0.74	-0.10
Machinery manufacturing	1.39	2.03	-0.64
Computer and electronic product manufacturing	1.07	12.60	-11.53
Electrical equipment	0.85	2.57	-1.72
Transportation equipment manufacturing	0.98	3.31	-2.32
Furniture and related product manufacturing	0.50	1.39	-0.89
Miscellaneous manufacturing	0.45	3.17	-2.72
Wholesale trade	2.48	1.69	0.79
Retail trade	1.66	1.68	-0.02
Transportation and warehousing	0.72	1.32	-0.60
Information and cultural industries	1.52	7.09	-5.58
Finance and insurance	1.53	-1.32	2.85
Professional services	0.55	1.33	-0.78
Administration, waste management	0.53	0.45	0.08
Educational services	1.03	0.09	0.94
Health care and social assistance	-0.44	0.34	-0.78
Arts, entertainment and recreation	0.19	1.43	-1.23
Accommodation and food services	0.44	0.25	0.19
Other services	1.20	-0.58	1.78

Sources: Statistics Canada, the Bureau of Economic Analysis, the Bureau of Labor Statistics, and authors' calculations.
Note: Percentage point changes represent compound annual growth rates.