October 2022

604-170 Laurier Ave. West
Ottawa, Ontario
K1P 5V5

613-233-8891
info@csls.ca

CENTRE FOR THE STUDY OF LIVING STANDARDS

Firm-level Productivity Research in Canada: Current State and Future Directions

Andrew Sharpe

CSLS Research Report 2022-06

October 2022

Ottawa, Canada

Firm-level Productivity Research in Canada: Current State and Future Directions

Table of Contents

Firm-level Productivity Research in Canada: Current State and Future Directions

Executive Summary

A key activity of the Productivity Partnership is to promote research using the micro-level databases developed by Statistics Canada. The evidentiary base from applying micro-level data may be used in direct analyses of productivity. The Centre for the Study of Living Standards is contracted by ISED to produce a report outlining an agenda for firm-level productivity research in Canada. This report has been developed in response to this request.

First, the report reviews the opportunities and challenges in the use of firm-level data for the analysis of productivity trends and determinants. The difficulties of using firm-level data can be separated into two categories: access issues and data issues. To access, at least one person involved in the application must be a permanent resident, must pay a fee (generally around 10,000), must go through security clearance (may take up to 3 months). In addition, there is a major learning curve in understanding the nature of the data and data preparation, including cleaning and treatment of outliers, can be labor-intensive. The data issues include but not limited to lack of firm-level data on human capital, long lags in data availability, changes in the firm landscape through mergers and acquisitions, lack of firm-level deflators and lack of controls for capacity utilization. However, there are efforts by Statistics Canada to reduce the significance of data issues and to make firm-level data more accessible.

The report identifies three areas of productivity research where firm-level data are needed: firm dynamics and productivity growth: decomposition of productivity growth into firm-specific and reallocation effects, dispersion of firm productivity. The concepts related to dynamics, decomposition, and dispersion can overlap considerably so clear-cut differentiation of research into these three areas is not always possible. CSLS research project on estimating productivity decompositions and dispersion for firms in Newfoundland and Labrador is included as an example.

As the firm-level data is difficult to work with for the reasons mentioned above, industry level data can be a cheaper and less cumbersome alternative to understand productivity. Although the analysis on the industry level is not able to exploit heterogeneity in firm-level characteristics, Statistics Canada provides an excellent industry-level data that can be used at no cost in the productivity research.

Second, the report identifies the research questions related to productivity that firm-level data can shed light on. These questions include 1) contributions to overall productivity growth in the industry by firm size group; 2) contributions to overall productivity growth in the industry by firm age group; 3) the contributions to overall productivity growth in the industry by firm dynamism (gazelles (fast growing firms) versus lifestyle firms): 4) explanations for firm heterogeneity in productivity dispersion and its persistence and policies to improve overall

performance; 5) contribution of market structure, prices, product quality and variable mark-ups to measured firm-level productivity performance; 6) the link between firms that perform R&D or patent and productivity

Third, the report reviews firm-level data availability in Canada and internationally. In Canada, The Centre for Data Development and Economic Research (CDER) at Statistics Canada provides access to various micro-level data that includes: 1) Canadian Employer-Employee Dynamics Database; 2) Capital and Investment Program; 3) Longitudinal Employment Analysis Program (LEAP); 4) T2-LEAP; 5) National Accounts Longitudinal Microdata File; 6) Survey of Financing of Small and Medium Enterprises; 7) Survey of Innovation and Business Strategies; and 8) Workplace Employee Survey. Among them, T2-LEAP is most commonly used, and it is constructed by linking corporate tax file (T2) to LEAP database. In addition, Statistics Canada provides firm-level data on business dynamics that includes entry, exit rates for 17 two-digit industries for Canada and for all ten provinces. Internationally, micro-level data can be found at: 1) Centre for Economic Studies at U.S. Census Bureau; 2) MultiProd; 3) OECD-Orbis Database; 4) MMD at Eurostat; 5) CompNet at European Central Bank

Fourth, the report reviews the literature on productivity research based on firm-level data in Canada and internationally. The CSLS has organized the productivity related studies into eight themes: global value chains, trade, offshoring, the post-2000 productivity slowdown, firm size, sector-specific studies, ICT and innovation, and multinationals. The size of the term has been positively associated with firm size (Baldwin, Rispoli, Leung (2014)), therefore a shift in distribution of employment over firm size groups can explain aggregate productivity. As each sector has different characteristics, their productivity also evolves differently over time. For example, Baldwin, Leung, Rispoli (2011) find that unincorporated sector has lower productivity growth compared to the corporate sector in Canada. Factors such as offshoring, tariff reduction and participation to global value chain can also increase firm productivity. There are different explanations on why labour productivity and total productivity growth slowed in Canada after 2000. One explanation is from Gu (2018), and they find that roughly one quarter of the decline in TFP in the Canadian business sector was due to an increase in the use of produced capital required to extract natural resources in the oil and gas and mining sector and a decline in the capital utilization in manufacturing. For ICT and innovation, the adoption of advanced technologies lead to higher productivity growth as demonstrated by Baldwin and Sabourin (2001 and 2002) on manufacturing plants.

Finally, the report identifies four areas of productivity research where use of firm-level data may have the potential to advance our understanding of the slowdown, namely 1) relative performance of frontier firm; 2) changes in the pace of technical progress; 3) secular stagnation or changing demand conditions; 4) falling business sector R&D and investment.

Firm-level Productivity Research in Canada: Current State and Future Directions[1]

I. Introduction

Background and Motivation

In 2011, the Economic Research and Policy Analysis (ERPA) Branch of Industry Canada produced for discussion purposes a document entitled "Research Frame: Excellence in Microeconomic Policy and Business Performance." The motivation for this document was Canada's poor productivity performance and the need to better understand it and to put forward policies to improve the performance. The objective of the document was to develop a medium-term research program aimed at better understanding productivity performance and determinants ranging from economy-wide to firm-level studies. [2]A key focus of the frame or plan was to extend productivity-related micro-econometric analysis of Canadian firms using a newly expanded set of micro-level databases developed collaboratively with Statistics Canada.

Industry Canada indicated that it was looking to partner with academic colleagues in building and interpreting this research program. This led to the development of the Productivity Network, started in 2012 under the leadership of Mike Veall at McMaster University through a SSHRC Partnership Development grant. The network was then successful in receiving significant funding under the SSHRC Partnership Program.

A key activity of the Productivity Partnership is to promote research using the micro-level databases developed by Statistics Canada. It does this by providing assistance and financial support to researchers including students.[3] Almost all of the research projects have focused on applying firm-level microdata and as a consequence that evidentiary base is much better understood.

---

[1] This report was written by CSLS Executive Director Andrew Sharpe, with contributions from CSLS economists Atakan Bakiskan and Daniel Kim. The CSLS thanks ISED for financial support and Larry Shute, Mike Veall, Danny Leung, and Jiang Beryl Li for comments. An earlier version was presented at the Productivity Partnership Conference at the Bank of Canada on April 30, 2019, and at the CSLS-Statistics Canada Session "Firm-level Perspectives on Canada's Productivity Performance" at the annual meeting of the Canadian Economics Association.

[2]The 2011 ERPA document identified five thematic areas for research: productivity and living standards; business strategy, growth ambitions and performance; business context; productivity performance and micro-economic policy research; and micro-econometrics. Under each theme, the document listed a number of potential research directions. From the perspective of this report on directions for firm-level productivity research, the most relevant research directions in the document were in the micro-econometrics section, followed by the productivity performance and micro-economic policy research.

[3]A list of the projects funded is found at https://productivitypartnership.ca/research.

Government officials and members of the Productivity Partnership leadership team feel that it is a good time to take stock of how that evidence may be used in further direct analyses of productivity and seek ways to stimulate interest in such research. One suggestion has been the elaboration of an agenda for firm-level productivity research in Canada, and that the Centre for the Study of Living Standards be contracted by ISED to produce a report outlining this agenda. This report has been developed in response to this request.

General Objectives of the Project

This report on the current state of and directions for firm-level productivity research in Canada has five general objectives.

1) To review the opportunities and challenges in the use of firm-level data for the analysis of productivity trends and determinants.

2) To identify the research questions related to productivity that firm-level data can shed light on.

3) To review firm-level data availability in Canada and internationally.

4) To review the literature on productivity research based on firm-level data in Canada and internationally.

5) To put forward a research agenda based on firm-level data that can contribute to the better understanding of productivity developments in Canada and can point to public policy measures and private section actions that can improve productivity performance.

Structure of the Report

The report consists of seven main sections (excluding the introduction). The first section provides an overview of the availability of firm-level data in Canada and internationally. The second section briefly discusses the availability of very detailed industry-level productivity data for Canada and the provinces, the first data stop for a productivity researcher. The third section reviews the firm-level data on business dynamics that Statistics Canada already makes publically available. Again, productivity researchers should be aware of these data before attempting projects using confidential firm-level data. The fourth part of the report discusses disadvantages related to firm-level data, both in terms of difficulties of access and weaknesses in the data. The fifth section examines the advantages of using firm-level data for three areas of productivity research, namely business dynamics, decomposition of productivity growth into firm-specific and reallocation effects, and firm dispersion of productivity performance. This section also include discussion of CSLS research in these areas and suggests specific research questions that can be addressed with firm-level data. The sixth section identifies the slower productivity growth since 2000 as the key issue for applied or empirical productivity researchers in Canada and outlines areas for research, namely frontier firms, the pace of technical progress, reasons for

falling business sector R&D and implications of secular stagnation. The seventh and final section concludes.

II. Firm-level Data Availability in Canada and Internationally

This section provides an overview of the availability of firm-level data in Canada through the Centre for Data Development and Economic Research (CDER) at Statistics Canada, and highlights firm-level data availability in the United States through the Center for Economic Studies at the Census Bureau and in three international organizations, the OECD, Eurostat, and the Competitiveness Research Network.

Centre for Data Development and Economic Research (CDER) at Statistics Canada

In Canada, the Centre for Data Development and Economic Research (CDER) at Statistics Canada provides access to various micro-level data for researchers undertaking analytical studies. CDER develops and manages business micro-level data both at the establishment- and the firm-level. The available establishment-level data at CDER are the Annual Survey of Manufacturers (ASM) and the ASM-Import Registry linked database. The databases available at CDER include eight separate firm-level databases namely: 1) Canadian Employer-Employee Dynamics Database; 2) Capital and Investment Program; 3) Longitudinal Employment Analysis Program (LEAP); 4) T2-LEAP; 5) National Accounts Longitudinal Microdata File; 6) Survey of Financing of Small and Medium Enterprises; 7) Survey of Innovation and Business Strategies; and 8) Workplace Employee Survey.

One of the most widely used database is T2-LEAP which is constructed by linking the corporate tax file (T2) to the LEAP database. The database includes all incorporated firms in Canada covering the 1984-2012.[4]The T2-LEAP database uses a statistical enterprise concept. That is, a firm defined in the data includes all entities controlled by the same corporation. Hence, a firm may consist of more than one legal entity filing a tax return with the Canadian Revue Agency (CRA).

T2-LEAP is a useful source of data as it contains almost all necessary information to conduct productivity research at the firm-level. That is, the data contain firm-level information on output (sales and value added), labour unit (average labour unit), and tangible capital stock.[5] These are key variables needed to estimate firm-level labour productivity and total factor productivity (TFP).[6] Value added is constructed as the sum of labour income and capital income based on the LEAP file and the General Index of Financial Information (GIFI), respectively. Tangible capital stock is available from the GIFI balance sheet items reported by individual firms. The average labour unit is developed based on the LEAP file. It is defined as the ratio of total

[4] The database is soon expected to be augmented to cover the 2013-2015 period.
[5] Tangible capital stock includes assets with a physical form such as buildings, land and machinery and equipment.
[6] Industry-specific deflators are available in the data (at the 3-digit NAICS). They are based on the KLEMS database.

payroll to average annual earnings of an average worker in the firm's 4-digit industry, province and firm size class.[7]

Apart from these variables, the T2-LEAP contains firm-level information such as R&D expenditure[8] and country of control. Also, each firm is assigned a 4-digit NAICS code in a given year allowing researchers to do analysis by industry.[9] Some additional information can be made available if such information exist in T2 or LEAP (*e.g.*, computer-related expenses which are available from Schedule 125 in T2). This allows researchers to explore heterogeneity in productivity performance across firms focusing on different dimensions.[10]

Also, the T2-LEAP database is adjusted to eliminate spurious entries and exits due to mergers and acquisition and legal restructuring. For instance, when two firms are merged, then the new firm is created and assumed to have existed from the organic birth of the oldest of the two firms. This eliminates some empirical issues often faced by researchers when they assess between-effects in a productivity decomposition exercise, but at the cost of creating a time series that reflects the corporate organizational structure of a benchmark year.

The database is suitable for various estimation strategies for total factor productivity (TFP). First, researchers often rely on semi-parametric approaches to estimate TFP to correct for certain empirical issues (*e.g.*, simultaneity bias). Most notable are the methodologies developed by Olley and Pakes (1996) and Levinsohn and Petrin (2003). To account for simultaneity bias, they rely on proxies such as tangible investment (Olley-Pakes) and intermediate inputs (Levinsohn-Petrin). In T2-LEAP, information on firm-level tangible investment is available from T2 files.[11] There is no separate information on intermediate inputs in the T2-LEAP database, but one can compute it based on the available data (*i.e.*, sales minus value added).[12] With a sufficiently long time series, the database appears to be suitable for Generalized Method of Moments (GMM) estimation using lagged values as instruments of dynamic production functions.

In order to obtain access to data at CDER, researchers must submit a research proposal and cover all costs -- CDER operates on a cost-recovery basis. Once the proposal is approved, researchers must go through the security screening process and take the Statistics Canada Oath of office in Section 6(1) of the Statistics Act. All data are accessible at Statistics Canada's head office in Ottawa, Ontario[13].

---

[7] The number of hours worked is not available in the database.

[8] But only for the 2000-2012 period.

[9] To be precise, there actually are more than one industry codes assigned to individual firms: the most dominant, second dominant and the third dominant industry -- dominant in terms of payroll (wages and salary). In most cases, researchers rely on the most dominant industry to classify a given firm.

[10] However, one issue in the T2-LEAP database is that it is difficult to allocate firm-level information (*e.g.* sales, payroll, capital income) across provinces for firms that operate in more than one province. This becomes an important issue when we conduct productivity analysis by province.

[11] This is from line 203 in Schedule 8 in the CRA form T2.

[12] However, the intermediate input retrieved this way may not be suitable for the Levinsohn and Petrin approach if it is highly volatile, causing some key assumption made for the estimation to break down.

[13] There were 2 pilot projects launched in 2018, making business microdata available in the Research Data Centres. Additionally, there are efforts to have business microdata available in the VDL.

Centre for Economic Studies at U.S. Census Bureau

The Center for Economic Studies (CES) at the U.S. Census Bureau provides researchers with rich establishment and firm-level micro-data. CES has a mandate to produce, maintain, and conduct research using longitudinal datasets. These datasets are constructed primarily based on information from respondents to Census Bureau censuses and surveys, which have data on individuals, households, and businesses. Traditionally, CES has focused on business data mostly from the manufacturing sector. See the appendix for a detailed discussion of this data source.

OECD

Multifactor Productivity Project (MultiProd)

The Directorate for Science, Technology, and Innovation (STI) at the OECD has developed a harmonized framework that provides *non-confidential* micro-aggregate statistics that are comparable across countries.[14] Such micro-aggregated statistics are constructed based on existing official confidential data at the firm level, which are in turn based on official surveys and administrative sources such as Business Registers. The whole process of collecting, processing, and constructing relevant productivity statistics is called the Multifactor Productivity (MultiProd) project. The resulting collection of micro-aggregated statistics is called the MultiProd database. See the appendix for a detailed discussion of this data source.

OECD-Orbis Database

There is another firm-level data source called the OECD-Orbis database. The database is developed jointly by six OECD Directorates (started in 2008).[15] The database contains several productivity measures (variants of labour productivity and MFP) as well as other firm-level information.[16] The most recent version of the database covers 24 OECD countries over the 1997-2014 period for the non-farm and non-financial business sector (roughly 55 million firms). The countries included are Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Great Britain, Greece, Hungary, Ireland, Italy, Japan, Korea, Netherlands, Norway, Poland, Portugal, Spain, Sweden, Slovenia, the Slovak Republic and the United States. Canada is not included. See the appendix for a detailed discussion of this data source.

---

[14] STI at OECD distributes the algorithm (*DynEmp* in Stata) that implements a distributed micro data analysis to statistical agencies in the countries participating in the MultiProd project. The algorithm is run on confidential firm-level data and the resulting aggregated statistics are compiled in the MultiProd database, implying that OECD has no access to confidential data in those countries. See Berlingieri *et al.* (2017b) for more detail.

[15] They are: Centre for Entrepreneurship, SMEs and Local Development (CFE), Directorate for Employment, Labour and Social Affairs (ELS), Environment Directorate (ENV), Statistics Directorate (STD), Directorate for Science, technology and Industry (STI) and Directorate for Trade and Agriculture (TAD). Note that the database is accessible to OECD researchers only.

[16] We have in the database not only the variables that underlie the productivity measures such as sales, net income, the number of employees, tangible, and intangible fixed assets but also more detailed information such as current and non-current liabilities, interest payment, and country of control (more than 200 variables). The OECD-Orbis database are also linked with other OECD databases such as the PATSTAT database, which have information on patent for individual firms.

Eurostat

The only firm-level data available at Eurostat is the Micro-Moments Dataset (MMD).[17] The MMD is a product of the Eurostat-funded projects. The main purpose of the database is to derive measures of the impact of ICT and innovation on business performance and productivity. The MMD relates ICT and innovation variables to various indicators of economic performance and characteristics of firms across industry groups and countries. Therefore, it is possible to link the data on ICT and innovation to other aggregate economic data on productivity such as EU KLEMS.[18] See the appendix for a detailed discussion of this data source.

Competitiveness Research Network

The Competitiveness Research Network (CompNet) is a research network founded by the European System of Central Banks in 2012 to promote and inform the debate on competitiveness and productivity. Its activities involve not only research but also producing, updating, and maintaining a firm-level database for a number of EU countries. The European Central Bank (ECB) is one of the main contributors to the CompNet through not only research but also data production. The ECB maintains the CompNet Competitiveness Dataset. The database contains firm-level information covering 18 European countries[19] and is released regularly based on its latest vintage. The most recent version was released in 2018 (*i.e.*, the 6th Vintage CompNet database). The database is constructed based on information available from national central banks and national statistical institutes. See the appendix for a detailed discussion of this data source.

.

III. Statistics Canada Industry-Level Productivity Data

Statistics Canada now provides a wealth of detailed labour productivity estimates at the industry level based on establishment data.[20] Annual estimates for the 1997-2017 period are provided for Canada and all 10 provinces for nominal output (value added), real output (value added), deflators, hours worked, labour compensation, unit labour costs or number of jobs, and labour productivity (real value added/hours worked) at the all business sector industries, good-producing industries, service producing industries 17 industries at the two-digit NAICS level, 100 industries at the three digit NAICS level and 300 industries at the four-digit NAICS level. Even some five-digit industries in mining and quarrying are included.

This is a massive database that provides a 20-year time series of key labour productivity-variables at a very detailed level both regionally and by industry (at the four-digit NAICS level

---

[17] Refer to https://ec.europa.eu/eurostat/web/microdata for all other micro-data available at Eurostat.

[18] The aggregate version of the MMD is publically available at https://ec.europa.eu/eurostat/web/digital-economy-and-society/methodology.

[19] They are Belgium, Croatia, Czech Republic, Denmark, Finland, France, Germany, Hungary, Italy, Lithuania, Netherlands, Poland, Romania, Slovakia, Slovenia, Spain, and Sweden.

[20] Statistics Canada. Table 36-10-0480-01 Labour productivity and related measures by business sector industry and by non-commercial activity consistent with the industry accounts

for each variable there are around 88,000 industry-province cells (400 industries *11 jurisdictions (provinces and Canada) for each of 20 years of the time series). To illustrate the breadth of the database, the table in Appendix 1 provides estimates of labour productivity (real value added per hour worked) for all available industries for Canada for 1997, 2007 and 2017 and growth rates between periods.

A major advantage of this database is the complete absence of data gaps, no matter how small the jurisdiction, or the industry in the jurisdiction or the number of firms operating in the industry. There appear to be no confidentiality restrictions, even when there is only one firm or establishment in an industry. Statistics Canada is able to provide these data as they are not releasing the actual information reported to Statistics Canada by the establishment or firm. Rather they are releasing data that has been manipulated and altered by Statistics Canada.

Let us give an example of the usefulness and insights that can be provided by the Statistics Canada industry productivity database. There is only one petroleum refinery in New Brunswick (the largest in Canada) in Saint John owned and operated by Irving. It would be impossible for outside researchers, even with access to firm-level data through CDER, to obtain data on the productivity performance of the Irving refinery and the importance of the refinery for the New Brunswick economy. Yet such information can be obtained in 10 minutes from the open access Statistics Canada website.

Table 1-3 in Appendix 2 shows the output, employment and labour productivity in the petroleum refining industry (NAICS 32411) in New Brunswick (the Irving refinery) over the 1997-2017 period. In 2017, real GDP expressed in 2012 chained dollars, was $630.8 million, down from $796.6 million in 1997. Employment in the industry was 965 in 2017, up from only 240 in 1997. Labour productivity in the petroleum refinery industry in New Brunswick was $326.2 per hour (2012 chained dollars) in 2017, down massively from S1,565 per hour in 1997.

It is interesting to observe that the output of this industry, which consists of only one refinery, accounted for 3.2 per cent of the real GDP in New Brunswick in 2017, down from 5.3 per cent in 1997 and 6.0 per cent of total real GDP of petroleum refining in Canada, down from 11.2 per cent in 1997. Employment on the NB petroleum refining industry accounted for 0.37 per of the provinces employment in 2017, up from only 0.10 per cent in 1997. These divergent trends in output and employment shares had major implications for the relative labour productivity of the New Brunswick petroleum refining industry. In 1997, the labour productivity level in the industry in New Brunswick was 46 times the provincial average, By 2017, it was only 7.7 times the average. Equally, in 1997 the relative labour productivity level of the petroleum refining industry in New Brunswick was 189.0 per cent of the national average for the industry, By 2017, it had fallen to only 47.5 per cent of the national average.

The point of this exercise is to illustrate that very granular productivity analysis can be conducted using excellent data that Statistics Canada makes readily accessible at no cost to the public. Such data sources should be full exploited before one embarking on research projects aimed at developing productivity estimates from firm-level data at the detailed industry/provincial level. Analysis at the industry level is however, constrained by not being able

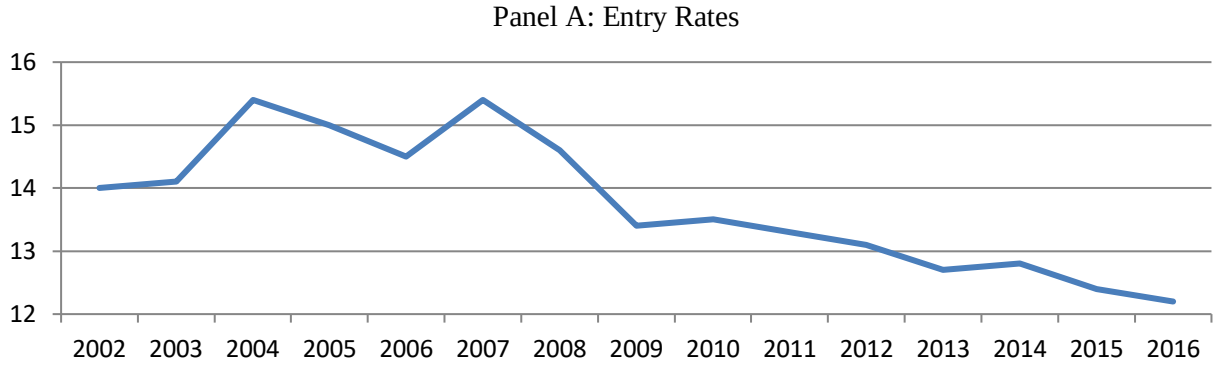
to exploit the heterogeneity that exists in firm-level characteristics and output and efficiency performance.

IV. Statistics Canada Firm-level Data on Business Dynamics

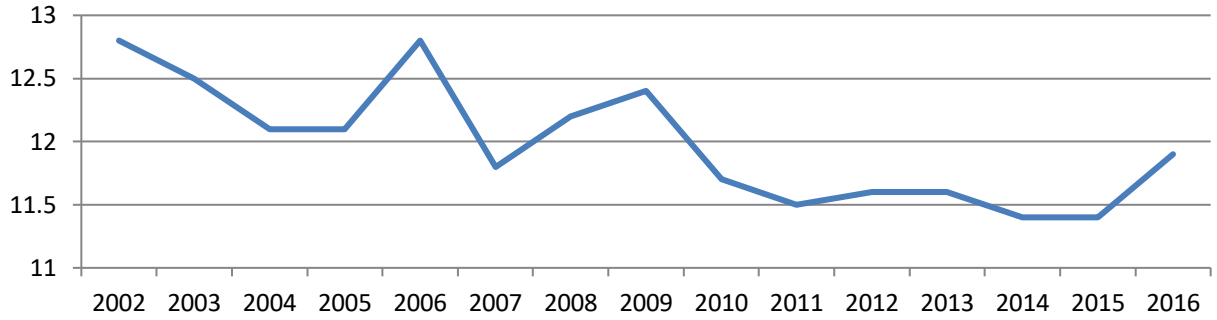
Firm dynamics, defined as the turnover of firms in the economy through exit and entry, can affect productivity in a number of ways. On the one hand, exiting firms may have low productivity levels so their departure may boost average productivity levels and productivity growth in an industry or in the economy as a whole through a reallocation effect. The entry of new firms may be positive for productivity performance as such firms may be innovative and productive, introducing new products, equipment, and production processes. A declining entry rate may be an indication that the economy is lacking in economic dynamism.

Before looking at firm-level data issues related to firm dynamics, it is important to review what information on firm dynamics is already available and easily accessible in Canada. Statistics Canada (Table 33-10-0087-01) makes available data on the number of incumbent, exiting, and entering firms for 17 two-digit industries for Canada and for all ten provinces and an aggregate for the territories. Estimates are available for the 2000-2016 period.

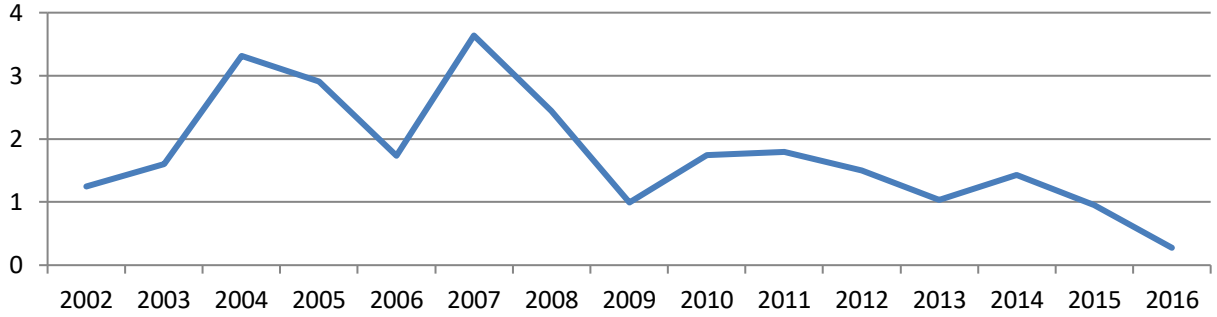
Chart 1: Entry Rates and Exit Rates of Private Sector Employer Businesses, Canada, 2002-2016 (per cent)



Panel B: Exit Rates



Panel C: Net Entry (Entry – Exit) Rates



Note: The entry rate for a year is defined as the number of entrants as a per cent of the average of the number of active employer businesses in the current year and the previous year. The exit rate for a year is defined as the number of exits as a per cent of the average of the number of active employer businesses in the current year and the previous year. The net entry rate for a year is defined as the number of net entry (the number of entrants – the number of exits) as a per cent of the average of the number of active employer businesses in the current year and the previous year. Source: Statistics Canada Table 33-10-0164-01 (formerly CANSIM 527-0001).

Chart A1 in the Appendix provides the time series for the 2000-2016 period of the number of firms (active employer business in the private sector economy) in Canada, broken down by incumbents, new firms or entrants, and exiting or exitor firms. In 2016, there was 1,111 thousand active employers in Canada, up from 907 thousand in 2001, a 22.5 per cent increase comparable to the rate of growth of the working age population (20.2 per cent). The number of firms consisted of 976 thousand incumbents and 135 thousand new entrants.

Chart 1 provides the exit and entry rates for firms in the private sector over the 2000-2016 period in Canada. One observes a significant decline in the entry rate, from around 15 per cent in the 2004-2007 period to 12 per cent in 2016.[21] Equally, the exit rate has also fallen, although less, from around 11.5 per cent on average of 12.5 per cent in 2002-2009 to 11.5 per

[21] Macdonald (2014) shows that the fall in the entry rate pre-dates 2001. He finds that the entry rates was 25 per cent in 1983/84. This means that 10 percentage points of the 13 percentage point fall in the entry rate between 1983/1984 and 2016 took place before 2001. From this perspective it is hard to explain the post-2000 slowdown in productivity growth by an increased rate of decline in business dynamics.

cent in 2011-2015, with an uptick to 12 per cent in 2018. The net entry rate, defined as the entry rate minus the exit rate, has fallen from around 3 per cent in 2004-2007 to around 1 per cent in 2013-2015, before dropping to almost zero (0.2 per cent) in 2016.

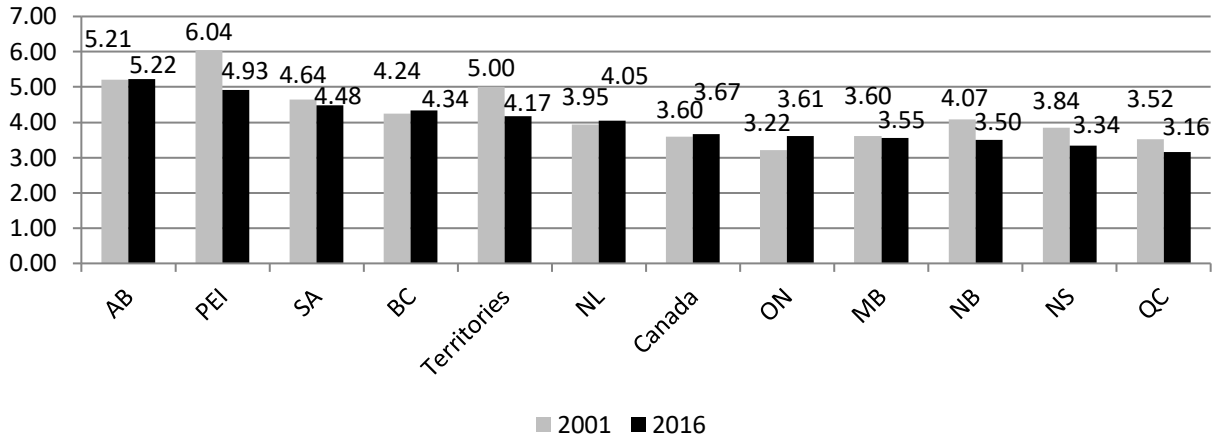
Chart A2 in the Appendix provides estimates of the entry, exit, and net entry rates by province for all private sector firms in 2016. If entry rates are indicative of business dynamism, then the two most dynamic jurisdictions are the territories and Prince Edward Island, and the least dynamic province is Quebec. It is unclear if this finding is consistent with other metrics of business dynamism. The highest exits rates were also in the territories, and Prince Edward Island (and Alberta) and the lowest exit rate was in Quebec. In terms of net entry Prince Edward Island had the highest rate at 1.65 per cent while Alberta had the lowest (-2.86 per cent), followed by the territories (-2.04 per cent).

Chart A3 in the Appendix provides entry, exit, and net entry rates for Canada for the 17 two-digit industries in 2016. One observes large differences in entry and exit rates across industries. Transportation and warehousing had the highest entry rate at 13.2 per cent while whole trade had the lowest at 5.7 per cent. Again, it is unclear if these inter-industry differences in entry rates are consistent with other measures of business dynamism at the industry level. Mining quarrying and oil and gas extraction had the highest exit rate at 17.4 per cent. This rate implies that nearly one in six firms in this industry exited in 2016, which appears to be a high rate of turnover. Manufacturing had the lowest exit rate at 7.6 per cent.

Chart 2 provides a measure of firm dynamism or entrepreneurialism by province/territory by dividing the number of firms by the working age population (15 and over). On this metric Alberta in 2016 appears to be the most entrepreneurial province with 5.22 businesses for every 100 Albertans of working age and Quebec the least entrepreneurial with 3.16 business for 100 Quebeckers of working age. Between 2001 and 2016 the province that experienced the largest increase in per capita businesses was Ontario (3.22 to 3.61) while the province experiencing the largest fall was PEI (6.04 to 4.93). The national average edged up slightly from 3.60 in 2001 to 3.67 in 2016. This stability in the number of active employers at the national level on a per capita basis may suggest that there have been no major changes in business dynamism in this country.

This brief review of trends in firm dynamics in Canada has had two purposes. First, to make readers aware of the wealth of readily accessible data on firm entry and exit that Statistics Canada already provides, admittedly in aggregated form. Second, to give readers a picture of overall trends in firm dynamics in Canada to both inform and motivate further research in the area.

Chart 2: Number of Active Employer Businesses in the Private Sector as a Per Cent of Working Age Population (15 and Over), Canada and the Provinces and Territories, 2001 and 2016



Source: Statistics Canada Table 33-10-0164-01 (formerly CANSIM 527-0001) and Table 33-10-0087-01 (formerly CANSIM 527-0007).

V. Review of Firm-Level Productivity Research in Canada

Statistics Canada have been producing firm-level data in Canada for several decades, so a significant body of research has been conducted. The vast majority of this research however has been done at Statistics Canada because of the confidentiality issues. With the creation of CDER and the establishment of the Productivity Partnership, this situation is changing and more researchers from outside Statistics Canada are accessing firm-level data.

At the request of the Productivity Partnership, CDER has provided a list of over 800 studies that the staff of the Economic Analysis Division (which included CDER) of Statistic Canada has conducted in the last 50 years. Out of this list the CSLS has identified around 100 studies that use firm-level data. All firm-level studies identify in the CDER list are included in the references to this report.

The CSLS has organized the productivity related studies into eight themes: global value chains, trade, offshoring, the post-2000 productivity slowdown, firm size, sector-specific studies, ICT and innovation, and multinationals. This section highlights key finding from what are considered the most important studies.

Global Value Chains

Participating in a global value chain can enhance productivity performance as it leads to a finer division of labour and specialization across countries. Using establishment-level data for Canadian manufacturing (*i.e.*, the Annual Survey of Manufacturers with the Import Register) Baldwin (2014) finds that becoming part of a global value chain enhances firms' productivity in Canadian manufacturing but the magnitude and timing of the enhancements vary by industry, internationalization process, and import-source/export-destination country.

Trade

Empirical research in productivity has focused on the role of trade liberalization and export market conditions on the productivity performance of manufacturing firms in Canada. For example, using establishment-level data, Baldwin (2012) finds that a tariff reduction leads to an increase in the probability that more efficient plants enter export markets and the productivity of entrants and those remained in export markets improved and was higher than the comparable plants that did not enter or exit export markets. However, macroeconomic events such as currency **appreciation** offsets the productivity growth advantages associated with the entrance to export markets.

Offshoring

Offshoring can also lead to better productivity performance of firms. For example, Couture, Sydor, and Tang (2015) find that offshoring firms in Canadian manufacturing tend to have higher productivity and that the gain in productivity is positively related to offshoring intensity (the share of inputs that are imported). They also find that offshoring facilitates resource reallocation within industries, positively affecting the aggregate productivity performance.

Post-2000 Productivity Slowdown

Both labour productivity and total factor productivity growth slowed in Canada after 2000. To explain this slowdown, Gu (2018) examines the role of intangible capital, natural capital, public infrastructure, and capacity utilization. The author finds that roughly one quarter of the decline in TFP in the Canadian business sector was due to an increase in the use of produced capital required to extract natural resources in the oil and gas and mining sector and a decline in the capital utilization in manufacturing. However, the slowdown is not associated with intangible capital and public infrastructure.

Another line of research is to examine the slowdown in productivity growth in manufacturing post 2000 in relation to the depreciating Canadian dollars and the slowdown in export growth in this period. Baldwin, Gu, and Yan (2013) find that most of the slowdown in labour productivity growth in manufacturing post 2000 can be explained by exporters.

Firm size

Researchers are interested in whether there is any relationship between firm size and productivity performance and if so, whether a shift in the distribution of employment or hours worked over firm size groups can explain the aggregate productivity performance or whether differences in such distribution among countries can explain cross-country gaps in productivity.

For example, Baldwin, Rispoli, and Leung (2014) find that there is a positive relationship between firm size and productivity performance both in Canada and the United States and that the decreasing relative importance of small firms and increasing small firm's productivity compared to large firms can account for most of the gap in productivity levels between Canada

and the United States in the early 2000s. Baldwin, Leung, and Rispoli (2013) also find that a positive relationship between firm size and labour productivity levels but increasing the employment share of large firms have a limited impact on the aggregate labour productivity level.

Sector-specific studies

Many firm-level studies have focused on a specific industry or on a specific business sector of the economy (*e.g.*, unincorporated sector). For example, Baldwin (2008) examines firm turnover and productivity growth in the Canadian retail trade sector as there is considerably more firm turnover in the sector compared to others. He finds that, unlike manufacturing, all of the aggregate productivity in the retail trade sector is driven by firm turnover and the reallocation of resources from less to more productive firms.

Chan, Gu, and Tang (2011) examine the labour productivity slowdown in the Canadian electronic and electrical product manufacturing following the bursting of the tech bubble in 2000. They find that the decline in labour productivity growth within continuing plants is a primary factor behind the decline while the reallocation effect is relatively small.

Gu and Lafrance (2014) study the dynamics of the rapid labour productivity growth in the Canadian broadcasting and telecommunications industry since the mid-1980s and find that the productivity growth within firms driven by technical change and scale economies was the main contributor to the aggregate productivity growth for the industry.

Gu (2014) constructs a direct measure of output for the hospital sector in Canada based on the number of inpatient and outpatient cases and their cost shares. Based on this measure, the author estimates the labour productivity of the sector to have increased 2.6 per cent per year over the 2002-2010 period.

Baldwin, Leung, and Rispoli (2011) examine the difference in the labour productivity growth between unincorporated and corporate businesses. They find that unincorporated sector has lower productivity growth compared to the corporate sector in Canada and incorporated/corporate sector in the United States. This accounted for the entire productivity gap between Canada and the United States in 1998 but its role declined over time.

ICT and innovation

The adoption of advanced technologies or innovative efforts leads to higher productivity growth. For example, Baldwin and Sabourin (2001 and 2002) find that manufacturing plants that adopted advanced technologies such as information and communications technology has much greater productivity growth throughout the following decade. Also, Baldwin, Gu, and Macdonald (2012) develop a measure of intangible investment (*e.g.*, software and R&D) and find that including in the National Accounts as investment leads to 0.2 percentage-point increase in the labour productivity.

Multinationals and Foreign Controls

Studies on multinationals in Canada using microdata have focused on the manufacturing sector. The main theme of these papers is the restructuring of the foreign ownership of the Canadian manufacturing sector. For example, Baldwin and Li (2017) find that almost all three-digit NAICS sub-sectors of the manufacturing sector experienced a decline in foreign control after 2000. In addition, Gu and Li (2017) identify that foreign-controlled enterprises were more important than domestically-controlled enterprises in the overall labour productivity growth from 2001 to 2010, but their contributions declined after 2006 because of an increase in the exits of large and productive foreign-controlled firms. Other related findings include the higher possibility of foreign plants being taken over than domestic plants (Baldwin and Wang, 2011) and the role of foreign direct investment in increasing productivity of domestically controlled plants (Lileeva, 2009).

VI. Challenges in Working with Firm-level Data for Productivity Analysis

This section discusses the challenges researchers face in working with firm-level data for productivity analysis in the Canadian context, focusing on both access and data issues

CSLS staff have been working with CDER officials for the last year and one half on three firm-level research projects.[22] Through this work we have obtained first-hand experience in both accessing the data including the procedures involved, and the characteristics of the data. Before outlining some of the challenges involved, it is important to stress that Statistics Canada staff have always been welcoming and cooperative, and most willing to explain protocols and provide advice on data issues.

Access issues

Unlike aggregate and industry level productivity estimates which are readily accessible on-line at no cost from Statistics Canada, even at the four-digit NAICS provincial level, firm-level data are much more difficult and costly to access. A firm-level research project at CDER by an outside researcher is a major undertaking with significant costs in time and money. Researchers should be aware of these costs before proceeding. There are summarized below.

- First, a project proposal must be submitted and approved by Statistics Canada. At least one person involved in the application must be a Canadian citizen or permanent resident, and no person involved in the application for on-site access to the data can own shares in a Canadian corporation, a barrier for older researchers.

[22]One project, supported by the Productivity Partnership, is on the private and external rate of return on R&D capital by firm size. The second project, supported by ISED, is on the impact of increased trade with China on business sector R&D in Canada. The third project, funded by Collaborative Applied Research in Economics (CARE) at Memorial University, is on productivity trends in Newfoundland and Labrador.

- Second, a fee, generally around $10,000, for accessing the firm-level data for a project must be paid.

- Third, for access to some, but not all, datasets (the university-based Research Data Centres have some micro-data sets, including T2-LEAP), researchers generally must go on a regular basis to the CDER site at Statistics Canada, a cost for researchers outside Ottawa.

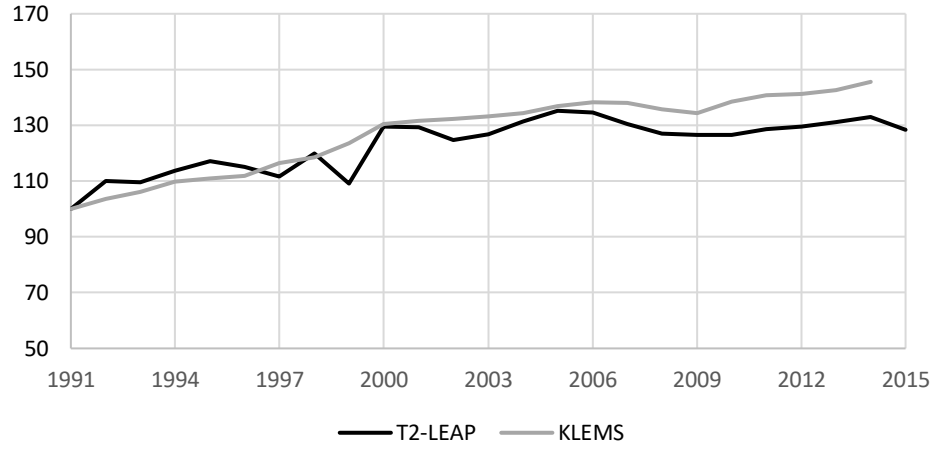
- Fourth, a security clearance, which can take up to three months, is required and can delay the start of a project.

- Fifth, internal vetting of results by Statistics Canada officials must be factored into timelines for the completion of a project.

- Sixth, data preparation, including cleaning and treatment of outliers, can be labour-intensive.
- Seventh, there are significant limitations on the firm level results that can be publically reported. Researchers may not actually see the firm-level data for a particular firm or even aggregated data for a number of firms, and may have very limited in the results they can publically report.

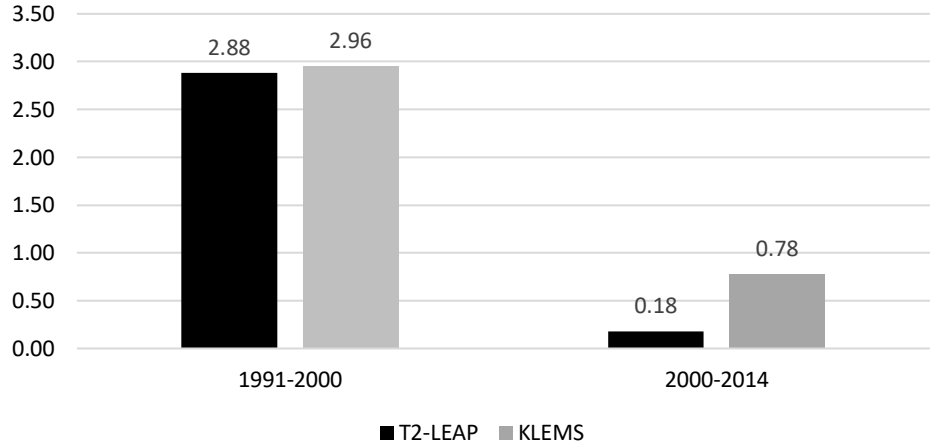
- Eighth, there is a major learning curve in understanding the nature of the data and the implications of changes in definitions or benchmarks (changes in ownership structures are less of a problem for establishment data which is not affected by changes in ownership). For example, in one CSLS project the movement to a more recent benchmark year for firm ownership structures resulted in major changes in the results.

Figure 1. Aggregate Labour productivity in Canada, 1991 to 2015, 1991=100



Source: Gu (2018b)

Figure 2. Annual average growth in aggregate labour productivity in Canada (% per year)



Source: Gu (2018b)

Data Issues

Lack of consistency between aggregated firm-level productivity estimates and Canadian Productivity Account estimates

As a general rule, monitoring and analysis of aggregate and industry level productivity trends should not use aggregations of firm-level data. In principle, such aggregation should be consistent with aggregations of the establishment data used to produce the national accounts and the Canadian Productivity Accounts (KLEMS data). In practice, this is not always the case. For example, Gu (2018) found that while firm-level data and national accounts data showed very similar growth rates for aggregate labour productivity in the 1991-2000 period (2.88 per cent per year for T2-LEAP and 2.96 per cent for KLEMS), in the 2000-2014 period the KLEMS-based

productivity growth rate was much higher at 0.78 per cent per year versus only 0.18 per cent for productivity estimates based on T2-LEAP data (Figures 1 and 2). It is likely that the KLEMS figure is more reliable. If the T2-LEAP numbers are correct, Canada's productivity problem is much greater than realized. It is very unusual for a major developed economy that functions relatively efficiently to have nearly zero labour productivity growth for 14 years.

Lack of firm-level data on human capital

The literature has identified quality of management as a key determinant of productivity growth, as the work of Nicholas Bloom. There are different metrics for quality of management. The most widely used is the formal education credentials (e. BA in business or MBA) of managers. Unfortunately, firm-level data do not generally provide information on the characteristics of the managers of a firm (e.g., education, age, gender, Indigenous identity, immigrants status, visible minority status). However, to address the issue of lack of firm-level data on human capital, linkage of Census to CEEDD is being evaluated. An integrated firm-household survey such as the Workplace-Employee Survey (WES) can in principle provide such data, but the WES was discontinued in 2006. It may be possible to link other data sources which contain personal characteristics of senior managers with firm-level databases such as T2-LEAP, but this is likely a substantial undertaking. The bottom line is that the lack of information on the T2-LEAP on the characteristics of managers at the firm level is a major limitation to using firm-level data for productivity analysis. It can be noted that both the Labour Force Survey and the census provide information on the educational attainment of senior managers at a detailed industry level.

Long lags in data availability

The relevance of firm-level data is reduced by the long lags in making the data available to researchers. For example, the T2-LEAP data file is currently officially only available to 2012. This delay reflects the significant amount of work needed to make the data accessible to researchers and relative priorities at Statistics Canada, given the competing demands for resources. The lack of timeliness reduces the impact that firm-level data can have on economic policy debate.

Industry allocation of firm output

For accurate productivity measures at the industry level, it is important that inputs and output be correctly allocated to the appropriate industry of use and production. This is a relatively straightforward procedure for a plant or establishment as output for such a production unit is generally confined to one industry. The problem is much more severe for firm-level data, especially for firms that operate in different industries. Rules for the industry allocation for firm level totals such as profits must be developed. Often the dominant industry or dominant industries are the only industries to which allocations of firm sales or revenues are made. This means that output from non-dominant industries controlled by the firm is excluded. For this reason, productivity analysis at the industry level based on firm data is less reliable than analysis based on establishment data.

Provincial allocation of national totals

The T2-LEAP database is for Canada, T2-LEAP databases for the provinces and territories have not been constructed but there is work in progress with the SNA. A key problem in such construction is the provincial/territorial allocation of national totals. For firms that operate in more than one province or territory, certain variables such as profits are only reported at the national level. Since profits are part of value added, and value added is needed for productivity calculation, a rule or formula must be developed for their provincial/territorial allocation from the national total. CSLS researchers are currently working with Statistics Canada on this issue in the context of a CSLS-CARE project on productivity in Newfoundland and Labrador.

Changes in the firm landscape through mergers and acquisitions

Because of mergers and acquisitions, the firm landscape in Canada is constantly evolving. These changes have important implications for time series on specific firms. For example, if a firm is taken over and no longer exists as a corporate entity, but continues to produce, its output will be included in that of the takeover firm, creating a discontinuity for the time series for that firm. For that reason, a certain vintage or benchmark year for ownership structures is created and that benchmark is then applied to all years in the series. In theory, a change in a benchmark year should have no effect on totals. In practice, this is not always the case. Ownership changes appear to be less a problem for establishments. If plants or establishments continue to operate when bought out, they report for the same entity so there is no discontinuity.

Non-comprehensive nature of firm-level data

A problem with firm-level data sets is that are not comprehensive in nature, covering sub-sets of the overall population. For example, the T2-LEAP data set includes for incorporated business only, excluding unincorporated businesses. On the other hand, CEEDD contains non-employers and unincorporated firms. This means that the employment and output totals found in the T2-LEAP will be less than in the national accounts where all agents producing economic output, including unincorporated businesses, are included. This can have implications for productivity performance when average productivity levels differ between incorporated and unincorporated firms. This is a particularly important problem in industries where unincorporated business are important. Productivity measures at the total economy and industry level should be comprehensive. This means that national accounts-based productivity measures are superior to productivity measures constructed from firm-level data from a non-comprehensive dataset.

Lack of Firm-level Deflators

Productivity growth rates (as opposed to productivity levels) at the firm level require real or constant price estimates of output. Such estimates are calculated from data on nominal gross output or value added and output prices. Unfortunately, information on output prices are not normally collected in firm surveys. This means that it is impossible to calculate real output at the

firm level based on the prices received by that firm. The standard solution is to use industry-level deflators. However, the consequences of this procedure are unclear and merit study.

Lack of Controls for Capacity Utilization

All data collected in firm surveys are affected by the stage of the business cycle during which the survey is conducted. This reality means that there may be a cyclical component in a variable, making comparisons over time of the variable risky unless comparisons are made at the same point n the business cycle. Various techniques have been developed to control for capacity utilization and produce cyclically adjusted estimates of variables. Currently, however there is no consensus on a satisfactory method for doing this.

VII. Advantages of Firm-level Data for Productivity Analysis

This section of the report will highlight the advantages to using firm-level data for productivity analysis that can offset the costs highlighted in the previous section.[23] The obvious strength of using firm-level data is that since economic decisions are made at the firm level, these data on the individual firm characteristics, on the inputs used in production as well as the information on firm output can led to a greater understanding of why these decisions are made, the outcomes of the decisions, and how public policies can influence these decisions.

Despite the limitations of firm-level data for productivity analysis outlined above, access to firm-level data is needed for certain productivity research questions. Working at CDER may be the only avenue for completing such research. This section identifies three areas of productivity research where firm-level data are needed: firm dynamics and productivity growth: decomposition of productivity growth into firm-specific and reallocation effects, dispersion of firm productivity. The concepts related to dynamics, decomposition, and dispersion can overlap considerably so clear cut differentiation of research into these three areas is not always possible. Many studies combine the areas of research. The section also outlines a CSLS research project on estimating productivity decompositions and dispersion for firms in Newfoundland and Labrador.

[23]Drummond, Ryan and Veall (2013:87) make the case that the use of firm-level data in productivity analysis by stating:

> "In particular, the availability and potential "linkability" of data sets including firm-level tax data and new firm-level national accounts micro-data could permit analyses involving the relationships between a wide variety of financial variables and variables gathered in other surveys. This would provide insight into the dynamics of firm creation and destruction, the growth decision by firms (perhaps, e.g. affected by special tax and regulatory provisions for small firms in Canada or access to different forms of capital), managerial decisions on innovation and business strategies and much else."

Firm dynamics

As already noted in this report, data on firm dynamics (exit, entrants and incumbent firms) are publically available on a provincial /territorial basis for 17 two-digit NAICS industries. But the characteristics of the firms in each of the three different categories of firms are not readily available and need to be calculated from firm-level data. These characteristics include firm size, sales/revenues, intermediate inputs, value added. payroll, profits, hours worked, labour productivity, capital input, total factor productivity, foreign ownership, and innovation indicators such as R&D spending. Researchers may be able to show, for example, that exiting firm have significantly lower productivity growth rates and levels than continuing firms and that the poor productivity performance contributed to the exit.

Productivity Decomposition

The overall productivity growth rate in an industry, or at the level of the total economy, is a function of both the firm-specific productivity growth rates and changes in the relative size, measured in terms of hours or value added, of that firm, known as reallocation effects.[24] For example, if the most productive firm in an industry expands rapidly, increasing its share of output and employment in the industry, this firm can make a significant contribution to the productivity growth in the industry even though its actual productivity growth rate may be zero.

There is a significant literature on methodologies to decompose productivity growth at the industry level into firm-specific productivity contribution to the industry's productivity growth and reallocation effects. Firm-specific contributions to productivity growth can in turn be broken down into contributions firm by productivity level quartile or decile of the firms, including frontier firms, by size of firm (small, medium, large), by age of firm (e.g start-ups, established firms), by firm growth rates (gazelles versus lifestyle firms). Different decomposition methodologies give different results based on the underlying properties of the decomposition formula.

In addition to firm decomposition of productivity growth, productivity levels can be decomposed into relative contribution of specific firms and groups of firms based on their relative productivity level and importance. For example, a firm accounting for 2 per cent of employment on the industry, but with a productivity level only one half the industry average would only be responsible for 1 per cent of the industry level. Decompositions of productivity levels do not have a reallocation effect as there is no changes in output and employment shares over time.

Decomposition analysis can be very useful for pin pointing the sources of productivity growth in a sector, whether through reallocation effects of output to high productivity, low cost firms or specific contributions from a particularly important high tech firm, (e,g. Amazon or

[24] Analogously, the overall productivity growth rare in an economy is a function of both the industry-specific productivity growth rates and the relative size, measured in terms of hour/employment or value added, of that industry. On the various formulas for decomposing aggregate productivity growth, see Sharpe (2010a) Sharpe (2010b), Tang and Wang (2004) and Reinsdorf (2015).

Apple) or from a particular growth of firms such a start-ups or gazelles. Such information can potentially be used for the development of public policies aimed at boosting productivity.

Dispersion of productivity

It has long been well known that firms within an industry can vary greatly in their level of productivity, and that these differences can persist over time, both for labour productivity and total factor productivity. Economists are often surprised by these productivity differences or heterogeneity in production, wondering how firms in the bottom part of the productivity distribution can survive (Syverson, 2011). Firm-level data allows researchers to obtain information on the characteristics of individual firms and groups of firms (quartiles or deciles) by their productivity level. Firm characteristics available from micro-data may include size, age, R&D spending, capital stock and investment, indicators of innovation such as intensity of broadband use, and exports. Analysis of the differences in characteristics between low productivity and high productivity firms can lead to the identification of the reasons for the better performance of the latter and this knowledge may be useful for the development of programs and policies to improve the performance of the former. For example, it is well known that small firms have on average lower productivity levels than large firms.

The causation may also run from productivity to firm behaviour and outcomes such as propensity to growth or exit. Studies have found that more productive plants are more likely to grow and less likely to exit than non-productive plants (Foster et al, 2016 and Foster et al, 2017).

In addition to dispersion in productivity levels, firms also exhibit dispersion in productivity growth rates, so the discussion above also applies to the firm distribution of productivity growth.

The literature on productivity dispersion is large. In a recent survey, Bartelsman and Wolf (2018) provide an excellent technical discussion of the productivity dispersion issue. Key issues highlighted include the choice of gross output or value added for the output measure in the productivity ratio (dispersion is much less for value added); the distinction between factors that operate within a firm to affect productivity versus factors beyond the control of a firm (e.g. externalities such as knowledge spillovers); approaches to measuring productivity or efficiency dispersion; methods to deal with the lack of information on plant-level prices; the endogeneity of a firm's factor input decision in response to firm productivity; the production function versus stochastic frontier estimation of the dispersion productivity distribution; measures of dispersion e.g. standard deviations or inter-quartile range; and the relationship between productivity dispersion and resource misallocation. Detailed discussion of these issues is beyond the scope of this paper.

Bartelsman and Wolf put forward a research agenda for the productivity dispersion issue, including the following topics:

- greater linkage of business surveys on production with information on employee skills and education and managerial quality;

- Better information on product markets to disentangle price, quality and markups thereby improving productivity measures;

- Research to isolate the sources driving heterogeneous productivity at the plant or firm level from market forces that select firms and allocate resources and market shares;[25]

- The role of adjustment frictions on measured productivity dispersion.

Industry Level Data vs. Firm Level Data

The Statistics Canada database provides time series of key labour productivity variables such as hours worked for all jobs and real value added both regionally and by industry. The database is accessible at no cost with no confidentiality restriction, and it spans the 1997-2021 period with complete absence of data gaps regardless of the number of firms operating in the industry. One disadvantage of the use of such industry-level dataset is that it does not capture the heterogeneity in firms, therefore any analysis made by this dataset will not be able to capture the firm-level effects of an outside macroeconomic shock. However, in the presence of such shock, all firms react in similar ways given that their objective is profit maximization regardless of the heterogeneity. Factors that affect aggregate labour productivity are at national level, thus one should not lose sight that Statistics Canada is providing industry level data with no discontinuity, a problem present in firm-level data due to Mergers and Acquisitions. Human capital is believed to be an indispensable determinant of productivity and it is a variable that is absent in firm-level data. The analysis done at national level can proxy human capital by the adult literacy rates, school enrolment ratios etc., but this type of proxy would not be feasible in firm-level data. However, it is important to note that the effect of firm size, age group of employees, firm dynamism on productivity can only be captured by firm-level data.

CSLS research on firm-level productivity decomposition and dispersion

The CSLS, working closely with CRED officials, is currently undertaking a study on firm-level productivity in Newfoundland and Labrador, with a particular emphasis on decomposition and dispersion firm heterogeneity, both in terms of levels and growth rates.

To understand whether aggregate labour productivity level dispersion comes from a firm-level dispersion or aggregate shocks that affect the whole sector, we follow Berlingieri *et al.* (2017a) and decompose the variance of the total economy labour productivity level at time t (V_t) into two components: (1) within-industry component ($V_{F,t}$) and (2) cross-industry component

[25]For discussion of the different approaches to sources of firm- level productvity differences, see Comin and Mulsani (2009) and Acemoglu et al (2013)

($V_{X,t}$). $V_{F,t}$ shows how much a firm's productivity level different from the aggregated average whereas $V_{X,t}$ captures how much sectors vary from other sectors. The arithmetic sum of these two components is the variance of the total economy labour productivity level. Formulae for each component is as follows.

$$V_{F,t} = \sum_j \frac{L_{j,t}}{L_t} \delta_{j,t}^2 \ , V_{Xt} = \sum_j \frac{L_{j,t}}{L_t} (\overline{P_{J,t}} - \overline{P_t}) \ \ , \ \delta_{j,t}^2 = \sum_{i \in j} \frac{L_{i,t}}{L_{j,t}} \left(P_{i,t} - \overline{P_{J,t}}\right)^2, \ \ V_t = V_{X,t} + V_{F,t}$$

where j refers to industry j, i denotes firm i in industry j, $L_{j,t}$ is the employment of industry j at time t, $L_{i,t}$ is the employment of firm i, L_t is the economy-wide employment, $\overline{P_{J,t}}$ is the average labour productivity and $\overline{P_t}$ is the average economy-wide labour productivity. If $V_{F,t}$ is larger than $V_{X,t}$, factors internal to the sector has a greater influence on the dispersion. Following Berlingieri *et al.* (2017a), we can quantify how much of the dispersion in aggregate labour productivity comes from the microeconomic dispersion by looking at the ratio $V_{F,t}/V_t$. We also calculate the average number of years a frontier firm stays on the frontier to understand the dynamics of frontier firms.

The labour productivity level at the industry and the aggregate level is also decomposed to identify the contributions from factors internal to the firm and the reallocation of labour input (Olley and Pakes, 1996). We decompose aggregate labour productivity level in the economy into contributions from within firms and from the reallocation of labour input among firms.

The study also analyzes the firm heterogeneity of labour productivity growth within and across industries, starting with an analysis of the distribution of labour productivity growth rates within an industry over time. Labour productivity growth is decomposed at the firm level using the CSLS method from de Avillex (2012) and the dynamic Olley-Pakes method developed by Melitz and Polanec (2015) to identify how reallocation of labour input among firms affects labour productivity growth.

Although the CSLS method was designed for decomposing labour productivity growth at the industry level, we explore the use of the CSLS method for firm-level data. We will use the CSLS method to decompose labour productivity growth (ΔP_t) at the aggregate and the industry level into contributions from each firm (i) at time t ($c_{i,t}$):

$$\mathrm{c_{i,t}} = \ \Delta P_{i,t} \Delta \ell_{i,t} + \left(P_{i,t-1} - P_{t-1}\right) \Delta \ell_{i,t} + \left(\Delta P_{i,t} - \Delta P_t\right) \Delta \ell_{i,t}$$

where $P_{i,t}$ is the labour productivity level of firm i at time t and $\ell_{i,t}$ is the labour share of firm i in the market at time t. The arithmetic sum of all $c_{i,t}$'s will be the change in aggregate labour productivity level between time $t-1$ and t (*i.e.*$\Delta P_t = \sum_i c_{i,t}$).

Moreover, to account for the effect of firm entry and exit, we use a dynamic version of equation (1) developed by Melitz and Polanec (2015):

$$P_{it} - P_{it-1} = \Delta\overline{P_{it,C}} + \Delta Cov_{i\in C}(s_{ft}, P_{ft}) + s_{i\in N,t}(P_{N,t} - P_{C,t}) + s_{i\in X,t-1}(P_{C,t-1} - P_{X,t-1}),$$

where $P_{i,t}$ is the firm-level productivity level in firm i at time t defined, p_{it} is the unweighted average of firm-level productivity for the firms in industry i, C denotes continuer firms (those with employment in both $t-1$ and t), N,t denotes entrants from $t-1$ to t, $X,t-1$ denotes firms that exist from $t-1$ to t.

Productivity Research Questions that Firm-level Data Can Elucidate

Productivity growth at the industry level is driven by both factors external to the industry that affect all firms in an industry such as competitive intensity and government policies like taxes and R&D subsidies, and the characteristics of firms, such as firm size and the education level of managers,[26] and more importantly, the distribution of those characteristics among the firms in the industry.[27] These firm characteristics and their distribution can directly affect the productivity performance of an industry. In addition, the impact of policies on productivity in an industry can be conditioned and influenced by the characteristics of the firms in that industry and the distribution of the characteristics. Firm-level data can thus shed light on productivity performance. This information includes the distribution or dispersion of firms by size (assets, output, employment), the distribution of firms by age, the share of firms by incumbents, new entrants, and exiting firms, the relative performance of frontier and non-frontier forms, the distribution or dispersion of firms by productivity levels and productivity growth.[28]

Productivity research questions that micro-data can elucidate include:

- contributions to overall productivity growth in the industry by firm size group;
- contributions to overall productivity growth in the industry by firm age group;
- contributions to overall productivity growth in the industry by type of firm (incumbent, new entrants, exiting firm);

[26]Other firm characteristics, for which data may or may not be available, include human capital intensity, IT capital intensity, process innovation, product innovation, organization innovation, new product turnover, broadband intensity, and supply chain integration.
[27]Strictly speaking, researchers do not need firm-level data to obtain the average characteristics of firms in an industry as Statistics Canada generally releases this information. On the other hand, firm-level data are needed for calculation of the distribution of these characteristics among the universe of firms in an industry and these data are not readily available from Statistics Canada.
[28]For an excellent discussion of measuring productivity dispersion, see Bartelsman and Wolff (2018).

- contributions to overall productivity growth by industry by exporters (incumbents and new entrants);

- the contributions to overall productivity growth in the industry by firm dynamism (gazelles (fast growing firms) versus lifestyle firms):

- explanations for firm heterogeneity in productivity dispersion and its persistence and policies to improve overall performance;

- contribution of market structure, prices, product quality and variable mark-ups to measured firm-level productivity performance;

- the link between firms that perform R&D or patent and productivity.

- the importance of resources reallocation effects, including misallocation, among firms for industry productivity growth;

- firm survival rates and links to productivity; and

- relative productivity levels and growth rates for frontier and non-frontier firms and reasons for these differences.

It is of course true that a number of the issues enumerated above them have been widely researched (for example, firm size and productivity; the contribution of entrants, exits and incumbents to productivity growth). What is important from a policy development perspective is to explain the productivity variation among firms. Policy makers want to know if specific investments or industry policies are currently playing a role playing a role in this variation and the persistence of this variation.

VIII. An Agenda for Firm-Level Productivity Research in Canada[29]

Canada's productivity performance

Since 2000 productivity growth in Canada, and in most other advanced countries, has been slow from both an historical and international perspective. In Canada, output per hour in the business sector rose around 0.9 per cent per year over the 2000-2016 period, down from 1.7 per

[29]For an earlier attempt at developing a framework for a research agenda to unbundle weak productivity growth in Canada, see Sharpe (2010), particularly the section on the diagnostic phase and the section on identification of knowledge gaps and research strategies and methodologies. When this report was written, access to firm-level data by researchers outside Statistics Canada was much more restricted than it is today.

cent in the 1981-2000 period and 3.5 per cent in 1961-1973 period (Sharpe and Tsang, 2018). Canada ranked 24th out of 33 OECD countries for aggregate productivity growth over the 2000-2016 period. Contributions by industry and province to the national slowdown can be calculated,[30] but the more fundamental drivers of the slowdown are still poorly understood.

From a public policy perspective the two key issues for productivity researchers are to better account for slower productivity growth[31] and to identify policies that can boost productivity growth. Many hope (e.g. Drummond, 2011) that better access to and use of firm-level data can shed light on both these issues. This section of the report identifies and discusses four areas of productivity research where use of firm-level data may have the potential to advance our understanding of the slowdown, namely

- relative performance of frontier firm;
- changes in the pace of technical progress;
- secular stagnation or changing demand conditions; and
- falling business sector R&D and investment.

The Role of Frontier Firms in the Slowdown

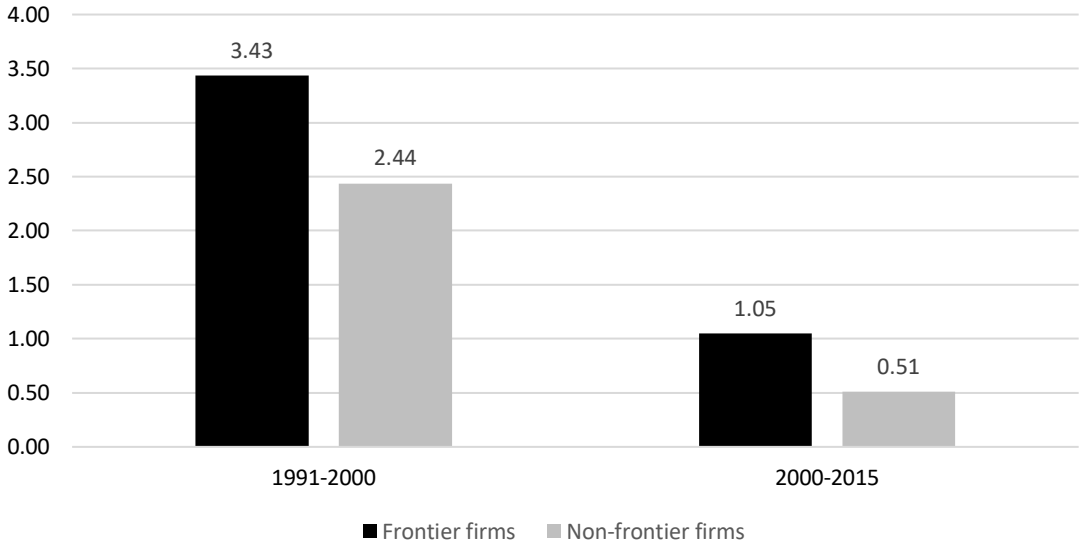
The post-2000 productivity slowdown is not just confined to Canada but is a global phenomenon. The OECD, a major centre for productivity research, has put the explanation, based on data from the OECD-Orbis firm database for 24 OECD countries, that the slowdown reflects a growing productivity growth gap between frontier forms, defined at the firms in the top 5 per cent of the productivity level distribution within each two-digit industry and the remaining 95 per cent of firms, the laggards (Andrews et al. 2016a and 2016b). There has been no productivity slowdown at the top, only among non-frontier firms. They attribute this situation to a decline in market dynamism and growth-enhancing reallocation, as manifested by fewer exits by weak firms and a decline in entry of new firms. This situation is in turn linked to a slowdown in the pace of structural reform in product markets. They believe that a failure of policy to

[30] Sharpe and Tsang (2018) show that manufacturing made a disproportional contribution to the slowdown accounting for 0.62 points of the 0.69 points slowdown in business sector labour productivity growth between the 1981-2000 and 2000-2016 periods.

[31] The issue of explaining slower productivity growth does not appear to be a priority for the academic economics community. In 2018, the CSLS and Productivity Partnership issued a call for papers on this topic for a series of sessions at the 2018 annual meeting of the Canadian Economics Association. Only one submission from university-based researchers was received. Officials from federal government economic departments and agencies such as ISED, Statistics Canada, and the Bank of Canada did submit proposals. This apparent lack of interest in explaining slower productivity growth in the academic community is also seen in the very limited number of funding requests on this topic made to the Productivity Partnership. This situation is also likely associated with the trend away from policy work among academic economists in Canada, as shown by Simpson and Emery in a recent *Canadian Public Policy* article.

encourage the diffusion of best practices has also contributed to the growing productivity gap between frontier and non-frontier firms.

Figure 3. Average labour productivity growth of frontier and non-frontier firms (% per year), 1990 to 2000 and 2000 to 2015



Source: Gu (2018b)

Unfortunately, this OECD analysis of the productivity slowdown does not include Canada since Canada is not included in the OECD-Orbis productivity database. Consequently, an obvious area for research is to see whether trends in firm-level data in Canada are consistent with the OECD story, with the productivity of frontier forms advancing faster than that of non-frontier firms.

Preliminary data from Statistics Canada provide only mixed support for the OECD hypothesis in Canada (Figure 3). It is true that labour productivity growth for frontier firms since 2000 in Canada has exceeded that of non-frontier firms: 1.1 per cent per year versus 0.5 per cent, a gap of 0.6 points. The productivity of the average frontier firm is moving away from that of the average non-frontier firm. But in the 1990s labour productivity growth among frontier firms was even faster than among non-frontier firms: 3.4 per cent per year versus 2.4 per cent, a gap of 1.0 points. Both frontier and non-frontier firms experienced slower productivity growth after 2000 and the slowdown for the former was nearly four times that of the latter (2.3 points versus 0.6 points).

The individual firms in the top 5 per cent of the productivity level distribution change every year as firms enter and leave this group based on their productivity growth rate and productivity level in the previous year. If high productivity growth firms tend to have above average productivity levels, then it may be a statistical artifact that the top 5 per cent in the productivity level distribution will have a higher productivity growth rate then non-frontier firms.

For individual firms, there is reversion to the mean. But this is not necessarily the case for the top group of firms in the distribution as this group is always being replenished by high productivity growth firms that enter this group.

In any case, the role of frontier firms in Canada's productivity performance needs more attention from researchers. Topics include work on the comparability of the T2-LEAP and OECD-Orbis databases, trends in the performance of frontier and non-frontier firms by industry and province, and the average duration of a firm's stay in the frontier firm category.

However, a caveat exists for frontier firm research. Care is needed in discussion of the role of frontier firms in productivity. By definition, frontier firms are those firms with highest productivity in each year. This means that the composition of frontier firms is different each year. Some argue that it may not makes sense to estimate productivity growth of frontier firms over time because a firm can be frontier firm this year and a non-frontier firm next year. It may be unclear that one can say that the productivity dispersion is a diffusion problem associated with technology or best practices.

Changes in the pace of technical change

In the long run the pace of technological change is the key driver on productivity growth. This suggests that the post-2000 slowdown in productivity growth reflects a slower rate of underlying technological change, a view put forward by a number of researchers of whom Robert J, Gordon (2014 and 2016) is the most prominent. In the Canadian context, Alexopoulos and Cohen (2018) have shown that the growth in the number of technical books held in libraries has fallen off, an indicator of slower technical progress.

Firm-level data may be able to shed light on this crucial issue of the pace of technological change. In theory, TFP is a measure of technological change, so the recorded slower TFP growth does support the view that underlying pace of technical advance has fallen off. But TFP is more a residual or measure of our ignorance than a true measure of technological change since so many factors affect TFP. These factors include measurement issues, resource depletion, imperfect competition, capacity utilization, economies of scale, among others. Techniques using firm-level data have been developed in recent years to control for many of these factors and estimate a measure of TFP than is closer to true underlying disembodied technological change. An important aspect of this is to isolate the price and markups over cost from the firm-level output measures to obtain better estimates of the technological change element,

Falling Business R&D

A key stylized fact of the Canadian economy in recent years has been the fall in business sector research and development spending, both in nominal terms and as a share of GDP. This is an important development because R&D is a key component of technological change and hence productivity growth. The reasons for this downward trend in R&D are still poorly understood.

Micro-data sets such as the T2-LEAP and R&D can be linked to shed light on the characteristics of R&D performers, including their productivity performance (Kim and Lester, 2019). Analysis of such data sets may shed light on the reasons for falling R&D. Is it because fewer firms are performing R&D, or average R&D spending per performing firm is down, or because there are fewer large R&D performers such as Nortel, Blackberry, or for all three reasons? The CSLS is currently undertaking a project that links R&D spending at the firm level to trade with China.

Secular Stagnation

Economic growth in developed economies including Canada has been weak since the Great Recession of 2008-2009. Some economists, of which Larry Summers is the most prominent, see the situation as one of secular stagnation, reflecting factors such as weak investment, slower world trade, government austerity at least in in Europe, and growing income inequality. These weak demand conditions in turn result in mediocre productivity growth, as has been the case in Canada since 2000 (Rao and Li, 2013 and Baldwin, Gu and Yan, 2013) and in the United States since 2004.

Firm-level data may be able to shed light on the secular stagnation hypothesis through the Verdoorn law literature, which positively relates the rate of growth of productivity to the rate of growth of output through learning by doing, economies of scale, and reductions in x-inefficiencies, and at least in the short-to-medium term, the lags in the adjustment of inputs to changes in demand and output due to labour hoarding and overhead labour. Firm data may be able to shed light on how firms change their inputs and output in response to changes in the external economic environment.

IX. Conclusion

This report reviews the current states of firm-level productivity data in Canada, including discussion of the challenges and advantages of firm-level data, and puts forward a research agenda to shed light on the reasons for slower productivity growth in Canada through the exploitation of firm-level data. This conclusion provided a number of points or recommendations for researchers contemplating undertaking a research project involving firm-level data accessed at CDER.

Given the availability of excellent and easily accessible productivity estimates at a detailed industry level for Canada and the provinces, researchers should gain familiarity with all of Statistics Canada's publically available productivity data related or potentially related to their area of research before embargoing on a firm-level productivity project.

Statistics Canada should make publically available more aggregated firm-level data. It is much more efficient or cost effective for Statistics Canada than for individual researchers to

produce these data. Examples of such data include the characteristics of incumbent, exiting and entering firms and the productivity level quartiles by firm size by industry.

The Centre for Economic Statistics (CES) at the US Census Bureau is a world leader in the area of firm-level research on productivity issues. The CES produces a wealth of working papers, many up top researchers, on the productivity issue from a firm perspective. Recent examples include Goldschlag and Perlman (2017), Alon et al, (2018), Pugsley et al (2018) Cunningham et al (2018), Ersahir (2018), Foster et al (2018, Aghion et al (2018) and Hsieh and Klenow (2018). Canadian researchers should follow closely this working paper series to keep abreast of methodological developments in the use of firm-level data and to identify research topics that may be relevant for Canada.

From the perspective of Canadian public policy, the most relevant productivity issue is explaining slower productivity growth and identifying policies to improve this performance. Priority research topics include the productivity of frontier and non-frontier firms, lagging business sector R&D, the pace of technological change, and the relationship between demand growth and productivity. Academic researchers should be encouraged to work on these topics.

References

Acemoglu, Daron, Ufuk Akcigit Nicholas Bloom and William Kerr (2013) "Innovation, Reallocation, and Growth,"' Centre for Economic Studies. US Census Bureau, Working Paper 13-23.

Adler et al. (2017), "Gone with the Headwinds: Global Productivity," IMF Staff Discussion Note.

Aghion, Philippe, Antonin Bergeaud, Timo Boppart, Peter J. Klenow & Huiyu Li, 2018. "Missing Growth from Creative Destruction," Working Papers 18-18, Center for Economic Studies, U.S. Census Bureau.

Alexopoulos. Michelle and Jon Cohen (2018) "Canadian Productivity Growth, Secular Stagnation, and Technological Change"' *International Productivity Monitor*, Number 35, Fall, pp, 113-137.

Andrews D., Criscuolo C. & Gal P. N. (2015), "Frontier Firms, Technology Diffusion and Public Policy: Micro Evidence from OECD Countries," OECD Productivity Working Papers N° 2, OECD Publishing.

Andrews, D., Criscuolo, C., & Gal, P. N. (2016a). The best versus the rest: the global productivity slowdown, divergence across firms and the role of public policy (No. 5). OECD Publishing.

Andrews, D., Chiara Criscuolo, and Peter N. Gal (2016b), "The Best Versus the Rest: The Global Productivity Slowdown, Divergence across Firms and the Role of Public Policy,"

OECD Productivity Working Papers, No.5, November 2016.

Arellano, M., & Bover, O. (1995), “Another look at the instrumental variable estimation of error-components models,” Journal of Econometrics, 68(1), 29-51.

Arnold, J., Scarpetta, S., & Nicoletti, G. (2011), “Regulation, Resource Reallocation and Productivity Growth,” European Investment Bank, Economics Department.

Baily, Martin Neil, and Nicholas Montalbano (2016), *Why is Productivity Growth so Slow? Possible Explanations and Policy Responses,* Brookings Institution.

Baldwin, JR (1989) "Innovation: the key to success in small firms," Productivity growth, plant turnover and restructuring in the Canadian manufacturing sector.

Baldwin, J (1995) "The importance of research and development for innovation in small and large Canadian manufacturing firms," Statistics Canada.

Baldwin, JR (1999) "Innovation and training in new firms," Statistics Canada.

Baldwin, JR and PK Gorecki (1983) "Firm entry and exit in the Canadian manufacturing sector, 1970-1982," Canadian Journal of Economics, 300-323, 1991.

Baldwin, J and J Johnson (1989) "Business strategies in innovative and non-innovative firms in Canada," Innovation: the key to success in small firms.

Baldwin, J and J Johnson (1990) "Human capital development and innovation: the case of training in small and medium-sized firms," Statistics Canada.

Baldwin, J and G Gellatly (1996) "Are there high-tech industries or only high-tech firms? Evidence from new technology-based firms," The dynamics of industrial competition: A North American perspective.

Baldwin, JR and J Johnson (1997) "Entry, innovation and firm growth," Are small firms important? Their role and impact, 51-77, 1999.

Baldwin, JR, L Bian, R Dupuy and G Gellatly (1998) "Failure rates for new Canadian firms: New perspectives on entry and exit," Failure Rates for New Canadian Firms: New Perspectives on Entry and Exit (2000).

Baldwin, JR and G Gellatly (1999) "A Firm-Based Approach to Industry Classification: Identifying the Knowledge-Based Economy," Doing Business in the Knowledge-Based Economy, 199-237, 2001.

Baldwin, J, P Hanel and D Sabourin (2000) "Determinants of innovative activity in Canadian manufacturing firms," Innovation and firm performance, 86-111, 2002.

Baldwin, JR and D Sabourin (2000) "Impact of the adoption of advanced ICTs on firm performance in the Canadian manufacturing sector," OECD, 2002.

Baldwin, JR and D Sabourin (2001) "Advanced technology use and firm performance in Canadian manufacturing in the 1990s," Industrial and Corporate Change 11 (4), 761-789, 2002.

Baldwin, JR, D Beckstead and R Caves (2001) "Changes in the Diversification of Canadian Manufacturing Firms and Plants (1973-1997): A Move to Specialization," Analytical Studies Branch Research Paper Series, Statistics Canada.

Baldwin, J, G Gellatly and V Gaudreault (2001) "Financing innovation in new small firms: New evidence from Canada," Statistics Canada.

Baldwin, JR, D Sabourin and D Smith (2002) "Impact of advanced technology use on firm performance in the Canadian food processing sector," The changing geography of the Canadian manufacturing sector in metropolitan and rural regions, 1976-1997.

Baldwin, JR and G Gellatly (2002) "Innovation strategies and performance in small firms," Statistics Canada.

Baldwin, JR, D Sabourin and D Smith (2003) "Firm Performance in the Canadian Food Processing Sector: the Interaction between ICT Advanced Technology Use and Human Resource Competencies," The economic impact of ICT: Measurement, evidence and implications, 153-81, 2004.

Baldwin, J and W Gu (2004) "Productivity Growth in the Canadian Retail Trade Sector: Evidence from Micro Data," Statistics Canada.

Baldwin, J.R., and W. Gu (2004), “Trade Liberalization: Export-market Participation, Productivity Growth, and Innovation,” *Oxford Review of Economic Policy*, vol. 20, issue 3, pp. 372-392.

Baldwin, J. R., & Gu, W. (2004a), “Industrial Competition, Shifts in Market Share and Productivity Growth,” Statistics Canada, Economic Analysis Research Paper Series.

Baldwin, JR and WM Brown (2005) "Foreign multinationals and head office employment in Canadian manufacturing firms," Renewing Canada's Manufacturing Economy: A Regional Comparison, 1973â€⍰1996.

Baldwin, J. R., & Gu, W. (2006), “Competition, Firm Turnover and Productivity Growth,” Statistics Canada, Economic Analysis Research Paper Series.

Baldwin, J.R., and W. Gu (2006), “Plant Turnover and Productivity Growth in Canadian

Manufacturing," *Industrial and Corporate Change*.

Baldwin, JR and W Gu (2008) "Firm turnover and productivity growth in the Canadian retail trade sector," Adapting to import competition: Effects of low-wage trade on commodity mix in Canadian manufacturing plants.

Baldwin, JR and G Gellatly (2008) "Innovation capabilities: The knowledge capital behind the survival and growth of firms," Statistics Canada.

Baldwin, JR, R Gibson and Y Wang (2009) "Plant Divestitures and Acquisitions in the Canadian Manufacturing Sector," Statistics Canada.

Baldwin, J, W Gu and B Yan (2010) "Accounting for Slower Productivity Growth in the Canadian Manufacturing Sector after 2000: Evidence from Micro Data," Statistics Canada.

Baldwin, JR, WM Brown and DL Rigby (2010) "Agglomeration economies: Microdata panel estimates from Canadian manufacturing," Journal of Regional Science 50 (5), 915-934, 2010.

Baldwin, JR and W Gu (2010) "Firm dynamics and productivity growth: a comparison of the retail trade and manufacturing sectors," Industrial and Corporate Change 20 (2), 367-395, 2011.

Baldwin, JR, WM Brown and W Gu (2010) "Geographic market access and the effects of trade on length of production run, product diversity and plant scale of Canadian manufacturing plants, 1974-1999," Economic Analysis (EA) Research Paper Series, Statistics Canada.

Baldwin, J and B Yan (2010) "The death of Canadian manufacturing plants: heterogeneous responses to changes in tariffs and real exchange rates," Review of World Economics 147 (1), 131-167, 2011.

Baldwin, JR and A Lafrance (2011) "Firm Turnover and Productivity Growth in Selected Canadian Services Industries, 2000 to 2007," Productivite du travail des entreprises individuelles et des societes de personnes non constituees: incidence sur l'ecart de productivite entre le Canada et les Etats-U....

Baldwin, JR, D Leung and L Rispoli (2011) "Labour Productivity of Unincorporated Sole Proprietorships and Partnerships: Impact on the Canada-United States Productivity Gap," Statistics Canada.

Baldwin, J and Y Wang (2011) "Plant Size, Nationality, and Ownership Change," International Journal of the Economics of Business 18 (3), 351-380, 2011.

Baldwin, J.R., and W. Gu (2011) "Firm Dynamics and Productivity Growth: A Comparison of Retail Trade and Manufacturing Sectors," *Industrial and Corporate Change.*

Baldwin, J and B Yan (2012) "Export Market Dynamics and Plantâ€Level Productivity: Impact of Tariff Reductions and Exchangeâ€Rate Cycles," Economic Analysis Research Paper Series, Statistics Canada

Baldwin, JR, W Gu and R Macdonald (2012) "Intangible capital and productivity growth in canada," Statistics Canada.

Baldwin, J.R., W. Gu, and B. Yan (2013) “Export Growth, Capacity Utilization and Productivity Growth: Evidence for Canadian Manufacturing Plants,” *Review of Income and Wealth.*

Baldwin, JR, D Leung and L Rispoli (2013) "Canadian Labour Productivity Differences Across Firm Size Classes, 2002 to 2008," Statistics Canada.

Baldwin, JR, W Gu and B Yan (2013) "Export growth, capacity utilization, and productivity growth: evidence from the Canadian manufacturing plants," Review of Income and Wealth 59 (4), 665-688, 2013.

Baldwin, JR, H Liu and W Wang (2013) "Firm Dynamics: Firm Entry and Exit in the Canadian Provinces, 2000 to 2009," Statistics Canada.

Baldwin, JR, L Rispoli and D Leung (2014) "Canada-United States labour productivity gap across firm size classes," The Canadian Productivity Review, Statistics Canada..

Baldwin, JR and A Lafrance (2014) "Firm turnover and productivity growth in Canadian manufacturing and services industries, 2000 to 2007," Journal of Industry, Competition and Trade 14 (2), 173-205, 2014.

Baldwin, JR and B Yan (2014) "Global value chains and the productivity of Canadian manufacturing firms," Statistics Canada.

Baldwin, JR, H Liu and M Tanguay (2015) "An Update on Depreciation Rates for the Canadian Productivity Accounts," Statistics Canada.

Baldwin, JR and B Yan (2015) "Empirical Evidence from Canadian Firm-level Data on the Relationship Between Trade and Productivity Performance," Statistics Canada.

Baldwin, JR and B Yan (2016) "Global value chain participation and the productivity of Canadian manufacturing firms," Statistics Canada.

Baldwin, JR, A Dar-Brodeur and B Yan (2016) "Innovation and Export-market Participation in Canadian Manufacturing," Statistics Canada.

Baldwin, JR, W Gu, A Sydor and B Yan (2017) "Material Offshoring: Alternate Measures," Review of Income and Wealth 63 (2), 253-268, 2017.

Baldwin, JR and J Li (2017) "The Changing Importance of Foreign Control in Canadian Manufacturing," Statistics Canada.

Barnes, Carla, Stewart Young and Charles Berube (no date) “Firm Turnover and Productivity Growth: Evidence from the Manufacturing Sector,” Unpublished paper, British Columbia Ministry of Finance.

Bartelsman, Eric and Mark Doms (2000) “Understanding Productivity: Lessons from Longitudinal Microdata,” *Journal of Economic Literature* 38 (3) pp, 569-594.

Bartelsman. Eric and Zoltan Wolf (2018) “Measuring Productivity Dispersion” in T*he Oxford Handbook of Productivity Analysis*, edited by Emili Griffell-Tatje, Knox Lovell and Robin Sickles (Oxford; Oxford University Press).

Bartelsman, E.J., E. Hagsten, and M. Polder (2013), "Cross-country Analysis of ICT Impact using Firm-level Data: Micro Moments Database and Research Infrastructure," Eurostat working paper
Behrens, K, WM Brown and T Bougna (2016) "The world is not yet flat: Transport costs matter!," The Industry Origins of Canada's Weaker Labour Productivity Performance and the Role of Structural Adjustment in the Post-2000 Period.

Behrens, K and WM Brown (2018) "Transport costs, trade, and geographic concentration: Evidence from Canada," Chapters, 188-235, 2018.

Berlingieri, Giuseppe, Patrick Blanchenay, Sara Calligaris and Chiara Criscuolo (2017a) “Firm-level Productivity Differences: Insights from the OECD’s Multiprod Project,” *International Productivity Monitor*, Number 31, Spring. Pp. 97-115.

Berlingieri, Giuseppe, Patrick Blanchenay, Sara Calligaris and Chiara Criscuolo (2017b) “The MultiProd project: A Comprehensive Overview,” OECD Science, Technology and Industry Working Papers, No. 2017/04.

Berthou, A. (2016), “Ajustements du compte courant et dynamiques de la productivité en europe pendant la crise,” Bulletin De La Banque De France, (207), 71-83.

Berube, C., B. Dostie, and L. Vilhuber (2012), "Labour reallocation and productivity growth: Evidence from Canada and the United States," Industry Canada.

Breau, S and WM Brown (2011) "Global Links: Exporting, Foreign Direct Investment, and Wages: Evidence from the Canadian Manufacturing Sector," Roulement des entreprises et croissance de la productivitÃ© dans certaines industries de services au Canada, 2000-2007.

Brown, David, Emin Dinlersoz amd John Earle (2016) “Does Higher Productivity Dispersion Imply Greater Misallocation? A Theoretical and Empirical Analysis” Centre for Economic

Studies, US Census bureau Working Paper No, 16-42.

Brown, WM and DL Rigby (2013) "Urban Productivity: Who Benefits from Agglomeration Economies?" Statistics Canada.

Brown, WM and L Rispoli (2014) "Metropolitan gross domestic product: Experimental estimates, 2001 to 2009," Statistics Canada.

Brown, WM, A Dar-Brodeur and J Tweedle (2017) "Firm Networks, Borders and Regional Economic Integration".

Cao, S and D Leung (2009) "Labour Reallocation, Relative Prices and Productivity," Bank of Canada Working Paper, 2010.

Cao, Shutao, MohanadSalameh, Mai Seki, and Pierre St-Amant(2017). Trends in Firm Entry and New Entrepreneurship in Canada. Canadian Public Policy XLIII, III: 202–221.

Caves, R. E., (1998), "Industrial Organization and New Findings on the Turnover and Mobility of Firms," Journal of Economic Literature, 36(4), pp. 1947-82.

Chan, K, J Tang and W Gu (2010) "Industry Mix, Plant Turnover and Productivity Growth: A Case Study of the Transportation Equipment Industry in Canada1," International Productivity Monitor, 24, 2011.

Ciobanu, O and W Wang (2011) "Firm dynamics: Firm entry and exit in Canada, 2000 to 2008".

Comin, Diego and Sunil Nulani (2009) "A Theory of Growth and Volatility at the Aggregate and Firm Level," *Journal of Monetary Economics*, Vol, 56, Number, pp. 1023-1042

CompNet (2018), "User Guide for the 6th Vintage of the CompNet dataset," available at https://www.comp-net.org/fileadmin/_compnet/user_upload/Documents/User_Guide_6th_Vintage.pdf.

Cette, G., Corde, S., & Lecat, R. (2017), "Stagnation of Productivity in France: A Legacy of the Crisis or a Structural Slowdown?" Économie et Statistique, 494(494), 11-36.

Chevalier, P., Lecat, R., & Oulton, N. (2008), "Convergence de la productivité des entreprises, mondialisation, technologies de l'information et concurrence," Economie et Statistique, 419(1), 101-124.

Cochrane, J. (1994), "Shocks," Carnegie-Rochester Conference Series on Public Policy, 41, pp.295-364

Couture, L, J Tang and B Yan (2015) "Offshoring and business organization: evidence from

Canadian manufacturing firms," Transnational Corporations Review 7 (2), 148-168, 2015.

Cunningham, Cindy, Lucia Foster, Cheryl Grim, John Haltiwanger, Sabrina Wulff Pabilonia, Jay Stewart & Zoltan Wolf, (2018). "Dispersion in Dispersion: Measuring Establishment-Level Differences in Productivity,"Working Papers 18-25, Center for Economic Studies, U.S. Census Bureau.

de Avillez, R. (2012). Sectoral contributions to labour productivity growth in canada: Does the choice of decomposition formula matter? No. 2012-09 Centre for the Study of Living Standards.

Decker, A. Ryan, John Haltiwanger, Ron S. Jarmin, and Javier Miranda (2016), Declining business dynamism: Implications for productivity, Brookings Institution.

De Loecker, Jan, and Frederic Warzynski (2012), "Markups and firm-level export status," American Economic Review, 102(6), pp.2437-71

Dixon, J and AM Rollin (2014) "The distribution of employment growth rates in Canada: the role of high-growth and rapidly shrinking firms," Economic Analysis (EA) Research Paper Series (2014), Statistics Canada.

Department of Finance in Ireland (2018), "Patterns of firm-level productivity in Ireland," Technical background paper for the Economic Development Review Committee.

Dobbelaere, Sabien, and Jacques Mairesse (2013), "Panel Data Estimates of the Production Function and Product and Labor Market Imperfections," Journal of Applied Econometrics, 28(1), pp. 1-46.

Drummond, Don (2006) "The Economists Manifesto to Curing Ailing Productivity," *International Productivity Monitor*, No. 13, Fall pp. 21-26.

Drummond, Don (2011) "Confessions of a Serial Productivity Researcher," *International Productivity Monitor*, No. 22. Fall. Pp. 3-10.

Drummond, Don (2015) "Progress on the Mystery of Productivity: A Review Article on the OECD Report *The Future of Productivit,"* *International Productivity Monitor*, Number 2, Fall.

Drummond, Don, Annette Ryan ad Michel Veall (2013) "Improving Canada's Productivity Performance: The Potential Contribution of Firm-level Productivity Research," *International Productivity Monitor*, No. 26. Fall, pp. 86-93.

Ersahin, N. 2018. "Creditor Rights, Technology Adoption, and Productivity: Plant-Level Evidence," Working Papers 18-20, Center for Economic Studies, U.S. Census Bureau.

Fontagné, L., & Santoni, G. (2015), “Firm-level Allocative Inefficiency: Evidence from France.”

Foster, Lucia, Cheryl Grim, John Haltiwanger and Zoltan Wolf (2017a) “Innovation, Productivity Dispersion and Productivity Growth,” NBER Working paper 24420.

Foster, Lucia, Cheryl Grim, John Haltiwanger and Zoltan Wolf (2017b) “Macro and Micro Dynamics of Productivity: From Devilish Details to Insights,” NBER Working paper 23666

Foster, Lucia, Cheryl Grim, John Haltiwanger, and Zoltan Wolf (2016a), “Firm-Level Dispersion in Productivity: Is the Devil in the Details?" *American Economic Review*, 106(5): 95-98.

Foster, Lucia, Cheryl Grim, John Haltiwanger (2016b), “Reallocation in the Great Recession: Cleansing or Not?”*Journal of Labour Economics*, vo. 34(S1): 293-331.

Foster. Lucia & Cheryl Grim & John Haltiwanger & Zoltan Wolf (2018) "Innovation, Productivity Dispersion, and Productivity Growth," Working Papers 18-08, Center for Economic Studies, U.S. Census Bureau.Handle: *RePEc:cen:wpaper:18-08*

Foster, Lucia, John Haltiwanger and C.J. Krizan (2001), “Aggregate Productivity Growth: Lessons from Microeconomic Evidence,” in New Developments in Productivity Analysis, edited by Charles R. Hulten, Edwin R. Dean and M. J. Harper, NBER Book Series Studies in Income and Wealth.

Gabaix, X. (2011), "The granular origins of aggregate fluctuations," Econometrica 79(3), pp.733-772.

Gal, P. (2013), “Measuring Total Factor Productivity at the Firm Level using OECD-Orbis”, OECD Economics Department Working Papers No. 1049, OECD, Paris.

Goldschlag, Nathan and Elisabeth Perlman, 2017. "Business Dynamic Statistics of Innovative Firms," Working Papers 17-72, Center for Economic Studies, U.S. Census Bureau.Handle: RePEc: cen: wpaper:17-72.

Gordon, R. J. (2014), “The Demise of U.S. Economic Growth: Restatement, Rebuttal, and Reflections,” National Bureau of Economic Research Working Paper Series, No. 19895.

Gordon, Robert J. (2016) The Rise and Fall of American Growth: The U.S. Standard of Living since the Civil War (Princeton, N.J.: Princeton University Press).

Gu, W, G Sawchuk and LW Rennison (2003) "The effect of tariff reductions on firm size and firm turnover in Canadian manufacturing," Review of World Economics 139 (3), 440-459, 2003.

Gu, W and G Surendra (2004) "The effect of organizational innovation and information technology on firm performance," International Performance Monitor 9 (3), 37-51, 2004.

Gu, W and S Morin (2014) "Experimental measures of output and productivity in the Canadian hospital sector, 2002 to 2010," Measuring Economic Sustainability and Progress, 575-594, 2014.

Gu, W and A Lafrance (2014) "Productivity Growth in the Canadian Broadcasting and Telecommunications Industry: Evidence from Micro Data," Economic Analysis (EA) Research Paper Series (2014), Statistics Canada.

Gu, W and J Li (2017) "Multinationals and Reallocation: Productivity Growth in the Canadian Manufacturing Sector," Statistics Canada.

Gu, W and J Li (2017) "Multinationals and Reallocation: Productivity Growth in the Canadian Manufacturing Sector, 2001-2010," Statistics Canada.
Gu, Wulong (2018a) "Accounting for Slower Productivity Growth in Canada after 2010: The Role of Capital Measurement Issues" *International Productivity Monitor,* Number 34, Spring.

Gu, Wulong (2018b) "Frontier Firms, Productivity Dispersion and Aggregate Productivity Growth," paper presented at the 35th General Conference of the International Association for Research in Income and Wealth, Copenhagen, Denmark August 20-24.

Gu, W. and M. Willox (2018), "Productivity Growth in Canada and the United States: Recent Trends and Potential Explanations," International Productivity Monitor Number 35, Fall.

Gu, W. and A Lafrance (2014), "Productivity Growth in the Canadian Broadcasting and Telecommunications Industry: Evidence from Micro Data," Economic Analysis Research Paper Series no. 89. Statistics Canada.

Gu, Wulong, Beiling Yan and Sylvie Ratte (2018) "Long-run Productivity Dispersion in Canadian Manufacturing," Economic Insights, Statistics Canada November 8.

Gutierrez, German and Thomas Philippon (2019) Fading Stars," NBER Working Paper No. 25529.February.

Harchaoui, TM (2003) "The role of industrial classification in the micro-macro integration: The case of the banking business in the 1997 North American industrial classification system," Review of Income and Wealth, 2004, 2, pp. 203-212.

Harchaoui, TM (2006) "Measuring the productivity of the insurance business at the firm level," Conference Dynamics of Insurance Markets: Structure, Conduct, andÂ â€¦, 2006.

Hsieh, C., and P. J. Klenow (2009), "Misallocation and Manufacturing TFP in China and

India", The Quarterly Journal of Economics, Vol. 124, No. 4, pp. 1403–1448.

Hsieh, C. T. (2015). *Policies for productivity growth* (No. 3). OECD Publishing.

Hsieh, C.T. and Peter J. Klenow (2018). "The Reallocation Myth," Working Papers 18-19, Center for Economic Studies, U.S. Census Bureau.

Industry Canada, Economic Research and Policy Analysis Branch (2011) "Research Frame: Excellence in Microeconomic Policy and Business Performance," discussion paper, April 14.

Jarmin, R.S. and J. Miranda (2002), "The Longitudinal Business Database," Center for Economic Studies

Jovanovic, B. (1987), "Micro shocks and aggregate risk," Quarterly Journal of Economics, 102(2), pp. 395-409.

Kalemli-Ozcan, S., B. Sorensen, C. Villegas-Sanchez, V. Volosovych and S. Yesiltas, 2015, "How to Construct Nationally Representative Firm Level data from the Orbis Global Database," NBER Working Papers 21558, National Bureau of Economic Research, Inc.
Lafrance, A (2012) "Firm Dynamics: Variation in Profitability Across Canadian Firms of Different Sizes, 2000 to 2009," The Canadian Economy in Transition, Statistics Canada.

Lafrance, A (2013) "Firm Size and the Risk/return Trade-off," Statistics Canada.
Leung, D (2015) "Quarterly Business and Employment Dynamics: Experimental Estimates, First Quarter 2001 to Third Quarter 2014," Statistics Canada.

Leung, D, L Rispoli and R Chan (2011) "Small, medium-sized, and large businesses in the Canadian economy: Measuring their contribution to gross domestic product from 2001 to 2008," Statistics Canada.

Leung, D and L Rispoli (2014) "The distribution of gross domestic product and hours worked in Canada and the United States across firm size classes," Economic Analysis (EA) Research Paper Series (2014), Statistics Canada.

Leung, D., L. Karasik and B. Tomlin (2016), "Firm-specific Shocks and Aggregate Fluctuations in the Canadian Manufacturing Sector, 2000 to 2012", Analytical Studies Branch Research Paper Series, Statistics Canada.

Levinsohn, James, and Amil Petrin (2003) "Estimating Production Functions Using Inputs to Control for Unobservables." The Review of Economic Studies 70(2), pp.317–341.

Lileeva, A (2009) "The benefits to domestically owned plants from inward direct investment: the role of vertical linkages," Canadian Journal of Economics, 43 (2), 574-603, 2010.

Linarello, Andrea and Andrea Petrella (2017) “Productivity and Reallocation: Evidence from the Universe of Italian Firms,” *International Productivity Monitor*, Number 32, pp. 116-135.

Liu, SB H (2015) "Unincorporated Self-employment in Canada, 1989 to 2010," The Canadian Economy in Transition, Statistics Canada.

Liu, H. and J. Tang (2017) “Age-productivity profiles of entrants and exits: Evidence from Canadian Manufacturing,” *Structural Change and Economic Dynamics*, Vol 40, pp. 26-36.

Liu, SB H (2015) "Unincorporated Self-employment in Canada, 1989 to 2010," The Canadian Economy in Transition, Statistics Canada.

Lydia, JT and Aaron Sydor (2015) "Industry Productivity in the Manufacturing Sector: The Role of Offshoring," Economic Analysis Research Paper Series, 2015, Statistics Canada.

Macdonald, R (2012) "Firm dynamics: The death of new Canadian firms: A survival analysis of the 2002 cohort of entrants to the business sector," Statistics Canada.

Macdonald, R (2013) "Business Entry and Exit Rates in Canada: A 30-year Perspective," Statistics Canada.

Macdonald, Ryan (2014) “Business entry and Exit Rates in Canada: A 30-year Perspective,” Economic Insights, Statistics Canada https://www150.statcan.gc.ca/n1/pub/11-626-x/11-626-x2014038-eng.htm

Melitz, M. J., & Polanec, S. (2015), “Dynamic Olley-Pakes Productivity Decomposition with Entry and Exit,” The Rand Journal of Economics, 46(2), 362-375.

Moussaly, K and W Wang (2014) "The Impact of Leased and Rented Assets on Industry Productivity Measurement," Statistics Canada.

Murray, Alex (2018), “The Explanations of the U.S. Productivity Slowdown,” International Productivity Monitor.

Newbold, KB and WM Brown (2017) "Human Capital Research in an Era of Big Data: Linking People with Firms, Cities and Regions," Regional Research Frontiers-Vol. 1, 317-328, 2017.

Nirei, M. (2006), "Threshold behaviour and aggregate fluctuation," Journal of Economic Theory 127(1), pp. 309-322.

OECD (2015), *The Future of Productivity*, OECD Publishing

OECD (2017), The *Multiproduct Project: A Comprehensive Review*, OECD.

Olley, G.S and A. Pakes (1996), "The Dynamics of Productivity in the Telecommunications Equipment Industry", *Econometrica*, 64(6), pp. 1263-97.

Petrin, A., and J. Sivadasan (2013), "Estimating Lost Output From Allocative Inefficiency, with an Application to Chile and Firing Costs", The Review of Economics and Statistics, Vol. 95, No. 1, pp. 286– 301.

Picot, G, J Baldwin and R Dupuy (1988) "Have Small Firms Created a Disproportionate Share of New Jobs in Canada? A Reassessment of the Facts," Changement structurel dans le secteur canadien de la fabrication, 1970-1990.

Pugsley, Benjamin, Peter Sedlacek & Vincent Sterk, 2018. "The Nature of Firm Growth," Working Papers18-30, Center for Economic Studies, U.S. Census Bureau.

Rao, S. and J. Li (2013), "Explaining Slower Productivity Growth: The Role of Weak Demand Growth," *International Productivity Monitor,* Fall 2013.

Reinsdorf, Marshall (2015) "Measuring Industry Contributions to Labour Productivity Change: A new Framework in a Chained Fisher Index Framework," *International Productivity Monitor*, Number 29, Spring.

Remes, Jaana, Jan Mischke and Meka;a (2018) "Solving the Productivity Puzzle: The Role of Demand and the Promise of Digitalization," *International Productivity Monitor* , Number 35, Fall. Pp. 28-51.

Ribeiro, P. S., S. Menghinello and K. De Backer (2010), "The OECD Orbis Database: Responding to the Need for Firm-Level Micro-Data in the OECD", OECD Statistics Working Papers, No. 2010/01, OECD Publishing, Paris.

Rigby, DL and WM Brown (2015) "Who benefits from agglomeration?" Regional Studies 49 (1), 28-43, 2015.

Rispoli, L, D Leung and B Gibson (2010) "Small, Medium-Sized and Large Businesses in the Canadian Economy: Measuring their Contribution to Gross Domestic Product in 2005," Statistics Canada.

Rispoli, L and D Leung (2010) "The contribution of small and medium-sized businesses to gross domestic product: a Canada-United States comparison," Statistics Canada.

Rollin, AM (2012) "Firm Dynamics: Employment Dynamics Arising from Firm Growth and Contraction in Canada, 2001 to 2009," The Canadian Economy in Transition, Statistics Canada.

Rollin, AM (2012) "Measures of Employment Turnover Post 2000: Gross Employment Gains

and Losses Versus Net Employment Change," Dynamique des entreprises: dynamique de l'emploi rÃ©sultant de la croissance et de la dÃ©croissance des entreprises au Canada, 2001 Ã 2009.

Sharpe, Andrew (2010) "Unbounding Canada's Weak Productivity Performance: The Way Forward," CSLS Research Report 2010-02 February, http://www.csls.ca/reports/csls2010-02.pdf

Sharpe, Andrew (2010a) "The Paradox of MarketOriented Public Policy and Poor Productivity Growth in Canada," A Festschrift in Honour of David Dodge. Ottawa: Bank of Canada. http:// www.bankofcanada.ca/wp-content/uploads/ 2010/09/sharpe.pdf

Sharpe, Andrew (2010b) "Can Sectoral Reallocations of Labour Explain Canada's Abysmal Productivity Performance," International Productivity Monitor, No. 19, Spring, pp. 40-49

Sharpe, Andrew and John Tsang (2018) "The Stylized Facts of the Productivity Slowdown in Canada," *International Productivity Monitor*, No. 35, Fall.

Syverson, C. (2004), "Product substitutability and productivity dispersion," Review of Economics and Statistics, 86(2), 534-550.

Syverson, Chad (2011) "What Determines Productivity?" *Journal of Economic Literature*,55 (3) pp. 60-82.

Tang, Jianmin and Weimin Wang (2004) "Sources of aggregate labour productivity growth in Canada and the United States" *Canadian Journal of Economics*, Vol. 37, Issue 2.

Thornhill, S, G Gellatly and A Riding (2003) "Growth history, knowledge intensity and capital structure in small firms," Venture Capital 6 (1), 73-89, 2004.

Titan, Alon, David Berger, Robert Dent, and Benjamin Pugsley, (2018). "Older and Slower: The Startup Deficit's Lasting Effects on Aggregate Productivity Growth," Working Papers 18-29, Center for Economic Studies, U.S. Census Bureau.

Trefler. D. (2004), "The Long and Short of the Canada-US Free Trade Agreement," *American Economic Review*, vol. 94, no. 4, pp. 870-895.

van Ark, Bart, 2016, "The Productivity Paradox of the New Digital Economy," *International Productivity Monitor.* Fall 2016.

Wang, W (2013) "Foreign Multinational Production in Canadian Manufacturing Sector," Transnational Corporations Review 6 (1), 26-41, 2014, 2014.

Wooldridge, Jeffrey M (2009) "On Estimating Firm Level Production Functions Using Proxy Variables to Control for Unobservables," Economics Letters, 104(3), pp. 112-14.

Appendix on International Sources of Firm-level Data

Centre for Economic Studies at U.S. Census Bureau

The Center for Economic Studies (CES) at the U.S. Census Bureau provides researchers with rich establishment- and firm-level micro-data. CES has a mandate to produce, maintain, and conduct research using longitudinal datasets. These datasets are constructed primarily based on information from respondents to Census Bureau censuses and surveys, which have data on individuals, households, and businesses. Traditionally, CES has focused on business data mostly from the manufacturing sector.

The very first longitudinal database produced by CES was the Longitudinal Research Database (LRD). The database contains establishment-level information from the Censuses and Annual Surveys of Manufacturing. See Bartelsman and Doms (2000) and Caves (1998) for reviews of research projects using the LRD. Especially, the former provides an overview of the existing firm-level productivity research using the CES micro data.

CES has improved upon the LRD by creating the Longitudinal Business Database (LBD) which, unlike the LRD covering only manufacturing, covers all the non-farm private economy and some public sector activities. The LBD is constructed based on a variety of sources such as the Business Register, the Standard Statistical Establishment List, and Economic Censuses, and surveys. The LBD covers all legally operating entities operating in the United States. and its territories for the 1976-2013 period (all employer establishments with a minimum of one employee).[32] For the industry coverage, the database covers all industries except for private households. The database has establishment-level information such as age, industry and geographical classification, payroll, and employment.[33]

The database has an attractive feature. Any limited detail on the LBD can be mitigated by the ease with which it can be linked to other sources of establishment- and firm-level information. By linking other sources of data to the LBD, it is possible to enhance the scope and depth of information for the LBD establishments. Thus, the database has large and statistically representative samples and can potentially represent the tremendous heterogeneity of the U.S. business population in terms of size and performance.

The database is available on a cost-recovery basis to qualified researchers for approved projects in secure Federal Statistical Research Data Centers.[34] The eligibility criteria for access is similar to the one at the Canadian Centre for Data Development and Economic Research (CDER) at Statistics Canada. Projects must provide benefits to Census Bureau programs, demonstrate scientific merit, require non-public data, be feasible given the data, and pose no risk of disclosure.

[32] In 2013, the data covers roughly 8.5 million establishments. For the 1973-1999, roughly 23 million establishments are covered. The exact numbers of annual observations over the entire sample period do not appear to be available to the public.

[33] For more detailed description of the database, refer to Jarmin and Miranda (2002) available at https://www.census.gov/ces/pdf/CES-WP-02-17.pdf.

[34] There are other micro-data available at CES. For the list of available data, refer to https://www.census.gov/ces/dataproducts/economicdata.html.

The CES discussion paper series includes over 500 papers using CES micro data covering a wide range of topics (including firm-level productivity) and is available at https://ideas.repec.org/s/cen/wpaper.html.

There are other databases produced by CES based on the LBD such as the Business Dynamics Statistics (BDS) and Synthetic Longitudinal Business Database (SynLBD). The aggregated version of BDS is publically available at the total economy, 2-digit SIC-, and state-level. The BDS contains information on the number of firms and establishments, employment, gross entry/exit, and job creation/destruction.[35]

The SynLBD is an experimental synthetic data product and unless validated, the CES does not guarantee that the results based on the data reflect phenomena in the underlying confidential data. The SynLBD is accessible through the Virtual RDC at Cornell University. Researchers have to submit an application package for access which is determined based solely on whether the data necessary to conduct the proposed analysis are included in the SynLBD data file. Similar to the LBD, the database contains establishment-level information on employment, payroll, birth and death years, and industrial classification. The synthetic data are created by fitting models on confidential information in the LBD and simulating replacement values from these models. The database is also tested for any disclosure risk. This appears to be similar to a synthetic version of the real T2-LEAP database created by CDER with the collaboration of the Productivity Partnership.

OECD

Multifactor Productivity Project (Multiprod)

The Directorate for Science, Technology and Innovation (STI) at the OECDhas developed a harmonized framework that provides *non-confidential* micro-aggregate statistics that are comparable across countries.[36] Such micro-aggregated statistics are constructed based on existing official confidential data at the firm level, which are in turn based on official surveys and administrative sources such as Business Registers. The whole process of collecting, processing, and constructing relevant productivity statistics is called the Multifactor Productivity (MultiProd) project. The resulting collection of micro-aggregated statistics is called the MultiProd database. OECD officials have indicated that they are willing to share access to the data with other researchers.

A key feature of the MultiProd project is that its framework builds harmonized micro-aggregated statistics, implying that productivity performance is measured in exactly the same way across countries. The comparability of results across countries is a huge advantage of the database. There are 18 countries included in the MutiProd database: Australia, Austria, Belgium,

[35] Refer to https://www.census.gov/ces/dataproducts/bds/definitions.html for the definitions of these variables.
[36] STI at OECD distributes the algorithm (*DynEmp* in Stata) that implements a distributed micro data analysis to statistical agencies in the countries participating in the MultiProd project. The algorithm is run on confidential firm-level data and the resulting aggregated statistics are compiled in the MultiProd database, implying that OECD has no access to confidential data in those countries. See Berlingieri *et al.* (2017b) for more detail.

Canada[37], Chile, Denmark, Finland, France, Hungary, Italy, Indonesia, Japan, Luxembourg, the Netherlands, Norway, New Zealand, Portugal and Sweden.

The firm-level data collected in MultiProd are processed by running a standardized algorithm (written in Stata). The algorithm produces a collection of statistics based on the firm-level longitudinal information on output, input, labour costs, sector of activity, age of firm, and ownership. The algorithm relies on two main sources of data: Administrative data or production surveys and business registers. To improve harmonization and representativeness, the algorithm reweights production surveys to construct statistics representative of the whole population in a given country. Weights are built based on information from business registers which tend to cover the whole population of firms. MultiProd is the first project to implement such reweighting.

The resulting statistics of the algorithm is a set of statistics at different levels of aggregation covering the period of 1994-2012 depending on data availability for each country. All the firm-level information is first aggregated to the 2-digit industry level separately for each year by country. However, some statistics are further refined to allow for aggregation in various dimensions: by productivity quantile; by sales quantile, by size (based on employees) group, by age group, by ownership status (independent firms vs. affiliated of a business group, and nationality of the group), and by demographic group (entrants, exitors, and incumbents).

The main variables are levels and growth rates of value added, employment, investment, labour productivity, MFP, and other firm-level characteristics (*e.g.* age, ownership) at different percentiles of the firm productivity distribution. Measures of within-industry productivity dispersion and the covariance with size also are produced following Olley and Pakes (1996). Also, structural measures of misallocation based on Hsieh and Klenow (2009) and Petrin and Sivadasan (2013) are constructed for analyses on the role of allocation and selection in productivity. Moreover, MultiProd provides results from distributed regressions to establish some stylized facts by country for the relationship between productivity, firm characteristics (*e.g.* size, age, ownership) and structural characteristics (*e.g*. concentration and misallocation).

There are two types of labour productivity measure available in the MutiProd database: the gross output or total revenue based labour productivity and value added based labour productivity. There are also two types for MFP: index number approach and production function approach (*i.e.* first estimate a production function and then obtain MFP as a residual).

The index number measure is based on the functional form that characterizes the relationship between output to a weighted sum of inputs. There are two types of index number approaches: Solow residuals and the Superlative-index measure. In the MultiProd database, the Solow residual-based MFP is provided.[38] There are various approaches developed in the

[37] The underlying data source for Canada in the MultiProd database is Statistics Canada's T2-LEAP longitudinal database.

[38] In the Solow residual approach, inputs are weighted using external, industry-specific factor shares. In the MultiProd database, MFP is constructed using cross-country industry-specific labour and intermediate shares.

literature in estimating a firm-level production function. These different approaches are developed to correct for well-known empirical issues such as simultaneity bias. In the MultiProd database, MFP is measured based on a (relatively) recent technique developed in Wooldridge (2009).[39]

As noted above, there are various dimensions in which researchers can analyze the statistics in the MultiProd database. For example, researchers can study the role of particular industries or groups of firms in explaining aggregate outcomes in productivity growth and dispersion (*e.g.* small vs. large; old vs. young; lagging firms vs. frontier firms). For example, Berlingieri *et al.* (2017a) use the MutiProd database to investigate the role of productivity heterogeneity across 18 countries over the period 2001-2012.

For example, the analysis in the size dimension can shed light on the so-called "granular" hypothesis. The hypothesis states that aggregate fluctuations are driven by microeconomic shocks and not economy-wide shocks. Those microeconomic shocks may not cancel on average if sectors are dominated by a small number of large firms. The MultiProd database offer empirical evidence for this hypothesis by allowing researchers to analyze how much aggregate economic activity is concentrated in a small number of large firms, and how much of the observed variation in productivity is stemmed from microeconomic variations.

OECD-Orbis Database

There is another firm-level data source called the OECD-Orbis database. The database is developed jointly by six OECD Directorates (started in 2008).[40] The database contains several productivity measures (variants of labour productivity and MFP) as well as other firm-level information.[41] The most recent version of the database covers 24 OECD countries over the 1997-2014 period for the non-farm and non-financial business sector (roughly 55 million firms). The countries included are: Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Great Britain, Greece, Hungary, Ireland, Italy, Japan, Korea, Netherlands, Norway, Poland, Portugal, Spain, Sweden, Slovenia, the Slovak Republic and the United States. Canada is not included.

The OECD-Orbis database are constructed based on annual balance sheet and income statements made available by Bureau van Dijk, an electronic publishing firm. These information is in turn based on various sources such as credit rating agencies, national banks, and financial

[39]Wooldridge (2009) developed an algorithm that builds upon the method introduced in Levinsohn and Petrin (2003). The algorithm overcomes the well-known identification problem in the Levinsohn-Petrin method. See Wooldridge (2009) for detail.

[40] They are: Centre for Entrepreneurship, SMEs and Local Development (CFE), Directorate for Employment, Labour and Social Affairs (ELS), Environment Directorate (ENV), Statistics Directorate (STD), Directorate for Science, technology and Industry (STI) and Directorate for Trade and Agriculture (TAD). Note that the database is accessible to OECD researchers only.

[41]The database contains not only the variables that underlie the productivity measures such as sales, net income, the number of employees, tangible and intangible fixed assets but also more detailed information such as current and non-current liabilities, interest payment, and country of control (more than 200 variables). The OECD-Orbis database are also linked with other OECD databases such as the PATSTAT database, which have information on patent for individual firms.

information providers (*e.g.* Thomson Reuters) -- see Appendix E in Andrews, Criscuolo, and Gal (2016) for the full list of data sources for the 24 countries included in the database.

Although the OECD-Orbis is the largest cross-country firm-level database for economic research, a series of adjustments are required before the data can be used for economic analysis. This is due to the fact that the underlying data are collected for use in the private sector with the purpose of financial benchmarking, which is not necessarily aligned with that of economic research. In general, the adjustments involve: 1) ensuring comparability of variables across countries and over time; 2) constructing new variables required in productivity analyses (*e.g.* value added and capital stock); and 3) procedures to resolve representative issues since the database is a subsample of the total firm population within countries, focusing more on large firms (and hence, potentially more productive firms).[42]

See Ribeiro, Menghinello and Backer (2010) for more detailed discussion of the OECD-Orbis database, especially for its disadvantages and advantages. As Orbis is a privately constructed database, with the OECD purchasing access for its researchers, non-OECD researchers do not have access without paying a significant fee,

Eurostat

The only firm-level data available at Eurostat is the Micro-Moments Dataset (MMD).[43] The MMD is a product of the Eurostat-funded projects. The main purpose of the database is to derive measures of the impact of ICT and innovation on business performance and productivity. The MMD relates ICT and innovation variables to various indicators of economic performance and characteristics of firms across industry groups and countries. Therefore, it is possible to link the data on ICT and innovation to other aggregate economic data on productivity such as EU KLEMS.[44]

The database is produced based on four sources: 1) the Survey of ICT Usage and e-Commerce in Enterprises; 2) the Community Innovation Survey; 3) the Business Register; and 4) Structural Business Survey. The database has firm-level information with a longitudinal structure, which are available for firms in Austria, Denmark, Finland, Germany, Ireland, Italy, the Netherlands, Norway, Slovenia, Sweden, and the UK. In general, the data cover the period 2010-2013 but the sample period varies from one country to another as it is subject to the availability of the Community Innovation Survey and the Survey on ICT Usage and e-Commerce in Enterprise.[45]

[42] See Gal (2013), Ribeiro, Menghinello and Backer (2010), Kalemli-Ozcan, Sorensen, Villegas-Sanchez, Volosovych and Yesiltas (2015), and Andrews, Criscuolo, and Gal (2016) for more detail regarding the adjustments.
[43] Refer to https://ec.europa.eu/eurostat/web/microdata for all other micro-data available at Eurostat.
[44] The aggregate version of the MMD is publically available at https://ec.europa.eu/eurostat/web/digital-economy-and-society/methodology.
[45] For more details of the database, refer to the document prepared by Eurostat available at https://ec.europa.eu/eurostat/documents/203647/6867168/MMD+description/f690281e-10e7-4407-9f32-3907746eaee3.

The MMD contains basic firm-level information such as employment, exit, entry, age, industry classifications, value added, gross output, payroll, and intermediates. These variables are linked to ICT- and innovation-related information such as education level of employees, share of employees with formal education in ICT and related fields and whether a firm has internet, broadband connection, website, or mobile access to internet, and whether a firm sells/orders using computer networks. The database also has information on R&D expenditure and R&D funding from the government or EU.[46] Bartelsman, Hagsten, and Polder (2013) provide a good overview on the MMD database and technical possibilities for cross-country firm-level analysis on the ICT impact on productivity. They also present the findings from their own analysis using the MMD database.

Researcher must submit a formal application package in order to gain access to the MMD and the database can only be used for scientific purposes. Only authorized researchers can use the MMD for an agreed research project through the Safe Centre at Eurostat. To qualify for access, researchers must be from recognized entities. To become a recognized entity, an organization must have research as one of its main activities; provide evidence of publication of research results; be independent and autonomous in formulating scientific conclusions; and have adequate data security safeguards.

Competitiveness Research Network

The Competitiveness Research Network (CompNet) is a research network founded by the European System of Central Banks in 2012 to promote and inform the debate on competitiveness and productivity. Its activities involve not only research but also producing, updating, and maintaining a firm-level database for a number of EU countries.

The European Central Bank (ECB) is one of the main contributors to the CompNet through not only research but also data production. The ECB maintains the CompNet Competitiveness Dataset. The database contains firm-level information covering 18 European countries[47] and is released regularly based on its latest vintage. The most recent version was released in 2018 (*i.e.* the 6th Vintage CompNet database). The database is constructed based on information available from national central banks and national statistical institutes.

The most recent version of the data covers the period 1999-2016 for most of the countries in the sample. The database covers non-financial corporations with at least one employee[48] across NACE (Nomenclature statistique des Activités économiques dans la Communauté Européenne) industries B-J and L-N. Various firm-level information is available such as employment, value added, revenue, payroll, and other variables that are necessary to assess firm-

[46] For the complete variable list, refer to https://ec.europa.eu/eurostat/documents/203647/6867168/Variables_breakdowns_coverage/568118b1-bc04-4960-84b2-6c77899a0ea5.

[47] They are Belgium, Croatia, Czech Republic, Denmark, Finland, France, Germany, Hungary, Italy, Lithuania, Netherlands, Poland, Romania, Slovakia, Slovenia, Spain, and Sweden.

[48] However, in some countries (*e.g.* Poland) firms are legally obliged to submit their balance sheet information only if certain thresholds are met (*e.g.* only firms with more than 10 employees).

level labour productivity and TFP.[49]

The CompNet Competitive database consists of four different types of datasets: 1) unconditional files (including all available variables); 2) productivity decomposition; 3) labour market imperfections; and 4) misallocation. The unconditional files contain all productivity, finance, labour, and competition indicators available in the CompNet database. They are available by country, industry (at the 2-digit NACE level), and size class dimension. The productivity decomposition files contain the estimates of various allocative and dynamic efficiency measures. The labour market imperfections files contain the labour share weighted Dobbelaere-Mairesse (2013) indicator. Lastly, the misallocation files contain the within-sector dispersion of 46 productivity and competition variables such as labour productivity, capital productivity, and De Loecker and Warzynski markups (see De Loecker and Warzynski, 2012).

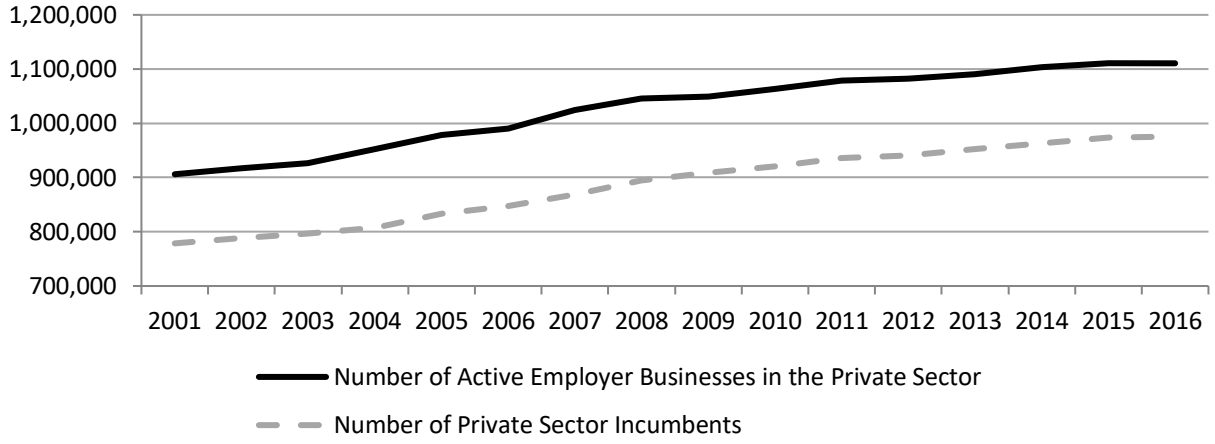
To gain access to the database, researchers must submit an application package to the CompNet.[50] If accepted, and the data are delivered through internal drives protected by password access and/or personal access privileges. As any other confidential micro data, researchers can use the database only for scientific purposes.

[49]For the complete list of variables, refer to Table 16 in CompNet (2018).
[50] The online application submission is available at https://www.iwh-halle.de/en/research/data-and-analysis/research-data-centre/compnet-database/request-form/.

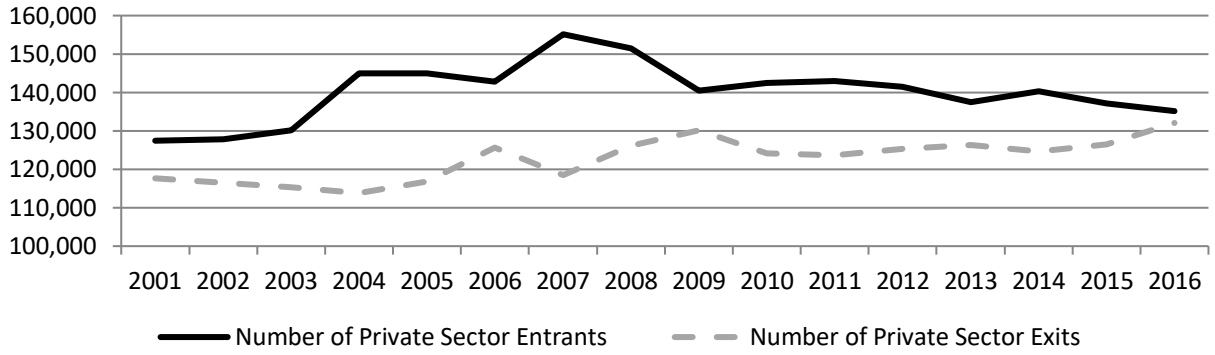
Appendix 1: Trends in Firm Dynamics in Canada, 2001-2016

Chart A1: Number of Active Employer Businesses, Incumbents, Entrants and Exits in the Private Sector, Canada, 2001-2016

Panel A: Number of Active Employer Businesses in the Private Sector (Entrants + Incumbents) and Number of Private Sector Incumbents



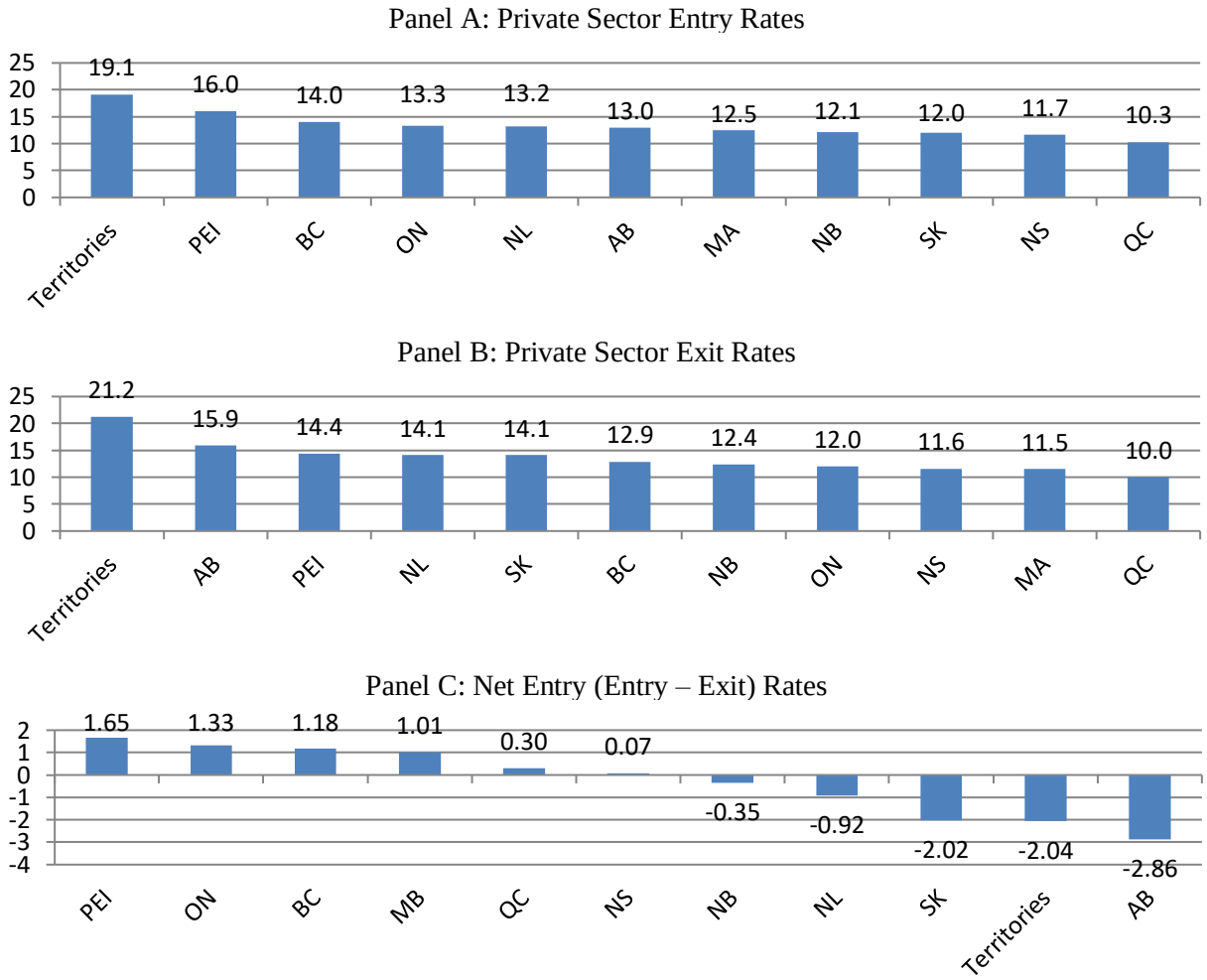
Panel B: Number of Private Sector Entrants and Number of Private Sector Exits



Note: According to footnote 1 of Statistics Canada Table 33-10-0164-01, employer businesses include both incorporated and unincorporated businesses that issue one or more statements of remuneration (T4 slip(s)) to their employee(s) for tax purposes. The number of active employer businesses in the private sector and the number of incumbents are stock variables while the number of private sector entrants and the number of private sector exits are flow variables.

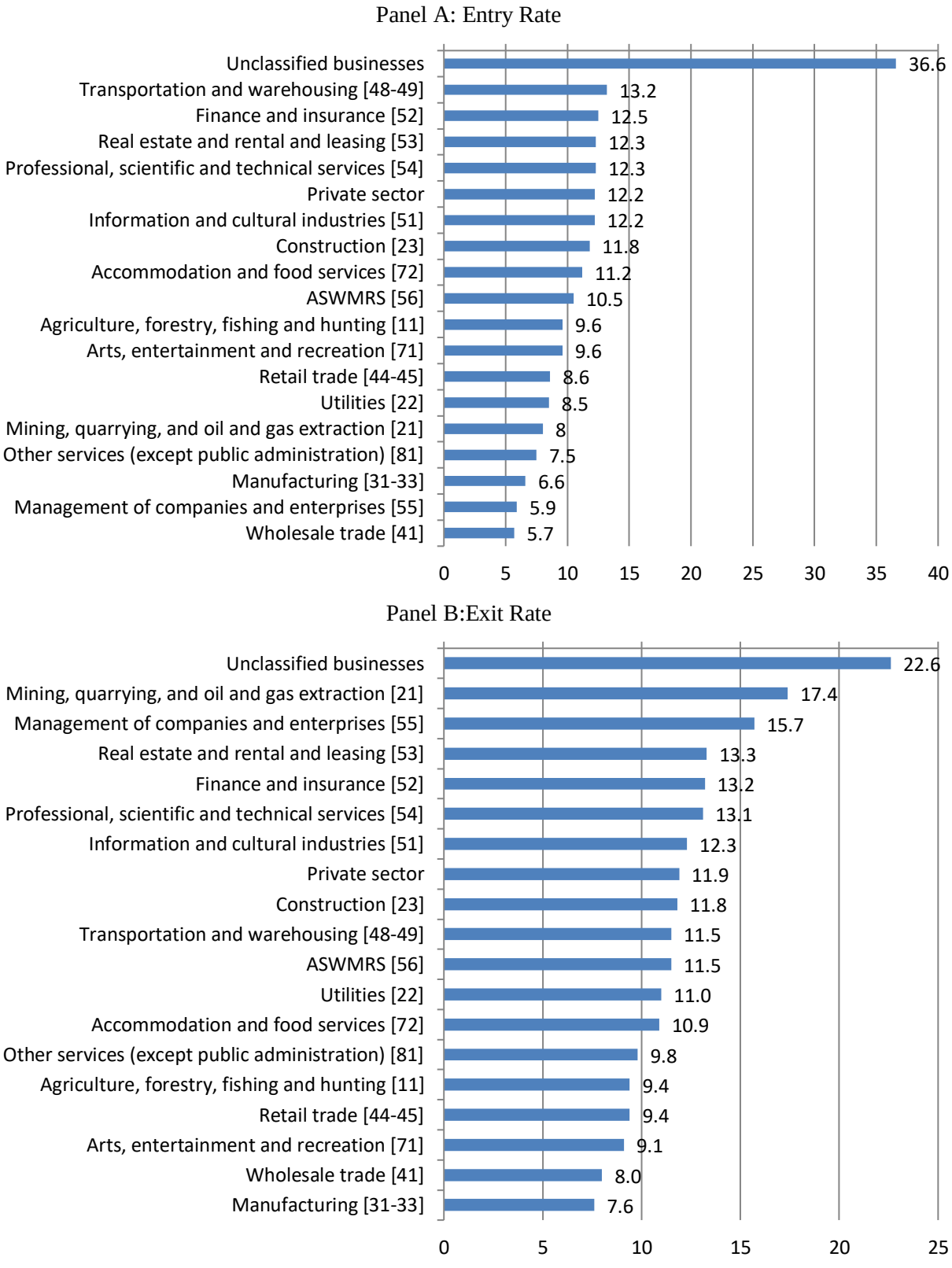
Source: Statistics Canada Table 33-10-0164-01 (formerly CANSIM 527-0001).

Chart A2: Entry Rates of Private Sector Employer Businesses by Province and Territories in Canada, 2016 (per cent)

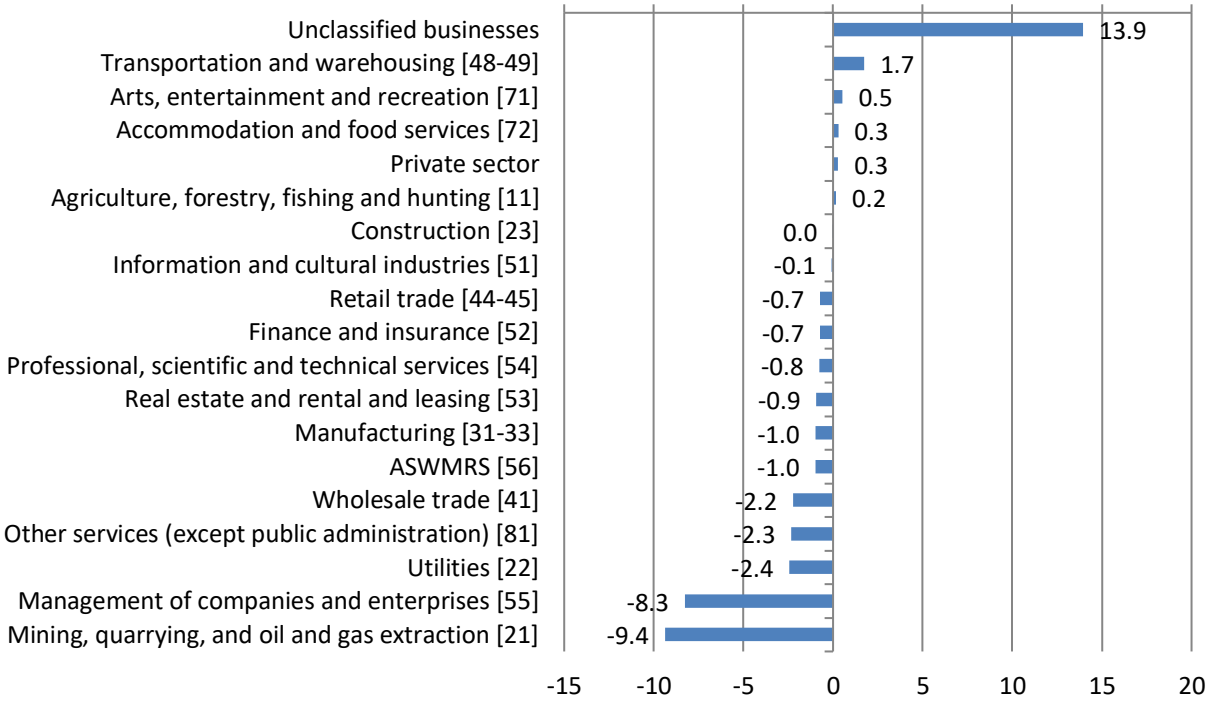


Note: The entry rate for a year is defined as the number of entrants as a per cent of the average of the number of active employer businesses in the current year and the previous year. The exit rate for a year is defined as the number of exits as a per cent of the average of the number of active employer businesses in the current year and the previous year. The net entry rate for a year is defined as the number of net entry (the number of entrants – the number of exits) as a per cent of the average of the number of active employer businesses in the current year and the previous year.
Source: Statistics Canada Table 33-10-0087-01 (formerly CANSIM 527-0007).

Chart A3: Entry Rates and Exit Rates by Industry, Canada, 2016



Panel C: Net Entry (Entry – Exit) Rates



Note: The entry rate for a year is defined as the number of entrants as a per cent of the average of the number of active employer businesses in the current year and the previous year. The exit rate for a year is defined as the number of exits as a per cent of the average of the number of active employer businesses in the current year and the previous year. The net entry rate for a year is defined as the number of net entry (the number of entrants – the number of exits) as a per cent of the average of the number of active employer businesses in the current year and the previous year.
ASWMRS stands for Administrative and support, waste management and remediation services.

Source: Statistics Canada Table 33-10-0164-01 (formerly CANSIM 527-0001).

Appendix 2: Petroleum refining industry (NAICS 32411) in New Brunswick (the Irving refinery)

Table A1: Real value added in petroleum refineries in national total and in New Brunswick, 1997-2017

	(1) National total Pet. Ref.	(2) Pet. Ref. in NB	(3) Total business sectors in NB	(2) / (1)	(2) / (3)
1997	7,115,768	796,606	14,954,007	11.2%	5.3%
1998	8,356,322	785,482	15,602,289	9.4%	5.0%
1999	9,464,386	326,466	16,899,811	3.4%	1.9%
2000	9,890,974	390,594	17,383,959	3.9%	2.2%
2001	10,990,477	526,029	17,681,840	4.8%	3.0%
2002	10,714,301	464,942	18,608,167	4.3%	2.5%
2003	11,116,155	641,187	18,969,456	5.8%	3.4%
2004	11,531,788	680,304	19,566,220	5.9%	3.5%
2005	10,982,551	783,991	19,746,217	7.1%	4.0%
2006	10,556,345	737,968	19,975,795	7.0%	3.7%
2007	10,992,684	669,109	19,918,425	6.1%	3.4%
2008	10,494,460	669,744	19,872,028	6.4%	3.4%
2009	10,839,443	717,229	19,134,584	6.6%	3.7%
2010	10,185,275	695,537	19,494,413	6.8%	3.6%
2011	9,516,276	673,870	19,478,958	7.1%	3.5%
2012	9,774,279	643,341	19,062,813	6.6%	3.4%
2013	9,861,805	653,940	18,910,996	6.6%	3.5%
2014	10,168,849	551,179	18,884,487	5.4%	2.9%
2015	10,148,698	600,345	19,151,024	5.9%	3.1%
2016	10,061,701	585,450	19,440,262	5.8%	3.0%
2017	10,575,685	630,834	19,916,968	6.0%	3.2%
		Average annual growth rate		Change between 1997 and 2017	
1997-2017	2.00%	-1.16%	1.44%	-5.2 % pt.	-2.2% pt.

Note: Value added is in 2012 chained thousand dollar.
Source: Statistics Canada Table 36-10-0480-01.

Table A2: Employment in petroleum refineries in national total and in New Brunswick, 1997-2017

	(1) National total Pet. Ref.	(2) Pet. Ref. in NB	(3) Total business sectors in NB	(2) / (1)	(2) / (3)
1997	4,265	240	233,915	5.6%	0.1%
1998	3,475	175	238,365	5.0%	0.1%
1999	4,465	115	245,490	2.6%	0.0%
2000	4,300	235	250,600	5.5%	0.1%
2001	5,125	330	245,480	6.4%	0.1%
2002	4,540	230	256,545	5.1%	0.1%
2003	5,685	270	254,320	4.7%	0.1%
2004	6,790	375	261,110	5.5%	0.1%
2005	7,385	660	258,970	8.9%	0.3%
2006	7,910	815	261,775	10.3%	0.3%
2007	10,155	875	267,760	8.6%	0.3%
2008	10,080	985	268,465	9.8%	0.4%
2009	10,340	1,375	265,410	13.3%	0.5%
2010	11,275	1,365	261,635	12.1%	0.5%
2011	11,430	1,200	259,760	10.5%	0.5%
2012	10,795	990	258,665	9.2%	0.4%
2013	8,235	1,195	258,560	14.5%	0.5%
2014	7,890	990	258,550	12.5%	0.4%
2015	8,095	1,095	254,930	13.5%	0.4%
2016	7,840	930	256,080	11.9%	0.4%
2017	7,760	965	259,460	12.4%	0.4%
		Average annual growth rate		Change between 1997 and 2017	
1997-2017	3.04%	7.21%	0.52%	6.8% pt.	0.3% pt.

Source: Statistics Canada Table 36-10-0480-01.

Table A3: Labour productivity in petroleum refineries in national total and in New Brunswick, 1997-2017

	(1) National total Pet. Ref.	(2) Pet. Ref. in NB	(3) Total business sectors in NB	(2) / (1)	(2) / (3)
1997	828.1	1,565.00	33.7	189.0%	4643.9%
1998	1,129.20	2,146.10	34.6	190.1%	6202.6%
1999	1,048.00	1,300.70	36.4	124.1%	3573.4%
2000	1,146.50	782.8	36.7	68.3%	2133.0%
2001	1,048.60	766.8	38.4	73.1%	1996.9%
2002	1,156.30	970.7	38.9	83.9%	2495.4%
2003	959.4	1,157.40	39.9	120.6%	2900.8%
2004	834.5	876.7	40.3	105.1%	2175.4%
2005	737.8	573.9	41.7	77.8%	1376.3%
2006	643.8	458.1	41.3	71.2%	1109.2%
2007	529.3	370.3	40.6	70.0%	912.1%
2008	504.3	338.9	40.3	67.2%	840.9%
2009	517.6	249.3	39.7	48.2%	628.0%
2010	445.4	254.6	40.7	57.2%	625.6%
2011	401.7	286.6	41.7	71.3%	687.3%
2012	443.7	316.3	40.2	71.3%	786.8%
2013	590.7	274.1	40.5	46.4%	676.8%
2014	632.2	261.8	40.9	41.4%	640.1%
2015	613.4	251.2	41.6	41.0%	603.8%
2016	645.9	318.7	41.9	49.3%	760.6%
2017	687.5	326.2	42.4	47.4%	769.3%
		Average annual growth rate		Change between 1997 and 2017	
1997-2017	-0.93%	-7.54%	1.15%	-141.5% pt.	-3874.6% pt.

Note: Labour productivity is in 2012 chained thousand dollar per hour worked.
Source: Statistics Canada Table 36-10-0480-01.