

# Editor's Overview

THIS 34TH ISSUE OF THE *International Productivity Monitor* contains seven articles on a range of productivity-related topics: the potential gains from more competitive regulatory settings for real per capita GDP growth in Canada; the role of capital measurement issues in accounting for slower productivity growth in Canada; the achievement of productivity lift-off in New Zealand; the productivity implication of a country's position within Global Value Chains; explanations for the U.S. productivity slowdown; cyclical versus trend slowdowns in productivity growth; and the rise of the intangible economy.

A priority for public policy in Canada is to identify measures that can be taken to boost growth in productivity and GDP per capita. In the lead article, **Aled ab Iorwerth** and **Carlos Rosell** from Finance Canada provide econometric evidence that making Canada's regulatory framework as competition friendly as that in the United States would produce significant economic dividends for the country. They find that GDP per capita in Canada could be 2.0 per cent higher in five years and 5.3 per cent higher after 20 years if Canada's foreign direct investment (FDI) regulations were as competitive as those in the United States. They recognize that there are a range of estimates of the benefits, but note that even in the lower bound (at the 95 per cent confidence interval), the gains would be 0.7 per cent and 1.8 per cent of GDP per capita for the medium and long term respectively.

Output per hour growth in the Canadian business sector fell from an average annual rate of advance of 1.7 per cent in 1980-2000 to 1.0 per cent in 2000-2015, with multifactor productivity (MFP) growth decreasing from 0.2 to -0.4 per cent. In the second article in this issue, **Wulong Gu** from Statistics Canada estimates the contribution of three types of capital that are not currently incorporated into the standard growth accounting framework, namely intangible capital, natural resource capital, and public infrastructure capital, to the productivity

slowdown. The impact of changes in capacity utilization on the slowdown is also estimated. The inclusion of natural capital and changes in capacity utilization reduces the MFP slowdown, while the inclusion of intangible capital and public capital in capital input do not contribute to the slowdown.

New Zealand's poor productivity performance has long puzzled economists, especially since the country has pursued market-oriented policies since the 1980s. In the third article in the issue, **Paul Conway** from the New Zealand Productivity Commission provides a comprehensive analysis of the factors holding back productivity in New Zealand and puts forward policies to achieve productivity lift-off in the country. He identifies weak international connections, the geographical segregation of domestic markets and their small size, and a low capital-labour ratio as factors that have contributed to weak productivity growth. New Zealand's reality of being a small country distant from major global market resonates throughout the economy in complex ways and the implications for the country's productivity performance and for productivity-enhancing policies are still poorly understood. Going forward, opening the economy to new opportunities for international connections is key to productivity lift-off.

A key aspect of globalization has been

the development of Global Value Chains (GVCs) where goods are assembled in a coordinated manner across a number of countries. Participation in GVCs can have important impacts on productivity through knowledge spillovers, technology transfer and catch-up. In the fourth article, **Chiara Criscuolo** and **Jonathan Timmis** from the OECD further the analysis of the productivity effects of GVCs by examining the implications of the structure of GVCs and a country's position within GVCs for productivity. They find that becoming more central as a customer or supplier was associated with faster productivity growth of firms in post-2004 EU members. The authors conclude that effective facilitation of GVC integration requires sophisticated policies based on a deep understanding of the nature of GVCs.

It is now widely recognized that productivity growth slowed down considerably in the United States after 2004. A large literature on this important development has appeared, but a consensus for the reasons for the slowdown has not yet emerged. In the fifth article, **Alexander Murray** from the Centre for the Study of Living Standards provides a comprehensive review of the state of knowledge of the US slowdown. He finds the slowdown to be broadly-based and identifies slower total factor productivity growth as the most important proximate driver of the labour productivity slowdown. He concludes that the slowdown is traceable to a decline in the productivity contribution from industries that produce and intensively use information and communications technology (ICT) products.

Separating actual productivity changes into the short-term cyclical component

and long-term trend component has always been a challenge for economists. The Global Financial Crisis (GFC) has made this issue particularly germane since it is paramount to know whether slower productivity growth since 2008 reflects the impact of the crisis or is related to long-term structural developments, or is a combination of both influences. In the sixth article in the issue, **John Fernald** from INSEAD and the Federal Reserve Bank of San Francisco provides a review of the book *Productivity Puzzles across Europe* edited by Philippe Askenazy, Lutz Bellman, Alex Bryson and Eva Moreno Galbis. He notes that the chapters of the book shed much light on the country-specific labour-market institutions that affected the cyclical productivity performance in major European countries in recent years, but that the book has less to say about the factors behind Europe's slowing productivity trend.

In recent years, intangible capital, defined as an asset that is not physical in nature, such as intellectual property and brand recognition, has emerged as a highly important factor on the supply side of the economy. In the seventh and last article in this issue **Chad Syverson** from the University of Chicago reviews the book *Capitalism with Capital: The Rise of the Intangible Economy* by Jonathan Haskel and Stian Westlake. Intangible capital differs from tangible capital in a number of dimensions: it is more a sunk cost; it creates more spillovers, it is more scalable, and it exhibits more synergies. Syverson concludes that the book represents an excellent introduction and overview of the extant thinking on intangible capital and calls it a "can't miss" volume for anyone interested in the topic.

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INTERNATIONAL PRODUCTIVITY MONITOR

NUMBER 34, SPRING 2018

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# The Gains from More Competitive Regulation Settings in Canada

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## ABSTRACT

This article explores potential gains for Canada from making its regulatory framework as competition friendly as that in the United States. We estimate standard cross-country GDP growth regressions incorporating the OECD's indicators of product market regulations (PMRs) that measure the extent to which regulations, laws and other rules inhibit product market competition. Based on the key point estimate (or the lower bound of its 95 per cent confidence interval), GDP per capita in Canada could be about 2.0 per cent (0.7 per cent) higher in the medium term (i.e. 5 years) and about 5.3 per cent (1.8 per cent) higher after 20 years as a result of making Canada's 2013 regulatory settings related to foreign direct investment (FDI) as competitive as in the United States. However, government actions taken since 2013 have improved the competitiveness of these regulations. As a result, further changes needed to reach the US benchmark are not as great as they were in 2013 and would not generate as substantial gains.

In addition to setting the right framework for economic growth, key objectives for government are attaining desirable non-financial outcomes for society such as safe workplaces and a clean environment. However, the multitude of such objectives and the many means of achieving them make design of regulation exceedingly difficult. For example, a particular objective (e.g. a given level of product safety) can be achieved through several approaches, with some designs being more economically costly than others.

In that context, there are potential gains from rationalizing and improving the regulatory framework, the regulations, laws and other rules influencing economic activity. However, the magnitude of these potential gains is unclear. The objective of this article is to examine the potential benefits of making regulations, laws and other rules more competition friendly after taking interactions within the economy into account. We concentrate in particular on the scale at the aggregate level of comprehensive reform rather than targeting

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<sup>1</sup> Aled ab Iorwerth was a Director in the Economic Studies and Policy Analysis Division of Finance Canada when this article was written. He is currently Deputy Chief Economist at Canada Mortgage and Housing Corporation (CMHC). Carlos Rosell is Senior Economist in the Economic Studies and Policy Analysis Division at Finance Canada. We thank Marcel Boyer, Claude Lavoie, Danny Leung, Fidèle Ndayisenga, Benoît Robidoux, Jing Xu, Julie Turcotte, and seminar participants at Finance Canada and the Canadian Economic Association annual general meeting as well as three anonymous referees for helpful comments. The views expressed in this paper are those of the authors and may not reflect those of Finance Canada. All errors are our own. Email: aiorwerth@cmhc-schl.gc.ca; carlos.rosell@canada.ca.

individual changes. To this end, we introduce the classic Solow model with a wedge between the resources spent and those that are effectively used to build productive capital. In other words, we assume the competition inhibiting nature of some regulations dissipate productive resources. In practical terms, and in the tradition of Mankiw *et al.* (1992) and Islam (1995), we estimate a dynamic equation for GDP per capita with an added term reflecting the extent to which regulations are anti-competitive.

Critical to this analysis is an indicator of the anti-competitiveness of regulation. To this end, we utilize the product market regulation (PMR) measures developed by the OECD. These measures are compiled from a survey of laws and regulations in each country.<sup>2</sup> They capture a variety of aspects such as state involvement (e.g. does the government restrict purchase of shares by foreigners?) and business operation restrictions (e.g. are there restrictions on store opening hours?) that increase the economic costs by limiting competition and the optimal allocation of resources. As such, changes in these indicators do not necessarily imply weaker standards on pollution, and health and safety, but rather affect the extent to which existing regulations reduce competition. Indeed, improvement in these indicators is consistent with the objective to put in place smarter, more effective approaches to regulation that enhance economic competitiveness, while maintaining high standards of public health and safety, and protecting the environment.

It is important to note that the OECD PMR indicators capture regulations, laws and other rules set by different levels

of government and by those organizations to which regulatory power has been delegated such as self-regulating professional associations. Consequently, we acknowledge that our use of the term “regulation” does not strictly adhere to the definitions used by different governments or international organizations and that, in some contexts, the broad term “policy” could be used interchangeably with “regulation.” Finally, the set of regulations on which the measures are based is narrow compared to the universe of all regulatory policies affecting economic activity. As a consequence, cross-country differences in the PMR indicators only arise from cross-country differences over relatively few policies. Nevertheless, these measures are adequate for our purposes so long as the regulations on which the indicators are based reflect their broader universe. We believe that the OECD indicators are the best available measures to evaluate the degree to which countries’ regulatory frameworks inhibit competition.

Though our methodology does not treat the possible endogenous relationship between growth and regulatory settings, our findings suggest anti-competitive regulation lowers GDP per capita, particularly if it raises barriers to trade and investment. This means that even though Canada performs well in several areas, such as having low barriers to entrepreneurship, Canada has room to improve and increase welfare. Reducing the anti-competitive elements of Canada’s regulatory framework as they stood in 2013, in particular those related to foreign direct investment (FDI), to US levels that serve as a feasible high-competition benchmark, would be expected to increase GDP per capita in Canada by up to 2.0

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<sup>2</sup> These measures are based on surveys that are answered by government organizations. Surveys are initially disseminated to finance ministries where upon the OECD encourages these departments to farm out questions to the most relevant bodies. As a result, questions may be provided by sub-national governments.

per cent within five years (i.e. the medium term). As the capital stock adjusts fully in the long run, this alignment could increase GDP per capita by about 5.3 per cent. Based on the lower bound of our main point estimate's 95<sup>th</sup> confidence interval, the medium and long-run impacts are estimated to be about 0.7 and 1.8 per cent respectively.

It is worth noting that convergence of the PMR indices between the two countries is not a convergence in regulations, laws and other rules but rather a convergence in the anti-competitive burden they impose. For barriers to FDI restrictions, this would entail in part relaxing to the same extent as in the United States, Canadian equity limits or obligatory screening and approval procedures for foreign investors as they attempt to acquire domestic businesses. Also worth noting is that since 2013, some elements of the regulatory environment have become more competitive in Canada; the OECD's FDI restrictiveness index suggests this is the case for Canadian FDI regulations. As a result, the reforms needed for current regulations to reach the US benchmark should not be as great and cannot be expected to generate as large benefits as indicated here.

We concentrate in this analysis on potential gains of making the regulatory framework more competitive and therefore remain at a high level of generality. We hope that the scope of such gains leads to further analysis of actual gains in the light of more specific reform proposals. Clearly, those actual gains may be smaller than those suggested here when practical constraints on policy are introduced. We emphasize, however, that the potential for gains are large: many of the industries examined

are networked industries that could benefit from greater scale and increased competition between providers of intermediate goods and services to downstream firms that could lead to large knock-on effects.

In what follows, the first section specifies the regression equation we estimate and describes the data we use. Section 2 presents the results and tests their robustness. Section 3 concludes and suggests some necessary caveats to the analysis.

## Data and Estimation Strategy

### Estimation Equation

The regression equation we estimate is derived from a modified version of the Solow model that accounts for how PMRs might affect growth (see the Technical Appendix for the derivation of the regression equation).<sup>3</sup> Specifically, the equation we estimate is given by,

$$\ln \frac{Y_{c,t}}{L_{c,t}} = \beta_1 PMR_{c,t} + \beta_2 \ln s_{c,t}^k + \beta_3 \ln s_{c,t}^h + \beta_4 \ln(n_{c,t} + g + \delta) + \beta_5 \ln \frac{Y_{c,t-\tau}}{L_{c,t-\tau}} + \eta_c + m_t + \epsilon_{c,t} \quad (1)$$

For the most part, equation (1) is a standard growth regression. In this equation,  $Y_{c,t}$  and  $L_{c,t}$  are respectively the levels of output (i.e. GDP) and population in country  $c$  in year  $t$ . As in the literature, this equation proposes output per capita is explained most notably by a country's investment rates in physical  $s_{c,t}^k$  and human  $s_{c,t}^h$  capital, the combined effect of its rates of population growth  $n_{c,t}$ , technological

<sup>3</sup> We acknowledge that this regression might be derived from different models or that it could be thought of as a simple reduced form equation without explicit theoretical underpinnings.

progress  $g$  and capital depreciation  $\delta$ ,<sup>4</sup> and output per capita in the previous period (in this case  $\tau$  periods in the past). Moreover, as in Islam (1995), equation (1) allows constant but unobserved country-specific factors  $\eta_c$  and time varying but global shocks  $m_t$  to influence growth. Finally,  $\epsilon_{c,t}$  represents idiosyncratic random and unobserved shocks that influence growth. These shocks are assumed to be independently and identically distributed as well as being unrelated to other factors that theory suggests also drive growth.

As elsewhere in the literature (e.g. Wolff *et al.*, 2010), equation (1) includes the anti-competitive nature of product market regulations  $PMR_{c,t}$  as a factor influencing growth. The intuition for why  $PMR_{c,t}$  affects growth is that with less competition caused by poorly designed regulations, less investment is able to build productive capital. As a result of this investment wedge, the marginal impact of more anti-competitive regulations is to decrease output per capita by  $\beta_1$  per cent in the medium term (here  $\tau$  or 5 years) and  $\frac{\beta_1}{1-\beta_5}$  per cent in the long term, once the effective stocks of capital fully adjust.

## Data

Analysis and estimation of equation (1) requires economic and education data as well as measures quantifying the general stance of country regulations towards competition.

## Product Market Regulation

The PMR measures used to estimate equation (1) are obtained from the OECD (Koske *et al.*, 2015). These measures are based on information about regulations, laws and other rules or policies set by different levels of government and self-

regulating bodies. The end result is a set of quantitative measures that allow one to trace indicator values to underlying policies. Furthermore, indicators are based on OECD member country surveys with few based on external data sets. Moreover, the indicators are based on a country's actual policies and not on opinions reflecting subjective assessments of market participants. They measure potentially anti-competitive elements of regulations and rules where competition is possible, and generally do not reflect market outcomes. Finally, national administrations of OECD member countries peer review these indicators.

The PMR indicators are available for OECD countries and selected non-OECD countries for up to four years (i.e. 1998, 2003, 2008, and 2013). As well, these PMR measures are available at various levels of aggregation. For example, at a high level of aggregation, the OECD PMR measures capture regulations limiting competition due to 1) state control, 2) barriers to entrepreneurship and 3) barriers to trade and investment. Moreover, these measures are aggregated from more specific types of regulations. At their most basic level, these metrics measure the scope by which public enterprise, license and permit systems, and barriers to FDI can limit competition. Finally, the PMR measures range in value from zero to six where higher values represent a higher anti-competitive burden.

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4 We follow Mankiw *et al.* (1992) and Islam (1995) in assuming the rate of technological progress and the depreciation of physical capital add up to 5 per cent (i.e.  $g + \delta = 0.05$ ) but we undertake sensitivity analysis around this value. These results are available upon request.

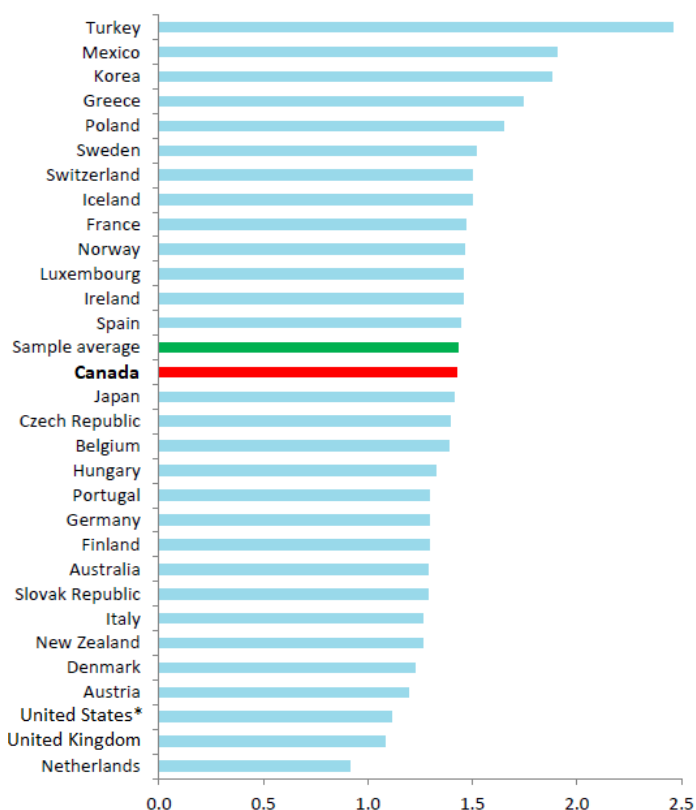
**Table 1: OECD Product Market Regulation Indicators by Country and Year, 1998, 2003, 2008, 2013**

|                       | Overall average high-level PMR |      |      |      | State Control   |      |      |      | Entrepreneurship |                 |      |      | Trade and investment |      |                 |      |      |      |      |                 |
|-----------------------|--------------------------------|------|------|------|-----------------|------|------|------|------------------|-----------------|------|------|----------------------|------|-----------------|------|------|------|------|-----------------|
|                       | 1998                           | 2003 | 2008 | 2013 | Country Average | 1998 | 2003 | 2008 | 2013             | Country Average | 1998 | 2003 | 2008                 | 2013 | Country Average | 1998 | 2003 | 2008 | 2013 | Country Average |
| Australia             | 1.72                           | 1.34 | 1.46 | 1.29 | 1.45            | 2.28 | 1.59 | 2.21 | 1.99             | 2.01            | 1.94 | 1.76 | 1.65                 | 1.69 | 1.76            | 0.95 | 0.67 | 0.53 | 0.19 | 0.58            |
| Austria               | 2.12                           | 1.61 | 1.37 | 1.19 | 1.57            | 3.09 | 2.33 | 1.95 | 1.67             | 2.26            | 2.50 | 1.79 | 1.46                 | 1.31 | 1.76            | 0.78 | 0.71 | 0.71 | 0.60 | 0.70            |
| Belgium               | 2.30                           | 1.64 | 1.52 | 1.39 | 1.71            | 3.16 | 2.35 | 2.15 | 2.19             | 2.46            | 3.02 | 2.26 | 2.12                 | 1.78 | 2.29            | 0.71 | 0.30 | 0.30 | 0.18 | 0.37            |
| Canada                | 1.91                           | 1.64 | 1.53 | 1.42 | 1.62            | 2.15 | 2.08 | 1.96 | 1.92             | 2.03            | 1.82 | 1.44 | 1.36                 | 1.34 | 1.49            | 1.75 | 1.40 | 1.27 | 1.01 | 1.36            |
| Czech Republic        | 2.64                           | 1.88 | 1.50 | 1.39 | 1.85            | 3.28 | 2.58 | 2.11 | 1.95             | 2.48            | 2.77 | 2.19 | 1.90                 | 1.82 | 2.17            | 1.87 | 0.85 | 0.48 | 0.42 | 0.90            |
| Denmark               | 1.66                           | 1.48 | 1.35 | 1.22 | 1.43            | 2.32 | 1.83 | 2.03 | 1.97             | 2.04            | 2.45 | 2.12 | 1.55                 | 1.26 | 1.85            | 0.23 | 0.48 | 0.48 | 0.45 | 0.41            |
| Finland               | 1.94                           | 1.49 | 1.34 | 1.29 | 1.52            | 2.75 | 2.26 | 2.18 | 2.13             | 2.33            | 2.36 | 1.77 | 1.58                 | 1.55 | 1.82            | 0.70 | 0.45 | 0.27 | 0.20 | 0.40            |
| France                | 2.38                           | 1.77 | 1.52 | 1.47 | 1.78            | 3.41 | 2.83 | 2.41 | 2.37             | 2.76            | 3.18 | 2.09 | 1.74                 | 1.68 | 2.17            | 0.54 | 0.40 | 0.40 | 0.35 | 0.42            |
| Germany               | 2.23                           | 1.80 | 1.41 | 1.29 | 1.68            | 2.57 | 2.15 | 1.99 | 1.86             | 2.14            | 2.95 | 2.41 | 1.90                 | 1.66 | 2.23            | 1.16 | 0.84 | 0.34 | 0.36 | 0.68            |
| Greece                | 2.75                           | 2.51 | 2.21 | 1.74 | 2.30            | 4.24 | 3.81 | 3.33 | 2.82             | 3.55            | 3.06 | 2.89 | 2.53                 | 1.91 | 2.60            | 0.96 | 0.82 | 0.79 | 0.49 | 0.77            |
| Hungary               | 2.66                           | 2.11 | 1.54 | 1.33 | 1.91            | 3.40 | 2.47 | 2.03 | 2.05             | 2.49            | 2.81 | 2.30 | 2.20                 | 1.69 | 2.25            | 1.78 | 1.57 | 0.38 | 0.24 | 0.99            |
| Iceland               | 2.03                           | 1.62 | 1.48 | 1.50 | 1.66            | 2.60 | 1.93 | 1.84 | 1.97             | 2.08            | 2.82 | 2.18 | 2.17                 | 2.07 | 2.31            | 0.68 | 0.74 | 0.43 | 0.45 | 0.58            |
| Ireland               | 1.86                           | 1.58 | 1.35 | 1.45 | 1.56            | 3.00 | 2.50 | 1.84 | 2.12             | 2.37            | 2.35 | 2.02 | 1.99                 | 1.98 | 2.08            | 0.23 | 0.23 | 0.23 | 0.26 | 0.23            |
| Italy                 | 2.36                           | 1.80 | 1.49 | 1.26 | 1.73            | 3.82 | 3.15 | 2.58 | 2.14             | 2.92            | 2.61 | 1.67 | 1.30                 | 1.22 | 1.70            | 0.65 | 0.59 | 0.58 | 0.42 | 0.56            |
| Japan                 | 2.11                           | 1.37 | 1.43 | 1.41 | 1.58            | 1.87 | 1.66 | 1.90 | 1.85             | 1.82            | 3.22 | 1.69 | 1.65                 | 1.67 | 2.06            | 1.24 | 0.75 | 0.74 | 0.71 | 0.86            |
| Korea                 | 2.56                           | 1.95 | 1.94 | 1.88 | 2.08            | 2.60 | 2.10 | 2.44 | 2.47             | 2.40            | 2.63 | 2.40 | 2.16                 | 1.87 | 2.26            | 2.44 | 1.37 | 1.23 | 1.30 | 1.58            |
| Luxembourg            |                                | 1.60 | 1.44 | 1.46 | 1.50            |      | 2.69 | 2.34 | 2.45             | 2.49            |      | 1.87 | 1.75                 | 1.71 | 1.78            | 0.29 | 0.22 | 0.22 | 0.21 | 0.24            |
| Mexico                | 2.76                           | 2.50 | 2.05 | 1.91 | 2.31            | 2.58 | 2.28 | 2.12 | 2.02             | 2.25            | 3.06 | 2.59 | 2.45                 | 2.19 | 2.57            | 2.63 | 2.63 | 1.58 | 1.52 | 2.09            |
| Netherlands           | 1.82                           | 1.49 | 0.96 | 0.92 | 1.30            | 2.97 | 2.28 | 1.44 | 1.43             | 2.03            | 2.22 | 1.92 | 1.31                 | 1.19 | 1.66            | 0.27 | 0.27 | 0.14 | 0.12 | 0.20            |
| New Zealand           | 1.45                           | 1.29 | 1.23 | 1.26 | 1.31            | 1.18 | 1.55 | 1.93 | 2.06             | 1.68            | 2.06 | 1.64 | 1.09                 | 1.18 | 1.49            | 1.10 | 0.66 | 0.66 | 0.53 | 0.74            |
| Norway                | 1.87                           | 1.56 | 1.54 | 1.46 | 1.61            | 2.81 | 2.18 | 2.20 | 2.13             | 2.33            | 2.19 | 1.88 | 1.82                 | 1.69 | 1.90            | 0.60 | 0.60 | 0.60 | 0.57 | 0.59            |
| Poland                | 3.19                           | 2.42 | 2.04 | 1.65 | 2.33            | 2.97 | 3.57 | 3.32 | 3.06             | 3.23            | 3.45 | 3.11 | 2.49                 | 1.64 | 2.67            | 3.15 | 0.59 | 0.33 | 0.24 | 1.08            |
| Portugal              | 2.59                           | 2.12 | 1.69 | 1.29 | 1.92            | 4.04 | 3.42 | 2.89 | 2.18             | 3.13            | 2.82 | 2.05 | 1.83                 | 1.35 | 2.01            | 0.91 | 0.91 | 0.35 | 0.35 | 0.63            |
| Slovak Republic       |                                | 2.18 | 1.62 | 1.29 | 1.69            |      | 3.07 | 2.36 | 2.17             | 2.53            |      | 2.15 | 1.74                 | 1.15 | 1.68            |      | 1.30 | 0.77 | 0.55 | 0.87            |
| Spain                 | 2.39                           | 1.79 | 1.59 | 1.44 | 1.81            | 3.69 | 2.49 | 2.16 | 1.86             | 2.55            | 3.06 | 2.47 | 2.20                 | 2.10 | 2.46            | 0.42 | 0.42 | 0.42 | 0.37 | 0.41            |
| Sweden                | 1.89                           | 1.50 | 1.61 | 1.52 | 1.63            | 2.21 | 1.91 | 2.39 | 2.22             | 2.18            | 2.85 | 1.99 | 1.81                 | 1.71 | 2.09            | 0.62 | 0.62 | 0.62 | 0.62 | 0.62            |
| Switzerland           | 2.49                           | 1.99 | 1.55 | 1.50 | 1.88            | 3.05 | 2.75 | 2.66 | 2.68             | 2.78            | 2.94 | 2.51 | 1.62                 | 1.56 | 2.16            | 1.46 | 0.71 | 0.37 | 0.26 | 0.70            |
| Turkey                | 3.28                           | 2.82 | 2.65 | 2.46 | 2.80            | 4.42 | 4.15 | 3.66 | 3.44             | 3.92            | 3.57 | 3.03 | 2.90                 | 2.78 | 3.07            | 1.86 | 1.29 | 1.40 | 1.16 | 1.43            |
| United Kingdom        | 1.32                           | 1.10 | 1.21 | 1.08 | 1.18            | 1.68 | 1.15 | 1.63 | 1.57             | 1.51            | 1.96 | 1.82 | 1.74                 | 1.49 | 1.75            | 0.32 | 0.32 | 0.25 | 0.20 | 0.27            |
| United States         | 1.50                           | 1.30 | 1.11 |      | 1.31            | 1.62 | 1.43 | 1.50 |                  | 1.52            | 1.97 | 1.64 | 1.23                 |      | 1.61            | 0.91 | 0.85 | 0.60 |      | 0.78            |
| Cross-country average | 2.21                           | 1.78 | 1.56 | 1.44 | 1.73            | 2.85 | 2.42 | 2.25 | 2.16             | 2.41            | 2.66 | 2.12 | 1.84                 | 1.66 | 2.06            | 1.08 | 0.79 | 0.58 | 0.49 | 0.74            |

Source: OECD Product Market Regulation database (See Koske *et al.*, 2015).

Note: Averages reflect the unweighted arithmetic averages. The cross-country average reflects the average value of specific PMR variable in a given year across countries. The country average reflects the average value a specific PMR variable takes for a specific country over the sample periods.

Chart 1: Overall Average Product Market Regulation Standings, 2013



Source: OECD PRM Database.

Note: The PMR index ranges from 0 to 6. Lower values connote regulations that are more competition friendly. In this respect, a value 0 identifies situations where existing regulations do not limit competition unnecessarily. The “Sample average” reflects the unweighted average PMR value of sample countries.

\* The US value is for 2008.

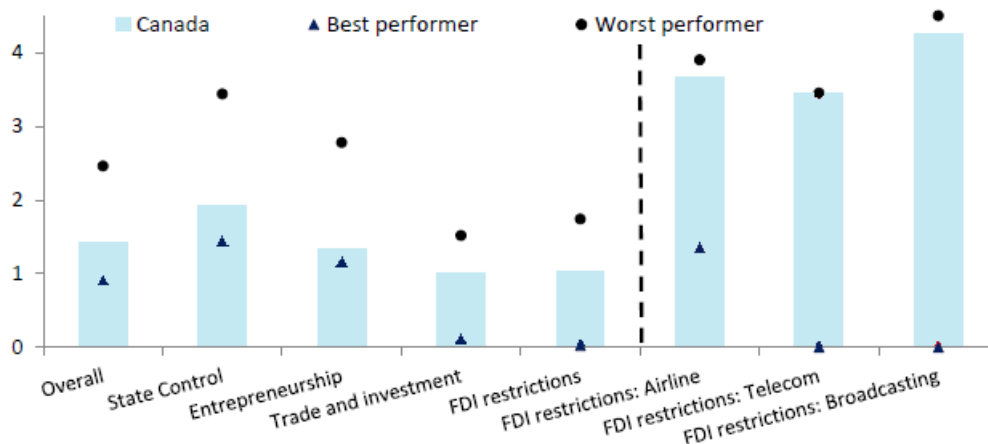
Table 1 shows three high-level PMR measures and their overall average in each year for the 30 OECD countries that compose our sample.<sup>5</sup> In 2013, Canada’s overall competitive level according to the PMR measures was near the sample median and average (Chart 1). This overall standing however hides a regulatory environment that was relatively competitive in many areas.<sup>6</sup> As shown by Chart 2, Canadian regulations related to state control inhibited competition relatively little as Canada’s PMR value was relatively close to that of Netherlands, the country with the most competition friendly state control regulations in the sample. Similarly, even though entrepreneurial barriers in

professional services and the retail sector were comparatively high, Canada’s average anti-competitive nature of regulations related to entrepreneurship was nearly as low as in the best performing sample country, the Slovak Republic. Canadian regulations that were fairly anti-competitive were those related to trade and investment. Here, Canada’s PMR was above the sample median. This standing was mainly driven by Canada’s barriers to FDI that were more anti-competitive than in most other sample country. Of particular note were Canada’s high FDI restrictions that affected the airline, telecommunications, and broadcasting sectors that influenced the general barriers to FDI measure.

5 The overall average PMR is the unweighted average PMR value for the State Control, Entrepreneurship, and Trade and Investment indicators.

6 Indeed, while Canada was the 16<sup>th</sup> and 26<sup>th</sup> in 2013 out of 30 OECD countries most competitive according to the overall and the trade and investment indicators, it was the 7<sup>th</sup> most competitive with respect to the entrepreneurship and state control indicators.

Chart 2: Canada's Relative PMR Performance by Component, 2013



Source: OECD PRM Database and OECD FDI restrictions Database.

Note: The PMR index ranges from 0 to 6. Lower values connote regulations that are more competition friendly. FDI restrictions is a subcomponent of the Barriers to trade and investment PMR measure. The FDI restrictions measure is, in part, a function of FDI restrictions in the Airline, Telecom and Broadcasting sectors.

Over time, the PMR measures declined in all countries, suggesting the regulatory frameworks are becoming more competitive. Increases in competitiveness however diminished over time. Chart 3 shows this as the overall PMR measure saw its greatest decline between 1998 and 2003 with only minor further declines. This was the case for Canada as well as the median, best and worst performing sample country. This potentially reflects that countries initially liberalized where it was easiest, leaving for the future further reform that would be harder to make (Koske *et al.*, 2015) or would have a smaller effect.

Table 1 and Chart 3 show Canada's PMRs became more competitive over time. However, these changes were not as substantial as in most other countries; while Canada's overall average PMR decreased by 0.48 points (1.91 to 1.42) from 1998 to 2013, the average and median decrease for sample countries was 0.79 and 0.85 respectively. This could have occurred if by 1998 Canada had already largely liberalized regulations that were easiest to change. Indeed, while

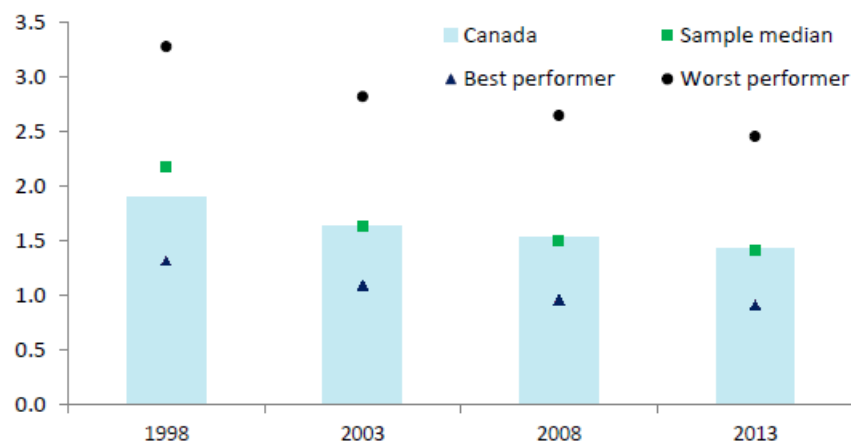
Canada's overall average PMR in 1998 was not as low as in the UK (1.32, the best performer in 1998) or the US (1.50), it was far lower than in Turkey (3.28, the worst performer in 1998) or the sample median (2.17). In fact, Canada's measure ranked it as the tenth most competitive regulatory framework in our sample in 1998. As a result of ranking relatively low initially on the PMR spectrum, Canada could have expected to see lower gains as liberalization could have been relatively more difficult than in most other countries.

### Economic Data

The economic data were obtained from the OECD productivity and national accounts databases<sup>7</sup> and the Penn World Tables (Version 7.0). These data sources provide international comparable data for various countries. They differ though in the periods they covered. OECD data extend forward enough in time to be able to be used with the most recent period available of PMR measures but some series do not go far enough back. Conversely, the Penn World

<sup>7</sup> These databases are available at stats.oecd.org.

Chart 3: Overall Average PMR Measure Over Time, 1998-2013



Source: OECD PRM Database.

Note: The PMR index ranges from 0 to 6. Lower values connote regulations that are more competition friendly.

Tables series extend far enough back in time but not enough forward to be compatible with the latest PMR data. As a result, we splice together these two data sources; we use OECD series and extend them back using Penn World Data. We use these data sources to determine the physical capital investment rate (i.e.  $s_{c,t}^k$ , annual physical capital investment as a share of GDP), population growth, and GDP per capita.

In creating the panel data we follow Islam (1995) and calculate  $s_{c,t}^k$  and  $n_{c,t}$  over multi-year periods. Specifically,  $s_{c,t}^k$  and  $n_{c,t}$  for 1998, 2003, 2008 and 2013 are averages calculated using data over the periods 1995-1999, 2000-2004, 2005-2009 and 2010-2014, respectively. These periods are chosen in part so that the year in which the PMR measures are available is near the midpoint of each period. Given the available PMR measures fall within each of these four periods, we presume these measures represent the average PMR level for each period in each respective country. Finally, the GDP per capita data used in our analysis

is the annual value of the last year of each five-year period in the sample. For example, in the 2010-2014 period, the dependant variable reflects GDP per capita in 2014.<sup>8</sup>

Merging the PMR and economic data leaves a panel of 30 OECD countries that have at least three or four consecutive years of data that we label as 1998, 2003, 2008 and 2013.<sup>9</sup> This gives an unbalanced panel with 116 observations. Given the constraints imposed by the OECD PMR measures, one may suspect estimates to be sensitive to small changes in the data or sample. This issue will only be alleviated with time as the time series length and country coverage expand.

Although consisting of only OECD members, our sample of countries is diverse. The sample ranges from advanced (e.g. G7 members) to emerging (e.g. Mexico, Poland, and Turkey) economies. This diversity is borne out, for example, by the range in the level of GDP per capita across sample countries. Expressed in internationally comparable dollars, GDP per capita in 2013

<sup>8</sup> Generally, a stronger relationship exists when we use GDP per capita in the year that coincides with the PMR measures. These results are not shown here but are available upon request.

<sup>9</sup> We only use the 30 OECD countries because the sparse availability of PMR measures over time for the other countries does not allow them to be included in our analysis.

**Table 2: Summary Statistics**

|  | Full sample: All<br>sample countries |        | Canada |       |
|--|--------------------------------------|--------|--------|-------|
|  | mean                                 | sd     | mean   | sd    |
| A. Product market regulations                      |                                      |        |        |       |
| Overall average high-level PMR                     | 1.74                                 | 0.48   | 1.62   | 0.21  |
| State control                                      | 2.42                                 | 0.67   | 2.03   | 0.11  |
| Entrepreneurship                                   | 2.07                                 | 0.56   | 1.49   | 0.22  |
| Trade and investment                               | 0.73                                 | 0.56   | 1.36   | 0.31  |
| B. Economic data (USD, constant prices, 2010 PPPs) |                                      |        |        |       |
| GDP per capita                                     | 35,238                               | 13,235 | 38,992 | 2,737 |
| Previous period GDP per capita                     | 32,565                               | 12,911 | 36,276 | 3,768 |
| Productivity (GDP per hour)                        | 43.72                                | 15.31  | 44.70  | 3.07  |
| Previous period productivity                       | 40.86                                | 15.29  | 42.11  | 3.27  |
| Physical capital investment rate<br>(per cent)     | 22.7                                 | 3.8    | 21.8   | 2.6   |
| Population growth rate<br>(per cent)               | 0.6                                  | 0.5    | 1.0    | 0.1   |
| C. Education data (per cent)                       |                                      |        |        |       |
| Secondary/tertiary education<br>enrolment rate     | 13.0                                 | 2.4    | 12.4   | 0.7   |

Sources: OECD PMR, OECD ESTAT database. Note: Averages and standard deviations are based on variable values for all 30 sample countries over the entire sample period. Investment reflects total economy investment and includes investment in dwellings. Investment is expressed in real terms, constant price PPP adjusted USD. Finally, enrollments rates are based on the total number of all students in all age groups enrolled in secondary/tertiary education.

ranged from a minimum of \$18,135 in Mexico to a maximum of \$102,101 in Luxemburg.

In our empirical work, we use GDP per capita as the dependant variable, consistent with the growth literature. Although GDP relative to the numbers of workers or hours worked would be more consistent with our theoretical model, GDP per capita is used for two main reasons. First, data on employment or hours are not as widely available on a comparable basis. For example, OECD labour data are often missing countries or years or contain series with various breaks. Second, using GDP per worker may lead to misleading conclusions on the impact of regulatory reforms on living standards. For example, if reforms were to increase the aggregate employment rate by

encouraging those previously not searching for work — and who may be less-skilled — to enter the labour force, it could lead to a fall in GDP per worker although per capita GDP would increase.<sup>10</sup> Nevertheless, later in the article, we test the robustness of our baseline results by using GDP per hour rather than GDP per capita as the dependant variable.

### Education Data

Following Mankiw *et al.* (1992) we proxy the national investment rate in human capital by the school enrolment rate (i.e.  $s_{c,t}^h$ ). However, unlike Mankiw *et al.* we use the rate of enrolment in tertiary and secondary education rather than just secondary education. This difference extends from the difference in samples used. Mankiw *et al.* use a

<sup>10</sup> This is a possible reason why previous work focusing only on OECD countries (e.g. Nonneman and Vanhoudt, 1996; Arnold *et al.*, 2007; Boulhol *et al.*, 2008) used GDP per capita as the dependant variable.

broader sample of developed and developing countries that would likely allow sufficient variation in the secondary school enrolment rate. In contrast, not as much variation is expected in the enrolment rate in secondary education of countries in our sample because most of our sample countries are developed. Consequently, we use the combined enrolment in tertiary and secondary education because this rate may provide more variation for the sample of countries we use. Panel C of Table 2 shows the summary statistics for this variable.

The data on tertiary enrolment rates are obtained from the OECD Education and Training database on student enrolment. These data are available for all sample countries on an annual basis for most years since 1990.<sup>11</sup>

## Results and Robustness

The OECD provides national measures of PMRs at various levels of aggregation. For the purposes of this note we focus on an overall average PMR measure before assessing more specifically what regulations most affect growth.

## Results

### Overall Average High-level PMR

As a baseline, Column 1 and 2 of Table 3 present OLS estimates of equation (1) when country-fixed effects are respectively excluded and included in estimation. In comparing these columns, it can be inferred that accounting for constant country-specific factors is important. Without country-fixed effects anti-competitive regulations are seen to have a positive although statistically insignificant effect on GDP per

capita. However, this result may be due to estimation bias stemming from omitted variables, a type of bias Islam (1995) suggests may exist in cross-sectional growth regressions that fail to include country fixed effects. Indeed, if country fixed effects are included in estimation, the conclusion about the potential impact of PMRs changes substantially. With fixed effects, Column 2 suggests PMRs are negatively related to growth in a statistically significant way. Specifically, the marginal impact of the PMR measure is estimated to be -0.062. Although country fixed effects resolve omitted variable bias in estimation, including these dummy variables introduces endogeneity that can also bias results. This endogeneity arises because the lagged dependant variable on the right-hand-side of equation (1) becomes correlated with the error term when country fixed effects are used. Moreover, this endogeneity is exacerbated when the time dimension of each panel is short, as in our case. Going forward, to resolve this endogeneity and the original omitted variable bias, we focus exclusively on a general method of moments (GMM) estimation procedure outlined by Arellano and Bond (1991). Briefly, this procedure first addresses the omitted variable problem by first differencing the estimation equation and then using instrumental variables (IVs) to deal with the correlation between the lagged dependent variable on the right-hand-side and the error term. Finally, it is important to note that the Arellano and Bond method does not address any issues related to the potential endogeneity inherent when using a policy variable like

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11 However, the data are missing in some years for some countries. Fortunately, every country in the sample has these data in at least one year in each of the sample periods. Consequently, any gaps in the data may not be a serious problem as we are ultimately interested in the average enrolment rate in each country over each period. As long as we have at least one year of enrolment in each period we should have a sufficient approximation of the actual average enrolment rate in the period.

**Table 3: Effect of Overall High-Level Average PMR on GDP per Capita**

|   | OLS<br>(1)         | OLS<br>(2)          | AB GMM<br>(3)       |
|---|--------------------|---------------------|---------------------|
| Overall average high-level PMR  | 0.0053<br>(0.023)  | -0.0621*<br>(0.029) | -0.0750*<br>(0.034) |
| log(physical capital investment rate)                                   | 0.081**<br>(0.031) | 0.120*<br>(0.052)   | 0.182**<br>(0.059)  |
| log(secondary/tertiary education enrolment rate)                        | 0.076*<br>(0.030)  | 0.099**<br>(0.036)  | 0.086*<br>(0.034)   |
| log(pop growth rate + 0.05)   | 0.028<br>(0.064)   | -0.133<br>(0.135)   | -0.241<br>(0.144)   |
| log(previous period GDP per capita)                                     | 0.934**<br>-0.023  | 0.682**<br>-0.1     | 0.802**<br>(0.129)  |
| Year fixed-effects  | YES                | YES                 | YES                 |
| Country fixed effects   | NO                 | YES                 | NO                  |
| R2/Pseudo-R2  | 0.98               | 0.99                | 0.97                |
| Observations  | 116                | 116                 | 86                  |
| Number of countries   | 30                 | 30                  | 30                  |
| Arellano/Bond second order auto-correlation coefficient (P-value below) | NA<br>NA           | NA<br>NA            | 1.26<br>(0.21)      |

Robust standard errors in parentheses. \*\*  $p < 0.01$ , \*  $p < 0.05$ . The pseudo-R2 is given by the correlation between the actual and predicted outcome variable.

the PMR measures in cross-country growth regressions.

Column 3 of Table 3 presents results based on the preferred Arellano and Bond estimation method. Using this method, the impact of the overall average PMR measure remains negative and statistically significant. However, the impact increases in magnitude; the marginal impact of the overall average PMR measure is estimated to equal -0.075.<sup>12</sup> These estimates thus suggest that lowering the Canadian PMR measure as it stood in 2013 (1.42) to the US level for 2008, the latest year for which data are available (1.11), a feasible

level in a comparable but generally more competitive economy, is expected to increase GDP per capita by about 2.4 per cent over the medium term (i.e. five years).<sup>13</sup> After 20 years, the change would yield an increase in GDP per capita of about 7 per cent. Due to estimation variability, however, the impact of these changes could be considerably lower. Based on the lower bound of the medium-term estimate's 95 per cent confidence interval, the medium-term and 20-year impacts on GDP per capita could be as low as 0.3 and 0.8 per cent respectively given the same estimate of  $\beta_5$ , the lagged GDP per capita's coefficient.

<sup>12</sup> It is important to note that with four years of observations it is possible to test an underlying assumption of the Arellano and Bond method, namely that the second order autocorrelation of the first differenced errors is insignificant. Based on our sample this auto-correlation is statistically significant at neither the 1 per cent nor 5 per cent level.

<sup>13</sup> We calculate the 2.4 per cent increase in GDP per capita by multiplying the coefficient on overall PMR variable in column 3 (-0.075) with the difference in this measure between US in 2008 and Canada in 2013 (about -0.31) and 100.

**Table 4: Effect of Underlying Regulations on GDP per Capita in OECD Countries**

|   | Arellano/Bond GMM  |                     |                      |
|---|--------------------|---------------------|----------------------|
|   | (1)                | (2)                 | (3)                  |
| State control PMR   | 0.0037<br>(0.015)  |                     |                      |
| Public Ownership  |                    | 0.0068<br>(0.013)   | 0.0075<br>(0.014)    |
| Involvement in business operation                                       |                    | -0.0016<br>(0.014)  | -0.0009<br>(0.014)   |
| Entrepreneurship PRM  | -0.043*<br>(0.020) |                     |                      |
| Complexity of regulatory procedures                                     |                    | -0.011<br>(0.007)   | -0.012<br>(0.007)    |
| Administrative Burden on start-ups                                      |                    | -0.032<br>(0.018)   | -0.034<br>(0.018)    |
| Regulatory protection of incumbents                                     |                    | -0.010<br>(0.020)   | -0.012<br>(0.020)    |
| Trade and investment PMR  | -0.039<br>(0.026)  |                     |                      |
| Explicit barriers to trade and investment                               |                    | -0.0365*<br>(0.016) |                      |
| Barriers to FDI   |                    |                     | -0.0392**<br>(0.013) |
| Tariff barriers   |                    |                     | -0.013<br>(0.008)    |
| Other barriers to trade and investment                                  |                    | -0.016<br>(0.014)   | -0.016<br>(0.014)    |
| Other controls  | YES                | YES                 | YES                  |
| Year fixed-effects  | YES                | YES                 | YES                  |
| Country fixed-effects   | NO                 | NO                  | NO                   |
| Pseudo R2   | 0.97               | 0.97                | 0.97                 |
| Observations  | 86                 | 86                  | 86                   |
| Number of countries   | 30                 | 30                  | 30                   |
| Arellano/Bond second order auto-correlation coefficient (P-value below) | 1.074<br>(0.28)    | 1.119<br>(0.26)     | 1.094<br>(0.27)      |

Robust standard errors in parentheses. \*\* p<0.01, \* p<0.05. The pseudo-R2 is given by the correlation between the actual and predicted outcome variable.

### PMRs by Component

The arbitrary nature in which OECD PMR indicators are aggregated to the overall average PMR could allow the true relationships between regulations and growth to be distorted. As well, some types of regulations may not negatively affect GDP per capita. For this reason, we re-estimate equation (1) using all three high-level PMR measures. We also re-estimate using the more disaggregated measures underlying the high-level measures to further avoid arbitrary weightings and to obtain a better indication of more specific regulations that obstruct growth.

Table 4 suggests reducing barriers to trade and investment may be what yields the GDP gains seen on Table 3. In disaggregating the overall average PMR into its three higher-level PMR measures, Column 1 in Table 4 suggests that regulations creating barriers to entrepreneurship are a drag on GDP per capita. Indeed, the estimated marginal impact of these barriers is -0.043

and is the only measure to be statistically significant. It is reasonable to suspect that less entrepreneurship can reduce growth. However, further disaggregation of the high-level PMRs may be still warranted to determine more narrowly the regulations that inhibit growth.

In disaggregating the high-level PMRs into their narrower components, Column 2 suggests barriers to entrepreneurship may not be the main driver of lower growth. Results in this column suggest instead barriers related to trade and investment have a significant impact. While no underlying PMR related to entrepreneurship has a statistically significant impact, regulations creating barriers to FDI and trade do; the marginal effect of this PMR is estimated to equal -0.037.

Finally, in distinguishing between regulations creating barriers to trade and investment (i.e. FDI), Column 3 shows that the impediment is created by barriers to FDI. These barriers would arise when, for

example, any equity limits or obligatory screening and approval procedures exist for foreign investors as they attempt to acquire domestic businesses.<sup>14</sup> Canada's barriers to FDI are comparatively high in the telecom and retail sectors. The marginal effect of regulations that explicitly impede FDI is estimated to be -0.039 with a statistical significance of one per cent. Given this estimate, if Canada were to reform and make its policies as competitive as in the US, GDP per capita would increase by 2.0 per cent in the medium term and 5.3 per cent after 20 years. Based on the lower bound of the 95 percent confidence interval for the medium term impact, the effect would be as slow as 0.7 per cent in the medium term and 1.8 per cent after 20 years.

## Extensions and Robustness

### GDP per hour as the dependant variable

According to our theoretical model, GDP per hour or productivity should be the dependant variable in our empirical work rather than GDP per capita (Durlauf *et al.*, 2005). The likely reason why most of the literature does not use GDP per worker or hours worked as the dependant variable is because these hours or employment data are not broadly available. Indeed, the productivity measures are not available for all current 35 OECD countries over the entire sample period in most OECD

databases. Furthermore, Korea experienced dramatic variation in its number of total hours worked during the Asian Crisis of the late 1990s and so this country's productivity measures likely incorporate substantial noise. If Korea is a general example, GDP per capita may also be the preferred dependant variable because it could be less susceptible than GDP per hour to noise introduced by the business cycle or economic crises.

Given the different considerations of which dependant variable is most appropriate for our work, in this section we test the robustness of our baseline results by using GDP per hours worked as the dependant variable.<sup>15</sup> The list of countries is the same as for the baseline results with the exception of Korea. Because outliers are known to affect significantly the empirical results in the growth literature (Durlauf *et al.*, 2005), we exclude Korea as an outlier.<sup>16</sup>

Panel A of Table 5 shows the GMM estimates of the regression model that differ based on the level of disaggregation of the PMR measures. In general, some evidence exists that anti-competitive regulations related to trade and investment are what matter most for growth. However, this evidence is not definitive. Column 1 shows that the only high-level PMR measure to have a statistically significant relationship with productivity is the one related to barriers to trade and investment.

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14 Other regulations featuring in the PMR measure for barriers to FDI are restrictions on the employment of foreigners as key personnel and operational restrictions (e.g. restrictions on branching and on capital repatriation or on land ownership) (Kalinova *et al.*, 2010). This is the same as for the OECD's FDI restrictiveness index. As a consequence, countries may raise FDI barriers even if foreigners are able to purchase fully domestic companies because they may face restrictions in other dimensions.

15 The GDP per hour series is obtained from the OECD Productivity database.

16 Korea is an outlier because of its amazing productivity growth observed over our sample period; GDP per hour worked in Korea increased by 100 per cent between 1995 and 2010 according to OECD data! This was about three times greater than the average or median productivity growth rate observed in our sample. This feat stands out in addition to Korea's significant variation in the number of hours worked during the Asian Crisis of the late 1990s.

**Table 5: Robustness - Productivity and Sample**

|   | A: Productivity as dep. var. |                     |                      | B: Sample excludes poorest 3 countries |                      |                      |
|---|------------------------------|---------------------|----------------------|--|----------------------|----------------------|
|   | (1)                          | (2)                 | (3)                  | (4)                                    | (5)                  | (6)                  |
| State control   | -0.0174<br>(0.011)           |                     |                      | 0.0124<br>(0.013)                      |                      |                      |
| Public Ownership  |                              | -0.0202*<br>(0.008) | -0.0216**<br>(0.008) |  | 0.0118<br>(0.0120)   | 0.0106<br>(0.011)    |
| Involvement in business operation                                       |                              | 0.0041<br>(0.012)   | 0.0046<br>(0.012)    |  | 0.0118<br>(0.012)    | 0.0122<br>(0.012)    |
| Entrepreneurship  | -0.0156<br>(0.017)           |                     |                      | -0.0428*<br>(0.020)                    |                      |                      |
| Complexity of regulatory procedures                                     |                              | -0.0092<br>(0.006)  | -0.0098<br>(0.005)   |  | -0.0056<br>(0.006)   | -0.0060<br>(0.006)   |
| Administrative burdens on start-ups                                     |                              | 0.0215<br>(0.0166)  | 0.0191<br>(0.017)    |  | -0.0472**<br>(0.018) | -0.0504**<br>(0.019) |
| Regulatory protection of incumbent                                      |                              | -0.0096<br>(0.019)  | -0.0086<br>(0.019)   |  | -0.0178**<br>(0.017) | -0.0154**<br>(0.016) |
| Trade and investment  | -0.0328*<br>(0.015)          |                     |                      | -0.0831**<br>(0.025)                   |                      |                      |
| Explicit barriers to trade and investment                               |                              | -0.0010<br>(0.016)  |                      |  | -0.0253<br>(0.031)   |                      |
| Barriers to FDI   |                              |                     | 0.0074<br>(0.028)    |  |                      | -0.0268*<br>(0.012)  |
| Tariff barriers   |                              |                     | -0.0078<br>(0.010)   |  |                      | -0.0024<br>(0.022)   |
| Other barriers to trade and investment                                  |                              | -0.0135<br>(0.010)  | -0.0128<br>(0.010)   |  | -0.0463**<br>(0.009) | -0.0453**<br>(0.010) |
| Other controls  | YES                          | YES                 | YES                  | YES                                    | YES                  | YES                  |
| Year fixed-effects  | YES                          | YES                 | YES                  | YES                                    | YES                  | Yes                  |
| Country fixed effects   | NO                           | NO                  | NO                   | NO                                     | NO                   | NO                   |
| Pseudo R2   | 0.86                         | 0.83                | 0.83                 | 0.96                                   | 0.96                 | 0.96                 |
| Observations  | 82                           | 82                  | 82                   | 77                                     | 77                   | 77                   |
| Number of countries   | 29                           | 29                  | 29                   | 27                                     | 27                   | 27                   |
| Arellano/Bond second order auto-correlation coefficient (P-value below) | -1.44<br>(0.15)              | -1.69<br>(0.09)     | -1.55<br>(0.12)      | 0.41<br>(0.68)                         | 0.27<br>(0.79)       | 0.17<br>(0.87)       |

Sample Robust standard errors in parentheses. \*\*  $p < 0.01$ , \*  $p < 0.05$ .

The pseudo-R2 is given by the correlation between the actual and predicted outcome variable.

Note: In Panel B, the poorest 3 countries are: Mexico, Poland and Turkey.

Determination of the poorest countries is based on PPP adjusted GDP per capita in 1998.

Its marginal effect is -0.033 and is of similar magnitude to the point estimates of underlying PMR measures that are statistically significant in Table 4 (i.e. -0.037 and -0.039). However, unlike Table 4, Column 2 and 3 in Table 5 show that no underlying measure of the high-level barriers to trade and investment PMR are statistically significant. Instead, these columns show that regulations directing the scope of public ownership are what matter for productivity growth. This is the only occasion when these regulations are found to have any sort of statistically significant relationship with productivity or GDP per capita. Consequently, we conclude that evidence exists showing that more anti-competitive regulations related to trade and investment limit GDP per capita and GDP per hour. However, this evidence should be taken with caution.

### Sample Countries

Sample countries are currently OECD members and can be considered as developed or as fairly advanced emerging economies.

Nevertheless, to consider what might be the impact of reducing the anti-competitive nature of regulations in more developed countries such as Canada, some sample countries might not be sufficiently advanced to be comparable. To this end, to assess the robustness of main results in Tables 3 and 4, we drop the poorest three countries (as judged by PPP adjusted GDP per capita in 1998) from the sample.

After dropping, Turkey, Poland and Mexico from the sample (i.e. the poorest sample countries in 1998), results in Panel B of Table 5 continue to indicate that regulations erecting barriers to trade and investment inhibit growth. That is, the main finding gleaned from Table 4 is robust. In all three specifications, a component of barriers to trade and investment is negatively and statistically significantly related to GDP per capita. For example, the marginal effect of the high-level trade and investment PMR measure in Column 4 is estimated to be -0.083. With further disaggregation, as Column 5 shows, this effect emerges from regulations labeled as

“other barriers to trade and investment.” These regulations pertain in part to the differential treatment of foreign suppliers and barriers to trade facilitation that would arise when, for example, foreign suppliers are treated less favourably regarding taxes or eligibility to subsidies than domestic suppliers. The combined marginal effect of these regulations is estimated to be -0.046. With further disaggregation, Column 6 shows that regulations creating explicit barriers to FDI are an additional source of lower GDP per capita; though smaller in magnitude than in Column 3 of Table 4, the marginal effect is negative (i.e. -0.027) and statistically significant.

An added finding from Columns 5 to 6 is that the source of the lower growth might be found more broadly than in just regulations related to barriers to trade and investment. Regulations limiting entrepreneurship might be more germane in inhibiting growth. Specifically, as Columns 5 and 6 suggest, administrative burdens on start-ups are statistically significantly related to growth.

## Conclusion

Our results suggest changing regulations to make them more competition friendly, while maintaining high standards of health and safety and environment protection, could have a positive impact on GDP per capita in Canada. Specifically, GMM estimates suggest that making Canadian regulations as competitive-friendly as in the United States with respect to FDI, as

measured by the OECD PMR measures, could increase GDP per capita by 2.0 per cent over the first five years and 5.3 per cent after 20 years as the capital stock increases. Such a change would in part entail relaxing, to the same extent as in the United States, Canadian equity limits or obligatory screening and approval procedures for foreign investors as they attempt to acquire domestic businesses. Since 2013 some FDI related regulations have been reformed and so further changes to reach the US benchmark are not as large and so may not generate as significant gains.

Our estimates are of similar magnitude to estimates elsewhere in the literature. Using Italian firm-level data, Lanau and Topalova (2016) suggest decreasing the PMR measure in nine regulated industries by a comparable amount as we do here would increase average total factor productivity in downstream industry by about 7.5 per cent.<sup>17</sup> Gal and Hijzen (2016) find that “the short-term effects of product market reforms are positive and strengthen over time.” At the firm level, major reform in 10 regulated industries seems to lead output to increase by about 3 per cent and employment between 1.5 and 2 per cent after two years, suggesting labour productivity also increases commensurately over this period.<sup>18</sup>

Finally, focusing on network industries across 26 industrialized countries, Bouis *et al.* (2016) find that major product market regulations that have facilitated entry have

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17 This estimate is based on the estimated impact of decreasing the PMR measure by one standard deviation. The change needed to make the Canadian barrier to FDI PMR level to the United States in 2008 is equivalent to 1.25 standard deviations of this variable in 2013.

18 One way Gal and Hijzen (2016) define “major reform” is as any annual change in their PMR regulation indicator that is greater than the 95th percentile. For our work, the change necessary to bring Canada level to the US PMR value for barriers to FDI is about the same as the 95th percentile of changes in this measure among OECD countries from 2008 to 2013.

allowed increases in output and productivity respectively of about 10 to 14 per cent after only about 5 years after reforms.

As suggested by Gal and Hijzen (2016) the long-term benefits of product market reform are well accepted though adjustment costs make it unclear what the net gains are in the shorter term. However, the work here and that of Gal and Hijzen (2016) and Egert and Gal (2016) suggest that net benefits of reform can be fairly immediate. As well, appropriately designed policies (e.g. active labour market policies) could be used to complement regulatory reform by mitigating some of the short-run costs of adjustment. As for the impact of PMR reform on income inequality, the impact is unclear. Reform seems to increase employment, which can diminish household income inequality, but it also widens wage disparities (OECD, 2011). Moreover, given that reform can impact people in the same part of the income distribution differently depending on where the reform bites in the economy, determination of the impact of PMR reform on income dispersion may need to be done on a case by case basis (OECD, 2014).

Given our analysis, some caveats are necessary. Some are relatively minor. For example, our findings may overestimate the net welfare gains arising from alignment with the United States. This may arise as the improved economic outcomes we measure come at the cost of exacerbating any negative externalities of competition that we cannot account for (e.g. changes in income inequality). Another minor caveat is that our findings may be sensitive to data revisions or other changes in the sample. This arises because data limitations give us

only a small sample with which to work.

Other caveats are more fundamental. The theoretical model we use does not endogenize the technological growth rate. This limitation may be important since regulations may affect this rate. Indeed, Conway and Nicoletti (2007) suggest that barriers to competition in Canada discouraged firms from exploiting advances in information and communication technology between 1980 and 2005. Another fundamental caveat is that the relationship between GDP and PMRs may be endogenous and so cause our estimates to be biased.<sup>19</sup> Given the different ways GDP and PMRs could be endogenously related it is difficult to assess the direction of any bias. Instrumental variable techniques could be used to obtain unbiased estimates but this approach often proves difficult to carry out satisfactorily and without controversy.

Finally, we note regulatory reform undertaken alone by any one level of government or self-regulating body may yield gains that are smaller than what we estimate. This is because the regulations, laws and other rules comprising the general regulatory environment and that are reflected by the PMR measures fall under various jurisdictions. Consequently, a concerted effort between all stakeholders would be needed to achieve the needed reforms and commensurate gains.

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## Technical Appendix

Following the treatment of the Solow model in some parts the growth literature, we assume each country  $c$  operates a constant returns to scale aggregate production,  $F_c(\cdot)$ , benefiting from total factor productivity (TFP),  $A_c(t)$ . Moreover, we assume production utilizes only three inputs: physical capital ( $K_c(t)$ ), human capital ( $H_c(t)$ ), and labour ( $L_c(t)$ ). For simplicity, the aggregate production function is assumed to be Cobb-Douglas and characterized by,

$$F(K_c(t), H_c(t), A_c(t)L_c(t)) = K_c(t)^\alpha H_c(t)^\theta [A_c(t)L_c(t)]^{1-\alpha-\theta} \quad (2)$$

In this functional form,  $\alpha$  and  $\theta$  are positive fractions, and  $\alpha + \theta \in (0, 1)$ .

As in the Solow model, we assume TFP

increases exogenously over time with technological progress. In our model, the rate of technological progress is assumed to be the same across all countries and constant over time. As a result, the path of TFP is given by,

$$A_c(t) = A_c(0)e^{gt} \quad (3)$$

In this equation,  $A_c(0)$  is country  $c$ ’s initial TFP level.

We introduce the effect of PMRs into the model as a wedge between what is invested in physical and human capital and what builds either type of capital. As in the Solow model, a country invests a share of aggregate output to build new capital to replace depreciated capital and potentially augment its stock. In our model, the shares of output invested in physical and human capital

are represented respectively by  $s_{c,t}^k$  and  $s_{c,t}^h$ . However, unlike the canonical Solow model, we assume that only a portion of investments builds productive capital. As a result, for capital type (either physical ( $k$ ) or human ( $h$ )) the effective investment rate is given by  $s_{c,t}^x G^x$  (PMR). Here, the value of  $G^x$  (PMR)  $\in [0, 1]$  and is a decreasing function of PMR (i.e.  $G^x(\text{PMR}) < 0$ ). In this respect, PMR is taken to be a measure reflecting the anti-competitive nature of the regulatory framework that wastes resources and is assumed to take on non-negative values (i.e.  $\text{PMR} \in [0, \infty)$ ).

Defining, physical and human capital per effective worker as  $k_c(t) = \frac{K_C(t)}{L_C(t)}$  and  $h_c(t) = \frac{H_C(t)}{L_C(t)}$ , the Solow model has two fundamental equations, one for each type of capital per effective worker. Given these two fundamental equations we can derive the steady state levels for each type of capital. These are

$$k_{c,t}^* = [(s_{c,t}^k G^k(\text{PMR}))^{1-\theta}]^{\frac{1}{1-\alpha-\theta}} [(s_{c,t}^h G^h(\text{PMR}))^\theta]^{\frac{1}{1-\alpha-\theta}} [n_{c,t} + g + \delta]^{-\frac{1}{1-\alpha-\theta}} \quad (4)$$

and

$$h_{c,t}^* = [(s_{c,t}^k G^k(\text{PMR}))^\alpha]^{\frac{1}{1-\alpha-\theta}} [(s_{c,t}^h G^h(\text{PMR}))^{1-\alpha}]^{\frac{1}{1-\alpha-\theta}} [n_{c,t} + g + \delta]^{-\frac{1}{1-\alpha-\theta}} \quad (5)$$

. By linearizing the system of fundamental

equations around  $k_{c,t}^*$  and  $h_{c,t}^*$  we can solve the system to express GDP per worker as a function of exogenous parameters, a country's PMR, and the lagged value of GDP per worker. If we assume  $G_{c,x}(\text{PRM}) = W_{c,x} e^{\gamma_x \text{PRM}}$  for  $x \in (k, h)$ , the dynamic equation is expressed specifically as,

$$\begin{aligned} \ln \frac{Y_c(t)}{L_c(t)} = & (\alpha\gamma_k + \theta\gamma_h) \left( \frac{1 - e^{-\lambda\tau}}{1 - \alpha - \theta} \right) \text{PMR} + \\ & \alpha \left( \frac{1 - e^{-\lambda\tau}}{1 - \alpha - \theta} \right) \ln(s_{c,t}^k) + \\ & \theta \left( \frac{1 - e^{-\lambda\tau}}{1 - \alpha - \theta} \right) \ln(s_{c,t}^h) + \\ & e^{-\lambda\tau} \ln \frac{Y_c(t-\tau)}{L_c(t-\tau)} - \\ & (\alpha + \theta) \left( \frac{1 - e^{-\lambda\tau}}{1 - \alpha - \theta} \right) \ln(n_{c,t} + g + \delta) + \\ & [(1 - e^{-\lambda\tau}) A_c(0) + \\ & \left( \frac{1 - e^{-\lambda\tau}}{1 - \alpha - \theta} \right) \ln(W_k^\alpha W_h^\theta)] + \\ & (t - e^{-\lambda\tau(t-\tau)})g \end{aligned} \quad (6)$$

Once a random shock term is added to equation (6), the equation can then be simplified to be expressed as equation (1),

$$\begin{aligned} \ln \frac{Y_{c,t}}{L_{c,t}} = & \beta_1 \text{PMR}_{c,t} + \beta_2 \ln s_{c,t}^k + \beta_3 \ln s_{c,t}^h + \\ & \beta_4 \ln(n_{c,t} + g + \delta) + \beta_5 \ln \frac{Y_{c,t-\tau}}{L_{c,t-\tau}} + \\ & \eta_c + m_t + \epsilon_{c,t} \end{aligned} \quad (1)$$

# Accounting for Slower Productivity Growth in the Canadian Business Sector after 2000: The Role of Capital Measurement Issues

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## ABSTRACT

Labour productivity growth and multifactor productivity (MFP) growth slowed in Canada and other advanced economies after 2000. This article focuses on the issues that are associated with measurement of capital and examines the roles of intangible capital, natural capital, public infrastructure capital and capacity utilization in explaining slower productivity growth. To do that, the article presents an extended growth accounting framework that is used to examine the role of the different types of capital in labour and multifactor productivity growth. It finds that about one quarter of the decline in multifactor productivity growth in the Canadian business sector between 1980-2000 and 2000-2015 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 utilization of capital in the manufacturing sector. The decline in labour and multifactor productivity growth after 2000 is not related to intangible capital and public infrastructure capital.

Labour productivity growth and multifactor productivity (MFP) growth slowed in the Canadian business sector after 2000 (Baldwin and Willox, 2016; Almon and Tang, 2011; Rao, Sharpe and Smith, 2005).<sup>2</sup> Labour productivity (value added per hour

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<sup>2</sup> While the productivity growth slowdown is widespread in advanced economies, the timing of the slowdown differs. In the United States, the productivity growth slowdown occurred in 2004 after the rapid productivity growth in the 1990s and early 2000s (Byrne *et al.*, 2016; and Cette *et al.*, 2016). For many European countries, the slowdown occurred in the mid-1990s (Cette *et al.* 2016; OECD, 2016). For Canada, the productivity growth slowdown occurred after 2000 (Baldwin and Willox, 2016).

worked) growth in the Canadian business sector declined from 1.7 per cent per year in 1980-2000 to 1.0 per cent per year in 2000-2015.<sup>3</sup> MFP growth declined from 0.4 per cent per year to -0.2 per cent per year between the 1980-2000 and 2000-2015 periods. This recent slowdown in productivity growth also occurred in the United States and other developed economies (Byrne, Fernald, and Reinsdorf, 2016; OECD, 2015).

Previous studies have identified a number of potential explanations for this development. They include a slower pace technological progress, a slowdown in the diffusion of innovation, a decline in competitive intensity, a fall in business dynamism, and the misallocation of resources due to the sharp decline in real interest rates (Baily and Montalbano, 2016; Cette, Fernald and Mojon, 2016; OECD, 2015; Murray, 2017 and 2018).

A number of measurement challenges have also been suggested as potential explanations. They include the measurement of gross domestic product and knowledge capital in a digital economy, the measurement of natural resource capital in the resource extraction sectors, the effect of public infrastructure capital, and the effect of cyclical fluctuations in the utilization of capital (Ahmad and Schreyer, 2016; Byrne *et al.*, 2016, Rao *et al.*, 2005).

This article focuses on the issues that are associated with measurement of capital and examines the roles of intangible capital, natural capital, public infrastructure capital and capacity utilization for slower productivity growth in Canada after 2000. First, the article extends the asset coverage to include intangible capital not already included in the System of National

Accounts (SNA), natural capital and public infrastructure capital so as to develop a more comprehensive measure of capital flows and services and to better understand the role of investment in output and labour productivity growth. Intangible knowledge capital such as innovative property (scientific and non-scientific R&D, design, product development, mineral exploration and the production of the artistic originals), economic competencies (firm-specific investment in brand equity, human and organizational capital), and computerized information (software and databases) has been identified as an important source of output growth and productivity growth. But growth accounting and national accounts currently only include R&D, software and mineral exploration in measured capital input. Natural capital represents an important input to the mining and oil and gas extraction sector, but it is excluded in the measure of capital input to the sector. Public infrastructure capital contributes to output and productivity growth of the business sector, but is often not included in the growth accounts for this sector.

While expanding the asset coverage to include intangible capital, natural capital and public infrastructure capital will affect MFP growth, the extent to which it accounts for the slowdown in labour productivity and multifactor productivity growth is not known.

Second, the article focuses on the role of short-run changes in the utilization of capital input for the slower MFP growth in manufacturing after 2000. The utilization of capital declined in the Canadian manufacturing sector in the early

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<sup>3</sup> The weak productivity growth in the business sector in the 2000-2015 period continued in 2016 when labour productivity increased only 0.6 per cent, while multifactor productivity increased 0.1 per cent. In 2017, because of the strong performance of the Canadian economy, labour productivity growth picked up to 2.2 per cent.

2000s resulting from slower export and output growth due to the appreciation of Canadian dollars and slower growth in the United States. The decline in MFP growth at least in manufacturing after 2000 is found to be partly due to this decline in the utilization of capital in that period (Baldwin, Gu, and Yan, 2013). While various procedures exist to examine the effect of changes in capacity utilization on MFP growth, they are often ad hoc. To address that gap, a new measure of capacity utilization has been developed that can be used to adjust MFP growth for changes in the utilization of capital input (Gu and Wang, 2013).

The methodologies that can be used to address those capital measurement challenges have been developed in previous studies in Canada and other countries. A contribution of this article is to use those methodologies to extend the estimates to more recent years and to ask to what extent those capital measurement issues account for the slower labour and MFP growth in Canada after 2000.

In addition to the input measurement issues examined, there are issues associated with the measurement of service sector output, the measurement of output from new goods and services, the measurement of information and communication equipment prices that could be important for explaining slower productivity growth in the recent years (Byrne and Corrado, 2017). The measurement of “free” digital services (e.g. social media, and search engines) is also mentioned as a factor for the slower productivity growth (Varian, 2011; Brynjolfsson and Oh, 2012; Nakamura, Samuels and Soloveichik, 2016). The output and productivity growth extended to include

the benefit of the digital services would have increased faster in the recent years. But such benefit is the output of nonmarket production and is outside the production boundary of the national accounts.

The article is organized as follows. The first section begins with a decomposition of MFP growth into the contributions by industry to identify the industries that are responsible for the slower MFP growth.<sup>4</sup> Section 2 extends the asset coverage to include intangible capital not currently included in the SNA. Section 3 discusses the role of public infrastructure capital. Section 4 examines the effect of natural capital. Section 5 takes into account changes in capacity utilization in MFP growth in the manufacturing sector. Section 6 summarizes the roles of intangible capital, public infrastructure capital, natural capital and capacity utilization for the slower MFP growth in the Canadian business sector after 2000. Section 7 concludes.

## **Aggregate and Industry Productivity Growth in Canada**

This section presents the recent trends in labour productivity growth and its main components: investment in capital, labour compositional changes arising from investment in human capital, and MFP growth at the aggregate business sector level. It shows that the decline in aggregate labour productivity growth after 2000 is largely attributed to a decline in MFP growth. The section also decomposes aggregate MFP growth into contributions of individual industries and identifies the industries that contributed to this decline in multifactor productivity growth after 2000. The data are taken from the productivity accounts of Statistics Canada.

The productivity accounts of Statistics

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<sup>4</sup> Calver and Murray (2016) provided another decomposition of MFP growth by industry and province.

**Table 1: Sources of Output and Labour Productivity Growth in the Business Sector in Canada, 1980-2000 and 2000-2015 (Average Annual Compound Rate of Change)**

|  | 1980-2000 | 2000-2015 | 2000-2015<br>less 1980-2000 |
|--|-----------|-----------|-----------------------------|
| Growth in real value-added                       | 3.18      | 1.84      | -1.35                       |
| Growth in hours worked                           | 1.48      | 0.88      | -0.59                       |
| Labour productivity growth                       | 1.70      | 0.95      | -0.75                       |
| Contributions to labour productivity growth from |           |           |                             |
| Capital deepening                                | 0.89      | 0.90      | 0.01                        |
| Labour composition                               | 0.38      | 0.23      | -0.15                       |
| Multifactor productivity growth                  | 0.43      | -0.18     | -0.61                       |

Source: Authors calculation from CANSIM Table 383-0021, Statistics Canada.

Canada follow the framework pioneered by Jorgenson (1963), Jorgenson and Griliches (1967), Jorgenson, Gollop and Fraumeni (1987), Jorgenson, Ho and Stiroh (2005), and Schreyer (2001) who have developed integrated industry and total economy growth accounts.<sup>5</sup> Industry-level productivity growth is estimated making use of detailed data on output and inputs, and aggregate productivity growth is estimated making use of the industry-level data. Industry productivity accounts and aggregate productivity accounts are fully integrated and multifactor productivity growth at the aggregate level and the industry level are related to one another through the Domar aggregation (Domar, 1961).

MFP growth in the productivity accounts is defined as output growth that is not accounted for by the growth of capital, labour and intermediate inputs. To estimate MFP growth, the user cost and volume index of capital input are estimated first. The user cost of capital is equal to the sum of the rate of return to capital, depreciation and

capital gains adjusted for the effects of tax treatments.<sup>6</sup>

### Aggregate Productivity Growth in the Total Business Sector

Table 1 presents the trend in output and productivity growth in the business sector for the 1980-2000 and the 2000-2015 periods. The first three lines in the table decompose output growth into the contribution from growth in hours worked and the contribution from growth in labour productivity. The last three lines decompose labour productivity growth into its three main components: capital deepening, changes in labour composition, and MFP. Capital deepening captures the effect of investment and increases in capital intensity on labour productivity growth. Changes in labour composition capture the effect of investment in education and training on labour productivity growth. A residual called MFP growth includes the effect of disembodied technological change and organizational innovation, economies of scale, and short-term changes in capacity utilization.

<sup>5</sup> The framework is also used to construct the World KLEMS productivity accounts for a large number of countries (Timmer, Inklaar and O'Mahony, 2010 and 2011; Jorgenson, 2012 and 2017).

<sup>6</sup> For discussion of recent changes Statistics Canada has made to the measurement of MFP, see Gu (2018).

Output growth in the business sector declined from 3.2 per cent per year in 1980-2000 to 1.8 per cent in 2000-2015. This decline in output growth after 2000 reflects both a decline in labour productivity growth and a decline in the growth of hours worked.

The decline in labour productivity growth from 1.7 per cent per year in 1980-2000 to 1.0 per cent per year in 2000-2015 was mainly due to a decline in MFP growth. MFP growth declined 0.6 percentage points from 0.4 per cent per year in 1980-2000 to -0.2 per cent in 2000-2015. There was little change in the contributions of capital deepening effects. The labour composition effect declined 0.2 percentage points from 0.4 per cent to 0.2 per cent between periods.

### **Industry Contributions to MFP Growth**

This section quantifies the contributions of industries to the decline in MFP growth in the business sector after 2000. Table 2 and Chart 1 present MFP growth based on value added by industry. Table 3 presents the industry contributions to aggregate MFP growth. The contribution of an industry to aggregate MFP growth is calculated as industry MFP growth multiplied by the industry share of aggregate capital and labour input costs.

For the pre-2000 period, MFP growth exceeded 2 per cent per year in agriculture, forestry, fishing and hunting; manufacturing; and wholesale trade (Table 2). Those industries accounted for almost all MFP growth in the business sector for that period (Table 3). The rapid MFP growth in manufacturing, which made by far the largest contribution to business sector multifactor productivity growth (0.50 percentage points per year) was a result of the trend towards trade liberalization that led to increased competition, innovation and adoption of advanced manufacturing technologies (Trefler, 2004; Baldwin and Gu,

2004).

After 2000, multifactor productivity growth slowed and became negative at the business sector level and in certain goods-producing industries, especially in mining and oil and gas extraction. The service industries that invested heavily in information and communication technologies maintained positive multifactor productivity growth and in general did not show a decline in multifactor productivity growth. Those service industries include the retail trade, information and cultural industries, and finance, insurance and real estate industries.

MFP increased at 0.4 per cent per year in the business sector in 1980-2000. It then fell 0.2 per cent per year in 2000-2015, a 0.6 percentage point decline between periods. This decline in aggregate MFP growth after 2000 was mostly due to a decline in MFP in two industries: manufacturing and mining and oil and gas extraction. The decline in multifactor productivity growth in the manufacturing sector accounted for a 0.4 percentage point decline in aggregate MFP growth, while the decline in the mining, oil and gas extraction industry accounted for another 0.4 percentage point (Table 3).

The findings that manufacturing and mining and oil and gas extraction are largely responsible for the decline in aggregate MFP growth after 2000 point to a further investigation of potential issues in those industries. Those issues include the decline in the utilization of capital in the manufacturing industry and the incorporation of natural capital input in the measurement of MFP growth in the mining and oil and gas extraction sector. The rest of this article will examine those issues and the roles of intangible capital and public infrastructure capital in the decline of aggregate productivity growth after 2000.

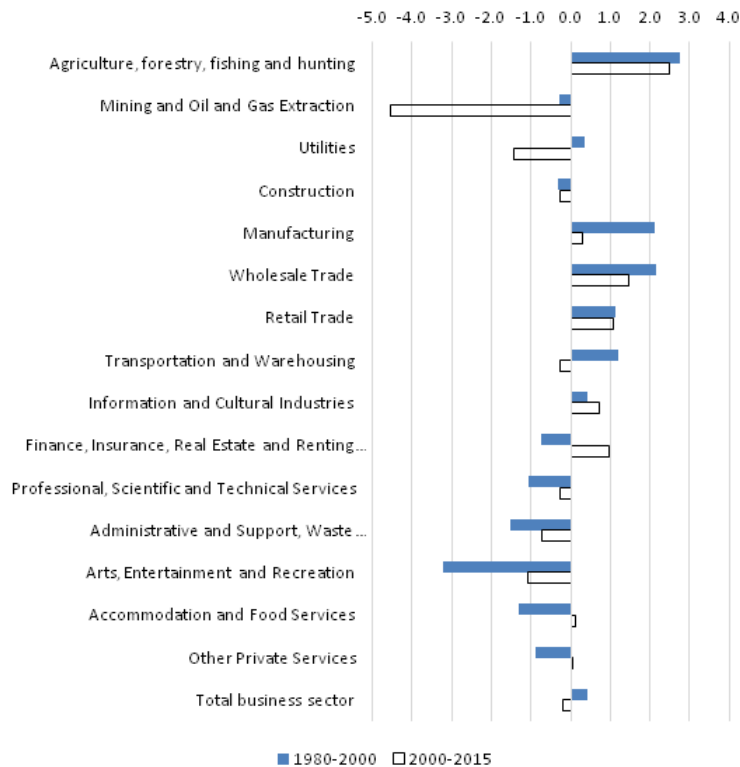
**Table 2: Multifactor Productivity Growth by Industry, 1980-2000 and 2000-2015 (Average Annual Compound Rate of Change)**

| Industry   | 1980-2000   | 2000-2015    | 2000-2015<br>less 1980-2000 |
|--|-------------|--------------|-----------------------------|
| Agriculture, forestry, fishing and hunting                               | 2.75        | 2.48         | -0.26                       |
| Mining and Oil and Gas Extraction  | -0.29       | -4.56        | -4.27                       |
| Utilities  | 0.33        | -1.43        | -1.76                       |
| Construction   | -0.33       | -0.26        | 0.07                        |
| Manufacturing  | 2.12        | 0.31         | -1.81                       |
| Wholesale Trade  | 2.15        | 1.47         | -0.68                       |
| Retail Trade   | 1.14        | 1.06         | -0.08                       |
| Transportation and Warehousing   | 1.21        | -0.26        | -1.47                       |
| Information and Cultural Industries                                      | 0.43        | 0.71         | 0.28                        |
| Finance, Insurance, Real Estate<br>and Renting and Leasing               | -0.75       | 0.97         | 1.72                        |
| Professional, Scientific and Technical Services                          | -1.06       | -0.26        | 0.80                        |
| Administrative and Support,<br>Waste Management and Remediation Services | -1.54       | -0.74        | 0.80                        |
| Arts, Entertainment and Recreation                                       | -3.22       | -1.09        | 2.13                        |
| Accommodation and Food Services  | -1.31       | 0.12         | 1.43                        |
| Other Private Services   | -0.88       | 0.06         | 0.94                        |
| <b>Total Business Sector</b>   | <b>0.43</b> | <b>-0.18</b> | <b>-0.61</b>                |

Note. Multifactor productivity growth is based on value added.

Source: Authors calculation from CANSIM Table 383-0021, Statistics Canada.

**Chart 1: Multifactor Productivity Growth by Industry (Average Annual Compound Rate of Change), 1980-2000 and 2000-2015**



Source: Authors calculation from CANSIM table 383-0021, Statistics Canada.

**Table 3: Industry Contributions to Multifactor Productivity Growth in the Business Sector, 1980-2000 and 2000-2015 (Average Annual Percentage Point Change)**

| Industry   | 1980-2000 | 2000-2015 | 2000-2015<br>less 1980-2000 |
|--|-----------|-----------|-----------------------------|
| Agriculture, forestry, fishing and hunting                               | 0.09      | 0.06      | -0.03                       |
| Mining and Oil and Gas Extraction  | -0.03     | -0.43     | -0.40                       |
| Utilities  | 0.01      | -0.05     | -0.06                       |
| Construction   | -0.03     | -0.02     | 0.01                        |
| Manufacturing  | 0.50      | 0.06      | -0.44                       |
| Wholesale Trade  | 0.14      | 0.10      | -0.03                       |
| Retail Trade   | 0.08      | 0.07      | -0.01                       |
| Transportation and Warehousing   | 0.09      | -0.02     | -0.11                       |
| Information and Cultural Industries                                      | 0.02      | 0.03      | 0.01                        |
| Finance, Insurance, Real Estate<br>and Renting and Leasing               | -0.10     | 0.15      | 0.25                        |
| Professional, Scientific and Technical Services                          | -0.05     | -0.02     | 0.03                        |
| Administrative and Support,<br>Waste Management and Remediation Services | -0.03     | -0.02     | 0.01                        |
| Arts, Entertainment and Recreation                                       | -0.02     | -0.01     | 0.01                        |
| Accommodation and Food Services  | -0.04     | 0.00      | 0.04                        |
| Other Private Services   | -0.04     | 0.00      | 0.04                        |
| Sum of Industry Contributions  | 0.61      | -0.09     | -0.70                       |
| Reallocation of Output   | -0.18     | -0.09     | 0.08                        |
| Total Business Sector  | 0.43      | -0.18     | -0.61                       |

Source: Authors calculation from CANSIM Table 383-0021, Statistics Canada.

## Intangible Capital and MFP Growth

MFP estimates are sensitive to the comprehensiveness of output and input measures. The definition of outputs and inputs are based on the National Account framework that is the foundation for the Productivity Program. Recent attention has been paid to the incomplete coverage of assets used for estimating capital input. In particular, it has been argued that a number of intangible assets exist that have not been appropriately taken into account in measuring the growth in capital. Intangible assets include computerized information (software and computerized databases), innovative property (scientific R&D and non-scientific R&D), and economic competencies (brand equity, training and organizational capital) (Corrado, Hulten and Sichel, 2009).

The multifactor productivity measures

published by Statistics Canada and others only include a small portion of intangible assets — those related to R&D, mineral exploration and software which in 2015 represented only 28 percent of total intangible investment. Whether the inadequate coverage of intangibles has a deleterious effect on the multifactor productivity measure is difficult to judge without an empirical study — since reclassifying intermediate expenses to investments both affects the measured output and measured capital.

Baldwin *et al.* (2009, 2012) developed a more extensive measure of intangible capital than is currently used in the National Accounts and they extended the growth accounting to include intangible capital. To estimate investment in intangibles, Baldwin *et al.* followed the method that is used to capitalize intangibles such as R&D and software in the national accounts and

**Table 4: Decomposition of Labour Productivity Growth With Intangibles in the Canadian Business Sector, 1980-2000 and 2000-2015 (Average Annual Compound Rate of Change)**

| Industry                        | 1980-2000 | 2000-2015 | 2000-2015<br>less 1980-2000 |
|---------------------------------|-----------|-----------|-----------------------------|
| Including SNA Intangibles       |           |           |                             |
| Value Added Growth              | 3.18      | 1.84      | -1.35                       |
| Labour Productivity Growth      | 1.70      | 0.95      | -0.75                       |
| Contributions from:             |           |           |                             |
| Capital Deepening               | 0.89      | 0.90      | 0.01                        |
| Tangibles                       | 0.69      | 0.79      | 0.11                        |
| Intangibles                     | 0.20      | 0.11      | -0.10                       |
| Labour Composition              | 0.38      | 0.23      | -0.15                       |
| Multifactor Productivity Growth | 0.43      | -0.18     | -0.61                       |
| Including All Intangibles       |           |           |                             |
| Value Added Growth              | 3.30      | 1.85      | -1.45                       |
| Labour Productivity Growth      | 1.82      | 0.97      | -0.85                       |
| Contributions from:             |           |           |                             |
| Capital Deepening               | 0.91      | 0.95      | 0.04                        |
| Tangibles                       | 0.53      | 0.71      | 0.18                        |
| Intangibles                     | 0.38      | 0.24      | -0.14                       |
| Labour Composition              | 0.35      | 0.21      | -0.14                       |
| Multifactor Productivity Growth | 0.56      | -0.19     | -0.75                       |

Source: Updated Table 3 in Baldwin, Gu and MacDonald (2012). Note: Intangibles already in the SNA are software, R&D and mineral exploration.

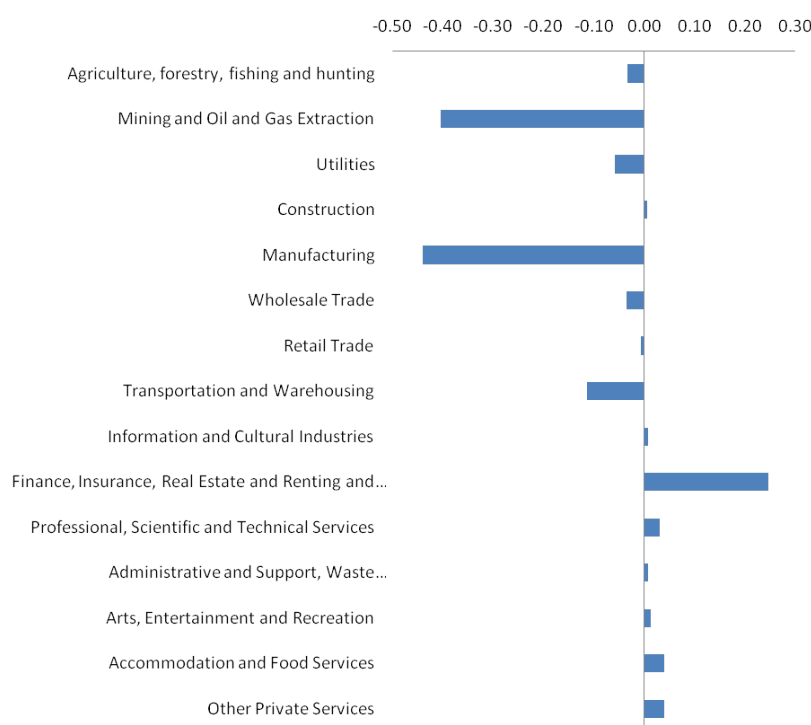
makes a distinction between purchased intangibles and own account intangibles. The purchased intangibles are re-classified from the intermediate inputs to investments in the industries that purchased intangibles. The own-account intangibles are directly added to the output of industries as they represent the intangible outputs in addition to the market outputs that are produced. Those two adjustments lead to an increase in the value added that equals the value of purchased and own-account intangibles.

Table 4 updates Baldwin *et al.* (2012) estimates to 2015. When expenditures on intangibles not already in the SNA are reclassified as investment from intermediate inputs and added to value added in the business sector, the real value added and labour productivity growth was higher in both 1980-2000 and 2000-2015 periods as the expenditures on intangibles increased faster than value added.

The upward adjustments to output and labour productivity growth were much larger in the 1980-2000 period than after 2000. As a result, incorporating intangibles not already in the SNA made the decline in aggregate labour productivity growth after 2000 even larger (from 0.75 points to 0.85 points). In other words, changes in intangible investment growth between the two periods do not explain the decline in aggregate labour productivity growth after 2000.

Expanding the asset coverage to include intangible capital not already in the SNA also affects the measurement of inputs and the decomposition of labour productivity growth into its three main components: capital deepening effect, labour composition effect and MFP growth. As Table 4 shows, when intangible capital not already included in the SNA is included, the effect of capital deepening (estimated as

**Chart 2: Industry Contributions to Decline in Average Annual Percentage Points Aggregate Multifactor Productivity Growth Between 1980-2000 and 2000-2015 (Percent per Year)**



Source: Derived from Table 3.

the share of capital costs in total input costs multiplied by the growth of capital-labour ratio) will increase as the share of capital costs becomes larger and the growth of the combined tangible and intangible input increases faster than tangible capital input. This lowers multifactor productivity growth estimates. The change to MFP growth estimates arising from those changes in labour productivity growth and its decomposition is found to increase MFP growth 0.13 points in the 1980-2000 period and to reduce MFP growth 0.01 points in the 2000-2015 period. Therefore the decline in multifactor productivity growth after 2000 became larger when intangibles not already included in the SNA are included in capital productivity measurement.

### Natural Capital and MFP Growth in the Oil and Gas Extraction and Mining

MFP has been declining in the oil and gas extraction sector since the early 1990s and it has been declining in coal, metal ores and non-metallic mineral mining since the early 2000s.<sup>7</sup> The decline in MFP in those two sectors accounted for 0.4 percentage point, or more than half of the decline in multifactor productivity growth in the total business sector after 2000 (Table 3).

The existing MFP measure does not take into account the depletion of natural resource stock or the flow of natural resource capital. When natural capital is not included in capital input, the multifactor productivity measure is biased as the output includes the rent while the input does not include the flow of natural resource

<sup>7</sup> MFP in Chart 2 is calculated based on value added. The MFP based on gross output shows a similar trend. The decline in MFP in the mining sector based on the standard growth accounting framework is also found in other countries including Australia, the United States and the Netherlands.

capital (or natural capital input) used to generate that output (Schreyer, 2012; Olewiler, 2017). Research in Australia and Netherlands shows that a substantial part of the decline in MFP in the oil and gas and mining sectors can be attributed to unmeasured natural capital input (Topps and Kuluys 2014; Veldhuizen and de Haan 2012; Australia Bureau of Statistics, 2014).<sup>8</sup> The resource extraction sectors in those countries involve more and more physical capital being applied for the extraction of natural resources due to an increase in the difficulties with which resources are being extracted. The growth in physical capital input is therefore higher than the growth in natural capital input, and the growth of the capital input estimate — that includes both natural and physical capital — will be slower than the growth in physical capital alone which boosts MFP growth. Multifactor productivity growth that accounts for the depletion of natural resource stock is much higher in Australia and Netherlands.

Schreyer (2012) presented an extended growth accounting framework for incorporating natural capital input in MFP measures for the oil and gas extraction and mining industry. In the extended framework, the quantity of natural capital input is equal to the volume index of resource extraction, while the user cost of natural capital input is the resource rent. The resource rent can be estimated residually. It is equal to the difference between the value of resource extracted and the costs of inputs other than natural capital where the user cost of physical capital

is calculated using an exogenous rate of return.<sup>9</sup>

This procedure for estimating the volume index of natural capital input differs from the one for estimating the volume index of the other capital inputs. The volume index of capital input other than natural capital is not observed and is assumed to be proportional to capital stock. In contrast, the volume index of natural capital input is observed and is equal to the extraction of the natural resources.

Primary industries often use various types of natural resource capital such as oil and gas, coal, metal ores and non-metallic minerals in their production. Those different types of natural resource capital need to be aggregated to derive an aggregate measure of natural capital input. Similar to the procedure for aggregating produced capital across asset types, the weights for the aggregation should be based on the user costs of natural capital inputs.<sup>10</sup>

The resource rents by assets are often difficult to estimate as revenues and input costs must be allocated between multiple extraction activities for those firms that engage in the extraction of multiple natural resource assets. For this article, the value of natural resource assets is used for aggregation. This assumes that resource rent per dollar value of resource extracted is equalized across different types of resource assets. This is the procedure used by Statistics Netherlands in its measure of natural capital input and multifactor productivity for the mining sector (Veldhuizen and de Haan, 2012).

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8 Australia Bureau of Statistics (2014) finds that the decline in the mining MFP is reduced significantly when natural capital input is included in the multifactor productivity measure, from -5.8 per cent per year to -2.2 per cent for the period from 2003-04 to 2012-13.

9 The resource rent is set equal to zero when negative. This occurs during the late 1980s and the early 1990s in Canada when natural resources prices were low.

10 Adams and Wang (2015) implemented such an approach using resource rent estimates for various types of natural capital inputs in the Canadian oil and gas extraction and mining industry.

**Table 5: Multifactor Productivity Growth in the Oil and Gas Extraction Sector, 1980-2000 and 2000-2013 (Percentage Points Contribution or Per Cent per Year)**

| Industry   | 1980-2000 | 2000-2013 | 2000-2013<br>less 1980-2000 |
|--|-----------|-----------|-----------------------------|
| Real gross output growth   | 3.73      | 2.37      | -1.36                       |
| Contributions from:  |           |           |                             |
| Labour input   | 0.11      | 0.48      | 0.36                        |
| Produced capital input   | 1.65      | 3.00      | 1.35                        |
| Natural capital input  | 0.39      | 0.12      | -0.28                       |
| Intermediate input   | 1.76      | 1.61      | -0.15                       |
| Multifactor productivity growth                                    | -0.19     | -2.83     | -2.64                       |
| Addendum   |           |           |                             |
| Labour input growth  | 2.40      | 7.60      | 5.20                        |
| Produced capital input growth                                      | 3.87      | 6.72      | 2.85                        |
| Natural capital input growth                                       | 3.38      | 2.32      | -1.05                       |
| Intermediate input growth  | 4.84      | 4.56      | -0.28                       |
| Official Multifactor productivity growth (without natural capital) | -0.67     | -3.63     | -2.96                       |

Source: Authors calculation from CANSIM Table 383-0032, Statistics Canada.

For Canada, the choice of weights for aggregation is found to have little effect on growth in estimated natural capital input.

Table 5 and Chart 3 present the extended growth accounts for oil and gas extraction and mining. The data on gross output, capital, labour and intermediate inputs are taken from the productivity accounts of Statistics Canada (CANSIM Table 383-0032). The volume index of natural capital input is derived from the make tables of input-output accounts and is available for the period up to the most recent input/output table reference year 2013.

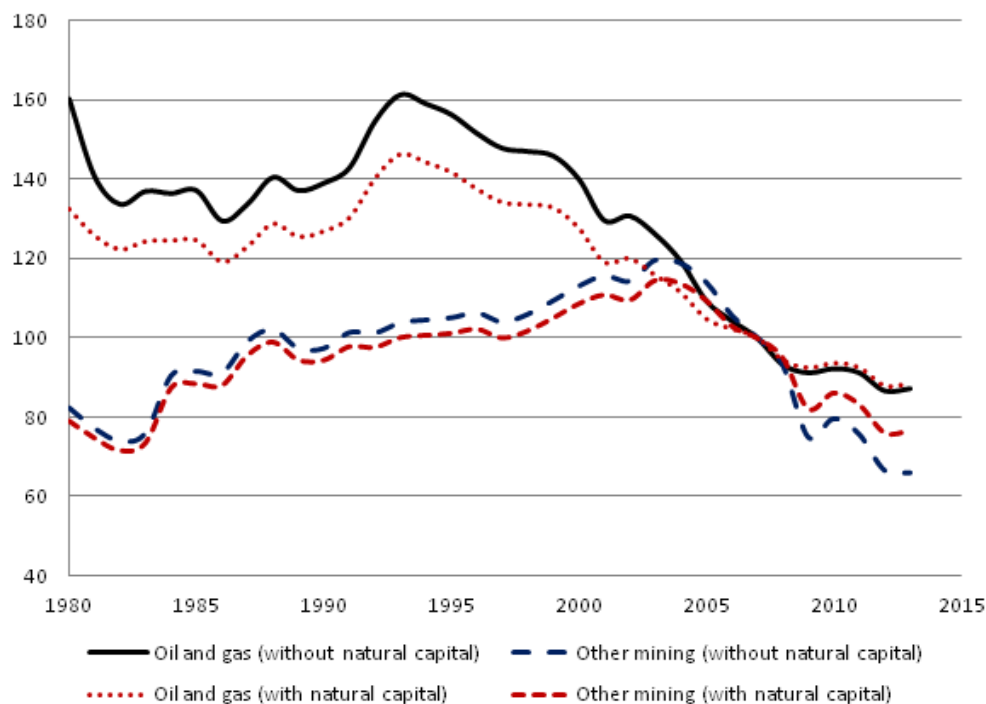
The growth in produced capital and labour is found to be faster than the growth in natural capital input in the Canadian oil and gas extraction over the period 1980 to 2013. This difference becomes larger in the post-2000 period. This reflects an increased use of produced capital and labour in the oil and gas extraction as oil and gas become increasingly more expensive to extract.

The extended growth accounts for oil and gas extraction in Table 5 also provide an assessment of the contribution of the natural capital input to economic growth. Over the

1980 to 2013 period, the largest contributors to output growth in the oil and gas extraction sector are the produced capital and intermediate inputs, followed by natural capital input and labour input. Natural capital input contributed 0.4 percentage points of 3.7 per cent annual growth in gross output in the oil and gas extraction in the period 1980 to 2000, and it contributed 0.1 percentage points of the 2.4 per cent annual growth in gross output in the 2000 to 2013 period.

The official MFP growth estimate, which is not corrected for the effect of natural capital, declined in the oil and gas extraction sector in both the 1980-2000 and the 2000-2013 periods. But the decline was much larger after 2000. It declined at 0.7 per cent per year in 1980-2000 period, and at 3.6 per cent in 2000-2013. This represents a 2.9 percentage point slowdown in MFP growth in the oil and gas sector between the two periods. When natural capital is included in the measurement of capital, the decline in MFP was smaller in both periods, and the slowdown in MFP growth after 2000 was also smaller (2.6 points versus 2.9 points).

Chart 3: Multifactor Productivity in the Oil and Gas and the Mining Sector, 1980-2013 (2007=100)



Source: Authors calculation from CANSIM table 383-0032 and the supply and use tables, Statistics Canada

The slowdown in MFP growth after 2000 in the oil and gas extraction sector is found to be partly due to unmeasured natural capital input in the sector.

Table 6 and Chart 3 present the growth accounts for the mining sector. MFP growth not adjusted for the effect of natural capital declined in the 2000-2013 period compared with the 1980-2000 period, from 1.6 per cent per year to -4.1 per cent, a 5.7 percentage point slowdown between the two periods. When natural capital input is included in the measure of total capital, the slowdown in MFP growth falls to 4.3 percentage points between the two periods from 1.6 per cent per year in 1980-2000 to -2.7 per cent in 2000-2013. The decline in MFP growth after 2000 in the mining sector is found to be partly due to unmeasured natural capital in the sector.

A better understanding of this decline in MFP growth requires a more explicit account of the decline in the quality

of natural resources being extracted that is often cited as a main source of this decline. It also requires micro data on production activities of mines and estimates of productivity growth for various resource extraction activities, such as conventional and non-conventional oil extraction. Such data will provide a decomposition of the decline in MFP growth into contribution from productivity growth in different types of mines and in different types of resource extraction activities, and the contribution from changes in the composition of those various mine and resource extraction activities.

### Public Infrastructure Capital and MFP Growth in the Business Sector

Public infrastructure capital (the nation's roads, bridges, sewer systems and water treatment systems, schools, and hospitals) constitutes a vital input for business sector

**Table 6: Multifactor Productivity Growth in the Mining Sector (Except Oil and Gas Extraction), 1980-2000 and 2000-2013 (Average Annual Percentage Points or Percent Change)**

| Industry  | 1980-2000 | 2000-2013 | 2000-2013<br>less 1980-2000 |
|---|-----------|-----------|-----------------------------|
| Real gross output growth  | 0.97      | 1.07      | 0.10                        |
| Contributions:  |           |           |                             |
| Labour input  | -0.35     | 0.39      | 0.73                        |
| Produced physical capital input                                       | -0.19     | 2.10      | 2.29                        |
| Natural capital input   | -0.03     | 0.11      | 0.14                        |
| Intermediate input  | -0.05     | 1.16      | 1.21                        |
| multifactor productivity growth                                       | 1.59      | -2.68     | -4.27                       |
| Addendum  |           |           |                             |
| Labour input growth   | -1.21     | 2.88      | 4.08                        |
| Produced capital input growth   | -0.51     | 6.63      | 7.13                        |
| Natural capital input growth  | 1.06      | 0.92      | -0.14                       |
| Intermediate input growth   | -0.10     | 3.56      | 3.66                        |
| Official multifactor productivity growth<br>(without natural capital) | 1.58      | -4.12     | -5.70                       |

Source: Authors calculation from CANSIM Table 383-0032, Statistics Canada.

production.<sup>11</sup> It contributes to productivity in the private business sector as it provides wider and deeper markets for output and employment and reduces the transportation and production costs.<sup>12</sup>

The contribution of public infrastructure capital to productivity growth can be examined using an extended growth accounting framework (Mas, 2006; Gu and Macdonald, 2009). The standard growth accounting framework employed for statistical agencies focuses on private sector inputs and outputs. The impact of public capital at present is subsumed in MFP.

To explicitly analyse the contribution of public capital to productivity growth, MFP growth from the traditional growth accounting for the business sector is decomposed into the contribution from

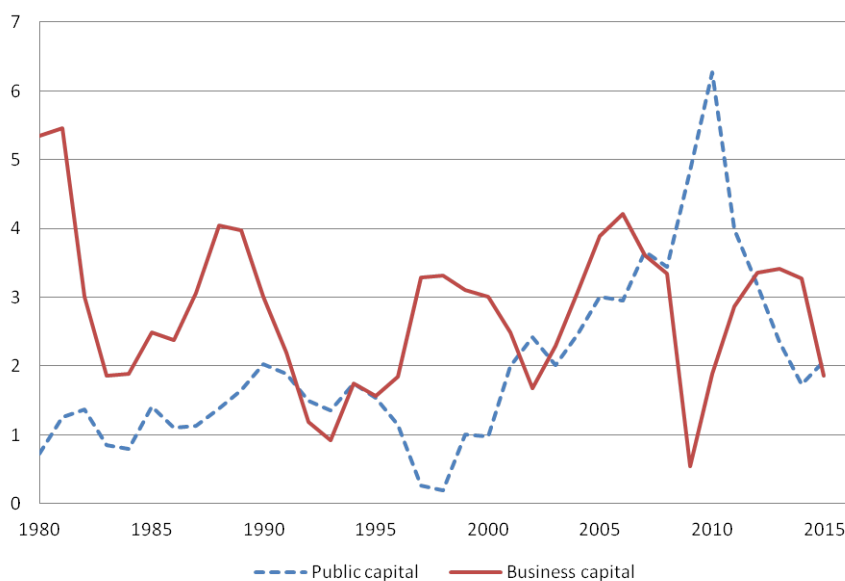
public capital and multifactor productivity growth net of the effect of public capital. This approach adopts the usual assumptions about constant returns to scale across private inputs and private inputs being paid their marginal revenue product. Public capital is assumed to affect output growth, but not the substitution between private capital and labour inputs.

Gu and Macdonald (2009) examined the contribution of public infrastructure capital to MFP growth in the business sector for the 1961-2006 period. The results from Gu and Macdonald (2009) are extended to 2015 in Table 7. The stock of public capital includes public capital stock of governments and public health and education sectors. The output elasticity of public capital is estimated assuming that the rate of return

11 This section examines the contribution of public infrastructure capital to labour productivity growth. The privately owned infrastructure is included in the business sector capital and its contribution to productivity growth is included in the capital deepening effect of the business sector.

12 Public infrastructure capital also benefits the household sector in terms of lower transportation costs and commute times. This article focuses on the benefits of infrastructure capital on the business sector production.

**Chart 4: Public Infrastructure Capital Stock and Business Capital Stock, 1980-2015 (Annual Growth)**



Source: Authors calculation from CANSIM table 383-0021 and the underlying investment data, Statistics Canada.

to public capital is equal to the after-tax return on capital in the business sector. The assumption is based on Macdonald (2008) who found that the rate of return to public capital is similar to the nominal after-tax return to capital in the business sector.

Chart 4 presents the growth of public infrastructure capital stock and business sector capital stock for the 1980 to 2015 period. During the 1980s and 1990s, the growth in public capital was slower than the growth in capital stock in the business sector as a period of cross-country highway expansion in the 1960s came to an end. In the late 2000s and early 2010s, the growth of public capital exceeded the growth in business sector capital, given the large investments in infrastructure from the government economic stimulus program during that period.

Table 7 presents the contribution of public capital to business sector productivity growth. Over the 1980-2000 period, public capital contributed 0.1 percentage points to average MFP growth in the business sector. During the period after 2000, the

contribution of public capital to the business sector multifactor productivity growth picked up as a result of increased investment in public infrastructure, contributing 0.2 percentage points.

The results in Table 8 suggest that public capital contributed to an increase in MFP growth after 2000 as a result of increased investment in public capital in that period. This decline in aggregate MFP growth after 2000 is not due to the declining effect of public capital.

### Capacity Utilization and MFP Growth in Manufacturing

MFP growth provides summary statistics that can help track technical progress. It is measured as output growth that is not accounted for by the growth in inputs. For such productivity residuals to provide an unbiased estimate of technical progress, all inputs should be corrected for the changes in their utilization. But productivity statistics published by Statistics Canada and most other statistical agencies do not correct for short-run variations in capacity utilization.

**Table 7: Contributions of Public Infrastructure Capital to Multifactor Productivity Growth in the Business Sector, 1980-2000 and 2000-2015 (Percentage Points per Year)**

|   | 1980-2000 | 2000-2015 | 2000-2015<br>less 1980-2000 |
|---|-----------|-----------|-----------------------------|
| Official MFP growth                               | 0.43      | -0.18     | -0.61                       |
| Public infrastructure capital contribution to MFP | 0.08      | 0.23      | 0.15                        |
| MFP growth net of public infrastructure capital   | 0.35      | -0.41     | -0.76                       |

Source: Authors calculation based on data from CANSIM Table 383-0021, Statistics Canada.

As such, the changes in MFP growth include the effect of changes in capacity utilization in the short run and do not necessarily measure technical progress. In this section, MFP growth is adjusted for short-term changes in capital utilization so as to examine the effect of capacity utilization on MFP growth.<sup>13</sup>

Correction for the effect of variations in capacity utilization is important when rates of capacity utilization change. In the early 2000s, Canada experienced a resource boom and an upward appreciation of the Canada-United States exchange rate. Based on micro-data on plant adjustments to pressures arising from changes in export markets and resulting declines in capacity utilization, Baldwin, Gu and Yan (2013) show that the decline in the standard measure of multifactor productivity during the early part of the 2000s was partly due to the decline in capacity utilization.

Numerous studies have tried to adjust the multifactor productivity measure for capacity utilization. But as Berndt and Fuss (1986) noted, the adjustment is mostly ad hoc, because it lacks a theoretical framework. Gu and Wang (2013) developed a non-parametric procedure for such an adjustment based on the economic theory of production. Capacity utilization is

measured based on the comparison of the ex post return with the ex ante expected return on capital. This is intuitively appealing, because changes in the ex post return on capital should mainly reflect the variation in capacity utilization. A higher level of unused capital and the resulting lower level of capacity utilization should be associated with a lower ex post rate of return, which is calculated on the actual level of capital. Similarly, a higher level of capacity utilization should be associated with a higher ex post rate of return on the actual level of capital.<sup>14</sup>

Table 8 presents MFP growth adjusted for the effect of capacity utilization in the manufacturing sector based on the Gu-Wang methodology. Changes in capacity utilization have little effect on MFP growth over the long run. But the changes in capacity utilization have a significant effect on MFP growth in the short-run. For example, over the period 2000 to 2009, MFP without utilization adjustment declined by 0.9 per cent per year over the period. In contrast, MFP adjusted for capacity utilization increased by 0.3 per cent per year.

MFP growth declined in the period 2000 to 2009 compared with the period 1980 to 2000. It fell from 2.1 per cent per year to

<sup>13</sup> In general, the utilization of both physical and intangible capital are subject to changes over the short-run. As estimates of intangibles for manufacturing industries are not available, this section will focus on the adjustment of multifactor productivity growth for changes in the utilization of physical capital.

<sup>14</sup> The changes in the ex post user cost of capital may also reflect the changes in the prices of output and inputs. Gu and Wang (2013) shows that the changes in the ex post user cost of capital is not correlated with the changes in the price cost markup or the changes in the price of output and inputs in manufacturing and most other industries.

**Table 8: Effects of Changes in Capacity Utilization on Multifactor Productivity Growth in the Manufacturing Sector, 1980-2015 (Average Annual Compound Rate of Change)**

|                                     | 1980-2000 | 2000-2015 | 2000-2009 | 2009-2015 |
|-------------------------------------|-----------|-----------|-----------|-----------|
| Unadjusted for Capacity Utilization | 2.12      | 0.31      | -0.93     | 2.18      |
| Adjusted for Capacity Utilization   | 2.18      | 0.75      | 0.32      | 1.41      |

Source: Authors calculation based on data from CANSIM Table 383-0021, Statistics Canada.

-0.9 per cent between the two periods, a slowdown of 3.0 percentage points. When changes in capacity utilization are taken into account, the decline is smaller at 1.9 points (from 2.2 per cent per year to 0.3 per cent per year across the two periods). Therefore, the decline in MFP growth between those two periods is partly due to the decline in the utilization of capital in the 2000-2009 period in the manufacturing sector.

During the period after 2009, output and employment showed a positive growth and capacity utilization increased. Multifactor productivity increased 2.2 per cent per year in the 2009 to 2015 period. The positive multifactor productivity growth was largely due to an increase in capacity utilization. Multifactor productivity adjusted for capacity utilization increased by only 1.4 per cent per year.<sup>15</sup>

### The Overall Impact of Capital Measurement Issues on MFP Growth after 2000

Table 9 presents the effects on MFP growth in the business sector of incorporating intangible capital, natural capital, public capital, and changes in capacity utilization.<sup>16</sup> MFP growth in the business sector declined by 0.61 percentage

points, from 0.43 per cent per year in 1980-2000 to -0.18 per cent in 2000-2015.

When natural capital is included, adjusted MFP growth for the business sector was 0.04 points faster in 1980-2000 and 0.13 points faster in 2000-2015. This means that natural capital boosted MFP growth by 0.09 points between the 1980-2000 and 2000-2015 periods. This reflects an increase in the use of produced capital required to extract natural resources in the oil and gas and mining sector.

When an adjustment is made to MFP for capacity utilization, MFP growth became 0.02 points higher in 1980-2000 and 0.09 points higher in 2000-2015. Like the inclusion of natural capital, this adjustment raises MFP growth between periods, with an increase of 0.07 points. The combined effect of these two factors is to increase MFP growth by 0.16 points between 1980-2000 and 2000-2015. This means that 0.16 points of the 0.61 point decline in MFP growth between 1980-2000 and 2000-2015 or 26 per cent of the MFP slowdown, was due to the exclusion of these two factors from the official MFP calculations.

On the other hand, the exclusion of both public infrastructure capital and the non-SNA components of intangible capital

<sup>15</sup> The utilization adjustment based on a comparison of the ex post with the ex ante user cost can be done for the period up to 2011 for which nominal value-added and capital income are available. The capacity utilization in the recent years are extended using the industrial capacity rates from the CAPEX survey.

<sup>16</sup> The adjustments to aggregate MFP growth in the business sector from incorporating the effects of capacity utilization and natural capital equal the changes to MFP growth in the manufacturing and mining and oil and gas extraction industries respectively multiplied by their shares of input costs in the total business sector.

**Table 9: Multifactor Productivity in the Business Sector With Various Adjustments, 1980-2000 and 2000-2015 (Average Annual Compound Percentage Point Contribution)**

|  | 1980-2000 | 2000-2015 | 2000-2015<br>less 1980-2000 |
|--|-----------|-----------|-----------------------------|
| Multifactor productivity growth                          | 0.43      | -0.18     | -0.61                       |
| Changes to MFP growth from accounting for the effects of |           |           |                             |
| Non-SNA intangible capital                               | 0.13      | -0.01     | -0.14                       |
| Public infrastructure capital                            | -0.08     | -0.23     | -0.15                       |
| Natural capital  | 0.04      | 0.13      | 0.09                        |
| Changes in capacity utilization                          | 0.02      | 0.09      | 0.07                        |
| Adjusted multifactor productivity growth                 | 0.54      | -0.20     | -0.75                       |

Source: Authors calculation based on data from CANSIM Table 383-0021 and 383-0032, Statistics Canada.

cannot explain slower MFP growth. When public infrastructure capital is included, adjusted MFP growth for the business sector is 0.08 points slower in 1980-2000 and 0.23 points slower in 2000-2015. This means that public infrastructure capital reduced MFP growth by 0.15 points between the 1980-2000 and 2000-2015 periods.

When intangible capital not already in the SNA is included, adjusted MFP growth for the business sector is 0.13 points faster in 1980-2000, but 0.01 points slower in 2000-2015. This means that intangible capital reduced MFP growth by 0.14 points between the 1980-2000 and 2000-2015 periods. The combined impact of these two effects is to decrease MFP growth by 0.29 points between 1980-2000 and 2000-2015. Thus the inclusion of intangible capital and public infrastructure makes the MFP slowdown even larger.

The 0.16 point boost to MFP growth between the 1980-2000 and 2000-2015 periods from natural capital and capacity utilization adjustment is more than offset by the 0.29 point reduction in MFP growth from intangible capital and public infrastructure capital. This means that the net effect of the four factors on MFP growth between the periods is -0.14, as evidenced by the increase in the MFP growth slowdown

between 1980-2000 and 2000-2015 from 0.61 points to 0.75 points.

## Conclusion

Labour productivity and MFP growth declined in the Canadian business sector after 2000. This article examines the roles of intangible capital, natural capital, public infrastructure capital and capacity utilization in this development. To do that, it first addresses the issues that are associated with their measurement in the national accounts and presents a growth accounting framework that is used to examine their roles in labour and MFP growth.

The article finds that only 25 per cent of the decline in multifactor productivity growth in the Canadian business sector in the period 2000-2015 compared with the period 1980-2000 is due to an increase in the use of produced capital required to extract natural resources with declining ore grade and a decline in the utilization of capital in the manufacturing sector. The decline in labour and MFP growth is not due to changes in intangible capital and infrastructure capital after 2000. Infrastructure capital contributed to an increase in labour and multifactor productivity growth after 2000 as a result of a large increase in infrastructure

investment in that period. The overall effect of incorporating intangibles not already included in the SNA is to increase the MFP growth estimate in the period 1980-2000 and reduce the MFP growth estimate in the period 2000-2015 contributing to an even larger decline in MFP growth after 2000.

Labour productivity and MFP growth have slowed in almost all advanced economies (OECD, 2016). This article has focused on the role of measurement issues that are associated with capital input for the slower productivity growth in Canada. The results suggest that the capital measurement issues alone cannot explain the slowdown in productivity in Canada. The future research should focus on the role of other factors in the recent productivity growth slowdown such as innovation, the diffusion of innovation, competition, and on business dynamism.

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# Can the Kiwi Fly? Achieving Productivity Lift-off in New Zealand

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## ABSTRACT

New Zealand's poor long-run productivity performance has puzzled domestic economists and international observers for decades. To provide answers, this article sketches out the broad reasons why lifting productivity has proven so difficult. Against the background of ongoing changes in technology and in the global trading environment, the article also puts forward a number of high-level policy suggestions aimed at countering the economic forces that have constrained productivity, including opening the economy to new opportunities for international connection, and encouraging capital deepening, greater competition and more effective innovation. Getting this right requires a deep understanding of New Zealand's productivity track record and potential in the 21st century global economy and presents a major challenge for the New Zealand public sector.

Material living standards in New Zealand were once among the highest in the world. In 1950, GDP per capita in New Zealand was around 125 per cent of the OECD average (Conway and Orr, 2000). At this time, colonial ties to the United Kingdom provided easy access to capital, expertise, and a secure market for New Zealand's agricultural exports at guaranteed prices. This facilitated specialization and scale in an area of strong comparative advantage. The economy was highly concentrated in the production and processing of primary products and much of the policy and

institutional focus was on distributing wealth generated from these activities across the population.

From the 1960s, New Zealand's relative standard of living began to slip as export revenues became insufficient for a growing population and volatile commodity markets highlighted the vulnerabilities of a narrow economic base. Britain's entry into Europe in 1972 and widespread increases in protectionism for agricultural products restricted the ability of primary producers to reap the benefits of their comparative advantage. In response, the government

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of the day implemented an increasingly protectionist and dirigist micro agenda along with expansionary fiscal and monetary policies. This contributed to a general worsening in New Zealand's economic situation and by 1980 GDP per capita had fallen to around 90 per cent of the OECD average.

From the mid-1980s, widespread dissatisfaction with the systematic underperformance of the New Zealand economy prompted a period of comprehensive economic reform aimed at improving both microeconomic efficiency and macroeconomic stability. These reforms transformed the economy from one of the most interventionist in the OECD to one of the most open and market-based. Over the latter part of the 1980s and into the early 1990s, the rigours of microeconomic adjustment coincided with a deep global recession and a shock market collapse. In 1992, GDP per capita fell to a low of around 80 per cent of the OECD average.

In the post-reform period, New Zealand's economic performance has improved and GDP per capita is currently around 90 per cent of the OECD average. Since the mid-1990s, growth in hours worked per capita has been strong while multi-factor productivity (MFP) increased markedly over the 1990s. However, this surge in MFP faded by 2000, consistent with the idea that economic reform delivered a level shift in productivity but did not significantly increase its long-run growth rate.

Notwithstanding strong growth over the 1990s, and despite a low level of productivity vis-à-vis high-income OECD economies, New Zealand's long-run productivity performance has been poor by international standards. This is unusual within the OECD, given that lagging economies have, in principle, greater scope for improving productivity more quickly than

leading economies. New Zealand's lack of productivity catch-up is even more perplexing given that its economic policies are often regarded as fit for purpose.

To shed some light, this article outlines recent evidence on the underlying reasons for New Zealand's comparatively poor long-run productivity performance. This review is undertaken against the background of a growing literature on potential reasons for sustained productivity differences across firms and economies, despite the expectation that technology diffusion and market selection effects should tend to equalize productivity over time.

From the outset, it is important to acknowledge that New Zealand with low population scale and density and extreme geographic isolation is not a typical OECD economy. Consequently, New Zealand's development path may be different from that of larger or better-connected economies. For example, New Zealand's unique economic geography might imply a development path based around tasks and activities that tend not to agglomerate in large global cities.

New Zealand's distinct mix of characteristics also adds to the challenge of understanding the economy and setting policy appropriately. Despite these challenges, important aspects of New Zealand's productivity story are yet to be researched in detail and parts of the diagnosis and policy prescription outlined in this article are exploratory. By highlighting areas of uncertainty, the article also serves as the basis of an ongoing research agenda aimed at lifting New Zealand's productivity.

The article proceeds as follows. Section 1 outlines New Zealand's productivity performance at the aggregate and firm levels. Section 2 discusses the underlying reasons for slow productivity growth in the market sector of the New Zealand economy. Section 3 focuses on the role of policy in responding

Chart 1: Contributions to Labour Productivity Growth in New Zealand, 1997-2017



Source: Statistics New Zealand

to New Zealand’s productivity challenges. Concluding remarks are offered in Section 4.

## New Zealand’s Productivity Performance

### Aggregate Drivers of Growth

Productivity growth in New Zealand has been reasonable in some years and in some industries but has generally been weak in international comparison over the long run. Consistent with this relatively poor long-run productivity growth performance, the level of labour productivity in New Zealand has been well below the average of high-income OECD economies for some time.

Since the mid-2000s, New Zealand has not suffered the same decline in MFP growth seen in many OECD economies apart from a strong negative outturn in 2009, MFP growth strengthened a little post the Global Financial Crisis (GFC) (Chart 1). However, as in a number of OECD economies, capital deepening declined from the mid-2000s, leading to a softening in labour productivity growth. However, this labour productivity slowdown has been comparatively minor and New Zealand’s decline in labour productivity relative to high-income OECD economies came to an end in the mid-2000s (Chart 2).

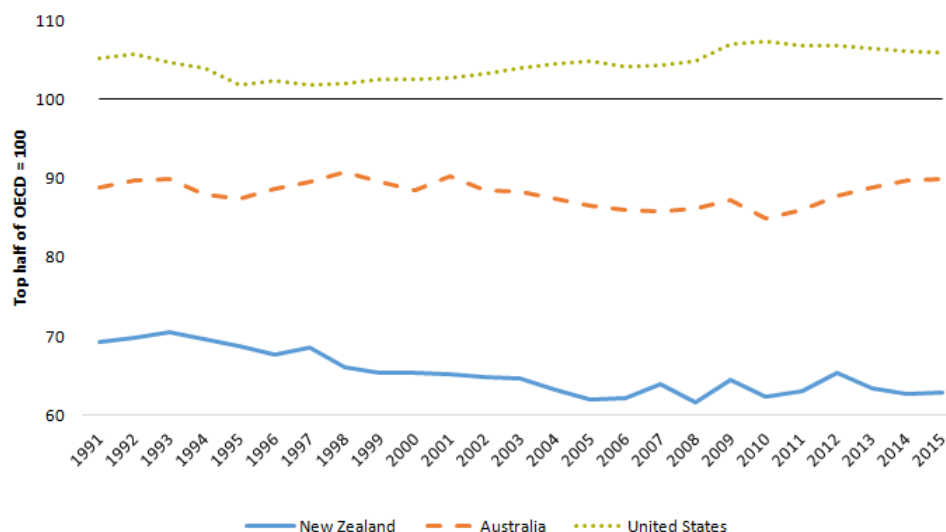
Although New Zealand’s labour productivity has been “keeping up” in the context of a generalized productivity slowdown across the OECD, there is still no evidence of any “catching up” and a sizable productivity gap remains.

In contrast to a relatively poor long-run productivity performance, growth in labour input has been a key driver of GDP growth. This reliance on the labour market as a driver of economic growth has intensified in recent years. For example, since 2000, growth in the New Zealand labour force has been more than twice the OECD average, driven by much faster growth in the working-age population and a greater increase in labour force participation (Culling and Skilling, 2018). In turn, rapid growth in the working-age population has largely been driven by strong immigration inflows, while participation rates have increased for older workers and, more modestly, for females. In addition, hours worked per worker has fallen by less in New Zealand than in the rest of the OECD, adding to the overall increase in labour supply.

### Productivity of New Zealand Firms

From a firm perspective, New Zealand’s poor long-run productivity performance

**Chart 2: New Zealand's Labour Productivity Level Relative to High-income OECD Countries, 1991-2015**



Source: OECD

Note: Population-weighted average for the top 17 OECD countries for labour productivity, calculated using 2010 purchasing power parity exchange rates.

could reflect a failure of productivity-enhancing technologies to diffuse from firms operating at the global productivity frontier to firms operating at the domestic frontier and then on to domestic laggards (OECD, 2015a). Weak market selection effects that impede the allocation of productive resources may also contribute to poor aggregate productivity. This includes the scope for relatively productive firms to grow, and the incentives faced by relatively unproductive firms to shrink and exit.

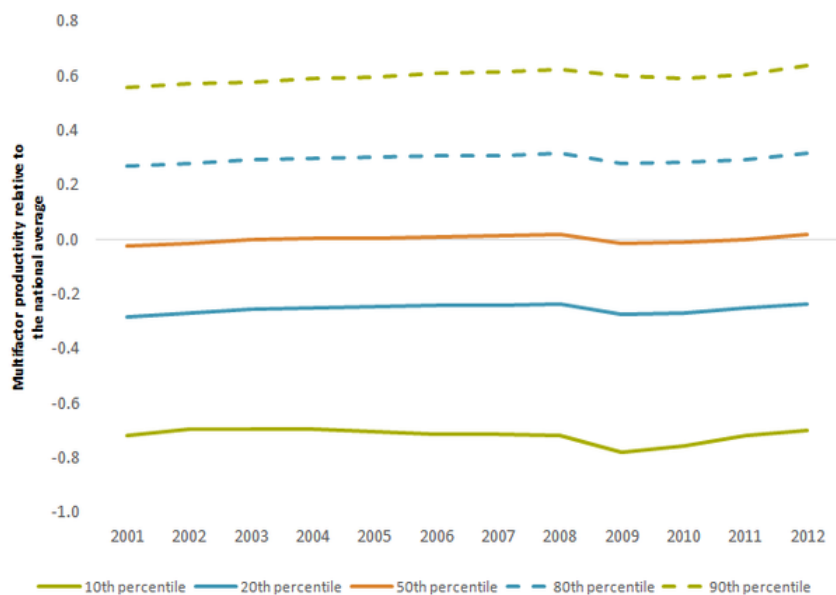
As a rough indicator of poor technology diffusion, MFP growth has generally been much weaker in firms operating at the New Zealand productivity frontier than in firms operating at the international frontier in the same industry (Conway, 2016).<sup>2</sup> This is consistent with the idea that New Zealand's most productive firms struggle to learn from global frontier firms in the same industry.

This lack of a cohort of leading firms with fast productivity growth is also apparent in the distribution of MFP across New Zealand firms, which has been remarkably stable (Chart 3). This contrasts with the recent experience in a number of other OECD economies in which leading high-productivity firms have pulled further ahead of lagging firms. Although stable, New Zealand's productivity distribution is extremely wide in international comparison, with top-decile firms producing around seven times more output per unit of input than firms in the lowest decile.

This coexistence of high and low-productivity firms may point to weak technology diffusion within the domestic economy. Conway, Meehan and Zheng (2015) find evidence of productivity convergence across manufacturing firms, but very slow or no convergence in parts of

<sup>2</sup> Given the difficulties in measuring technology, the globally most productive firms are assumed to operate with the globally most advanced technologies (OECD, 2015a). The most productive domestic and international firms are defined as firms in the top 5 per cent of the respective industry-level productive distribution.

**Chart 3: Firm-level Multifactor Productivity Distribution in New Zealand, 2001-2012**



Source: New Zealand Productivity Commission calculations.

the services sector and in the construction industry, which dominate in aggregate.

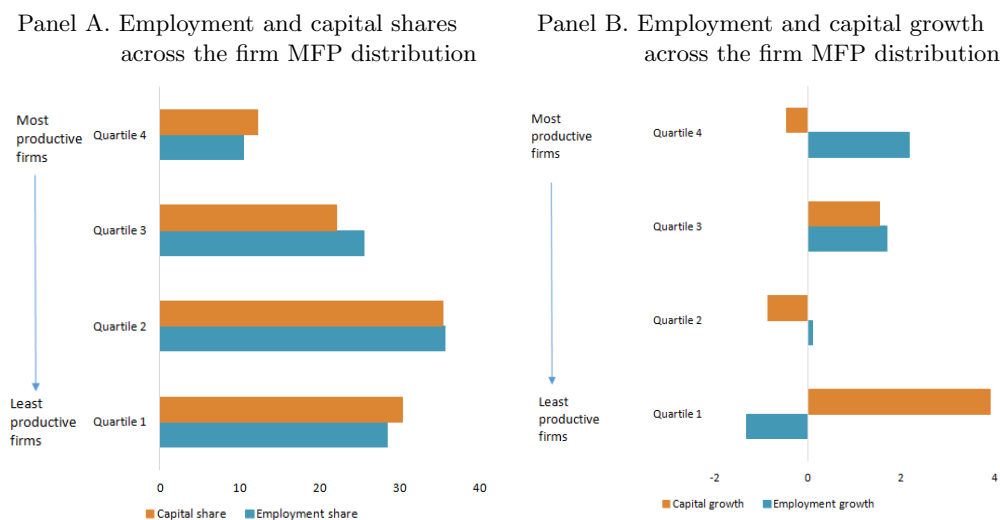
New Zealand’s wide and stable productivity distribution may also reflect weak market selection effects that allow low-productivity firms to survive in parts of the economy. Indeed, firms in the lower two quartiles of the productivity distribution in their industry account for a larger share of employment and capital compared to firms in the upper two quartiles (Panel A in Chart 4). This contrasts with the pattern in a number of other OECD economies in which firm productivity and size distributions are positively correlated. As well as weak competition that allows low-productivity firms to survive, this result may also reflect size constraints for relatively productive firms operating in New Zealand’s small domestic markets. More encouragingly, employment growth over the 2000s was weighted towards relatively productive firms, although capital tends to flow to relatively unproductive firms (Panel B in Chart 4) (Meehan, 2018).

### Why New Zealand Firms Have Low Productivity

The previous section paints a picture of an economy that has generally struggled to “catch up” with the productivity performance of high-income OECD economies, despite the emergence of a considerable productivity gap. Consistent with the aggregate results, firm-level analysis highlights issues with technology diffusion and resource allocation across firms, with a large share of labour and capital employed in low-productivity firms.

A growing literature has identified a range of possible reasons for weak technology diffusion and productivity-detracting resource reallocation, despite theoretical predictions and empirical evidence of productivity convergence within the OECD. This includes a host of structural factors, such as weak international connection and the geographic segmentation of domestic markets. Firm-level differences in productivity-enhancing investment, including in knowledge-based assets such as R&D and managerial capability, have

**Chart 4: (Re)allocation by Multifactor productivity quartile, 2000-2012**



Note: The left-hand chart shows the share of employment and capital across the (lagged) distribution of MFP across firms. The right-hand chart shows growth in employment and capital stock across the (lagged) distribution across firms. Both charts show the deviation from the 2000-2012 average.

Source: Meehan (2018).

also been found to play a role (Harris and Le, 2018). Against the background of this literature, this section investigates some of the deeper causes of the productivity dynamics reported in the previous section.

### Small Markets and Firms

The size of the market in which firms operate influences their productivity. Large markets reduce search costs and facilitate specialization by allowing a finer division of labour. They can also encourage better knowledge flows and spillovers across firms and facilitate increased competition that improves reallocation. The funding necessary to invest in capital and to innovate may also be more forthcoming for firms operating in large markets.

In small economies, international connection is the only way of securing the benefits that come with large markets. While international connection is important in general – for example, more open economies converge more quickly (Melitz

and Ottaviano, 2008) – it is especially important for small economies. As such, there is a clear negative cross-country relationship between economic size and trade intensity (Chart 5).

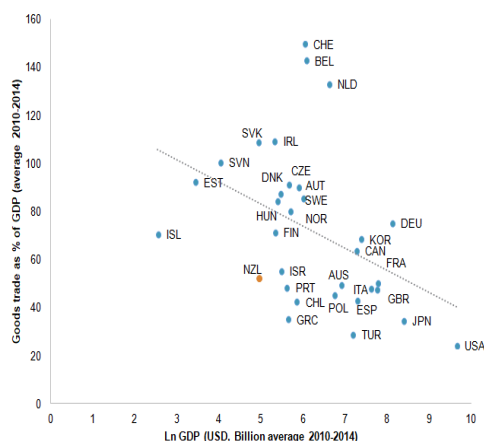
For a small economy, New Zealand is not well connected internationally. The intensity of international trade in both goods and services has declined over recent years and is one of the lowest among economies of a similar or smaller size (Figures 5 and 6). New Zealand firms also participate to a minimal extent in global value chains (de Backer and Miroudot, 2014).

The stock of FDI in New Zealand peaked at around 50 per cent of GDP in the late 1990s and has fallen slightly since. In contrast, global cross-border investment flows increased markedly over the late-1990s and 2000s as globalization deepened. The stock of FDI in New Zealand as a share of GDP is now around the OECD median, while outward direct investment is

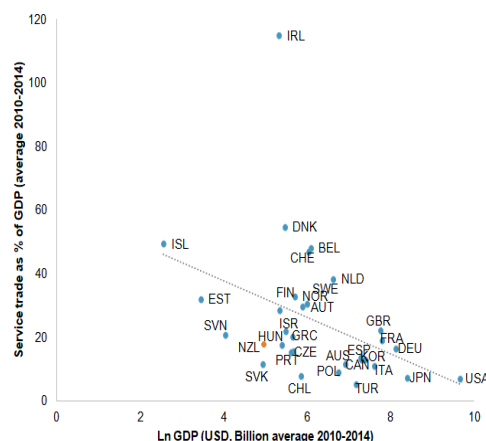
<sup>3</sup> Based on this performance, Wilkinson and Acharya (2013) argue that since the mid-1990s, New Zealand has been left behind in the international growth of cross-border investment flows.

Chart 5: Trade Shares of GDP in OECD Countries, 2005-2015

Pannel A. Goods Trade



Pannel B. Services Trade



Source: OECD

Note: Trade intensity is measured as (exports plus imports) divided by GDP.

among the lowest in the OECD.<sup>3</sup> Firm-level analysis also finds no evidence of technology spillovers from relatively productive foreign-owned firms operating in New Zealand to lower-productivity domestic firms (Doan, Maré and Iyer, 2015; Conway *et al.*, 2015).

More optimistically, although digital connection to the rest of the world measured as international bandwidth per capita use is relatively low, it has grown at a reasonable pace since 2006. International connection via people flows is also relatively high, with a large share of workers born overseas. However, as discussed below, given capacity constraints in the New Zealand economy, currently very high inward migration may work against capital deepening.

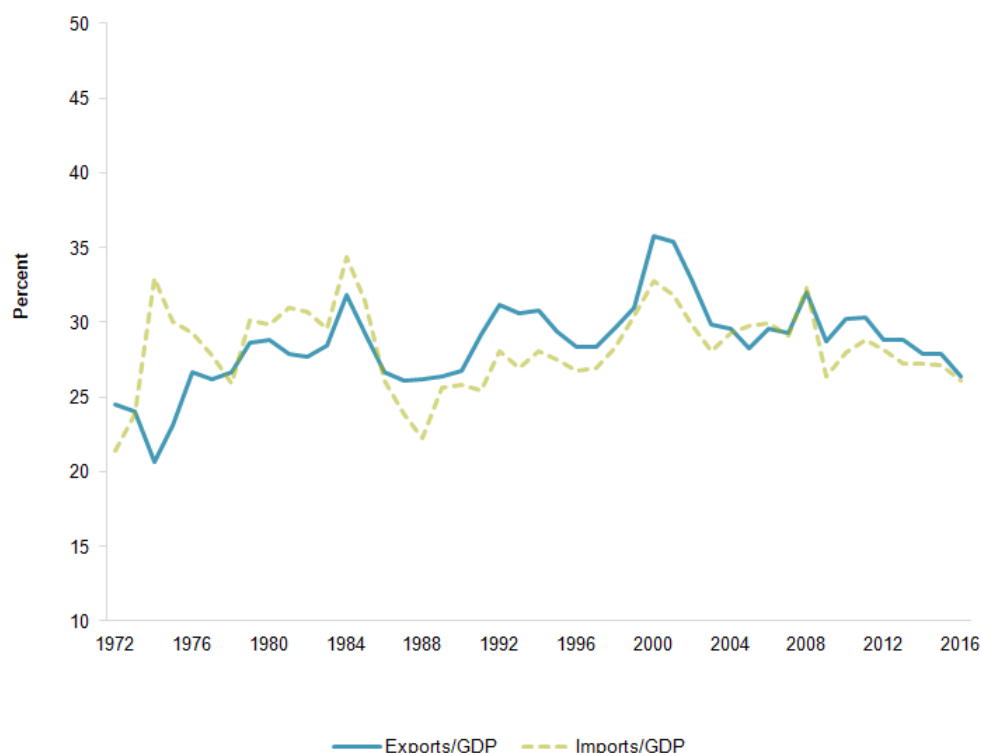
On balance, weak international connection is the key explanation for the “technology disconnect” between leading New Zealand firms and leading international firms outlined above. Compared to firms focused on domestic markets, exporting and foreign-owned firms operating in New Zealand are typically more productive and larger, suggesting that international connection facilitates technology diffusion and allows productive firms to grow and benefit from scale effects. However, despite

these productivity and size advantages, there are relatively few outward-looking firms operating in New Zealand.

This challenge of weak international connection is compounded by small and geographically segmented domestic markets. The associated negative impact on productivity may be considerable in New Zealand – a long, thin, mountainous and sparsely populated country in which infrastructure provision to link regional economies is challenging. This is likely to be an important reason for weak market selection effects and limited productivity “catch up” across firms within the domestic economy. For example, Zheng (2016) finds that firms in some services industries and in the construction industry tend to focus on the local market in which they are geographically situated and these firms are also the least likely to catch up to the national productivity frontier in their industry.

Overall, because the size of the market affects the size of constituent firms, weak international connection and small, insular domestic markets mean that New Zealand firms are relatively small in international

Chart 6: Trade Shares of GDP in OECD in New Zealand, 1972-2016



Source: Statistics New Zealand

comparison.<sup>4</sup> They also grow relatively slowly on average – within-firm employment growth is driven by a small cohort of high-growth firms whereas a large number of firms do not grow at all (Meehan and Zheng, 2015).

### A Capital-shallow Economy

Investment lifts labour productivity directly by adding to the capital workers have at their disposal and indirectly through MFP, as new technologies are often embedded in new capital. Capital intensity can also influence an economy’s areas of comparative advantage and specialisation. For example, Johansson and Olaberria (2014) show that across OECD economies, higher capital intensity is associated with

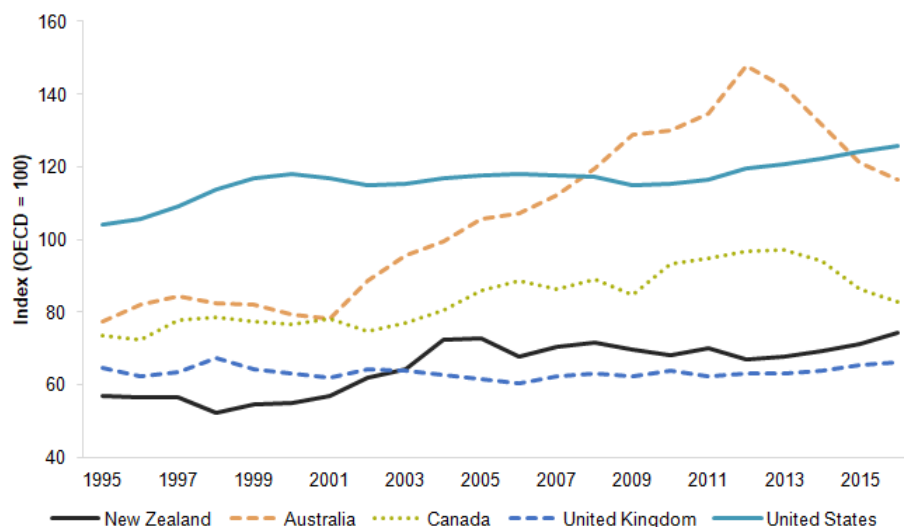
higher exports.

Over recent decades, non-residential business investment as a share of GDP in New Zealand has averaged slightly below the OECD median (Conway, 2016). However, with low GDP per capita and rapid employment growth, this is spread across relatively more workers compared to other OECD countries. Put differently, rapid population growth necessitates a higher investment share of GDP if New Zealand is to maintain capital per worker relative to countries with lower employment growth. In any case, investment per New Zealand worker is relatively low in international comparison (Chart 7).

These rough indications of capital

<sup>4</sup> For example, firms employing fewer than 50 people account for around 98 per cent of New Zealand firms and well over half of employment. In comparison, only 30 per cent of employees in the United States work for firms in this size category. At the other end of the size distribution, firms employing over 250 people account for 25 per cent of New Zealand employment compared with 55 per cent in the United States (Crisuolo, Gal and Menon, 2014).

**Chart 7: Gross Fixed Non-residential Capital Formation per Person in the Labour Force, OECD = 100, 1995-2016**



Source: OECD

Note: Data for gross non-residential capital formation are in current prices and were converted into a common currency using 2010 purchasing power parity exchange rates. The labour force includes only people aged 15-64. Data for the OECD exclude Chile, the Czech Republic, Estonia, Greece, Hungary, Iceland, Israel, Latvia, Luxembourg, Mexico, Norway, the Slovak Republic, Slovenia and Turkey. Data for New Zealand excludes investment related to the Canterbury earthquake rebuild.

shallowness are borne out by more detailed cross-country analysis. Mason (2013) finds that capital per hour worked in the market sector of the New Zealand economy was almost 40 per cent lower than in Australia in 2010, with New Zealand firms investing considerably less per hour worked in 19 of the 24 industries included in the study.<sup>5</sup> This is found to account for 39 per cent of the trans-Tasman gap in labour productivity.

While investment per New Zealand worker has increased slightly relative to the OECD average (Chart 7), New Zealand's capital-to-labour ratio has essentially been flat since 2010 as net investment has only just matched rapid growth in labour input (Chart 8). This is particularly concerning in an environment of historically low interest rates and highlights the labour-intensive nature of New Zealand's recent economic

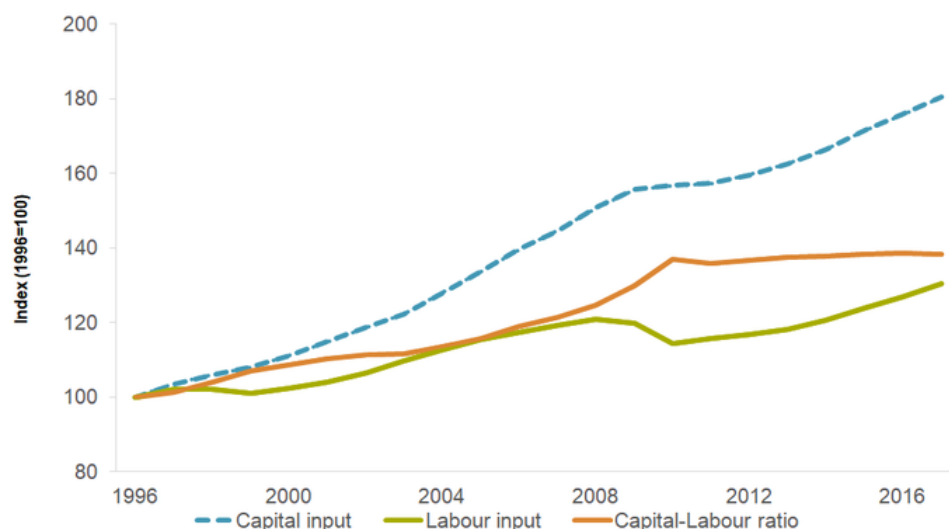
growth.

More encouragingly, New Zealand firms have invested strongly in ICT over recent years and the share of ICT investment in total investment and in GDP is now among the highest in the OECD (OECD, 2017). As with investment in general, this will be diluted to some extent by rapid employment growth. However, this might still hint at the potential for future productivity improvements, particularly in parts of the services sector where ICT has been a key input for innovation and productivity growth in some OECD economies.

There are a number of possible explanations for generally weak investment and the associated capital shallowness of the New Zealand economy. Although low historical interest rates since the GFC have been insufficient to lift capital intensity,

<sup>5</sup> Of the five industries in which capital per hour worked is higher in New Zealand, the utilities industry (electricity, gas and water) is the only significant user of capital.

Chart 8: Capital-Labour Ratio in the New Zealand Market Sector, 1994-2016



Source: Statistics New Zealand

unusually high long-term interest rates relative to other countries have most likely worked against capital deepening in the New Zealand economy over recent decades (Chart 9).

There is some debate as to the underlying reasons why long-term real interest rates are relatively high in New Zealand. The “risk premium” explanation contends that New Zealand’s net international (private) debt position and/or volatile exchange rate obliges international lenders to charge a premium for holding New Zealand-based assets. In contrast to private debt, public debt is very low in New Zealand and therefore an unlikely source of any interest rate risk premium.

An alternative explanation is that higher interest rates are principally the result of persistent demand pressure in the economy. With modest savings and low productivity, high real interest rates effectively reconcile elevated demand pressures with the economy’s more limited supply capacity. In this “macro imbalance”

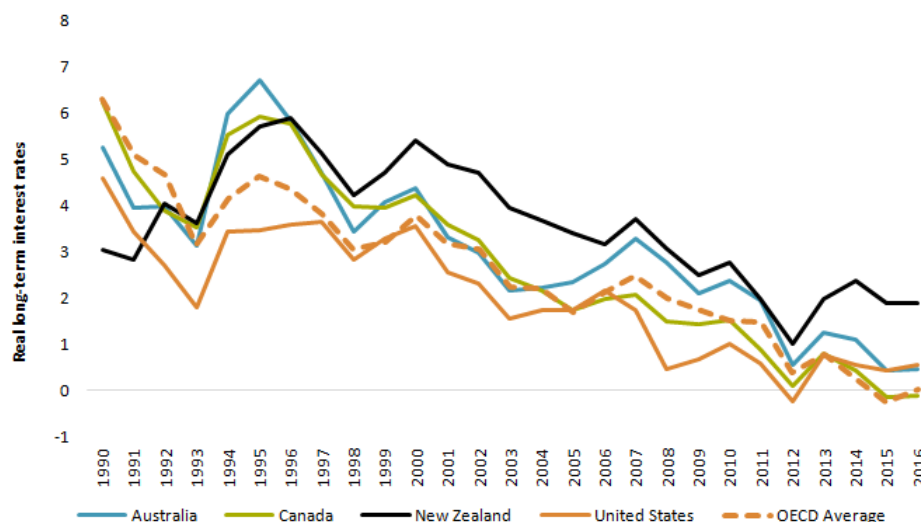
view, high real interest rates are associated with an overvalued exchange rate that is expected to depreciate but does not do so given the persistent nature of the demand shock.

Reddell (2013) argues that rapid migration-fuelled population growth is the underlying cause of these persistent demand pressures. This hypothesis potentially explains a range of puzzles about New Zealand’s macro-economy – including no evidence of Balassa-Samuelson effects (Steenkamp, 2013) – but has not been investigated empirically.<sup>6</sup>

Capital shallowness may also arise because the very small firms that make up the bulk of the New Zealand economy simply do not have the scale and sales volumes necessary to justify significant capital outlays. This is consistent with work showing that by increasing the return on investment, access to international markets can convince potential investors that a project has a better chance of exploiting returns to scale (de Serres, Yashiro and

<sup>6</sup> The Balassa-Samuelson hypothesis suggests there should be a relationship between a country’s relative productivity performance and its real exchange rate (Steenkamp, 2013).

Chart 9: Long-term Real Interest Rates in Selected OECD Countries, 1990-2016



Source: OECD

Note: The real long-term interest rates have been calculated using five-year moving averages of inflation rates. The OECD average has been calculated using the available OECD countries real long-term interest rate. Greece has been excluded from the average.

Boulhol, 2014). Although this “small-firms” explanation should also apply to ICT, it is possible that “software as a service” and cloud computing have increased the feasibility of ICT investment for small New Zealand firms.

At the other end of the size distribution, weak investment by New Zealand’s largest firms may reflect governance issues. Among firms with \$1 billion plus turnover is a prevalence of farmer-owned cooperatives and partly-privatized state-owned enterprises. A common factor across these firms is a reluctance to provide capital for growth and a strong aversion to risk, especially associated with expansion into overseas markets. More generally, government involvement in the business sector is

relatively high in New Zealand, which may run the risk of crowding out private investment.<sup>7</sup>

Finally, for reasons that are not well understood, the off-the-shelf cost of investment goods is also high in New Zealand compared with other OECD countries.<sup>8</sup> This mix of a real interest rate premium, small firms operating in small markets, relatively widespread government influence and an abundant supply of labour encourages New Zealand firms to grow by investing relatively little in capital and taking on additional workers.

### Low Investment in Knowledge and Skills Mismatch

Investing in knowledge-based assets is important not only for firms operating at the

7 For example, in the OECD’s indicators of product market regulation, New Zealand ranks 25th out of 35 countries on the extent of “public ownership” in the economy. This indicator is made up of sub-indicators covering “scope of SOEs”, “Government involvement in network sectors”, “Direct control over enterprises” and “governance of SOEs”.

8 Using the International Prices Comparison data, Gemmill (2014) finds that the price of investment goods in New Zealand is around 19 per cent higher than the OECD average and 15 per cent higher than in Australia. The price of machinery and equipment is 12 per cent and 5 per cent higher than the OECD average and Australia respectively while the cost of non-residential construction is estimated to be 22 per cent above the OECD average.

global frontier but also for lagging firms to facilitate the adoption of new technology and its adaptation to local conditions. Because aspects of new technology are not easily codified, lagging firms need to undertake some R&D to successfully incorporate new technologies into their production processes. Synergistic investment in skills, organizational know-how and managerial capability are also important in improving firms' ability to absorb and benefit from new technologies (Bloom, Sadun and Van Reenen, 2016).

While data on knowledge-based capital is relatively poor in New Zealand, there are indications that low investment in these types of assets may be an important part of the reason for weak long-run productivity growth. In particular, de Serres *et al.* (2014) estimate that as much as 40 per cent of New Zealand's productivity gap compared with the OECD average reflects weak investment in knowledge-based assets.

Most obviously, public and private investment in R&D as a share of GDP is among the lowest in the OECD, with New Zealand's large firms performing particularly poorly (OECD, 2017). In part, this reflects the structure of the New Zealand economy and composition of exports, which are skewed towards low-R&D industries and products respectively. However, compared to other countries, business spending on R&D is also low within industries, indicating that structural factors offer only a partial explanation.

As with investment in general, a relatively high cost of borrowing and the impact of small markets may dampen the incentives

firms face to undertake R&D. Sparse networks of researchers and innovative firms may also restrict R&D and other types of innovation. This fits with the fact that internationally-connected New Zealand firms are much more likely to innovate compared to firms focused solely on domestic markets (Wakeman and Le, 2015). Internationally-engaged firms are also more likely to improve their productivity as a result of innovation, whereas a domestic market focus on domestic markets can stifle these gains (Wakeman and Conway, 2018).

Across all firms, "working on the business" is just as important as developing new and improved products in lifting productivity. This highlights the importance of management capability, which has been assessed as relatively poor in New Zealand on average (Green *et al.*, 2011).

More broadly, the human capital available to firms is a key determinant of their ability to absorb and benefit from new ideas and technology – skilled workers adopt innovations earlier and are associated with greater firm investment in knowledge-based assets. While New Zealand's education system has accommodated strong growth in student numbers, results from the Programme for international Student Assessment (PISA) show a deterioration in the performance of 15 year olds relative to other countries up to 2012 and then a slight absolute deterioration to 2015.<sup>9</sup> Results also show that the difference between high and low achievers in New Zealand and the influence of socio-economic factors on student performance are among the highest in the OECD.

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9 While raw PISA scores increased between 2009 and 2012, New Zealand's relative position in the OECD slipped from 7th in reading, 7th in science and 13th in maths to 13th, 18th and 23rd respectively. In 2015, the scores for New Zealand students declined slightly but rankings improved a little. The Programme for the International Assessment of Adult Competencies (PIACC) shows that the skills of older cohorts in New Zealand rank more highly in international comparison compared to younger cohorts, consistent with a relative deterioration in performance through time.

There is also evidence of a high incidence of skills mismatch in the New Zealand labour market, which may also restrict the ability of firms to successfully adopt new ideas and technology. Indeed, results from the Programme for the International Assessment of Adult Competencies (PIACC) show that skills mismatch in New Zealand is among the highest in the OECD. Consistent with this, the returns to education in New Zealand are among the lowest in the OECD and have declined over recent years.<sup>10</sup> Although some level of skills mismatch is inevitable especially in the context of a small New Zealand economy largely comprised of many small firms extensive mismatch and falling wage premiums for education indicate a disconnect between the education system and the skill requirements of firms.

### **The Challenge for Policymakers**

New Zealand's broad policy settings are often assessed as comparing well with other countries. Yet they have been unable to move the economy onto a high-productivity growth path. In part, this apparent disconnect between policy and performance reflects the uniqueness of New Zealand's economic situation. The reality of being a small country distant from major global markets resonates through the economy in complex ways that are not always well understood, adding to the challenge of setting policy appropriately.

Although policy settings might look highly supportive of productivity growth when viewed through the long-range telescopes of the OECD and the World Bank, economic reform clearly lost momentum in New Zealand after the initial burst from the mid-1980s to the early-1990s. For example, Conway (2011) argued as early as 2011 that New Zealand was no longer

at the forefront in many areas of product market regulation. Since then, successive inquiries by the New Zealand Productivity Commission have identified serious weakness in policymaking and regulatory governance. As such, successfully responding to the challenge of improving New Zealand's long-run productivity performance will require significant capability improvements within the public sector.

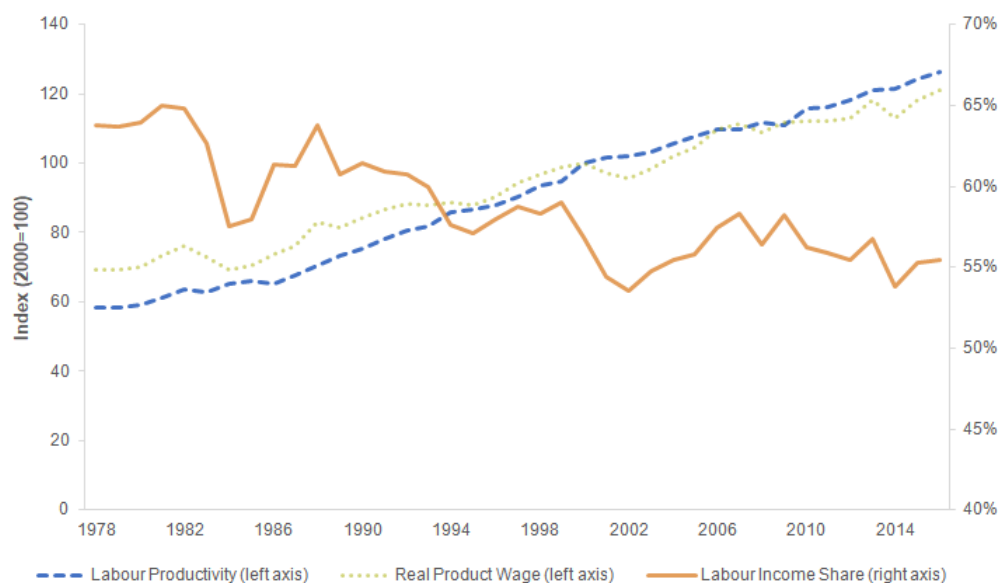
Another obvious way in which government can contribute to higher aggregate productivity is by lifting its own performance. In its inquiry into state sector productivity, the Productivity Commission identifies examples of extremely poor productivity growth within the public sector. For example, government funding per school student increased by 66 per cent from 2003 to 2016, which includes the period in which New Zealand's PISA scores declined in relative and absolute terms. However, despite much room for improvement, measuring and lifting state sector productivity is currently not a priority for officials (NZPC, 2017a).

Helpfully, changes in technology have the potential to counter some of the economic forces that have constrained the productivity of New Zealand firms. Most obviously, dramatic falls in spatial transaction costs and the rise of global value chains are fundamentally changing global trade. In aggregate, these developments may increase the negative impact of distance on international connection. For example, McCann (2009) argues that this has made it more difficult for New Zealand firms to connect internationally. However, a multitude of stories are playing out within the aggregate picture and in some areas of activity, the forces that have restricted

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<sup>10</sup> For example, the wage premium for degree-qualified workers relative to workers without degrees fell from 73 per cent in 2000 to 52 per cent in 2017 (Maré, 2018).

Chart 10: The Labour Income Share in New Zealand, 1978-2016



Source: Fraser (2018).

international connection by New Zealand firms may be loosening their grip.<sup>11</sup>

As well as bringing great potential for higher productivity and living standards, new technology also carries a risk of increased inequality if the benefits are skewed towards the owners of capital, a relatively small group of people in society. This dynamic is apparent in recent falls in the share of national income accruing to workers in some OECD economies. While the labour-income share has fallen overall in New Zealand, it has been relatively stable since the late-1990s, consistent with limited technology adoption and international connection (Chart 10).

In this environment, the challenge for New Zealand policymakers is to work against the economic forces outlined above that have kept productivity growth low for decades. A key aspect of this is to build on the opportunities that new technology brings while mitigating downside risks. The fact of

a broadly stable labour income share implies a grace period in which to make the economy more flexible and resilient to new technology while ensuring that the benefits are widely spread.

In what follows, the elements of such a policy response are outlined. While this does not constitute a full economic strategy, it highlights some of the economics that needs to sit at the heart of such an agenda. As indicated, the Productivity Commission has written inquiry reports outlining detailed policy recommendations in some of these areas. In other areas, the economics and public policy is more speculative and in need of further work.

### Help Small and Remote Firms into Global Markets

To make the most of a growing window of opportunity for international connection by New Zealand firms, trade in services and digital products need to be key elements in New Zealand’s trade strategy. To a

<sup>11</sup> For example, while the production of ICT equipment has become increasingly agglomerated, the provision of ICT services has become increasingly dispersed across the globe (OECD, 2017).

large extent, trade facilitation in these areas involves international regulatory cooperation and coherence to reduce “behind the border” trade barriers. Given the complexities, this can be a long slow process. However, this will only become more important as the global economy becomes more interdependent and multipolar. As such, New Zealand should leverage its good reputation in multi-country fora and international organizations with the aim of using best-practice regulatory governance to improve cross-country coordination issues.

At home, looking outwards to assess the potential impact of domestic regulation on international connection needs to be a cornerstone of regulatory stewardship. For example, where appropriate, the adoption of reputable international standards is an increasingly important part of international regulatory coherence that can reduce costs for firms wanting to operate across borders. However, given variable quality, international standards and regulatory regimes should only be adopted within New Zealand if in the national interest (which includes the need to strengthen international connection).

On goods trade, although most imports enter New Zealand duty-free, tariffs still generate costs, including higher-priced intermediate inputs for some New Zealand firms. As such, New Zealand’s remaining tariffs should be reviewed with a view to removal.

### **Improve the Matching of Skills to Jobs**

The strong performance of the New Zealand labour market in creating jobs and soaking up labour – including low-skilled workers – may have detracted from human capital and productivity growth. For example, Maré, Hyslop and Fabling (2015) estimate that the average quality of New Zealand workers fell slightly from the early

2000s as the impact of lower-skilled new entrants more than offset improvements in the qualifications and experience of existing workers. This is estimated to have reduced MFP growth from 0.24 per cent to 0.14 per cent per year over the sample period of the study.

Although the labour market dynamics behind this result are not well understood and in need of deeper analysis, these interdependences between the labour market and economic growth raise important questions about the performance of New Zealand’s education system. If the creation and adoption of new technologies is to play a part in improving New Zealand’s long-run productivity performance, then a large share of the working population will need to be equipped with the skills and experience necessary to operate with these technologies. Accordingly, the education system potentially plays a key role in “winning the race between skills and technology” and spreading the benefits of new technologies across the population.

Fortunately, there are some encouraging signs. For example, consistent with strong ICT investment, PIACC results show that New Zealand workers have very high proficiency for problem-solving in technology-rich environments. More broadly, however, the evidence outlined above suggests that New Zealand’s education system may not be keeping up with leading OECD countries and could be doing more to alleviate skills mismatch and improve social mobility. As such, a major challenge for the skills system is to become more effective at equipping all New Zealanders with relevant skills and the ability to update their skills as labour market demand changes into the future.

In an inquiry into new models of tertiary education, the New Zealand Productivity Commission found that a high degree of

central control restricts the incentives for tertiary institutions to innovate. This report put forward a number of specific recommendations aimed at making the system more adaptive and responsive to changing labour market demands (NZPC, 2017b).

### **Use Immigration to Lift Human Capital**

Immigration policy could also do more to improve human capital and skills matching within the New Zealand economy. PIACC results show that the overseas-born population in New Zealand are highly skilled relative to immigrants in other OECD countries but still less skilled than the New Zealand-born population on average. It also shows a relatively high incidence of qualification mismatch among immigrants in New Zealand.

As with labour market dynamics in general, the broader impacts of immigration on the New Zealand economy are not well understood and in need of deeper study. However, available evidence implies a risk that strong migration inflows might restrict wage growth and encourage a reliance on low-cost labour by some firms and industries. While strong employment growth has kept pace with strong immigration inflows, many immigrants are poorly paid and working in unskilled occupations in lower-productivity industries (McLeod, Fabling & Maré, 2014). This may suppress investment and productivity improvements and work against efforts to increase the employment of lower-skilled New Zealanders.

The limited available evidence suggests that the government's objectives around immigration for labour market purposes should be more firmly focused on lifting the skill composition of the workforce, with the

aim of improving international connection and the flow of new technology into the economy. New Zealand is currently an attractive destination internationally and policy needs to use that advantage to more clearly target high-skilled migrants.

### **Make Investment Easier and More Effective**

Although the capital-to-labour ratio has been flat recently in the face of low interest rates, it is highly likely that the cost of capital features in firm investment decisions. As such, low capital intensity over the long run most likely reflects, in part, higher borrowing cost for New Zealand firms relative to firms in some other OECD economies.

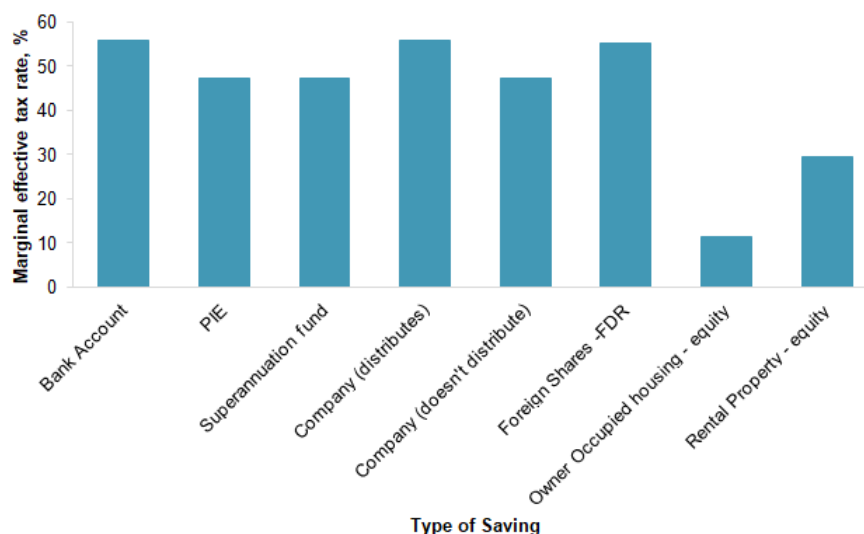
Of course, New Zealand is an open economy and firms are free to borrow in international capital markets. However, imperfect capital mobility, home-biased investors and relatively unsophisticated New Zealand firms may result in a link between domestic savings and investment. Alternatively, if a risk premium is the cause of relatively high interest rates, then higher national savings would alleviate this by improving New Zealand's net international debt position. Even if higher savings have no impact on interest rates or investment, lower consumption may enable structural adjustment into the tradable sector, with a positive impact on MFP.

So conditional on a deeper analysis of the underlying economics, policies aimed at increasing savings may need to be considered in raising capital intensity (Brook, 2014). The impact of tax settings would need to be part of this consideration. Currently, savings in New Zealand are taxed on a "Taxed-Taxed-Exempt" basis, whereas most other OECD countries provide more favourable

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12 "Taxed-Taxed-Exempt" means that contributions to savings schemes are made out of after-tax income and that the returns on savings are taxed while withdrawals are exempt from tax. Australia and Turkey

Chart 11: Marginal Effective Tax Rates on Savings in New Zealand



Source: Tax Working Group (2018)

Notes: Marginal effective tax rates measure the tax rate on real, pre-tax income from investments that earn the same rate of return. The figures in the graph are based on the assumption that the risk-free return is 3 per cent, inflation is 2 per cent, the real capital gain on rental property is 1 per cent per year, and the statutory marginal tax rate is 33 per cent. “PIE” stands for “portfolio investment entity”, which have a maximum tax rate of 28 per cent.

tax treatments to encourage savings (OECD, 2015b).<sup>12</sup> In contrast to savings and business assets, housing is taxed relatively lightly in New Zealand (Chart 11).

There is a risk that this differential tax treatment may skew investment into housing over financial assets. For example, in the ten years to 2017, the housing-share of household wealth increased by 20 percentage points and accounted for around 85 per cent of the total increase in New Zealanders’ wealth. It follows that conditional on corroborating research, a more consistent tax treatment across different asset classes could potentially lift private savings, improve the composition of investment and spread the ownership of capital across the population.

Outside of the tax system, improving the performance of the housing market could redirect investment flows into the

tradables sector and reduce skills mismatch by allowing people to live where their talents are most valued. The New Zealand Productivity Commission has made numerous recommendations aimed at improving the institutional, legislative and regulatory frameworks used in the design and implementation of the urban planning system (e.g., NZPC, 2015 and 2017c). Improving productivity in the construction sector – which has been at the centre of a number of construction disasters over recent decades – would also help.

Relatively high central and local government control in the market sector of the New Zealand economy runs the risk of crowding out private investment, including in infrastructure. While privatization should always be an option, improving the ways in which government funds and regulates its involvement in markets is also important.

are the only other two OECD countries that use this approach (OECD, 2015b).

For example, a well-understood pipeline of public infrastructure projects and clear frameworks for the use of third-party capital could alleviate tax and borrowing constraints and improve the performance of government-owned assets.

Increased inward foreign investment is another way of lifting capital intensity. New Zealand's FDI regime is subject to considerable discretion, adding uncertainty and cost to an already complex system. As such, the FDI regime could be simplified, with any restrictions on foreign ownership of specific asset types clearly specified.

Strong investment flows to firms with low productivity levels (Panel B of Chart 4) might reflect a New Zealand banking system that struggles to provide credit to high-productivity firms with no credit history or a lack of tangible assets to use as collateral. This highlights the importance of reviewing financial regulations to remove inhibitions to the development of deep capital markets. As well as developing New Zealand's small venture capital and share markets, new funding sources such as crowd funding also need to be encouraged. Issues with private-sector funding for intangible-intensive firms also highlights the importance of government support for business innovation, which is discussed below.

### **Moderate Population Growth to Encourage Capital Deepening**

Immigration has had a strong impact on the New Zealand labour market – around a quarter of New Zealand's current population were born elsewhere compared with a worldwide average of about three per cent (Fry, 2014). Recently, with lower departures and increased arrivals, immigration has surged to a net inflow

of about 60-70 thousand people per year, contributing up to 1.5 percentage points to New Zealand's population growth (Chart 12), which is consequently one of the fastest in the OECD.

If low investment constrains the ability of the New Zealand economy to produce housing, infrastructure and business capital, then reducing high labour force growth would be an important key in lifting capital intensity. Reducing inward immigration from currently very high levels is the only practical way of doing this. Importantly, as future productivity improvements lift the capacity of the New Zealand economy to respond to higher demand, then net migration can be increased again, according to the preferences of New Zealanders.

Although the lags involved probably preclude migration policy being used as a macroeconomic stabilisation tool, better management of the volatility in net migration could potentially improve long-range construction and investment planning in the public and private sectors.

Although the devil is in the detail, the sharper focus on genuine skills proposed above could be used as a basis for reducing migration inflows. This would most likely have a negative short-run impact on GDP growth.<sup>13</sup> This cost could be mitigated by efforts to encourage more low-skilled New Zealanders into the workplace, including more attractive career options for low-skilled workers and changes in the interface between the tax and welfare systems. For example, Nolan (2018) shows that effective marginal tax rates are over 100 per cent for some categories of workers moving off benefits and into part-time work.

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13 For example, Coleman and Karagedikli (2018) find that net inward migration is “hyper-expansionary”, in that the immediate demand for housing from immigrants exceeds their productive potential, thereby creating pressure for additional inward migration. Conversely, a reduction in migration would reduce economic activity.

Chart 12: Migration Flows into New Zealand, 1990-2017, (% of the Population)



Source: Statistics New Zealand

### Improve Competition to Lift the Contribution of Services

Parts of the services sector are the epicentre of New Zealand’s poor productivity performance.<sup>14</sup> Enhancing competition in this part of the economy would improve technology diffusion and energize market selection effects, making it less likely that productive resources – including skills and intellectual property – become trapped in lagging incumbents and, instead, flow to more innovative new entrants.

As well as a significant direct effect, higher productivity in services would also contribute indirectly to aggregate productivity growth, given that almost half of services-sector output is used as intermediate inputs by firms in other parts of the economy. With services deeply embedded in virtually all products made in New Zealand, performance improvements would lift comparative advantage across the

board, including in prospective new areas of international connection.<sup>15</sup>

A New Zealand Productivity Commission inquiry into the services sector made a number of recommendations to lift competition by reducing the costs for consumers and businesses of searching and switching between service providers (NZPC, 2014). Comparison websites, information disclosure and reasonable contract termination arrangements all have a role to play. As in most other OECD countries, reforming occupational regulation also has the potential to improve competition and lift performance in a key part of the services sector.

New Zealand’s competition policy framework could also do more to enhance competition. The government’s recent decision to give the competition regulator the power to conduct market studies is a step in the right direction. Shifting to an effects-based test in the abuse of market

14 Service industries are among the most and least productive in the economy both in terms of the levels and growth rates of labour productivity (Conway and Meehan, 2013; NZPC, 2014). In broad terms, service industries that invest in and use ICT intensively have relatively high productivity, skills intensity and wages. The distributive and person-centred service industries are generally the converse.

15 While the direct contribution of services to gross exports is around 30 per cent, the total services content embodied in New Zealand’s gross exports is almost double that at 60 per cent of total exports (Rajanayagam, 2017).

power provisions is the obvious next step.<sup>16</sup> As well as being competition enhancing, this would also improve cross-country regulatory coherence, including with Australia, given the aspiration of a single trans-Tasman economic market.

Infrastructure provision is another way in which government can influence competitive intensity by better linking small markets across New Zealand's towns and cities, thereby improving proximity between customers and providers. By facilitating firm-to-firm connections, this also has the potential to improve technology diffusion. As such, infrastructure provision could be more responsive, including pricing and funding that reflects actual costs, use and impacts.

Pro-competition regulation was once world-leading in New Zealand (Conway and Nicoletti, 2006). A key current challenge for policymakers is to rediscover that commitment, with a strong focus on parts of the services sector. This should include potential new opportunities to lift competition. For example, bank account number portability has the potential to lower the costs of switching between banks, increasing customer churn and the impact of competition on bank performance.

### **Strength the Economic Return from Science and Innovation**

The ongoing policy challenge in this space is to develop a science and innovation system that is open and responsive to new opportunities and focused on creating rich, dense innovation ecosystems in areas appropriate for New Zealand's economic geography. This may entail a greater focus on thematic research platforms in areas conducive to small, remote firms engaging

internationally.

Although it has increased recently, government support for business R&D in New Zealand is still among the lowest in the OECD. On the face of it, this suggests that greater support could yield increased innovation and productivity benefits. However, if weak innovation reflects poorly-managed firms operating in small, fragmented and uncompetitive markets, then further R&D subsidies risk being ineffective. Accordingly, a much better understanding of the impact of innovation support on firm performance and the contribution of the science system to New Zealand's economic performance would be extremely valuable. Ideally, these evaluations should reflect back into the policy design process.

As well as a tighter focus on thematic research platforms and improvements in policy evaluation, innovation prizes could also be considered for solutions to well-defined issues. Relatively small prizes seem to be effective in motivating research and innovation to solve practical problems. This would complement the existing framework of R&D grants and a soon-to-be-introduced tax credit and recognize that there is more to innovation than R&D, especially in the services sector.

Given that innovation and international connection go hand-in-hand in New Zealand, there may also be scope for greater coordination or merger between the government agencies that administer government support for innovation and international connection.

More could also be done to encourage knowledge diffusion across firms and to leverage the intellectual property in the

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<sup>16</sup> Currently, abuse of dominance cases are assessed using a "purpose test" that the conduct had an anti-competitive purpose and a "counterfactual test" that the conduct could not have occurred in the absence of market power. This is out of step internationally, with competition law in almost all other OECD countries focussing on whether a dominant firm's behaviour creates demonstrable harm to consumers.

national science system. For example, in the context of transitioning to a low-emissions economy, the New Zealand Productivity Commission has suggested a government program aimed at scanning international developments in low-emissions technologies and feeding relevant information to New Zealand firms and industry associations. Efforts to increase collaboration between research organizations and firms and to encourage firms to improve management practices could also encourage diffusion.

Experimentation is a critical part of catching up to the productivity frontier and firms need the flexibility to discover and learn about emerging technological possibilities and business models. As such, because failure is an inherent part of innovation, tax and regulatory settings should be consistent with risk taking and not overly penalize failure.

## Conclusion

Since the beginning of the GFC, growth in per capita income in New Zealand has been above the OECD average. In large part, this reflects terms of trade improvements and a labour market that has continued to be very successful at providing employment and absorbing strong growth in the labour force. New Zealand's productivity performance relative to high-income OECD countries has also improved and the economy is managing to "keep up" in the context of a generalized productivity slowdown. However, there is still no evidence of "catching up" despite a substantial productivity gap.

Of course, getting workers into jobs is important in improving well-being and testament to the benefits of New Zealand's flexible labour market. However, New Zealand cannot continue to rely on strong labour market growth as a predominant driver of economic growth. First, with constraints on investment, ongoing strong employment growth works

against capital deepening and labour productivity improvements. Second, because productivity growth is the key driver of higher wages, a strong reliance on employment growth runs the risk of creating many low-productivity jobs that are not well remunerated. As such, New Zealand's key economic challenge is to move from a growth strategy based on labour absorption to one in which productivity improvements play a much bigger role.

This article argues that New Zealand's poor long-run productivity performance reflects a number of economic features. Firms are generally not well integrated into international markets, leading to a "technology disconnect" and limited scope for productive firms to grow. In the domestic economy, firms focused on small insular local markets are less likely to be exposed to new technologies and competitive pressures that facilitate productivity-enhancing reallocation. Low investment, including in knowledge-based assets such as innovation and management capability, also contributes to weak technology diffusion across New Zealand firms.

This diagnosis is undertaken against the backdrop of rapid changes in technology and in the global trading environment. Although face-to-face connection is still paramount, these changes are opening areas of economic activity in international markets that are less constrained by distance, firm size and the legacy of past investment choices. These trends are likely to continue as a growing part of production is digitized and delivered remotely through fibre-optic cables and the scope for using technology to communicate, learn and interact from a distance keeps improving. In much the same way that colonial ties to the United Kingdom once offset the impact of distance, new technology is opening a window of opportunity for New Zealand firms to engage internationally

in areas of activity that are no longer disadvantaged by remoteness.

To make the most of these opportunities, this article outlines a number of policy considerations aimed at countering the economic forces that have constrained New Zealand's long-run productivity performance. These include opening the economy to new opportunities for international connection and improving comparative advantage through capital deepening and MFP growth. In turn, higher MFP could come about through the more effective use of domestic and international human capital, greater service sector competition and a more effective science and innovation system.

Because many aspects of New Zealand's productivity story are under-researched, important parts of the analysis and policy conclusions offered in the article are in need of further work. For example, a deeper understanding of the impact of the tax system on capital intensity and productivity is highly desirable. Other prospective research areas include understanding the cause of New Zealand's interest rate premium and the impact of immigration on the economy, in addition to developing a much deeper understanding of labour market dynamics more generally. The apparently very poor allocation of productive resources across firms is also in

need of deeper investigation.

New Zealand is well placed to make the transition from employment-led growth to productivity-lead growth. The economy has weathered the GFC in good shape and aspects of New Zealand's macro imbalances are showing signs of improvement. Increasing export diversity and a growing high-tech sector, including strong growth in the market capitalization of various ICT firms, suggest improved international connection in some areas. By building on these developments, policymakers have a good shot at finally breaking free of the economic constraints that have kept productivity low for so long.<sup>17</sup>

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17 Some of the results in this paper are not official statistics. They have been created for research purposes from the Integrated Data Infrastructure (IDI), managed by Statistics New Zealand. Access to the anonymized data used in this study was provided by Statistics New Zealand under the security and confidentiality provisions of the Statistics Act 1975. Only people authorized by the Statistics Act 1975 are allowed to see data about a particular person, household, business, or organization, and the results in this paper have been made confidential to protect these groups from identification and to keep their data safe. Careful consideration has been given to the privacy, security, and confidentiality issues associated with using administrative and survey data in the IDI. Further detail can be found in the Privacy impact assessment for the Integrated Data Infrastructure available from [www.stats.govt.nz](http://www.stats.govt.nz). The results are based in part on tax data supplied by Inland Revenue to Statistics New Zealand under the Tax Administration Act 1994. This tax data must be used only for statistical purposes, and no individual information may be published or disclosed in any other form, or provided to Inland Revenue for administrative or regulatory purposes. Any person who has had access to the unit record data has certified that they have been shown, have read, and have understood Section 81 of the Tax Administration Act 1994, which relates to secrecy. Any discussion of data limitations or weaknesses is in the context of using the IDI for statistical purposes, and is not related to the data's ability to support Inland Revenue's core operational requirements.

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# The Changing Structure of Global Value Chains: Are Central Hubs Key for Productivity?

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## ABSTRACT

This article uses “centrality” metrics reflecting position within Global Value Chains (GVCs) to identify central hubs and peripheral European economies and sectors. We find evidence of large changes in the structure of European production networks, with rising importance of Eastern European economies coinciding with the timing of their EU accession. Using cross-country firm-level data from ORBIS, we find that changing structure of GVCs can play a role in the catch-up of firms, but the effects are heterogeneous across firms and countries. First, becoming more central is associated with faster productivity growth of firms in post-2004 EU members. Second, the average productivity (centrality weighted) of buyers/suppliers matters for the productivity of firms overall in other European economies, and particularly non-frontier (initially less productive) firms in both groups of countries. The results for post-2004 EU members suggest that policies to encourage integration into GVCs are particularly important for the productivity of emerging or less integrated economies, whereas for more advanced economies a more sophisticated policy is needed that encourages the formation of linkages with productive, frontier foreign firms and economies.

The productivity effects of Global Value Chains (GVCs) may stem from position within them and not just participation. It is well-established that GVC participation can increase productivity.<sup>2</sup> In addition, changes in the structure of GVCs and position within them may also matter for productivity. Firms and industries positioned at the

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<sup>2</sup> On the relationship between Global Value Chains and productivity, see Criscuolo and Timmis (2017).

centre of complex production networks have access to a greater variety of foreign knowledge, compared to those at the periphery. Potential knowledge spillovers may be further reinforced when firms are part of networks connecting highly productive frontier suppliers or customers, with access to more advanced knowledge. Therefore whether firms and industries sit at the fringes of global production or are tightly knotted at the centre of a complex network, connecting highly productive foreign firms, is likely to affect economic outcomes.

The aim of this article is twofold. First, it shows there have been large changes in the structure of GVCs over the period 1995-2011. We present “centrality” metrics that go beyond GVC participation, reflecting central hubs and peripheral industries and countries within global production networks. Whilst some activities remain clustered around the same central hubs, as was the case at the start of the period, and some countries industries’ remain relatively peripheral, for others there have been dramatic restructuring of the geography of economic activity. Many of these patterns in the data concord with anecdotal evidence concerning the shifting patterns of production. For example, European motor vehicle manufacturing remains centred around key hubs in Germany, but there has also been a pivot away from many traditional centres of manufacturing towards Eastern European countries. More generally, these countries have become more central to global production networks, with their growing importance coinciding with the timing of their EU accession.

Second, the article finds that the changing structure of GVCs can play a role in the catch-up of firms, but that the correlations are heterogeneous across firms and countries. We match our centrality metrics to cross-country firm-level data,

to examine the effects of the structure of the GVC network on the diffusion of productivity. Becoming more central as a customer or supplier is associated with faster productivity growth of firms in post-2004 EU members, particularly those initially less productive firms. But we find either insignificant or even negative impacts for larger or frontier (initially more productive) firms and for firms more generally in other European countries. In addition, we find that being connected to more productive foreign sectors can also play a role in firm catch-up. We supplement the standard centrality metrics by examining changes in the average productivity (centrality weighted) of buyers/suppliers. Supplying or buying from faster growing foreign sectors is correlated with faster productivity growth of non-frontier (initially less productive) firms and of firms overall in other European economies. But again these correlations weaken with firm size or proximity to the frontier.

Our work draws heavily upon the growing body of work that uses centrality metrics to describe the structure of real-world production networks. We apply the “Bonacich-Katz” eigenvector centrality metric to the OECD ICIO 2015 edition data, which underlie OECD-WTO TiVA metrics. We focus on Europe because of the salient changes that have taken place, and the good coverage of both the trade flow and later firm-level data. Cerina *et al.* (2015) compute a range of centrality metrics using WIOD input-output (IO) data, and find that industries are highly asymmetrically connected and also that GVCs are regionally clustered. Other researchers have applied centrality metrics to trade in value-added data, rather than IO data. Santoni and Taglioni (2016) and Amador and Cabral (2017) find that foreign value added in exports became denser, more

complex and tightly connected over time. Gourdon *et al.* (2016) highlight the growing importance of China in electrical machinery manufacturing.

The literature has most often applied centrality metrics to study shock transmission and granularity, often within a single country, rather than productivity in a cross-country setting as we do here. This strand of work is based on the fact that in real-world production networks input flows are not distributed symmetrically and so well-connected agents, by linking remote parts of the network, can play a key role in the transmission of shocks (Acemoglu *et al.*, 2012). For instance, productivity growth in the 10 most central US sectors (out of 417 sectors in the U.S. Input-Output tables, approximately at the NAICS four-digit level) account for 80 per cent of the variation in U.S. aggregate output growth over the period 1959-2009 (Carvalho, 2014). Using novel firm-to-firm transaction data for Belgium, Magerman *et al.* (2016), find productivity shocks to the 100 most central Belgian firms (out of 80,000 firms in their sample) account for 91.3 per cent of Belgian aggregate volatility. Imbs and Pauwels (2017) find that GDP volatility between developed countries is explained by differences in foreign centrality, but not centrality due to domestic linkages, and that this link has strengthened over time.

A related stream of research considers the importance of centrality for the diffusion of knowledge or new technologies, often using social networks rather than production networks as in this article. Central players by definition have a high degree of connectivity (both directly and indirectly), more widespread and closer linkages to other agents, and therefore potentially broader access to knowledge that these other agents possess. Villagers in India consistently identify the most central person in terms of

both direct and indirect social linkages as the person best-placed to spread information (Banerjee *et al.*, 2016). Students randomly allocated into groups of other students with high centrality tend to out-perform those randomly allocated to groups with lower centrality (Hahn *et al.*, 2015). Diffusion of participation in a weather insurance scheme reaches a greater proportion of farmers, when information on insurance is provided to those farmers that are more central, in terms of social linkages within the village (Caie *et al.*, 2015). Social linkages between farmers predict the diffusion of fertilizer technology in Ghana, with farmers copying neighbours who were unexpectedly successful in prior periods (Conley and Udry, 2010).

The article proceeds as follows. The first main section explains the centrality concept as applied to GVCs and presents graphical illustrations of key changes in the structure of value chains within Europe. The second section, briefly describes the firm-level data and empirical framework and present correlations between firm productivity and the changes in GVCs. The final section discusses our main conclusions.

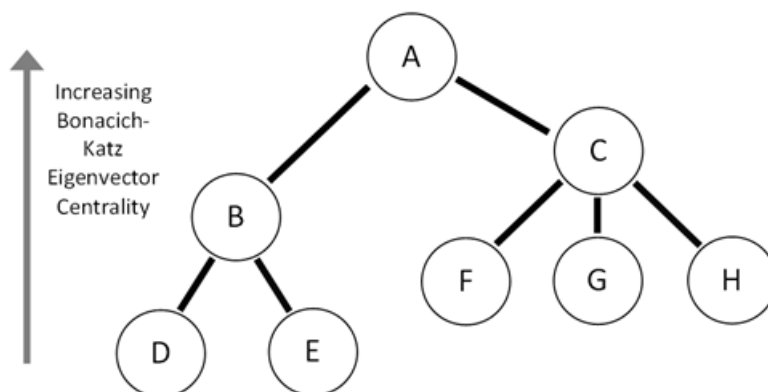
## Central Hubs in GVCs

The first part of this article provides an overview of centrality and how this has changed over time for different countries and sectors within Europe. We focus on Europe because of the salient changes that have taken place, and the good coverage of both the trade and later firm-level data.

## Measuring Centrality

Our work leverages standard network measures of Bonacich-Katz eigenvector centrality. These are measures of influence or connectivity within production networks that take into account both direct and indirect network linkages to identify central hubs. Thus centrality is determined not only based on direct trade linkages, but also

Figure 1: Bonacich-Katz Eigenvector Centrality Illustration



the linkages of your trade partners, and the trade partners of your trade partners and so on. To illustrate the Bonacich-Katz eigenvector centrality metric, consider the simplified production network of Figure 1, where we have neglected input flow weights for simplicity. Here C sources inputs from F, G and H, so has the highest number of direct connections. However, eigenvector centrality reflects the strength of both direct and indirect linkages. Although A only has two direct linkages (to B and C), it has five linkages one-indirect linkage away (D to H). A is a key hub in the network and would have highest centrality.

Specifically, we apply the theoretically-grounded centrality of Acemoglu *et al.* (2012) and Carvalho (2014).<sup>3</sup> This class of measure encompasses several variants applied in the sociology literature (such as eigenvector, Katz and Bonacich centrality) or in computer science, such as Google’s PageRank search algorithm (Brin and Page, 1998). One key point is that input flows are scaled, such that we are concerned with input shares rather than absolute value of flows. This implies that centrality is a

relative measure, relative to other country-industries in the network.<sup>4</sup>

Our centrality metrics are derived from the 2015 edition of the OECD-ICIO data that underlies the OECD-WTO TiVA indicators. The data employed here contain rich information of flows of goods and services across 34 ISIC revision three sectors and 62 economies for the 1995-2011 period. However, we focus upon the narrative for European economies for this article. The data have a broad coverage of the main actors in global production networks and also reflect flows of services as well as goods, with the former not captured for instance in network analysis of customs data (e.g. De Benedictis *et al.*, 2013). However, one limitation of the data is the relatively broad definition of sectors.

The centrality metrics we use distinguish between key suppliers and key customers, using forward export and backwards import linkages respectively, and report total centrality as the average of forwards and backwards centrality. Countries and industries can be central because of their linkages to domestic sectors or linkages to

<sup>3</sup> Specifically, these models show the parameters used in the centrality calculation are proportional to the average share of intermediates in production. We use the same parameters as Carvalho (2014), since the average share in our data is close to that found by Carvalho (0.52 to 0.54 in our data, compared to 0.5).

<sup>4</sup> A technical discussion of the centrality metric adopted in the article is detailed within Criscuolo and Timmis (2018a and 2018b).

foreign sectors. Given our concern with GVCs, this article focuses on the foreign component of centrality, where we find the majority of cross-section and time series variation (Criscuolo and Timmis, 2018a and 2018b). The domestic component of centrality is included as a control variable in our regressions.

### **Changing Structure of Factory Europe**

At an economy-level we find that a minority of central hubs dominated European value chains in both 1995 and 2011. Chart 1 shows the aggregate centrality metrics for European economies. However, the underlying calculation relies on the full data dimensions of all countries and industries.<sup>5</sup> The size of nodes represents the total centrality from foreign sources; key hubs are denoted with large nodes and peripheral economies (of lower centrality) with small nodes. Overall, Germany is the most central economy in Europe both in 1995 and 2011, accompanied by several other central economies such as France, Italy and the UK. In contrast, there are several more peripheral economies, including those of a smaller market size such as Malta or Cyprus, but also Portugal, as well as Luxembourg and Eastern European economies at the start of the period.

However, there is rising centrality beyond the key hubs in European production networks. Several of the economies in Europe that were most peripheral (i.e. least central) in 1995 became increasingly central by 2011. This is particularly true of many Eastern European economies. One of the major changes within Factory Europe has been increasing centrality of the periphery and Chart 1 also shows increased production linkages between European economies over time, particularly

Eastern European economies. Indeed, as we show later, for some industries such as computer and electronic or automotive manufacturing there is a particularly strong shifting influence from many developed economies to these emerging economies.

Several of most peripheral European sectors have become more central within Factory Europe, which has been mainly driven by post-2004 EU accession countries. Chart 2 shows the distribution of centrality across European country-industries in 1995 and 2011. For post-2004 EU member countries there has been a large rightward shift in this distribution, reflecting a general trend of increased centrality of their industries (Panel A in Chart 2). Conversely, for other European countries there is a much less noticeable change (Panel B). Note however that despite these changes, at the end of the period the post-2004 EU countries remain less central than other European economies on average (as reflected in Chart 1).

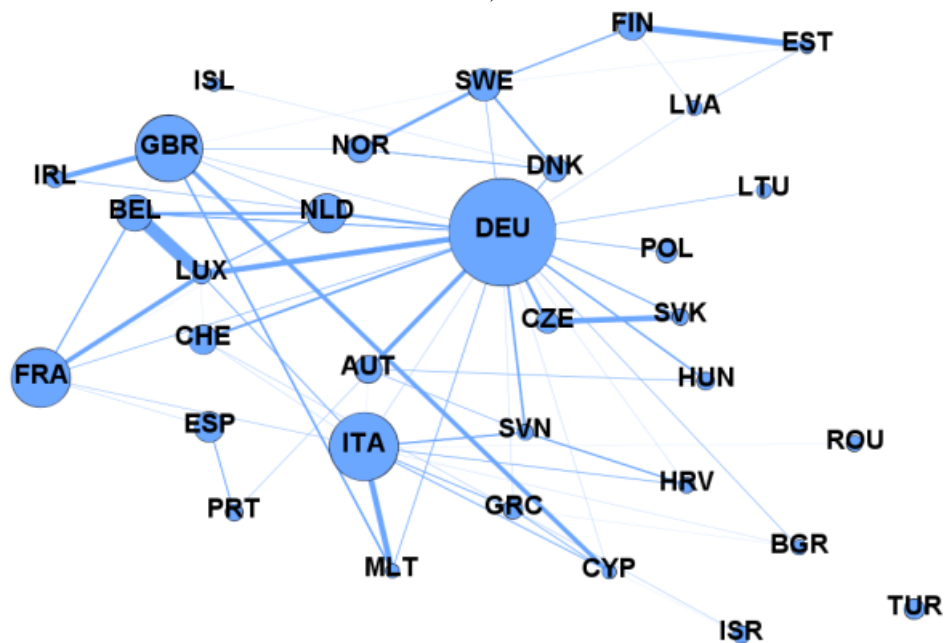
The centrality growth of post-2004 EU accession countries coincides with the timing of their EU accession. Chart 3 shows the centrality growth of various parts of the distribution of centrality over time for these economies, where centrality is normalized relative to the signing of the accession treaty in 2003. As in Chart 2, for these economies centrality increases over time across all parts of the distribution, reflecting a general trend of increasing centrality for post-2004 EU countries' industries. However, the centrality growth is particularly marked from 2004 onwards, with little obvious trend before that point. Surprisingly, centrality growth appears to be strongest for the most peripheral sectors of these post-2004 EU economies (10th and 30th percentiles),

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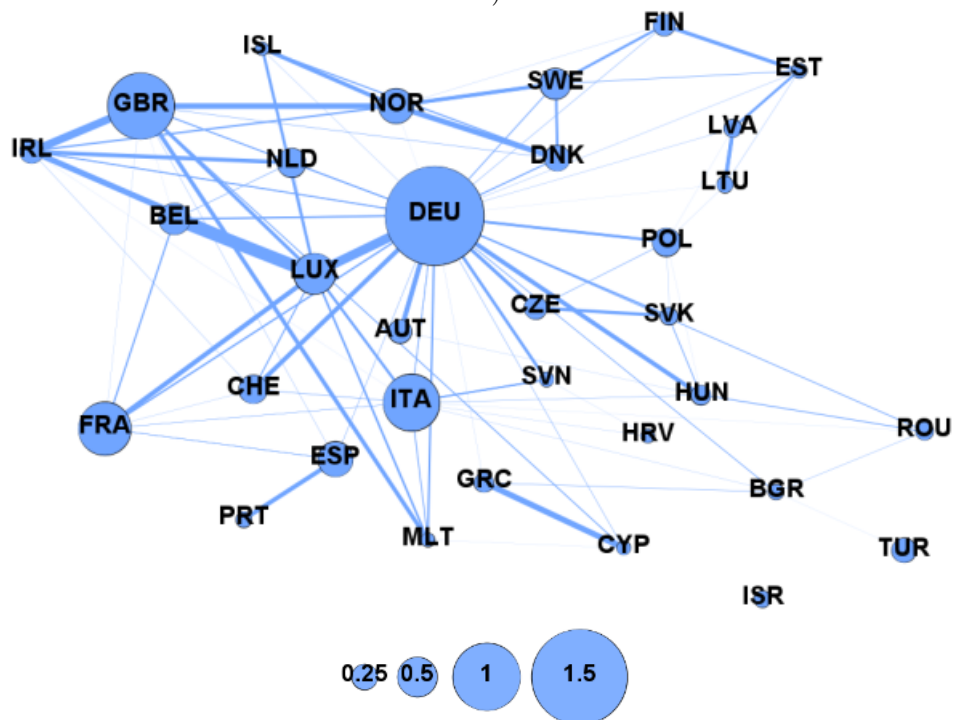
<sup>5</sup> We aggregate industry metrics using their share of the economy's output as weights (results are also similar when using export weights).

Chart 1: Aggregate Central and Peripheral European Economies, 1995 and 2011

Panel A) 1995

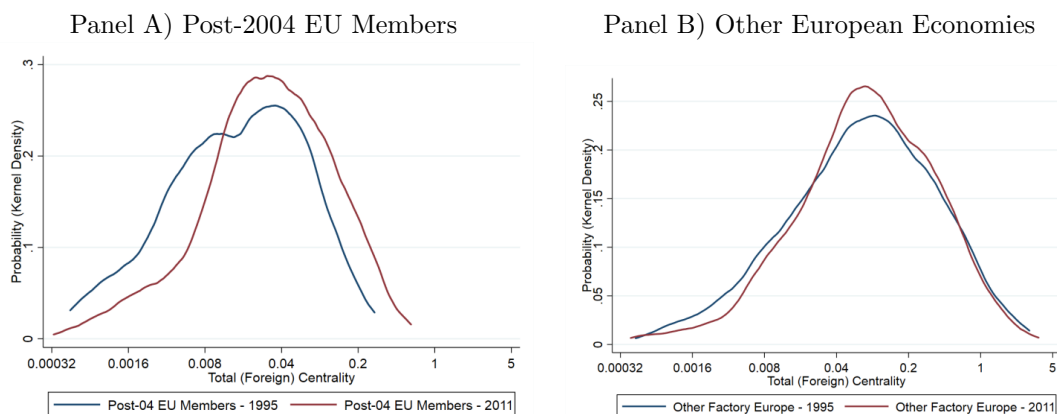


Panel B) 2011



Economies are placed according to their location. Node size denotes total centrality (forward and backward) aggregated at an economy-level and includes all sectors within global production networks. Edges reflect direct input flows. For clarity only the largest input flows are reflected, those exceeding 2 per cent of total inputs used in the importing or exporting economy.

**Chart 2: Increasing Centrality of Post-2004 EU Accession Members**



The charts show the distribution of foreign centrality across European country-industries in 1995 and 2011, with Panel A showing post-2004 EU accession countries and Panel B showing all other European countries. Comparing the two charts shows that most of the changes appear to reflect post-2004 EU countries, more so than other European countries. Total (foreign) centrality is measured at the country-industry level. Post-2004 EU Accession economies include: Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Lithuania, Latvia, Malta, Poland, Romania, Slovakia and Slovenia. Other Factory Europe economies include: Austria, Belgium, Croatia, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey and UK.

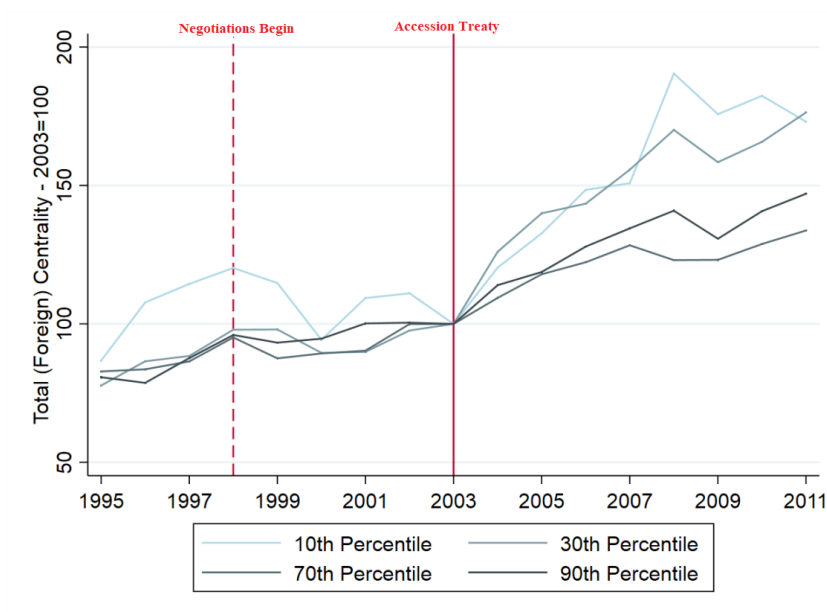
rather than those sectors that were already more central and already more integrated into European value chains (70th and 90th percentiles). These same economies experienced large increases in FDI following their EU accession, suggesting there may be complementarities between ownership and input linkages. Indeed, other researchers have found that the entry of foreign firms into Eastern Europe has been an important factor affecting their integration into GVCs (e.g. Harding and Javorcik, 2012; Bajgar and Javorcik, 2016). These FDI inflows have been associated with increases in productivity both of the receiving country-industries, but also in supplier and customer industries (Bijsterbosch and Kolasa, 2010; Arnold *et al.*, 2011; Javorcik and Yue, 2013).

At an industry-level there are profound changes in the organization of some production networks, but some of the same central hubs persist throughout the period, mirroring the earlier findings at a country-level. Chart 4, Panel A shows the changes in centrality for one particular industry, motor vehicles manufacturing, over the

period 1995-2011. The colour of the nodes reflects the sign of the change (green for positive, red for negative) and node size the absolute size of the change. For motor vehicles there has been a general eastwards shift, with declining importance of some traditional centres of production (such as the UK, France) and increasing influence of many Eastern European economies. This is consistent with a narrative of increasing offshoring of motor vehicle production. However, the narrative is not solely about offshoring of production. For instance, Germany was the most central hub for motor vehicles industry in 1995 yet actually increased influence over the period 1995-2011.

Service inputs are also becoming increasingly important to global production networks, in both emerging and high-income economies. We find that a number of economies specializing in services have become more influential in several services sectors, such as the UK or Luxembourg (see Figure 2). However, the growth of services in production networks is not

**Chart 3: Centrality Growth of 2004 EU Accession Countries over the period of EU Accession, 1995-2011**



The percentiles reflect different parts of the distribution of centrality for 2004 EU accession countries' industries. 2004 EU Accession economies include: Cyprus, Czech Republic, Estonia, Hungary, Lithuania, Latvia, Malta, Poland, Slovakia and Slovenia. The percentiles are defined afresh for each year and so represent different country-industries over time. Total (foreign) centrality is measured at the country-industry level.

simply a restructuring story for a minority high-income economies. For particular services industries, however, such as R&D and business services, these have become more important to production networks for the majority of economies for which we have data, as shown in Chart 4, Panel B. These trends are consistent with a rising importance of services for global value chains in general, and also for the performance of manufacturing firms even in emerging economies (e.g. Arnold *et al.*, 2011; 2016).

### GVC Centrality and Productivity

The first part of this article has provided an overview of centrality and how this has changed over time for different countries and sectors within Europe. In the second part

we analyze how centrality and its changes relate to the productivity of firms. We first briefly summarize the firm-level data, before outlining the empirical framework and presenting the results.

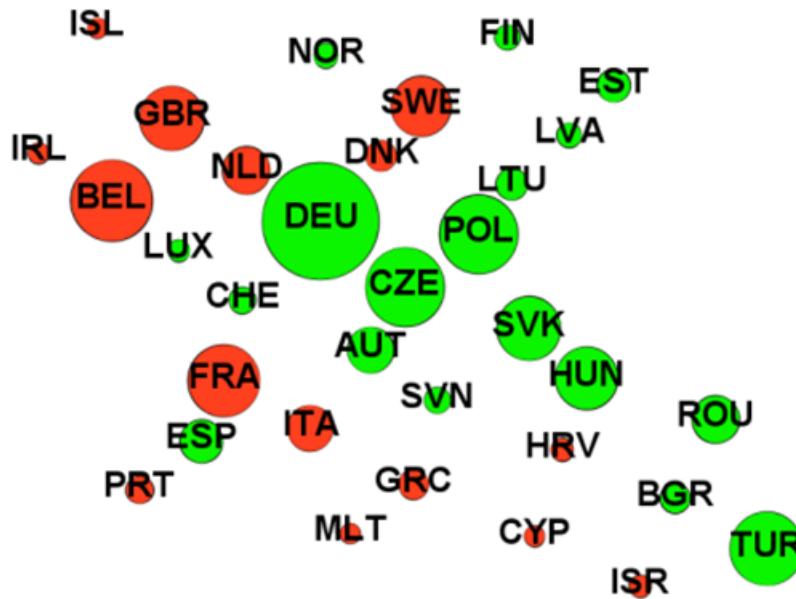
### Measuring Firm Productivity

We use Orbis firm-level data, which is a harmonized cross-country dataset provided to the OECD by the commercial provider Bureau Van Dijk. The industry detail is at the two-digit in NACE (revision two) and comprise the non-farm non-financial business sector excluding mining, petroleum manufacturing and real estate activities (i.e. codes 10-82, excluding 19, 64-66 and 68). We retain 22 European countries with more than 500 (firm-year) observations

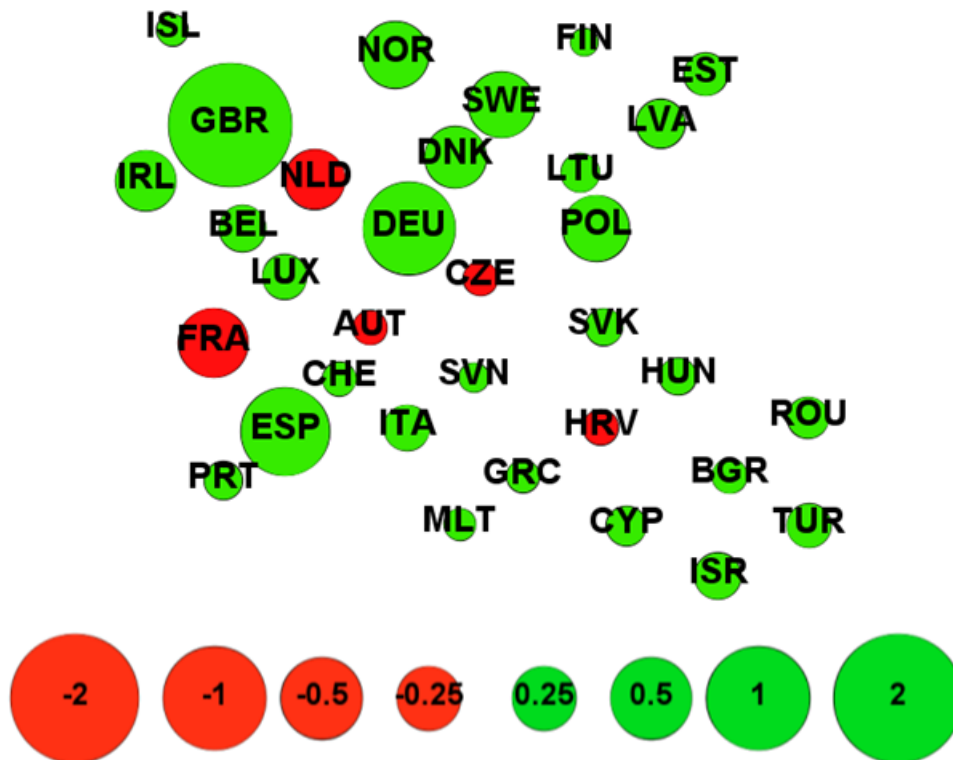
6 These economies are Austria, Belgium, Bulgaria, Denmark, Estonia, Finland, France, Germany, Hungary, Ireland, Italy, Latvia, Luxembourg, Netherlands, Poland, Portugal, Romania, Spain, Sweden, Slovenia, Turkey and the United Kingdom. The results are unchanged if we further restrict this to countries with more than 5000 observations, results are available upon request.

Chart 4: Changes in Centrality, 1995-2011

Panel A) Motor Vehicles



Panel B) R&D and Business Services



Economies are placed according to their location. The size of the nodes reflects the magnitude of the change (in levels) of total foreign centrality over the period 1995-2011. As reflected in the key, these changes are graphed using a log scale for readability. Green coloured nodes reflect increasing centrality and red denotes falling centrality. Motor vehicles manufacturing reflects ISIC rev.3, 34: Motor vehicles, trailers and semi-trailers. R&D and business services reflect ISIC rev.3, 73-74: R&D and other business activities.

in the matched data.<sup>6</sup> Since Orbis has relatively poor coverage of small firms, we restrict the sample to firms with more than 20 employees (on average over the sample period). We perform a number of cleaning steps to identify outliers and jumps, following the suggestions by Kalemli-Ozcan *et al.* (2015) and previous OECD analyses (Gal, 2013). We focus on unconsolidated data, out of a concern that consolidated data may consolidate information from subsidiaries in different industries and/or countries. To extend coverage, value-added has been internally imputed using the factor incomes given within Orbis, i.e. the cost of employees and earnings before interest, taxes, depreciation and amortisation, as suggested by Gal (2013).

We match firm-level Orbis data to the centrality metrics calculated using OECD ICIO data, using a firm's country, NACE (revision two) industry code and year. We employ a concordance between two-digit NACE (revision two) and 34 Trade in Value Added - TiVA (ISIC revision three) industries to account for differing industry definitions between Orbis and OECD ICIO data. The OECD ICIO data are available over 1995-2011, which ultimately determines the number of years of our analysis. We use one year lagged values of centrality, meaning that our period of analysis is 1996-2012.

Firm-level multifactor productivity (MFP) is estimated using the instrumental variable (IV) method proposed by Wooldridge (2009). To allow for technological differences across industries,

the production function is estimated separately for each two-digit industry, controlling for year fixed effects.<sup>7</sup> Estimation uses a real value added-based production function estimation with the number of employees and real capital as inputs (deflated using two-digit country-specific deflators to 2005 PPP international dollars).<sup>8</sup>

The firms included in the final sample are predominantly of medium to large in size and older, with a mean employment of 248 employees and a mean age of 22 years (Table 1).<sup>9</sup> Therefore it is not possible to comment on the productivity of the smallest firms. Just under half these firms are in the manufacturing sector, reflecting that Orbis tends to have better coverage of manufacturing firms.

### Empirical Framework

We focus on how productivity changes in foreign sectors diffuse through key hubs to influence the productivity of domestic firms. We consider two aspects of this diffusion. The first reflects the effect of becoming a central hub (for a given composition of sectors connected), and the second, the effect of connecting fast growing foreign sectors (for a given level of centrality). We measure the former using the centrality metric explained earlier, and the latter using the average productivity (centrality weighted) of buyers/suppliers.<sup>10</sup>

We first examine whether becoming more central within GVCs translates into firm productivity growth. Specifically, we consider whether firms in industries that

<sup>7</sup> The results are robust to the use of mark-up adjusted firm MFP, which controls for unobservable firm markups using the method of De Loecker and Warzynski (2012). These results are available upon request.

<sup>8</sup> We use the country-industry level purchasing power parity database of Inklaar and Timmer (2014).

<sup>9</sup> The descriptive statistics for these larger firms is consistent with papers using similar data, for example, Andrews *et al.* (2015).

<sup>10</sup> To remove noise, we measure each foreign sector's productivity as the 3 year moving average of log labour productivity (value-added per worker in international PPP dollars).

**Table 1: Summary Statistics of Firm-Level Data**

|                        | Mean | Std. Dev | N         |
|------------------------|------|----------|-----------|
| MFP (logs)             | 11.0 | 1.0      | 2,264,646 |
| Employment (number)    | 248  | 3296     | 2,264,646 |
| Sales (PPP\$ millions) | 76.5 | 978.0    | 2,235,358 |
| Age (years)            | 22.2 | 18.3     | 2,264,646 |
| Services               | 0.44 | 0.50     | 2,264,646 |

Note: Age is not included as a control variable in the regressions reported in the remainder of the paper as it is collinear with firm fixed effects.

become more central over time, increase productivity faster than those in industries that become more peripheral. As noted in the introduction, central hubs play a key role in linking agents throughout the network. Central hubs by definition have a high degree of connectivity (both directly and indirectly), more widespread and closer linkages to other buyers and suppliers, and therefore potentially broader access to knowledge that these other agents possess. This first metric therefore reflects whether becoming more or less influential within GVC networks matters for firm productivity.

Second, we examine whether who an industry connects with matters for firm productivity growth. We measure whether firms have faster productivity growth in industries connected to faster growing foreign buyers or suppliers. The diffusion path of new knowledge is unlikely to be determined solely by influence within GVC networks, but rather those sectors that are highly connected to new sources of knowledge are likely to benefit more. For instance, a central hub connecting highly productive, technologically advanced foreign buyers and suppliers is likely to have greater access to knowledge than a central hub connecting less productive ones. The diffusion of foreign knowledge may therefore depend upon the composition of buyer/supplier connections. We reflect this with the (centrality weighted) average productivity of foreign buyers/suppliers. The latter therefore reflects whether the productivity of a sector's more

influential buyers or sellers matters for firm productivity.

Our empirical framework estimates the correlation between within-firm productivity growth and sector centrality or being connected to more productive (foreign) sectors:

$$\begin{aligned}
 MFP_{ist} = & \beta_1 c_{st-1} + \beta_2 PROD_{st-1} + \\
 & \beta_3 IndustryControls_{st-1} + \\
 & \beta_4 FirmControls_{st-1} + \quad (1) \\
 & \delta_i + \delta_t + \epsilon_{ist}
 \end{aligned}$$

where  $MFP_{ist}$  refers to the multifactor productivity of firm  $i$ , in sector  $s$  and time  $t$ .  $c_{st-1}$  is the centrality of sector  $s$ , which is lagged one period, and refers to either total, forwards or backwards centrality in the results below.  $PROD_{st-1}$  is the average productivity (centrality weighted) of foreign buyers/suppliers, lagged one period, using either total, forward or backward linkages. Industry controls include domestic sources of centrality, total (forward and backward) GVC participation, Fally's (2011) GVC upstreamness measure, exports of intermediate goods and services, industry imports of intermediate goods and services, gross output (as a measure of industry size), Balassa's Gross Revealed Comparative Advantage and Koopman *et al.*'s (2014) Value-Added Revealed Comparative Advantage. Lagged firm employment is included as a control for firm size; firm age is not included since it

is reflected in the fixed effects. The model also includes both firm and year fixed effects while robust standard errors are clustered at the country-industry level, where industry reflects the 34 TiVA industries in the underlying centrality measure.

The inclusion of both firm and time fixed effects means we are comparing within-firm changes in productivity, due to industry-level changes in centrality or changes in productivity of their suppliers/customers. The firm fixed effects control for any time-invariant firm (and thus also industry or country) characteristics and year fixed effects control for any time-variant factors common across firms. We therefore reflected within-firm changes based on changes in centrality across country-industries.

As noted earlier, centrality is a relative measure such that it is relative to all other countries and industries in the network. Including further fixed effects, such as industry-year or country-year dummies, would depart from this. For example, including industry-year dummies would mean we are measuring changes across countries but within the same industry and year (e.g. computing and electronics manufacturing in 2000). We follow the approach of Imbs and Pauwels (2017) and do not include further fixed effects, but instead introduce a broad range of industry controls reflecting factors that may explain any link between centrality and firm productivity.

Although we do not claim a causal link, one obvious concern is that the network of input linkages underlying our measures may not be exogenously determined. For example, since more productive firms tend to trade more intensively and with more countries and trade partners (e.g. Bernard *et al.*, 2011; 2014), productivity increases themselves may lead to increased centrality within the GVC network, rather than the other way round. However, the

use of firm-level data and industry-level centrality measures reduces the scale of the problem, as it is unlikely that many firms are able to influence the centrality of their entire industry within the GVC network. Centrality of the industry is therefore likely to be exogenous from a firm perspective, especially when considering small and medium sized firms. However, a minority of highly productive firms often account for the bulk of input flows across borders and a minority of multinationals are often found to drive GVCs (De Backer and Miroudot, 2017). To mitigate this concern, we examine our results separately for different firm types, isolating whether the productivity effects are driven by a minority of these frontier firms (those that are initially more productive) that may be able to influence industry centrality or those smaller and medium-sized firms, far from the frontier, that are not likely to be able to influence industry metrics. We leave further examination of causality as a direction for future research.

### **Firm Productivity and the Changing Structure of Factory Europe**

Firms in post-2004 EU member countries show faster productivity growth in sectors that become more central, but this is not the case in other European economies (other than post-2004 EU members). Table 2 presents the baseline estimates of equation 1, examining the correlation between changes in (foreign) centrality and productivity of foreign suppliers/buyers on domestic firm productivity. For post-2004 EU members, firm productivity growth is correlated with becoming more central as a supplier through forward linkages (column 2), as a customer through backward linkages (column 3) or overall (column 1). The mean increase in (total) industry centrality for post-2004 EU economies is associated with 0.8 per

**Table 2: Baseline Results**

| MFP Wooldridge   | (1)                              | (2)                | (3)                 | (4)                      | (5)                 | (6)                |
|--|----------------------------------|--------------------|---------------------|--------------------------|---------------------|--------------------|
|  | Post-2004 EU Accession Economies |                    |                     | Other European Economies |                     |                    |
|  | Total                            | Forward            | Backward            | Total                    | Forward             | Backward           |
| Centrality   | 5.310***<br>(1.491)              | 3.503**<br>(1.540) | 3.930***<br>(1.190) | 0.157<br>(0.097)         | 0.205***<br>(0.071) | -0.057<br>(0.055)  |
| Average Productivity<br>(Centrality Weighted)<br>of Buyers / Suppliers | 0.769**<br>(0.333)               | 0.816*<br>(0.427)  | 0.106<br>(0.240)    | 0.456***<br>(0.121)      | 0.407***<br>(0.111) | 0.206**<br>(0.087) |
| Observations   | 245,124                          | 245,124            | 245,124             | 2,019,522                | 2,019,522           | 2,019,522          |

Robust standard errors clustered at country-(34 TiVA) industry level, \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

All regressions include year and firm fixed effects, as well as firm size and industry controls. Firm size control reflects lagged employment. Industry controls include GVC participation, domestic sources of centrality, Fally's (2011) GVC Upstreamness and GVC Length measures, Exports of intermediates, Imports of intermediates, Industry production (as a measure of industry size), Balassa's Gross Revealed Comparative Advantage, and Koopman *et al.*'s (2014) Value-Added Revealed Comparative Advantage. The post-2004 EU accession economies in our sample are Bulgaria, Estonia, Hungary, Latvia, Poland, Romania and Slovenia. Other European economies comprise Austria, Belgium, Germany, Denmark, Finland, France, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Sweden, Spain, Turkey and the United Kingdom.

cent annual firm productivity growth.<sup>11</sup> In contrast, we observe no correlation between the productivity growth of firms overall and changes in centrality for the rest of factory Europe (excluding post-2004 EU members), both in terms of total centrality and as a key supplier or customer (columns 4, 5 and 6 at Table 1 respectively). Thus becoming a central hub or becoming more peripheral does not seem to be correlated with productivity growth of European firms in general, but rather for emerging economies that are initially less integrated within value chains.

In contrast, the productivity of foreign buyers/suppliers matters for the productivity growth of firms in other European economies, but less so for firms in post-2004 EU member countries. The average productivity (centrality weighted) of buyers is weakly correlated with firm

productivity in post-2004 EU members, but there is no discernible correlation with the productivity of sellers (columns 2 and 3 respectively). Conversely, the average productivity of suppliers but particularly buyers is strongly positively correlated with firm productivity in the rest of factory Europe (columns 6 and 5 respectively). A 1 per cent productivity growth of foreign buyers (through forward linkages) is correlated with a 0.4 per cent increase in domestic firm productivity. This is consistent with the notion that productive foreign buyers share knowledge with their suppliers, backwards through the value chain. A large literature on the productivity effects of FDI finds similar mechanisms, with evidence of spillovers from multinationals to their affiliate suppliers, with less evidence of forwards spillovers to their customers (Godart and Gorg, 2013; Havrnek and Irova,

<sup>11</sup> An annual rate of 0.8 per cent productivity growth is equivalent to 14 per cent growth over 1995-2011, which is calculated as  $\exp(0.025 * 5.310)$ . Where 0.025 reflects the mean growth in total (foreign) centrality for industries of post-2004 EU economies over the sixteen year period 1995-2011 and the coefficient 5.310 is taken from Table 2.

2011).

Thus far we have examined productivity correlations for the “average” firm in our sample. However, it is not necessarily true that these correlations will be homogeneous across firm types. Further, if the positive correlations are present for only a subset of firms, they may not be revealed in the previous section. On the one hand, frontier firms are more likely to be directly engaged in GVCs through trade and FDI linkages, so will have the greatest direct exposure to foreign technologies. In addition, these larger firms are more likely to be able to overcome the sunk costs of the complementary organizational investments needed to benefit from exposure to new technologies (see for example Brynjolfsson and Hitt, 2000). On the other hand, those firms further from the frontier are most likely to have the largest catch-up potential productivity gains from knowledge spillovers from foreign sectors.

The correlation between firm productivity and centrality for post-2004 EU members is stronger for non-frontier firms and weakens with proximity to the productivity frontier. We examine whether there are heterogeneous effects by proximity to the frontier by interacting our variables of interest with initial firm productivity (MFP)<sup>12</sup>. The non-interacted term captures the correlation for those (initially) least productive firms in our sample, whereas the interaction captures additional impact for more productive firms. Table 3 shows that the earlier average result for post-2004 EU members masks substantial heterogeneity across firm types for both forward centrality (becoming a key supplier) and backward centrality (becoming a key

customer), with the fastest productivity growth for those furthest from the frontier in each sample (columns 2 and 3). However, this is significantly weaker for more productive firms in either group of countries. Assuming this correlation weakens in a linear fashion suggests that this correlation becomes negative for the 7-9 per cent most productive, frontier firms in the post-2004 EU sample. In contrast, we find centrality is uncorrelated with productivity growth of either frontier or non-frontier firms in other European economies (columns 4 to 6).

The correlation between firm productivity and the average productivity of buyers/sellers is stronger for non-frontier firms in both post-2004 EU and other European economies. Previously, we found the productivity of buyers/suppliers is only correlated with average firm productivity in other European economies, but not post-2004 EU members. However, here we find the productivity of those least productive firms in both samples is positively correlated with both the productivity of buyers (forward linkages columns 2 and 5) and suppliers (backward linkages columns 3 and 6). Again we find that these positive correlations are concentrated within those least productive firms, with the correlation weakening for those closer to the frontier. Assuming a linear decay suggests that this becomes negative for the 9-25 per cent most productive firms in the post-2004 EU sample and for the 9-13 per cent most productive firms in other European economies.

## Conclusion

This article presents new “centrality” metrics that go beyond GVC participation, reflecting central hubs and peripheral

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<sup>12</sup> We use firm characteristics at the start of the period, since these characteristics may be influenced by changes in the trade network over time. The term “frontier” as used here relates to the most productive firms in post-2004 EU Accession Economies or in Other European Economies in columns 1 to 3, and 4 to 6 respectively.

**Table 3: Frontier vs Non-Frontier Firms**

| MFP Wooldridge  | (1)                              | (2)                  | (3)                  | (4)                      | (5)                  | (6)                  |
|---|----------------------------------|----------------------|----------------------|--------------------------|----------------------|----------------------|
|   | Post-2004 EU Accession Economies |                      |                      | Other European Economies |                      |                      |
|   | Total                            | Forward              | Backward             | Total                    | Forward              | Backward             |
| Centrality  | 20.893***<br>(1.887)             | 31.453***<br>(4.443) | 13.115***<br>(1.607) | 0.214<br>(0.315)         | 0.258<br>(0.232)     | 0.452<br>(0.320)     |
| Centrality * Initial Firm MFP   | -1.481***<br>(0.275)             | -2.554***<br>(0.374) | -0.924***<br>(0.213) | -0.011<br>(0.027)        | -0.006<br>(0.018)    | -0.049*<br>(0.028)   |
| Average Productivity (Centrality Weighted) of Buyers/Suppliers                    | 6.847***<br>(0.917)              | 5.254***<br>(1.151)  | 6.561***<br>(0.832)  | 4.127***<br>(0.641)      | 4.388***<br>(0.637)  | 3.425***<br>(0.558)  |
| Average Productivity (Centrality Weighted) of Buyers/Suppliers * Initial Firm MFP | -0.601***<br>(0.078)             | -0.426***<br>(0.106) | -0.633***<br>(0.076) | -0.330***<br>(0.054)     | -0.358***<br>(0.053) | -0.288***<br>(0.048) |
| Observations  | 245,124                          | 245,124              | 245,124              | 2,019,522                | 2,019,522            | 2,019,522            |

Robust standard errors clustered at country-(34 TiVA) industry level, \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

All regressions include year and firm fixed effects, as well as firm size and industry controls. Firm size control reflects lagged employment. Industry controls include GVC participation, domestic sources of centrality, Fally's (2011) GVC Upstreamness and GVC Length measures, Exports of intermediates, Imports of intermediates, Industry production (as a measure of industry size), Balassa's Gross Revealed Comparative Advantage, and Koopman *et al.*'s (2014) Value-Added Revealed Comparative Advantage. See Table 2 for a list of the countries in our sample.

industries and countries within production networks. We utilize well-established metrics from the network literature to identify those sectors and countries that are highly central hubs and those that are peripheral. Central sectors reflect those that are highly connected (both directly and indirectly) and influential within global production networks, and conversely, peripheral sectors exhibit weak linkages to other sectors and countries and so are less influential.

We illustrate profound changes in the structure of European production networks over the period 1995-2011. Whilst some activities remain clustered around the same key hubs as at the start of the period, for others there have been dramatic relocation of economic activity. We find that while motor vehicle value chains remain centred around Germany, there has also been a pivot away from many traditional centres of manufacturing towards increasing influence of Eastern Europe. In contrast, R&D

and business services have become more important for production networks for many countries.

Policy can play a role in determining centrality and hence position within GVCs. Advances in communication technology have enabled the fragmentation of production, and permitted production to develop into the complex global network it is today. However, the changing structure of GVCs has not entirely been a technology story. We find that Eastern European economies have increased their overall importance within global production networks, with their growing importance coinciding with the timing of their EU accession.

We find that the changing structure of GVCs can play a role in the productivity catch-up of firms, although our empirical analysis reflects descriptive correlations, rather than causal effects. We match centrality metrics to cross-country firm-level data from ORBIS to examine how changes in centrality relate to domestic firm

productivity. Becoming more central as a customer or supplier is associated with faster productivity growth of firms in post-2004 EU member countries, particularly non-frontier firms. But we find either insignificant or even negative effects for frontier firms and for firms in other European economies. Consequently becoming more influential in GVCs appears to be important for the catch-up of those non-frontier firms and economies, whereas for those firms or economies that are already large or near the frontier, becoming more influential does not appear to impact productivity substantially. Further data are needed to examine the precise channels of productivity gains, for example, diffusion of technology or organizational practices or whether access to larger markets incentivises productive investments.

We find that the composition of buyers (in terms of their industry productivity) matters for firms in our data overall. This is particularly the case for the catch-up of non-frontier or smaller firms. We supplement the standard centrality metrics by examining changes in the (centrality weighted) average productivity of foreign buyers/suppliers. Supplying or buying from faster growing foreign sectors is correlated with faster productivity growth of non-frontier firms in both post-2004 EU members and other European economies, with these effects weakening with proximity to the frontier. But these correlations are only present for firms overall in the rest of Factory Europe (excluding post-2004 EU members).

Our results suggest that traditional policy measures to encourage integration into and influence within GVCs (such as trade facilitation and export guarantees) might be particularly important for the productivity of non-frontier firms, and also firms in emerging or less integrated economies. Although our work examines international input linkages, it is also

suggestive that policies that strengthen the domestic linkages between domestic suppliers and foreign firms may also be important in the diffusion of productivity gains, such as local content requirements. However, our results also suggest the composition of buyer and supplier networks (in terms of their productivity) appear to also matter for spillovers to non-frontier firms and also for firms overall in higher-income economies. These results suggest that more sophisticated policy to facilitate GVC integration may be needed, which particularly encourages the formation of particular linkages that encourage the diffusion of spillovers from productive, frontier foreign firms and economies.

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# What Explains the Post-2004 U.S. Productivity Slowdown?

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## ABSTRACT

Economic theory and history show that labour productivity growth is the main driver of rising living standards, so changes in the trend rate of productivity growth have profound implications for a society's future prosperity. The average annual rate of business sector labour productivity growth in the United States declined by 1.9 percentage points between the 1995-2004 period and the 2004-2015 period, from 3.2 per cent to 1.3 per cent. This article summarizes the state of knowledge on the causes of the post-2004 slowdown in U.S. productivity growth. Official growth accounting estimates indicate that 60-65 per cent of the labour productivity decline is accounted for by a decline in total factor productivity growth, while 30-35 per cent is accounted for by a decline in the rate of capital deepening. Three industries account for over 80 per cent of the aggregate labour productivity decline: manufacturing, wholesale trade, and retail trade. The aggregate productivity slowdown is traceable to a decline in the productivity contributions arising from industries that produce or intensively use information and communication technology (ICT) products.

Business sector labour productivity growth in the United States averaged 3.22 per cent per year over the 1995-2004 period, then declined to 1.33 per cent per year over the 2004-2015 period.<sup>2</sup> (From 2010 to 2015, U.S. labour productivity grew by just 0.57 per cent per year.) Economic theory and history show that

labour productivity growth is the main driver of rising living standards, so the 1.89 percentage-point decline in the trend rate of productivity growth after 2004 has profound implications for the future prosperity of the United States.<sup>3</sup> Had labour productivity maintained its 1995-2004 pace, U.S. business sector real output would have been some

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<sup>2</sup> Labour productivity is defined as real output per hour worked.

<sup>3</sup> Productivity growth makes rising material living standards for the average person possible, but it does not guarantee it. Indeed, in recent decades median real wage growth in many OECD countries (including Canada and the United States) has failed to keep pace with labour productivity growth. Ugucioni and Sharpe (2016) study this puzzle for OECD countries.

\$2.9 trillion higher in 2015 (in 2009 dollars); the cumulative loss of real output due to slower productivity growth over the 2005-2015 period was \$13.8 trillion.

What explains the U.S. productivity slowdown in the mid-2000s?<sup>4</sup> In this article, we address this question by contributing original data analysis and by reviewing the research literature. We find that the trend rate of U.S. productivity growth (whether measured using labour productivity or total factor productivity) declined around 2004. About 60-65 per cent of the labour productivity decline is accounted for by a decline in total factor productivity growth, while 30-35 per cent is accounted for by a decline in the rate of capital deepening (i.e. growth of capital per hour worked). Three industries, collectively representing 28 per cent of business-sector hours worked in 2015, account for over 80 per cent of the aggregate labour productivity decline: manufacturing, wholesale trade, and retail trade.

The aggregate productivity slowdown is traceable to a decline in the productivity contributions arising from industries that produce or intensively use information and communication technology (ICT) products. The decline in the productivity contribution of ICT was driven by some combination of a) slower technological progress in ICT and b) a reduction in business dynamism in the ‘high tech’ sector (mainly industries producing ICT goods and services) resulting in a decline in the rate of resource reallocation from less-productive to more-productive

firms.

The article is structured as follows. In the first main section, we discuss sources of data on U.S. productivity and review aggregate U.S. productivity trends over the 1987-2015 period. In Section 2, we decompose U.S. labour productivity growth into its industry sources. In Section 3, we decompose it into its proximate growth accounting sources: total factor productivity growth, capital deepening, and labour quality growth. In Section 4, we review research on possible explanations for the slowdown. Section 5 discusses implications for Canada and concludes.

## Data Sources and Aggregate Trends in U.S. Productivity

In this section, we discuss sources of data on U.S. productivity and review the recent U.S. productivity performance. It is well-established that U.S. productivity growth experienced a structural shift toward a slower growth path in 2004.<sup>5</sup> We provide a descriptive illustration of this using a variety of measures of labour productivity and total factor productivity (TFP) for the U.S. business sector, private business sector, and total economy.

### Data<sup>6</sup>

Our main source of U.S. productivity data is the Bureau of Labor Statistics (BLS). Two BLS programs provide productivity estimates: the Labor Productivity and Costs program and the Multifactor Productivity

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4 This article focuses on the United States, but productivity growth has slowed in recent years across the OECD. Cetto *et al.* (2016) find that the explanations for the slowdown are somewhat different in the United States than elsewhere; the U.S. slowdown is attributable to developments in the production and use of ICT, while unfavorable resource reallocation (driven in part by low real interest rates) has contributed to the slowdown in Europe.

5 A short review of the literature providing statistical evidence for this claim is presented in Murray (2017), Appendix B

6 An online database associated with this article contains URLs for the specific source data files on the web sites of the BLS, the BEA, and the San Francisco Federal Reserve. The database is available online at URL: [http://www.csls.ca/reports/USslowdown\\_database.xlsx](http://www.csls.ca/reports/USslowdown_database.xlsx).

program.<sup>7</sup> The Labor Productivity and Costs program provides estimates of labour productivity for the U.S. business sector; the Multifactor Productivity program provides estimates of labour productivity and total factor productivity (TFP) for the private business sector and for the total economy.<sup>8</sup>

We augment the official BLS data with estimates from two additional sources. The first is the growth accounting database maintained by John Fernald at the Federal Reserve Bank of San Francisco. It is described in Fernald (2014b). Fernald's estimates are based mainly on disaggregated industry data from the BLS and the Bureau of Economic Analysis (BEA), augmented with data from other sources in some cases. We include it in this article because it allows us to examine the influence of variable factor utilization on productivity growth rates.

For our industry decomposition, we use labour productivity estimates for private industries constructed by CSLS researchers using hours data from the BLS and output data from the BEA's GDP by Industry database. This approach allowed for the construction of labour productivity estimates in both levels and growth rates for a broad set of industries up to 2015.

## Recent U.S. Productivity Performance

Table 1 summarizes measures of aggregate productivity growth in the United States over the 1987-2015 period. Consider first the labour productivity growth measures in the left panel of the table. According to the official BLS measure of labour productivity in the U.S. business sector, labour productivity grew at 2.0 per cent per year over the 1987-2015 period. The alternative measures for the business sector and the private business sector yield the same 2.0 per cent compound annual growth rate for the 1987-2015 period. The total economy measure grew somewhat more slowly, at 1.7 per cent per year. This is not surprising; the total economy measure includes government, non-profit and household sector activities that exhibit low productivity growth relative to the business sector. The private industries measure excludes government activities (both general government and government-owned enterprises) and the imputed rental value of owner-occupied housing. Its growth was similar to that of the total economy measure over the full 1987-2015 period.<sup>9</sup>

The full-period average growth rates mask substantial variation across sub-periods.

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7 Multifactor productivity (or MFP) is another name for total factor productivity (or TFP). MFP is the term used by the BLS. We use TFP throughout this article.

8 The total economy encompasses all paid activity in the economy, whether undertaken by the government or by the private sector. The business sector is the total economy minus general government, the output of household workers and nonprofits, the gross housing product of owner-occupied dwellings and the rental value of nonprofit institutional real estate. The private business sector is the business sector minus government enterprises.

9 The main conceptual difference between the business sector and private industries is that the former includes government enterprises and excludes the nonprofit sector and the output of household workers. Empirically, most of the discrepancy between the BLS's business sector labour productivity measure and our private industries measure (based on BEA and BLS data) over the 1987-2015 period is traceable to a difference in the growth rates of the implicit deflators used to transform nominal output into real output. The BLS's business sector price deflator grew by 1.84 per cent per year over the period, while our private industries price deflator grew by 2.04 per cent per year.

10 The cut-off dates for the main sub-periods are chosen to reflect structural breaks in trend productivity growth in the U.S. economy. An alternative approach would be to choose business cycle peaks, so as to minimize the influence of business cycle factors on comparisons across sub-periods. Since we are primarily interested in trend productivity, we opted to use estimated structural break dates for trend productivity

**Table 1: Measures of Productivity Growth, United States, Compound Annual Growth Rates, 1987-2015**

|           | Labour Productivity   |                           |                               |                                  |                                  | Total Factor Productivity     |                                       |   |                                  |
|-----------|-----------------------|---------------------------|-------------------------------|----------------------------------|----------------------------------|-------------------------------|---------------------------------------|---|----------------------------------|
|           | Business Sector (BLS) | Business Sector (Fernald) | Private Business Sector (BLS) | Private Industries (BEA and BLS) | Total Economy <sup>a</sup> (BLS) | Private Business Sector (BLS) | Business Sector, Unadjusted (Fernald) | Business Sector, Utilization-adjusted (Fernald) | Total Economy <sup>a</sup> (BLS) |
| 1987-2015 | 2.00                  | 2.05                      | 2.01                          | 1.75                             | 1.74                             | 0.93                          | 0.93                                  | 0.96  | 0.76                             |
| 1987-1995 | 1.55                  | 1.51                      | 1.61                          | 1.37                             | 1.41                             | 0.60                          | 0.46                                  | 0.47  | 0.57                             |
| 1995-2004 | 3.22                  | 3.32                      | 3.27                          | 2.94                             | 2.65                             | 1.75                          | 1.83                                  | 2.04  | 1.34                             |
| 2004-2015 | 1.33                  | 1.41                      | 1.27                          | 1.07                             | 1.20                             | 0.51                          | 0.54                                  | 0.44  | 0.39                             |
| 2004-2008 | 1.33                  | 1.21                      | 1.33                          | 1.11                             | 1.28                             | 0.27                          | 0.04                                  | -0.01   | 0.22                             |
| 2008-2015 | 1.33                  | 1.53                      | 1.23                          | 1.04                             | 1.14                             | 0.66                          | 0.83                                  | 0.71  | 0.50                             |
| 2008-2010 | 3.25                  | 3.37                      | 3.36                          | 2.97                             | 2.43                             | 1.36                          | 1.22                                  | 1.45  | 0.46                             |
| 2010-2015 | 0.57                  | 0.80                      | 0.40                          | 0.28                             | 0.51                             | 0.38                          | 0.68                                  | 0.41  | 0.52                             |

Sources: Series labelled ‘BLS’ are drawn directly from BLS sources. Series labelled ‘Fernald’ are taken from the growth accounting database of John Fernald, described in Fernald (2014b). Fernald’s series were constructed using data from the BLS and BEA. Series labelled ‘BEA and BLS’ were constructed by CCLS researchers using BEA output data and BLS hours data. For links to the source data, see Tables 1-5 in the database accompanying this article:

[http://www.ccls.ca/reports/USslowdown\\_database.xlsx](http://www.ccls.ca/reports/USslowdown_database.xlsx). Note a. Series for the Total Economy end in 2014 rather than 2015.

The remaining rows of Table 1 present growth rates for sub-periods within the 1987-2015 period.<sup>10</sup> Chart 1 plots the five-year moving averages of the annual growth rates of the five labour productivity measures from the table and illustrates the pattern of accelerations and slow-downs. Business sector labour productivity grew by 1.55 per cent per year between 1987 and 1995, accelerated to 3.22 per cent per year over the 1995-2004 period, then fell back to 1.33 per cent per year post-2004.<sup>11</sup> Much of the labour productivity growth after 2004 occurred during a brief burst of fast growth associated with the Great Recession; over the 2008-2010 period, labour productivity grew by 3.25 per cent per year as hours

worked fell much faster than real output. From 2010 to 2015, labour productivity growth has averaged 0.57 per cent per year, well below the rates observed in earlier periods.<sup>12</sup>

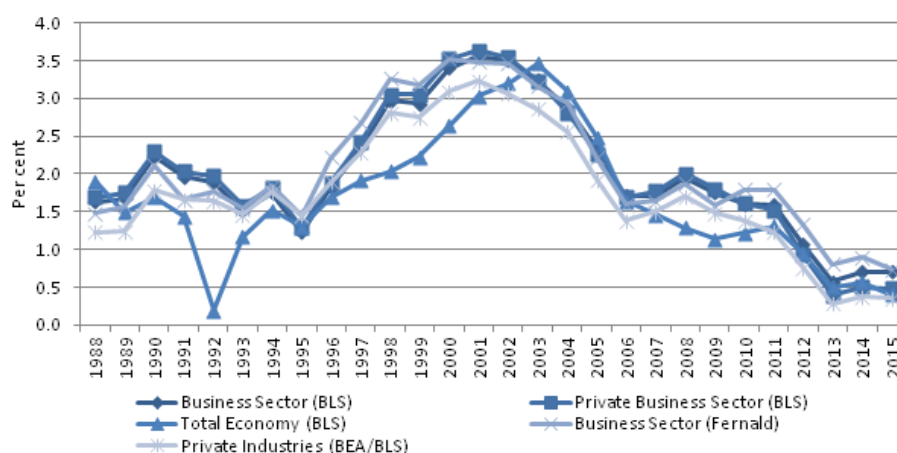
The right-hand panel of Table 1 presents measures of TFP growth. Chart 2 depicts the five-year moving averages of TFP growth implied by these TFP measures. According to the official BLS measure for the private business sector, TFP grew by 0.93 per cent per year over the 1987-2015 period. The business sector measures from Fernald’s database yield an identical average growth rate for the full period. As in the case of labour productivity, TFP growth was slower in the total economy, at 0.76 per cent per

growth drawn from the econometric literature. Sprague (2017) discusses productivity growth across U.S. business cycles and shows that U.S. labour productivity growth in the current business cycle (i.e. the period since 2008) is the lowest among the ten post-war U.S. business cycles.

<sup>11</sup> Total economy labour productivity exhibits the same pattern as the business sector measures: fast growth between 1995 and 2004, a slowdown thereafter except for the 2008-2010 period, and very slow growth since 2010. Within each sub-period, the growth rates for the total economy are smaller than those for the business sector, especially during the fast-growth periods. The measure for private industries tended to grow faster during high-growth periods and slower during low-growth periods.

<sup>12</sup> At the time the research for this article was completed data were available only to 2015. U.S. business sector labour productivity estimates for 2016 and 2017 are now available from the BLS. According to those data, U.S. labour productivity grew by 0.1 per cent and 1.2 in 2016 and 2017 respectively, making the average growth per year, 0.65 per cent, similar to the 2010-2015 average of 0.57 per cent per year.

**Chart 1: Labour Productivity Growth, Per Cent per Year (Five-Year Moving Average), United States, 1988-2015**



Source: Tables 1-5 in the database, [http://www.csls.ca/reports/USslowdown\\_database.xlsx](http://www.csls.ca/reports/USslowdown_database.xlsx).

year.

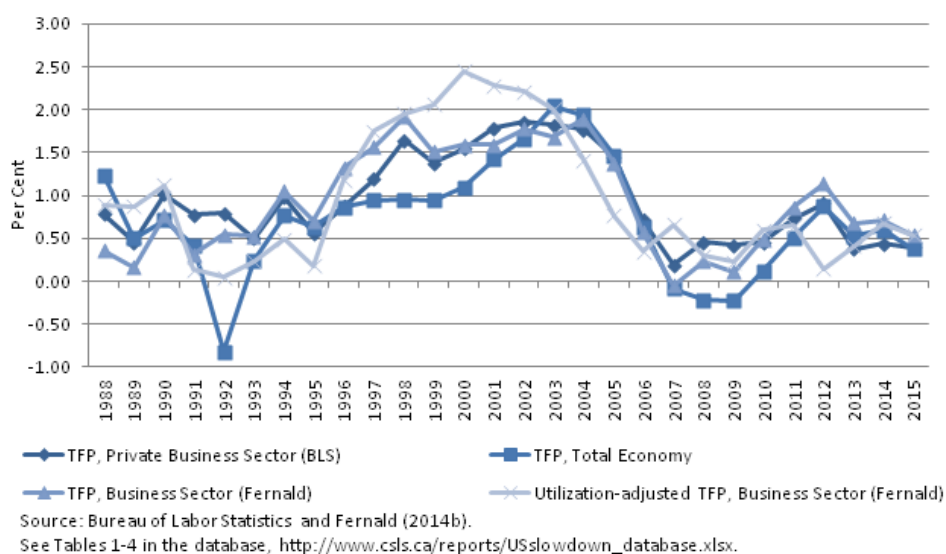
TFP growth varied across the sub-periods. Private business sector TFP grew by 0.60 per cent per year between 1987 and 1995, accelerated to 1.75 per cent per year between 1995 and 2004, then fell to 0.51 per cent per year after 2004. As in the case of labour productivity, TFP growth experienced a short-lived spike associated with the Great Recession. Our main focus in this article is on productivity growth trends, not on the relationship between productivity and business cycles.<sup>13</sup> In breaking down the 2004-2015 period into sub-periods, our purpose is to emphasize that since 2010 (i.e. after the end of the Great Recession) productivity growth has been especially slow for a sustained period of time.

A TFP measure commonly used in the academic literature is the utilization-adjusted measure of Fernald (2014b), which is also summarized in Table 1 and depicted in Chart 2. This measure strips out the influence of variable factor utilization (i.e. variation over time in the intensity with which labour and capital are used, conditional on total hours worked and on the total capital stock) from TFP, thereby yielding a purer indicator of technological progress.<sup>14</sup> Over a long span of time this should not matter because factor utilization rates tend to revert to their long-run averages. (This is true by construction under Fernald's approach.) Indeed, the utilization-adjusted and unadjusted measures for the business sector in Table 1 exhibited almost

<sup>13</sup> That labour productivity surged during the Great Recession is not especially surprising. Capital and labour quality tend to change slowly relative to hours worked, resulting in countercyclical labour productivity growth. The spike in business-sector TFP growth during the Great Recession is perhaps more surprising. The business cycle literature does show that positive TFP shocks – especially after adjusting for variation in factor utilization – cause hours worked to decline; everything else equal, this tends to make TFP countercyclical (Basu *et al.*, 2006). See Fernald and Wang (2016) for an extensive analysis of the cyclical properties of U.S. productivity measures.

<sup>14</sup> TFP is often regarded as a proxy for technological progress, but it is influenced by other economic forces (as well as measurement error). In addition to variation in factor utilization, these include non-constant returns to scale, static resource misallocation, and departures from perfect competition. Moreover, even leaving aside these issues, the relationship between TFP growth and technological progress is complicated and requires subtle interpretation. See Murray (2016) for a comprehensive discussion of these issues.

Chart 2: Total Factor Productivity Growth, Per Cent per Year (Five-Year Moving Average), United States, 1987-2015



identical growth over the full 1987-2015 period.

Nevertheless, the utilization-adjusted series is worth considering for two reasons. First, factor utilization has a non-negligible influence on TFP growth within sub-periods. During the fast-growth period of 1995-2004, in particular, the unadjusted measure appears to understate annual TFP growth by 0.2 percentage points.<sup>15</sup> Second, the adjustment affects the timing of the trend growth break in the mid-2000s. With the utilization-adjusted measure, TFP growth slows around 2005, more or less consistent with labour productivity. With the unadjusted business-sector measures, the turnaround appears to occur somewhat later.

Fernald also presents utilization-adjusted

TFP series for the consumption sector and the investment sector separately.<sup>16</sup> TFP growth has consistently been far faster in the investment sector than in the consumption sector.<sup>17</sup> Over the full 1987-2015 period, TFP grew by 3.34 per cent per year in the investment sector and by only 0.21 per cent per year in the consumption sector.

Between the 1995-2004 and 2004-2015 periods, the rate of investment sector TFP growth declined by 2.68 percentage points (from 5.46 per cent per year to 2.78 per cent per year) and the rate of consumption sector TFP growth declined by 1.17 percentage points (from 0.91 per cent per year to -0.25 per cent per year). While the decline in the investment sector was larger, the consumption sector made a slightly larger contribution to the overall slowdown in

15 This implies that the factor utilization rate declined over the 1995-2004 period. This decline was largely associated with the 2001 U.S. recession. Factor utilization fell 2.49 per cent (a large one-year decline) in 2001.

16 Here, the 'investment' sector refers to industries producing equipment, intellectual property and consumer durables. It does not include structures, either residential or non-residential. The 'consumption' sector encompasses all of business sector output other than those parts included in the investment sector (Fernald, 2014b). On the differing macroeconomic effects of technology growth in the investment sector and the consumption sector, see Basu *et al.* (2013).

17 For additional analysis see Murray (2017).

business sector TFP growth because of its large output share.<sup>18</sup> Thus, the aggregate TFP growth decline is attributable to both sectors in roughly equal proportion.

## Industry Sources of U.S. Productivity Growth

We decompose aggregate U.S. labour productivity growth into two-digit NAICS industry contributions. This procedure reveals which industries have been drivers of U.S. growth and which have been hindering growth. We perform the decomposition for the 1987-1995, 1995-2004, and 2004-2015 periods and study the industry sources of the changes in trend productivity growth between periods.

### Decomposition Method

There is a large body of research on methods for decomposing aggregate productivity growth into industry contributions. A comparison of some leading methods is provided by de Avillez (2012).<sup>19</sup> In this article, we use the CSLS decomposition (Sharpe, 2010; Sharpe and Thomson, 2010). The CSLS decomposition is a variant of a standard approach, used frequently in the literature, that decomposes aggregate labour productivity growth into industry contributions from within-sector productivity growth and labour reallocation across industries. It does not count relative price increases as part of an industry's

productivity growth contribution.<sup>20</sup>

Define the following notation:

|           |   |  |
|-----------|---|--|
| $A_t$     | = | Aggregate labour productivity                |
| $A_{i,t}$ | = | Labour productivity in industry $i$          |
| $S_{Q,t}$ | = | Industry $i$ share of aggregate real output  |
| $h_{i,t}$ | = | Industry $i$ share of aggregate hours worked |

The CSLS decomposition expresses the relationship between aggregate labour productivity growth and industry-level labour productivity growth as follows:<sup>21</sup>

$$\begin{aligned} \frac{\Delta A_t}{A_{t-1}} &= \sum_{i=1}^N [s_{Q,t} \left( \frac{\Delta A_{i,t}}{A_{i,t-1}} \right) + \Delta h_{i,t} \left( \frac{A_{i,t} - A_t}{A_t} \right) \\ &\quad + \Delta h_{i,t} \left( \frac{\Delta A_{i,t} - \Delta A_t}{A_{t-1}} \right)] \\ &= \sum_{i=1}^N [WSE_{i,t} + RLE_{i,t} + RGE_{i,t}] \end{aligned}$$

(The notation  $\Delta X_t$  denotes the change  $X_t - X_{t-1}$  for any variable  $X$ .) Thus, the contribution of each industry  $i$  to aggregate productivity growth is the sum of three components:

- Within-sector Effect ( $WSE_{i,t}$ ): productivity growth within industry  $i$  raises aggregate productivity growth;
- Reallocation Level Effect ( $RLE_{i,t}$ ): reallocation of labour into industry  $i$  increases aggregate productivity

18 The consumption sector contributed -0.88 percentage points (or 55 per cent) of the total change in TFP growth between the two periods, compared to a contribution of -0.72 percentage points (or 45 per cent) from the investment sector.

19 Important recent contributions include Tang and Wang (2004), Diewert (2015; 2016), Reinsdorf and Yuskavage (2010), Reinsdorf (2015), Calver and Murray (2016), and Baldwin and Willox (2016).

20 We have also produced results based on an alternative decomposition, the Generalized Exactly Additive Decomposition (GEAD) of Tang and Wang (2004) and Diewert (2015). This decomposition method does include relative price increases as part of an industry's productivity growth contribution. These results are in the appendix of Murray (2017).

21 See de Avillez (2012) for details of the derivation of this decomposition. The key assumption underlying it is the additivity of real output, i.e. aggregate real output equals the sum of industry-level real outputs. The BLS measures real output using chained Fisher indexes, which do not satisfy this additivity assumption. As a result, there will be a small discrepancy between aggregate productivity growth and the sum of the industry contributions generated by the CSLS decomposition. This discrepancy is evaluated quantitatively below; it turns out to be small.

growth if industry  $i$  has an above-average productivity level;

- Reallocation Growth Effect ( $RGE_{i,t}$ ): reallocation of labour into industry  $i$  increases aggregate productivity growth if industry  $i$  has an above-average productivity growth rate.

The CSLS decomposition thus embodies the idea that the sign of an industry's reallocation effect should reflect the productivity performance of that industry *relative* to the other industries from which it is gaining (or to which it is losing) labour share. This treatment of the reallocation effects is what distinguishes the CSLS decomposition from other commonly-used decomposition methods.

We have applied this decomposition to the labour productivity measure for U.S. private industries, the aggregate growth of which was displayed in Table 1. Alternatively, the industry decomposition could have been performed using the KLEMS Multifactor Productivity Tables for manufacturing and non-manufacturing industries from the BLS. Baily and Montalbano (2016) performed an industry decomposition of U.S. TFP growth using these data (and a different decomposition method based on Domar weights). Their results on the industry sources of the mid-2000s productivity slowdown are similar to ours. We regard our analysis as complementary to theirs.

## Decomposition Results

Our primary interest is the mid-2000s productivity slowdown.<sup>22</sup> The decomposition results are informative about the industry origins of that slowdown. Panel A of Table 2 presents the CSLS decomposition of U.S. labour productivity growth for the 1995-2004 and 2004-2015 periods separately, while Panel B presents the implied changes in industry contributions to productivity growth between the two periods.

Between the 1995-2004 and 2004-2015 periods, aggregate labour productivity growth declined by 1.87 percentage points (from 2.94 per cent to 1.07 per cent per year). Of this change, -1.84 percentage points (or 98.1 per cent of the total slowdown) was driven by the within-sector effect. Labour productivity growth slowed in eleven of the fourteen industries between the two periods. Labour reallocation across industries contributed negligibly to the productivity slowdown. Together, the reallocation level and growth effects contributed -0.04 percentage points (or 1.9 per cent) to the slowdown.

The industry total contributions to the aggregate productivity growth slowdown are depicted in Chart 3. The three industries that made the largest contributions to the slowdown were manufacturing (-0.79 percentage points), wholesale trade (-0.41 percentage points), and retail trade (-0.32 percentage points). Together, these three industries accounted for 80.5 per cent of

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<sup>22</sup> The decomposition results for U.S. labour productivity growth over the full 1987-2015 period are found in Murray (2017). The aggregate labour productivity growth of 1.76 per cent per year is entirely attributable to labour productivity growth within industries; the total within-sector effect contributed 1.90 percentage points to the overall growth rate, while inter-industry labour reallocation reduced overall growth by 0.14 percentage points (the sum of the reallocation level and growth effects). As noted earlier, the non-additivity of chained quantity indexes introduces a discrepancy between aggregate productivity growth and the sum of the total industry contributions. That discrepancy is small. For the full 1987-2015 period, the aggregate labour productivity growth rate is 1.76 per cent per year while the sum of the total industry contributions is 1.66 per cent; the discrepancy is just 0.1 percentage points. The discrepancy is similarly small within each sub-period we consider. In our tables of results, we have scaled the contributions by the ratio 1.76/1.66 so that the industries' total contributions sum to the true aggregate growth rate.

**Table 2: Decomposition of U.S. Productivity Slowdown between 1995-2004 and 2004-2015, Private Industries**

| Panel A: Productivity Growth Decomposition by Period |                            |       |       |       |       |                            |       |       |       |       |
|--|----------------------------|-------|-------|-------|-------|----------------------------|-------|-------|-------|-------|
|  | 1995-2004                  |       |       |       |       | 2004-2015                  |       |       |       |       |
|  | Labour Productivity Growth | TC    | WSE   | RLE   | RGE   | Labour Productivity Growth | TC    | WSE   | RLE   | RGE   |
| Private industries                                   | 2.94                       | 2.94  | 3.11  | -0.10 | -0.06 | 1.07                       | 1.07  | 1.27  | -0.16 | -0.04 |
| Agriculture, forestry, fishing, hunting              | 6.20                       | 0.10  | 0.07  | 0.03  | 0.00  | 2.58                       | 0.03  | 0.03  | 0.00  | 0.00  |
| Mining   | 0.02                       | -0.05 | 0.00  | -0.04 | 0.00  | 1.91                       | 0.10  | 0.06  | 0.06  | -0.02 |
| Utilities  | 2.15                       | -0.03 | 0.06  | -0.08 | 0.00  | -0.78                      | -0.02 | -0.02 | 0.00  | 0.00  |
| Construction   | -0.75                      | -0.06 | -0.07 | 0.01  | -0.01 | -1.21                      | -0.06 | -0.09 | 0.03  | 0.00  |
| Manufacturing  | 6.42                       | 1.07  | 1.09  | 0.00  | -0.02 | 2.09                       | 0.28  | 0.35  | -0.06 | -0.01 |
| Wholesale trade                                      | 6.58                       | 0.48  | 0.50  | -0.02 | 0.00  | 0.97                       | 0.07  | 0.07  | 0.00  | 0.00  |
| Retail trade   | 4.46                       | 0.39  | 0.38  | 0.01  | 0.00  | 0.69                       | 0.08  | 0.05  | 0.02  | 0.00  |
| Transportation and warehousing                       | 1.31                       | 0.05  | 0.05  | 0.00  | 0.00  | 0.50                       | 0.02  | 0.02  | 0.00  | 0.00  |
| Information  | 5.16                       | 0.25  | 0.27  | 0.00  | -0.01 | 5.24                       | 0.25  | 0.33  | -0.07 | -0.01 |
| Other services, except government                    | 0.36                       | 0.02  | 0.02  | 0.00  | 0.00  | -0.80                      | -0.02 | -0.03 | 0.01  | 0.00  |
| FIRE   | 2.78                       | 0.45  | 0.39  | 0.06  | 0.00  | 2.36                       | 0.31  | 0.34  | -0.04 | 0.00  |
| Professional and business services                   | 1.73                       | 0.27  | 0.27  | 0.01  | -0.01 | 0.96                       | 0.14  | 0.15  | -0.01 | 0.00  |
| AERAF  | 1.64                       | 0.06  | 0.09  | -0.03 | 0.00  | -0.42                      | -0.06 | -0.02 | -0.04 | 0.00  |
| EHSA   | 0.00                       | -0.06 | 0.00  | -0.05 | -0.01 | 0.27                       | -0.04 | 0.03  | -0.07 | 0.00  |

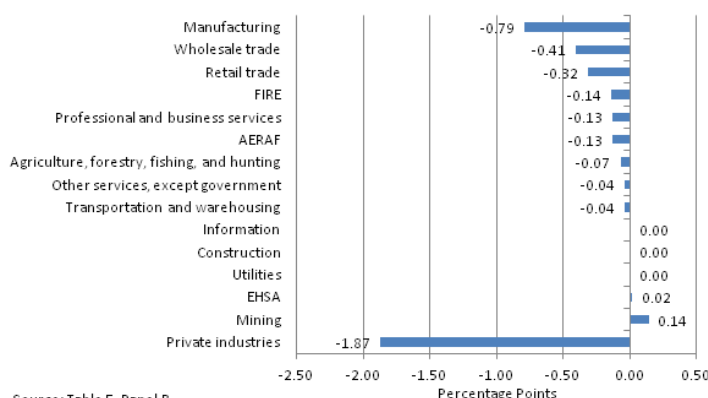
  

| Panel B: Industry Contributions to Productivity Slowdown between 1995-2004 and 2004-2015 |                                      |                                |       |       |       |                       |      |      |      |  |
|--|--------------------------------------|--------------------------------|-------|-------|-------|-----------------------|------|------|------|--|
|  | Change in Labour Productivity Growth | Percentage Point Contributions |       |       |       | Per Cent Total Change |      |      |      |  |
|  |                                      | TC                             | WSE   | RLSE  | RGE   | TC                    | WSE  | RLSE | RGE  |  |
| Private industries   | -1.87                                | -1.87                          | -1.84 | -0.06 | 0.02  | 100.0                 | 98.1 | 3.0  | -1.1 |  |
| Agriculture, forestry, fishing, hunting  | -3.62                                | -0.07                          | -0.04 | -0.03 | 0.00  | 3.7                   | 2.0  | 1.7  | 0.0  |  |
| Mining   | 1.89                                 | 0.14                           | 0.06  | 0.10  | -0.01 | -7.7                  | -3.0 | -5.4 | 0.7  |  |
| Utilities  | -2.93                                | 0.00                           | -0.08 | 0.08  | 0.00  | -0.2                  | 4.2  | -4.4 | 0.0  |  |
| Construction   | -0.45                                | 0.00                           | -0.02 | 0.02  | 0.00  | -0.2                  | 1.1  | -1.1 | -0.1 |  |
| Manufacturing  | -4.33                                | -0.79                          | -0.74 | -0.06 | 0.01  | 42.0                  | 39.3 | 3.2  | -0.6 |  |
| Wholesale trade  | -5.61                                | -0.41                          | -0.43 | 0.02  | 0.00  | 21.7                  | 23.0 | -1.1 | -0.2 |  |
| Retail trade   | -3.77                                | -0.32                          | -0.33 | 0.01  | 0.00  | 16.9                  | 17.4 | -0.5 | 0.0  |  |
| Transportation and warehousing   | -0.81                                | -0.04                          | -0.03 | 0.00  | 0.00  | 1.9                   | 1.6  | 0.2  | 0.1  |  |
| Information  | 0.09                                 | 0.00                           | 0.06  | -0.07 | 0.01  | -0.1                  | -3.3 | 3.5  | -0.3 |  |
| Other services, except government  | -1.16                                | -0.04                          | -0.04 | 0.01  | 0.00  | 1.9                   | 2.3  | -0.4 | 0.0  |  |
| FIRE   | -0.43                                | -0.14                          | -0.05 | -0.09 | 0.00  | 7.5                   | 2.6  | 4.9  | 0.0  |  |
| Professional and business services   | -0.77                                | -0.13                          | -0.12 | -0.02 | 0.01  | 7.0                   | 6.4  | 0.9  | -0.3 |  |
| AERAF  | -2.06                                | -0.13                          | -0.11 | -0.01 | 0.00  | 6.7                   | 6.1  | 0.6  | 0.0  |  |
| EHSA   | 0.27                                 | 0.02                           | 0.03  | -0.01 | 0.00  | -1.1                  | -1.6 | 0.7  | -0.2 |  |

Notes:

1. TC = Total contribution; WSE = within-sector effect; RLE = reallocation level effect; RGE = reallocation growth effect.
2. FIRE = Finance, insurance, real estate, rental and leasing; AERAF = Arts, entertainment, recreation, accommodation, and food services; EHSA = Educational services, health care and social assistance.

**Chart 3: Total Contributions to the U.S. Labour Productivity Slowdown between 1995-2004 and 2004-2015, Percentage Points, Private Industries**



Source: Table 5, Panel B.

Note: FIRE = Finance, insurance, real estate, rental and leasing; AERAF = Arts, entertainment, recreation, accommodation and food services; EHSA = Educational services, health care and social assistance.

the total slowdown. The contributions of manufacturing, wholesale trade and retail trade to the aggregate slowdown were driven almost entirely by within-sector productivity growth slowdowns in those industries.

While three industries account for 80 per cent (or four fifths) of the aggregate slowdown, nine of the fourteen industries contributed to it. In that sense, the slowdown has been broad-based. The only industry that contributed non-negligibly in the direction of faster productivity growth in the 2004-2015 period relative to the 1995-2004 period was mining. Its 0.14 percentage-point positive contribution was driven by a substantial increase in within-industry productivity growth and by a positive reallocation level effect as the industry (which has an above average productivity level) increased its hours share.

## Growth Accounting

The previous section examined industry contributions to aggregate productivity growth. An alternative

perspective is provided by the growth accounting framework, which decomposes aggregate labour productivity growth into contributions from the following proximate sources:<sup>23</sup>

- **Labour composition:** growth of the quality of the economy's labour input;
- **Capital deepening:** growth of the ratio of physical capital services to labour hours;
- **Total factor productivity (TFP):** the residual part of labour productivity growth unexplained by the other two components.

Table 3 presents growth accounting results for the U.S. private business sector and total economy, based on the BLS measures of labour productivity from Table 1. For the private business sector (Panel A of the table), labour productivity growth over the full 1987-2015 period (2.01 per cent per year) was driven mainly by contributions

<sup>23</sup> For any variable  $X$ , let  $\Delta X$  denote the logarithmic first-difference of  $X$  (which is approximately equal to the per cent growth rate of  $X$ ). Following standard procedures, labour productivity growth  $\Delta(y-h)$  (i.e. the log first-difference of the output-hours ratio) can be expressed as

$$\Delta(y-h) = \Delta a + \alpha \Delta(k-h) + (1-\alpha) \Delta q$$

where  $\Delta a$  is TFP growth,  $\Delta(k-h)$  is capital deepening (i.e. growth of the capital-hours ratio),  $\Delta q$  is labour quality growth, and  $\alpha$  is the share of capital costs in nominal value added.

**Table 3: Sources of Labour Productivity Growth, Private Business Sector and Total Economy, United States, 1987-2015**

| <b>Panel A. Private Business Sector</b>          |                     |                       |                                   |                   |                |
|--|---------------------|-----------------------|-----------------------------------|-------------------|----------------|
|  | Labour Productivity | Average Capital Share | Contributions (Percentage Points) |                   |                |
|  |                     |                       | Total Factor Productivity         | Capital Deepening | Labour Quality |
| 1987-2015  | 2.01                | 0.35                  | 0.93                              | 0.80              | 0.28           |
| 1987-1995  | 1.61                | 0.33                  | 0.60                              | 0.63              | 0.37           |
| 1995-2004  | 3.27                | 0.33                  | 1.73                              | 1.24              | 0.25           |
| 2004-2015  | 1.27                | 0.37                  | 0.51                              | 0.52              | 0.25           |
| 2004-2008  | 1.33                | 0.36                  | 0.27                              | 0.81              | 0.23           |
| 2008-2010  | 3.36                | 0.37                  | 1.33                              | 1.58              | 0.44           |
| 2010-2015  | 0.40                | 0.38                  | 0.37                              | -0.15             | 0.18           |
| Percentage-point Change, 1995-2004 to 2004-2015  | -2.00               | 0.04                  | -1.22                             | -0.72             | 0.00           |
| Per cent of Total Change, 1995-2004 to 2004-2015 | 100.0               | –                     | 61.0                              | 35.9              | 0.1            |
| <b>Panel B. Total Economy</b>                    |                     |                       |                                   |                   |                |
|  | Labour Productivity | Average Capital Share | Contributions (Percentage Points) |                   |                |
|  |                     |                       | Total Factor Productivity         | Capital Deepening | Labour Quality |
| 1987-2014  | 1.74                | 0.38                  | 0.75                              | 0.73              | 0.26           |
| 1987-1995  | 1.41                | 0.35                  | 0.57                              | 0.50              | 0.34           |
| 1995-2004  | 2.65                | 0.35                  | 1.33                              | 1.04              | 0.25           |
| 2004-2014  | 1.20                | 0.42                  | 0.39                              | 0.60              | 0.20           |
| 2004-2008  | 1.28                | 0.41                  | 0.21                              | 0.84              | 0.21           |
| 2008-2010  | 2.43                | 0.44                  | 0.45                              | 1.62              | 0.31           |
| 2010-2014  | 0.51                | 0.43                  | 0.52                              | -0.16             | 0.13           |
| Percentage-point Change, 1995-2004 to 2004-2015  | -1.45               | 0.07                  | -0.94                             | -0.44             | -0.06          |
| Per cent of Total Change, 1995-2004 to 2004-2015 | 100.0               | –                     | 64.9                              | 30.1              | 3.9            |

Source: Bureau of Labor Statistics, Multifactor Productivity Program.

Notes: Labour productivity growth rates are compound annual growth rates. The contribution of capital deepening is the growth rate of the capital-hours ratio multiplied by the average capital share for the period. The contribution of labour quality is the growth rate of labour composition multiplied by one minus the average capital share for the period. The time periods for the average capital shares end one year earlier than the date indicated (e.g. the average is computed over 1995-2003 instead of 1995-2004) to avoid double counting cut-off years. The sum of the contributions may differ slightly from labour productivity growth due to rounding.

from TFP growth (0.93 percentage points) and capital deepening (0.80 percentage points), with growth of labour quality contributing 0.28 percentage points per year.

The bottom two rows of Panel A shows the changes in labour productivity growth and in the contributions of the three components between the 1995-2004 period and the 2004-2015 period. The 2.0 percentage-point slowdown in labour productivity growth is attributable to a 1.22 percentage-point decline in TFP growth and a -0.72 percentage-point contribution from capital deepening. Labour quality growth held steady between the two periods (although it exhibited substantial variation within the post-2004 period, as shown in the table).

Panel B of Table 3 displays the growth accounting results for the total economy. Productivity growth and its components tended to be smaller in the total economy than in the private business sector, but the relative magnitudes of the contributions from TFP, capital deepening and labour quality are similar to those in Panel A. Over the full 1987-2015 period, TFP growth and capital deepening contributed 0.75 and 0.73 percentage points, respectively, to labour productivity growth in the total economy. The contribution of labour quality growth, at 0.26 percentage points, was comparatively small but certainly not negligible.

Again, we are primarily interested in the sources of the slowdown post-2004. The 1.45 percentage-point slowdown in labour productivity growth between 1995-2004 and 2004-2015 was the result of a -0.94 percentage-point contribution from slower TFP growth and a -0.44 percentage-point contribution from slower capital deepening. The contribution of labour quality growth was -0.06 percentage points. At 1.45 percentage points, the slowdown in the total economy was smaller than the slowdown in

the business sector (2.0 percentage points).

These results indicate that a large decline in TFP growth was the most important proximate driver of the post-2004 labour productivity slowdown. Slower capital deepening also made a substantial contribution to the slowdown. It is particularly noteworthy that the rate of capital deepening has been negative since 2010; hours worked are recovering from the Great Recession, but capital investment has remained sluggish. Hall (2014) points to the failure of the U.S. capital stock to rebound as a major lasting effect of the recession. Note, however, that the contribution of capital deepening to productivity growth was already well below its 1995-2004 level (though not its 1987-1995 level) over the 2004-2008 period, before the recession.

## Explanations for the U.S. Productivity Slowdown

Why did U.S. productivity growth decline in the mid-2000s and why has it remained low since then? In this section, we discuss a number of potential explanations for the slowdown. The discussion is based on a review of the research literature on the question, together with the empirical results from the previous sections of this article. We organize the discussion in terms of three broad categories of explanation: mismeasurement, supply-side explanations, and demand-side explanations.

### Measurement Issues

Why did measured productivity growth decline in the mid-2000s? One possible answer is that the measured slowdown is the result of measurement error and not a reflection of any real economic phenomena. This explanation the mismeasurement hypothesis has been advanced by several authors in both the popular press and the

academic literature.<sup>24</sup>

## Measuring Output in the Digital Economy

Technological changes have occurred throughout the post-2004 period in areas such as robotics (e.g. autonomous vehicles, drones), communication equipment (e.g. smart phones), digital platforms (e.g. Uber, Airbnb), and data analytics (e.g. artificial intelligence, ‘big data’). Official output statistics may fail to capture some of the output arising from these innovative technologies and business models, due either to conceptual or compilation challenges. Mokyr (2014: 88) makes this point forcefully:

“[Economists] are trained to look at aggregate statistics like GDP per capita and its derivatives such as factor productivity. These measures were designed for a steel-and-wheat economy, not one in which information and data are the most dynamic sector. Many of the new goods and services are expensive to design, but once they work, they can be copied at very low or zero cost. That means they tend to contribute little to measured output even if their impact on consumer welfare is very large. ... The aggregative statistics miss much of what is interesting.”

If these measurement problems have become

more severe since 2004 as the use of these technologies has expanded, the result could be a decline in the pace of measured real output growth, and hence measured productivity growth. The decline would be illusory; it would reflect a statistical failure rather than a true slowdown in growth.

Ahmad and Schreyer (2016) provide a comprehensive discussion of the conceptual and practical challenges to GDP and productivity measurement posed by the digital economy.<sup>25</sup> They identify the following key output measurement challenges:

- **Rising importance of peer-to-peer transactions:** New technology has facilitated the matching of consumers with non-business service providers (e.g. homeowners letting their owner-occupied homes via Airbnb). How can the value added of the providers be measured?
- **‘De-marketization’ of production:** Digital technology has shifted some activities from the market sector to the household production sector (e.g. online banking, online flight booking and check-in, etc.). Should these activities be included in GDP?
- **Free products and services:** Many digital services are provided to users at zero or near-zero prices, which complicates their inclusion in national accounts. Such services may be financed by advertising revenues, may be traded for users’ behavioural data, or may represent an investment in the

<sup>24</sup> For discussions of the mismeasurement hypothesis in the popular press, see Ito (2013), Feldstein (2015), Smith (2015) and Aeppel (2015).

<sup>25</sup> The digital economy refers to the matching of service providers with end users via intermediating digital platforms. Two characteristics distinguish the digital economy from the ‘traditional’ economy. First, digital platforms are characterized by powerful network effects, which tend to encourage market concentration. Second, digital technologies tend to reduce barriers to entry, and this tends to increase market contestability by new entrants.

provider's brand. Different methods of measuring the value of these 'payments' have different implications for output measurement.

- **Price vs. quality changes:** Digital technology has exacerbated problems in separating price changes from quality changes. Specific challenges include increasing product or service customization, non-volume-based pricing models (e.g. fee-for-access rather than price-per-unit pricing), and substitution of new services for old ones (e.g. substituting Airbnb for hotel rooms).

The first three challenges pertain to the measurement of current-dollar output in the digital economy, while the fourth pertains to the measurement of prices and hence of real output volumes.<sup>26</sup>

Much of the output from peer-to-peer transactions may already be captured in GDP (e.g. in the imputed rental value of owner-occupied housing, which assumes full-time occupancy), and in principle the records of the intermediaries could be used to capture the rest. The activities that have moved from the market sector to the non-market sector arguably should not be counted in GDP; this is a long-standing issue in national accounts measurement. Ahmad and Schreyer (2016) argue that the latter two issues – free products and, especially, price versus quality measurement – are the challenges for which further research efforts are most warranted.

That said, they suggest that the size of the digital economy may (so far) be too small for these issues to have affected output growth or productivity growth to a

significant degree. It is therefore unlikely that these measurement issues can explain away the post-2004 productivity slowdown.

Recent quantitative research supports that conclusion. Syverson (2016) shows that even the largest estimates of the unmeasured value added associated with digital technology account for, at most, a third of the \$2.9 trillion reduction in U.S. output in 2015 due to the productivity slowdown. He also finds that the tendency of measured U.S. nominal GDI to exceed measured nominal GDP – a pattern consistent with some output being produced and given away for free or at steep discounts, as is often the case in the digital economy – began in 1998, well before the U.S. productivity slowdown, and did not get worse after 2004.

Byrne *et al.* (2016) argue that the value of 'free' digital services to consumers is largely non-market and ought not to be included in market sector output or productivity measures. If they nevertheless include it (using estimates of the unmeasured value of 'free' digital services based on the opportunity cost of the time users spend using them), they find that business sector labour productivity growth would be about 0.3 percentage-points higher over the 2002-2011 period, with slightly larger effects after 2005 than before. Since business sector labour productivity growth slowed by about 2 percentage points after 2004, most of the slowdown remains unexplained even after this adjustment.

### **Mismeasurement of Information and Communication Technology (ICT)**

The U.S. productivity boom of 1995-2004 coincided with an acceleration in the rate

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<sup>26</sup> Aside from these output measurement issues, an important implication of the rising digital economy for productivity measurement is the blurring of the line between consumer durables and productive capital. Is an Uber driver's car a consumer durable or a part of the capital stock of the transportation sector?

of decline of prices for ICT investment. After 2004, the prices of ICT goods and services fell more slowly than before and the contribution of ICT production to productivity growth declined. Some research has suggested that the official price indexes for ICT investment understate the rate of decline of ICT prices in recent years (Byrne and Corrado, 2015 and 2017; Byrne and Pinto, 2015; Byrne *et al.*, 2015). If this measurement problem became worse around 2004 for some reason, it might explain some part of the decline in measured productivity growth.

Byrne *et al.* (2015) find that this is not the case; that is, while there is substantial error in the measurement of ICT price indexes, the measurement problems did not become worse after 2004. They correct for the mismeasurement of ICT prices using new price indexes and find that the correction actually exacerbates the post-2004 productivity growth decline rather than explaining it away. ICT prices were mismeasured well before the slowdown, and since U.S. production of these products has declined, the impact of their mismeasurement on U.S. productivity was larger during the 1990s than it has been post-2004.

Syverson (2016) also provides evidence against the view that ICT mismeasurement explains the measured productivity growth slowdown. First, many countries experienced a productivity slowdown in the 2000s and the size of the slowdown is uncorrelated with the intensity with which countries consume or produce ICT

products. The same is true across U.S. states (Cardarelli and Lusinyan, 2015). Second, the true output growth of ICT-producing industries would have to have been some 500 per cent greater than their measured output growth since 2004. This is an implausible degree of mismeasurement.

### **International Profit Shifting**

Another potential source of error in productivity measurement arises from a failure to properly account for the economic activity of U.S. multinational enterprises (MNEs) that engage in significant offshore profit shifting (usually for tax purposes). Using a variety of tax planning strategies, MNEs are able to book profits in low-tax jurisdictions even though the productive activity that gave rise to those profits occurred in other jurisdictions.<sup>27</sup> This leads to an understatement of GDP in the high-tax jurisdiction and an overstatement of GDP in the low-tax jurisdiction. For example, suppose a U.S.-based MNE develops new intellectual property that is used in production abroad. The flow of payments for the services of this intellectual property should be accounted for in U.S. value added as part of net exports. But if the U.S. MNE legally transfers ownership of the intellectual property to a subsidiary in a relatively low-tax jurisdiction (and manages to ‘underprice’ it in the transfer), that value added will be attributed to that jurisdiction rather than to the United States.<sup>28</sup>

If the extent of international profit shifting was greater in the post-2004 period than in earlier times, then it could explain

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27 One such strategy is to underprice the services of intangible capital developed in the United States and used by foreign subsidiaries. Another is to arrange for loans from subsidiaries in low-tax jurisdictions to subsidiaries in high-tax jurisdictions, thereby shifting profits to the low-tax jurisdiction.

28 The payments would still be captured in U.S. gross national income, as part of earnings on direct foreign investment. Note that this is true even if the foreign earnings are not repatriated; the BEA accounts for U.S. foreign direct investment income at the time the earnings are earned, not when they are distributed as dividends (Bureau of Economic Analysis, 2006).

part of the measured productivity growth slowdown. Guvenen *et al.* (2017) investigate this possibility and develop adjusted measures of U.S. GDP and labour productivity to account for international profit shifting. They allocate the worldwide earnings of U.S. MNEs across countries based on measures of the amount of the company's economic activity that actually occurs in each country.<sup>29</sup>

They find that the effect of international profit shifting on measured U.S. GDP was small from the 1970s to the late 1990s, but became more important in the early 2000s. Their adjustments to GDP raise measured labour productivity growth by 0.1 percentage points per year over the 1994-2004 period and by 0.25 per cent per year over the 2004-2008 period. However, they found that international profit shifting did not affect productivity growth after 2008. These findings imply that the adjustments raise average productivity growth over the 2004-2015 period by about 0.09 per cent per year, which is essentially the same as the pre-2004 adjustment. Thus, accounting for international profit shifting explains none of the measured slowdown in U.S. labour productivity growth between the 1994-2004 and 2004-2015 periods. At best, it explains a small share of the slowdown in the 2004-2008 period. But productivity growth has remained low after 2008 for reasons unexplained by international profit shifting.

### **Conclusions Regarding Mismeasurement**

While the measurement of productivity growth is subject to substantial error and uncertainty, the balance of the evidence suggests that the post-2004 slowdown in measured productivity growth is a true

economic phenomenon and not an illusion driven by worsening measurement error. In the remainder of this section, we review possible supply-side and demand-side explanations for the slowdown.

### **Supply-side Explanations**

This section discusses possible structural explanations for the decline in U.S. productivity growth in the mid-2000s. We first discuss whether the pace of technological progress has declined, due either to a decline in the rate of frontier innovation or to a decline in the rate of technology diffusion. We then discuss the role of resource reallocation across firms and across industries. Finally, we touch upon labour quality growth.

### **Frontier Innovation: The Exhaustion of Major Innovation Opportunities**

A leading explanation of the post-2004 productivity slowdown is that it reflects the exhaustion of opportunities to enhance productivity via the adoption of new ICTs (together with the absence of any other new technology to drive fast productivity growth). This is related to a broader idea: that opportunities for fundamental, economy- and society-altering technological advances were exhausted by the early 1970s, and that aside from a transitory ICT-driven blip in the 1995-2004 period slow productivity growth since 1973 represents a permanent decline in the economy's innovative potential relative to the 1920-1970 period.

We first discuss the narrower story about the role of ICT in the 1995-2004 productivity acceleration and the subsequent slowdown. We then discuss the broader hypothesis that the pace of technological progress has slowed

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<sup>29</sup> This approach is called 'formulary apportionment.' To measure the amount of a company's economic activity that occurs in a given country, they use information on the company's labour compensation payments and sales to unaffiliated parties in that country.

more or less permanently.

## Information and Communication Technology

There is a sizable literature on the sources of the 1995-2004 U.S. productivity boom and a growing one on the reasons that boom ended in 2004. The leading explanation is that the two trend breaks are tied together by a single factor: the diffusion of information and communications technology (ICT) throughout the U.S. economy. According to this explanation, an increase in the rate of technological improvement in the ICT-producing industries after 1995 led to rapid price declines in ICT and a boom in ICT investment in other sectors. That investment boom caused fast productivity growth across sectors that use ICT intensively. By 2004, the productivity gains from the adoption of ICT had all been exploited and productivity growth declined.

Rapid ICT price declines predate the mid-1990s. Before economists noticed the mid-1990s increase in trend productivity growth, there had emerged a large body of research seeking to explain the “Solow paradox” of high ICT investment and low productivity growth. When trend productivity growth increased after 1995, however, ICT became the leading explanation.<sup>30</sup>

The distinction between labour productivity and TFP is important in terms of the ways in which ICT diffusion shows up in productivity statistics in the late 1990s and early 2000s. The high rate of aggregate TFP growth from 1995 to 2000 was driven mainly by fast TFP growth within ICT-producing industries (especially semiconductor production). TFP growth

in ICT production slowed somewhat after 2000, but until 2004 that slowdown was offset by a surge in TFP growth in industries that intensively use ICT (Jorgenson and Stiroh, 2000; Cette *et al.*, 2016). That surge reflected complementary innovations and business reorganization that ICT made possible in the intensive ICT-using industries. In terms of labour productivity, the growth increase was broad-based across both ICT-producing and intensive ICT-using industries (but not in industries that do not use much ICT) throughout the 1995-2004 period because TFP growth in ICT-producing industries led to lower relative prices for ICT goods and, hence, to capital deepening in ICT-using industries.

The ICT-based story is broadly consistent with our industry decomposition results. Wholesale trade, retail trade, and finance – three of the industries that drove the productivity slowdown after 2004 – are all ICT-intensive service industries according to Cette *et al.* (2016). The other key contributor, manufacturing, includes both ICT-producing and ICT-using industries, though it also includes some industries that are neither. The decomposition results of Cette *et al.* (2016), which focus explicitly on ICT producers and users, confirm the importance of intensive ICT-using industries in the post-2004 slowdown.

## Slowdown in the Pace of Technological Progress

A view associated most closely with Robert Gordon (2016a) holds that the 1995-2004 period of fast ICT-driven productivity growth was a temporary deviation from the normal state of affairs, which is modest

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30 Jorgenson (2001) decomposes aggregate U.S. productivity growth into industry contributions using the Domar approach. He finds that the ICT sector (comprising the computer, software, and communication equipment industries) accounted for 49 per cent of the TFP growth increase between 1990-1995 and 1995-1999, and 77 per cent of the labour productivity increase between those two periods. He attributes this to an increase in the rate of technological advance in the development of semiconductors after 1995.

technological innovation and moderate productivity growth. Gordon argues that the period between 1920 and 1970 represented a unique period in U.S. economic history. A set of ‘great inventions’ developed during the decades before 1920 (electricity, the internal combustion engine, etc.) spread throughout the economy during the 1920-1970 period and led to an explosion of productivity growth that was unprecedented in history and that is in Gordon’s view unlikely ever to be repeated.

The slowdown in U.S. productivity growth in the early 1970s marked the end of this period of revolutionary technological transformation. Subsequent innovations, Gordon argues, have been ‘evolutionary rather than revolutionary’; that is, they represent incremental improvements in some aspect of economic life but not fundamental transformations of the kind that occurred during the 1920-1970 period. The ICT-driven productivity boom of the 1995-2004 period was short-lived because it did not take long for the associated opportunities for productivity enhancement to be exhausted. The productivity improvements in communication and information processing associated with ICT are simply smaller and less far-reaching in their impact than were the productivity improvements associated with, say, electrification.

Some other productivity and innovation experts disagree with Gordon’s pessimistic outlook for U.S. productivity growth. Syverson (2013) points out that the productivity effects of earlier general purpose technologies (e.g. electricity) occurred in waves separated by periods of slow growth, and that there is no basis for certainty that the productivity growth

benefits of ICT have all been exhausted. The findings of Byrne *et al.* (2015) suggest that technological progress in ICT continues at a fast pace.<sup>31</sup> Brynjolfsson and McAfee (2011; 2014) and Mokyr (2014) suggest that emerging technologies such as 3-D printing, artificial intelligence and genomics could lead to heretofore unimagined societal and economic transformations.

People on both sides of this debate agree that the post-2004 productivity slowdown is traceable to a decline in the measured contribution of ICT-producing and intensive ICT-using industries to aggregate productivity growth. The debate is over how to interpret this decline. Is it a return to normal that we should expect to be permanent, as Gordon claims? Or will further waves of fast productivity growth driven by ICT occur in the future, so that the post-2004 slowdown will turn out to have been temporary? Only time can answer this question.

### **Technology Diffusion: Growing Gap between Frontier Firms and Laggards**

The process of productivity growth occurs in two stages: technological innovation and technology *diffusion*. The Gordon view is that the pace of innovation has slowed; that is, that new ideas at the technological frontier are arriving more slowly or are less significant relative to the past. An alternative possibility is that the process of diffusion is somehow being impeded; the frontier continues to be pushed forward as in the past, but the new technologies are not being adopted as readily by businesses.

It has been known for some time that there is substantial dispersion in productivity levels across firms within the same industry (Syverson, 2004; 2011).

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<sup>31</sup> See Sichel (2016) for some challenges to Gordon’s outlook, and Gordon (2016b) for a response.

Decker *et al.* (2017a) show that this dispersion has been rising over time, both in terms of TFP (for firms in the manufacturing sector) and in terms of labour productivity (for the entire U.S. private sector). Using firm-level data from 23 OECD countries including the United States, Andrews *et al.* (2015) find that the productivity gap between firms at the global productivity frontier (within an industry) and all other firms increased over the 2000s. Moreover, their econometric evidence suggests that, within countries, the productivity gap between firms at the national productivity frontier (as opposed to the global frontier) and laggard firms also increased.

If we expect best-practice technologies to diffuse through the productivity distribution from productivity leaders to the laggards, an increase in the dispersion of productivity levels may signal a problem in that diffusion process which may result in slower productivity growth. Taking a long-run perspective, Comin and Mestieri (2016) find that the diffusion of new technologies across countries has grown faster over time but that the diffusion of those technologies within countries (following initial adoption by early adopters) has slowed.

While the evidence suggests that the dispersion of firm-level productivities has been growing over time, there is no sign that this trend changed in any way around 2004. Indeed, Decker *et al.* (2017a) find that productivity dispersion in the United States has been trending upward at least since the late 1980s. It is therefore unlikely that the post-2004 productivity slowdown can be attributed to a decline in the rate of diffusion of best-practice technologies from the frontier to the laggards. That being said, problems in technology diffusion may

be imposing a longer-term drag on U.S. productivity growth. This is an area that warrants further research.

Aggregate productivity depends on both the distribution of firm-level productivities and the relative sizes of the firms (measured in terms of input shares). Having discussed the changing productivity distribution, we now turn to the matter of resource reallocation.

## Reallocation

Recent evidence suggests that the tendency of resources to be reallocated toward high-productivity firms in the United States has grown weaker in recent years and that this is tied to the productivity slowdown in the mid-2000s. We review this evidence in the first part of this section. In the second part, we discuss a different reallocation issue: the reallocation of resources across industries with different productivity levels and the so-called Baumol Effect.

### Reallocation Across Firms: Declining Business Dynamism

An emerging literature documents a decline in the rate of labour reallocation across firms in recent decades.<sup>32</sup> Decker *et al.* (2017a; 2017b) study the relationship between labour reallocation and aggregate productivity growth and find that a rise and fall in the pace of reallocation in information industries helps to explain the 1990s U.S. productivity acceleration and the post-2004 slowdown.

Decker *et al.* (2017a) note that trends in within-industry labour reallocation differ substantially across industries. Measures of business dynamism (e.g. start-up rates, firm exit rates, cross-firm labour reallocation rates, etc.) in the aggregate U.S. economy

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<sup>32</sup> See Davis *et al.* (2007), Decker *et al.* (2014; 2016), Davis and Haltiwanger (2014), Hyatt and Spletzer (2013), Molloy *et al.* (2016) and Alon *et al.* (2017).

have been declining since (at least) the early 1980s, but the implications of changes in dynamism for aggregate productivity depend on which industries are driving the aggregate labour reallocation trends. In the 1980s and 1990s the decline in overall U.S. labour reallocation rates was being driven by the retail trade industry, and this was productivity-enhancing because it reflected the growing concentration of activity in that industry in highly productive 'big box' retailers. In the 1990s and 2000s, changing rates of labour reallocation in 'high-tech' industries (a set of ICT-related manufacturing industries) became relatively important. High-tech business dynamism declined throughout the 1980s, increased throughout the 1990s, then declined again after 2000.

On the relationship between high-tech labour reallocation and aggregate productivity growth, Decker *et al.* provide two main results. First, trends in high-tech labour reallocation were driven not by changes in the distribution of firms' productivities but by changes in firms' responsiveness to productivity shocks. The dispersion of productivity across high-tech firms rose steadily over time, but the responsiveness of firms to productivity changes (measured in terms of employment growth or equipment investment growth) increased in the 1990s and fell in the 2000s. This is what explains the pattern of labour reallocation rates in that sector.

Second, the rise and fall of labour reallocation rates in high-tech industries contributed significantly to the rise and fall of productivity growth in high-tech manufacturing. Firms' rising responsiveness to productivity shocks contributed about 0.5 percentage points to annual TFP growth in the 1990s, while declining responsiveness subtracted as much as 2.0 percentage points from TFP growth in the 2000s. The

authors' econometric simulations suggest that declining labour reallocation became a drag on productivity growth in the high-tech sector around 2003, which is close to the date of the aggregate U.S. productivity slowdown.

As discussed earlier, a declining productivity growth contribution from the ICT sector has been a major driver of the aggregate productivity slowdown (Fernald, 2014a). The results of Decker *et al.* (2017a) are consistent with this view, but they suggest that the decline in the productivity contribution of the ICT sector may be the result of a decline in the efficiency of the allocation of labour across firms in the ICT sector rather than (or in addition to) a decline in technological progress in the sector. Efficiency-enhancing labour reallocation is supposed to occur as the result of a number of forces: the exit of the least productive firms from the marketplace, the entry of firms with new ideas to challenge incumbents, and the reallocation of market share toward relatively productive firms through competition. Evidently, these forces are growing less effective at channelling resources toward the most productive firms in the tech sector.

Decker *et al.* (2017b) provide further evidence in support of the view that declining allocative efficiency is part of the explanation of the post-2004 slowdown. Using measures of labour productivity and employment for firms in the U.S. business sector, they show that the positive correlation between productivity and employment share declined in the early 2000s. As a result, the positive contribution of labour reallocation to aggregate labour productivity growth fell significantly. Both a decline in reallocation among continuing firms and a decline in the contribution of net firm entry to reallocation led to slower productivity growth after the early 2000s.

These results suggest that changes in U.S.

business dynamism may play a substantial role in explaining aggregate productivity trends in recent years. That said, this line of research is still in its infancy and there remains much uncertainty about the magnitudes of the effects. Much more work needs to be done to develop more reliable quantitative estimates of the relationship between business dynamism and aggregate productivity. One important issue that the literature must address is the possibility that the changes in business dynamism, rather than (or in addition to) being causes of changing productivity growth, have themselves been caused by underlying changes in the rate of technological progress.

### **Reallocation Across Industries: The Baumol and Denison Effects**

The previous subsection discussed the implications of labour reallocation across firms. Aggregate productivity growth is also affected by the reallocation of labour (or other inputs) across industries. For completeness, we address this now.

The idea that resource reallocation across industries may tend to cause a slowdown in aggregate productivity growth is associated with the work of William Baumol on unbalanced growth and the 'cost disease'.<sup>33</sup> If some industries (say, manufacturing) exhibit fast productivity growth while others (say, health services) exhibit slow productivity growth, the relative prices of the outputs of the slow-growth industries will tend to rise. Baumol thought that this would lead to an increase in the share of slow-growing industries in total output, and hence to lower aggregate productivity

growth even if productivity growth rates within each industry remain unchanged over time.

On the other hand, there has been a long-run tendency for labour (and other inputs) to move from low-productivity to high-productivity uses over time. Edward Denison pointed this out in the context of the shift from agriculture to manufacturing in advanced economies in the middle of the 20th century.<sup>34</sup> In general, aggregate productivity growth will rise if labour is reallocated into industries with high productivity levels.

We already touched upon both these ideas in our industry decompositions of productivity growth earlier in this article. What we called the reallocation level effect and the reallocation growth effect could have been called the 'Denison effect' and the 'Baumol effect', respectively.<sup>35</sup>

Our industry decomposition revealed that reallocation accounted for only 0.04 percentage points (or 1.9 per cent) of the labour productivity growth slowdown between the 1995-2004 period and the 2004-2015 period (Table 2). Of this, 0.06 percentage points (or 3.0 per cent of the total slowdown) were attributable to the reallocation level effect (or the 'Denison effect'). The reallocation growth effect (or the 'Baumol effect') actually worked against the slowdown, but its impact was quantitatively negligible. The contribution of the reallocation level effect to the slowdown was driven by the FIRE, information and manufacturing industries, while mining and utilities made substantial contributions in the opposite direction (i.e.

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33 See Baumol (2012) for a recent exposition of the cost disease argument. Classic references include Baumol (1967) and Baumol *et al.* (1985).

34 See Denison (1967), especially chapter 16.

35 Indeed, this is the terminology used by Nordhaus (2001) in his industry decomposition of productivity growth.

toward faster overall productivity growth) through the reallocation level effect.

Overall, our industry decomposition results make it clear that cross-industry reallocation was not a dominant driver of the slowdown.

### Labour Quality Growth

Our growth accounting exercise in Section 3 revealed that change in the growth of labour quality was not a significant driver of the productivity slowdown (Table 3). Labour quality growth contributed nothing to the productivity decline in the private business sector, while in the total economy it contributed -0.06 percentage points (or 3.9 per cent of the total decline).

That being said, it is noteworthy that the contribution of labour quality growth to labour productivity growth was high during the 2008-2010 period and has been quite low since 2010. The brief surge in labour quality growth during the Great Recession may reflect the concentration of job losses among relatively low-wage workers. It remains to be seen whether the low contribution of labour quality since 2010 is a temporary effect of the recovery from that recession (as those relatively low-productivity workers return to work) or a permanent slowdown in labour quality growth (perhaps due to declining growth in educational attainment).<sup>36</sup> If it is the latter, then the labour productivity growth slowdown may become even worse in the coming years. The projection exercises of Bosler *et al.* (2016) and Jorgenson *et al.* (2016) suggest that slow U.S. labour quality growth is likely going forward due to a plateau in educational attainment, and a recovery of labour market

participation among unskilled workers would reduce labour quality growth further.

## Aggregate Demand and Productivity Growth

All the explanations discussed so far might be described as supply-side explanations. An alternative view (or perhaps a complementary one) is that, since 2008, part of the decline in productivity growth has been the endogenous result of a shortfall in aggregate demand. Theoretical models of endogenous growth provide reasons to think that demand shocks might affect TFP growth (at least temporarily) through endogenous changes in R&D spending. Empirical evidence in support of this mechanism as a driver of the productivity slowdown is limited.

The recession of 2008-2009 involved both a financial crisis and a large decline in aggregate demand in the U.S. economy. A disruption of financial markets or an aggregate demand shortfall could lead to lower TFP growth via a number of channels. Financial market disruption could lead to a reduction in resource reallocation, and hence to lower TFP due to a higher degree of misallocation.<sup>37</sup> Financial disruption or low demand could lead firms to reduce their investment in research and development and technology commercialization, leading to slower TFP growth (Queralto, 2015; Anzoategui *et al.*, 2015; Bianchi *et al.*, 2016). Duval *et al.* (2018) find evidence consistent with this view in a large sample of firms in OECD countries. Both lower capital investment and lower TFP growth contribute to lower labour productivity

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<sup>36</sup> Labour quality is measured using information on the relative wages of workers across age, gender and skill categories.

<sup>37</sup> Quantitative findings on the importance of financial market frictions for TFP are mixed. Some studies find that financial frictions have a large effect on TFP through resource misallocation (e.g. Moll, 2014; Greenwood *et al.*, 2012), while others find that the effects are small (e.g. Midrigan and Xu, 2012; Gilchrist *et al.*, 2012). Further research in this area is warranted.

growth, everything else being equal.

Reifschneider *et al.* (2015) develop an econometric model of potential output and find that the financial crisis in 2007 and 2008 was followed by a substantial decrease in U.S. potential output growth. The largest contributors to this decline were reductions in capital formation and in their estimates of trend TFP growth.<sup>38</sup> In an accounting analysis, Hall (2014) measures the sources of the shortfall of U.S. output in 2013 relative to its 1990-2007 trend and finds that the largest contributors were reduced capital accumulation and reduced TFP growth.<sup>39</sup> Reifschneider *et al.* speculate that the decline in TFP growth might be the endogenous result of demand-driven declines in R&D activity. Hall is skeptical of this view, given that “similar slowdowns [of TFP growth] over 6-year periods have been common.” In a more recent study, Fernald *et al.* (2017) find that slow output growth since 2009 reflects two structural forces slow TFP growth and declining labour force participation that already existed before the Great Recession.

Blanchard *et al.* (2015) examine recoveries from 122 recessions in 23 countries. They note that, in many cases, output growth (not just the output level) remains below its pre-recession trend for a long time after the recession. While they consider the possibility that these growth slowdowns are caused by the recessions, they think it more likely that the reverse is true: the recessions were caused by the arrival of news that future growth would be slower than expected. Along similar lines, Blanchard *et al.* (2013; 2017) argue that the

weakness of U.S. aggregate demand since the Great Recession is a reflection of Americans’ downward revisions of expectations for future growth, not a cause of them.

The growth accounting exercises presented in Section 3 of this article revealed that a decline in the rate of capital deepening accounted for 36 per cent of the private business sector labour productivity slowdown between the 1995-2004 and 2004-2015 periods (Table 3). Indeed, the contribution of capital deepening to labour productivity growth has been negative since 2010. Low capital investment could reflect depressed aggregate demand, but it could also reflect low expectations of future productivity growth. If productivity growth is expected to be low, then expected returns to capital investment will be low as well.

The cause and effect relationship between current aggregate demand and future productivity growth is difficult to untangle. Estimated structural models such as those of Anzoategui *et al.* (2015) and Bianchi *et al.* (2016) can do so, but their results are contingent upon all the assumptions embedded in the models. Given that U.S. productivity growth remained high following the 2001 recession and then declined a few years before the 2008 recession, it seems likely that the post-2004 slowdown in trend productivity growth was not primarily a demand-driven phenomenon (Fernald, 2014b). Still, further research on the question is warranted.

## Conclusion

The post-2004 U.S. productivity slowdown resulted in a decline of some

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38 They did find an increase in TFP growth in 2009 and a decline thereafter, broadly consistent with the numbers in our Table 1.

39 Together, slower TFP growth and low capital deepening contributed 7.4 percentage points to the 13 per cent shortfall of U.S. output in 2013 relative to the level implied by its 1990-2007 trend. Low labour force participation and labour market slack (i.e. high unemployment and low hours worked relative to past trends) also made substantial contributions in Halls’ decomposition.

\$3 trillion in U.S. real output in 2015 relative to the counterfactual in which the slowdown had not occurred. In this article, we aimed to provide an overview of the current state of knowledge on the causes and descriptive characteristics of the slowdown. We summarized recent trends in U.S. productivity measures and identified the proximate sources of the slowdown in a standard growth accounting framework. We presented new findings on the industry sources of the slowdown based on the CCLS labour productivity growth decomposition. We reviewed the extensive literature aimed at explaining the slowdown.

Based on our analysis, the state of knowledge about the slowdown can be summarized in the following four points:

- The trend rate of U.S. productivity growth declined around 2004. The decline occurred in both labour productivity growth and TFP growth, and in both the business sector and the total economy.
- Labour productivity growth in the private business sector slowed by 2.0 percentage points per year after 2004. Of this decline, 60-65 per cent was accounted for by a decline in TFP growth and 30-35 per cent was accounted for by a decline in the rate of capital deepening. Changing growth of labour quality played a comparatively small role.
- Three industries collectively accounted for 80.5 per cent of the labour productivity slowdown: manufacturing (42.0 per cent), wholesale trade (21.7 per cent), and retail trade (16.9 per cent). These industries' contributions to the slowdown were driven by within-sector productivity slowdowns. Labour reallocation across industries

accounted for only 1.9 per cent of the labour productivity slowdown.

- The slowdown is traceable to a decline in the productivity contributions arising from industries that produce or intensively use information and communication technology (ICT) products. The decline in the productivity contribution of ICT was driven by some combination of a) slower technological progress in ICT and b) a reduction in business dynamism in the ICT sector resulting in a decline in the rate of resource reallocation from less-productive to more-productive firms.

It is important to emphasize that the role of ICT in the slowdown does not mean that the entire slowdown is attributable to a slowdown of productivity growth in ICT-producing industries. The slowdown is also evident in industries that intensively use ICT, particularly market service industries. During the 1995-2004 period, such industries were able to raise their productivity by adopting ICT. Evidently, these gains were played out by 2004. The industry decomposition results in this article are broadly consistent with this account. In retail trade, for example, ICT made possible the rise of Big Box' retail and facilitated productivity gains in inventory and supply chain management. These gains were exhausted once these management changes had been made and all the best locations for Big Box' stores had been developed.

What implications might the U.S. productivity growth slowdown have for Canada? Over the 1987-2015 period, business sector labour productivity growth in Canada lagged that of the United States by 0.78 percentage points per year (Table 4). The gap has tended to be larger during periods of fast growth in the United States. During the 1995-2004 period (the ICT-

**Table 4: Labour Productivity Growth in the United States and Canada, Business Sector, 1987-2015**

|           | United States | Canada | Growth Gap |
|-----------|---------------|--------|------------|
| 1987-2015 | 2.00          | 1.22   | 0.78       |
| 1987-1995 | 1.55          | 1.12   | 0.43       |
| 1995-2004 | 3.22          | 1.69   | 1.53       |
| 2004-2015 | 1.33          | 0.91   | 0.42       |
| 2004-2008 | 1.33          | 0.79   | 0.54       |
| 2008-2010 | 3.25          | 0.88   | 2.38       |
| 2010-2015 | 0.57          | 1.02   | -0.45      |

Sources: U.S. data are from the Bureau of Labor Statistics, Labor Productivity and Costs. Canadian data are from Statistics Canada, CANSIM Table 383-0008.

driven productivity boom), U.S. labour productivity grew by 3.22 per cent per year. Canadian labour productivity grew by 1.69 per cent per year over the same period; while this was above the Canadian average for the 1987-2015 period, it was 1.53 percentage points below the U.S. growth rate an enormous gap.<sup>40</sup> During the slow-growth periods of 1987-1995 and 2004-2015, the gap was about 0.4 percentage points. The U.S. productivity slowdown has slowed the labour productivity divergence between the United States and Canada relative to the 1995-2004 period.

Indeed, since 2010, the gap has turned negative. U.S. labour productivity growth over the 2010-2015 period has averaged 0.57 per cent per year, the lowest rate of any extended period since 1987. In Canada, by contrast, labour productivity growth picked up after 2010 and has averaged 1.02 per cent per year over the 2010-2015 period. Thus, Canadian labour productivity growth has exceeded U.S. growth by 0.45 percentage points. In the near term, this bodes well for the growth of Canadian living standards relative to those of the United States.

In the longer term, however, a slowdown in U.S. productivity growth portends slower growth in Canada as well. The United States is at the global technological frontier in many sectors, including the important information technology sector. To the extent that the U.S. slowdown reflects a decline in the pace of technological change at the frontier, then it is almost certain that productivity growth in the countries chasing the frontier like Canada will eventually fall as well.

We conclude by suggesting some areas for future research. First, we provided industry decomposition results for labour productivity. It would be informative to perform a similar decomposition for TFP growth.<sup>41</sup> Second, our decomposition based on two-digit industries could be extended to a more detailed level of industry disaggregation. This would allow us to identify the sub-industries that drove the large contributions of two-digit manufacturing, retail trade, and wholesale trade to the productivity slowdown.

The industry-level results could be examined in greater detail in other ways. For example, how much of the decline

<sup>40</sup> The gap was even larger during the 2008-2010 period, at 2.38 percentage points. This probably reflects the larger impact of the Great Recession on hours worked in the United States relative to Canada.

<sup>41</sup> Calver and Murray (2016) show how to apply the CSLS decomposition method to TFP data. They present decomposition results for Canadian TFP growth over the 1997-2014 period.

in manufacturing is attributable to a slowdown in the rate of semiconductor price decline versus increased offshoring of ICT production?

Our growth accounting results indicated that U.S. labour quality growth spiked during the Great Recession and has been slow since 2010. We speculate that this pattern reflected cyclical changes in the skill composition of the workforce, but it would be worthwhile to examine this formally.

A topic that we did not discuss in this article and that has received little attention in the literature is the potential role of international trade in the productivity slowdown. Modern trade theory emphasizes the relationship between trade and firm-level productivity dynamics, and the Great Recession was associated with a significant slowdown in global trade. Could this have affected U.S. productivity growth?

The emerging literature using firm-level data to link aggregate productivity growth to industry-level trends in business dynamism suggests that declining labour reallocation across firms might be a key driver of the productivity slowdown. This should be a major focus of future research, since this driver of slower aggregate productivity growth might carry very different policy implications than a decline in the pace of fundamental technical progress would.

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# Cyclical Downturn or Slowing Trend? A Review Article on *Productivity Puzzles across Europe*

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## ABSTRACT

*Productivity Puzzles across Europe* examines European productivity before, during, and since the Great Financial Crisis, with a special focus on country-specific labour-market institutions. This review emphasizes first, that European productivity growth has been slowing for decades — it is not just a recession and post-recession phenomenon. Second, the book’s analysis of labour markets, which highlights incentives to hoard labour, is relevant for understanding cyclical fluctuations in total factor productivity (TFP) around that trend. For example, institutions in Germany encouraged use of intensive margins (hours per worker and maybe effort), so measured TFP fell sharply in the recession but then rebounded quickly. The labour-market analysis in the book sheds little light on the slowing TFP trend.

In the past few years, the healing process from the Global Financial Crisis (GFC) has finally become broadly entrenched. But with the global cyclical upswing has come the increasing recognition of a different, and potentially longer lasting, concern: Trend growth rates are slow. The “surprise,” relative to expectations from before the GFC, has been in trend productivity.<sup>2</sup>

This global productivity slowdown is the

backdrop for the book, *Productivity Puzzles across Europe* edited by Philippe Askenazy, Lutz Bellman, Alex Bryson and Eva Moreno Galbis and published by Oxford University Press in 2016. The first paragraph of the introduction motivates the book as follows: “The EU as a whole is experiencing a surprising slowdown in productivity.” The book focuses in depth on aspects of European productivity performance before,

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<sup>2</sup> For example, the International Monetary Fund’s World Economic Outlook (WEO) in April 2015 made the following observation: “Potential output growth across advanced and emerging market economies has declined in recent years. In advanced economies, this decline started as far back as the early 2000s...” (IMF, 2015: 69). Each of the twice-annual WEO’s since then has taken this slow down in potential growth as a given.

during, and since the GFC, with a deep dive into country-specific labour-market institutions in France, the U.K., Germany, and Spain. The book comprises nine chapters plus a lengthy introduction and a conclusion. Fifteen authors from a range of European countries contribute.

The strength of the book is its detail on how labour-market institutions across countries shape the short-term adjustments to shocks. As a result, despite the motivating quote above, most of the book turns out to be about cyclical fluctuations in productivity during the GFC itself, rather than the slowing trend that has continued. Over the past decade, both the cycle and the trend are important. But in the global context, the book did not persuade me that Europe's experience was that distinctive. Like the United States, the big picture is that Europe suffered a deep recession superimposed on a slowing trend.

### What Are the Puzzles?

The introduction and conclusion suggest two distinct big-picture “puzzles” — or, perhaps, stylized facts — about recent European productivity growth. These puzzles are restated in various ways throughout the book, with additional nuances:

- Productivity in many countries fell more than usual during the GFC itself.
- Productivity did not pick up in the recovery the way it usually does, i.e. the trend has been low.

The flip side of the first puzzle is that, in the

U.K. and Germany, the unemployment rate response to the recession appeared muted — considerably so, in the case of Germany.

In order to document that these are, in fact, puzzles, the productivity data since 2008 would ideally be compared with long historical experience. Yet despite the large number of tables and charts in the book, most of the productivity data reported start only in the early 2000s. (The nice paper by Bart Van Ark, in chapter 1, is an exception.)

To provide this broader context, Chart 1 illustrates both of these stylized productivity facts for the euro-area as a whole. The chart shows the year-over-year growth in euro-area total factor productivity (TFP) since 1960, using data from Bergeaud *et al.* (2016).<sup>3</sup> It also shows a smoothed trend line, estimated as a biweight filter with a smoothing parameter of 12 years.<sup>4</sup>

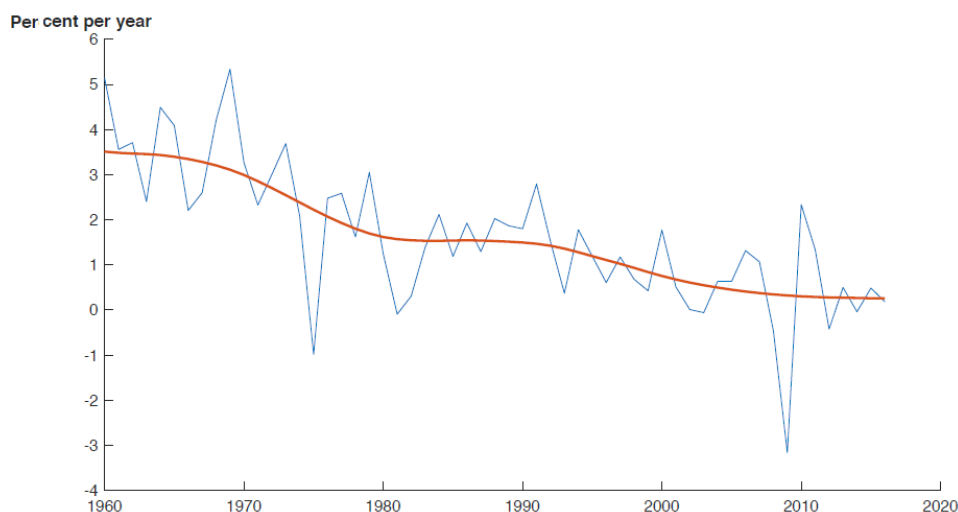
The chart illustrates the two puzzles. First, looking at the year-over-year fluctuations, the decline in euro-area TFP in 2009, during the most severe portion of the GFC, was deeper than any previous European recession. That said, it is only modestly worse relative to trend than in the early 1970s, and was not as persistent as the downturn in the early 1980s. Second, the trend line has continued to weaken in the recovery. The slow trend in the chart is common across countries. For example, the Van Ark chapter finds, strikingly, that every major country in Europe had negative TFP growth in the 2008-2014 period. Conceptually, the two puzzles are distinct. A large economic literature looks at cyclical productivity. A separate, large literature

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<sup>3</sup> The data refer to the total economy. A virtue of the Bergeaud *et al.* data is their long time series for the (pseudo) euro area. A shortcoming is that they do not adjust hours worked for labour quality or composition. Labour quality tends to rise in downturns, since lower-skilled workers are more likely to lose their jobs. So if TFP were measured with quality-adjusted labour, it would have declined even more than Bergeaud *et al.* estimate in 2009. Capital services data are also constructed with relatively aggregated types of capital.

<sup>4</sup> The trend line is close to being a 12-year centered moving average, except it is smoother and it becomes increasingly one-sided at the end points.

Chart 1: Trend and Cycles in Euro-Area Total Factor Productivity (TFP), 1960-2015



Source: Bergeaud *et al.*(2016). Trend is a biweight filter, with bandwidth of 12 years.

looks at trend growth.

### Europe's Slowing Trend

My first main reaction to the book is that the slowing trend is not new. Looking at Chart 1, TFP growth in Europe has been declining since the 1960s.

Moreover, although the book's introduction highlights the slowing trend, very little of the book is actually about the trend. The trend is mainly addressed in the first two chapters, by Bart Van Ark (2016) (comparing Europe to the United States) and Nick Crafts (2016)(asking whether secular stagnation is the future of Europe).

The implicit framework that underpins these first two chapters is familiar from the conditional convergence literature. In this literature, growth depends on innovation as well as the forces of convergence. Specifically, growth at the frontier is determined primarily by innovation. But frictions might keep countries from achieving that frontier — they might converge to their own steady state relative to the frontier. A corollary is that countries can grow faster than the frontier if they can remove impediments and converge towards the frontier.

The long-term slowing trend in Chart 1

reflects several forces. One force is the end of post-war economic convergence. A second, and more worrying, is some deterioration relative to the U.S. frontier following the U.S. ICT boom of the mid-1990s. This second force is a major focus of the Van Ark chapter (see also Cetto *et al.*, 2016). Van Ark notes that a continuing post-crisis divergence from the United States could occur if the crisis caused labour, product and capital market frictions to increase misallocation. But while this is possible, the book does not actually show that any of these events took place. In addition, there is evidence that digitalization has had a more muted effect on growth in Europe than in the United States and, perhaps relatedly, intangible capital appears to contribute less to growth in Europe.

In terms of policy implications, the Van Ark and Crafts chapters do suggest policies aimed at innovation and catch-up. For example, Crafts suggests easing labour and product market regulations that have slowed the diffusion of ICT; completing the single market in services; and improving education.

## Labour Markets, Labour Hoarding, and Cyclical Productivity

After chapter 2, analysis of the trend slowdown largely disappears from the book (though not always from the book's rhetoric). In particular, the core contribution of the book is contained in four country chapters that look, separately, at the experiences of France (Askenazy and Erhel, 2016), the U.K. (Bryson and Forth, 2016), Spain (Hospido and Moreno-Galbis, 2016), and Germany (Bellman *et al.*, 2016). Those four countries account for some 60 percent of European Union (EU) GDP. These chapters focus in depth on labour market issues and each provides some novel firm- and workplace-level analysis. These country chapters are accompanied by valuable essays by Dan Andrews (2016) (discussing the U.K. and French chapters) and Tito Boeri (2016) (discussing the Spain and Germany chapters).

The distinguishing feature of the country chapters is that they explore the role of labour-market institutions, and to a lesser extent rising educational attainment, in explaining productivity movements. The editors argue for focusing on labour markets because they have “received limited attention in the productivity literature thus far”. The introduction states (Askenazy *et al.*, 2016: 24):

...the hoarding of skilled workers and the dramatic educational amelioration of the workforce, combined with labor market reforms and labor market policy reactions to the recession, constitute important hypotheses to explain a lesser adjustment of the aggregated workforce in the three largest European economies [Germany, the U.K., and France] during the Great

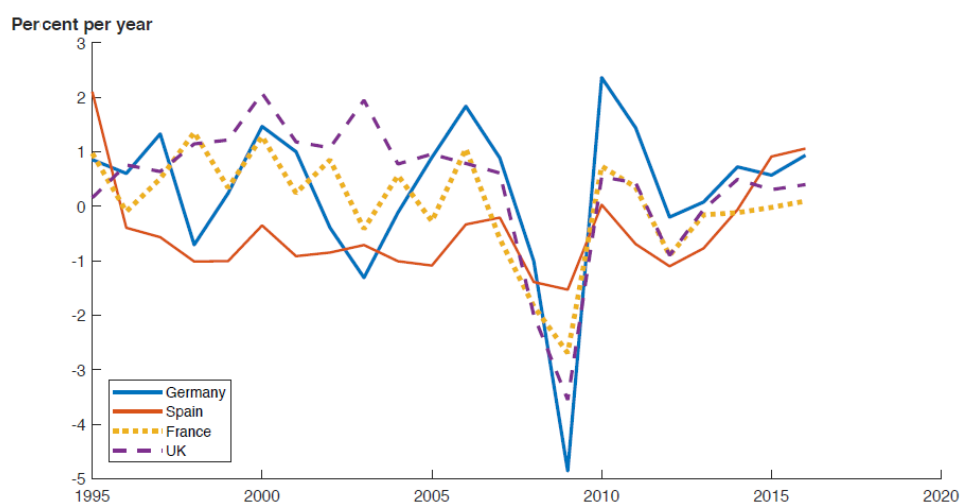
Recession and the apparent productivity slowdown.

My second main reaction to the book is that its labour-market focus — which emphasizes incentives to hoard labour — is primarily about the cyclical productivity dynamics in 2009 and 2010. The last line of the above quote suggests that the labour market issues that are discussed might also explain the persistent slowdown in growth. But to my reading, the country chapters provide little or no insight into the broader issues of that slowing productivity trend. It is confusing to the reader that the rhetoric of the editors, and some of the chapter authors, blurs the distinction between the cycle and the trend. Sometimes, there is an attempt to shoehorn these conceptually distinct issues together.

In particular, a large literature discusses why measures of productivity vary systematically over the business cycle. TFP is generally procyclical — rising in booms and falling in recessions. The conventional view of procyclical TFP is that it reflects procyclical factor utilization — arising from labour hoarding and variable capital utilization (see Fernald and Wang, 2016, for a review). Labour hoarding, of course, is the idea that, in a cyclical downturn, firms might hold onto workers to avoid losing valuable skills that they will need when the economy turns up again.

Given the book's focus on labour markets, the country chapters all focus extensively on incentives to hoard labour (or not) during the GFC. But firms do not hoard labour forever — labour hoarding is related to the business cycle, not the trend. That is, it is most naturally an explanation for negative TFP growth in 2009 and, though barely noted in the book, the cyclical rebound in TFP in 2010. If one wants to use labour hoarding to explain what is now close to a decade of weak productivity growth, one

Chart 2: TFP Growth in Germany, Spain, France and the U.K, 1995-2017



Source: Conference Board Total Economy Database.

needs to make a strong case that firms are hoarding labour for that long.

Chart 2 shows a plot that I wish had been in the book’s introduction. Using Conference Board data, and focusing on 1995-2017 period, it shows TFP growth for the four countries. Note that TFP growth in all of the countries fell in the depths of the GFC — mostly fairly sharply. On the flip side, TFP growth rebounded in 2010, with the rebound inversely proportional to the decline.

The TFP decline in 2009 and rebound in 2010 were sharpest in Germany. The Germany chapter (Bellman *et al.*, 2016) documents what margins of adjustment firms used in the GFC. For example, institutions in Germany (such as short-time work) encouraged use of the intensive margin (hours per worker, and perhaps effort per hour) rather than the extensive margin of hiring and firing. Economic conditions and business expectations also supported the intensive margin. For example, manufacturing surveys show that businesses thought the downturn would be temporary, so they had an incentive to hold onto workers they would want in the

recovery.

Spain, in contrast, saw the smallest TFP decline in 2009 and the smallest rebound in 2010. That is, TFP growth was only slightly procyclical. As the chapter highlights (Hospido and Moreno-Galbis, 2016: 253), firms disproportionately used the extensive margin of labour-input adjustment: “When the crisis began, firms disproportionately fired individuals with temporary contracts”. One reason for the large use of temporary contracts is that, relative to other countries, a high share of employment was seasonal (e.g., linked to summer tourism) or tied to particular contracts in the construction sector. In addition, “hours of work are not easily an adjustment variable in Spain because firms are, in general, covered by collective agreements at a sector level which ... specify hours of work” (Hospido and Moreno-Galbis, 2016: 254). As Tito Boeri (2016: 299) says in his comment on the Spain chapter, “the strong responsiveness of employment/unemployment to output changes in Spain is not so surprising.”

Interestingly, in terms of trend, Spain’s TFP growth was negative before the recession and for most of the period since. In

the chart, TFP growth only turned positive after the recovery gained traction in 2015 and 2016. Until then, there was little apparent pickup in TFP growth after the recession.

Of course, as the book notes, Spanish labour productivity (output per hour) did look quite different — it rose in 2009 and was relatively strong for the next few years. The book seems to consider that to be a puzzle. As a reader, I would have liked it if the Spain chapter had been clearer on the growth accounting. The literature on cyclical productivity points out that TFP is likely to be procyclical (because of cyclical factor utilization), but all the other cyclical forces affecting labour productivity are countercyclical. After all, capital per hour worked is strongly countercyclical; and in recessions, low-productivity workers disproportionately lose jobs. Both of these factors work to make labour productivity countercyclical — consistent with Spain's experience.

In particular, given the depths of Spain's recession, I would argue that it is no surprise at all that labour productivity rose in the recession. TFP was only weakly countercyclical because all the incentives were to adjust labour input through the extensive margin, not the intensive margin. And all the other forces push strongly for countercyclical labour productivity.

In Chart 2, the U.K. and France were intermediate in terms of the cyclical TFP decline in 2009. The chapter on France has many rich details (Askenazy and Erhel, 2016). Unfortunately, I had a hard time

figuring out how most of the details mattered for productivity dynamics. Still, one interesting detail was the rise in educational levels. Surprisingly, employment of workers with a tertiary education was completely acyclical in the Great Financial Crisis. This illustrates a more general point: As the introduction notes, tertiary employment in France, Germany, and the U.K. is uncorrelated with GDP growth. All of the cyclical adjustment in employment is done by workers with lower levels of education.

A feature I liked about the U.K. chapter is that it sought to explain the mechanisms through which labour hoarding makes TFP procyclical. (The chapter on France seems to just presume this link, which made the discussion less useful than it could have been.) Labour hoarding naturally makes employment less cyclical, so it mechanically makes output per **worker** move procyclically along with output. But if the intensive margin of hours per worker can adjust relatively flexibly, then the implications of labour hoarding for labour productivity (output per hour) and for TFP might be different.<sup>5</sup>

The key question is what the hoarded workers are doing. The U.K. chapter (Bryson and Forth, 2016) makes some effort to figure that out. For example, one thing that skilled workers might do is undertake innovation — a form of unmeasured intangible investment. The evidence is mixed, but there is little evidence that hoarding of labour raised the rate of innovation. I would have liked it if the chapters on France, Spain, and Germany

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<sup>5</sup> More formally, if the hoarded workers are pure overhead workers, then that is a form of increasing returns to scale; and increasing returns makes TFP move in the same direction as overall inputs (i.e., procyclically). Alternatively, labour hoarding can lead to mismeasurement of either inputs or outputs. On the input side, labour effort might be low when there is less work to do (see Basu, Fernald, and Kimball, 2006, for a model and empirical work that assumes this). On the output side, workers might shift to doing unmeasured tangible or intangible investments (painting the factory walls, for example, or developing new products.) If there are increasing returns, or if there is mismeasurement of inputs or outputs, then labour hoarding does push measured TFP to be procyclical.

had tried to provide similar evidence on what hoarded workers were doing.

In terms of policy, Boeri points out that we do not actually know much about the relative costs and benefits of using the extensive versus intensive margins of labour-market adjustment. We all tend to think that the limited cyclical fluctuation in employment in Germany is “better” than the large fluctuations in Spain. But as Boeri notes (2016: 296), there is limited evidence on the “welfare properties of different adjustment mechanisms”. For example, policies (such as work accounts) that are helpful in downturns might also interfere with needed reallocations of resources, which could be relevant for productivity trends.

### **Is Europe’s Recent Productivity Experience Really Puzzling?**

For the United States, the leading hypothesis is that the U.S. economy suffered a deep recession superimposed on a sharply slowing trend (e.g., Fernald, Hall, Stock, and Watson, 2017). In the U.S. context, it is quite clear that the productivity slowdown predated the GFC (Fernald, 2014).

Is Europe’s experience inconsistent with this same narrative? In particular, is anything inconsistent with the view that this was an unusually deep and long recession leading to a sizeable but temporary decline in factor utilization in many countries — that was superimposed on a sharply slowing productivity trend? The book, in combination with Charts 1 and 2, does not provide evidence against this view.

In particular, Chart 1 shows that the TFP trend has been slowing for a long time. And the Van Ark and Crafts chapters — the only ones that are primarily focused on the trend — do suggest that this interpretation is consistent with Europe. Certainly, there

are potential channels through which the recession could have made the trend worse, by reducing innovation or by pushing Europe further inside the “frontier.” The country chapters provide little new insight on these issues.<sup>6</sup>

### **Conclusion**

Boeri makes a comment about the Spain and Germany chapters that resonated with me in terms of both the strengths, and the weaknesses, of the book. He notes that those chapters provide “a large body of relevant institutional details, which are often missed by those researchers who are interested only in the so-called big picture...” (Boeri, 2016: 296). That comment applies more broadly to much of the book. The strength of the book is its discussion of labour market issues and adjustment mechanisms. But the weakness is that many of the chapters, including the introduction and conclusion, often lose sight of the big picture. As a result, the reader often struggles to understand the purpose of all the details.

In this regard, it is helpful to understand that Europe’s productivity trend has been slowing for a long time. It is also important to recognize that the main focus of the core of the book (the country chapters) is on cyclical adjustment during the depths of the GFC — where Europe’s experience is consistent with the standard paradigm of procyclical TFP.

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<sup>6</sup> Adler *et al.* (2017) do provide some evidence on this.

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# What's New About Capitalism?: A Review Article on *Capitalism without Capital: The Rise of the Intangible Economy*

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## ABSTRACT

I review Jonathan Haskel and Stian Westlake's recent book on intangible capital. It is an excellent introduction to and overview of the economics of intangibles. Using a combination of colorful examples and rigorous economic logic, it builds an interesting and useful reference for readers of many types, including academics, policymakers, and business people. While there is much left to be learned about the nature and role of intangible capital, this book will serve as a summary of what we know now as well as a roadmap for future explorations of the subject.

In their new book *Capitalism without Capital: The Rise of the Intangible Economy* (Princeton University Press, 2017), Jonathan Haskel from the Imperial College Business School and Stian Westlake from NESTA have written an excellent introduction to and overview of the extant economic thinking on intangible capital. Using numerous well-chosen, colorful examples that both appeal to a broad audience and explain by analogy, Haskel and Westlake demonstrate how intangible capital is becoming a highly important factor (in both the economically literal and figurative senses of that word) on the economy's supply side. The book draws out in notable detail how the growth of intangibles interacts with an impressive

array of economic phenomena. While not purely a work of formal scholarship, Haskel and Westlake's exposition remains true to rigorous economic logic and brings empirical evidence to bear whenever possible. As a result, the book is simultaneously able to inform academic economists, business people, policymakers, and curious non-experts.

The book begins with a vivid story about accounting. (Yes, that's right.) It compares the asset valuation process conducted prior to the 2013 sale of Stansted Airport to a valuation of Stansted village ordered almost a millennium earlier by William the Conqueror. While the valuations arrived at in the two surveys came to different final numbers (£1.5 billion vs. £11 —

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you can guess which one corresponds to which), Haskel and Westlake remark on the striking similarities between the processes: the assessors inventory assets, apply unit valuations to those assets, and sum the results to find what the place is worth. Haskel and Westlake's main point is that the biggest substantive difference in the two valuations processes is that the 11th Century valuation counted only tangible capital (a mill, livestock, slaves), while the modern valuation also included intangible capital (software, relationships with airlines and retailers, organizational know-how). The airport valuation was more than an academic exercise; it became associated with an actual transaction when the airport eventually sold — for £1.5 billion, it turns out. The eventual buyer appeared quite willing to pay for the airport's intangibles.

This comparison and contrast between the valuations is the starting point for the book's exposition of its argument about the growing importance of intangible capital in the modern economy. It bolsters and broadens its case by pointing to the high market-to-book valuations of modern companies and the fast-growing attention the academic literature is paying to intangibles. The bottom line of this accounting exercise: intangibles are here in force, still growing fast, and worthy of study.

## **How Intangible Capital Is Different**

Having documented the rise of intangibles, the authors assert a core thesis of the book: intangible capital is not just physical capital that is harder to see. It is fundamentally different. Haskel and Westlake sum up the differences as “The Four S's of Intangibles”: sunk, spillovers, scalable, synergies. What do these mean in detail? Investments in intangibles are by-and-large sunk costs. Resale markets for intangibles are not as nearly developed

as they are for tangible capital, and many intangibles are inherently harder to transfer for other reasons.

Intangibles create more spillovers than tangible capital because they tend to be much less excludable. It is easy to lock up a factory, but hard to lock up an idea (especially when intellectual property rights are weak).

Intangible capital tends to be more scalable; its marginal product declines very slowly in the breadth of its application. For example, a brand can be simultaneously extended over many products without necessarily losing its efficacy, while a machine can only make one thing at a time. (One might characterize this property along the dimension of rivalrousness, with intangibles being considerably less rivalrous than tangible capital, even within an organization.)

Intangible investments tend to exhibit synergies (complementarities) among themselves. The iPod wasn't the first MP3 player, but it was the first to combine that technology with Apple's design know-how and relationships with content producers, the key to making it a highly successful product. These four properties summarize the basic economic properties tied to intangibles.

## **The Rise of Intangible Capital**

After this introduction, Haskel and Westlake split their discussion and analysis of intangibles into two major parts. The first, accounting for about one third of the book, documents and analyzes multiple facets of the rise of intangible capital in the economy. The second offers analyses of how intangibles' rise has shaped various economic phenomena from productivity to inequality to finance and beyond.

Another vivid example sets the stage for the book's first major part. Here, the comparison spans 40 years rather

than a millennium, contrasting a typical gym in 2017 to one in 1977. In terms of physical capital, gyms are basically unchanged since 1977. What differentiates the modern version from its predecessor is intangible capital. The modern gym's membership rolls and scheduling information are on software. Its brand is likely to be more widely recognized and more carefully cultivated than a generation ago. Organizational practices, both codified and uncoded, govern employee practices in structured ways that would have been quite unusual in the industry several decades ago. Even more to the point, the book's prototypical modern gym offers its members a class called Bodypump. Bodypump is branded and administrated by Les Mills International, a completely separate company from the one that owns the gym. Les Mills International designs Bodypump classes' choreography and certifies instructors, but owns little space of its own and does not employ the instructors. Yet Bodypump classes are offered in thousands of gyms around the world by tens of thousands of instructors. Les Mills is able to achieve this while remaining a firm whose capital is almost completely intangible.

Data on aggregate tangible and intangible capital stocks over time and countries follows the gym example. The trend toward intangibility is clear, though the rate of the shift varies across countries.<sup>2</sup> The book briefly explores explanations for this growth, offering verdicts on each: reductions in intangible capital's relative price (if anything, this effect probably goes the wrong way), the growth of IT

(yes), the shift away from manufacturing and toward services (unclear), reductions in factor market regulations (yes — more flexible labour markets are associated with greater intangible investment), and openness to trade (yes, though the relationship is not particularly strong).

The first major part of the book concludes with an expanded discussion of the four S's of intangible capital. At this point in the exposition, all but the most skeptical of readers will be convinced that intangible capital has been increasingly taking a more important role in production at both the micro and macro levels. This conclusion sets the stage for book's second major set of analyses and the bulk of its pages: explanations of how the rise of intangibles has shaped a wide variety of economic realities.

## **Impacts of Intangible Capital**

### **Slower Investment and Productivity Growth**

The first such topic for discussion is one of the biggest, and likely of the most direct interest to readers of this journal, the slowdown in measured investment and productivity growth. The book summarizes these as "secular stagnation," which Haskel and Westlake define as a collection of four related facts: low investment despite low interest rates, weak productivity growth, high profits, and increasing variance of productivity and profits across producers. While this may not be the only definition of that oft-discussed phenomenon as of late, it is a reasonable one. The book examines intangibles' potential ties to each of these facts.

Low measured investment is seemingly

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<sup>2</sup> Of course, measuring intangible capital in the first place is inherently difficult, and in fact the book dedicates an entire chapter to that issue. In most of the empirical expositions, the book measures intangible capital similarly to the approach in the pioneering work of Corrado, Hulten and Sichel (2005). This uses a somewhat more expansive definition of intangibles than the U.S. Bureau of Economic Analysis more recently applied.

easy enough to explain given the shift in capital composition toward harder-to-measure intangibles. Measured investment would slow even if total investment (tangible plus intangible) grew at a constant rate. Interestingly, however, Haskel and Westlake show that while trying to correct for missing intangibles creates a level effect on measured investment, there is little in the way of a shift in trend. The composition change has been gradual enough to explain only a tiny fraction of the investment slowdown over the past decade or so. While clear enough *ex post*, this result did surprise me the first time through; Haskel and Westlake are offering an important result to what is known about the topic with this exposition.

The remaining discussion of intangible capital's possible effects on the secular stagnation facts is a tug-of-war between two of the S's: scalability and spillovers. Scalability tends to favor intangible investment. Its ability to create "right-tail" outcomes raises intangible investment's expected return. Spillovers, on the other hand, reflect the limited excludability of intangible investments and therefore reduce the returns from intangible investment.

One might conclude this leaves the issue utterly ambiguous, but the authors add one more element to their analysis: firm heterogeneity. Suppose firms are heterogeneous in their abilities to scale up intangible capital or their ability to benefit from the spillovers of other firms. This is plausible; decades of research have shown that firms exhibit remarkable heterogeneity along a number of dimensions even in narrowly defined markets. If such disparities exist, then even if the average effect on the incentive to do intangibles investment is zero, a segment of firms with some combination of high scalability and spillover appropriation would still stand to gain considerably from such investment. This

would explain the increase in variance of productivity and profits and the increasing average profit level, driven by the right tail.

While this hypothesis might seem a bit "just-so" in isolation, the book helps its case by showing (albeit only in a small sample of two sectors in each of nine countries) a strong correlation between a country-sector's share of investment accounted for by (measured) intangibles and the average change over 2001-07 in the spread between the top and bottom quartiles of labour productivity in the country-sector.

The final secular stagnation fact to address is the productivity growth slowdown that most developed economies have experienced over the past decade or so. Here, the book notes — in somewhat of an incongruity, given the tone in much of the rest of the book about the oncoming intangible tide — that the intangible investment rate has been falling over the past decade. Hence a slowdown in the growth of intangible capital stocks may be at least partly behind the productivity slowdown. (An intangible investment slowdown is of course not inconsistent with an economy becoming more intangible intensive, if the tangible investment rate fell more.)

Haskel and Westlake note there is indeed a strong positive correlation, at least for the small sample of countries with available data, between the growth of intangible capital services in an economy and its TFP growth. However, the book develops its argument on this point still further. Namely, it asserts that not only has intangible investment slowed, but the spillovers any average unit of intangibles confers may also be falling.

The primary reasoning behind this falling spillovers hypothesis is presented in an intriguing discussion about the contestability of intangible capital and how

this is related to firms' rent seeking and rent protection efforts. Rent seeking and preservation are topics of great speculation lately, both by themselves as well as through possible connections to the productivity slowdown. While the authors do not arrive at a definitive verdict on the issue, the discussion is a welcome addition to the conversation and well worth the pages dedicated to it.

While these arguments are not dispositive how large of an influence intangible capital might be having on the current investment and productivity growth slowdowns, the book makes an effective case that there is likely to be some connection. It certainly raises several potential connections for productivity researchers to probe and for policymakers to continue to monitor. This is one of its key contributions.

#### **Other Impacts of Intangible Capital**

The book's remaining chapters draw out connections between intangibles and inequality, infrastructure, corporate finance, and corporate management. Many of the topics therein are at least one step removed from productivity issues, but it is worth noting some of the closer connections.

One is a tie between inequality and the increase in firm-level performance dispersion discussed above. Song *et al.* (2015) demonstrated that firm effects account for a considerable share of the growth of employee earnings inequality. However, this firm-performance/worker-earnings correlation appears to be more about the sorting of workers of a particular earnings level than about rent-sharing by successful firms (although there is evidence that this occurs to some degree as well). A related, broader connection the book makes between intangibles and worker earnings is a variant on the classic skill-biased technology story. Here, it is tied to the complementarity between particular worker

skills and intangibles. This can also interact with intangibles' scalability properties, creating superstar-type effects that can lead to skewed earnings distributions.

Interactions between intangibles and management practices are also related to productivity, as management practices are currently one of the more active areas of research into sources of productivity differences across firms, industries, and economies. The authors devote most of a chapter to exploring how management should respond to the expansion and deepening of intangibles in firms. Again, complementarities take center stage, with the chapter's bottom line being that good management is more valuable in an intangible-laden corporate world.

Interestingly, though, the book draws out a contrast in the prescribed organizational structure for companies, depending on whether a firm is primarily a maker or user of intangibles. It argues that makers of intangibles benefit from flat organizational structures that offer mid-level managers a lot of autonomy and only loosely monitor short-term performance metrics. Essentially, the idea is to keep the proverbial creative juices flowing by allowing people and ideas freedom to flow through the company. On the other hand, companies that are heavy users of intangible capital see greater benefits from having more rigid, control-from-the-top organizational structures, because the name of the game is coordinating the firm's efforts to apply its intangible assets to the uses that offer the greatest return at the moment.

The chapter also offers its take on one of the still unresolved questions in the productivity and management literature — namely, whether it is simply management practices, or also managers, that make a difference. The book comes down squarely on the side of the latter when it comes to intangibles. Haskel and Westlake argue

that people and personalities matter because taking advantage of intangibles' scalability and complementarities requires individuals who can effectively motivate loyalty and effort from their employees.

The book closes with a discussion of policy questions raised by the rise of intangibles. Perhaps the deepest and most novel involves whether significant modifications to property rights institutions are necessary to maximize the social return to intangible capital. By its nature this discussion is quite speculative, but it is very thought provoking.

*Capitalism without Capital* is a comprehensive look at the growing importance of intangible capital in the economy. It is a can't-miss volume for anyone interested in the topic. Readers of the *International Productivity Monitor* in particular will appreciate the many overlaps intangibles have with productivity-related

issues, in both the cross section and over time, and at the micro and macro levels. As comprehensive in breadth as the book is, however, it can only mine the shallow deposits of intangible "ore." Digging into deeper veins will be the work of researchers guided by this book. This work will not be easy; by their nature, data on intangibles is still sparse. However, this only raises the expected return to collecting and analyzing such data. Let's get to work.

## References

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