March 2017

The Canadian Productivity Stagnation, 2002-2014*

Juan Carlos Conesa
Stony Brook University

Pau S. Pujolas
McMaster University

ABSTRACT_____
Total Factor Productivity's (TFP) growth during the 2002-2014 period in Canada has been only 0.16%. This figure is substantially smaller than that of the U.S. during the same period (1.33%), or for Canada during the 1970-2002 period (1.45%). We perform multiple counterfactual exercises to show that the lack of TFP growth cannot be accounted for by measurement issues in, nor misallocation of, factors of production. However, despite the lack of TFP growth Canada has experienced sustained income growth because on a prolonged period of appreciation of the terms of trade. In fact, computing TFP using real Gross Domestic Income (instead of real GDP) reveals a very similar performance in terms of productivity growth between Canada and the U.S., with productivity growth falling in 2002-2014 relative to 1970-2002 in both economies.
_____

1. Introduction

Canada's total factor productivity (TFP) growth between 1970 and 2002 was 1.45% per year. This number is lower than, but similar to, that of the United States during the same period, 1.55%. During the 12 years that followed, between 2002 and 2014, Canada's TFP grew by a dismal 0.16% per year while that of the United States grew by 1.33%.[1] We refer to this phenomenon as the Canadian Productivity Stagnation. Lack of TFP growth constitutes a puzzle, as documented in various studies — see Kehoe and Prescott (2002) and Costa et *al.* (2016a,b), among many —: In the long run GDP per working age person in developed economies grows at around 2% per year, and this growth is entirely driven by TFP growth.[2]

After establishing that Canada had negligible growth of TFP during 2002-2014, we analyze whether this lack of productivity growth can be accounted for by several issues regarding the measurement of factors of production, or by how factors of production are allocated. Within the set of possibilities that we explore, we do not find any support for this hypothesis. However, we show that during the Canadian Productivity Stagnation, Canadian terms of trade greatly appreciated, while U.S. terms of trade slightly depreciated — and the terms of trade are not reflected in the measurement of GDP (see Kehoe and Ruhl, 2008). Hence, real Canadian income grew more than real Canadian output (and the opposite is true for the U.S.). Using real Gross Domestic Income (GDI) growth instead of real GDP growth captures the increase in income. We perform the same growth accounting exercise using GDI instead of GDP and find that during 2002-2014 Canadian TFP-GDI growth is 0.95% per year, whereas this number is 1.13% in the U.S. (compared to 1.71% and 1.61% for Canada and the U.S. respectively in 1970-2002). Hence, using GDI instead of GDP greatly narrows the difference in performance between the two countries, and points to a reduction in productivity growth in both countries relative to the past.

Our growth accounting decomposition exercise is based on the work of Cole and Ohanian (2002) and Kehoe and Prescott (2002) to study Great Depressions. It has been used to study Great Depression episodes in many countries, including Canada between 1929-1939 (Amaral and MacGee, 2002), business cycles (Chari, Kehoe and McGrattan, 2007), fiscal policy (Conesa,

---

[1] Our findings are in line with those of the Groningen Growth and Development Center. In their analysis, they control for labor quality and different types of capital, and find that TFP in Canada grows even less than what we find.
[2] Without claiming causality, there are many examples of countries that end up suffering severe recessions after decades of no TFP growth. During the 1980's and 1990's, see the examples of Argentina (Kydland and Zarazaga, 2003), Brazil (Bugarin et *al.*, 2002), and Mexico (Bergoeing et *al.*, 2002), or Spain in 1990-2014 (Conesa and Kehoe, 2016; Diaz and Franjo, 2016; and Moral-Benito et *al.*, 2016).

Kehoe and Ruhl, 2007), and development (Bosworth and Collins, 2008). We are by no means the first ones to perform a growth accounting exercise of the Canadian economy. On top of the aforementioned Amaral and MacGee (2002) for the Great Depression, Cociuba and Ueberfeldt (2008) apply the methodology of Chari, Kehoe and McGrattan (2002) to the analysis of the Canadian business cycles. Our analysis differs from previous work along two elements: first, we document the Canadian stagnation in productivity growth during 2002-2014; second, we analyze the robustness of this result to several measurement and compositional issues.

Our paper is also related to the literature that analyses the relationship between TFP and changes in the terms of trade. We find that the period of high appreciation of terms of trade in Canada is unrelated to increases in Canadian TFP, a result that is in line with the theoretical findings of Kehoe and Ruhl (2008). In contrast, De Soyres (2016) shows that the two can be connected by the amount of profits that firms make. We leave the exploration between the two for the case of Canada for future work.

The battery of exercises we perform to understand the impact of measurement issues on TFP growth is split into four blocks: how capital is constructed, how labor is constructed, how the production function is used, and whether we should use output or income. First, we look at the construction of the series of capital. We begin by looking at how capital depreciates in Canada. As Diewert (2005) points out, consumption of fixed capital in the National Accounts of Canada (driven by the different types of investments done) is larger than in the U.S., which implies that the depreciation of Canadian capital is larger. Diewert (2005) calculates the depreciation rate of the economy using micro data on many different industries from Statistics Canada. In contrast, we use aggregate data on investment and consumption of fixed capital. Still, we reach the same conclusion: the depreciation of Canadian capital (7.54%) is higher than in the U.S. (6.77%). Using the depreciation rate of the U.S. to measure Canadian TFP has little impact on solving the puzzle, though: TFP grows by 0.18% per year during the 2002-2014 instead of 0.16%.

We next explore the implications for the measurement of capital of its composition between construction and other types of investment. Diaz and Franjo (2016) argue that the lack of TFP growth in Spain can be accounted for by the increase of investment in construction. For the case of Canada, investment in construction represents 55.56% of total investment in 2002, increasing to 69.22% in 2014. We construct a counterfactual series of GDP and capital leaving investment in construction out of the series, and perform the growth accounting exercise again. We find that

2

under this scenario TFP falls by -0.10% per year during 2002-2014, with most of the fall happening between 2002 and 2009, with an average fall of 0.99% per year, and growth at 1.16% afterwards. Performing the same exercise for the period 1970-2002 implies a TFP growth of 1.34% in Canada, while the figures for the U.S. are 1.45% for the period 1970-2002 and 1.47% for 2002-2014.

In the second block of counterfactual exercises we look at the construction of the series of labor. Between 2002 and 2014, females' participation rate in the labor market increases, they earn less than males, and the difference in earnings narrows. Since females earn less than males and their labor participation increases, we ask whether the lack of TFP growth is caused by this compositional change in the labor force. We find that this is not the case: if the participation rate of females (relative to that of males) had stayed at its 2002 level, TFP growth would have been only 0.17%, instead of 0.16%. If the gender wage gap had remained constant at their 2002 level (instead of shrinking) and hours worked by females evolved the way they did, we would have had a TFP growth of -0.03% per year.

A similar analysis can be done by looking at the industry composition of the labor market. There is a lot of heterogeneity across industries in terms of the wage they pay, how much labor they employ, and the evolution of these variables between 2002 and 2014. We find that if relative wages had stayed constant at their 2002 levels, TFP would have fallen by -0.36% per year. If, instead, relative employment across sectors had stayed constant at their 2002 levels, TFP would have also fallen, in this case by -0.02% per year. This exercise points out that the allocation of labor across industries, on average, went from low paying jobs to high paying jobs, and that industries that grew most were the ones that were paying higher wages. There is growing literature understanding misallocation of capital or labor across individual firms in developing economies, in the spirit of Hsieh and Klenow (2009), Restuccia and Rogerson (2008, 2013) and others. We do not explore this option here, but we conjecture that this feature cannot be that important quantitatively for the case of Canada.

In the third block we look at the specification of the production function. We start by looking at a crucial term in the Cobb-Douglas production function: the parameter that governs the fraction of total output that is devoted to paying for labor, typically called the labor share. Most developed economies build the National Accounts dividing the economy in three different sectors: the household sector, the government sector, and the corporate sector. In the latter two, total compensation of employees accurately reflects payments to the labor force. For the household

sector, instead, most of the income generated by small unincorporated businesses directly goes to mixed income, even though a large fraction might be the compensation of the labor services provided by the business owner (and often family members). Hence, when computing the labor share of an economy a common practice suggests to exclude the household sector of both GDP and compensation of employees, and use the rest of the economy to compute the labor share (see Conesa et *al.*, 2007, for a detailed explanation). Unfortunately, the Canadian National Accounts are built without properly distinguishing these three sectors. Due to this, the labor share we use in our benchmark exercise is the one for the U.S., which is 0.65. We show that using alternative labor shares — around the values found in Gollin (2002) — does not change the main result: with a labor share of 0.6, TFP growth is 0.00% during 2002-2014 (1.21% in the U.S.), and with a labor share of 0.75, TFP growth is 0.52% (1.60% in the U.S.).

It is worth pointing out that we do not explore alternative specifications of the production function. In particular, we abstract from the growing literature on changes in the labor share. See Karabarbounis and Neiman (2013), Koh et al (2016), or Autor et al (2017). We believe that the time period we analyze is short enough so that the long run trend in labor income shares should not matter much.

Next, we perform a growth accounting exercise at the sectoral level. We find that two of the sectors, *manufacturing* and *mining and oil and gas extraction*, are i) very large (at least they account for 25% of total employment and GDP in Canada), ii) have negative TFP growth (-0.78% for manufacturing and -2.70% in mining and oil and gas extraction), iii) in the U.S. they have a positive TFP growth (3.74% and 6.33%), and iv) they are sectors heavily exposed to international trade (at least 71% of Canadian trade occurs in these two sectors, and at least 65% in the U.S.). This exercise shows that the differences in TFP growth between the two economies are largely driven by a handful sectors that are highly exposed to international trade.

This last finding brings us to the fourth (and last) block of counterfactual exercises, where we are concerned with whether we should use a measure of output or a measure of income for our analysis. The standard growth accounting practice is done using real GDP. The use of GDP reflects the productive ability of an economy, which is tightly linked to its purchasing ability. However, in periods of large movements in the terms of trade, real GDP can move differently than real Gross Domestic Income (GDI). The terms of trade are not incorporated in the measurement of real GDP, but they are incorporated in the measurement of real GDI (see Kehoe and Ruhl,

2008). During the period of the Canadian Productivity Stagnation, Canada had a large appreciation of the terms of trade (1.44% per year) while the U.S. had a mild depreciation (0.16% per year). In our last exercise we redo the growth accounting exercise for the Canadian and the U.S. economy using real GDI instead of real GDP. The measure that we obtain, which we call GDI-TFP, experiences growth of 0.95% per year in Canada during the 2002-2014 period (substantially larger than the 0.16%) and by 1.13% in the U.S. (slightly smaller than 1.33%). Also, with this metric productivity growth in both Canada and the U.S. is substantially smaller than in the 1970-2002 period (1.71% for Canada and 1.61% for the U.S.).

2. Measuring total factor productivity

In this section we show how to measure TFP, closely following Conesa et *al.* (2007) and report the results of the growth accounting exercise for Canada and the United States. The exercise consists of attributing all the growth in GDP per wap to a capital, a labor, and a TFP component. First, suppose the production function of the economy is given by the following Cobb-Douglas production function

$$Y_t = K_t^\alpha (E_t L_t)^{1-\alpha},$$

(1)

where Y_t is a measure of income/output (GDP in our benchmark measurement), K_t is the capital stock, L_t is the total amount of labor in the economy, E_t is the total factor productivity,[3] and α is the capital share in the economy. Then, GDP per working age population, Y_t / N_t, can be expressed as

$$\frac{Y_t}{N_t} = \underbrace{E_t}_{\text{TFP factor}} \underbrace{\left(\frac{K_t}{Y_t}\right)^{\frac{\alpha}{1-\alpha}}}_{\text{Capital intensity}} \underbrace{\frac{L_t}{N_t}}_{\text{Labor intensity}},$$

(2)

which implies that the series of output per working age population is accounted for by the combination of the evolution of the TFP factor, the capital intensity factor, and the labor intensity factor. Notice that in a balanced growth path the intensity in the use of capital and labor should

---

[3] This formulation is equivalent to $Y_t = A_t K_t^\alpha L_t^{1-\alpha}$, where $E_t = A_t^{1/(1-\alpha)}$. Often people refer to E_t as labor efficiency, while they reserve the term TFP for A_t. For consistency, we choose the formulation in expression (1) since it comes more natural when we later (Section 4) decompose E_t in terms of the efficiency of different type of workers.

be constant, and the TFP factor drives entirely the evolution of output. In what follows, we show how to construct a series for all the objects in (2) using the National Accounts and labor survey data.

2.1. Construction of the series

In order to measure TFP for Canada and the United States we need measures on GDP, labor, working age population, and capital.

We start with GDP. We use series on gross domestic product at current and at constant prices for GDP, from the OECD for both Canada and the United States. Then, we compute the GDP deflator taking the ratio between the two, with base year prices in the year 1970. The series of GDP at 1970 prices is our series of Y_t.

We compute the amount of labor, L_t, multiplying the series of the number of workers in each period by the average hours worked. The series of working age population, N_t, is given the series on working age population 15-65. The data is also reported by OECD.

We compute the series for capital using data on gross capital formation and consumption of fixed capital at current prices. We deflate both series by the GDP deflator. The series on deflated gross capital formation is our measure of investment, I_t. Then, we assume that capital is formed using the perpetual inventory method,

$$K_{t+1} = (1-\delta)K_t + I_t, \tag{3}$$

where δ is the depreciation rate of capital. We choose the value for this parameter to match the average value of the ratio of consumption of fixed capital to GDP in the data,[4]

$$\frac{1}{34}\sum_{t=1981}^{2014} \frac{\text{Cons of fixed capital}_t}{GDP_t} = \frac{1}{10}\sum_{t=1971}^{1980} \frac{\delta K_t}{Y_t}, \tag{4}$$

and assume that the first capital stock is such that the capital-ouput ratio is the same as the average for the first 10 years of the series

---

[4] Ideally we would like to match the average consumption of fixed capital to GDP in the data going back to 1970. Unfortunately, consumption of fixed capital is only available after 1981.

$$\frac{K_{1970}}{Y_{1970}} = \sum_{t=1971}^{1980} \frac{K_t}{Y_t}. \tag{5}$$

We find that the depreciation rate for Canada is 7.54% and the depreciation rate in the U.S. is 6.77%.

Finally, we are left with the computation of the capital share parameter, α. The national accounts divide all the economy in three sectors: households, corporate and government. While it is clear that salaries paid by the corporate and the government sector to employees is labor compensation, it is less clear that the same object in the household sector coincides with labor compensation. The household sector includes small firms operated by the business owners and may not include all payments to labor in compensation of employees. To avoid this problem and to get a proper estimate of the capital share, we would like to compute the following object

$$\alpha = 1 - \sum_{t=1970}^{2014} \frac{\text{Compensation Employees}_t - \text{HH C.E.}_t}{GDP_t - \text{HH C.E.}_t - \text{HH Mixed Income}_t - \text{Ind Tax}}, \tag{6}$$

where the series of Compensation Employees consists of all payments to employees in the economy, HH C.E. is the payments to employees done by the household sector, HH Mixed Income is the payment from the household sector to other factors — including capital, but also labor — and Ind Tax consists of Indirect Taxes. This number can easily be computed for the United States: 0.35. However, Canadian National Accounts feature the following curiosity: all payments to employees are attributed to the household sector. This would imply that the numerator in the right term of equation (6) expression is always 0. Given that, we use the same parameter for the capital share in Canada as in the United States. We perform robustness exercises and the results do not change.

2.2. Results

As is well-known, from the series for the United States, in Figure 1, the pattern that emerges consists of a growth rate of GDP per working age population mostly driven by the growth rate of TFP, with the labor per working age population and the capital-output ratio components being very stable.

The picture that emerges for Canada, in Figure 2, is similar, but it has a key difference: between 2002 and 2014, the series for TFP is (almost) flat.
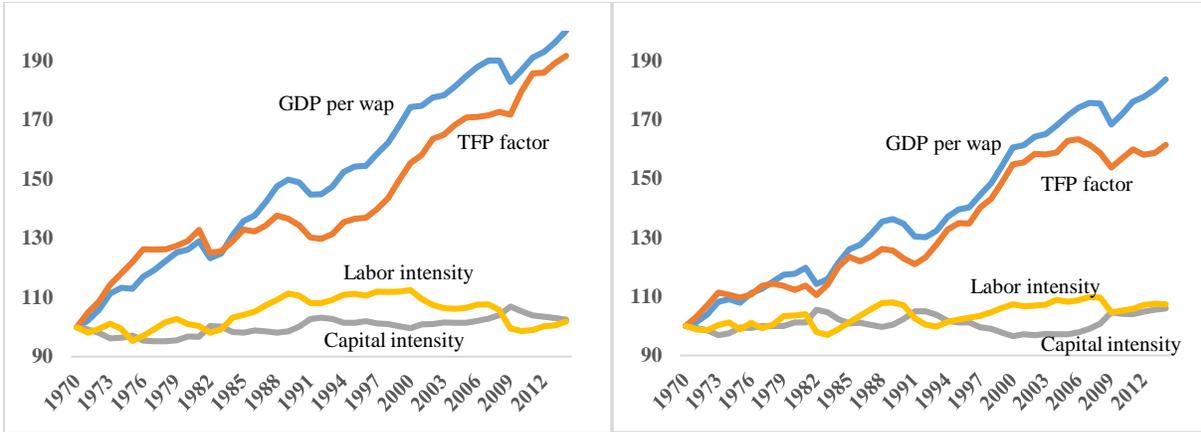
Figure 1 (left): Growth Accounting Decomposition for the United States, 1970-2014

Figure 2 (right): Growth Accounting Decomposition for Canada, 1970-2014

An alternative way to see the difference between the series consists of computing the annualized growth rate for the periods of 1970-2002 for the four series and the two economies, and repeating the computation for the period 2002-2014. We show the results in Table 1.

	United States		Canada	
	1970-2002	2002-2014	1970-2002	2002-2014
GDP per wap	1.81%	1.00%	1.56%	0.94%
TFP factor	1.55%	1.33%	1.45%	0.16%
Capital intensity	0.03%	0.12%	-0.10%	0.74%
Labor intensity	0.22%	-0.44%	0.21%	0.04%

Table 1: Annualized growth rates

During the period 2002-2014 GDP growth is very similar in the U.S. and in Canada, but TFP growth differs dramatically. TFP in the U.S. grew at an annualized rate of 1.33%, while Canadian TFP grew much less, at only 0.16%. In contrast, factor intensity grew more in Canada than in the United States, and that is why GDP growth is similar across the two economies. This difference is not present in the period 1970-2002, and that is why we will look at compositional and measurement issues that might have artificially generate this different patterns in 2002-2014.

If the lack of TFP growth were robust, it might point to potential concerns for future growth in Canada, since growth through factor accumulation is by definition finite.

3. Aggregate measurement of capital

In this section we perform a robustness check on the measurement of capital, and find that the results on productivity stagnation remain.

3.1. Depreciation of capital

A common concern about how to measure capital in the Canadian economy is posed by Diewert (2005), since Canada depreciates a larger stock of its capital than the United States. Indeed, in our baseline case, the depreciation rate for Canada is 7.54%, while the depreciation rate for the United States is 6.77%. This concern is very important since it affects the measurement of capital and hence the measurement of TFP. Furthermore, the calibrated delta has an impact on the calibrated capital level of the initial period; in the benchmark case this ratio is only 2.08 in Canada, while in the United States it is 2.25. However, from the perspective of this paper we can solve the problem posed by a large depreciation rate by simply imputing the same depreciation rate to the two economies. When we compute the change in TFP of the Canadian economy for the period 2002-2014 using the depreciation rate of the United States, we get that the ratio of initial capital stock to GDP is 2.20, very similar to the one in the United States. Still, under this alternative scenario we measure that the TFP component grows at 0.18%, instead of 0.16% in the baseline case.

3.2. Investment in buildings and dwellings

According to Diaz and Franjo (2016) the lack of TFP growth in Spain during the 1990-2014 period can be accounted for by the rise in the share of investment in buildings and dwellings. The Canadian economy is similar to the Spanish economy in that it also had a tremendous increase in the fraction of total investment devoted to buildings and dwellings during the period 2002-2014: it went from 55.56% of total investment at the beginning of the period to 69.22% at the end of it. In order to determine the impact of this feature of investment data for our measurement of TFP we subtract all investment in buildings and dwellings from the series of investment and GDP, and repeat the growth accounting exercise.

We find that instead of 12 years of roughly flat TFP, the series splits into 7 years of pronounced negative growth (-0.99%) followed by 5 years of positive growth (1.16%) for a combined effect of a fall of 0.10% per year during 2002-2014. Hence, investment in buildings and

dwellings cannot account for the lack of TFP growth in Canada, but it changes the overall picture: instead of a Productivity Stagnation that lasted twelve years, we find a severe fall in TFP for a shorter time period.

Repeating the same exercise for previous periods does not have major effects on the growth rates we report in Section 2. In the case of the U.S. during 2002-2014, the growth rate would have been 1.34% (instead of 1.33%). During 1970-2002, Canada would have grown at 1.45% (exactly the same we got including buildings and dwellings) and the U.S. would have been 1.47% (instead of 1.55%).

4. Measurement of labor

When we measure labor, the exercise consists of counting how many bodies are working, and multiply that number by the average amount of hours worked. One concern that we may have, though, is that different bodies are different levels of productivity. If the composition of labor changes over time, with some types of labor growing at the expense of others, then the resulting aggregate TFP growth may be affected.

Consider the labor and total factor productivity term in brackets of equation (1), $E_t L_t$. Suppose that different labor units have different efficiencies, namely that E_t is a vector of efficiencies, and L_t is a vector of bodies/hours working with those efficiencies, and then $E_t L_t = \sum_{i \in N_t} e_{it} \ell_{it}$. Then, the decomposition equivalent to equation (2) becomes

$$\frac{Y_t}{N_t} = \frac{\sum_{i \in N_t} e_{it} \ell_{it}}{L_t} \left(\frac{K_t}{Y_t} \right)^{\frac{\alpha}{1-\alpha}} \frac{L_t}{N_t} \tag{7}$$

Expression (8) points to potential effects of compositional changes for the lack of productivity growth in Canada. If the composition of aggregate employment is shifting towards less productive individuals, then the aggregate efficiency of labor might be growing less than in the absence of those compositional changes.

We use employment data and wage data in order to perform counterfactuals that determine if the efficiency of labor is not growing because of compositional changes. The underlying assumption in our exercise is that efficiency of some type of workers, $e_{i,t}$, is well captured by the

wage data of that type of worker. We perform counterfactuals quantifying the role of increasing female participation in the labor force, as well as different sectoral composition of employment in the economy.

We do not explore the implications of skill composition of the labor force,[5] and we do not explore potential misallocation of resources across firms with heterogeneous productivity. See Restuccia and Rogerson (2013) for an excellent survey of the growing misallocation literature.

4.1. Gender wage gap and female labor force participation

An important difference between different types of workers is that of gender. Canadian females have been earning between 72% and 87% of what their male counterparts earned during the 1981-2014 period, females active in the labor force represented between 68% and 90% of males active in the labor force, and females have worked between 79% and 84% of the hours worked by their male counterparts. See Figure 3 for the evolution of these three gaps. With this information, we construct the series for

$$\sum_{i \in N_t} e_{it} \ell_{it} = M_t \text{Av.H.Worked-Male}_t + F_t \text{Av.H.Worked-Female}_t GAP_t \tag{8}$$

where the first term consists of the number of males working times the amount of hours worked by them on average, and the second is the female counterpart, where GAP_t is the relative wage of females with respect to males. We can perform two interesting counterfactual exercises: what would have been the evolution of Canadian TFP if the gender wage gap remained constant to their 2002 level throughout the period analyzed; and what would have been the evolution of Canadian TFP if female's participation rate and hours worked stayed constant to their 2002 level throughout the period.

---

[5] Lack of data prevents us from performing a skill decomposition exercise, because the public version of the Survey of Labour and Income Dynamics (SLID) of the Bank of Canada, which contains information on wages by education level, does not allow to perform longitudinal analysis. However, it is very unlikely that the educational level of the labor force can explain the lack of TFP growth in Canada: between 2002 and 2014 there has been a 50% increase in workers with above bachelor and bachelor education, a 20% increase in workers with post-secondary education, and either a roughly constant or a fall in workers with some post-secondary, high-school, some high-school and 0-8 years of education.
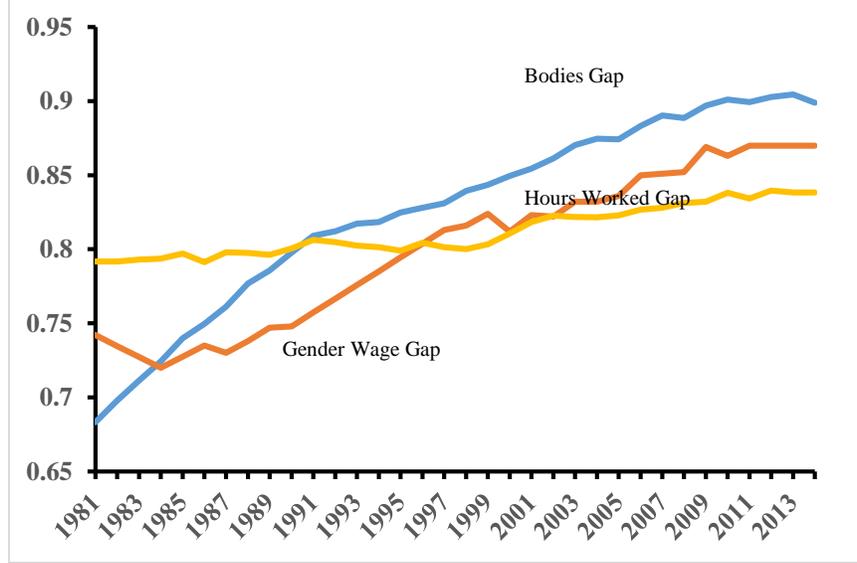
Figure 3: Gender gaps in Canada, 1981-2014.

If the gender wage gap had remained at its 2002 level, but female participation rate was the one observed, TFP would have been

$$TFP_t' = TFP_t \frac{\sum\limits_{i \in N_t} e_{i2002} \ell_{it}}{\sum\limits_{i \in N_t} e_{it} \ell_{it}} \quad . \tag{9}$$

The series of TFP_t' from equation (9) has negative growth, equal to -0.02% per year during the 2002-2014, compared to the growth of 0.10% in the baseline case. The fall of these series has a clear explanation: the gender wage gap narrowing between 2002 and 2014, in our framework, is equivalent to having females increasing their productivity. If they were as productive as in 2002, overall productivity would have fallen more than it actually did.

Similarly, we can compute what would have been TFP, had the labor participation decisions remained constant to those of 2002, but the gender wage gap changed as it did. In this case,

$$TFP_t'' = TFP_t \frac{\sum\limits_{i \in N_t} e_{it} \ell_{i2002}}{\sum\limits_{i \in N_t} e_{it} \ell_{it}} \frac{L_t}{L_{2002}} \quad . \tag{10}$$

The series for TFP_t'' from equation (10) increases, but only at 0.11% per year. Since throughout the period females are less productive than males, and there is an increase in the female

12

participation rate, that means that there was a relative increase of less efficient workers (at least as measured by wage data). However, this effect is very small and it cannot account for the lack of TFP growth for the entire period.

4.2 Sectoral composition of labor

Next, we investigate the relationship between the sectoral composition of labor and the lack of TFP growth. The analysis that follows is similar to the one in the section before, but using data on the 19 different sectors of the economy.

There is heterogeneity in the volume of employment per industry — Trade is the largest sector, with over 2.000.000 workers, and Forestry, Logging and Support is the smallest, with less than 100.000 — as well as in wages — Accommodation and food services pay 22.6% of what Utilities pay in 2002. Using information by sector, we compute effective hours worked, $\sum_{i \in N_t} e_{it} \ell_{it}$, where N_t is the set of industries, e_{it} is computed using the wage of sector i, deflated using the GDP deflator, and ℓ_{it} is the number of workers in sector i — Canadian data does not include hours worked in each sector, only the body count of workers.

In the first exercise we make use of the formulation of equation (9), keeping relative wages constant and changing the relative employment in each sector. In this counterfactual case, TFP would have had a negative growth rate of -0.23% per year. The reason for this fall — compared to the growth of 0.10% in the baseline case — is the same as in the case of lower growth when the gender wage gap stays constant: the sum of efficiency increases, weighted by the employment level in each sector, is positive, i.e.

$$\frac{TFP_{2014}'}{TFP_{2001}'} < \frac{TFP_{2014}}{TFP_{2001}} \Leftrightarrow \frac{\sum_{i \in N_t} e_{i2000} \ell_{i2014}}{\sum_{i \in N_t} e_{i2014} \ell_{i2014}} < \frac{\sum_{i \in N_t} e_{i2000} \ell_{i2000}}{\sum_{i \in N_t} e_{i2000} \ell_{i2000}} \Leftrightarrow \sum_{i \in N_t} \left(e_{i2014} - e_{i2000} \right) \ell_{i2014} > 0 \ . \quad (11)$$

Similarly, in the second exercise we make use of the formulation of equation (10), keeping relative employment in each sector constant and changing the relative wages in each sector. In this counterfactual exercise, the series for TFP falls by -0.01% per year. Notice that this result is exactly the opposite of what we found in the case of the gender wage gap. In fact, and similar to the case where wages are fixed, this number being smaller than 0.10% implies that the sum of labor increases, weighted by the efficiency level in each sector, is positive, i.e.

$$\frac{TFP_{2014}"}{TFP_{2000}"} < \frac{TFP_{2014}}{TFP_{2000}} \Leftrightarrow \sum_{i \in N_t} e_{i2014}\left(\frac{\ell_{i2014}}{L_{2014}} - \frac{\ell_{i2000}}{L_{2000}}\right) > 0 \; . \qquad (12)$$

These two results imply that the reallocation of labor and the relative increases in efficiency during the last 14 years in Canada have been in the direction of increasing productivity, referred to as productivity-enhancing structural transformation by McMillan and Rodrik (2011).

5. Measurement of the production function

When we measure TFP, we need to assume a certain specification of the production function. We follow the convention in most growth accounting exercises and use the Cobb-Douglas specification. There is an increasing literature regarding the long run decrease of the labor share that naturally departs from that framework. The simplicity of the Cobb-Douglas specification is that it relies on obtaining one parameter, the capital share. The first exercise we perform consists of investigating the role that this parameter plays further. The second exercise consists of measuring sectoral TFPs by performing a growth accounting exercise at the industry level.

5.1 Capital share

When we computed the capital share in the economy, equation (6), we stated that due to the strange compilation of the household sector in National Accounts data in Canada, the capital share was borrowed from the United States. The number we have used in our baseline analysis is 0.35, slightly larger than the 1/3 measured in Gollin (2002).

To perform this robustness analysis, we compute the increase in TFP during the 2002-2014 period in Canada if the capital share was different. If the capital share were equal to 0.25, TFP would have grown at 0.52% (in the U.S. this figure would be 1.60%). If the capital share were 0.40, TFP would have experience 0.00% growth (in the U.S. this figure would be 1.21%).

5.2 Multiple sectors

We next turn to measuring a series for TFP for each sector in the economy for both the U.S. and Canada, to determine where the difference in aggregate TFP might come from. We use investment by each sector, and split it between investment and repair. Then, we compute a sector-specific depreciation rate in order to i) capture the significant differences in repair investment across sectors, and ii) match the aggregate depreciation rate from the benchmark exercise. We use

information on payments to labor by sector in order to get a sector-specific capital share (See Table A.1 in the Appendix for the sector specific factor shares and depreciation rates). Proceeding as we did for the aggregate economy, we compute the series of TFP for each sector (see Figures A.1 and A.2 in the Appendix for the evolution of sectoral TFPs).

Our analysis shows that there are two sectors that stand out: *mining and oil and gas extraction* and *manufacturing*. During our period of interest, the first one generates on average 8.5% of Canadian GDP, has 18.8% of Canadian capital, and employs 13.1% of Canadian labor; for the second one, the equivalent figures are 12.6% of GDP, 18.2% of capital and 11.9% of labor. The first sector's TFP factor falls at -2.70% per year during the 2002-2014, and manufacturing TFP falls at -0.78% per year. By comparison, in the U.S. these figures are positive growth of 6.33% and 3.74% respectively. Given their size and the substantially different evolutions of TFP in these two sectors between Canada and the U.S., it is clear that a big part of the difference in the overall evolution of productivity is tightly linked to these two sectors.

There is one dimension in which these two sectors are very similar: they are very important in the foreign sector. In Canada, the combined share of exports in these two categories as a percentage of overall exports is 71%. In the U.S. this number is 65%. Hence, this exercise points toward the direction that, perhaps, the foreign sector contains an answer to the Canadian Productivity Stagnation puzzle. We dig further into this question in the next section.

6. Income, Output, and the terms of trade

In this section we want to emphasize a big difference between Canada and the U.S. during the 2002-2014 period: their terms of trade had a substantially different evolution. Figure 4 shows that Canada's relative price of imports over exports falls by 1.44% per year between 2002 and 2014, whereas the number in the U.S. increases by 0.16% per year (the units are normalized to 1 in 2007).
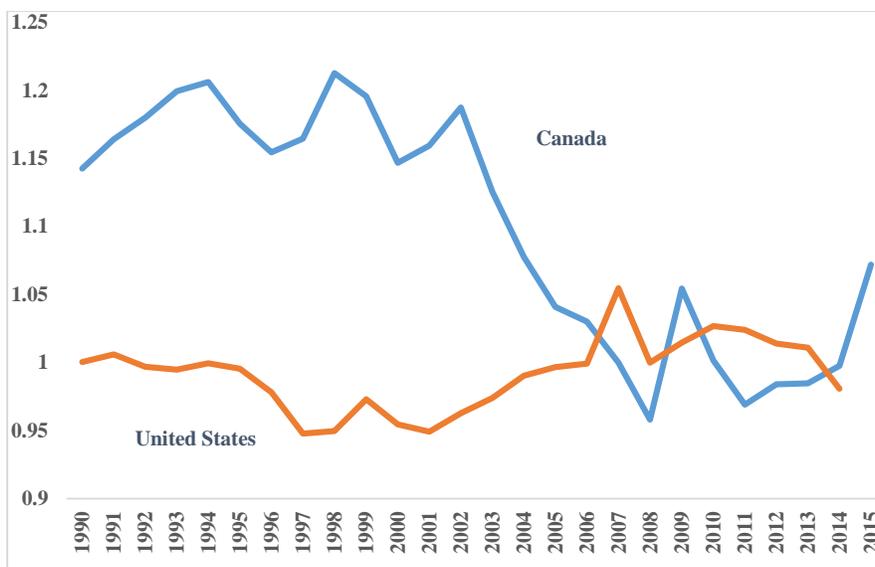
**Figure 4: Terms of trade in Canada and U.S. 1990-2014.**

A fall in the price of imports implies that domestic goods become relatively more expensive and foreign goods become relatively cheaper. That means that the country does not need to produce as much in order to enjoy a larger amount of goods. This point is key to differentiate output from income. When the terms of trade are stable, the two objects are the same. However, in periods of a prolonged appreciation or depreciation of the terms of trade, real measures of output differ from real measures of income.

Take, for instance, Canada in the picture. For the period 2002-2014, if Canadian output and exports were kept constant, Canadian citizens could have enjoyed an additional 1.44% of foreign goods every year. Hence, even though the ability to produce goods would not change (output), the ability to purchase goods would have been growing (income).

In the national accounts, the first object is referred to as real GDP, whereas the second object is real Gross Domestic Income (GDI). By construction, in nominal terms they are the same, perhaps with some statistical discrepancy. However, in real terms, the difference between the two has to do with the price index used to deflate the foreign sector. In the case of real GDP, each category (private consumption, investment, public consumption, exports and imports) is deflated by its own price index. In the case of real GDI, however, both exports and imports are deflated using the same price index — in the cases of Canada and the U.S the chosen price index is the import price index. Other countries use the export price index or a combined index of the two that reflects the value of domestic absorption (exports minus imports). As shown by Kehoe and Ruhl

16

(2008), changes in the terms of trade do not induce first order changes on real GDP. If exports become more expensive than imports, nominal GDP increases because the value of a component that adds to nominal GDP increases; however, in this scenario, real GDP does not change because the larger increase in the price of exports is entirely captured by its price index, which is different from the price of imports. Changes in the terms of trade, however, have an effect on real GDI: when exports become more expensive than imports, real GDI increases because exports are deflated by the price of imports, and the deflator does not capture the price increase.[6] For more details on the difference between real GDI and real GDP, we refer the reader to section 7 of Kehoe and Ruhl (2008).

The exercise we perform consists of reproducing the growth accounting exercise but using GDI instead of GDP, in order to get how differently the incomes of both countries changed during the period. We refer to the TFP equivalent measure as GDI-TFP, in this case. Figures 5 and 6 contain the growth accounting decomposition for the U.S. and Canada for the period using GDI instead of GDP.[7]
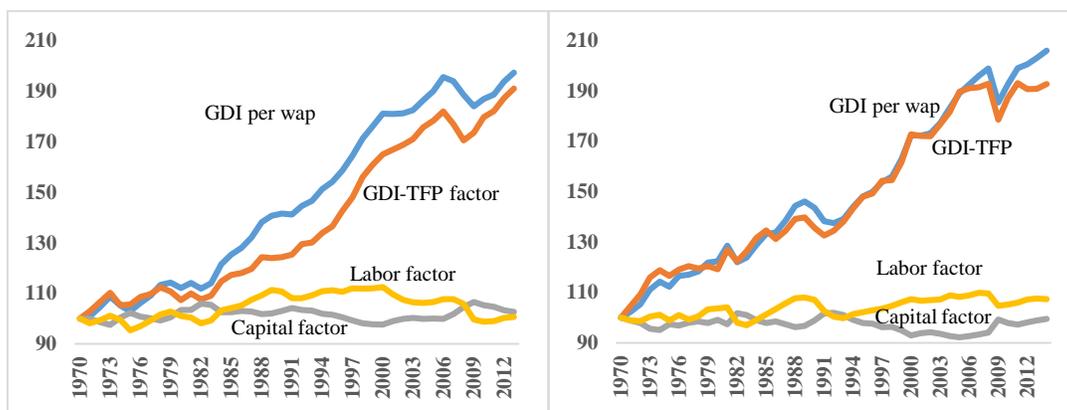
Figure 5 (left): GDI-Growth Accounting Decomposition for the United States, 1970-2014

Figure 6 (right): GDI-Growth Accounting Decomposition for Canada, 1970-2014

We find that the growth in GDI-TFP is 0.95% per year in Canada during the 2002-2014 period (substantially larger than the 0.16%) and by 1.13% in the U.S. (slightly smaller than 1.33%).

---

[6] The same logic follows when the price index is that of exports: The price deflator increases, the component of exports on real GDI is unchanged, but the value of imports, which are also deflated by the price index of exports, shrinks. Since imports subtract from GDI, the latter increases. Using the domestic absorption price index has the same effect because it is a combination of the two price indices.

[7] See figure A.3 in the Appendix for a comparison of GDI-TFP of the U.S. and Canada for 1970-2014.

Also, with this metric productivity growth in both Canada and the U.S. is substantially smaller than in the 1970-2002 period (1.71% for Canada and 1.61% for the U.S.). Notice that the differences in productivity growth between Canada and the U.S. are very small, both in the recent period, but also in the past.

7. Conclusion

We document the puzzling observation that TFP growth has been only 0.16% per year in Canada for the period 2002-14, in contrast with robust growth in the U.S. for the same time period and in the past experience of Canada.

We argue that this feature is not driven by compositional effects related to the measurement of factors of production. When we further disaggregate our analysis at the sectoral level, we notice that the differential productivity growth is almost entirely driven by two sectors: *manufacturing* and *mining and oil and gas extraction*.

These two sectors comprise a large fraction of existing trade, both in Canada and in the U.S. Based on that, we look at the differential evolution of the terms of trade, and find that dismal productivity growth coincides in time with a substantial appreciation in Canadian terms of trade. In periods of a prolonged appreciation or depreciation of the terms of trade, real measures of output differ from real measures of income (see Kehoe and Ruhl, 2008). We construct a counterfactual measure of productivity by using data on real income instead of real output, and show that with this alternative measure productivity growth for Canada is very similar to that of the U.S. (both recently and in the past as well).

Our analysis is limited since it only looks at a subset of the potential sources of mismeasurement and misallocation that could be considered. Part of it is due to data availability, and we do abstract of other potential sources of misallocation of resources at a more disaggregated level. See Hsieh and Klenow (2009) and Restuccia and Rogerson (2008, 2013) for a growing literature that considers misallocation of resources across firms that differ in their productivity. We conjecture that this type of misallocation might be quantitatively more relevant for developing economies than for the case of Canada, and that the sources of this potential misallocation might not change so much across time periods in Canada as the terms of trade did.

References

Amaral, P. and J.C. MacGee (2002), "The Great Depression in Canada and the United States: A Neoclassical Analysis," *Review of Economic Dynamics*, 5(1), 45–72.

Autor, D., Dorn, D., Katz, L. F., Patterson, C., and Van Reenen, J. (2017), "Concentrating on the Fall of the Labor Share," National Bureau of Economic Research wp 23108.

Bergoeing, R., P.J. Kehoe, T.J. Kehoe and R. Soto (2002), "A Decade Lost and Found: Mexico and Chile in the 1980s," *Review of Economic Dynamics*, 5(1), 166–205.

Bosworth, B. and S.M. Collins (2008), "Accounting for Growth: Comparing China and India," *Journal of Economic Perspectives*, 22(1), 45–66.

Buarin, M.S., R. Ellery Jr., V. Gomes and A. Teixeira (2002), "The Brazilian Depression in the 1980s and 1990s," Computing in Economics and in Finance series, 338.

Chari, V.V., P.J. Kehoe and E.R. McGrattan (2007), "Business Cycle Accounting," *Econometrica*, 75(3), 781–836.

Cociuba, S. and A. Ueberfeldt (2008): "Driving Forces of the Canadian Economy: An Accounting Exercise," Bank of Canada Staff Working Paper 2008-14.

Cole, H.L. and L.E. Ohanian (2002), "The U.S. and U.K. Great Depressions though the Lens of Neoclassical Growth Theory," *American Economic Review*, 92(2), 28–32.

Conesa, J.C., T.J. Kehoe and K.J. Ruhl (2007), "Modeling Great Depressions: The Depression in Finland in the 1990s," *Federal Reserve Bank of Minneapolis Quarterly Review*, 31(1), 16–44.

Conesa, J.C. and T.J. Kehoe (2016), "Productivity, Taxes and Hours Worked in Spain: 1970-2014," mimeo.

Costa, D., T.J. Kehoe and G. Raveendranathan (2016a), "The Stages of Economic Growth Revisited, Part 1: A General Framework and Taking Off into Growth," *Economic Policy Paper*, Federal Reserve Bank of Minneapolis, 16(5).

Costa, D., T.J. Kehoe and G. Raveendranathan (2016b), "The Stages of Economic Growth Revisited, Part 2: Catching Up to and Joining the Economic Leader," *Economic Policy Paper*, Federal Reserva Bank of Minneapolis, 16(6).

Diaz, A. and L. Franjo (2016), "Capital Goods, Measured TFP and Growth: The Case of Spain," *European Economic Review*, 83, 19–39.

Diewert, W.E. (2005), "Issues in the Measurement of Capital Services, Depreciation, Asset Price Changes, and Interest Rates," NBER Working Paper 479–556.

Gollin, D. (2002), "Getting the Income Shares Right," *Journal of Political Economy*, 110(2), 458–474.

Hsieh, C. T., and Klenow, P. J. (2009), "Misallocation and manufacturing TFP in China and India," *The Quarterly Journal of Economics* 124(4), 1403-1448.

Karabarbounis, L. and B. Neiman (2014), "The global decline of the labor share." *The Quarterly Journal of Economics* 129.1, 61-103.

Kehoe, T.J. and E.C. Prescott (2002), "Great Depressions of the Twentieth Century," *Review of Economic Dynamics*, 5(1), 1–18.

Kehoe, T.J. and K. J. Ruhl (2008), "Are shocks to the terms of trade shocks to productivity?." *Review of Economic Dynamics*, *11*(4), 804-819.

Koh, D., R. Santaeulalia-Llopis, and Y. Zheng (2016), "Labor share decline and intellectual property products capital," mimeo.

Kydland, F.E. and C.E.J.M. Zarazaga (2003), "Argentina's Lost Decade and the Subsequent Recovery Puzzle," Center for Latin America Working Papers, Federal Reserve Bank of Dallas Working paper no.0403.

Moral-Benito, E., M.J. Garcia-Santana, J. Pijoan-Mas, and R. Ramos (2016), "Growing Like Spain: 1995-2007," CEPR Working Paper 11144.

Restuccia, D. and R. Rogerson (2008), "Policy distortions and aggregate productivity with heterogeneous establishments," *Review of Economic Dynamics* 11(4), 707-720.

Restuccia, D. and R. Rogerson (2013), "Misallocation and productivity," *Review of Economic Dynamics* 16(1), 1-10.

Appendix

Table A.1 has all the computed labor shares by industry.

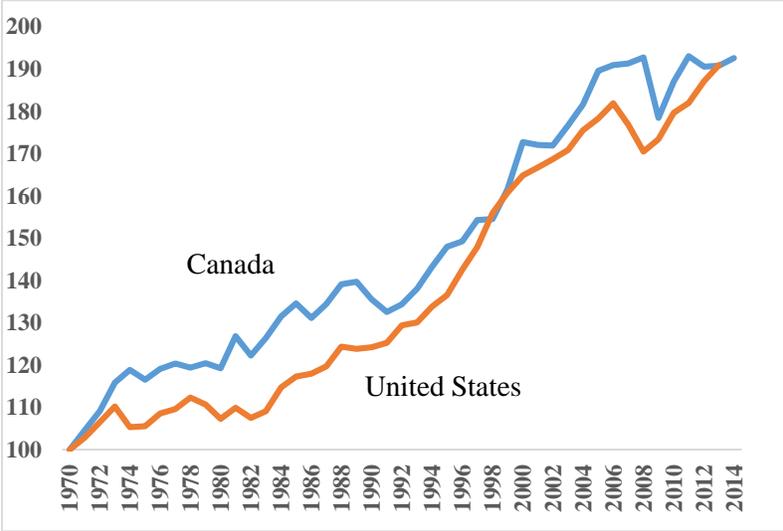| Sector	Labor share	Depreciation rate
Agriculture, forestry, fishing and hunting	0.713093	0.100329
Mining and oil and gas extraction	0.757911	0.0655815
Utilities	0.725885	0.0742349
Construction	0.357464	0.0882383
Manufacturing	0.468768	0.0849815
Wholesale and retail trade	0.459617	0.0693078
Transportation and warehousing	0.371787	0.0674871
Information and cultural industries	0.607247	0.0931426
Finance and insurance	0.430929	0.0631249
Real estate and rental and leasing	0.9404	0.0585438
Professional, scientific and technical services	0.603305	0.0638743
Management of companies and enterprises	0.15195	0.0626876
Admin. and sup., waste manag. and rem. services	0.271026	0.0812066
Educational services	0.887525	0.0827709
Health care and social assistance	0.175205	0.0750604
Arts, entertainment and recreation	0.425303	0.0756487
Accommodation and food services	0.376163	0.0721747

Table A.1: Labor shares by industry

Figures A.1 and A.2 show the evolution of measured TFP by sector for the U.S. and Canada. The thick, green line is the evolution of manufacturing TFP and the thick, grey line is the evolution of mining and oil and gas extraction TFP. All the series are normalized so that in 2002 the sector's TFP is 100.
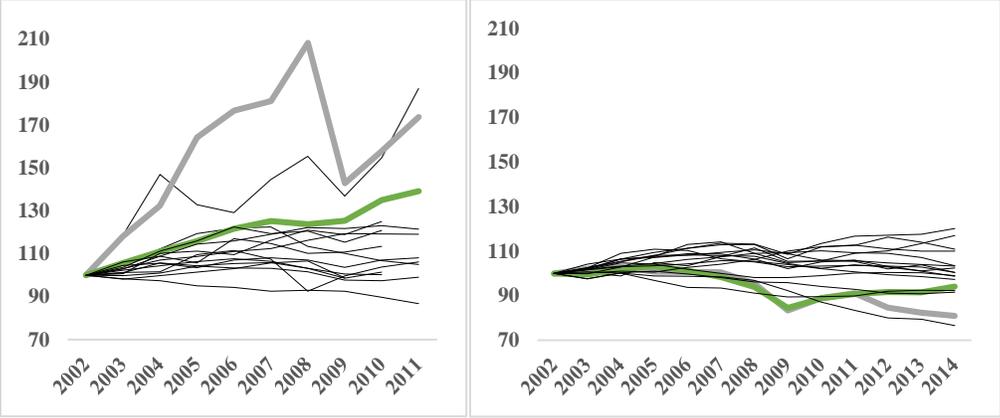
Figure A.1 (left): Sectoral evolution of TFP for the U.S. 2000- 2014

Figure A.2 (right): Sectoral evolution of TFP for Canada 2000- 2014

Figure A.3: GDI-TFP, Canada and U.S.