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The Canadian Productivity Stagnation, 2002-2014*

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ABSTRACT

Total Factor Productivity (TFP) growth in Canada between 2002 and 2014 has been only 0.16% per year. This figure is substantially smaller than that of the U.S., or that of Canada in the past. We perform multiple counterfactual exercises to show that this small TFP growth cannot be accounted for by several compositional effects and/or mismeasurements of factors of production. We identify two key sectors (mostly Mining, and to a lesser extent Manufacturing) that drive all of the TFP growth difference with the U.S. Despite the lack of TFP growth, Canada has experienced sustained income growth due to a prolonged period of appreciation of the terms of trade (while terms of trade in the U.S. have deteriorated), making real income in the two countries grow at similar rates.

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1. Introduction

Since the early 1990's, but more prominently since the beginning of the XXI century, many countries — including Canada and the U.S. — have experienced a reduction in Total Factor Productivity (TFP) growth, in what is commonly referred to as the global productivity slowdown (see Fernald 2015; Cette et *al.* 2016). Lack of TFP growth constitutes a puzzle: In the long run, GDP per working age person grows at around 2% per year in the leading developed economies, and this growth is driven by TFP growth (see Kehoe and Prescott, 2002; and Costa et *al.*, 2016a,b; among many). Between 2002 and 2014, instead, Canadian TFP has been stagnant: It grew by a dismal 0.16% per year (compared to 1.08% in the U.S.).[1] In contrast, Canada's TFP grew by 1.45% per year in the period 1970-2002 (1.65% in the U.S.). We refer to this phenomenon as the Canadian Productivity Stagnation and, after a battery of robustness checks, we conclude that the lack of TFP growth is not driven by composition effects or mismeasurement of inputs, but is driven by the relatively bad performance of some key sectors: Mining and Manufacturing.

The battery of exercises that we perform is meant to capture whether measurement and compositional effects are behind the lack of TFP growth. To this end, we build counterfactual series of capital and labor, and re-compute TFP with each new series. None of the exercises is able to explain the lack of TFP growth in Canada relative to the U.S. 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 is higher than in the U.S. Using the depreciation rate of the U.S. to measure Canadian TFP barely changes the figure for TFP growth during the Canadian Productivity Stagnation, though.

Another concern that we have has to do with the cost of investment: Whenever we are deflating the series of investment, we have in mind a one sector model, and hence we use the GDP deflator for all of the GDP components. However, the evolution of the investment costs in the two countries may be different, so we construct a new series of capital deflating investment by its own deflator. We cannot link lack of TFP growth to a slower decrease in the relative price of investment goods in Canada relative to the U.S.

[1] These 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. Our numbers for TFP growth in the U.S. are even larger than those found by Basu et *al.* (2006), who control for labor quality and capital utilization.

We next explore the role that the composition of investment has on the series of capital. Diaz and Franjo (2016) argue that the lack of TFP growth in Spain can be accounted for by increased investment in the construction sector. In Canada residential investment is growing as a share of total investment. However, abstracting from residential investment we still find that TFP falls substantially, while the same exercise in the U.S. barely impacts its TFP growth.

We then turn our attention to potential compositional issues in the measurement of labor. Between 2002 and 2014, females' participation rate in the labor market increased but females still earned less than males (even though the difference in earnings narrowed). We ask whether the increased participation of females in the labor force can explain the lack of TFP growth, by a composition effect, and we find it cannot. The same applies when we look at the sectoral composition of the labor force: The reallocation of labor across industries, on average, went from low paying jobs to high paying jobs, and the industries that grew most were the ones that were paying higher wages. So negative sorting across sectors cannot explain lack of TFP growth.

Next, we turn to the specification of the production function. We start by analyzing whether the labor share parameter in the production function affects our results. We show that using alternative labor shares — around the values found in Gollin (2002), roughly 0.66 — does not change the result of large differences in TFP growth rates between the U.S. and Canada: either with a labor share of 0.6 or 0.75, the difference in TFP growth rates between the two countries is still over 1 percentage point per year.

Finally, we perform the growth accounting exercise at the sectoral level. We construct series of capital that are sector specific (with a depreciation rate in each sector), and measure sectoral TFP growth using sector-deflated GDP, and sector-specific labor shares. We find that the relatively bad performance of TFP growth in Mining, and to a lesser extent Manufacturing, accounts for the lower TFP growth in Canada relative to the U.S. When we look at the evolution of prices, we find that the correlation between the growth rate of sectoral TFP and the growth rate of the sectoral price deflator is highly negative, -0.73 (and -0.76 in the U.S.). We then ask whether this result can also be extrapolated to the aggregate. If the productivity of one country grows less than the other, the relative price of that country should increase, and vice versa. During the Canadian Productivity Stagnation, Canadian terms of trade appreciated at 1.44% per year, and U.S. terms of trade deteriorated at 0.52% per year. In periods of large movements in the terms of trade, real GDP is not a good measure of the purchasing ability of an economy. To measure the latter, a better metric is real Gross Domestic Income (GDI), which takes into account the effect of terms of trade changes (Kehoe and Ruhl, 2008). We find that Canadian real income grows by 0.95%, much closer to the number for the U.S. economy during that period, 1.13%. While our results suggest that productivity growth affects the evolution of the terms of trade, there is ongoing research trying to disentangle the exact relationship between the two (see Kehoe and Ruhl, 2008; De Soyres, 2016; Costa, 2017).

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 et *al*. 2007), fiscal policy (Conesa et *al.* 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 et *al*. (2007) to the analysis of the Canadian business cycles. Our analysis differs from previous work along two dimensions: First, we document that Canada had stagnant productivity growth during 2002-2014; second, we analyze the robustness of this result to several measurement and compositional issues.

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 U.S. The exercise consists of attributing all the growth in GDP per working age person to a capital, a labor, and a TFP component. Suppose the production function takes the commonly used Cobb-Douglas form:

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

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 factor,[2]

[2] 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 types of workers.

and α is the capital share in the economy. Then, GDP per working age person, Y_t / N_t, can be expressed as:

$$\frac{Y_t}{N_t} = \underbrace{E_t}_{\text{TFP factor}} \underbrace{\left(\frac{K_t}{Y_t}\right)^{\frac{\alpha}{1-\alpha}}}_{\text{Capital intensity}} \underbrace{\frac{L_t}{N_t}}_{\text{Labor intensity}} , \tag{2}$$

which implies that the series of output per working age person is accounted for by the product 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 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 U.S. we need measures of GDP, labor, working age population, and capital. We start with output, Y_t. We use the series of GDP at constant prices as our measure of output, found at the OECD for both Canada and the U.S. Then, we compute the GDP deflator taking the ratio between GDP at current prices and GDP at constant prices, with base year prices in the year 1970.

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 of population in ages 15-65. The data is also reported by the OECD.

We compute the series for capital using data on gross capital formation and consumption of fixed capital at current prices. We deflate the series of gross capital formation by the GDP deflator to obtain our measure of gross investment, I_t (measured in units of output). Then, we assume that capital is built 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,[3]

3 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.

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

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

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

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 as 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. We compute this way the capital income share as an average for the U.S.: 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 expression (6) is always 0. Given that, we use the same parameter for the capital share in Canada as in the U.S. We perform robustness exercises in Section 5.1 and the conclusions do not change.

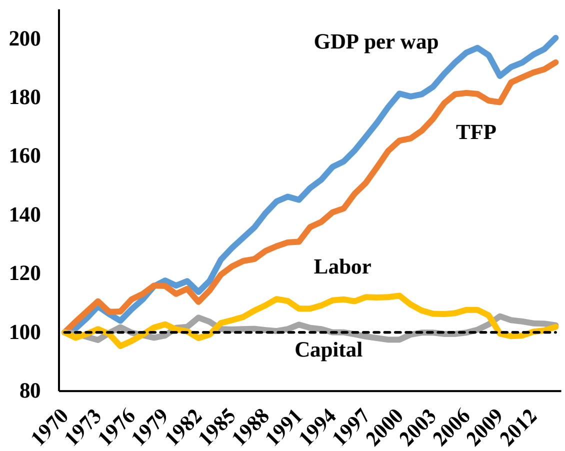
2.2. Results

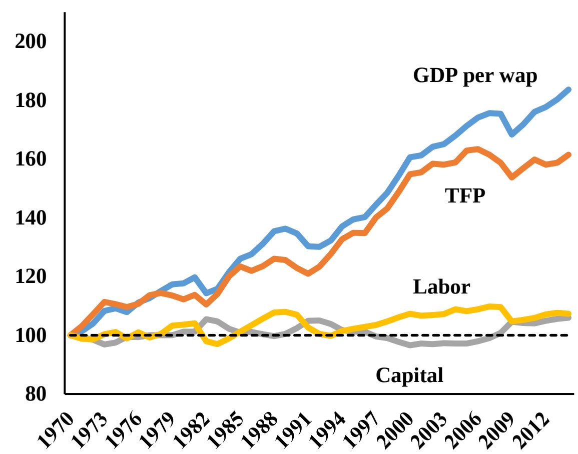
It is well-known from the U.S. experience, see Figure 1, that the growth of GDP per working age person is mostly driven by the growth of TFP, while labor per working age person and the capital-output ratio components are quite stable.

The picture that emerges for Canada in Figure 2 is similar, except for 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.

Table 1: Annualized growth rates

	United States		Canada	
	1970-2002	2002-2014	1970-2002	2002-2014
GDP per wap	1.87%	0.85%	1.56%	0.94%
TFP factor	1.65%	1.08%	1.45%	0.16%
Capital intensity	0.00%	0.21%	-0.10%	0.74%
Labor intensity	0.22%	-0.44%	0.21%	0.04%

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 1.08%, 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 generated these different patterns in 2002-2014.

First, we want to establish that the Canadian productivity stagnation started in 2002. Moreover, since the Great Recession happens to be around the middle of the time period we look at, it is important that we get a sense of how productivity grew before and after the Great Recession. We find that Canadian TFP grew at the same pace as U.S. TFP (2.14% and 2.15% respectively) for the period spanning from 1990 to 2002. Moreover, during the period 2002-2007, right before the Great Recession, Canadian TFP grew below that of the U.S. (0.39% vs. 1.45%), and in the period that immediately followed the difference became even larger (-0.01% vs 0.83%). Thus, we conclude that the Canadian productivity stagnation is genuine and that, even though it started before the Great Recession, after that period it became more severe.

Now we turn to the issue of whether mismeasurement of inputs accounts for the lack of measured TFP growth. The kind of mismeasurement we focus on arises because of compositional changes. This could be the case because new inputs that are incorporated into the economy are less productive per se than previously existing inputs (i.e. the workers or capital that are added to the production process are different — and less productive — than the ones already employed), or because these entering inputs are the same than those already employed but are allocated to less productive activities.

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 U.S.. Indeed, in our baseline case, the depreciation rate for Canada is 7.54%, while the depreciation rate for the U.S. is 6.77%. This concern is very important since the depreciation rate affects the measurement of capital and hence the measurement of TFP. Furthermore, the calibrated depreciation rate has an impact on the calibrated level of capital in the initial period. In the benchmark case this ratio is only 2.08 in Canada, while in the U.S. it is 2.25. When we compute the change in TFP of the Canadian economy for the period 2002-2014 using the depreciation rate of the U.S. as a counterfactual, we get that the ratio of initial capital stock to GDP is 2.20, very similar to the one in the U.S. Still, under this counterfactual scenario we measure that the TFP component grows at 0.18%, instead of 0.16% in the baseline case.

This exercise is silent about the potential reasons why the depreciation rate is higher in Canada than in the U.S. In Section 5 we perform an analysis of the evolution of TFP for different sectors of the economy and as part of that exercise we will measure different depreciation rates across sectors in Canada.

3.2.Investment cost of capital

When we construct the benchmark series of capital we deflate the series of investment using the GDP deflator. In that way, investment goods becoming cheaper relative to consumption goods shows up in our accounting exercise as an increase in TFP. We want to determine whether the differences in measured TFP come from differences in the evolution of the relative price of investment goods. In order to do so we construct an alternative measure of capital using investment series deflated by the country specific investment deflator. We find that in this case, TFP in Canada falls at -0.24% per year during the Canadian Productivity Stagnation, and TFP in the U.S. grows at 0.99% per year.[4] This result suggests that, in fact, the cost of capital evolved differently than that of the overall economy, making the difference in productivity growth even larger.

Alternatively, when we compute the capital series of Canada using the U.S. investment deflator, and re-compute TFP, we again find that TFP in Canada grows less than in the benchmark accounting exercise (only by 0.05%).

3.3.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

[4] Here we are abusing notation by referring to TFP as the residual factor productivity growth once the decrease in the price of investment goods has already been accounted for.

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.

In the case of the U.S. during 2002-2014, the growth rate of TFP in this counterfactual would have been 1.34% (instead of 1.08%). In contrast, 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 grown by 1.47% per year (instead of 1.55%).

We thus conclude that the composition of investment (in terms of the size of residential investment) cannot account for the differences in measured TFP growth. Now we turn to the potential implications of composition effects in the measurement of the other production factor, labor.

4. Measurement of labor

When we measure labor in our benchmark accounting, we count how many people are working, and multiply that number by the average amount of hours worked. One concern that we may have, though, is that different people have 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 (7) 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.

Because of lack of data we do not perform a skill decomposition exercise. 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, is not suited for a 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.[5] Moreover, the Conference Board, which measures Total Factor Productivity using, among others, labor quality finds that Canadian TFP during the period of analysis grew at -2%, whereas the U.S. grew at 0.3% per year. Hence, we think it is very unlikely that the lack of productivity growth during the Canadian Productivity Stagnation can be due to the skill composition of the labor force.

4.1. Gender wage gap and female labor force participation

The data shows that Canadian female employment and hours worked have been growing relative to those of males. In addition, females get paid less than males, even though the gap has been

[5] See CANSIM Table 282-0004.

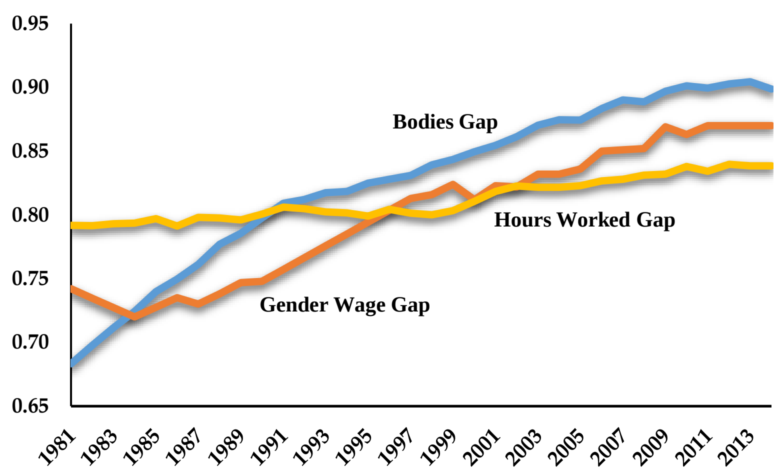
narrowing over time. See Figure 3 for the evolution of these three gaps for Canada. We now explore whether this compositional change can account for the differences in TFP growth.

With this information, we construct the series for efficiency units of labor actually worked as:

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

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 perform two 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.

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

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

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 0.16% in the baseline case (in the U.S., this figure is 1.54%, see Table 2). 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,

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

The series for TFP_t'' from equation (10) increases, but only at 0.30% per year (in the U.S., this figure is 1.82%, see Table 2). Since throughout the period females are less productive than males, and there is an increase in the female 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.

Alternatively, we can perform an alternative measurement of TFP, but this time computing it with "effective male" units, where the new series for labor — not efficiency units of labor used — is measured using the following formula

$$L_t^* = M_t H_t^M + GAP_t F_t H_t^f , \tag{11}$$

and then, the counterfactual TFP is measured as

$$TFP_t''' = TFP_t \left(\frac{L_t}{L_t^*} \right)^{1-\alpha} . \tag{12}$$

The series for TFP_t''' from equation (12) increases, but only at 0.13% per year (in the U.S., this figure is 1.15%, see Table 2). Since throughout the period, the number of "male" units increase as the gender wage gap narrows, the resulting figure is smaller than that of actual TFP. Again, this measurement cannot account for the lack of TFP growth for the entire period.

Table 2: Counterfactual growth rates of TFP with gender wage gap.

	United States		Canada	
	1981-2002	2002-2014	1981-2002	2002-2014
TFP factor	1.76%	1.08%	1.52%	0.16%
TFP’	0.93%	1.54%	1.38%	-0.02%
TFP’’	1.12%	1.82%	1.60%	0.30%
TFP’’’	1.64%	1.15%	1.34%	0.13%

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 20 different sectors of the economy.[6] There is substantial heterogeneity in the volume of employment and in wages across sectors. Manufacturing is the largest sector, with over 2,000,000 workers, and Utilities is the smallest, with around 100,000. Regarding wages, accommodation and food services pay around 20% of what Utilities and Mining, quarrying, and oil and gas extraction pay.

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. Unfortunately, the data does not include hours worked in each sector, only the body count of workers. In what follows we explain the exercises, which replicate the ones that we did for the labor wage gap but for different sectors, and all the results are reported in Table 3.

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 -0.73% per year for Canada, compared to -0.39% for the U.S. The reason for this fall — compared to the growth of 0.16% in the baseline case — is the

[6] These sectors are Agriculture, forestry, fishing and hunting, Mining, quarrying, and oil and gas extraction, Utilities, Construction, Manufacturing, Wholesale trade, Retail trade, Transportation and warehousing, Information and cultural industries, Finance and insurance, Holding companies, Real estate and rental and leasing, Professional, scientific and technical services, Administrative and support, waste management, Educational services, Health care and social assistance, Arts, entertainment and recreation, Accommodation and food services, Other services (except public administration), and Public administration. In the U.S. data, Holding companies does not appear, and there is Management of companies and enterprises, instead.

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.

$$\frac{TFP_{2014}'}{TFP_{2001}'} < \frac{TFP_{2014}}{TFP_{2001}} \Leftrightarrow \frac{\sum_{i \in N_t} e_{i2000} \ell_{i2014}}{\sum_{i \in N_t} e_{i2014} \ell_{i2014}} < \frac{\sum_{i \in N_t} e_{i2000} \ell_{i2000}}{\sum_{i \in N_t} e_{i2000} \ell_{i2000}} \Leftrightarrow \sum_{i \in N_t} \left(e_{i2014} - e_{i2000} \right) \ell_{i2014} > 0 \ . \tag{13}$$

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 increases by 0.11% per year in Canada (compared to 1.31% in the U.S.). 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 0.16% implies that the sum of labor increases, weighted by the efficiency level in each sector, is positive, i.e.

$$\frac{TFP_{2014}''}{TFP_{2000}''} < \frac{TFP_{2014}}{TFP_{2000}} \Leftrightarrow \sum_{i \in N_t} e_{i2014} \left(\frac{\ell_{i2014}}{L_{2014}} - \frac{\ell_{i2000}}{L_{2000}} \right) > 0 \, . \tag{14}$$

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).

In the last exercise, making use of equation (11) (changing the gender wage gap by the relative wages) and (12), where we impute all the changes in real wages to differences in hours supplied, we again get that TFP would have fallen, this time at -0.45% per year, compared to a positive 0.25% for the U.S..

Table 3: Counterfactual growth rates of TFP with sectoral composition of labor.

	United States	Canada
TFP factor	1.08%	0.16%
TFP’	-0.39%	-0.73%
TFP’’	1.31%	0.11%
TFP’’’	0.25%	-0.45%

In all of the counterfactuals, the gap in TFP growth between the United States and Canada is still there. Therefore, we conclude that compositional changes of the labor force cannot account for the lack of TFP growth observed in our benchmark accounting exercise.

There is a 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.

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. The simplicity of the Cobb-Douglas specification is that it relies on obtaining only 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 U.S. 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 for different values of the capital share. If the capital share were equal to 0.25, TFP would have grown at 0.52% (in the U.S. this figure would have been 1.36%). If the capital share were 0.40, TFP would have experience 0.00% growth (in the U.S. this figure would have been 0.97%). Either way, it seems like our results are not affected by different values for the capital shares.

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 (2014), Koh et *al*. (2016) or Autor et *al*. (2017). We believe that the time period we analyze is short enough so that differences in the long run trend in labor income shares between Canada and the U.S. should not matter much.

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 whether some sectors in the U.S. perform substantially different than their Canadian counterparts.

In order to measure sectoral TFP we use sectoral real output (deflated by the sectoral price index), total employment per sector (as hours worked per sector are not available), capital constructed with a sector specific depreciation rate, and the sector specific labor share.

In order to construct the series for capital, we use investment data per sector. A very nice feature of Canadian sector-specific investment data is that it is split between investment and repair. The variation in the composition in the two types of investment is consistent with different sectors having different depreciation rates. We make use of this data in order to compute a different depreciation rate for each sector ensuring that the overall depreciation in the economy is consistent with the depreciation we used in the benchmark case. In particular, we compute

$$\delta_i = \bar{\delta} + \frac{1}{21}\sum_{t=1994}^{2014} \frac{\text{Repair Investment}_{\text{t}}}{\text{Capital stock}_{\text{t}}}, \tag{15}$$

with $\bar{\delta}$ such that

$$\frac{1}{45}\sum_{t=1970}^{2014} \frac{\text{Cons of fixed capital}_t}{Y_t} = \frac{1}{21}\frac{\sum_{t=1994}^{2014}\sum_{i} K_{i,t}\delta_i}{Y_t}. \tag{16}$$

Unfortunately, U.S. depreciation data is not as detailed as Canadian data; hence, we use the same sectoral depreciation rates found in Canada for the U.S.

We have information on the overall wage bill paid by each industry and total sectoral GDP. As mentioned in section 5.1, we would like to correct for the labor income that is generated by small business owners and does not get recorded as compensation of employees. Unfortunately, the sectoral data does not have this level of detail. Table 4 reports our sectoral estimates. Computing the weighted (by value added shares in 2002) average of sectoral factor shares we obtain a value of 0.37 for Canada, which is very similar to the value of 0.35 that we used for the aggregate economy.

Our analysis shows that the growth rate of sectoral TFPs is positively correlated between the two countries, with a correlation of 0.42. We observe that the second and third more important sectors in Canada are Manufacturing and Mining, respectively. In Canada Manufacturing TFP grew by 1.3%, while it grew by 1.9% in the U.S., and in Mining Canadian TFP fell by 5.2% while it only fell by 1.6% in the U.S. The importance of Manufacturing and, especially, Mining in accounting for the difference between Canadian and U.S. TFP growth can be assessed by eliminating these two sectors of both output and inputs and re-computing TFP growth. We find that, once we remove these two sectors, Canadian TFP would have grown by 0.93% per year, whereas U.S. TFP would have grown by 0.71%. Clearly, these two sectors play a major role explaining the different behavior of TFP for the two countries.

The case of the Mining sector deserves further study, but that goes beyond the scope of this paper. Between 2002 and 2014 the share of capital and labor going to the Mining sector almost doubled in Canada. The share of capital in the Mining sector went from 15% to 27%, while the share of labor increased from 0.9% to 1.5%. However, the share of value added dropped from 8.9% in 2002 to 8.5% in 2014. This disproportionate inflow of inputs without a corresponding growth of output results in the large drop of Canadian measured TFP in the Mining sector. The same pattern is observed in the U.S., but it is less drastic and Mining is much smaller in the U.S. (only 2% of value added in 2002, compared to 8.9% in Canada).

The most important sector in Canadian value added is Finance, Insurance and Real State, but in this sector Canadian TFP grew by 2% while U.S. TFP grew by only 0.4%. Construction is also a very important sector, with 6.4% of VA in Canada in 2002. Canadian TFP in Construction fell by 0.24% per year, compared to the U.S., where TFP fell by 1.93% per year in the Construction sector. This very bad performance of the Construction sector in the U.S. is consistent with the findings in Jorgenson and Schreyer (2013).

Table 4: Capital shares, depreciations, TFP growth rates, and price growth rates by industry

Sector*	Capital share Canada	Capital share U.S.	Depreciation rate	Can TFP growth	Can price growth**	U.S. TFP growth	U.S. price growth
Agriculture, forest, fish and hunt	0.49	0.75	0.10	3.86	-1.77	-0.24	-0.47
Mining, oil, gas extraction	0.81	0.75	0.07	-5.24	3.54	-1.64	5.53
Utilities	0.70	0.70	0.07	-3.82	-0.39	-1.35	0.77
Construction	0.30	0.37	0.09	-0.24	1.55	-1.93	1.67
Manufacturing	0.38	0.48	0.07	1.33	-0.51	1.90	-1.71
Wholesale trade	0.39	0.39	0.07	2.56	-1.23	1.06	-0.33
Retail trade	0.30	0.32	0.09	1.14	-1.20	-0.61	-0.40
Transport and warehousing	0.36	0.46	0.06	-0.31	0.55	0.91	-0.63
Information and cultural industries	0.55	0.67	0.06	3.17	-0.38	3.64	-2.23
Finance and insurance	0.44	0.43	0.06	1.99	-1.27	0.37	-0.00
Prof. scientific and tech. services	0.42	0.59	0.08	0.69	0.24	-1.15	0.41
Educational services	0.23	0.84	0.08	-0.12	-0.38	-4.13	2.79
Health care and social assistance	0.23	0.17	0.08	-1.09	0.70	-0.23	1.11
Arts, entertainment and recreation	0.50	0.40	0.07	-0.58	-0.07	0.52	-0.23
Accommodation and food services	0.44	0.31	0.08	0.91	-0.28	-0.51	0.50
Other services (not public admin)	0.44	0.25	0.07	0.06	-0.17	-1.69	1.04

*Real estate and Management of Companies excluded because of data availability; Government and Administrative and Waste management excluded because wage bill larger than Value Added.

**Only computed 2002-2013 due to data availability.

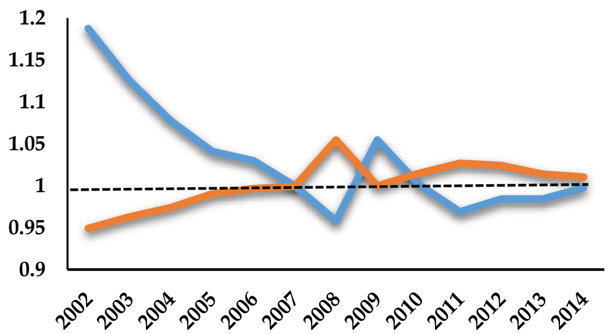
We also analyze how sectoral price deflators and the evolution of TFP are related. We find that the relationship is negative. The correlation between sectoral TFP growth and the change in relative prices is -0.73 in Canada (and -0.76 in the U.S.).

The same pattern (higher productivity growth is related to falling relative prices) that we find across sectors is also true for the comparison of the aggregates of Canada and the U.S. In Canada TFP grew less than in the U.S., and Canadian terms of trade appreciated while U.S. terms of trade depreciated. Now we turn to exploring the impact of terms of trade in Canada for measures of purchasing power.

6. Income, Output, and the terms of trade

Canada and the U.S. are highly integrated. In the previous section we have shown that sectoral prices are negatively correlated with sectoral productivities. In this section we inquire whether the same logic applies at the aggregate level as well. In particular, given that during the 2002-2014 period TFP in Canada stagnates while it grows in the U.S., we should expect that Canadian prices increase relative to those in the U.S. We find that this is the case: 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 0.52% per year (the units are normalized to 1 in 2007).

Figure 4: Terms of trade in Canada and U.S. 2002-2014.



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.

For instance, 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 the two are the same. 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. As shown by Kehoe and Ruhl (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.[7]

GDI can be expressed as,

$$GDI = \underbrace{E_t^{1-\alpha} \underbrace{\left(1 - \frac{X / P_X}{GDP}\left(1 - \frac{P_X}{P_M}\right)\right)}_{\text{real purchasing index}}}_{\text{real purchasing-productivity index}} K_t^{\alpha} L_t^{1-\alpha}, \quad (17)$$

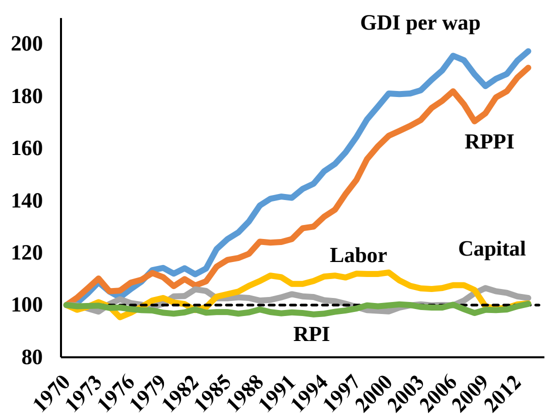
where the real purchasing index is affected by the size of exports and the terms of trade. Hence, we can use the growth accounting exercise, using GDI instead of GDP, and report the combination of the real purchasing index and TFP, instead of only TFP. This object, which we call Real Purchasing-Productivity Index (RPPI) measures how much income is generated by the factors of production.

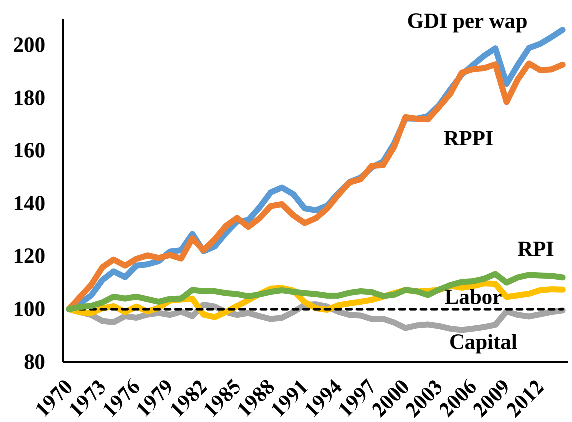
Expression (17) comes from real $GDP = \frac{C}{P_C} + \frac{I}{P_I} + \frac{G}{P_C} + \frac{X}{P_X} - \frac{M}{P_M}$, real $GDI = \frac{C}{P_C} + \frac{I}{P_I} + \frac{G}{P_C} + \frac{X - M}{P_M}$, $GDP = K^{\alpha}(EL)^{1-\alpha}$ and simple algebra.

[7] For more details on the difference between real GDI and real GDP, we refer the reader to section 7 of Kehoe and Ruhl (2008).

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 RPPI is 0.95% per year in Canada during the 2002-2014 period (substantially larger than the 0.16%) and 1.13% in the U.S. (roughly the same as 1.08%). Also, RPPI growth in both Canada and the U.S. is substantially smaller than during the 1970-2002 period (1.71% for Canada and 1.65% for the U.S.). The role of the Real Purchasing Index (RPI), as defined in equation (17), for the case of Canada is clear from Figure 6. In contrast to the US, where the RPI is constant, in Canada the RPI has been growing, contributing to the growth of RPPI beyond the impact of TFP growth.

7. Conclusion

We document the puzzling observation that TFP growth has been only 0.16% per year in Canada for the period 2002-2014. This figure contrasts with the larger growth in the U.S. for the same time period, and also in the past experience of both Canada and the U.S. We argue that this feature is not driven by compositional effects related to the measurement of factors of production. In contrast, we document that the performance of two key sectors (especially Mining, and to a lesser extent Manufacturing) accounts for all of the difference in TFP growth between Canada and the U.S.

At the same time, the evolution of the terms of trade in the two countries is dramatically different. In fact, the dismal productivity growth in Canada 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 real purchasing-productivity index that takes changes in the terms of trade into account, and show that this index grows similarly in Canada and in the U.S. both in the 2002-2014 period and before.

Our results could be contrasted with the literature that tries to tackle the reasons for the global productivity slowdown. For example, Fernald (2015) argues that industries that produce information technology are tied to having a larger slowdown in productivity, and Decker et *al*. (2016) indicate that lower dynamism in the business sector is responsible for the productivity slowdown. Alternatively, Duernecker et *al*. (2017) propose that the slowdown is a result of structural transformation, and Bloom et *al*. (2017) suggest that having good ideas is an increasingly hard task.

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., D. Dorn, L.F. Katz, C. Patterson and J. Van Reenen (2017), "Concentrating on the Fall of the Labor Share," *American Economic Review*, 107(5), 180–185.

Basu, S., J.G. Fernald and J.S. Kimball (2006), "Are Technology Improvements Contractionary?" *American Economic Review*, 96(5), 1418–1448.

Bloom, N., C.I. Jones, J. Van Reenen and M. Webb (2017), "Are Ideas Getting Harder to Find?" NBER working paper 23782.

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

Cette, G., J.G. Fernald and B. Mojon (2016), "The Pre-Great Recession Slowdown in Productivity," *European Economic Review*, 88, 3–20.

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.

Costa, D.V., 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.V., 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).

Costa, D.V. (2017), “From Primary Commodities to Output Fluctuations,” unpublished manuscript.

De Soyres, F. (2016), “Value Added and Productivity Linkages across Countries,” unpublished manuscript.

Decker, R.A., J. Haltiwanger, R.S. Jarmin and J. Miranda (2016), “Where Has All the Skewness Gone? The Decline of High Growth (Young) Firms in the U.S.” *European Economic Review*, 86, 4–23.

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.

Duernecker, G., B. Herrendorf and Á. Valentinyi (2017), “Structural Change within the Service Sector and the Future of Baumol’s Disease,” unpublished manuscript.

Fernald, J.G. (2015), “Productivity and Output Before, During, and After the Great Recession,” Chapter in NBER Macroeconomics Annual 2014, volume 29, edited by J. A. Parker and M. Woodford, 1–51.

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

Hsieh, C.T. and P.J. Klenow (2009), “Misallocation and Manufacturing TFP in China and India,” *Quarterly Journal of Economics* 124(4), 1403–1448.

Karabarbounis, L. and B. Neiman (2014), “The Global Decline of the Labor Share,” *Quarterly Journal of Economics* 129(1), 61–103.

Jorgenson, D.W. and P. Schreyer (2013), "Industry-Level Productivity Measurement and the 2008 System of National Accounts." *Review of Income and Wealth* 59(2), 185-211.

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," unpublished manuscript.

McMillan, M.S. and D. Rodrik (2011), "Globalization, Structural Change and Productivity Growth," in *Making Globalization Socially Sustainable*, edited by Mark Bachetta and Marion Jansen, International Labor Organization, Geneva Switzerland.

Morisette, R., G. Picot, Y. Lu (2013), "The Evolution of Canadian Wages over the Last Three Decades," Analytical Studies Branch Research Paper Series No. 347.

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: Description of the data

Canadian data

<u>Original</u>

Aggregate

O.1 Employment (thousands of workers) — 1960-2014, OECD database.

O.2 Annual hours (units) — 1961-2014, OECD database.

O.3 Total Population (thousands) — 1960-2014, OECD database.

O.4 Dependency ratio (%) — 1960-2014, OECD database.

O.5 Nominal GDP (millions) — 1970-2014, OECD database.

O.6 Nominal Gross Capital Formation (millions) — 1970-2014, OECD database.

O.7 Nominal Consumption of Fixed Capital (millions) —1981-2014, OECD database.

O.8 Real GDP (millions of 2010) — 1970-2014, OECD database.

O.9 Real Gross Domestic Income (millions) — 1970-2014, OECD database.

O.10 Nominal investment in construction (millions) —1970-2014, OECD database.

O.11 Real Gross Capital Formation — 1970-2014, OECD database.

O.12 Male employment (thousands) — 1981-2014, CANSIM Table 282-0002.

O.13 Female employment (thousands) — 1981-2014, CANSIM Table 282-0002.

O.14 Gender wage gap (%) — 1981-2011, Morisette et *al.* (2013). Years missing filled with linear interpolation; from 2011 to 2014, use 2011 value.

O.15 Male average hours worked (units) — 1981-2014, CANSIM Table 282-0018.

O.16 Female average hours worked (units) — 1981-2014, CANSIM Table 282-0018.

O.17 Imports, nominal — 1970-2014, OECD database.

O.18 Exports, nominal — 1970-2014, OECD database.

O.19 Imports, real — 1970-2014, OECD database.

O.20 Exports, real — 1970-2014, OECD database.

Sectoral

O.21 Sectoral GDP, real — 2002-2014, CANSIM Table 379-0031.

O.22 Sectoral GDP, nominal — 2007-2013, CANSIM Table 379-0030.

O.23 Sectoral GDP, nominal — 2002-2008, CANSIM Table 381-0016.

O.24 Labor force by sector (thousands) — 2001-2014, CANSIM Table 383-0031

O.25 Wage bill (thousands of dollars) — 2001-2014, CANSIM Table 383-0031

O.26 Capital expenditures by sector (millions) — 1991-2014, CANSIM Table 029-0005.

O.27 Repair expenditures by sector (millions) — 1991-2014, CANSIM Table 029-0005.

<u>Constructed</u>

Aggregate

C.1 Population 15-64 — O.3/ (1+O.4/100).

C.2 CFC/GDP — O.7/O.5.

C.3 Real Investment (millions) — O.6 x O.8/O.5.

C.4 Depreciation rate — Equation (4), O.8, C.2 and C.5.

C.5 Capital — Equation (3), (5), O.8, C.3, C.4.

C.6 Capital with U.S. depreciation — Re-construction of C.5, using C.46.

C.7 TFP — Equation (2), and O.1, O.2, O.8, C.5, and C.44.

C.8 TFP with U.S. depreciation — Re-construction of C.7, using C.6 instead of C.5.

C.9 RPPI — Re-construction of C.7, using O.9 instead of O.8.

C.10 RPI — C.9/C.7.

C.11 TFP with 0.25 capital share — Re-construction of C.7, using $\alpha = 0.25$.

C.12 TFP with 0.4 capital share — Re-construction of C.7, using $\alpha = 0.4$.

C.13 Real investment without investment in buildings — (O.6-O.10) x O.8/O.5.

C.14 Capital without investment in buildings — Re-construction of C.5, using C.13.

C.15 GDP without investment in buildings — O.8 x (1-O.10/O.5).

C.16 TFP without investment in buildings — Re-construction of C.7, using C.14 and C.15.

C.17 Real investment, using US deflator — Re-construction of C.3, using U.S. deflator.

C.18 Capital, using US deflator — Re-construction of C.5, using C.17.

C.19 TFP using capital with US deflator — Re-construction of C.7 using C.18.

C.20 Capital using real investment — Re-construction of C.5, using O.11.

C.21 TFP using capital with real investment — Re-construction of C.7 using C.20.

C.22 Annual hours worked, male — O.15 x 52.

C.23 Annual hours worked, female — O.16 x 52.

C.24 Hours worked — C.22+C.23.

C.25 Constant gap TFP — Equation (9), and C.7, C.44, O.12, O.13, O.14, C.22, C.23, C.24.

C.26 Constant labor TFP — Equation (10), and C.7, C.44, O.12, O.13, O.14, C.22, C.23, C.24.

C.27 Labor adjusted gap — Equation (11) and O.12, O.13, O.14, O.15, O.16.

C.28 TFP using labor adjusted gap — Re-construction of C.7, using C.27.

C.29 Export deflator — O.18/O.20.

C.30 Import deflator — O.17/O.19.

C.31 Terms of Trade — C.30/C.29.

Sectoral

C.32 Constant Labor — Re-construction of C.45, using labor from 2002.

C.33 Constant wages TFP — Re-construction of C.26, using C.47.

C.34 Constant labor (sector) TFP — Re-construction of C.27, using C.32.

C.35 TFP using labor adjusted — Re-construction of C.28, using O.24 and O.25.

C.36 Capital Investment by sector, deflated — O.26 x O.8 / O.5.

C.37 Repair Investment by sector, deflated — O.27 x O.8 / O.5.

C.38 Total investment by sector — C.36+C.37.

C.39 Capital per sector — First period, average of three initial investments divided by C.22; from then on, using C.21 x (1-C.22) + C.20.

C.40 Sectoral depreciation rates — Such that average of (C.37/C.39) + common term = C.4.

C.41 Labor share per sector — average of O.25/C.43.

C.42 TFP per sector — Re-construction of C.7, using O.24, O.21, C.39, C.41.

C.43 GDP nominal — Combination of O.22 and O.23.

C.44 Sectoral deflator — C.43/O.23

C.45 Wages — O.25/O.24.

C.46 Real Wage — C.45/O.5 x O.8.

C.47 Constant Wage — Re-construction of C.45, using salaries from 2002.

C.48 Adjusted labor without manufacturing and mining — O.2 x fraction of employment not in manufacturing or mining, from O.24).

C.49 Adjusted capital without manufacturing and mining — C.5 x fraction of capital not in manufacturing or mining, from C.39).

C.50 Adjusted GDP without manufacturing and mining — O.8 x fraction of GDP not in manufacturing or mining, from O.21).

C.51 TFP without manufacturing and mining — redoing of C.7 with C.48, C.49 and C.50.

U.S. data

Original

Aggregate

O.28 Real GDP (millions of 2010) — 1970-2014, OECD database.

O.29 Compensation of Employees (millions) — 1955-2014, OECD database.

O.30 Household Compensation of Employees (millions) — 1955-2014, OECD database.

O.31 Household Gross Operating Surplus and Mixed Income (millions) — 1955-2014, OECD database.

O.32 Net Taxes (millions) — 1955-2014, OECD database.

O.33 Real Gross Domestic Income (millions) — 1970-2014, OECD database.

O.34 Nominal investment in construction (millions) —1970-2014, OECD database.

O.35 Real Gross Capital Formation — 1970-2014, OECD database.

O.36 Male employment (thousands) — 1981-2014, OECD database.

O.37 Female employment (thousands) — 1981-2014, OECD database.

O.38 Gender wage gap (%) — 1981-2014, OECD database.

O.39 Employment (thousands of workers) — 1956-2014, OECD database.

O.40 Annual hours (units) — 1956-2014, OECD database.

O.41 Male average hours worked (units) — 2003-2014, Bureau of Economic Analysis.

O.42 Female average hours worked (units) — 2003-2014, Bureau of Economic Analysis.

O.43 Population 15-64 — 1954-2014, OECD database.

O.44 Nominal GDP (millions) — 1970-2014, OECD database.

O.45 Nominal Gross Capital Formation (millions) — 1970-2014, OECD database.

O.46 Nominal Consumption of Fixed Capital (millions) —1954-2014, OECD database.

O.47 Imports, nominal — 1970-2014, OECD database.

O.48 Exports, nominal — 1970-2014, OECD database.

O.49 Imports, real — 1970-2014, OECD database.

O.50 Exports, real — 1970-2014, OECD database.

Sectoral

O.51 Gross capital formation per industry, real — 1970-2014, OECD database, STAN rev 4.

O.52 Labor force by sector (thousands) — 2000-2014, BEA data.

O.53 Wage bill (thousands of dollars) — 2000-2014, OECD database, STAN rev 4.

O.54 Value Added per sector, nominal — 2000-2014, OECD database, STAN rev 4.

O.55 Value Added per sector, real — 2002-2014, OECD database, STAN rev 4.

<u>Constructed</u>

Aggregate

C.52 TFP with 0.4 capital share — Re-construction of C.71, using $\alpha = 0.4$.

C.53 Real investment without investment in buildings — (O.45-O.34) x O.28/O.44.

C.54 Capital without investment in buildings — Re-construction of C.67, using C.53.

C.55 GDP without investment in buildings — O.28 x (1-O.34/O.44).

C.56 TFP without investment in buildings — Re-construction of C.71, using C.54 and C.55.

C.57 Capital using real investment — Re-construction of C.67, using O.35.

C.58 TFP using capital with real investment — Re-construction of C.71 using C.57.

C.59 Constant gap TFP — Equation (9), C.71, C.64, O.36, O.37, O.38, O.41, O.42.

C.60 Constant labor (gap) TFP — Equation (10), C.71, C.64, O.36, O.37, O.38, O.41, O.42.

C.61 Labor adjusted gap — Equation (11) C.71, C.64, O.36, O.37, O.38, O.41, O.42.

C.62 TFP using labor adjusted gap — Re-construction of O.36, O.37, O.38, O.41, O.42.

C.63 CFC/GDP — O.46/O.44.

C.64 Labor Share — average of 1 – (O.29 – O.30) / (O.44 – O.30 – O.31 – O.32).

C.65 Real Investment (millions) — O.45 x O.28/O.44.

C.66 Depreciation rate — Equation (4), O.28, C.63 and C.67.

C.67 Capital — Equation (3), (5), O.28, C.64, C.65.

C.68 Export deflator — O.48/O.50.

C.69 Import deflator — O.47/O.49.

C.70 Terms of Trade — C.69/C.68.

C.71 TFP — Equation (2), and O.39, O.28, C.64, and C.67.

C.72 RPPI — Re-construction of C.71, using O.33 instead of O.28.

C.73 RPI — C.72/C.71.

C.74 TFP with 0.25 capital share — Re-construction of C.71, using $\alpha = 0.25$.

Sectoral

C.75 Sectoral deflator — O.54/O.55.

C.76 Constant Wage — Re-construction of C.31.

C.77 Constant Labor — Re-construction of C.32.

C.78 Constant wages TFP — Re-construction of C.33.

C.79 Constant labor (sector) TFP — Re-construction of C.34.

C.80 TFP using labor adjusted — Re-construction of C.35.

C.81 Labor share per sector — average of O.53/O.54.

C.82 Capital per sector — Using C.81, O.51 and C.40.

C.83 TFP per sector — Re-construction of C.42, using C.82, C.81, O.55, O.52.

C.84 Wages — O.53/O.39.

C.85 Adjusted labor without manufacturing and mining — O.40 x fraction of employment not in manufacturing or mining, from O.52).

C.86 Adjusted capital without manufacturing and mining — C.67 x fraction of capital not in manufacturing or mining, from C.82).

C.87 Adjusted GDP without manufacturing and mining — O.28 x fraction of GDP not in manufacturing or mining, from O.55).

C.88 TFP without manufacturing and mining — redoing of C.71 with C.85, C.86 and C.87.

C.89 Real Wage — C.84/O.52 x O.28.

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