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REAL GDI, PRODUCTIVITY, AND THE TERMS OF TRADE IN CANADA

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In this paper, a quarterly dataset of productivity is built for the Canadian business sector, and the Diewert and Yu (2012a) estimates of annual productivity growth are revised and updated to reflect changes in the new Canadian system of national economic accounts. The quarterly data are then used to study the contribution of total factor productivity and the terms of trade to growth of real gross domestic income. In most years of the 2000s, the contribution of the terms of trade became significant in real income growth, whereas that of total factor productivity growth was stagnant. Improvement in the terms of trade arises froma decline in the import price index and an increase in the export price index.

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1. INTRODUCTION

Two important determinants of real domestic income in an open economy are productivity and the terms of trade. Historically, total factor productivity (TFP) has been a main source of income and output growth. Improvement in the terms of trade—that is, the price of exports relative to the price of imports—also tends to increase domestic income and wealth. In the 2000s, some resource-rich small open economies, such as Canada, have been faced with large swings in their terms of trade and the slowdown of productivity growth. In addition to having implications for real domestic income, these swings have led to a significant reallocation of economic resources. Economic welfare depends on how well and how

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quickly an economy can adjust to such changes in economic circumstances (Duguay, 2006).

It is now well known that, in national accounts, improvement in the terms of trade can lead to an increase in measured real income (i.e. nominal income deflated by domestic prices), while it may have little impact on measured real output (i.e. nominal income deflated by the implicit price of aggregate output), as shown in Diewert and Morrison (1986) and Kohli (2004), among others. This trading gain in real income increases a country's consumption possibilities because an increased export price relative to import price raises the purchasing of domestic income power (e.g. getting more for less).[1] This has policy implications because real gross domestic output may be inadequate in measuring income and welfare in the presence of trading gains.

One challenge for policymakers interested in having a real-time assessment of the extent and implications of structural adjustment is data availability. In Canada, annual datasets of total factor productivity have been produced by Statistics Canada (using a bottom-up industry-based approach) and by Diewert and Yu (2009, 2012a) (using a top-down approach with national accounts data). However, two weaknesses of annual data are that they are available with a lag and the low frequency of the data limits their usefulness for examining issues where meaningful economic variation and responses may occur within a year. For example, possible delays of the annual data complicates real-time estimation and understanding of the drivers of potential output and the output gap, important economic measures for the conduct of monetary policy. Likewise, impacts of shocks to total factor productivity and the terms of trade on income, wealth, investment, employment, and labor productivity can be different within a year than at longer horizons, such as across years, raising the need for quarterly data when assessing policy decisions that are made multiple times within a year and tend to have effects within a year (e.g. monetary policy).

In this paper, a quarterly dataset of total factor productivity for the Canadian business sector is constructed using the top-down methodology of Diewert and Yu (2012a). The availability of such data will facilitate economic research and timely analysis and monitoring of structural economic developments. Diewert and Yu (2012a) measure historical total factor productivity for the Canadian business sector. The advantage of their methodology is that because it uses national accounts data which exports and imports, it provides a unified framework for measuring total factor productivity and quantifying the contribution of the terms of trade to real income growth. By contrast, the current industry-based bottom-up approach of measuring productivity does not measure the contribution of changes in the terms of trade.

The quarterly productivity data are then used to decompose the growth of real gross domestic income into contributions from trading gains, total factor productivity, and primary inputs (e.g. capital and labor). Trading gains capture the contribution of improvement in the terms of trade and changes in the price of tradables

[1]Presumably, improvement in terms of trade may also affect measured real gross domestic output. However, Kohli (2004) shows that such an effect is small and real output underestimates the growth in real income when the terms of trade improve.

relative to non-tradables. We find that in the 2000s, the growth of real gross domestic income in the Canadian business sector was sustained by significant trading gains, largely due to improvements in the terms of trade, while the contribution from total factor productivity dropped substantially from the 1990s. In addition, over the 2008–9 recession, the decline in real gross domestic income was accounted for almost entirely by both the losses of trading gains and decline in total factor productivity. These findings suggest that taking into account the contribution of trading gains is important for understanding and assessing the sources of income growth, in particular in episodes with large changes in export and import prices.

These results extend earlier studies by Kohli (2006) and Diewert and Yu (2012a) on the contribution of improved terms of trade to income growth. The contribution of this paper lies in growth accounting based on quarterly data, and the further decomposition of trading gains at the aggregate level into contributions from different types tradables. Accounting for real income growth based on quarterly productivity data, on average or in the longer run, yields similar results, as if it is based on annual data. Nevertheless, the advantage of quarterly data is that they allow changes in real income to be decomposed more frequently and on a timely basis, which is important for certain policy analysis, in particular in times of economic turbulence. Moreover, quarterly data are useful for understanding business cycles, where the frequency of data may matter for the results.[2]

The rest of the paper is organized as follows. The next section overviews the top-down approach to measuring total factor productivity and to growth accounting of real income. Section 3 describes the construction of the quarterly productivity data. In Section 4, real income growth is decomposed, and the analysis focuses on trading gains and total factor productivity. Finally, Section 5 concludes the paper.

2. Growth Accounting for Real Income: An Overview

This section briefly overviews the growth accounting methodology of Diewert and Yu (2012a) and Kohli (2004), among others, to understand how the growth of real income can be decomposed into contributions from total factor productivity, primary inputs, and relative prices. This overview not only guides the data construction, but also facilitates the explanation of the decomposition results later on. First, it is convenient to introduce some notation. Let G^t be the current-price (or nominal) gross domestic income (GDI) or, equivalently, the nominal gross domestic output (GDP). Let y^t be the period-t aggregate output in real value, and let y_j^t be its jth component, where $j=1, \cdots, J, X, M$. J is the number of domestic outputs, X represents exports, and M represents imports. Let P^t be the GDP deflator, and let P_j^t be the deflator of the output j. By definition, $G^t=P^t \cdot y^t$. Two primary inputs are used for production: capital, K^t, and labor, L^t. We first decompose the growth of nominal gross domestic income into

[2]For example, in our working paper, Cao and Kozicki (2015), we find that correlations between quarterly total factor productivity and quarterly labor input have the opposite signs from the correlations using annual data. A simple vector auto-regressive (VAR) model finds that, following a positive shock to total factor productivity, labor input drops in the short run, which can be explained by the presence of nominal or real rigidities, as shown in Basu *et al.* (2006).

contributions from total factor productivity, primary inputs, and relative prices. The decomposition of the growth of real gross domestic income follows in a straightforward manner.

The growth of total factor productivity captures the change in gross domestic income assuming that the same amounts of inputs are used for production and that the price level remains the same between two periods:

$$\gamma^t = G^t(P, K, L)/G^{t-1}(P, K, L).$$

Such a change in output while keeping inputs and prices constant is often interpreted as a change in technology. The growth factor of gross domestic income due to changes in prices only is given by

$$A^t = G^t(P^t, K, L)/G^t(P^{t-1}, K, L).$$

Analogous to this concept is the growth factor of income due to changes only in primary inputs:

$$\beta^t = G^t(P, K^t, L^t)/G^t(P, K^{t-1}, L^{t-1}).$$

Using these definitions, the growth of nominal gross domestic income can be decomposed as follows:

(1) $$G^t(P^t, K^t, L^t)/G^{t-1}(P^{t-1}, K^{t-1}, L^{t-1}) \approx A^t \gamma^t \beta^t.$$

If the production technology has the translog functional form, the above decomposition identity holds exactly, as shown in Diewert and Morrison (1986). Moreover, A^t is then the Törnqvist index of the GDP deflator, $A^t = \frac{P^t}{P^{t-1}}$, and β^t is the Törnqvist index of input quantities. Let $A_j^t = \left(\frac{P_j^t}{P_j^{t-1}}\right)^{s_j^t}$ be the Törnqvist price index of the output j, where s_j^t is the share of output j in gross domestic income, $s_j^t = \frac{1}{2}\left(\frac{P_j^{t-1} y_j^{t-1}}{P^{t-1} \cdot y^{t-1}} + \frac{P_j^t y_j^t}{P^t \cdot y^t}\right)$. The contribution of changes in output prices to gross domestic income growth is given by $A^t = \left(\prod_{j=1}^{J} A_j^t\right) \cdot A_X^t A_M^t$. It should be noted that the share of imports in gross domestic income, s_M^t, is negative.

Similarly, the contribution of changes in primary inputs can be further decomposed as $\beta^t = \beta_K^t \beta_L^t$, where $\beta_K^t = \left(\frac{K^t}{K^{t-1}}\right)^{s_K^t}$ and $\beta_L^t = \left(\frac{L^t}{L^{t-1}}\right)^{s_L^t}$. In these indexes, s_K^t and s_L^t are, respectively, the shares of capital and labor in gross domestic income, defined in the same way as the output shares. Finally, the total factor productivity growth, γ^t, is measured as a residual from Equation (1).

Decomposing the growth of real gross domestic income is similar to the above case for nominal gross domestic income. Let $g^t = G^t/P_i^t$ be the real gross domestic income. The deflator P_i^t can be the price of consumption P_1^t (say, if the first output is consumption) or the price index of domestic expenditure P_D^t, defined as

$$\frac{P_D^t}{P_D^{t-1}}=\prod_{j=1}^{J}\left(\frac{P_j^t}{P_j^{t-1}}\right)^{\sigma_j^t} \quad \text{and} \quad \sigma_j^t=\frac{1}{2}\left(\frac{P_j^{t-1}y_j^{t-1}}{\sum_{h=1}^{J}P_h^{t-1}y_h^{t-1}}+\frac{P_j^t y_j^t}{\sum_{h=1}^{J}P_h^t y_h^t}\right).$$

Using P_1^t as the deflator, let $p_j^t=\frac{P_j^t}{P_1^t}$, and note that the sum of shares equals 1. The growth of real gross domestic income is then decomposed as follows:

$$\text{(2)} \qquad \begin{aligned}\frac{g^t}{g^{t-1}}&=\frac{P^t/P_1^t}{P^{t-1}/P_1^{t-1}}\cdot\gamma^t\cdot\beta_K^t\cdot\beta_L^t\\&=\alpha^t\cdot\gamma^t\cdot\beta_K^t\cdot\beta_L^t,\end{aligned}$$

in which

$$\alpha^t=\prod_{j=2}^{J}\left(\frac{p_j^t}{p_j^{t-1}}\right)^{s_j^t}\cdot\left(\frac{p_X^t}{p_X^{t-1}}\right)^{s_X^t}\cdot\left(\frac{p_M^t}{p_M^{t-1}}\right)^{s_M^t}=\prod_{j=2}^{J}\alpha_j^t\cdot\alpha_X^t\alpha_M^t.$$

Let $\alpha_{XM}^t=\alpha_X^t\alpha_M^t$, which defines the trading gains due to relative changes in the prices of exports, imports, and consumption.[3] The trading gains can be further decomposed into two effects on real income growth: the terms-of-trade effect and the relative-price effect, as shown in Diewert and Yu (2012a), Kohli (2004, 2006), and Reinsdorf (2010). The terms-of-trade effect reflects the contribution of changes in the export–import price ratio to real income growth; the relative-price effect captures the contribution resulting from trade imbalance, as well as from deviation of the price of tradables from the price of non-tradables. Define $P_T^t=(P_X^t\cdot P_M^t)^{\frac{1}{2}}$ as the price of tradables. The two effects in trading gains are given by

$$\text{(3)} \qquad \begin{aligned}\alpha_{XM}^t&=\left(\frac{P_X^t}{P_1^t}\Big/\frac{P_X^{t-1}}{P_1^{t-1}}\right)^{s_X^t}\cdot\left(\frac{P_M^t}{P_1^t}\Big/\frac{P_M^{t-1}}{P_1^{t-1}}\right)^{s_M^t}\\&=\left(\frac{P_X^t}{P_M^t}\Big/\frac{P_X^{t-1}}{P_M^{t-1}}\right)^{\frac{s_X^t-s_M^t}{2}}\cdot\left(\frac{P_T^t}{P_1^t}\Big/\frac{P_T^{t-1}}{P_1^{t-1}}\right)^{s_X^t+s_M^t}.\end{aligned}$$

The first term in the second line is the terms-of-trade effect on real income growth. The second term is the relative-price effect, which is 1 if either the trade is balanced (i.e. $s_X^t+s_M^t=0$) or the ratio of tradable to non-tradable prices does not change from one period to the next. In Equation (3), instead of using the price of consumption P_1, we can use the price of domestic expenditure, P_D. The price ratio, P_D/P_T, can be interpreted as the real exchange rate.[4]

[3]The name "trading gains" is to differentiate the welfare and productivity gains from trade or trade liberalization, which have been studied extensively in the literature of international trade.

[4]Later, in Section 4, we use the price of domestic expenditure in implementing Equation (3).

Finally, we can further decompose the aggregate trading gains into contributions from disaggregated traded goods. Suppose that the types of exported goods are the same as the types of imported goods, $X=M$. The overall trading gains can be written as $\alpha_{XM}^{t}=\prod_{i=1}^{M}\alpha_{i,XM}^{t}$. Each term $\alpha_{i,XM}^{t}$ represents the trading gains of the traded good i, which also consists of the terms-of-trade and relative-price effects in a form similar to Equation (3).

There are alternative measures of trading gains. While Diewert and Yu (2012a) use the consumption price to deflate nominal gross domestic income, Kohli (2004, 2006) measures the trading gains as the change of the GDP price relative to the price of domestic demand. Reinsdorf (2010) decomposes the trading gains into a terms-of-trade effect and a relative-price effect, but in the Fisher index framework. The advantage of the method reviewed above is that the translog form of production technology forces the decomposition of the real income growth to be exact, so that an approximation or an econometric estimation is not necessary.

3. Quarterly Productivity in the Business Sector

To apply the above method of growth accounting to the Canadian data, we use the quarterly productivity series developed based on Diewert and Yu (2012a). This section provides an overview of the construction of quarterly productivity data for the Canadian business sector; more details can be found in the working paper version, Cao and Kozicki (2015). Some series from the annual estimates of productivity are needed for measuring quarterly productivity. The annual Diewert–Yu estimates were therefore first revised and updated to reflect changes in the new national accounts (CSNA12) and national balance sheet accounts (NBSA12), details of which can also be found in our working paper.

In estimating quarterly total factor productivity, the top-down methodology of Diewert and Yu (2012a) is applied to the quarterly series of output and inputs from the new national accounts and new national balance sheet accounts. The goal is to construct the seasonally unadjusted real values and the related implicit price indexes.[5] Real values are measured as chained-dollar values; that is, chain-weighted indexes multiplied by current-dollar values of a reference period.[6] One issue that does not exist in the annual data, but which must be addressed in constructing the quarterly estimates, is that of seasonality. The preferred approach would be to use raw seasonally unadjusted data at all stages to construct seasonally unadjusted chain-type indexes. These seasonally unadjusted chain-type series could then be seasonally adjusted if such a format of data is desired. Unfortunately, data limitations prevented straightforward application of the same approach as for the annual exercise to quarterly seasonally unadjusted data.

[5]In the real world, production is not organized in the seasonally adjusted way and the use of seasonally adjusted (i.e. smoothed) series may distort the true production.

[6]To compare chain-weighted indexes and fixed-weighted indexes, see, for example, Landefeld *et al*. (2003).

3.1 *Seasonality*

Seasonally unadjusted chain-type series are often unavailable in the new Canadian national accounts. To overcome this limitation, some adjustments were made to the data. First, the existence of price seasonality was checked by comparing the seasonally adjusted and unadjusted constant-dollar series. For some variables, the implicit price indexes of seasonally unadjusted constant-dollar series are identical or very close to the implicit price indexes of the seasonally adjusted measures, suggesting that there is no seasonality in those price indexes.[7] For these variables, the real quantity used in the growth accounting exercise is the seasonally adjusted chained-dollar quantity. For some others, price indexes of seasonally adjusted and unadjusted constant-dollar series differ, suggesting the existence of price seasonality. When this is the case, the price seasonality is obtained as a ratio of two implicit price indexes, one calculated using the seasonally unadjusted current-price values and the seasonally unadjusted constant-dollar quantities, and the other using the seasonally adjusted current-price values and the seasonally adjusted constant-dollar quantities. This price seasonality ratio is then applied to the implicit price indexes obtained from the seasonally adjusted chained-dollar series, giving measures of implicit price indexes which are then used to obtain seasonally unadjusted chained-dollar quantities.[8]

3.2 *Quarterly Outputs and Inputs*

Other than the seasonality, measuring outputs and inputs is largely the same as in Diewert and Yu (2012a). The quarterly output consists of five categories of domestic output, 12 exports, and 12 imports. Domestic output includes household final expenditure, sales of businesses to non-businesses, business investment, government investment, and changes in business inventories. These components are constructed following Diewert and Yu (2012a). However, it should be noted that exports and imports may still include some of the trade activities of the non-business sector (e.g. software imported by the government), though we excluded special transactions from both exports and imports.[9]

Current-price and seasonally-unadjusted chained-dollar values of all components can be obtained from CSNA12. Price seasonality ratios can be calculated, except for 11 types of traded goods, because the seasonally unadjusted

[7]The implicit prices of the chained-dollar series can differ from those of the constant-dollar series because of changes in the composition of the variable over time. One such example is investment in machinery and equipment, with the price index of the seasonally adjusted chained-dollar series being very different from that of the seasonally adjusted constant-dollar series. This difference arises from the significantly declined prices of computers and the increased use of computers.

[8]Let $P^{\text{adj,const}}$ be the deflator of the seasonally adjusted constant-dollar series, calculated as the current value divided by the constant-dollar quantity, $P^{\text{adj,const}} = V^{\text{adj}} / Q^{\text{adj,const}}$. The deflator of the seasonally unadjusted constant-dollar series, $P^{\text{unadj,const}}$, is defined and calculated in the same way. Price seasonality is defined as $\xi = P^{\text{unadj,const}} / P^{\text{adj,const}}$, which is used to calculate the deflator for seasonally unadjusted chained-dollar quantities as $P^{\text{unadj,chain}} = \xi \cdot P^{\text{adj,chain}}$. The seasonally unadjusted chained-dollar quantity is then obtained as $Q^{\text{unadj,chain}} = V^{unadj} / P^{\text{unadj,chain}}$.

[9]According to Statistics Canada (2008), special transactions of exports and imports include low-value transactions, the cost of repairs to equipment, merchandise returned to the country of origin, unidentified items, and diplomatic and confidential transactions.

constant-dollar values are unavailable. Price seasonality for trades in services can be obtained. An examination of the price indexes of merchandise trade indicates that there is no significant price seasonality for these exports and imports except for the import price of energy products.[10] The price indexes of seasonally adjusted chained-dollar series for the exports and imports of goods are therefore used as proxies for the price indexes of seasonally unadjusted series for those with small differences between the price indexes of adjusted and unadjusted series. For the rest of the exports and imports, the price seasonality of aggregate export and import prices is applied respectively to the implicit price indexes of the seasonally adjusted chained-dollar exports and imports at the two-digit level of the North America Product Classification System (NAPCS).[11]

The quarterly labor inputs, including hours worked and compensation for 36 types of workers, are constructed from the Labour Force Survey (LFS) public-use microdata files.[12] Hours worked are measured as actual hours worked on all jobs.[13] In calculating the quarterly hours worked for each type of worker, these actual hours worked are adjusted for holidays. The LFS also provides hourly earnings for usual hours worked on the main job (available starting from 1997q1), but not for actual hours worked on all jobs. For each of these 36 worker types, total quarterly compensation for all hours worked is estimated assuming that the compensation rates for usual hours and actual hours are the same. For compensation series, quarterly data before 1997q1 are obtained by linearly interpolating the annual data, and applying aggregate wage seasonality obtained from the Survey of Employment, Payrolls, and Hours (SEPH). Thus, for periods before 1997q1, seasonal changes in compensation are the same for all types of workers. Finally, to ensure consistency, the 72 quarterly series of hours worked and compensation are benchmarked to the data used in measuring annual total factor productivity. Benchmarking proportionally adjusts each quarterly data point in a given year so that, after being benchmarked, each quarterly series displays quarterly variation according to the LFS data, and summing quarterly values in each year will replicate the annual values used in measuring annual total factor productivity.[14]

The quarterly capital stocks, used to measure capital services, are constructed with the perpetual inventory method, similar to the annual estimates. This requires the initial-period capital stocks, quarterly depreciation rates, and quarterly investment flows. Investment data are directly available from CSNA12. The initial-period capital stocks are from the annual data of productivity estimates, because the quarterly capital stock data in NBSA12 are available for only three

[10]Energy prices, for both oil and natural gas, can be seasonal due to factors such as weather and seasonality of demand (e.g. vacation travels in summer and heating in winter).

[11]This may create a bias in the volatility for some exports and imports, because the degree of seasonal variation for some exports and imports is smaller than that for the aggregate export and import. For instance, the seasonality for imported energy products is significant; a large portion of the seasonality of aggregate imports may arise from that of imported energy products. At the time of our estimates, no other ways to obtain the price seasonality for individual exports and imports seem to exist.

[12]The 36 worker types consist of three levels of education achievement, three age groups, two gender groups, and employees versus self-employed.

[13]The LFS includes information on usual and actual weekly hours worked for both main jobs and all jobs.

[14]The proportional Denton method is used for benchmarking; for details of this method, see Bloem *et al*. (2001).

types of assets (non-residential structures, machinery and equipment, and IPP), while nine types of assets are used for the quarterly estimates. For the same reason, quarterly depreciation rates are calculated from annual values, assuming these quarterly rates do not vary within any given year. Use of the annual data requires that the asset types are the same between the annual and the quarterly source data. Because the asset types in annual data do not correspond exactly with those of investment in quarterly data, primarily for machinery and equipment, it is necessary to aggregate assets to nine types, including four types of machinery and equipment, two types of non-residential structures, and three types of intellectual property products (IPP). Machinery and equipment includes computers, telecommunications equipment, industrial machinery, and transportation and furniture. Grouping machinery and equipment in this way permits the matching of asset types between annual and quarterly data by current-price investments. This grouping also allows the constructed capital services to separate out the faster technological progress made in computers and telecommunications equipment relative to other types of capital.

3.3 *Productivity Growth in Quarterly Data*

The general trends in the quarterly series for output, total factor productivity, and labor inputs and capital services are close to the annual data. First, as in the annual data, although quarterly total factor productivity on average expanded over the period from 1981q1 to 2013q4, at a rate of 0.18 percent or 0.57 percent year-over-year, it contracted between 2001q1 and 2013q4 at a quarterly rate of 0.06 percent.[15] Over the 2008–9 recession, total factor productivity dropped significantly, year over year, by 1.9 percent in 2008 and 2.4 percent in 2009. Some positive growth was observed in the early part of the recovery from the recession, but growth subsequently stalled. Second, along with the slowdown of total factor productivity since the early 2000s, the business sector has experienced capital deepening (i.e. changes in capital services per hour worked). This suggests that the business sector may have experienced structural transformation over this period.[16]

Just as differences in the measurement of capital services by Diewert and Yu (2012a) and by Statistics Canada had implications for the measurement of total factor productivity in the top-down versus bottom-up approaches, the

[15]The statistics reported in this section are based on seasonally adjusted series, where the adjustment is done using the X-13ARIMA-SEATS Seasonal Adjustment Program developed by the United States Census Bureau.

[16]Our estimates of quarterly total factor productivity do not control for changes in capacity utilization, so the quarterly TFP measures constructed in this study may confuse technological changes with changes in capacity utilization. While there is no consensus on how the effects of capacity utilization should be separated out from measured TFP, a rough adjustment for capacity utilization can be made by subtracting the change in capacity utilization rates estimated by Statistics Canada from TFP growth. Assuming an additive relation between technological change and change in capacity utilization, $\Delta \ln \text{TFP} = \Delta \ln A + \Delta \ln U$, where A is the "true" technology and U is the capacity utilization rate. Subtracting capacity utilization from the measured TFP gives the utilization-adjusted TFP (or A). The measured TFP and utilization-adjusted TFP do deviate, most notably over the recent recession. The correlation between $\Delta \ln \text{TFP}$ and $\Delta \ln U$ is 0.22, while it is -0.23 between $\Delta \ln A$ and $\Delta \ln U$. This suggests that the quarterly TFP estimates may indeed be influenced by changes in capacity utilization. A more formal study incorporating capacity utilization into growth accounting is left for future research.

differences in quarterly and annual measures of capital services also have important implications.[17] The correlation between the growth rate of annual total factor productivity estimated from the quarterly constructions and the growth rate of the directly estimated annual total factor productivity series is 0.91, indicating some gaps between the two—differences which can be traced primarily to the measurement of capital services. Harmonizing the quarterly and annual investment data used to construct real capital stocks would reduce the differences between quarterly and annual capital services. Finally, output measures are close between the annual estimates and the annual values based on the quarterly estimates, and the labor input is virtually identical.

As a robustness check, labor productivity, or real value of output per hour worked, calculated from our quarterly series can be compared to the quarterly labor productivity data published by Statistics Canada. In general, real value of output, hours worked, and labor productivity are similar, although the measures constructed in this paper are more volatile.[18] On average, the year-over-year growth rate of labor productivity in this paper is 1.16 percent, slightly lower than the 1.22 percent in Statistics Canada's estimates. This difference, however, disappears if we calculate the averages excluding the data for 2013. This is a little surprising though, given that measured output differs between the two estimates. Output excludes both paid rent and the rental value of owner-occupied dwellings in this study, whereas only the rental value of owner-occupied dwellings is excluded in the Statistics Canada estimates, leading to slightly slower output growth in this study. Differences in the growth of hours worked between the two estimates are also small, even though the hours worked are drawn from different data sources. The hours worked series in the Statistics Canada labor productivity program take into account information in both the LFS and the business survey on employment, while the analysis in this study relies solely on the LFS data.[19]

4. Real Income Growth, Productivity, and Trading Gains

In measuring total factor productivity, one advantage of the top-down approach relative to the bottom-up approach is that the former allows one to examine the contribution of the trading gains to the growth of real gross domestic income. Such gains arise from changes in the terms of trade and trade imbalances, as shown in Section 2. This is particularly useful for studying the effect of improved terms of trade in the 2000s in Canada, when the terms of trade improved substantially. In this section, the trading gains due to changes in relative export and import prices are examined by applying the method described in Section 2 to the quarterly productivity data described in Section 3. The emphasis

[17]For different estimates of total factor productivity for the Canadian business sector, see Diewert (2012b) and Gu (2012).

[18]This higher volatility may be related to possible differences in implementing the seasonal adjustment between this study and Statistics Canada.

[19]In constructing quarterly hours worked, Statistics Canada uses the geometric mean of hours worked in the LFS and the business survey for employees to smooth the measured hours worked, and uses hours worked from the LFS for the self-employed.

is on the relative importance of total factor productivity and trading gains, though contributions of primary inputs are also reported.

4.1 *Decomposing Real GDI Growth*

Decomposition of real GDI growth can be implemented using both the annual and the quarterly data. The resulting trading gains, on average, are close to each other, since the overall trends of quantities and prices are similar between the annual and the quarterly data. We choose to decompose the quarterly growth of real income using the seasonally unadjusted quarterly data series, as the contribution of this paper is on quarterly data. We examine the average quarterly growth of real income and the decomposition over different sub-periods, so that the effect of seasonality is reduced or even entirely smoothed away.

We should emphasize that though the overall trends are similar between the quarterly and the annual data, quarterly data make it possible to examine changes in real income and contributing factors more frequently and on a more timely basis. Further, the dynamics of contributing factors to real income in short run (e.g. by quarter) can deviate from that based on annual data, in particular over recessions. A better understanding of these dynamics provides a more accurate real-time assessment of real income growth, which potentially has implications for analyzing and conducting certain policies, such as those targeting economic stability.

We choose the implicit price of domestic demand (P_D) as the deflator for nominal gross domestic income.[20] This allows us to simplify the decomposition so that we can focus on trading gains. Experimenting with the prices of both domestic demand and household consumption suggests that the resulting trading gains are similar across the two prices. The reason for this is that these two prices grew at similar rates for a large part of the sample, and at fairly different rates in only a few years, in the early 1990s.

Table 1 shows the contributions of total factor productivity, primary inputs, and the trading gains to the average quarterly growth of real gross domestic income over different periods.[21] Adding the four components gives the average quarterly growth rates of real income. Overall, the growth of real gross domestic income has been supported by total factor productivity growth and trading gains, although their relative importance has changed over time. Prior to 2001, trading gains were small, whereas total factor productivity was a main source of real income growth. In particular, in the 1990s, total factor productivity grew at an average quarterly rate of 0.5 percent, contributing close to half of the real income growth. This rapid growth of total factor productivity was largely attributable to the increased use of information technology, as suggested by empirical evidence (see, e.g. Gu and Wang, 2004).

Trading gains contributed significantly to real income growth in the 2000s at about the same time that total factor productivity growth slowed down. From 2001 to

[20]Domestic demand in this case includes household consumption spending, sales from businesses to the non-business sector, business investment, government spending, and changes in business inventory.

[21]To make the decomposition additive, we use the logarithm of growth factors for all variables; hence the growth rates are log-differences.

TABLE 1
Quarterly Growth of Real Gross Domestic Income and Decomposition (Percentage Points)

	Trading gains	TFP	Labor input	Capital services	Real income
1982q2–1990q4	−0.01	0.20	0.30	0.20	0.69
1991q1–2000q4	0.07	0.46	0.29	0.22	1.03
2001q1–2007q4	0.27	−0.17	0.31	0.26	0.67
2008q1–2009q4	−0.28	−0.40	−0.18	0.09	−0.76
2010q1–2013q4	0.03	0.19	0.35	0.19	0.77

2007, total factor productivity dropped and the growth of real gross domestic income was sustained largely owing to trading gains. Over this period, about 40 percent of quarterly real income growth was attributed to an increase in trading gains, a sufficiently sizable boost such that the standard of living measured by real income growth did not worsen even though total factor productivity growth actually dropped.

In the recession of 2008–9, aggregate real income in the business sector dropped by 0.76 percent per quarter, mainly due to lower trading gains and negative growth of total factor productivity. Together, these two factors accounted for close to 90 percent of the drop in real income. Trading gains alone, dropping 0.28 percent per quarter, accounted for close to 40 percent of the decline in real income. Finally, in the recovery period following the recession, trading gains and total factor productivity continued to be important, together contributing on average 30 percent of quarterly real income growth. After a decade of stagnation, total factor productivity started to show modest growth.

Trading gains over the sample period came primarily from the terms-of-trade effect. The relative-price effect is small, because the trade imbalance is small on average relative to the level of nominal gross domestic income, and overall the price of tradables does not vary much relative to that of non-tradables. Over the period from 2001 to 2007 when the trading gains were large, the relative-price effect, though small, was negative, as the price of tradables relative to price of domestic demand declined.

The significant trading gains over the period from 2001 to 2007 reflects the fact that the terms of trade have been improving, primarily because the import price index declined, while the export price increased (Figure 1).[22]

4.2 *Trading Gains at the Product Level*

Many factors can contribute to improvements in the terms of trade, and hence trading gains. Investigating the causes can be complicated, as improvements in the terms of trade have been accompanied by many other developments, both in Canada and globally.[23] It is beyond the scope of this paper to explore in this direction. Instead, we examine which types of exports and imports contributed

[22]The plotted series are seasonally adjusted, but are essentially the same as the seasonally unadjusted series. The export and import prices are possibly different from the aggregate prices, as in our quarterly data, special transactions of both exports and imports were excluded. In addition, any measurement bias of these prices in the national accounts is carried over in measuring the terms of trade.

[23]For example, in the early 2000s, the information technology boom slowed, China joined the World Trade Organization, total factor productivity growth slowed down, commodity prices surged, and the Canadian currency appreciated.

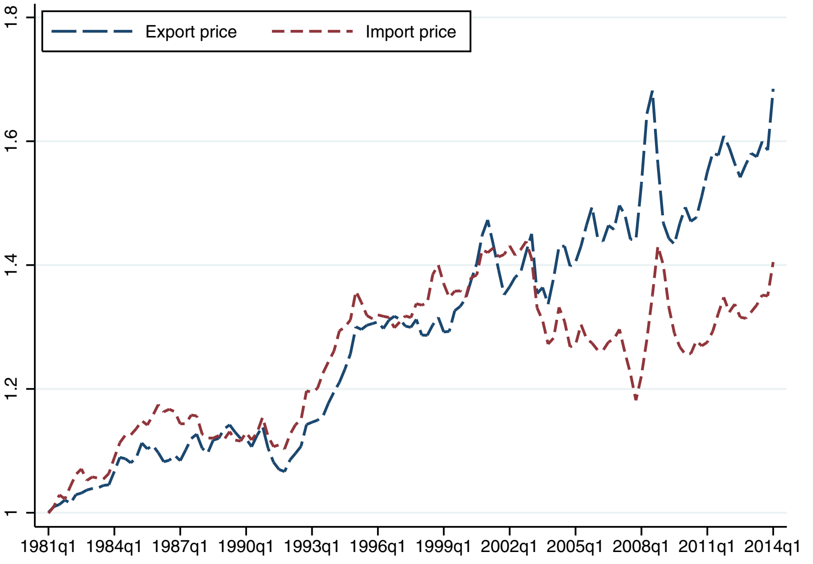

Figure 1. Price Indexes of Exports and Imports 1981–2013, Seasonally Adjusted

more to the aggregate trading gains, which comes naturally under the translog assumption of the real income function.

In measuring exports and imports in the business sector, 12 types of traded goods and services at the two-digit level of the NAPCS were used. To further decompose the aggregate trading gains into contributions from individual goods, we group these products into four categories: non-energy commodities, energy products, manufactured goods, and services. Non-energy commodities include farming, fishing, and intermediate food products; metal ores and non-metallic minerals; metal and non-metallic mineral products; and forestry products, building, and packaging materials. Energy products include crude oil, natural gas, refined petroleum, electricity, and other energy products. Manufactured goods include chemicals, plastics, and rubber products; industrial machinery, equipment, and parts; electronic and electrical equipment and parts; motor vehicles and parts; aircraft and other transportation equipment; and consumer goods. Among these four categories, manufactured goods have the largest share in both total exports and total imports. The export share of energy products was small until the early 2000s, when it started to increase along with the rising energy price.

Overall, trading gains in manufactured goods were the most important contributing factors to the aggregate trading gains, as shown in Table 2. Manufactured goods accounted for about 80 percent of the aggregate trading gains over the period from 2001 to 2007. Over the 2008–9 recession, manufactured goods were also responsible for the drop in trading gains. In the 1980s, trading gains in manufactured goods were offset by the losses in commodities. Though the export of energy (mainly crude oil) increased in the 2000s, trading gains of energy products were small, as the improvement in the terms of trade for energy products was small.

TABLE 2

Contribution to Aggregate Trading Gains (Percentage Points)

	Non-energy commodity	Energy	Manufactured goods	Services	Total
1982q2–1990q4	−0.06	−0.05	0.08	0.02	−0.01
1991q1–2000q4	0.01	0.09	0.01	−0.04	0.07
2001q1–2007q4	0.02	−0.01	0.21	0.05	0.27
2008q1–2009q4	−0.07	−0.05	−0.16	0.00	−0.28
2010q1–2013q4	−0.01	−0.03	0.06	0.01	0.03

Unlike the aggregate trading gains, both the terms-of-trade effect and the relative-price effect were important in contributing to the product-level trading gains. Focusing on the period from 2001 to 2007, the relative-price effect was important for both manufactured goods and energy products. Over this period, the import price index for manufacturing products declined at a faster pace than the export price, leading to a large contribution to the improvement in the aggregate terms of trade. The relative-price effect was also important, accounting for close to 30 percent of average quarterly trading gains in manufactured goods. For energy products, the oil-price boom in the same period led to an increase of both export and import prices, though the import price increased slightly more than the export price, resulting in a deterioration in the terms of trade.[24] We find that the relative-price effect was positive, offsetting much of the deterioration in the terms of trade.

To sum up, real income growth in the 2000s was sustained by large trading gains when total factor productivity growth was slow. Improvement in the terms of trade for manufactured goods was the main source for the aggregate trading gains, and its deterioration was a main factor leading to real income drop over the 2008–9 recession. Trading gains in energy products were small, largely due to the overall small improvement in the terms of trade for energy products.

5. Concluding Remarks

In this paper, quarterly data on total factor productivity for the Canadian business sector have been constructed for the period from 1981 to 2013, and the data on annual total factor productivity of Diewert and Yu (2012a) have been revised to reflect changes in the new national accounts and national balance sheet accounts. The quarterly data are more timely than annual data, and are useful for studying short-run dynamics.

The quarterly data are used to decompose the growth of real gross domestic income into contributions from trading gains, total factor productivity, and primary inputs. In the absence of strong productivity growth, the trading gains have contributed to real income growth since 2001, helping improve the standard of living in Canada. Manufactured goods are the main contributing factors to the large trading gains over this period. We also find that both total factor productivity and deterioration in the terms of trade played significant roles in the drop of

[24]The sign of changes in the terms of trade for energy products is sensitive to the choice of time span for calculating the averages because of large movements in energy prices over the period from 2001 to 2007.

real income over the 2008–9 recession. Looking forward, boosting productivity growth will be important for growth of output and real income, in particular if the terms of trade stabilize or fall.

The growth accounting for real income presented in this paper reveals rich dynamics in the drivers of income growth in Canada. The large contribution from one factor relative to another over different episodes suggests that well-designed policies intending to promote real income growth and improve welfare need to properly assess the growth of both real output and real income, as well as their sources. Such assessment can be deepened by identifying the main contributing factors of the trading gains and, more broadly, of the primary inputs. The availability of quarterly data enables this analysis to be more timely than with annual data.

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