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Abstract

Treating imports as intermediate inputs to domestic production, the author adopts the translog function approach to model real gross domestic income (GDI) in Canada over the 1961–2006 period. She explores the role of price ratios, such as terms of trade and the real effective exchange rate, in explaining changes in real GDI, trade openness, trade balance, and labour share of income, after controlling for factor endowments and technological improvements. Models are developed for both the total economy and the business sector, with alternative assumptions about the flexibility of labour input, user cost of capital, and the representation of technological changes.

JEL classification: F10, O47, C43, D33
Bank classification: Productivity; Econometric and statistical methods

Résumé

L’auteure adopte une fonction translog pour modéliser l’évolution du revenu intérieur brut (RIB) réel du Canada au cours de la période 1961-2006 (les importations y sont traitées comme des intrants de la chaîne de production au pays). Elle examine le rôle joué par les ratios de prix tels que les termes de l’échange et le taux de change effectif réel dans les variations du RIB réel, du degré d’ouverture des échanges, du solde commercial et de la part du revenu qui revient au travail, après prise en compte des dotations en facteurs et des progrès de la technologie. L’auteure élabore des modèles pour l’ensemble de l’économie et le secteur des entreprises et formule différentes hypothèses concernant la flexibilité du facteur travail, le coût d’usage du capital et la représentation des changements technologiques.

Classification JEL : F10, O47, C43, D33
Classification de la Banque : Productivité; Méthodes économétriques et statistiques

1 Introduction

Real output per hour worked (labour productivity) underpins a country's standards of living in the long run, since its growth helps the economy stay on a sustainable path of non-inflationary expansion via technological progress, capital deepening, and better labour quality.[1] Combined with total hours worked (labour input) per capita, it defines real gross domestic product (GDP) per capita, a widely used proxy for living standards. A likely better proxy, however, is the amount of real domestic spending per capita on goods and services that can be afforded with the revenue of production. In an open economy such as Canada, this real income per capita measure is determined not only by the volume of output, but also by the price of that output relative to the price of domestic expenditures, or the so-called trading gains. Over the past five years, real domestic demand (a variable largely determined by real income) in Canada has grown at a much faster pace than real output. This would not have been possible without substantial trading gains (Chart 1).

There are two possible sources of trading gains: changes in the terms of trade, defined as the price of exports relative to imports, and movements in the real exchange rate of the home currency, defined as the average price of exports and imports relative to domestic absorption. In fact, it can be shown, using a superlative index number approach, that the growth in trading gains can be represented as a weighted average of the growth in the terms of trade and the real exchange rate, with the weights corresponding to the average share of exports and imports in nominal GDP and to the trade balance as a share of GDP, respectively (Kohli 2007). Intuitively, holding the volume of output constant, a gain in the terms of trade causes the export revenue to increase or the import bill to decrease, making the country richer as a whole. Even if the terms of trade stay constant, a real (exogenous) depreciation of the country's currency can help boost real income via the balance of trade by stimulating the production and export of tradables while restraining demand for imports destined for domestic consumption.

An appropriate measure of real income should thus incorporate the trading-gains effects in order to fully capture the variations in the "purchasing power" that an economy derives from trading

1. Technological progress is used in its broadest sense; i.e., advances in production technology as well as improvements in organization, the institution, and policies.

with other countries. One way to do this is to deflate nominal GDP by a domestic price deflator.[2] Such a measure can facilitate a more accurate assessment of domestic demand conditions than could be obtained from the conventional GDP measure (which emphasizes production possibilities), thus supplying a useful input to monetary policy-making.

The main objective of this paper is to analyze the growth in Canada's real income and clarify the impacts of various contributing factors over the past four and a half decades. Instead of using a superlative index number approach (e.g., Törnqvist) to measure these impacts, we adapt the translog GDI function approach proposed by Kohli (2004, 2007, 2008) to the Canadian total economy and the business sector.[3] As an extension, alternative assumptions about the flexibility of labour input, user cost of capital, and the representation of technology are adopted in variants of the baseline model. The modelling technique in this paper not only allows us to decompose the growth in real income, but also sheds light on the potential explanation for developments in several other variables of interest to economists and policy-makers.

The translog GDI function models real income based on the production theory in which factor endowments, technology, and the prices of export, import, and domestic demand are exogenous. In this setting, a country's terms of trade are not simply a price phenomenon. Given the increasingly global nature of production processes, it is appropriate to treat imports as intermediate inputs that flow through the domestic production chains and are "transformed" before meeting final demand.[4] The same holds for exports, which are essentially intermediate inputs to foreign production. As trade becomes an integral part of the production process, its prices, be it export or import, clearly influence a firm's decisions regarding its level and mix of

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2. For example, Kohli (2004, 2007, 2008) uses the domestic demand deflator (a Törnqvist price index of the deflators of consumption, investment, and government purchases), while Diewert (2008) advocates the consumption deflator. On the other hand, the *command* GDP, regularly published by the United States, adjusts for the influence of the terms of trade on the purchasing power of the economy by deflating nominal exports with import prices.
3. Kohli (2006) assesses the contribution of trading gains to real income for Canada over the 1981–2005 period based on a superlative index number approach. Macdonald (2007) examines trading gains in Canada by province over the same period.
4. According to the World Trade Organization, intermediate goods (such as agricultural raw material, fuel and mining products, iron and steel, chemicals, and other semi-finished goods) account for 40 per cent of world merchandise trade as of 2006. Even so-called "final" traded products need to undergo a series of domestic processing, by adding transportation, wholesale and retail margins, insurance, financing, etc., before meeting final demand in the importing country.

input and output.[5] For firms that engage in production for both the domestic and export markets, the relative price between traded and domestic goods matters as well. This relative price is essentially determined by the exchange rate. As firms make their optimal decisions with respect to the supply of output to different markets (domestic or foreign), the demand for imports, and factor payments, they also collectively determine the real GDI, the income share of labour, the openness of trade, and the trade balance in the economy.

Our empirical results indicate that trading gains in Canada have been primarily driven by changes in the terms of trade. Although the long-term effects of trading gains on real income are quite small, they do figure prominently during episodes of rapid relative-price movements. For instance, up to one-third of the gains in real income in Canada over the 2002–06 period stemmed from rising terms of trade. While fluctuations in trading gains are found to have a statistically significant association with the changes in trade openness, trade balance, and the labour share of income in Canada, the main drivers of these variables are technological progress and capital deepening (capital per unit of labour input). Accounting for trading gains also leads to a different picture of the historical performance of Canada and the United States, in terms of their relative real income growth, than would be suggested by real output alone.

This paper proceeds as follows: section 2 outlines the baseline model and discusses the estimation results; section 3 describes an alternative model where labour input is treated as variable, followed by the results in comparison with the baseline model; section 4 provides some concluding remarks.

2 The Baseline Model

2.1 Specification

We adopt the following assumptions for our baseline model: (i) there is perfect competition in all markets; (ii) the country (Canada) is a small open economy, and therefore it faces import and export prices that are determined in the rest of the world; (iii) all goods (including services) are tradable; (iv) there is free entry and exit, and constant returns to scale; and (v) the country's factor endowments are given (in the alternative model discussed later, the labour input is allowed

5. A further outcome of the changes in the terms of trade, if sustained, is the stress and dislocation experienced by the real economy as it adjusts to the shock by shifting production and employment towards activities that generate higher income. However, this adjustment effect is not modelled explicitly in our framework.

to vary).[6] Under competitive equilibrium, and in keeping with the view that all international trade takes place in intermediate products, the country (or the collection of firms in that country) chooses the level of its imports, Q_M, combining them with primary inputs (labour, X_L, and capital, X_K) to produce two types of outputs (one for domestic absorption, Q_D, and the other for exporting, Q_X), in order to maximize real GDI (Q_Z), subject to the aggregate technology (Ψ), and exogenous prices (import price, P_M, export price, P_X, and domestic absorption price, P_D):[7]

$$\begin{aligned} Q_Z &= Z(\tau, \varepsilon, X_K, X_L, t) = (P_D Q_D + P_X Q_X - P_M Q_M)/P_D \equiv \\ &\max_{Q_D, Q_X, Q_M} \{Q_D + \varepsilon\tau^{1/2} Q_X - \varepsilon\tau^{-1/2} Q_M \ : \ (Q_D, Q_X, Q_M, X_K, X_L) \in \Psi\}, \end{aligned} \tag{1}$$

where Q_D represents a combination of consumption, investment, and government purchases, τ is the terms of trade, defined as the price of exports relative to that of imports:

$$\tau_t \equiv \frac{P_{X,t}}{P_{M,t}}, \tag{2}$$

and ε is the real effective exchange rate (given the terms of trade), or the Salter ratio, defined as the relative price of traded to domestic goods:[8]

$$\varepsilon_t \equiv \frac{P_{X,t}^{1/2} P_{M,t}^{1/2}}{P_{D,t}}. \tag{3}$$

Note that the real GDP in the conventional national accounts can be thought of as nominal GDP deflated by an implicit GDP deflator (P_Y):

$$Q_Y \equiv (P_D Q_D + P_X Q_X - P_M Q_M)/P_Y. \tag{4}$$

The difference between the real GDI defined in equation (1) and the real GDP thus reflects essentially the difference between the deflators:

$$\kappa_t \equiv \frac{Q_{Z,t}}{Q_{Y,t}} = \frac{P_Y}{P_D}. \tag{5}$$

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6. This is consistent with the assumptions of the traditional trade theories.
7. This identity is defined for each time period t, but the time subscript is omitted for simplification of notation.
8. An increase in the Salter ratio denotes a real depreciation of the home currency. We assume that the trade prices are precisely estimated with nominal exchange rate pass-through appropriately accounted for by Statistics Canada. We further assume that domestic price differentials between countries, in themselves, play no role in firms' production decisions. See Kohli (2008) for a discussion of this ratio.

Kohli (2008) refers to this ratio as the trading gains, which captures the changes in real aggregate income resulting from movements in the terms of trade and the real effective exchange rate. When large movements in trading gains occur, the GDP measure fails to provide an accurate picture of changes in real income, leading to underestimation when trading gains improve, or overestimation vice versa. Chart 2 depicts the indices of $\kappa, \tau,$ and ε in the Canadian economy over the 1961–2006 period.[9] The trading-gains index shows considerable volatility over time, with sharp increases tending to be reversed completely later on. However, there have been episodes where the rise and the fall in trading gains each lasted multiple years. For example, trading gains increased by about 3.4 per cent cumulatively between 1971 and 1976, only to be reversed gradually over the next decade. This was mainly associated with an initial 15.2 per cent gain and a subsequent unwinding in Canada's terms of trade. The most recent uptick in trading gains started in 2003, again coinciding with a surge in terms of trade. Unlike in the early 1970s—when the gains in the terms of trade were due to export price growth that outpaced the growth in import prices—this time round, the rise in the terms of trade was as much propelled by falling import prices as by surging export prices (Chart 3).[10] By 2006, Canada's trading gains had reached a level unsurpassed in at least the previous 45 years.[11] With commodity prices and the Canadian dollar correcting downward recently, the trading-gains index has reversed course as well, but there likely is still some way to go before the trading gains accumulated over the past five years will be entirely wiped out. Chart 2 also indicates that there is some correlation between the real effective exchange rate and trading gains, although the relation is not as strong as in the case of the terms of trade and trading gains.[12]

The importance of the terms of trade and the real effective exchange rate in explaining the growth in trading gains and real GDI can be assessed empirically by estimating the model

9. The appendix contains a description of the data used in this study.
10. The cumulative decline in Canada's import prices since 2003 reached 11 per cent by the first half of 2008. Export prices increased at a pace of 12.5 per cent over the same period.
11. By the first half of 2008, the trading-gains index reached a level almost 8 per cent higher than that registered in 2002. In other words, terms-of-trade gains and the rise in the relative price of traded and non-traded goods/services generated 8 per cent more real income than indicated by real GDP over this 6-year span.
12. As we will show later in this paper, the growth in trading gains is essentially a weighted average of the growth in the terms of trade and the growth in the real exchange rate. The weight for the former is roughly $\frac{0.5(V_X + V_M)}{V_{GDP}}$, while the weight for the latter is $\frac{V_X - V_M}{V_{GDP}}$, where V stands for nominal values of export (X), import (M), and GDP. When $V_M > \frac{V_X}{3}$, the terms of trade get more weight and thus correspond more closely with trading gains. Such is the case in Canada.

outlined in equation (1) with a suitable functional form.[13] Following Kohli (2008), we adopt the translog function shown in equation (6) as a second-order approximation in logarithms of an arbitrary real GDI function, with the usual homogeneity and symmetry conditions imposed:

$$\begin{aligned}\ln Q_{Z,t} = {} & \ln X_{L,t} + \alpha_0 + \alpha_\tau \ln \tau_t + \alpha_\varepsilon \ln \varepsilon_t + \beta_K \ln(X_{K,t} / X_{L,t}) \\ & + \frac{1}{2}\gamma_{\tau\tau} \ln \tau_t^2 + \gamma_{\tau\varepsilon} \ln \tau_t \ln \varepsilon_t + \frac{1}{2}\gamma_{\varepsilon\varepsilon} \ln \varepsilon_t^2 + \frac{1}{2}\phi_{KK} \ln(X_{K,t} / X_{L,t})^2 \\ & + \delta_{\tau K} \ln \tau_t \ln(X_{K,t} / X_{L,t}) + \delta_{\varepsilon K} \ln \varepsilon_t \ln(X_{K,t} / X_{L,t}) + \delta_{\tau T} \ln \tau_t t + \delta_{\varepsilon T} \ln \varepsilon_t t \\ & + \phi_{KT} \ln(X_{K,t} / X_{L,t}) t + \beta_T t + \frac{1}{2}\phi_{TT} t^2,\end{aligned} \tag{6}$$

where t denotes technology, as proxied by the time trend. Logarithmic first differentiation of equation (6) yields the following first-order conditions in share form:

$$\frac{\partial \ln Z(\cdot)}{\partial \ln \tau} = S_{A,t} = \alpha_\tau + \gamma_{\tau\tau} \ln \tau_t + \gamma_{\tau\varepsilon} \ln \varepsilon_t + \delta_{\tau K} \ln(X_{K,t} / X_{L,t}) + \delta_{\tau T} t, \tag{7}$$

$$\frac{\partial \ln Z(\cdot)}{\partial \ln \varepsilon} = S_{B,t} = \alpha_\varepsilon + \gamma_{\tau\varepsilon} \ln \tau_t + \gamma_{\varepsilon\varepsilon} \ln \varepsilon_t + \delta_{\varepsilon K} \ln(X_{K,t} / X_{L,t}) + \delta_{\varepsilon T} t, \tag{8}$$

$$\frac{\partial \ln Z(\cdot)}{\partial \ln X_K} = S_{K,t} = \beta_K + \delta_{\tau K} \ln \tau_t + \delta_{\varepsilon K} \ln \varepsilon_t + \phi_{KK} \ln(X_{K,t} / X_{L,t}) + \phi_{KT} t, \tag{9}$$

$$\frac{\partial \ln Z(\cdot)}{\partial \ln X_L} = S_{L,t} = 1 - \beta_K - \delta_{\tau K} \ln \tau_t - \delta_{\varepsilon K} \ln \varepsilon_t - \phi_{KK} \ln(X_{K,t} / X_{L,t}) - \phi_{KT} t, \tag{10}$$

$$\frac{\partial \ln Z(\cdot)}{\partial t} = \mu_t = \beta_T + \delta_{\tau T} \ln \tau_t + \delta_{\varepsilon T} \ln \varepsilon_t + \phi_{KT} \ln(X_{K,t} / X_{L,t}) + \phi_{TT} t, \tag{11}$$

where S_A is the average share of exports and imports in nominal GDP (i.e., the conventional trade openness measure divided by two), S_B is the share of trade balance in nominal GDP, S_K and S_L are, respectively, the shares of capital and labour income in nominal GDP, and μ is the rate of technological change, proxied by the growth rate of multifactor productivity (MFP). The system of equations (6)–(8) and (10)–(11) can be estimated jointly to maximize efficiency. Note that equation (9) is dropped, since the two factor income shares sum up to one. In this setting, the real GDI, the openness of trade, the trade balance, and the labour share of income are all

13. While Kohli (2006, 2007) and Diewert (2008) calculate trading gains and contributions from terms of trade based on a superlative index number approach without estimation of a model, they do rely on the assumption that the real GDI function can be exactly represented by a translog function. We choose to let the data speak and therefore take an estimation approach to verify the suitability of the translog function.

functions of the terms of trade, the real effective exchange rate (or the relative price of tradables), the capital intensity, and the time trend.

2.2 Estimation results: baseline model

The baseline model was estimated by iterative three-stage least squares (3SLS) to account for potential correlation between the right-hand-side variables and the error terms (endogeneity), as well as heteroskedasticity and contemporaneous correlation in the residuals.[14] The following instruments were used: lagged values of the terms of trade (in logarithm), lagged values of the real effective exchange rate (in logarithm), capital and labour inputs (in logarithm), real government expenditures on goods and services (in logarithm), government savings as a share of GDP, the Bank Rate, and the time trend and its squared value. These variables were chosen because they likely correlate with domestic demand and supply conditions that have an impact on various prices.

We apply the model to both the total Canadian economy (parameter estimates in Table 1) and the business sector (Table 2) over the 1961–2006 period. The data for the total-economy models largely come from the System of National Accounts and the KLEMS database maintained by Statistics Canada. Business sector data are from Diewert (2008). This latter dataset contains adjustments to, among other things, official Statistics Canada series on domestic demand components, in order to account for transactions in goods and services between the business and non-business sectors and the export taxes/import duties that distort the prices faced by the producers. Moreover, Diewert (2008) provides an estimate of the price of capital that yields a different profile of the growth in aggregate capital services, as compared with KLEMS.[15] The differences in the source data and in the methodology used to derive the user cost of capital make it difficult to judge which price deflator of capital is superior.[16] We therefore experiment with both—Models I and III use the deflator from Diewert (2008), while Models II, IV, and V use the deflator from KLEMS. A second experiment is to substitute the time trend in the model with the

14. The model was also estimated using iterative seemingly unrelated regression (SUR) under the assumption of strict exogeneity. Results are not shown, but available upon request. Overall, they are very similar to those obtained with 3SLS.
15. The average annual growth rate of business sector capital services in the KLEMS database is close to 5 per cent, while the corresponding aggregate capital stock grew 3.2 per cent per year. Diewert (2008) estimates the growth rate of capital services to be 3.3 per cent per year, and that of capital stock to be 2.8 per cent.
16. Among the differences, the KLEMS deflator is based on a formula for user cost of capital that contains the capital gains term (Diewert 2008 does not), and it is derived bottom-up from a much more refined set of assets (30 types) with different rates of return by industry, whereas Diewert (2008) applies one aggregate rate of return to five major groups of assets listed in the National Balance Sheets. According to Diewert (2008), such differences explain only part of the discrepancy between the two sets of capital stock and service profiles.

share of information and communications technology (ICT) capital in total capital as a proxy for the state of technology. This is motivated by the finding in Leung and Zheng (2008) that ICT accumulation appears to partly explain the long-term growth in MFP. Owing to space limitations, we provide the results of this substitution only for the business sector using the KLEMS price of capital (Model V).

Judging by the values of the t-statistic in Tables 1 and 2, the majority of the coefficients are highly significant in all variants of the baseline model. While only indicative in nature, the values of R^2 of each equation shown at the bottom of the tables suggest that the equation of MFP has a poor fit, regardless of the proxy for technology used in the model. Dropping this equation does not change the rest of the estimates in a material way; therefore, we will keep this equation in the system for the sake of completeness.[17]

The value and sign of the coefficients differ somewhat by model. As expected, the use of different price deflators for capital has a noticeable influence on the coefficients attached to the capital-intensity term in the system. The total-economy model seems more sensitive than the business sector model in that some other coefficients are affected as well. This could be due to imprecise measurement of capital prices in the non-business sector.[18] Substituting the ICT share of capital for the time trend tends to have a less pronounced impact on the coefficients, but the overall goodness-of-fit of the model is not improved.

Table 4 summarizes the effects of changes in the terms of trade, the real effective exchange rate, capital intensity, and technology on trade openness, trade balance, and the labour share of income over the 1961–2006 period.[19] The effects are calculated by substituting estimated parameter values into the first-differenced share equations (7), (8), and (10). Results vary by model, but, again, those obtained for the business sector are more robust to the choice of capital price deflator than their total-economy counterpart. The two total-economy models attribute the increase of 34 percentage points (2×0.169) in Canada's trade relative to GDP exclusively to technological progress.[20] The two models are also consistent in suggesting that technology improvement penalizes the income share of labour (down 4 percentage points relative to GDP),

17. Kohli (2008) also reports a poor fit for the MFP equation for the U.S. economy, although the goodness of fit in his paper seems higher for the trade openness and trade balance equations.
18. The data on the non-business sector regarding capital and labour inputs were obtained through a special request to the Statistics Canada KLEMS program, since such data are not published.
19. Charts 4–7 depict the evolution of capital intensity, trade openness, trade balance, and labour share of income in Canada over 1961–2006.
20. Recall that technology here could mean institutional or policy improvements. The signing of the two free trade agreements would fit into this category.

but this effect is mitigated substantially by rising capital intensity. The fact that capital intensity is labour share enhancing is consistent with a Hicksian elasticity of complementarity greater than one between the two primary factors of production.[21] Either technology or capital intensity could be the driving force behind the 3 percentage point increase in the trade balance relative to GDP in the total economy. In the case of the business sector, capital intensity has been found to associate most closely with the rise in both the openness of trade and the trade balance over time, while technology's effect on the labour income share remains negative.

Throughout, the real exchange rate effects appear to be quite small. It is somewhat surprising that the terms of trade tend to be negatively correlated with trade openness and trade balance, since one would normally expect improving terms of trade to encourage firms to engage in international trade and to boost trade surplus or reduce the deficit as imports become cheaper relative to exports, *ceteris paribus*. However, all else is not equal. In Canada's case, although its terms-of-trade gains slowed considerably following a peak around the mid-1970s, and did not regain upward momentum until 2003, its volume of trade relative to real GDP rose substantially over the same period, largely benefiting from the growing economic ties with the United States, especially following the signing of the two free trade agreements in the early 1990s. The growth in the volume of exports had been equal to or ahead of that of imports until 2000, thus lending support to trade balance even if terms-of-trade gains slowed. The negative correlation between the terms of trade and Canada's trade openness/trade balance after 2000 is likely due to a combination of cyclical and structural factors. Specifically, the U.S. recession in 2000–01 and one-off events such as the SARS outbreak and the mad-cow scare in 2003 sharply reduced demand for Canadian exports for an extended period of time. Since 2003, Canada's terms of trade have experienced a large gain, thanks to a substantial rise in the export price of commodities driven by accelerating demand from the emerging economies, on the one hand, and a sharp fall in the prices of goods imported from those economies on the other. Another likely explanation for the negative association between Canada's terms of trade and its trade balance and trade openness is that the increases in commodity prices that drove up the terms of trade also tended to cause the home currency to appreciate, thereby discouraging real exports of goods and

21. The Hicksian elasticity of complementarity between capital and labour fluctuates between 1.97 and 2 over the entire sample, based on Model I.

services.[22] Such negative effects could overwhelm the positive impact on exports from the primary sector, thus reducing the weight of overall exports in the total economy.[23]

If the real GDI function is well approximated by the translog form, one can decompose the growth in real GDI as follows (Kohli 2007):

$$Z_t = \frac{Q_{Z,t}}{Q_{Z,t-1}} = Z_{\tau,t} \times Z_{\varepsilon,t} \times Z_{K,t} \times Z_{L,t} \times Z_{T,t} \times Zu,t, \tag{12}$$

where the growth factors (1 plus the growth rate) of the terms-of-trade effect, the real effective exchange rate effect, the capital endowment effect, the labour endowment effect, the technological change effect, and the residual effect are defined as:[24]

$$Z_{\tau,t} = \exp[\frac{1}{2}(\hat{S}_{A,t} + \hat{S}_{A,t-1}) \ln \frac{\tau_t}{\tau_{t-1}}], \tag{13}$$

$$Z_{\varepsilon,t} = \exp[\frac{1}{2}(\hat{S}_{B,t} + \hat{S}_{B,t-1}) \ln \frac{\varepsilon_t}{\varepsilon_{t-1}}], \tag{14}$$

$$Z_{K,t} = \exp[\frac{1}{2}(\hat{S}_{K,t} + \hat{S}_{K,t-1}) \ln \frac{X_{K,t}}{X_{K,t-1}}], \tag{15}$$

$$Z_{L,t} = \exp[\frac{1}{2}(\hat{S}_{L,t} + \hat{S}_{L,t-1}) \ln \frac{X_{L,t}}{X_{L,t-1}}], \tag{16}$$

$$Z_{T,t} = \exp[\frac{1}{2}(\hat{\mu}_t + \hat{\mu}_{t-1})], \tag{17}$$

$$Z_{u,t} = \frac{(Q_{Z,t} / Q_{Z,t-1})}{(\hat{Q}_{Z,t} / \hat{Q}_{Z,t-1})}. \tag{18}$$

Note that the product of $Z_{\tau,t}$ and $Z_{\varepsilon,t}$ gives the estimated growth factor of trading gains, κ_t. Tables 5 and 6 report the decomposition of real GDI for Canada from 1961 to 2006, based on Model I (total economy) and Model III (business sector), respectively. The growth factor of real

22. See Bailliu and King (2005) for a review of the determinants of exchange rate movements.
23. This is exactly what would be predicted by ToTEM (see Fenton and Murchison 2006).
24. Fitted values are denoted by a $\hat{}$ (hat).

GDP is also listed, for comparison. Annual averages for the entire sample and subsamples are given toward the bottom of the tables. Between 1961 and 2006, real GDI in Canada grew at an annual average rate of 3.6 per cent for the total economy and 4.1 per cent for the business sector. Quality-adjusted labour input was the leading contributing factor, accounting for somewhat less than half of the growth in real GDI in both cases. In the long run, trading gains contributed only about 0.1 percentage points per year to real GDI growth in the total economy and 0.2 percentage points in the business sector—a much smaller contribution compared with technology. Over the last 10 years of the sample, however, trading gains (essentially, terms-of-trade effects) contributed 0.4 percentage points per annum to total-economy real GDI growth, double the contribution from changes in technology. The contribution from trading gains in the business sector was even larger, at 0.7 percentage points a year. The gap between real GDP and real GDI growth widened significantly over the 2003–06 period (and this continued until early 2008), to an annual average of 1.2 per cent in the total economy and 2.2 per cent in the business sector. A surge in the terms of trade played a predominant role, since the fall in the relative price of traded to domestic goods due to the exchange rate appreciation tended to depress trading gains and had a marginal negative impact on real GDI over the same period.

Real GDP over- or underestimates real income growth in the total economy by more than 1 percentage point in 9 out of 46 years in the sample, and, in 7 years out of 46, the business sector's real income growth is more than 2 percentage points higher or lower than the rate indicated by real GDP. Clearly, the large impact from trading gains or losses from time to time renders economic decision-making challenging for agents in the economy, although it tends to even out over longer periods of time.

On a per capita basis, the growth in real GDI in Canada averaged 2.3 per cent per year between 1961 and 2006, only marginally above the growth rate in real GDP per capita (Table 7). The contribution from trading gains amounted to more than 40 per cent of the real income gains over 2003–06. The growth in capital intensity and labour input remain the two most important drivers in the long run, but with the population growth effect filtered out, their role is more comparable in size to that of technology. One also notices that per capita real income growth in the 1996–2006 episode benefited more from hours worked than from labour quality improvements, compared with earlier times.

Bringing total hours worked to both sides of equation (12) yields a decomposition of real GDI per hour into contributions from the trading-gains effect (terms of trade and real exchange rate), the factor-endowment effect (capital intensity and labour quality), the technology effect, and the residual effect. Charts 8 and 9 show the cumulative contribution of these effects since 1961 for

the total Canadian economy (Model I) and the business sector (Model III). The lowest line (TG) represents the trading-gains effect, the next line up (TG_KL) adds the factor-endowment effect, the third line (TG_KL_T) further includes the effects from technological change, and finally the observed real GDI per hour (QZPH) is depicted along with the conventional measure of labour productivity (QYPH). Real GDI per hour more than doubled in the total economy and almost tripled in the business sector over the 1961—2006 period. Technological change has been the driving force in real GDI per hour, followed by the growth in capital intensity and labour quality. The conventional measure of labour productivity understates the real income earned per hour of labour in Canada, since it does not take into consideration the trading gains, which would add 0.1 (0.25) percentage points a year, on average, to the growth rate of real GDP per hour in the total economy (business sector).

It is well known that labour productivity growth in Canada has lagged that of the United States, with the gap averaging 1.5 percentage points per year between 2000 and 2007. How does real GDI per hour in Canada compare with that in the United States? Chart 10 illustrates the performance of Canada's labour productivity (real GDP per hour), real GDI per hour, and the decomposition of real GDI per hour vis-à-vis those of the United States.[25] Relative to the situation in 1970, Canada's cumulative growth in labour productivity had been 9 percentage points short of that in the United States by 2005, largely due to a widening gap on the technology front. Indeed, the growth in capital intensity has been in favour of Canada since the mid-1980s.[26] On the other hand, Canada's real GDI per hour had grown 1 per cent faster than in the United States by 2005, as the shortfall in labour productivity growth relative to that in the United States was more than offset by Canada's lead on trading gains. Therefore, the growth rate in the average "purchasing power" generated by one hour of work in Canada has kept up with that in our southern neighbour as far as the past three and a half decades are concerned.

25. Data used in this comparison apply to the total economy. U.S. data are obtained from Kohli (2008).
26. The level of real output per hour in the United States in 2005 was 1.712 times its level in 1970. In Canada, the corresponding growth factor was 1.623; thus, between 1970 and 2005, Canada's labour productivity grew (1.623/1.712-1) 5 per cent less than in the United States. Note also that the contribution from factor endowments to labour productivity growth includes both capital intensity and labour quality for Canada, but only capital intensity for the United States. Therefore, the factor-endowment gap in favour of Canada is exaggerated. However, the U.S. technology advantage would be similarly exaggerated as well.

3 Alternative Model with Flexible Labour Input

3.1 Specification

In the baseline model discussed above, both capital and labour inputs are treated as given, along with product prices. This treatment is consistent with the traditional international trade theory, which assumes that factor endowments are exogenous. It is appropriate in cases where the supply of factors is inelastic, for example, over a short period of time. In other cases, there may be rigidities in the rental price of some factors, while the supply of such factors could be rather elastic. Labour input, especially over the medium run, may fit into this latter category. We therefore consider an alternative specification to equation (1), called the real capital-cost function, that treats the prices of exports, imports, domestic absorption, and labour, along with the supply of capital, as exogenous:

$$\begin{aligned} Q_K &= R(\tau, \varepsilon, \omega, X_K, t) = (P_D Q_D + P_X Q_X - P_M Q_M - P_L X_L)/P_D \equiv \\ &\max_{Q_D, Q_X, Q_M, X_L} \{Q_D + \varepsilon\tau^{1/2} Q_X - \varepsilon\tau^{-1/2} Q_M - \omega X_L \ : \ (Q_D, Q_X, Q_M, X_K, X_L) \in \Psi\}, \end{aligned} \tag{19}$$

where ω is the real rental price of labour, defined as:

$$\omega_t \equiv \frac{P_{L,t}}{P_{D,t}}. \tag{20}$$

The translog representation of the real capital-cost function is as follows:[27]

$$\begin{aligned} \ln Q_{K,t} = \ln X_{K,t} &+ \alpha_0' + \alpha_\tau' \ln \tau_t + \alpha_\varepsilon' \ln \varepsilon_t + \alpha_\omega' \ln \omega_t \\ &+ \frac{1}{2}\gamma_{\tau\tau}' \ln \tau_t^2 + \gamma_{\tau\varepsilon}' \ln \tau_t \ln \varepsilon_t + \frac{1}{2}\gamma_{\varepsilon\varepsilon}' \ln \varepsilon_t^2 + \frac{1}{2}\gamma_{\omega\omega}' \ln \omega_t^2 \\ &+ \delta_{\tau\omega}' \ln \tau_t \ln \omega_t + \delta_{\varepsilon\omega}' \ln \varepsilon_t \ln \omega_t + \delta_{\tau T}' \ln \tau_t t + \delta_{\varepsilon T}' \ln \varepsilon_t t \\ &+ \phi_{\omega T}' \ln \omega_t t + \beta_T' t + \frac{1}{2}\phi_{TT}' t^2, \end{aligned} \tag{21}$$

27. This is a variant of the variable profit function in Kohli (1983, 1991).

with the following first-order conditions in share form:

$$\frac{\partial \ln R(\cdot)}{\partial \ln \tau} = S_{A,t}^{'} = \alpha_{\tau}^{'} + \gamma_{\tau\tau}^{'} \ln \tau_t + \gamma_{\tau\varepsilon}^{'} \ln \varepsilon_t + \delta_{\tau\omega}^{'} \ln \omega_t + \delta_{\tau T}^{'} t, \tag{22}$$

$$\frac{\partial \ln R(\cdot)}{\partial \ln \varepsilon} = S_{B,t}^{'} = \alpha_{\varepsilon}^{'} + \gamma_{\tau\varepsilon}^{'} \ln \tau_t + \gamma_{\varepsilon\varepsilon}^{'} \ln \varepsilon_t + \delta_{\varepsilon\omega}^{'} \ln \omega_t + \delta_{\varepsilon T}^{'} t, \tag{23}$$

$$\frac{\partial \ln R(\cdot)}{\partial \ln \omega} = S_{L,t}^{'} = -\alpha_{\omega}^{'} - \delta_{\tau\omega}' \ln \tau_t - \delta_{\varepsilon\omega}^{'} \ln \varepsilon_t - \gamma_{\omega\omega}^{'} \ln \omega - \phi_{\omega T}^{'} t, \tag{24}$$

$$\frac{\partial \ln R(\cdot)}{\partial t} = \mu_t^{'} = \beta_T^{'} + \delta_{\tau T}^{'} \ln \tau_t + \delta_{\varepsilon T}^{'} \ln \varepsilon_t + \phi_{\omega T}^{'} \ln \omega + \phi_{TT}^{'} t, \tag{25}$$

where shares on the left-hand-side are as defined before, but relative to nominal capital income, rather than nominal GDP.

3.2 Estimation results: alternative model

Table 3 provides the parameter estimates for the alternative model as applied to the total economy (Model I-a) and the business sector (Model III-a). Both versions of the model adopt the Diewert (2008) deflator for capital costs and include a time trend as a proxy for technology. Thus they are broadly comparable to Model I and Model III, except that the alternative models assume flexible labour supply with given wage rates, while the baseline models treat wage rates as variable given labour endowment. As in the case of the baseline models, the vast majority of the parameter estimates are statistically significant and the MFP equation has a poor fit. In the case of Model III-a, the goodness-of-fit of the trade balance equation turns negative, but the other equations are not affected.

With the fitted values of the left-hand-side variables in equations (21)–(25), one may calculate the fitted values of real GDI, the shares of trade openness, trade balance, capital income, and labour income in nominal GDP according to the following rules of transformation:

$$\hat{Q}_{Z,t} = \hat{Q}_{K,t} \cdot (1 + \hat{S}_{L,t}^{'}), \tag{26}$$

$$\hat{S}_{A,t} = \frac{\hat{S}_{A,t}^{'}}{(1 + \hat{S}_{L,t}^{'})}, \tag{27}$$

$$\hat{S}_{B,t} = \frac{\hat{S}'_{B,t}}{(1+\hat{S}'_{L,t})}, \tag{28}$$

$$\hat{S}_{K,t} = \frac{1}{(1+\hat{S}'_{L,t})}, \tag{29}$$

$$\hat{S}_{L,t} = \frac{\hat{S}'_{L,t}}{(1+\hat{S}'_{L,t})}, \tag{30}$$

One could thus obtain an alternative decomposition of the growth in real GDI per hour. To conserve space, only the results for the total economy based on Model I-a are shown (Chart 11). In comparison with the results obtained from Model I (Table 8), technology, while still the main driver, contributed less to real GDI per hour over the period 1961–73, but it was more important in the last 10 years of the sample (1996–2006). In both episodes, the residual term provided an offset, so that the results pertaining to other contributing factors (trading gains, capital intensity, and labour quality) were little changed from the baseline model. For the two decades between 1974 and 1995, there is almost no difference in the decomposition results, regardless of the model. Since the residuals in Model I-a decline over time relative to those in Model I, one implication of this exercise is that the assumption of flexible labour input in Canada has become increasingly more plausible.

4 Conclusion

Trading gains or losses stemming from changes in the terms of trade or the real exchange rate can exert significant influence on an open economy's real income from time to time, leaving real GDP an inadequate measure of a country's "purchasing power." Even if the income gains generated by swings in the terms of trade may not be as durable as those generated by improvements in productivity, there is no fundamental difference between the two forces in their relevance to determining living standards. Indeed, the strong growth in Canada's domestic demand over the past five years wouldn't have been sustained without the advances in the terms of trade that accounted for a third of the real income gains. By the same token, the recent sharp decline in commodity prices in anticipation of a global recession, as well as the abatement of the downward price trend of imports from low-cost countries, may well lead to an abrupt fall in Canada's terms of trade, thus exacerbating the dampening effect of slowing output growth in Canada on domestic demand.

Our empirical results indicate that technological changes and capital deepening played leading roles in the rising trade openness, trade balance, and declining labour share of income in Canada over the past four and a half decades. Another interesting finding is that the cumulative growth in Canada's real income per hour of work between 1970 and 2005 kept up with that of the United States, even though our cumulative growth in real GDP per hour fell behind by as much as 9 percentage points as of 2005.

The model we adopted in this paper does have limitations. It has no mechanism for exploring the direction of causality between the various relative-price ratios (terms of trade, exchange rate, trading gains) and the variables on the left-hand-side (real GDI, trade openness, trade balance, and labour share of income). It does not allow both labour input and wage rates to vary, as would be the case in a flexible labour market. Nor does it allow both labour and capital inputs to be variable. These would be interesting extensions for future research.

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Table 1
Parameter Estimates for Total-Economy Baseline Models

(*t*-values are shown in parentheses; all models are estimated by iterative 3-stage least squares)

	Model I	Model II
$\hat{\alpha}_0$	0.773 (40.961)	0.759 (47.305)
$\hat{\alpha}_\tau$	0.111 (7.300)	0.144 (14.404)
$\hat{\alpha}_\varepsilon$	-0.012 (-1.543)	0.002 (0.356)
$\hat{\beta}_K$	0.319 (37.383)	0.389 (88.906)
$\hat{\gamma}_{\tau\tau}$	-0.600 (-5.581)	-0.247 (-2.860)
$\hat{\gamma}_{\tau\varepsilon}$	-0.207 (-5.320)	0.011 (0.316)
$\hat{\gamma}_{\varepsilon\varepsilon}$	-0.004 (-0.135)	0.003 (0.112)
$\hat{\phi}_{KK}$	-0.242 (-11.143)	-0.084 (-6.156)
$\hat{\delta}_{\tau K}$	-0.162 (-5.558)	-0.052 (-2.204)
$\hat{\delta}_{\varepsilon K}$	-0.038 (-2.059)	0.028 (1.948)
$\hat{\delta}_{\tau T}$	0.006 (12.369)	0.007 (8.310)
$\hat{\delta}_{\varepsilon T}$	0.001 (6.092)	-0.000 (-0.261)
$\hat{\phi}_{KT}$	0.003 (16.195)	0.004 (8.610)
$\hat{\beta}_T$	0.009 (6.475)	-0.007 (-4.648)
$\hat{\phi}_{TT}$	-0.000 (-3.347)	-0.000 (-1.732)
R_Z^2	0.983	0.992
R_A^2	0.760	0.869
R_B^2	0.397	0.256
R_L^2	0.696	0.798
R_T^2	-0.407	-0.077

Notes:
Model I uses Diewert's (2008) deflator for capital costs.
Model II uses the KLEMS deflator for capital costs.
Both models include a time trend as a proxy for technology.

Table 2
Parameter Estimates for Business Sector Baseline Models

(*t*-values are shown in parentheses; all models are estimated by iterative 3-stage least squares)

	Model III	Model IV	Model V
$\hat{\alpha}_0$	0.602 (29.481)	0.664 (40.986)	0.803 (103.656)
$\hat{\alpha}_\tau$	0.269 (7.206)	0.338 (10.819)	0.476 (25.243)
$\hat{\alpha}_\varepsilon$	0.148 (7.086)	0.030 (1.436)	0.038 (4.957)
$\hat{\beta}_K$	0.224 (8.735)	0.317 (20.519)	0.322 (84.310)
$\hat{\gamma}_{\tau\tau}$	-0.323 (-2.091)	-0.427 (-2.562)	-0.162 (-0.929)
$\hat{\gamma}_{\tau\varepsilon}$	-0.177 (-2.947)	-0.217 (-3.780)	-0.189 (-3.243)
$\hat{\gamma}_{\varepsilon\varepsilon}$	-0.084 (-1.834)	-0.116 (-2.662)	-0.098 (-2.543)
$\hat{\phi}_{KK}$	-0.072 (-2.537)	0.030 (1.564)	0.034 (5.079)
$\hat{\delta}_{\tau K}$	0.007 (0.166)	0.096 (2.519)	0.223 (9.280)
$\hat{\delta}_{\varepsilon K}$	0.200 (8.911)	0.075 (2.898)	0.053 (5.002)
$\hat{\delta}_{\tau T}$	0.009 (13.212)	0.006 (4.972)	-0.020 (-0.362)
$\hat{\delta}_{\varepsilon T}$	-0.000 (-0.274)	-0.000 (-0.065)	-0.150 (-3.560)
$\hat{\phi}_{KT}$	0.003 (7.668)	0.001 (1.137)	0.063 (3.148)
$\hat{\beta}_T$	0.026 (16.741)	0.011 (7.936)	0.095 (3.977)
$\hat{\phi}_{TT}$	-0.001 (-11.260)	-0.000 (-6.304)	-1.067 (-3.844)
R_Z^2	0.992	0.996	0.987
R_A^2	0.851	0.843	0.771
R_B^2	0.228	0.291	0.230
R_L^2	0.765	0.710	0.658
R_T^2	0.106	0.001	-0.169

Notes:
Model III uses Diewert's (2008) deflator for capital costs.
Model IV uses the KLEMS deflator for capital costs.
Both Models III and IV include a time trend as a proxy for technology.
Model V is a variant of Model IV, but it uses the ICT share of capital as a proxy for technology.

Table 3
Parameter Estimates for Alternative Models

(*t*-values are shown in parentheses; all models are estimated by iterative 3-stage least squares)

	Model I-a	Model III-a
$\hat{\alpha}_0'$	0.390 (9.064)	0.524 (11.215)
$\hat{\alpha}_\tau'$	0.469 (17.566)	0.732 (14.105)
$\hat{\alpha}_\varepsilon'$	0.019 (1.753)	-0.295 (-7.736)
$\hat{\alpha}_\omega'$	-1.195 (-55.065)	-1.930 (-39.040)
$\hat{\gamma}_{\tau\tau}'$	-0.984 (-3.888)	-1.547 (-2.792)
$\hat{\gamma}_{\varepsilon\varepsilon}'$	0.041 (0.725)	0.131 (0.728)
$\hat{\gamma}_{\omega\omega}'$	-1.545 (-17.363)	-2.509 (-10.854)
$\hat{\gamma}_{\tau\varepsilon}'$	-0.322 (-3.740)	-0.391 (-1.873)
$\hat{\delta}_{\tau\omega}'$	-0.059 (-0.599)	1.101 (4.226)
$\hat{\delta}_{\varepsilon\omega}'$	-0.043 (-1.095)	1.131 (10.131)
$\hat{\delta}_{\tau T}'$	0.008 (7.249)	0.010 (4.834)
$\hat{\delta}_{\varepsilon T}'$	0.002 (4.449)	-0.004 (-2.941)
$\hat{\phi}_{\omega T}'$	0.014 (16.099)	0.036 (14.202)
$\hat{\beta}_T'$	0.006 (2.233)	0.024 (6.618)
$\hat{\phi}_{TT}'$	-0.000 (-1.727)	-0.000 (-6.567)
R_R^2	0.899	0.923
$R_{A'}^2$	0.645	0.771
$R_{B'}^2$	0.347	-0.609
$R_{L'}^2$	0.520	0.671
$R_{T'}^2$	-0.671	-0.119

Notes:
Model I-a applies to the total economy.
Model III-a applies to the business sector.
Both models assume a flexible labour supply, use Diewert's (2008) deflator for capital costs, and include a time trend as a proxy for technology.

Table 4
Accounting for Changes in Trade Openness, Trade Balance, and Labour Share, 1961–2006

	Total economy Models		Business sector Models		
	I	II	III	IV	V
Trade openness	*0.169*			*0.249*	
Terms of trade	-0.093	-0.038	0.016	-0.100	-0.038
Real effective exchange rate	0.057	-0.003	0.002	0.019	0.017
Capital intensity	-0.036	-0.079	0.384	0.117	0.273
Technology	0.271	0.330	-0.078	0.276	-0.002
Residual	-0.031	-0.042	-0.075	-0.064	-0.001
Trade balance relative to GDP	*0.030*			*0.058*	
Terms of trade	-0.032	0.002	-0.041	-0.051	-0.044
Real effective exchange rate	0.001	-0.001	0.007	0.010	0.009
Capital intensity	-0.008	0.042	0.076	0.091	0.064
Technology	0.058	-0.006	-0.005	-0.002	-0.011
Residual	0.011	-0.007	0.021	0.009	0.040
Labour share of GDP	*-0.043*			*-0.091*	
Terms of trade	0.025	0.008	-0.002	-0.022	-0.052
Real effective exchange rate	-0.010	0.008	0.018	0.007	0.005
Capital intensity	0.054	0.128	0.027	-0.037	-0.041
Technology	-0.147	-0.193	-0.120	-0.030	-0.005
Residual	0.036	0.007	-0.014	-0.008	0.003

Table 5
Decomposition of Real GDI in Canada: Total Economy, Model I

	Real GDP	Real GDI	Trading gains	Terms of trade	Real exchange rate	Capital input	Labour input	Technology	Residual
1961	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1962	1.066	1.065	0.999	0.999	1.000	0.999	1.026	1.007	1.032
1963	1.055	1.052	0.997	0.997	1.000	1.010	1.018	1.007	1.019
1964	1.066	1.069	1.003	1.003	1.000	0.994	1.026	1.007	1.037
1965	1.064	1.067	1.002	1.003	1.000	1.030	1.026	1.007	1.001
1966	1.068	1.070	1.001	1.001	1.000	1.020	1.030	1.007	1.011
1967	1.025	1.025	1.000	1.000	1.000	1.043	1.019	1.007	0.958
1968	1.050	1.048	0.998	0.998	1.000	1.008	1.005	1.006	1.030
1969	1.048	1.046	0.998	0.998	1.000	1.015	1.016	1.006	1.011
1970	1.033	1.035	1.003	1.003	1.000	1.008	1.005	1.006	1.013
1971	1.053	1.048	0.994	0.994	1.000	1.031	1.013	1.006	1.003
1972	1.048	1.051	1.003	1.004	1.000	1.027	1.019	1.006	0.995
1973	1.068	1.082	1.015	1.015	1.000	0.984	1.031	1.006	1.045
1974	1.032	1.054	1.017	1.017	1.000	1.011	1.021	1.006	0.997
1975	1.024	1.018	0.995	0.996	1.000	0.992	1.005	1.006	1.020
1976	1.049	1.057	1.006	1.006	1.000	1.016	1.002	1.006	1.026
1977	1.043	1.033	0.992	0.992	1.000	1.008	1.008	1.006	1.019
1978	1.039	1.028	0.991	0.991	1.000	1.015	1.019	1.005	0.998
1979	1.031	1.041	1.008	1.008	1.000	1.008	1.025	1.005	0.994
1980	1.016	1.018	1.001	1.001	1.000	1.014	1.018	1.005	0.980
1981	1.032	1.023	0.993	0.993	1.000	1.040	1.015	1.005	0.970
1982	0.970	0.963	0.994	0.995	0.999	1.037	0.982	1.005	0.946
1983	1.029	1.030	1.002	1.002	0.999	0.981	1.007	1.005	1.035
1984	1.055	1.050	0.996	0.996	1.000	0.996	1.018	1.004	1.035
1985	1.045	1.041	0.996	0.997	1.000	1.019	1.020	1.004	1.001
1986	1.024	1.017	0.993	0.993	0.999	1.035	1.020	1.004	0.966
1987	1.043	1.052	1.009	1.010	0.999	1.006	1.024	1.004	1.009
1988	1.043	1.050	1.006	1.007	0.999	1.033	1.023	1.004	0.983
1989	1.028	1.033	1.005	1.006	1.000	1.031	1.015	1.004	0.978
1990	1.001	0.996	0.993	0.994	0.999	1.039	1.005	1.004	0.957
1991	0.978	0.973	0.993	0.994	0.999	1.038	0.990	1.004	0.951
1992	1.011	1.007	0.996	0.995	1.000	1.021	0.999	1.004	0.987
1993	1.024	1.018	0.995	0.994	1.001	0.993	1.011	1.003	1.017
1994	1.045	1.043	0.999	0.998	1.001	0.970	1.014	1.003	1.058
1995	1.022	1.032	1.011	1.010	1.001	1.010	1.011	1.003	0.997
1996	1.016	1.022	1.005	1.006	1.000	0.962	1.010	1.003	1.043
1997	1.040	1.037	0.997	0.998	1.000	1.009	1.010	1.002	1.018
1998	1.042	1.026	0.986	0.986	1.000	1.040	1.013	1.002	0.986
1999	1.055	1.060	1.004	1.005	1.000	1.028	1.017	1.002	1.007
2000	1.050	1.069	1.015	1.015	1.001	0.985	1.016	1.002	1.050
2001	1.017	1.010	0.994	0.994	1.000	1.029	1.008	1.002	0.978
2002	1.027	1.015	0.989	0.991	0.999	1.013	1.010	1.002	1.002
2003	1.017	1.036	1.019	1.021	0.998	1.034	1.010	1.001	0.971
2004	1.031	1.046	1.016	1.016	1.000	0.981	1.017	1.002	1.031
2005	1.028	1.040	1.013	1.013	1.000	1.002	1.008	1.001	1.016
2006	1.032	1.033	1.002	1.002	1.000	1.017	1.010	1.001	1.003

continued…

Table 5 (concluded)
Decomposition of Real GDI in Canada: Total Economy, Model I

	Real GDP	Real GDI	Trading gains	Terms of trade	Real exchange rate	Capital input	Labour input	Technology	Residual
1961 - 2006	1.035	1.036	1.001	1.001	1.000	1.013	1.014	1.004	1.004
1961 - 1973	1.054	1.055	1.001	1.001	1.000	1.014	1.019	1.006	1.013
1974 - 1995	1.026	1.026	1.000	1.000	1.000	1.014	1.011	1.004	0.996
1996 - 2006	1.032	1.036	1.004	1.004	1.000	1.009	1.012	1.002	1.009
2003 - 2006	1.027	1.039	1.012	1.013	0.999	1.008	1.011	1.001	1.005

Table 6
Decomposition of Real GDI in Canada: Business Sector, Model III

	Real GDP	Real GDI	Trading gains	Terms of trade	Real exchange rate	Capital input	Labour input	Technology	Residual
1961	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1962	1.083	1.078	0.996	0.996	0.999	1.003	1.030	1.023	1.025
1963	1.055	1.051	0.997	0.997	1.000	1.005	1.018	1.022	1.008
1964	1.088	1.094	1.005	1.005	1.000	1.006	1.030	1.021	1.028
1965	1.067	1.074	1.006	1.006	1.000	1.010	1.030	1.021	1.005
1966	1.074	1.077	1.003	1.003	1.000	1.014	1.036	1.020	1.002
1967	1.021	1.022	1.001	1.001	1.000	1.018	1.014	1.019	0.970
1968	1.052	1.052	1.000	1.000	1.000	1.013	1.003	1.019	1.016
1969	1.056	1.054	0.998	0.997	1.000	1.010	1.017	1.018	1.011
1970	1.042	1.045	1.003	1.003	1.000	1.011	1.002	1.017	1.010
1971	1.050	1.042	0.992	0.992	1.000	1.010	1.015	1.017	1.008
1972	1.044	1.050	1.006	1.006	1.000	1.009	1.020	1.016	0.998
1973	1.082	1.107	1.023	1.024	1.000	1.009	1.040	1.016	1.014
1974	1.027	1.043	1.014	1.016	0.998	1.013	1.024	1.015	0.977
1975	1.020	1.016	0.997	0.997	1.000	1.016	1.000	1.015	0.989
1976	1.073	1.089	1.014	1.014	1.000	1.016	1.000	1.014	1.042
1977	1.068	1.054	0.988	0.988	0.999	1.015	1.007	1.014	1.030
1978	1.040	1.026	0.987	0.988	1.000	1.014	1.028	1.013	0.984
1979	1.036	1.050	1.012	1.013	0.999	1.013	1.037	1.012	0.975
1980	1.012	1.014	1.002	1.003	0.999	1.017	1.022	1.012	0.964
1981	1.043	1.018	0.979	0.979	1.000	1.015	1.017	1.011	0.996
1982	0.959	0.948	0.989	0.989	1.000	1.019	0.969	1.010	0.963
1983	1.034	1.041	1.008	1.008	0.999	1.007	1.005	1.009	1.012
1984	1.068	1.065	0.997	0.997	1.000	1.005	1.024	1.008	1.029
1985	1.048	1.046	0.998	0.998	1.000	1.008	1.026	1.008	1.005
1986	1.025	1.016	0.992	0.992	1.000	1.010	1.028	1.007	0.981
1987	1.053	1.068	1.015	1.016	1.000	1.009	1.031	1.006	1.005
1988	1.045	1.057	1.012	1.012	1.000	1.012	1.029	1.006	0.997
1989	1.024	1.034	1.010	1.010	1.000	1.015	1.017	1.005	0.986
1990	0.985	0.977	0.989	0.990	1.000	1.015	1.001	1.005	0.967
1991	0.956	0.950	0.989	0.991	0.998	1.010	0.979	1.004	0.968
1992	1.001	0.994	0.994	0.993	1.001	1.007	0.993	1.003	0.997
1993	1.028	1.023	0.996	0.995	1.001	1.003	1.014	1.002	1.006
1994	1.069	1.068	1.000	0.999	1.002	1.003	1.025	1.002	1.037
1995	1.026	1.046	1.019	1.018	1.001	1.006	1.018	1.001	1.001
1996	1.056	1.067	1.010	1.010	1.000	1.008	1.019	1.000	1.029
1997	1.056	1.054	0.999	0.999	1.000	1.010	1.020	1.000	1.025
1998	1.044	1.020	0.980	0.980	1.000	1.018	1.020	0.999	1.005
1999	1.044	1.054	1.008	1.009	1.000	1.016	1.022	0.998	1.008
2000	1.071	1.101	1.024	1.023	1.000	1.015	1.023	0.998	1.039
2001	1.014	1.002	0.990	0.990	1.000	1.016	1.009	0.997	0.991
2002	1.038	1.021	0.985	0.986	0.999	1.011	1.013	0.996	1.017
2003	0.983	1.011	1.031	1.032	0.998	1.008	1.012	0.996	0.966
2004	1.047	1.074	1.028	1.028	1.000	1.007	1.022	0.995	1.020
2005	1.026	1.048	1.023	1.024	1.000	1.011	1.009	0.995	1.009
2006	1.027	1.031	1.005	1.005	1.000	1.013	1.011	0.995	1.007

continued …

Table 6 (concluded)
Decomposition of Real GDI in Canada: Business Sector, Model III

	Real GDP	Real GDI	Trading gains	Terms of trade	Real exchange rate	Capital input	Labour input	Technology	Residual
1961 - 2006	1.039	1.041	1.002	1.003	1.000	1.011	1.016	1.008	1.002
1961 - 1973	1.059	1.062	1.002	1.002	1.000	1.010	1.021	1.019	1.008
1974 - 1995	1.029	1.029	1.000	1.000	1.000	1.011	1.013	1.008	0.996
1996 - 2006	1.037	1.044	1.007	1.008	1.000	1.012	1.016	0.997	1.010
2003 - 2006	1.020	1.041	1.022	1.022	0.999	1.010	1.013	0.995	1.000

Table 7
Decomposition of Real GDI Per Capita in Canada: Total Economy, Model I

	Real GDP	Real GDI	Trading gains	Terms of trade	Real exchange rate	Capital input	Labour input	Hours worked	Labour quality	Technology	Residual
1961	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1962	1.046	1.045	0.999	0.999	1.000	0.992	1.014	1.007	1.007	1.007	1.032
1963	1.036	1.032	0.997	0.997	1.000	1.002	1.007	0.998	1.009	1.007	1.019
1964	1.046	1.049	1.003	1.003	1.000	0.986	1.015	1.007	1.008	1.007	1.037
1965	1.045	1.048	1.002	1.003	1.000	1.022	1.015	1.004	1.011	1.007	1.001
1966	1.049	1.050	1.001	1.001	1.000	1.012	1.019	1.013	1.005	1.007	1.011
1967	1.006	1.006	1.000	1.000	1.000	1.035	1.008	1.003	1.005	1.007	0.958
1968	1.033	1.031	0.998	0.998	1.000	1.001	0.996	0.990	1.006	1.006	1.030
1969	1.033	1.031	0.998	0.998	1.000	1.008	1.007	1.003	1.004	1.006	1.011
1970	1.019	1.021	1.003	1.003	1.000	1.003	0.997	0.993	1.004	1.006	1.013
1971	1.031	1.025	0.994	0.994	1.000	1.022	1.001	0.996	1.005	1.006	1.003
1972	1.027	1.030	1.003	1.004	1.000	1.019	1.007	1.000	1.007	1.006	0.995
1973	1.055	1.069	1.015	1.015	1.000	0.979	1.024	1.018	1.006	1.006	1.045
1974	1.017	1.039	1.017	1.017	1.000	1.005	1.013	1.011	1.002	1.006	0.997
1975	1.009	1.003	0.995	0.996	1.000	0.986	0.996	0.993	1.003	1.006	1.020
1976	1.035	1.043	1.006	1.006	1.000	1.010	0.995	0.992	1.003	1.006	1.026
1977	1.030	1.021	0.992	0.992	1.000	1.003	1.001	0.997	1.004	1.006	1.019
1978	1.028	1.018	0.991	0.991	1.000	1.010	1.013	1.011	1.002	1.005	0.998
1979	1.021	1.031	1.008	1.008	1.000	1.004	1.019	1.019	1.000	1.005	0.994
1980	1.003	1.005	1.001	1.001	1.000	1.008	1.011	1.007	1.004	1.005	0.980
1981	1.019	1.010	0.993	0.993	1.000	1.035	1.008	1.006	1.002	1.005	0.970
1982	0.958	0.952	0.994	0.995	0.999	1.032	0.975	0.967	1.008	1.005	0.946
1983	1.019	1.020	1.002	1.002	0.999	0.977	1.001	0.996	1.005	1.005	1.035
1984	1.045	1.040	0.996	0.996	1.000	0.992	1.013	1.011	1.002	1.004	1.035
1985	1.035	1.031	0.996	0.997	1.000	1.015	1.015	1.015	0.999	1.004	1.001
1986	1.014	1.007	0.993	0.993	0.999	1.031	1.015	1.010	1.005	1.004	0.966
1987	1.030	1.039	1.009	1.010	0.999	1.000	1.017	1.014	1.003	1.004	1.009
1988	1.029	1.036	1.006	1.007	0.999	1.027	1.015	1.012	1.004	1.004	0.983
1989	1.010	1.015	1.005	1.006	1.000	1.023	1.005	1.002	1.004	1.004	0.978
1990	0.986	0.980	0.993	0.994	0.999	1.032	0.997	0.992	1.005	1.004	0.957
1991	0.965	0.960	0.993	0.994	0.999	1.032	0.983	0.976	1.007	1.004	0.951
1992	0.999	0.995	0.996	0.995	1.000	1.017	0.992	0.987	1.006	1.004	0.987
1993	1.012	1.007	0.995	0.994	1.001	0.988	1.004	0.998	1.006	1.003	1.017
1994	1.033	1.032	0.999	0.998	1.001	0.965	1.008	1.007	1.001	1.003	1.058
1995	1.011	1.022	1.011	1.010	1.001	1.005	1.006	1.003	1.003	1.003	0.997
1996	1.006	1.012	1.005	1.006	1.000	0.958	1.004	1.004	1.000	1.003	1.043
1997	1.030	1.027	0.997	0.998	1.000	1.004	1.005	1.003	1.002	1.002	1.018
1998	1.033	1.017	0.986	0.986	1.000	1.036	1.008	1.007	1.001	1.002	0.986
1999	1.046	1.051	1.004	1.005	1.000	1.024	1.013	1.011	1.002	1.002	1.007
2000	1.041	1.059	1.015	1.015	1.001	0.981	1.011	1.007	1.004	1.002	1.050
2001	1.006	1.000	0.994	0.994	1.000	1.024	1.003	0.998	1.004	1.002	0.978
2002	1.016	1.004	0.989	0.991	0.999	1.007	1.004	1.002	1.002	1.002	1.002
2003	1.008	1.027	1.019	1.021	0.998	1.030	1.005	1.003	1.002	1.001	0.971
2004	1.021	1.037	1.016	1.016	1.000	0.976	1.012	1.010	1.002	1.002	1.031
2005	1.018	1.031	1.013	1.013	1.000	0.997	1.003	1.000	1.003	1.001	1.016
2006	1.021	1.023	1.002	1.002	1.000	1.012	1.004	1.004	1.001	1.001	1.003

continued…

Table 7 (concluded)
Decomposition of Real GDI Per Capita in Canada: Total Economy, Model I

	Real GDP	Real GDI	Trading gains	Terms of trade	Real exchange rate	Capital input	Labour input	Hours worked	Labour quality	Technology	Residual
1961 - 2006	1.022	1.023	1.001	1.001	1.000	1.007	1.006	1.002	1.004	1.004	1.004
1961 - 1973	1.035	1.036	1.001	1.001	1.000	1.007	1.009	1.003	1.006	1.006	1.013
1974 - 1995	1.014	1.014	1.000	1.000	1.000	1.009	1.005	1.001	1.004	1.004	0.996
1996 - 2006	1.022	1.026	1.004	1.004	1.000	1.004	1.007	1.004	1.002	1.002	1.009
2003 - 2006	1.017	1.029	1.012	1.013	0.999	1.004	1.006	1.004	1.002	1.001	1.005

Table 8
Decomposition of Real GDI Per Hour: Total Economy (%)

	Model	Real GDI per hour	Trading gains	Capital intensity & labour quality	Technology	Residual
1961–2006	I	1.84	0.10	0.64	0.73	0.37
	I-a	1.84	0.10	0.62	0.64	0.48
1961–1973	I	3.16	0.11	0.66	1.11	1.29
	I-a	3.16	0.10	0.62	0.65	1.79
1974–1995	I	1.16	-0.04	0.89	0.71	-0.41
	I-a	1.16	-0.04	0.89	0.72	-0.41
1996–2006	I	1.77	0.38	0.10	0.37	0.91
	I-a	1.77	0.36	0.09	0.48	0.83
2003–2006	I	2.11	1.25	0.04	0.32	0.51
	I-a	2.11	1.19	0.04	0.50	0.39

Chart 1
Trading Gains, Real Domestic Demand, and Real GDP in Canada
(Index, 2002 = 1)

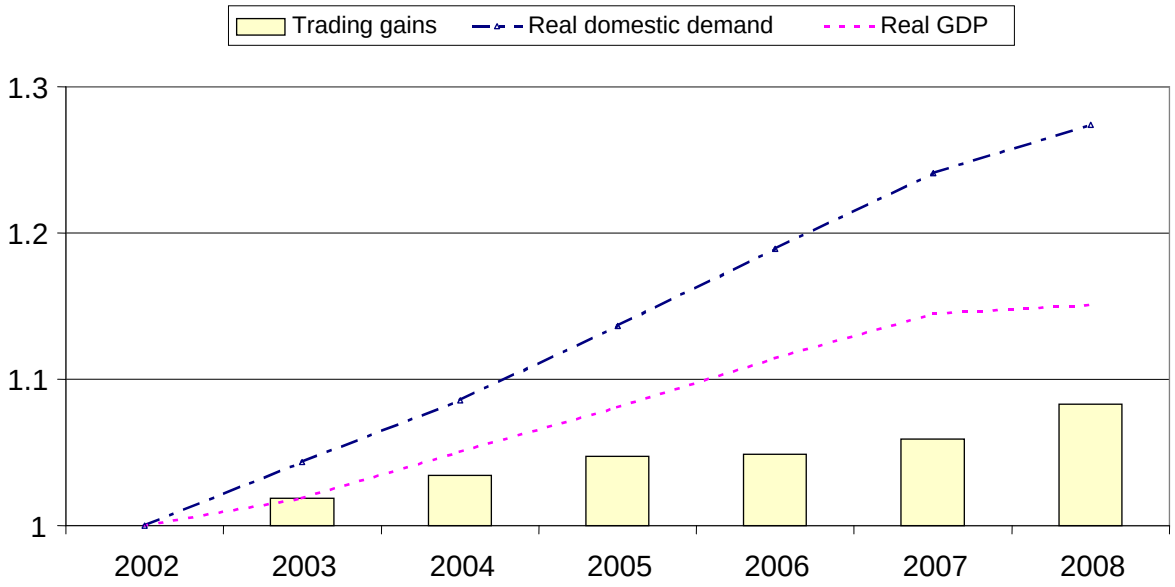


Chart 2
Terms of Trade, Real Effective Exchange Rate, and Trading Gains
(Index, 1961 = 1)

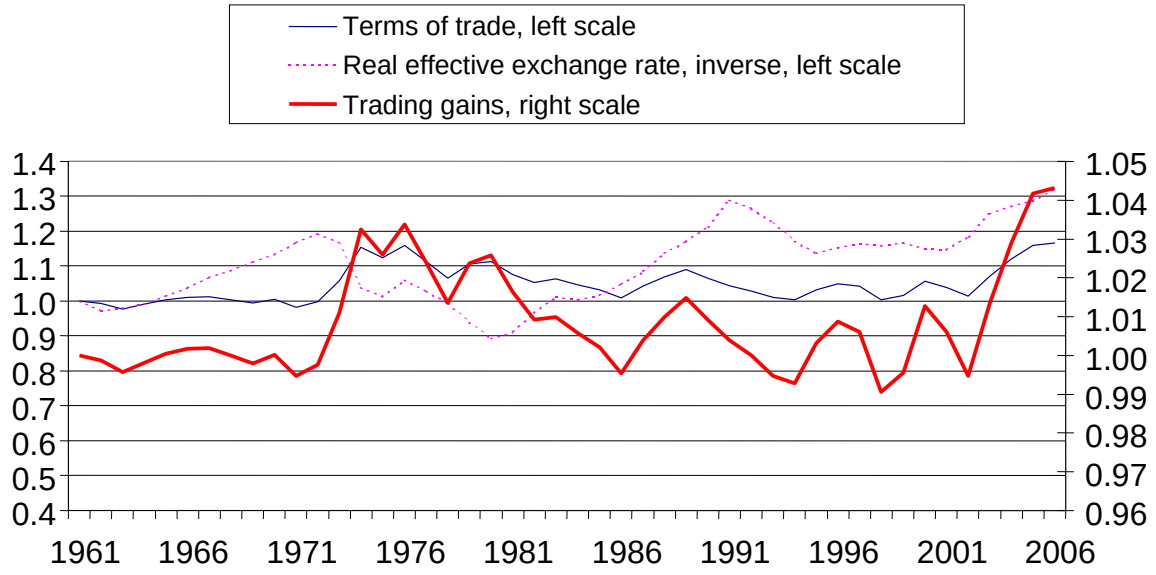


Chart 3
Prices of Exports, Imports, and Terms of Trade
(Index, 1961 = 1)

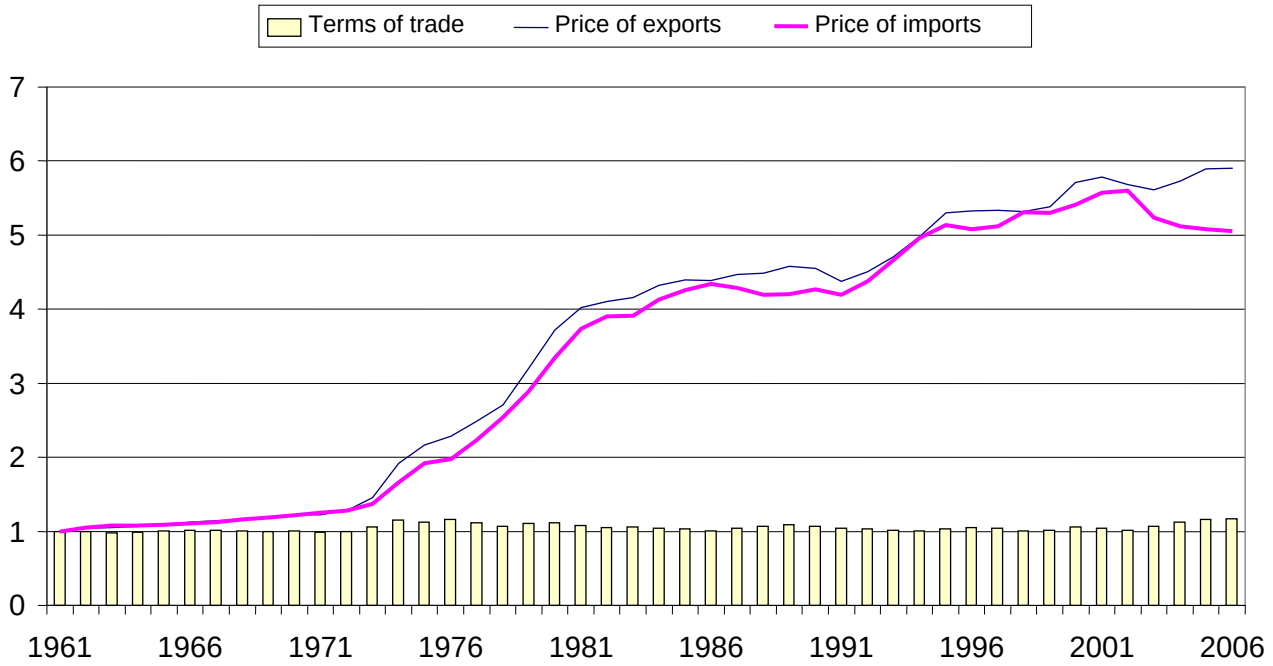


Chart 4
Capital-Labour Ratio

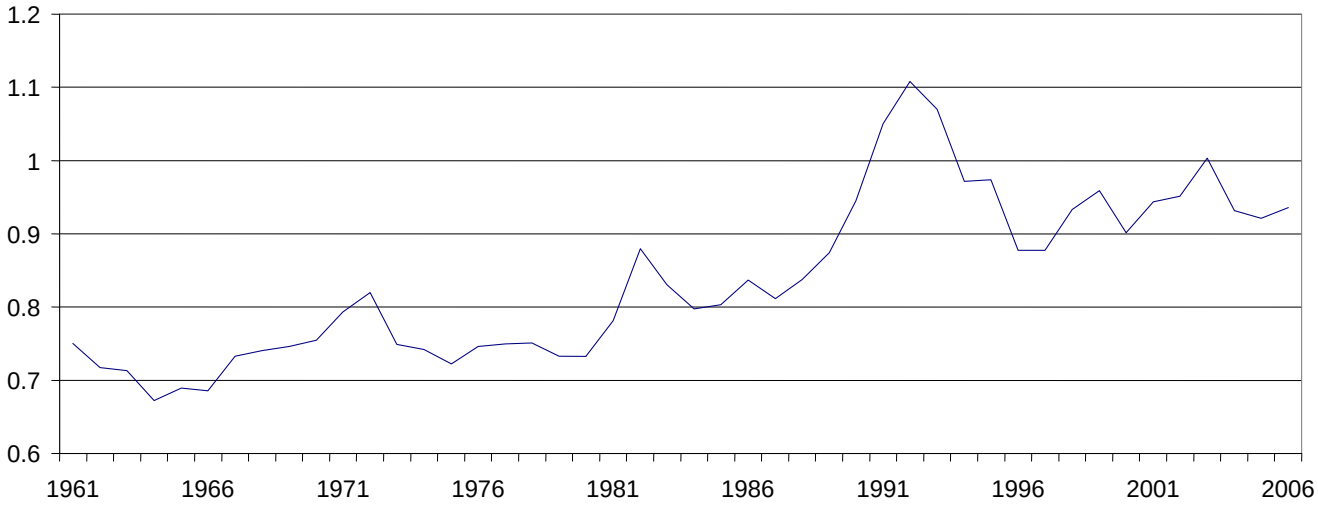


Chart 5
Trade Openness

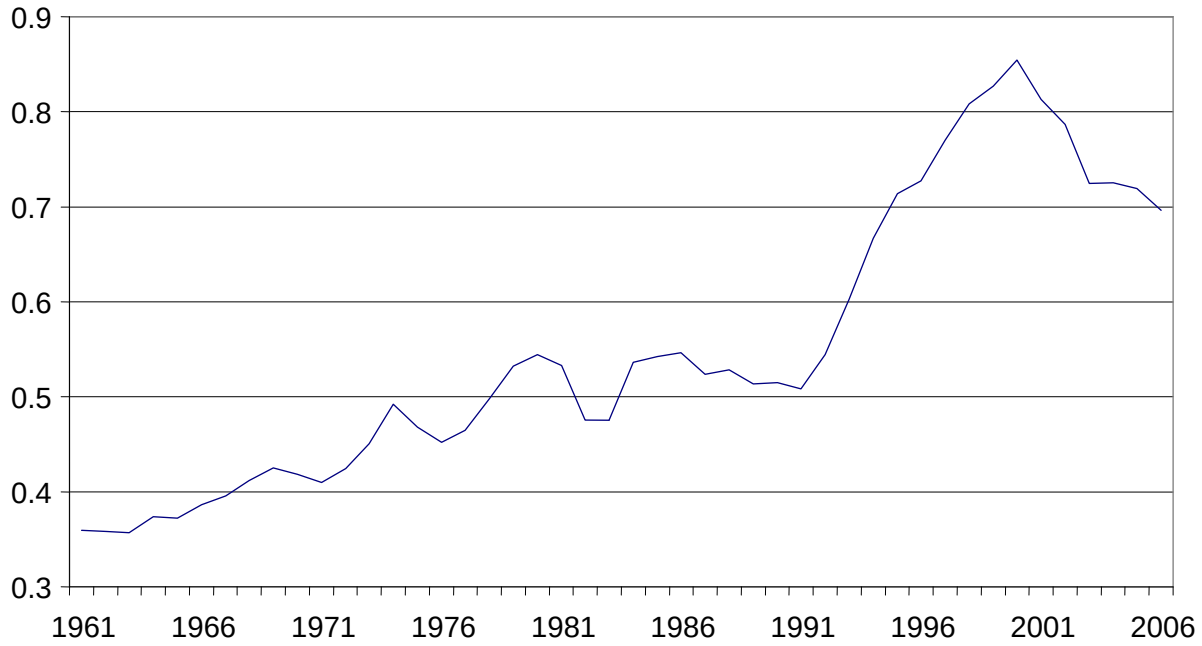


Chart 6
Trade Balance as a Share of Nominal GDP

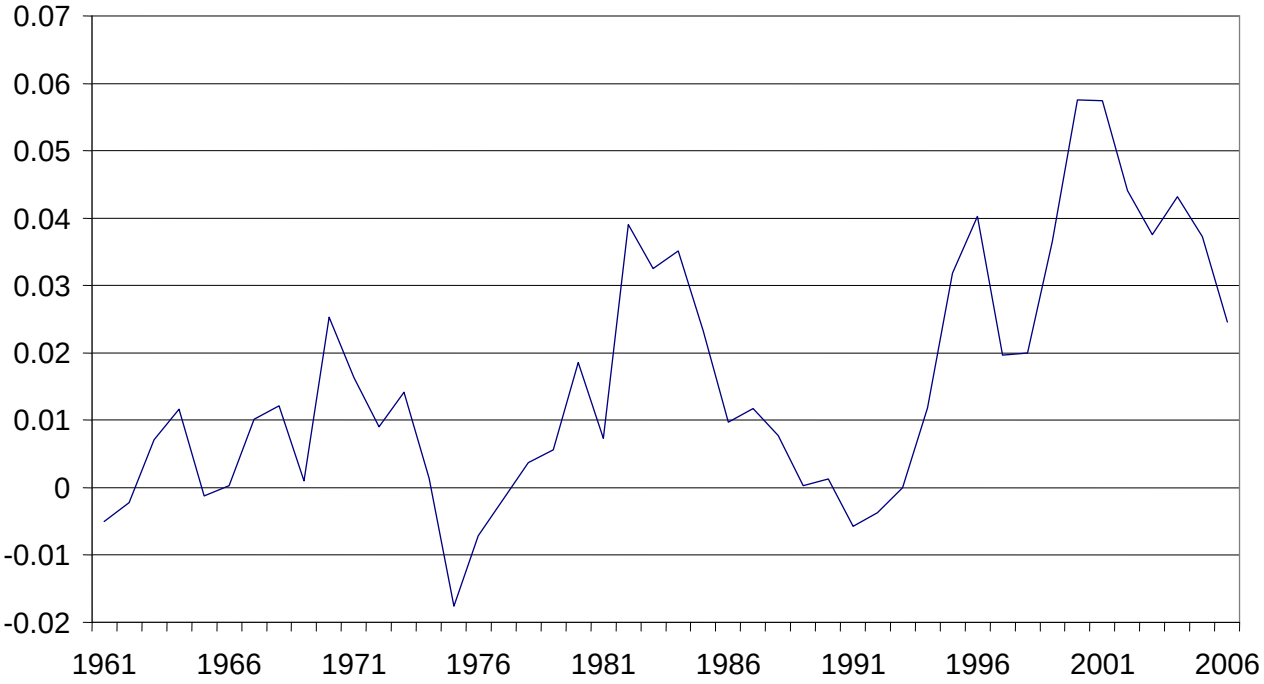


Chart 7
Labour Share of Income

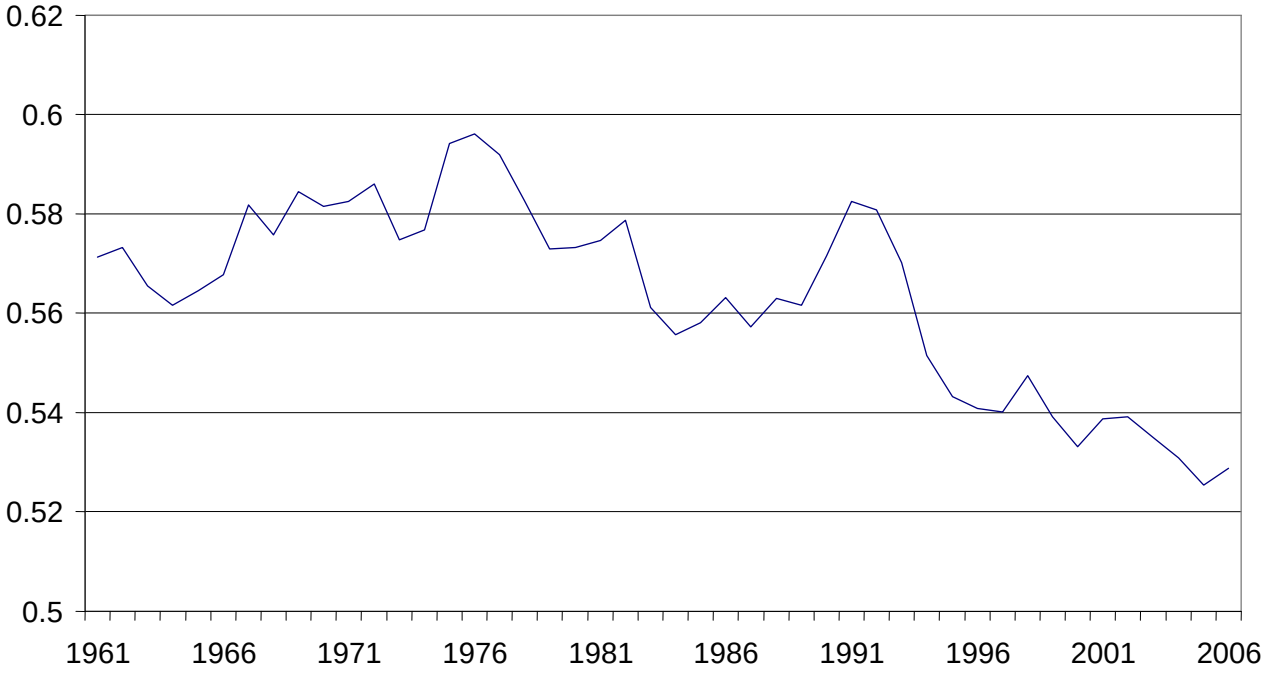


Chart 8
Decomposition of Real GDI Per Hour: Canada, Total Economy

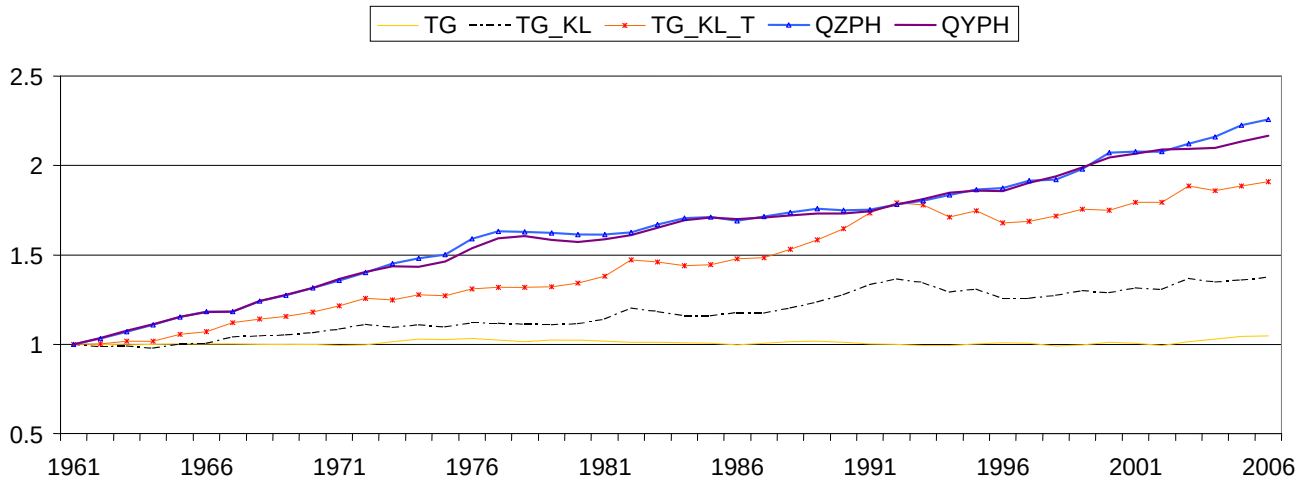


Chart 9
Decomposition of Real GDI Per Hour: Canada, Business Sector

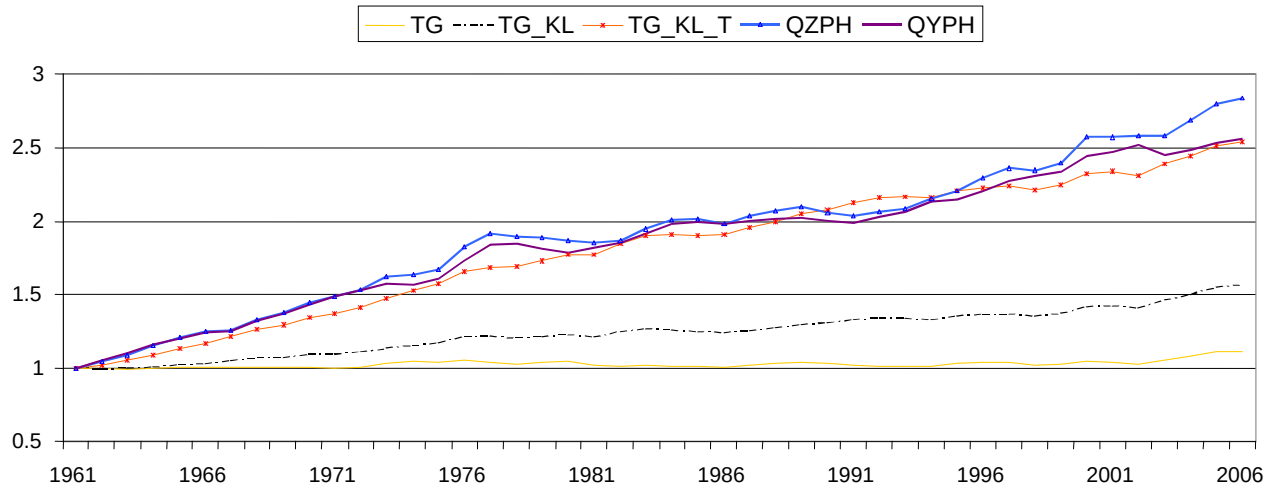


Chart 10
Real GDI Per Hour and Real GDP Per Hour: Canada vs, the United States

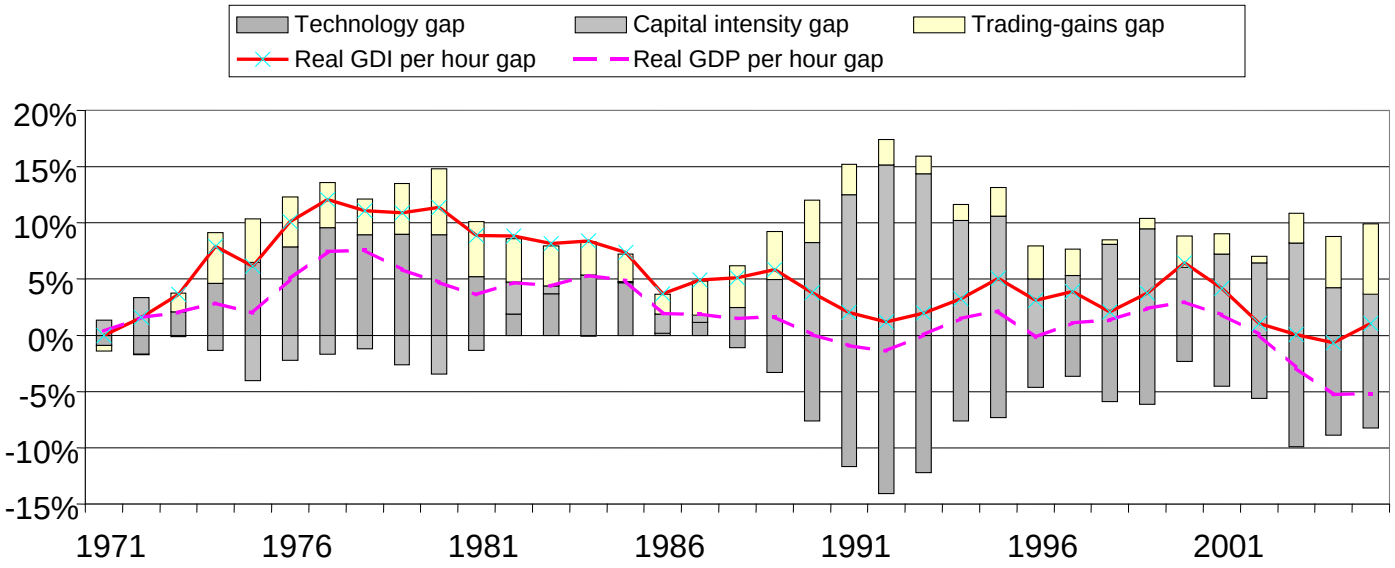
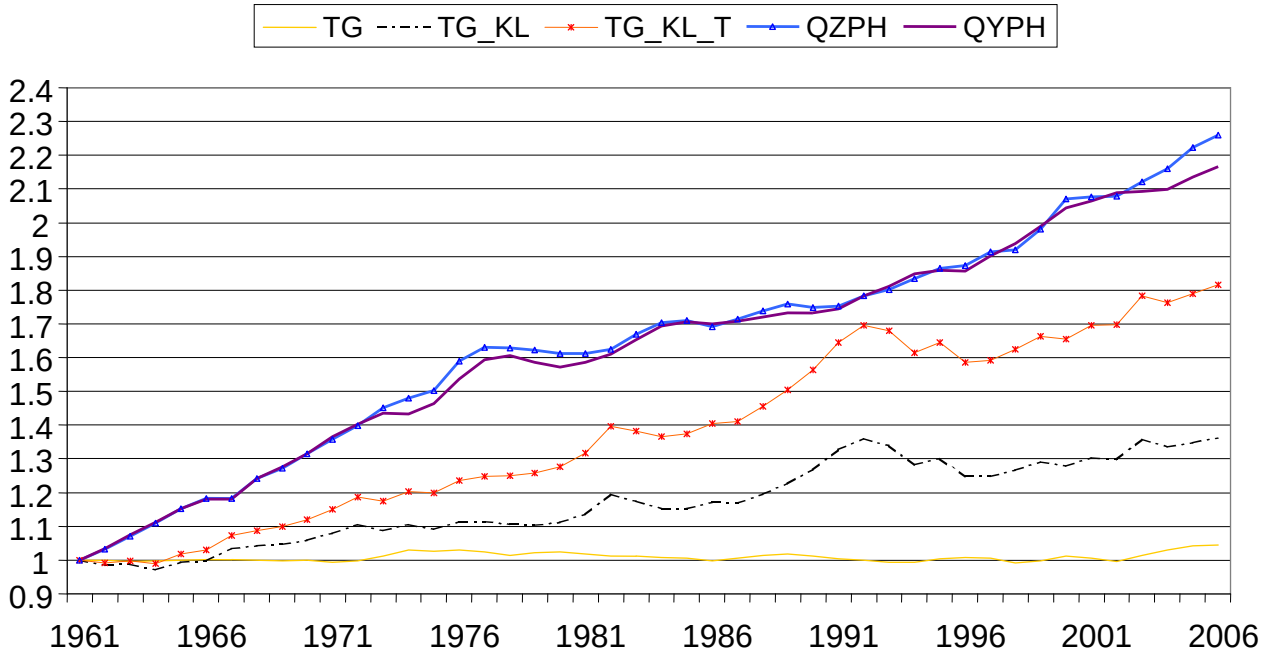


Chart 11
Decomposition of Real GDI Per Hour: Canada, Total Economy, Alternative Model



Appendix: Main Data Source

All data are annual from 1961 to 2006. All prices are set to unity in 1961 and quantities are obtained by deflating nominal values. The data on GDP and its components and the corresponding prices for the total economy are from the System of National Accounts, while those on the quantity and price of labour and capital inputs are from the KLEMS database (Statistics Canada CANSIM Tables 383-0021 and 383-0022). The data for the business sector are from Diewert (2008), with the exception of data on ICT capital inputs, which are taken from KLEMS. The price of domestic demand used to deflate nominal GDP is a Törnqvist index of the deflators of consumption, investment (residential, business machinery and equipment, business structures, government, and inventory), and government purchases. Total real output for the total economy is calculated as a Törnqvist index of these same components plus exports and imports (with a minus sign).