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Energy Prices and Real Economic Activity in Canada: A Multi-Sector Dynamic General Equilibrium Analysis

by

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Abstract

As a net exporter of oil, the recent upward trend in the world prices of energy products represents both an opportunity and a challenge for Canada. This study investigates the aggregate and sectoral effects of a sustained increase in these prices on the Canadian economy using a multi-sector forward-looking dynamic general equilibrium model. Counterfactual simulation results suggest that these price shocks would be beneficial to the Canadian economy on an aggregate basis, as real GDP would increase during most periods and households would increase their consumption profile during all periods and would thereby improve their well being. Nevertheless, the price increases would also shift resources toward export booming sectors and would lead to an appreciation of the real exchange rate that would not be beneficial to traditional manufacturing export industries.

Keywords: *Energy prices; commodity prices; aggregate and sectoral impacts; dynamic general equilibrium modeling; Canada*
JEL classification*:* C68; E30; F14; Q33; Q43; N72

Résumé

En tant qu'exportateur net de pétrole, la récente montée des cours mondiaux des produits énergétiques représente à la fois une opportunité et un défi pour le Canada. Cette étude analyse les impacts agrégés et sectoriels d'une augmentation soutenue de ces prix sur l'économie canadienne à l'aide d'un modèle d'équilibre général multisectoriel dynamique avec anticipations rationnelles. Les résultats de simulation suggèrent que cette hausse de prix serait en général bénéfique à l'économie canadienne dans son ensemble, puisque le PIB réel augmenterait pendant plusieurs périodes et les ménages pourraient augmenter leur bien-être grâce à une augmentation soutenue de leur consommation. Toutefois, l'augmentation de ces prix drainerait les ressources vers les secteurs pétroliers et conduirait à une appréciation du taux de change réel qui ne serait pas bénéfique pour des industries qui exportent traditionnellement des biens manufacturiers.

Mots clés: *Prix de l'énergie; impacts agrégés et sectoriels; modèles d'équilibre général dynamique; Canada.*

Classification JEL: C63; C68; E30; F14; Q33; Q43; N72

Introduction

In this study, we analyze the potential impacts of the increase in oil prices on the real economic activity in Canada. In the last five years, oil prices have increased dramatically. They have more than doubled as the prices of Brent and WTI have increased from U.S. $30 a barrel in early 2004 to more than U.S. $70 per barrel by mid-2006. The tendency towards oil price hikes in the world market is likely to continue in the near future for a host of reasons among which, rising exploration cost, increasing depletion rate, and inadequate discovery rate of new reserves coupled with the unstable international political atmosphere are a few to mention. All these facts make the expectation of prices to return under the threshold of U.S. $30 per barrel very low, even in the medium run.

With a relatively well-diversified economy, Canada is one of the few net-exporters of natural resources among the OECD countries. Natural resource products represent a non-negligible share in Canadian total exports of goods (24% on average between 2000 and 2004). Interestingly, however, the Oil and Gas industry, the most important natural resource industry, constitutes less than 5% of overall Canadian GDP, while energy-intensive industries constitute a relatively larger share of the same. With such an economic structure, rise in oil prices introduces an interesting trade-off for Canada.

While the increase in oil prices could, in general, be positive because of the terms-of-trade improvement, energy-intensive industries could be adversely affected by the same shock. As oil is a primary source of energy in the economy, a rise in its prices would lead to a rise in the cost of production for the energy-intensive industry and hence would result in a loss of competitiveness. This, in turn, would stir up a change in the sectoral composition of the economy. The extent of such an adjustment, of course, would depend, among other factors, on the energy-intensity of the latter industries, on their ability to substitute away from fossil energy products and on the inter-industrial structure of the Canadian economy as a whole.

In addition to the increase in the production cost for the energy-intensive industry, non-oil-producing industries (irrespective of their energy-intensity) would also suffer from a potential appreciation in the real exchange rate. These industries would lose competitiveness, which would eventually shift resources from the affected sectors to the booming sectors. In this context, it is interesting to mention that an increase in the world prices of the other natural resources could also lead to the same phenomenon that is well documented and known in the literature as the "Dutch disease". This term historically refers to the change in the industrial structure in the Netherlands during the late 1950s and early 1960s following the discovery of natural gas reserves. The adjustment was triggered by an appreciation of real exchange rate that resulted in a booming natural gas export sector while simultaneously leading to a contraction of the export-manufacturing sector[1].

Besides, the prospect of resource shift from the manufacturing sector is another potential source of concern for policy makers as far as labour productivity growth is concerned. Indeed, when a boom in the resource sector shifts resources from the manufacturing sector that is the most productive in the economy, aggregate labour productivity growth may be reduced. This issue has been addressed by several authors, like van Wijnbergen (1984), Sachs and Warner (1995), and Rodríguez and Sánchez (2005), among others. They found that an export boom in the natural resource sector could reduce productivity growth in the economy.

In light of the potential adverse impacts on the economy due to a booming resource sector, it is worth emphasizing that the development of Dutch disease is not systematic. Its occurrence and magnitude depend on the structure of the affected economy (namely the degree of diversification and the inter-industry relationships).

Several studies have been carried out in most OECD oil-exporting countries to assess the relevance of Dutch disease[2]. While most of these studies found little evidence of Dutch disease, Stijns (2003) found that the increase in energy exports could indeed affect manufacturing exports. Using a gravity model, he found that a one-percent increase in energy net exports in an energy exporting country could decrease its real manufacturing exports by 8 percent. As rightly noticed in the latter study, the main challenge of the studies that rely on econometric methods resides in

[1] See Corden (1982) for a detailed review of the concept of Dutch disease.
[2] See Stijns (2003) for an interesting review of these studies.

separating the pure Dutch disease effects from the negative impacts on exports generated by the economic slow-down due to the energy price hike. Simulation models could however overcome at least one of these endogeneity problems by running counterfactual simulations that would keep the export demand constant.

Detailed recent analyses of the potential impacts of energy price increase on the Canadian economy are scarce. The potential adjustment of the Canadian economy to a sustained increase in the world oil prices deserves a careful empirical assessment. This analysis is much needed in an international context where the rising growth in demand for natural resource-based products in China, India and other emerging economies would raise the real prices of these products. The price increase could lead to a shift of productive resources from high-tech manufacturing and knowledge-based service industries in Canada. These adjustments could have unintended consequences on economic adjustments, regional income disparities, productivity, etc. Ultimately, a good understanding of these potential impacts would be a good input in designing effective policy responses.

The few interesting existing studies on the impacts of oil price increase in Canada used macroeconomic models, which were more preoccupied with the aggregate economic impacts than with the sectoral adjustment processes. See for example Bayoumi and Mühleisen (2006), Cuñado, and Pérez de Gracia (2003), Dib (2007), Hunt, Isard and Laxton (2001), and Jimenez-Rodriguez and Sanchez (2005). Similarly, a large body of research has been carried out to analyse the effects of oil shocks on the U.S. economy focusing mostly on the aggregate impacts only. Rotemberg and Woodford (1996), Finn (200), Hamilton (2003), Leduc and Sill (2004) and Radchenko, (2005) are few examples among others. Since these models included only final goods and did not capture inter-industry transactions, they missed an important channel through which changes in oil prices could affect the economy. Specifically they were unable to capture adequately the cost-push effects of oil price increase.

Multi-sector dynamic general equilibrium models seem to provide a very good framework for the analysis of the potential impacts of an increase in oil and other commodity prices. An interesting characteristic of these models is their ability to trace the impacts of large policy changes in a particular industry or sector throughout the entire economy. Resulting changes in the structure of consumption, production and trade could then be understood correctly. General equilibrium models have been extensively used in Canada and other OECD countries to analyze the potential impacts of policies affecting energy prices such as climate change policies. See McKibbin & al. (2000), and Rotemberg and Woodford (1996) for further references on this subject.

In this study, we use a single-country, multi-sector dynamic general equilibrium model to analyze the potential short- and long-term impacts of the increase in the prices of oil in Canada. We analyze the impacts on aggregate and sectoral variables of interest, such as GDP, household welfare, sectoral output, employment, investment, imports and exports, prices and real exchange rate. We ran some simulations related to the increase in oil and gas prices and we perform sensitivity analyses of the results with regards to the values of behavioural parameters.

The remainder of the document is as follows. The next section presents an overview of the structure of the Canadian economy. Section 3 discusses briefly the model characteristics and the data. Section 4 analyzes the simulation results and the last section provides some concluding remarks.

2. A quick overview of the theoretical structure of the model

In this section, we present a thumbnail description of the model. The model shares similar modeling philosophy with several interesting contributions on multi-sector intertemporal general-equilibrium modeling for policy reform by Goulder and al. (1999), Keuschnigg and Kohler (1995), among others. It also shares several characteristics with the model presented in Dissou (2006) that was designed to analyze alternative climate change policies. However, the model used for this study differs from the above-cited models for its theoretical structure does not incorporate any GHG[3] related features, like emissions, tradable permits and command and control policy instruments[4].

Although multi-sector intertemporal general equilibrium models are now commonly used in the literature, we believe that a short discussion on the main components of the specific model used in this study would be very useful for a good understanding of the following results. Eighteen industries and twenty commodities are considered, respectively, on the supply side, and on the demand side of the economy. (See Table 1 for a listing of industries and commodities). In contrast to one-sector macro-models, considering a sectoral disaggregation in analyzing energy price increase is useful, since it provides interesting insights related to the sectoral adjustments led by the changes in relative prices, while, simultaneously, accounting for the inter-industry relationships.

Population growth rate as well as technological progress is assumed exogenous, while households and firms derive their behaviors from an explicit intertemporal optimization program. In addition to firms and households, government and the rest of the world are the other economic agents present in the model. Finally, all agents operate in a competitive framework. Canada is considered as a small-open economy that produces both tradable and non-tradable goods and takes prices as given in the world markets of goods and financial capital.

2.1 Households

The representative household has preferences over consumption and leisure. It derives income from salaries, returns on financial assets and net transfers received from the government and the rest of the world. Transfers from the rest of the world are exogenous, while those received from the government are endogenous. The representative household pays sales taxes on commodities and income taxes on returns to primary factors of production.

The representative household maximizes an intertemporal utility function subject to a lifetime budget constraint, i.e. a private wealth constraint that includes

[3] Greenhouse gases.
[4] A full listing of the model equations is available from the author upon request.

both human and financial wealth. The instantaneous utility in the intertemporal utility function is a logarithmic function that has a Cobb-Douglas formulation with aggregate of the consumption index and leisure as arguments. Through intertemporal optimization process, the representative household determines the optimal path of its consumption spending (consumption index), labour supply and saving. Within each period, using a cost-minimizing rule, it allocates consumption expenditures across goods and services within a nested CES utility function. As specified, the household preference representation allows for rich substitution possibilities among commodities especially, on the one hand, between the aggregates of energy and non-energy goods, and, on the other hand, among energy goods.

The three first-order conditions of household intertemporal optimization problem give: (i) the well-known Euler equation that shows the relationship between consumption growth rate between two consecutive periods and the real interest rate; (ii) the usual trade-off between labour supply and consumption; (iii) and the budget constraint that shows the motion law of household financial wealth. Any shock that affects relative prices would change the real interest rate and would alter household consumption profile and its composition. In particular, a change in energy prices would trigger some substitution and income effects that alter the composition of the consumption basket. Detailed discussions on the transmission mechanisms of energy price changes on household behaviour will be discussed further in the paper.

2.2 Firms

The representative firm in each industry chooses its optimal levels of labour, intermediate inputs and investment so as to maximize the firm's stock market value, subject to both technological and capital accumulation constraints, in the presence of convex capital installation costs. Capital, labour, energy and material inputs are combined to produce output using a constant-returns-to-scale technology as represented by the nested CES functions. Akin to the household optimization behavior, the specified representation of firm technology allows interesting substitution possibilities among the inputs used.

Physical capital stock of the firm increases from one period to the other with capital formation that accounts for new investment and physical capital depreciation.

In a given period, the capital stock is considered as given, as it is inherited from initial capital stock and past investment decisions. It follows that in any period the firm will only determine the optimal level of labour, intermediate inputs and investment in physical capital that will affect next period physical capital stock. It is important to note that the constant-returns-to-scale property of the technology does not imply a flat short-run supply curve because of capital installation costs.

The forward-looking behavior of the firm and the presence of adjustment costs make firm's current demand for investment goods sensitive to the expectations of future changes in prices. Investment is a function of marginal version of *Tobin's q* and adjustment cost parameters. A change in the relative prices triggered by an increase in energy prices would reduce the demand for investment in non-energy sectors through the decline in the price of sectoral value added and the increase in the price of capital goods. This change in investment would generate an interesting dynamics in the production sector that is discussed further in Section 3 related to the interpretation of the simulation results.

The optimal values of the other production factors are chosen according to the common rule in static optimization problems that consists in equalizing the cost of the factor to its marginal product.

2.3 The government, trade and financial flows

The government derives revenue from taxes on commodities and on factor income, consumes goods and services and enacts lump-sum transfers to households. It is compelled to have in each period a balanced budget that is achieved by adjusting transfers to households accordingly. Government's real expenditures on commodities are set exogenously to their base-run values. They increase according to the population growth rate (including the technological progress).

In line with most computable general equilibrium models, the present model adopts the Armington approach of differentiation, on the one hand, between domestic goods and imports, and on the other hand, between domestic sales and exports. Firm's gross output is modeled as a CET-composite[5] of exports and domestic sales and the total domestic demand of each commodity is modeled as CES-composite[6] of imports and domestic goods. To account for the importance of Canada's trade relationship with the U.S. a second type of differentiation is introduced between traded goods, i.e., on the one hand, between exports to the U.S. and exports to the rest of the world (ROW) and, on the other hand, between imports from the US and imports from the ROW.

As Canada is considered as a small country in the world market, it considers foreign prices of imports and exports along with the world interest rate as given. The latter assumption implies that in each period, the net capital inflows to Canada are endogenous and they must offset any imbalance in the current account. Still, the real exchange rate has to adjust in order to achieve, over the long run, the sustainability of households' net claim over foreign assets. In other words, the real exchange rate would adjust to avoid a *Ponzi game* where the country could lend or borrow forever.

2.4 Equilibrium conditions, data and calibration

In equilibrium, in addition to the requirement that, within any period, all agents respect their budget constraints, domestic prices and the wage rate adjust to achieve balance between the supply of and demand for produced goods and labour. Moreover, on an intertemporal level, expected future prices must equal their realizations. The market clearing condition considered for the labour market assumes that the wage rate is flexible and that labour can move freely among sectors.

The impacts of policy shocks analyzed in this model will be measured with respect to a base-run situation in which the economy is assumed to be in an initial steady state characterized by a constant growth rate of 3.2% (population growth rate and the rate of Harrod-neutral technological progress).

Calibration of the model is based on the structure of the Canadian economy as depicted by the social accounting matrix (SAM) in the year 2002 that we built. A SAM provides some useful information on the structural interdependence of an

[5] Constant Elasticity of Transformation.
[6] Constant Elasticity of Substitution.

economy by showing the transaction flows between economic agents and production factors.

The year 2002's SAM was built using the same year's data from the Canadian input-output table, national accounts, trade statistics and government accounts. Among other characteristics, the SAM features a sectoral disaggregation of the Canadian economy into eighteen industries and twenty commodities. Tables 2 and 3 provide some characteristics of the SAM that might be useful for the understanding of the results.

Extraneous parameters required for the model calibration consist of substitution elasticities in household preferences, firm technology and Armington functions, and of adjustment cost parameters. It is important to note that since these extraneous parameters are point estimates of the true unknown parameters that are most often taken from econometric studies, there is no single "correct" value for each of them. This situation, therefore, calls for some sensitivity analyses of results in order to gauge the impact of uncertainty pertaining to model parameters[7]. The assumed elasticities are deemed conservative and are based on literature search on Canadian economy. See Tables 4 and 5 for the values of selected elasticities used in this study.

As is usual in most computable general equilibrium models, the calibration of the model entails the use of the base-run situation data and the extraneous behavioural parameters to find the values of the unobserved variables and other parameters, so as to replicate the base-run steady-state equilibrium using the model without a shock. In that equilibrium solution, all physical quantities should grow at the exogenous growth rate, while relative prices remain unchanged.[8]

The calibration of this multi-sector intertemporal general equilibrium model involves the dynamic aspects as well as the static aspects of the model. The methods used in this study follow the ones described in Dissou (2002).

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[7] It is noteworthy to recall the reader's attention to the fact that this problem is not inherent to the calibration method used in this study alone. It is common to all analyses that rely on a point estimate of a true unknown parameter.

[8] Stated differently, in the steady state, physical quantities expressed per efficiency unit of labour should be constant.

3. Simulations results

3.1 Description of the simulations

In this section, we report one main simulation result related to the increase in world prices of oil. We consider a permanent 20 percent increase in the world prices of oil products, i.e., crude oil and refined petroleum products[9]. In addition to the main simulation, we run two other simulations to perform some sensitivity analyses to assess the robustness of the qualitative findings. In the first sensitivity analysis, we consider a permanent 40-percent increase in the world prices of oil products, while in the second, we assess the impacts of the values of trade elasticity parameters.

Although numerical models such as the present one have the advantage of being able to handle simultaneous interdependencies that would have been otherwise impossible to consider in other analytical models, they often produce numerous and complex results that may confront one's initial intuition. In order to provide intuitive explanations of the results, we will focus on the main transmission channels at play and make an artificial distinction in our discussions firstly, between the short- and long-run impacts, and secondly, between aggregate and sectoral impacts. To avoid unnecessary repetition, detailed explanations will be provided for the main simulation alone.

We would also like to emphasize the fact that the results presented in this study are not forecasts; rather, they are the results of counterfactual simulations that, *ceteris paribus*, indicate the impacts on real economic activity of the price shocks considered. Finally, unless otherwise mentioned, all results are expressed in percentage deviations from their base-run values; they are not percentage growth between periods.

3.2 Simulation 1: Permanent 20 percent increase in the world (import and export) prices of oil products

In this simulation, the trajectory of world prices (exports as well as imports) of oil products is assumed to be annually 20 percent higher than the base-run situation. As

[9] The choice of 20 percent is arbitrary and is done for illustration purpose only.

Canada is a net exporter of oil products, this may initially seem to be only a positive terms-of-trade shock, which would in general lead to an expansion of the economy. A typical response of the economy to this type of shock, as predicted by the "Dutch disease" phenomenon, is an export boom that would appreciate the real exchange rate by bidding the prices of domestic goods up and making imports more competitive.

However, this need not be the case in the present context. Indeed, because on the one hand, imports represent a non-negligible share of total domestic demand for oil products in Canada, and on the other hand, increases in energy prices have a negative impact on production costs, the increase in world prices of oil products would trigger other adjustments in the economy. This would dilute the typical results predicted by the Dutch disease theory. Caution is thus called for in the interpretation of the potential implications of the increase in oil prices on an oil-exporting country with a diversified manufacturing sector like Canada.

Aggregate impacts

Table 6 presents the aggregate impacts in this simulation and Figures 1 and 2 show the transitional dynamics of selected variables. As economic agents respond to relative prices in the present setting, the permanent increase in the world prices of oil products would trigger some income and substitution effects as well as changes in the rate of capital accumulation. Aggregate real GDP at factor cost decreases in the first year by 0.3 percent, but increases later on and settles in the long run at a level that is 0.4 percent higher than in the base run, as shown in Figure 1.

Alongside with changes in real GDP at factor cost that reflect changes in resource allocation in the productive sector, especially on income generation, we also provide the results of the impacts on real GDP at market prices. The latter impacts, which reflect adjustments on the demand side (expenditures on final demand), need not to be identical to those of real GDP at factor costs in a particular year, as expenditures on goods are not based on domestic income only. Domestic absorption is also affected by net foreign capital inflows. While changes in real GDP at market prices follow the same pattern as those of GDP at factor cost, figures in Table 6 suggest that their magnitudes are lower because of, among other factors, households' consumption smoothing behaviour. Indeed, in the present model, households are assumed to consume not according to their current income but their permanent income. Hence, they can smooth their consumption stream over time despite a temporary decline in their current income. Household real consumption increases in the first period by 0.2 percent and, in the long run, settles at a level that is 0.3 percent higher than in the base-run situation.

The increase in the world prices of oil products leads to a permanent increase in the consumption price index of about 1.2 percent. This change, in conjunction with a decrease in nominal wage rates, leads to a decrease in real wage rates that, in turn, would decrease household labour supply. Still, the decline in labour supply would be modest, as total employment would fall by about 0.2 percent in the first period. Overall, household welfare increases, as the measure of welfare change is positive, 0.24[10].

As expected, the increase in the world prices of oil products leads to the appreciation of the aggregate real exchange rate in the first period by 0.4% and with a lower magnitude in the subsequent periods. Total real exports drop in the first year by 1.1 percent and this decline continues further in time until it settles in the long run at a value that is 0.8 percent lower than in the reference situation (Figure 1). The pattern is similar for total real imports, although with a smaller magnitude, as they fall by only 0.1% in the first year for example. Finally, total real investment increases by 0.9 percent in the first year and increases slightly in the transitional period and finally settles in steady state at a level that is 0.8 percent higher than in the base run.

In general, the magnitudes of the impacts on aggregate variables reported so far are small; they are in line with the magnitude of the initial shock and they are not quite different from the ones obtained in other (macro) models. For example, an IMF (2004) study that used a single-sector dynamic general equilibrium model found that a permanent 20 percent increase in oil prices would have a negative impact on Canadian GDP (about -0.45 percent) in the first year. The magnitude of these

[10] The measure of welfare change used in this dynamic framework encompasses the household's entire lifetime. See Dissou (2002) for discussions on this measurement.

aggregate impacts may be misleading as they hide wide sectoral adjustments. The increase in world prices of oil products, does not affect all sectors equally.

Sectoral impacts

Tables 7a-8b report the impacts on some relevant sectoral variables in selected years. A discussion on the sectoral and dynamic impacts of the shock will shed some light on these aggregate effects. On the supply side of the economy, oil price increases will induce some resource reallocation effects, with factors moving from other sectors to oil producing sectors. As shown in Table 7a, in the short run, sectoral GDP, employment and real investment increase in the Oil & Gas sector as well as in Petroleum Refining industries; and fall in all other sectors except the Power Generation industry[11].

As argued in the section on the model description, one of the key advantages of using an intertemporal framework is the ability to capture consistently the effects of changes in the values of future variables on investment. The permanent increase in oil prices provides additional incentives to invest in oil industries as the ratio of the shadow price of capital to its purchasing price has increased. In contrast, in the other industries, the increase in energy cost reduces firms' incentives to invest; capital formation decreases in these sectors. As an illustration, investment increases in oil producing industries especially in Oil & Gas industry by 24 percent in the first year (Table 7a) and settles in the long run at a level that is 21 percent higher than in the base run. In non-oil producing industries, investment decreases in both the short and long run. For example in the first year, investment falls by 14.5 and 9.7 percent in Pulp & Paper and Smelting industries, respectively.

The adjustment in sectoral capital stocks, alongside with the sectoral shift of labour towards oil industries leads to a change in the sectoral value added. GDP at factor cost increases by 5.8 and 0.5 percent, respectively, in the Oil & Gas, and Petroleum Refining industries, and falls by 3.0 and 2.5 in Pulp & Paper and Smelting industries, respectively.

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[11] Power Generation industry includes the production of hydroelectricity. Through substitution effects, the rise in oil prices induces an increase of hydroelectricity.

As a corollary to the shift of factors towards the oil industries, exports increase in these industries and fall in others. In reality, as indicated above, non-oil producing industries suffer not only from the resource shift towards oil industries, but they have also been adversely affected by an increase in their production costs through the increase in energy prices. Consequently, their exports decrease further than what would be required, if export prices of oil alone were only considered (i.e. without an increase in oil import prices).[12] The increase in exports of oil products is not sufficient to counter the decrease in foreign sales experienced by other industries. Thus, total real exports fall as mentioned in the discussion on aggregate results.

Considering the demand side, an increase in the prices of oil products leads to a decrease in their domestic uses by 3.0 and 5.1 percent for crude oil and refined petroleum products respectively in the first year (Table 8a). Because of the Armington differentiation between imports and domestic goods, imports of crude oil and refined petroleum fall by 6.8 and 10.6 percent respectively, while their domestic sales increase or decline by a lower magnitude of 2.6 and -4.0 percent respectively in the first period (Table 8a).

Despite the increase in household consumption, total domestic demand falls in non-oil-producing industries mainly because of the decline in the demand for intermediate inputs. Apparently, output expansion in the oil industry has not generated sufficient demand for intermediate inputs that would counteract the decline in output suffered by non-oil producing industries.

Since domestic demand is a composite of domestic goods and imports, it is interesting to note that imports are less affected when total demand falls. For example, in the Pulp & Paper industry, the decrease of -1.1 percent in total demand is achieved through a reduction of 1.5 percent in the demand for domestic goods and de fall of imports by and 0.2 percent. Some industries, such as Cement, have even experienced an increase in their imports, while their domestic sales had seen a decline. This result is not surprising if one considers the fact that non-oil producing

[12] In a non-reported simulation with a 20% increase in oil exports prices *alone, without import prices*, we found that output contraction in non-oil industries is less important.

industries (especially energy intensive industries) suffer from, not only an increase in their production cost, but also from an appreciation of the real exchange rate.

As mentioned earlier, not all the typical effects of Dutch disease are observed in this scenario since we do not observe a boom in the non-traded sector that could be represented in this model by the Services industry. The reason for this is that, in addition to the increase in the prices of tradable goods, we find a negative shock that stems from the increase in energy prices. Nevertheless, analysing sectoral adjustment results, one could perceive a glimpse of the Dutch disease phenomenon in the sense that the non-tradable sector is relatively less affected than the manufacturing sector.

3.3 Sensitivity analysis

In order to assess the robustness of the qualitative results discussed above, we performed some sensitivity analyses. We ran two additional simulations. In the first, we considered a 40-percent increase in world oil prices instead of a 20 percent as discussed earlier. Table 9 reports on the aggregate impacts of this simulation. In general, aggregate variables move in the same direction, though with higher magnitudes, in comparison to the previous simulation. For example, GDP at factor cost falls more in the short run (-0.8% vs. -0.3% previously), but settles at a higher level a few periods later, for example, at 0.3% vs. 0.1% after ten years. The appreciation of the real aggregate exchange rate is more severe in this simulation resulting in a greater fall in the total real exports. Non-booming industries, as expected, also experience a larger decrease in their output. Households, on the other hand, benefit more from the higher oil revenue as they experience a higher consumption stream leading to a welfare increase.

In the second sensitivity analysis, we respectively decreased and increased the substitution elasticity parameters (in the Armington CES and CET function) by 25 percent in all industries. With these modifications, we ran the simulation related to the 20 percent increase in world oil prices again. Table 10 reports the aggregate impacts of these simulations. While the magnitudes of the impacts are slightly lower and larger with, respectively, lower and higher values of elasticity, the qualitative results obtained for the impact of oil prices on the Canadian economy are still valid.

Conclusions

In this paper, we have investigated the potential effects of a sustained increase in the world prices of oil products on the Canadian economy. We have used a multi-sector intertemporal general equilibrium model that makes it possible to trace out the short- and long-run adjustment of aggregate and sectoral variables.

The simulation results suggest that oil shocks would be beneficial to the Canadian economy since, because of the improvement in Canadian terms of trade, real GDP would increase during most periods and the consumption profile would be higher in all periods. Household's welfare change would be positive. For example, a permanent 20-percent increase in world oil prices would in the long run lead to a 0.4 percent increase in GDP at factor cost in comparison to the reference situation, even though this variable declines slightly in the short run. The results also suggest that the magnitude of the long-run impact depends on the magnitude of the price change.

As expected, the increase in the prices of these tradable goods would shift resources (labour and capital) towards the export booming sectors and lead to an appreciation of the real exchange rate, which in turn would hurt traditional manufacturing exports. Contrary to prior studies that used one-sector models, results from this multi-sector analysis suggest that not all industries will be affected in similar ways. A permanent 20-percent increase in world oil prices would be beneficial to the petroleum industry while it would harm the manufacturing industries.

Yet, caution should be wielded in jumping to the conclusion that an increase in oil prices would create a pure Dutch disease phenomenon in Canada. While this study held constant export demand for Canadian goods in the non-booming sector, the reported impacts on sectoral variables account, however, for one type of endogeneity: the cost-push effect of the oil price increase on domestic industries. The decline in exports experienced by traditional manufacturing industries, especially the energy–intensive ones, could not therefore be attributed to a pure Dutch disease effect. Nevertheless, the simulation results suggest that when oil prices increase, traditional manufacturing industries could suffer from, not only appreciation of the real exchange rate, but also from the domestic slowdown led by the increase in production cost.

Finally, it is worth calling the reader's attention to the fact that the results reported in this study are not forecasts. They are rather counterfactual simulation results that were obtained while keeping certain variables constant. For example, the central bank reaction to price increase that may be critical to economic agents' behaviour has not been modelled. Moreover, the induced technological change and the innovation processes that could be triggered by the increase in oil prices and potential supply bottlenecks in resource industries in Canada have not been considered in this analysis. The actual figures of the impact of oil price increase on economic activities may be different from the ones presented in this study.

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Table 1: Sectoral disaggregation in the model

Industries	Commodities
Agriculture	Agriculture
Oil & gas	Crude oil
	Natural gas
Coal	Coal
Other mining	Other mining
Power generation	Power generation
Gas pipelines	Gas pipelines
Lumber	Lumber
Wood industries	Wood industries
Pulp & paper	Pulp & paper
Paper manufacturing	Paper manufacturing
Cement	Cement
Iron & steel	Iron & steel
Smelting	Smelting
Chemicals	Chemicals
Petroleum refining	Petroleum refining
Other manufacturing	Other manufacturing
Transport industries	Transport industries
Services	Services
	Non-competitive imports

Table 2: Selected sectoral characteristics of the Canadian Social Accounting Matrix

	Share in total domestic demand		Share in total supply	
	Imports	Domestic good	Domestic supply	Exports
Agriculture	11.0	89.0	81.4	18.6
Crude oil	57.7	42.3	36.1	63.9
Natural gas	0.0	100.0	53.9	46.2
Coal	79.5	20.6	23.2	76.8
Other mining	31.8	68.2	44.0	56.0
Power generation	2.5	97.5	87.3	12.7
Gas pipelines	6.7	93.4	69.1	30.9
Lumber	12.9	87.1	38.9	61.1
Wood industries	21.0	79.0	44.9	55.1
Pulp & paper	32.4	67.7	25.1	74.9
Paper manufacturing	30.6	69.4	73.5	26.5
Cement	20.0	80.0	76.8	23.2
Iron & steel	37.2	62.8	70.8	29.2
Smelting	55.7	44.4	27.4	72.6
Chemicals	56.3	43.7	49.7	50.3
Petroleum refining	14.1	85.9	80.1	19.9
Other manufacturing	67.5	32.5	35.3	64.7
Transport industries	12.1	87.9	81.1	18.9
Services	4.5	95.5	94.4	5.7
Non-competitive imports	100.0	0.0	0.0	0.0

Source: Statistics Canada and Author's calculations

Table 3: Selected industry characteristics of the Canadian Social Accounting Matrix

	Share of sectoral GDP at factor cost in gross output	Share in sectoral GDP at factor cost of	
		Labour	Capital
Agriculture	38.1	41.5	58.5
Oil & gas	67.2	12.9	87.1
Coal	60.7	49.1	50.9
Other mining	56.2	40.8	59.2
Power generation	67.7	24.9	75.1
Gas pipelines	71.9	19.0	81.0
Lumber	34.4	53.3	46.7
Wood industries	37.7	53.8	46.2
Pulp & paper	37.5	40.3	59.7
Paper manufacturing	39.8	65.4	34.6
Cement	43.1	49.1	50.9
Iron & steel	33.7	63.8	36.3
Smelting	25.2	43.3	56.7
Chemicals	33.5	45.2	54.8
Petroleum refining	6.8	48.7	51.3
Other manufacturing	31.2	53.3	46.7
Transport industries	48.1	75.9	24.1
Services	56.0	69.1	30.9

Source: Statistics Canada and Author's calculations

Table 4: Selected values of technology parameters used in the model

Substitution elasticities between:	
Aggregate of value-added-energy and aggregate of other inputs	0.5
Labour and aggregate of capital and energy	0.8
Capital and total aggregate of energy inputs	0.5
Electricity and non-mobile fossil energy inputs	0.5
Fossil energy inputs	0.5
Refined petroleum products	0.5
Material inputs and mobile energy inputs	0.5
Mobile energy inputs	0.5
Capital adjustment cost parameter	4-12

Source: Various studies

Table 5: Trade substitution elasticities

	Elasticity of substitution between			
	Aggregate of imports and domestic good	**Aggregate of exports and domestic good**	**Imports from the U.S. and imports from the rest of the world**	**Exports to the U.S. and exports to the rest of the world**
Agriculture	1.5	1.5	2.25	2.25
Crude oil	0.7	0.7	1.05	1.05
Natural gas	0.7	0.7	1.05	1.05
Coal	0.95	0.95	1.43	1.43
Other mining	0.95	0.95	1.43	1.43
Power generation	1.5	1.5	2.25	2.25
Gas pipelines	0.7	0.7	1.05	1.05
Lumber	0.6	0.6	0.9	0.9
Wood industries	0.6	0.6	0.9	0.9
Pulp & paper	0.9	0.9	1.35	1.35
Paper manufacturing	0.9	0.9	1.35	1.35
Cement	1.1	1.1	1.65	1.65
Iron & steel	0.9	0.9	1.35	1.35
Smelting	0.8	0.8	1.2	1.2
Chemicals	0.9	0.9	1.35	1.35
Petroleum refining	0.7	0.7	1.05	1.05
Other manufacturing	0.5	0.5	0.75	0.75
Transport industries	1.5	1.5	2.25	2.25
Services	1.5	1.5	2.25	2.25

Source: Anabi, Decaluwe and Lemelin (2003)

Table 6: Impacts of 20% permanent increase in world prices of oil on selected aggregate variables
Percentage deviation from base-run

	After 1 year	After 5 years	After 10 years
GDP at market prices	-0.2	-0.1	0.0
GDP at factor cost	-0.3	-0.1	0.1
Petroleum industries	4.9	9.9	13.9
Primary resource industries	-1.7	-2.9	-3.9
Manufacturing	-1.6	-2.3	-2.7
Other industries	-0.4	-0.3	-0.3
Employment	-0.2	-0.2	-0.1
Household consumption	0.2	0.3	0.3
Consumption price index	1.3	1.2	1.2
Total real investment	0.9	1.0	1.0
Total real exports	-1.1	-1.2	-1.1
Petroleum industries	6.5	13.0	18.0
Primary resource industries	-1.9	-3.3	-4.5
Manufacturing	-1.8	-2.8	-3.4
Other industries	-2.5	-2.5	-2.5
Total real imports	-0.1	-0.2	-0.3
Petroleum industries	-7.5	-7.5	-7.4
Primary resource industries	-1.4	-2.4	-3.0
Manufacturing	0.0	-0.2	-0.3
Other industries	1.8	1.8	1.7
Real exchange rate*	-0.4	-0.3	-0.2
Measure of welfare change		0.24	

** A positive sign corresponds to a depreciation of the real exchange rate*
Source: simulation results

Table 7a: Impact of 20% permanent increase in world prices of oil on selected sectoral industry variables after one year
Percentage deviation from base-run

	Gross output	Sectoral GDP	Employment	Real investment
Agriculture	-2.0	-2.5	-2.1	-5.7
Oil & gas	5.3	5.8	7.9	24.0
Coal	-1.7	-2.1	-2.1	-6.8
Other mining	-1.6	-1.9	-2.1	-6.0
Power generation	0.1	0.1	0.3	0.1
Gas pipelines	0.2	0.1	0.7	5.2
Lumber	-1.9	-1.6	-2.3	-6.0
Wood industries	-1.1	-1.1	-1.5	-3.2
Pulp & paper	-2.6	-3.0	-2.9	-14.5
Paper manufacturing	-0.9	-0.9	-1.1	-3.4
Cement	-0.8	-1.0	-1.0	-2.2
Iron & steel	-1.5	-1.8	-1.8	-4.8
Smelting	-2.1	-2.5	-2.6	-9.7
Chemicals	-1.8	-2.3	-2.1	-4.9
Petroleum refining	-2.5	0.5	2.0	5.1
Other manufacturing	-1.4	-1.4	-1.6	-6.3
Transport industries	-1.5	-2.1	-1.2	-2.7
Services	-0.2	-0.3	-0.1	0.0

Source: simulation results

Table 7b: Impact of 20% permanent increase in world prices of oil on selected sectoral industry variables after 10 years
Percentage deviation from base-run

Industries	Gross output	Sectoral GDP	Employment	Real investment
Agriculture	-3.3	-3.5	-3.3	-4.2
Oil & gas	15.3	15.9	15.8	22.0
Coal	-4.4	-4.4	-4.7	-6.8
Other mining	-4.1	-3.9	-4.6	-6.4
Power generation	-0.1	0.2	-0.4	-0.7
Gas pipelines	3.5	3.5	3.9	6.0
Lumber	-4.2	-3.9	-4.4	-5.6
Wood industries	-2.2	-2.0	-2.3	-2.9
Pulp & paper	-6.2	-6.0	-6.3	-8.0
Paper manufacturing	-1.9	-1.6	-1.8	-2.1
Cement	-1.1	-1.0	-1.3	-1.5
Iron & steel	-2.5	-2.3	-2.7	-3.4
Smelting	-6.0	-6.0	-6.3	-9.0
Chemicals	-2.3	-2.1	-2.6	-3.0
Petroleum refining	-0.2	1.9	3.0	4.0
Other manufacturing	-2.5	-2.5	-2.6	-3.1
Transport industries	-1.5	-1.8	-1.2	-1.2
Services	-0.1	-0.1	-0.1	-0.1

Source: simulation results

Table 8a: Impact of 20% permanent increase in world prices of oil on selected sectoral trade variables after one year

Percentage deviation from base-run

	Total real supply	Real exports	Real domestic supply	Real total domestic demand	Real imports	Sectoral real exchange rate*
Agriculture	-2.0	-3.4	-1.6	-1.4	0.2	-1.2
Crude oil	9.5	13.1	2.6	-3.0	-6.8	15.5
Natural gas	2.1	2.4	1.9	1.9	0.0	0.7
Coal	-1.7	-1.9	-0.7	0.2	0.5	-1.3
Other mining	-1.6	-1.6	-1.5	-1.6	-1.5	0.0
Power generation	0.1	-2.3	0.4	0.5	3.2	-1.8
Gas pipelines	0.2	-1.4	0.9	1.0	3.2	-3.3
Lumber	-1.9	-2.1	-1.6	-1.6	-1.1	-0.8
Wood industries	-1.1	-1.4	-0.8	-0.7	-0.1	-1.1
Pulp & paper	-2.6	-2.9	-1.5	-1.1	-0.2	-1.6
Paper manufacturing	-0.9	-1.6	-0.7	-0.4	0.2	-1.0
Cement	-0.8	-1.6	-0.6	-0.4	0.4	-0.9
Iron & steel	-1.5	-1.9	-1.3	-1.1	-0.8	-0.6
Smelting	-2.1	-2.2	-1.8	-1.7	-1.5	-0.5
Chemicals	-1.8	-2.2	-1.3	-0.8	-0.5	-1.0
Petroleum refining	-2.5	3.1	-4.0	-5.1	-10.6	11.7
Other manufacturing	-1.4	-1.7	-0.8	-0.1	0.2	-1.9
Transport industries	-1.5	-4.2	-0.9	-0.5	2.4	-2.2
Services	-0.2	-1.9	0.0	0.0	1.9	-1.3

Source: simulation results

** A positive sign corresponds to a depreciation of the real exchange rate*

Table 8b: Impact of 20% permanent increase in world prices of oil on selected sectoral trade variables after 10 years

Percentage deviation from base-run

	Total real supply	Real exports	Real domestic supply	Real total domestic demand	Real imports	Sectoral real exchange rate*
Agriculture	-3.3	-5.1	-2.9	-2.7	-0.6	-1.5
Crude oil	20.7	26.7	8.7	-0.6	-6.7	23.5
Natural gas	11.1	15.3	7.2	7.4	0.0	9.8
Coal	-4.4	-4.9	-2.6	-0.7	-0.2	-2.6
Other mining	-4.1	-4.2	-3.8	-3.8	-3.4	-0.4
Power generation	-0.1	-1.0	0.1	0.1	1.1	-0.7
Gas pipelines	3.5	2.1	4.1	4.3	6.2	-2.9
Lumber	-4.2	-4.7	-3.4	-3.4	-2.0	-2.4
Wood industries	-2.2	-2.9	-1.5	-1.2	0.0	-2.4
Pulp & paper	-6.2	-7.0	-3.6	-2.4	0.0	-4.2
Paper manufacturing	-1.9	-3.2	-1.4	-0.9	0.3	-2.0
Cement	-1.1	-2.1	-0.8	-0.6	0.5	-1.2
Iron & steel	-2.5	-3.1	-2.2	-1.8	-1.4	-1.0
Smelting	-6.0	-6.5	-4.7	-3.7	-2.9	-2.4
Chemicals	-2.3	-2.8	-1.8	-1.3	-0.9	-1.1
Petroleum refining	-0.2	7.6	-2.3	-3.7	-11.3	15.4
Other manufacturing	-2.5	-3.0	-1.5	-0.6	-0.1	-3.0
Transport industries	-1.5	-4.1	-0.9	-0.5	2.4	-2.2
Services	-0.1	-1.8	0.0	0.1	1.9	-1.3

Source: simulation results

** A positive sign corresponds to a depreciation of the real exchange rate*

Table 9: Sensitivity analysis - Impacts of 40% permanent increase in world prices of oil on selected aggregate variables
Percentage deviation from base-run

	After 1 year	After 5 years	After 10 years
GDP at market prices	-0.5	-0.3	-0.2
GDP at factor cost	-0.8	-0.2	0.3
Petroleum industries	9.4	21.6	32.1
Primary resource industries	-4.1	-6.9	-9.4
Manufacturing	-3.8	-5.5	-6.4
Other industries	-0.8	-0.6	-0.5
Employment	-0.6	-0.5	-0.3
Household consumption	0.9	1.0	1.0
Consumption price index	3.1	3.0	3.0
Total real investment	2.1	2.5	2.4
Total real exports	-3.0	-3.1	-2.9
Petroleum industries	12.0	27.5	40.5
Primary resource industries	-4.5	-8.0	-10.8
Manufacturing	-4.4	-6.7	-8.1
Other industries	-5.7	-5.8	-6.0
Total real imports	0.3	-0.1	-0.3
Petroleum industries	-13.0	-12.7	-12.4
Primary resource industries	-3.3	-5.6	-7.1
Manufacturing	0.3	-0.1	-0.4
Other industries	4.6	4.5	4.6
Real exchange rate*	-1.4	-1.3	-1.2
Measure of welfare change		0.70	

** A positive sign corresponds to a depreciation of the real exchange rate*
Source: simulation results

Table 10: Impacts of 10% permanent increase in world prices of oil on selected aggregate variables: sensitivity analysis on trade substitution elasticities

Percentage deviation from base-run

	After 1 year			**After 5 years**		
	Low elasticities	**Base elasticities**	**High elasticities**	**Low elasticities**	**Base elasticities**	**High elasticities**
GDP at market prices	-0.16	-0.18	-0.20	-0.09	-0.10	-0.11
GDP at factor cost	-0.27	-0.32	-0.36	-0.07	-0.08	-0.10
Petroleum industries	4.42	4.90	5.25	8.41	9.94	11.27
Primary resource industries	-1.70	-1.74	-1.75	-2.68	-2.90	-3.09
Manufacturing	-1.46	-1.62	-1.73	-1.96	-2.31	-2.62
Other industries	-0.34	-0.41	-0.46	-0.25	-0.31	-0.37
Employment	-0.17	-0.20	-0.23	-0.14	-0.17	-0.19
Household consumption	0.19	0.22	0.26	0.23	0.26	0.29
Consumption price index	1.31	1.26	1.21	1.27	1.22	1.18
Total real investment	0.72	0.88	1.02	0.78	0.98	1.18
Total real exports	-0.96	-1.10	-1.22	-1.01	-1.18	-1.32
Petroleum industries	5.83	6.54	7.09	10.80	13.01	15.00
Primary resource industries	-1.86	-1.89	-1.89	-3.09	-3.35	-3.55
Manufacturing	-1.66	-1.84	-1.98	-2.41	-2.84	-3.21
Other industries	-1.97	-2.46	-2.91	-1.97	-2.49	-2.98
Total real imports	-0.09	-0.07	-0.03	-0.22	-0.24	-0.24
Petroleum industries	-6.65	-7.48	-8.06	-6.44	-7.48	-8.27
Primary resource industries	-1.34	-1.39	-1.43	-2.14	-2.40	-2.62
Manufacturing	0.04	0.04	0.05	-0.12	-0.15	-0.18
Other industries	1.39	1.80	2.20	1.35	1.75	2.15
Real exchange rate*	-0.44	-0.38	-0.34	-0.34	-0.29	-0.25

Source: simulation results

** A positive sign corresponds to a depreciation of the real exchange rate*

Base elasticities' refers to the simulation with base elasticity values

Low elasticities' refers to the simulation with 25% lower than base elasticity values

Base elasticities' refers to the simulation with 25% higher than base elasticity values

Figure 1: Impacts of 20% permanent increase in world oil prices on various variables