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Energy, the Exchange Rate, and the Economy: Macroeconomic Benefits of Canada's Oil Sands Production

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Energy, the Exchange Rate, and the Economy:
Macroeconomic Benefits of Canada's Oil Sands Production

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Abstract

This paper describes potential benefits from Canada's expanding oil sands production, higher energy exports, and further improvements in the terms of trade. Contrary to the previous Canadian exchange rate literature, this paper finds that both energy and nonenergy commodity prices have an influence on the Canadian dollar, and some upward pressure on the exchange rate would therefore be expected. Model results suggest, however, that the impact on other tradable goods exports is limited.

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Keywords: Balance of Payments, Energy Trade, Exchange Rate Models, Macroeconomic Modeling, Canada

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I. Introduction

The boom in global energy markets has again focused attention on the role of Canada as a major energy producer. The rapid rise in oil and gas prices over the last two years has lifted energy exports back on par with other commodity exports. It also holds prospects for higher energy production as the development of nontraditional energy reserves, especially in oil sands, is set to increase in a major way.

This paper explores the macroeconomic consequences of Canada's expanding oil sands production, with a particular focus on the exchange rate impact. It will describe potential benefits from higher energy exports and, with North American energy markets expected to remain tight for the foreseeable future, analyze the impact of possible further improvements in the terms of trade. The paper will also discuss the risk that these gains could be offset by a decline in exports of other tradable goods, owing to a possible appreciation of the exchange rate ("Dutch disease").

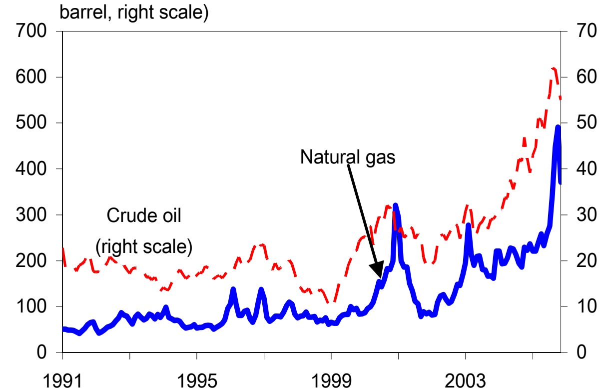
An exchange rate equation relates the Canadian dollar's value to energy and nonenergy commodity trade, with a particular focus on changes in the composition of trade over time. Although a close link between nonenergy commodity prices and the value of the Canadian dollar has been well established in earlier studies, the role of energy prices has remained unclear. We analyze the degree to which the recent appreciation of the exchange rate reflects stronger fundamentals and provide an estimate of the likely impact of the development of oil sands. The results suggest that a permanent increase of net energy exports lifts the equilibrium value of the Canadian dollar, but the impact on nonenergy exports remains modest.

II. Outlook for Energy Production

As the world's third largest producer of natural gas—and eleventh largest of oil—Canada has benefited enormously from the run-up in energy prices in recent years. Canadian gas exports reached C$27 billion in 2004 (2 percent of GDP), a 150 percent increase from their value in the late 1990s, with all but 5 percentage points of revenue gains the result of higher prices. Oil exports also improved on the back of both rising prices and higher production, but a concomitant rise in the value of petroleum imports, especially into eastern Canada, kept net oil exports at around 0.7 percent of GDP.

Figure 1. Oil and Natural Gas Prices

(U.S. $ per thousand cubic meters, left scale; U.S. $ per barrel, right scale)

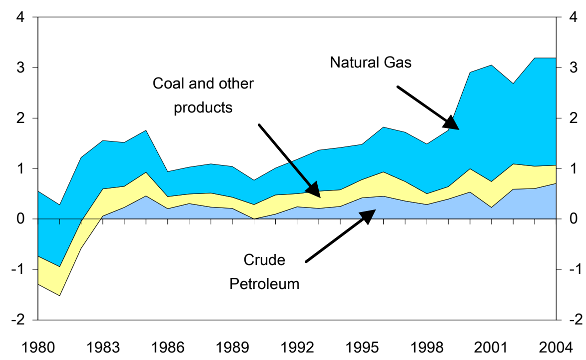


Source: IMF staff estimates.

Canada's future as an energy-exporting nation increasingly rests on the development of unconventional oil and gas production. Despite record drilling in the Western Canada Sedimentary Basin—Canada's most important source of crude oil and natural gas—

production in that area appears to have reached its peak. Activity in offshore locations and the Northern Territories is being stepped up, but will likely prove insufficient to stave off the decline in traditional oil and gas reserves over the medium to long term (NEB, 2003). Canada still has access to large reserves of coal, and especially coal bed methane gas that, if exploitation proves commercially feasible, could boost gas production for years to come. In the near term, however, oil production from Canada's tar sands offers the greatest potential for expanding Canada's energy exports.

Figure 2. Net Hydrocarbon Energy Exports
(Percent of GDP)



Source: Haver Analytics.

A. Producing Oil from Tar Sands

Canada's tar sands—located mostly in the province of Alberta—are difficult to exploit but contain one of the largest known hydrocarbon deposits in the world.[2] Extracting oil from tar sands requires large amounts of capital and energy, which has made most of these resources prohibitively expensive to access. However, commercial success in some locations has now been firmly established, using either of two approaches:

- *Mining and upgrading*. Deposits close to the surface are mined and mixed with water to produce a slurry from which bitumen can be extracted. Bitumen must be blended with a diluent to be transportable, and upgraded with hydrogen to create an acceptable feedstock for conventional oil refineries. The upgrading process uses natural gas as a source of heat, electrical power, and hydrogen for hydroprocessing.

- *"In-situ" production*. Deposits underground are typically exploited by directing steam through drilled wells into a bitumen reservoir. The steam reduces the bitumen viscosity, allowing a mixture of heated oil and water to be pumped to the surface through another set of pipes. In-situ output has lower viscosity than mined bitumen, and is therefore often blended with lighter products, rather than upgraded, before being shipped to downstream refineries.[3]

The tightening of global energy markets has made oil sands production much more profitable. Technological improvements brought down supply costs in the 1980s and early 1990s, although a comparison by Birol and Davie (2001) suggests that production costs from

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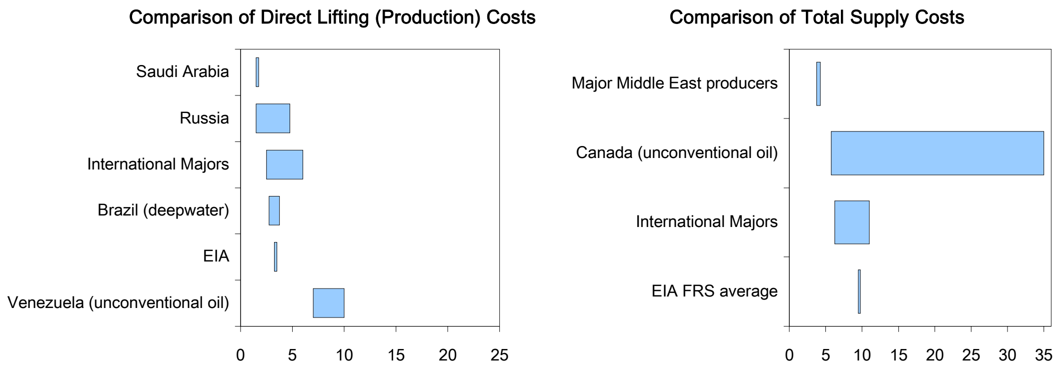
[2] Oil sands consist of quartz sand, silt and clay, water, and 10–12 percent bitumen.

[3] Integrated mining/upgrading operations require around 900 cubic feet of natural gas per barrel of oil (cf/bbl) produced. The in-situ process requires about 1,000–1,200 cf/bbl, with an additional 650 cf/bbl for upgrading (Schroeder, Mui, and Maxwell, 2005).

Figure 3. Oil Supply Costs, 2001 1/

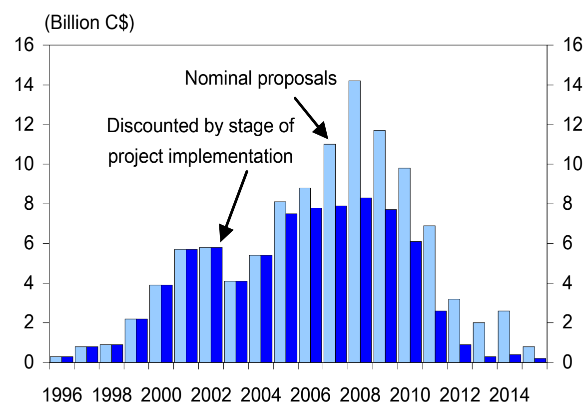


Sources: Birol and Davie (2001); and IMF staff calculations.
1/ EIA refers to *Performance Profiles of Major Energy Producers 1999.* The direct lifting (production) costs per barrel are those costs incurred during production to operate and maintain wells and related equipment. The total supply costs include direct lifting costs, production costs, and finding and development costs. The cost data do not reflect the differing values of the crude grades produced. Ranges reflect both geographical and geological variety of the oil deposits, as well as their chemical properties.

most other sources remain significantly lower.[4] Although the increase in natural gas prices has reportedly raised the long-term break-even point for oil sands projects to US$30–35/bbl over the past 12 months, from about US$25/bbl in 2004, it remains well below long-term oil price expectations.

These developments have led to a significant upward revision in estimates of Canada's commercially accessible oil reserves. According to the Alberta Energy and Utilities Board (EUB), tar sands containing about 174 billion bbl of oil are classified as recoverable with current technologies. Together with conventional oil fields, this would leave Canada with about a sixth of an estimated 1,277 billion bbl of global oil reserves, second only to Saudi Arabia's 262 billion bbl (Radler, 2002).[5]

Figure 4. Oil Sands Industry: Capital Expenditure Forecast



Source: Alberta Economic Development, 2005.

As a result, investment in the Canadian oil sands is expected to take off sharply. A recent industry survey suggests that capital spending in the oil sands sector industry could amount to C$8.5 billion (¾ percent of GDP) per year by 2008, plus an additional

[4] Supply costs are equal to the price needed to cover capital expenditures, operating costs, royalties and taxes, and typically allow for a 10 percent return on investment over the lifespan of the project (around 30-40 years).

[5] Estimates of the size of energy reserves are highly uncertain, given geological uncertainties and intrinsic measurement problems. There has also been a discussion on the extent to which oil sands can be compared to traditional reserves, given the resource and time-intensive nature of their exploitation (Reynolds, 2005).

C$15 billion in replacement investment over 2005–2015 (Alberta Economic Development, 2005). This is a relatively conservative estimate, given that the size of existing investment proposals has been discounted based on the project's position in the approval and implementation process, leaving the projected peak of investment activity well below its nominal value of around $14 billion.[6]

B. Obstacles and Possible Solutions

Development of Canada's oil sands could be constrained by four fundamental constraints, some short-term, some more long-term in nature. While possible solutions exist for all of them, their realization will require time, technological progress, and considerable investment.

- *Skilled labor*. Past projects have suffered from severe cost overruns, owing in part to difficulties in attracting manpower in a tight Albertan labor market. The industry is seeking to attract skilled workers, with internal trade and immigration restrictions apparently causing some concern, at least in individual cases.

- *Other production inputs and infrastructure*. Given the geographic concentration of the oil sands industry, providing additional amounts of electricity, water, diluents, and other critical production inputs to feed an expansion of output is likely to emerge as a key challenge. Augmenting the existing transportation and pipeline capacity will also require substantial resources.

- *Natural gas*. The demand for natural gas by oil sands operations is expected to roughly double by 2015, contributing to a tightening in the North American gas market and adding to the cost of oil sands production. Coal bed methane gas and gasification of residual hydrocarbons begin to serve as alternative energy sources, but greenhouse gas emissions could increase as a result.

- *Greenhouse gas (GHG) emissions*. Notwithstanding considerable improvements in the energy efficiency of oil sands projects, the anticipated production increase complicates Canada's efforts to meet its emissions reduction objectives stated under the Kyoto Protocol. The government has agreed to limit Kyoto-related compliance costs for large single emitters to the cost equivalent of about C$0.25/bbl through 2012. However, uncertainty about the success of emissions-reducing technologies and the costs of future environmental regulation could become a limiting factor.[7]

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[6] It should be assumed that additional projects will be forthcoming, increasing currently projected investment levels after 2008.

[7] Canada is exploring the feasibility of sequestering CO_2 emissions underground, building on its experience with advanced oil recovery technologies. A large pilot with international participation (the Weyburn Project) is currently underway in the province of Saskatchewan.

III. Export Prospects and Dutch Disease

A. Production and Exports

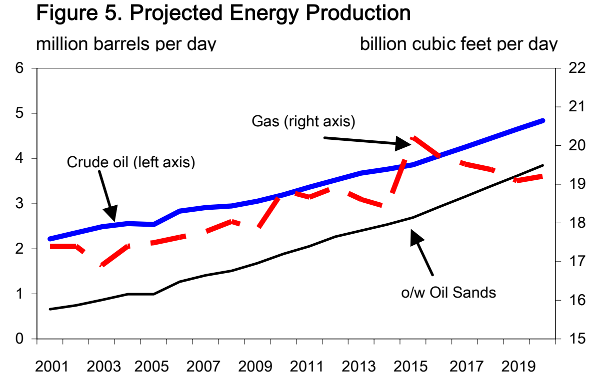
The capital already committed to oil sands projects is expected to provide a significant boost to Canadian oil production. Canada produced 2.4 million barrels of crude oil per day (mb/d) in 2004, the bulk of it from conventional oil fields. However, oil sands production has rapidly increased—doubling since the late 1990s—and now stands at 1 mb/d, with most forecasters projecting a further tripling to 2½–3 mb/d by 2015. Further increases are projected thereafter, depending on supply and demand conditions in the oil market and the pace of technological progress in the interim (Table 1).

Table 1. Oil Sands Production Forecasts

RIWGA (2005)	Oil sands production potential at 3 mb/d by 2020 and 5 mb/d by 2030, provided infrastructure investment comes through to support post-2010 projections.
CAPP (2005)	Oil sands produce 2.7 mb/d by 2015 (moderate case). Total Canadian oil production: 3.9 mb/d.
Söderbergh (2005)	Oil sands production from mining to drop sharply after 2040, with a peak at 2.2 mb/d after 2015. Depending on pace of *in situ* exploration, total oil sands production could peak in 2040 around 3.5-6 mb/d.
CERI (2004)	Assumes WTI at $32/bbl, NYMEX $4.25 per MMBtu. Investment would amount to $6 billion/year. Oil sands would produce 2.8 mb/d by 2017 (the "unconstrained" case of 3.5 mb/d is not expected to be feasible).
NEB (2004)	Assumes WTI at $24/bbl, NYMEX $4.00 per MMBtu. Investment would be around $4.4 billion/year. Oil sands potential at 2.2 mb/d by 2015 (Techno Vert case). Total Canadian oil production: 2.8 mb/d.

Within the next 15 years, additional oil exports could add the equivalent of 1 percent of GDP to Canada's energy trade surplus at current prices. This estimate is based on a simple static calculation, using assumptions from a comprehensive Canada energy supply forecast (NEB, 2003), except that oil sands projections are based on CAPP's (2005) moderate case, which is around the mid-point of the range of recent forecasts. Non-oil GDP would grow at 2¾ percent, non-energy exports and imports would remain unchanged relative to non-oil GDP, and relative prices, including the exchange rate, would also remain constant.[8]

Figure 5. Projected Energy Production



Sources: National Energy Board; Canadian Association of Petroleum Producers; staff projections.

[8] Canada will likely remain a price taker in the international market for oil. Although reserves are likely to last for many decades, the long lead times and high costs of expanding oil sands production suggest that additional Canadian oil to market will not meaningfully affect prices on the global marketplace (Söderbergh, 2005; Reynolds, 2005).

Table 2. Canadian Energy Exports: Static Projection

CAPP, Moderate case	2001	2002	2003	2004	2005 (Forecast)	2010 (Forecast)	2015 (Forecast)	2020 (Forecast)
Canada oil and gas production								
Crude oil (mb/d)	2.2	2.4	2.5	2.6	2.5	3.2	3.9	4.8
of which : Oil Sands	0.7	0.7	0.9	1.0	1.0	1.9	2.7	3.8
Gas (bcf/d)	17.4	17.4	16.9	17.4	17.5	18.8	20.2	19.2
Oil and gas exports								
Crude oil (mb/d)	1.3	1.4	1.5	1.6	1.5	2.1	2.6	3.5
Gas (bcf/d)	10.6	10.5	9.3	9.7	9.6	10.1	10.6	8.8
				(in percent of GDP)				
Energy Exports	5.0	4.3	5.0	5.3	6.4	6.5	6.4	6.4
Oil and gas exports	4.7	4.1	4.8	5.1	6.2	6.4	6.3	6.3
o/w: Crude oil	1.4	1.6	1.7	2.0	2.6	3.1	3.4	4.0
o/w: Natural gas	2.3	1.6	2.1	2.1	2.7	2.4	2.2	1.6
Electricity	0.4	0.2	0.2	0.2	0.1	0.1	0.1	0.1
Energy Imports	1.6	1.4	1.6	1.9	2.3	2.1	1.7	1.5
o/w: Crude oil	1.2	1.0	1.1	1.3	1.7	1.6	1.2	1.1
Trade balance	6.4	5.0	4.7	5.1	4.3	4.6	4.9	5.1
Net energy exports	3.4	2.8	3.3	3.3	4.0	4.4	4.7	4.9
Net oil and gas exports	3.1	2.7	3.2	3.2	3.9	4.3	4.6	4.8

Sources: IMF staff calculations, based on CAPP (2005); NEB (2003); and Timilsina, LeBlanc, and Walden (2005).

- Under these assumptions, exports of crude oil could increase by about 2 mb/d by 2020. For the purposes of this simulation, the resulting excess demand for gas relative to the NEB's projection is assumed to be met from alternative sources, but the downward trend in gas production after 2015 would not be abated.

- Total oil export revenues would rise to 4 percent of GDP by 2020, leading to an improvement in the net energy trade balance of about 1 percent of GDP (Table 2). The price sensitivity is such that an average increase in real prices of 1 percent per year would yield an additional ¾ percent of GDP in net export revenues by 2020.

B. Are There Risks of Dutch Disease?

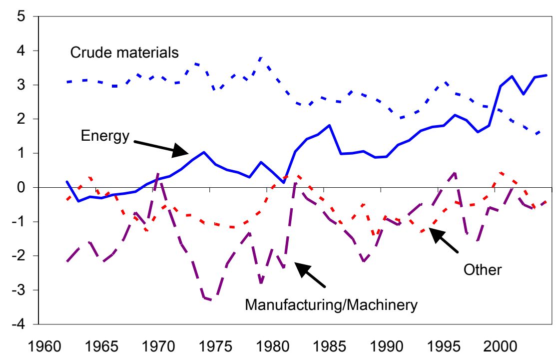
The beneficial economic impact of oil production could be dented if a rising exchange rate were to negatively affect other tradable goods sectors. Overall, higher production and export of crude oil should provide a boost to the Canadian economy, both by offering high value-added employment opportunities and raising national income through additional foreign exchange earnings. However, the non-energy tradable sector could come under increased pressure if current account surpluses as well as rising capital inflows were to put upward pressure on the exchange rate ("Dutch disease"). Moreover, the economy's sensitivity to global oil market conditions would increase as the share of oil production in total GDP rises.[9]

[9] Following Corden's (1981) seminal paper on Dutch disease, two out of three possible factors apply in Canada's case: technological progress in exploiting tar sands, and an exogenous price increase. The third factor, (continued…)

The literature suggests that Dutch disease effects in resource-exporting industrial countries tend to be small. The effect is most often associated with the Netherlands, the United Kingdom, and Norway, all of which have developed energy reserves in the North Sea, and Australia and Canada as major commodity exporters. The first three countries experienced both exchange rate appreciation and a contraction in manufacturing output and employment over the period when their energy exports soared (Figure 7). However, although some analyses have reported a statistically significant correlation of exchange rate effects with manufacturing activity, causality has been more difficult to establish.[10] In any case, the effects were of a size that led most authors to conclude that the manufacturing decline in these countries was part of a longer-term deindustrialization trend, and not specifically linked to higher energy exports. Indeed, some studies suggest manufacturing output has benefited from higher demand induced by energy revenues.

A review of the Canadian experience also yields few signs that natural resource exports have persistently hurt the manufacturing sector. Although Canada's energy exports have risen steadily relative to GDP since 1980, the real effective exchange rate has declined over that period, both output and exports of manufacturing goods have been stable, and the decline in share of manufacturing employment has been smaller than in other resource-exporting industrial countries. Within this long-term trend, there has been a steep increase in manufacturing activity between 1994 and 2000, succeeded by a similarly dramatic decline which may still be ongoing. However, these shifts have not been closely correlated with movements in the real effective exchange rate, which only began to appreciate in 2002. Instead, the timing suggests that Canadian manufacturing remains dependent on the U.S. economic cycle, especially in view of the relatively close correlation between U.S. investment and Canadian goods exports.

Figure 6. Composition of Net Exports
(Percent of GDP)



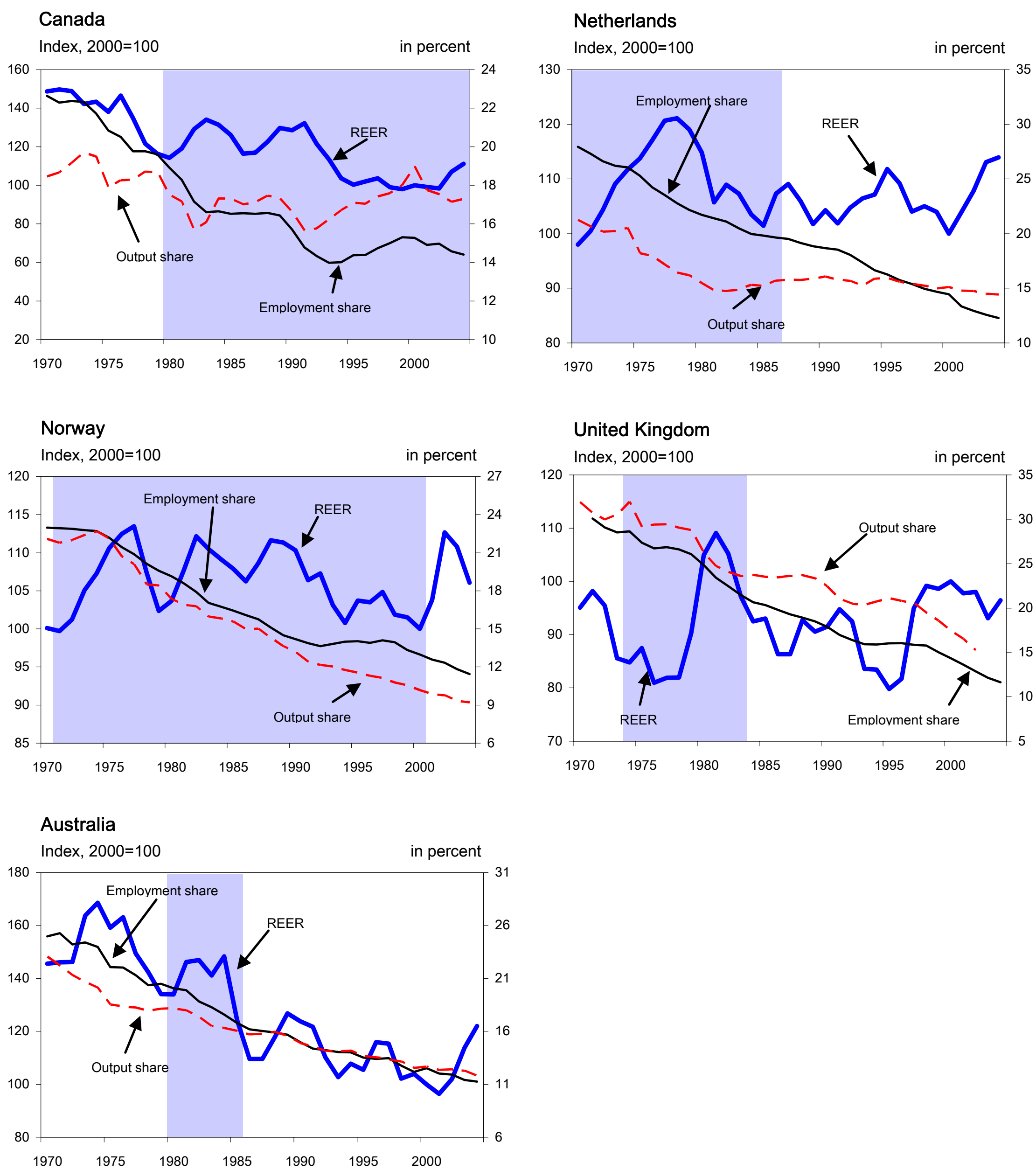
Source: OECD.

For a more detailed analysis of the nexus between energy exports and the exchange rate, a new exchange rate equation is developed in the following section. The model revisits earlier studies that identified non-energy commodity trade as one of the key drivers of the

a windfall discovery, does not apply, given that the rough extent of the tar sands region was already established in 1882 by the Geological Survey of Canada.

[10] See Hutchinson (1994), Bjørnland (1998), Spatafora and Warner (2001), and an overview by Stevens (2003). More recently, Stijns (2003) presented some evidence for the presence of Dutch Disease effects using a gravitational trade model.

Figure 7. Exchange Rate and Manufacturing Activity 1/



Source: OECD.

1/ The charts depict the real effective exchange rate (REER) for major commodity-exporting industrial countries, as well as the output and employment share of each country's manufacturing sector.

Note: Shaded areas indicate periods of a rising share of energy exports in GDP.

Table 3. Exchange Rate and Manufacturing in Energy-Exporting Industrial Countries					
	Canada	Netherlands	Norway	U.K.	Australia
Period of export run-up	1980-	1963-86	1971-2000	1974-83	1980-85
Change in net energy exports (percent of GDP)	2.9	4.8	24.6	6.6	2.8
	(Average Annual Change During Export Run-Up)				
REER	-0.1	1.2	0.0	1.4	-1.9
Manufacturing Output Share	0.0	-0.3	-0.4	-0.9	-0.4
Manufacturing Employment Share	-0.2	-0.5	-0.3	-0.8	-0.7

Source: Haver; IMF staff calculations.

Canadian exchange rate.[11] Having found a specification that assesses the potential impact of higher energy exports on the exchange rate, the results of the equation are fed into Oxford Economic Forecasting's global economic model for a simulation of the overall impact of higher oil production in Canada.

IV. EXCHANGE RATE EQUATION

A. Theoretical Considerations

Commodity exports affect the exchange rate through changes in their volumes and in the terms of trade. Commodities are generally exchanged at a single world price with quantities determined by production capacities. This implies that commodity trade (in foreign currency) is largely independent of exchange rate considerations. The Canadian trade balance in U.S. dollars can thus be written as:

$$TBUS\$ = p_C\, COM + p_X^{(+)}\, XNC^{(-)} - p_M\, MNC^{(+)} \qquad (1)$$

where *TBUS$* is the trade balance; p_C and *COM* are the (U.S. dollar) price and real net exports of commodities, respectively; p_X and *XNC* are the U.S. dollar price and volume of noncommodity exports; and p_M and *MNC* are the U.S. dollar price and volume of noncommodity imports. Superscripts *(+)* and *(-)* indicate whether a particular variable would have a positive or negative impact on the trade balance under a Canadian dollar appreciation. As the Canadian commodity trade balance is positive, higher commodity prices (or volumes) improve the trade balance, allowing a larger deficit in the trade of other goods. This occurs through a real exchange rate appreciation, which boosts real imports and reduces real exports by raising the price of Canadian noncommodity goods.

The impact of a shock in net commodities trade on the exchange rate depends on the size of the net commodities trade relative to noncommodity imports. Standard elasticities imply that

[11] See, for example, the exchange rate equation reported in Ammano and van Norden (1993). Similar approaches are discussed in Helliwell and others (2005), Issa and others (2005), and Bailliu and King (2005).

a rise in U.S. dollar noncommodity export prices is approximately offset by the fall in export volumes. As a result, the exchange rate appreciation primarily affects the U.S. dollar value of noncommodity imports. Accordingly, in the model reported below, the ratio of net commodity exports divided by the size of noncommodity imports (the variable *tbcom*) is used as a measure of the relative importance of shocks in commodity trade for exchange rate adjustment.[12]

Empirically, it is likely that commodity export volumes affect exchange rates more over the longer term. In the short-term, exchange rates primarily respond to unanticipated news, as implied by the "random walk" model. Over the same time scale, commodity prices are also close to "random walks" that incorporate information on underlying conditions—for example, news of bad weather will affect the spot price of a commodity well before its impact on physical exports.

Accordingly, the estimated exchange rate equation incorporates a short-term "dynamic" model that relates the change in the exchange rate to changes in commodity prices and a long-term "error correction" mechanism that relates the exchange rate level to commodity prices and volume. More specifically,:

$$\Delta e_t = \phi \Delta p_t^c tbcom_{t-1} + \alpha' X_t - \lambda(e_{t-1} - \theta tbcom_{t-1} - \beta' Z_{t-1}) \tag{2}$$

where e is the logarithm of the real exchange rate, $p^c{}_t$ is the logarithm of the price of commodities, and X and Z represent other short- and long-term explanatory variables, respectively. The long-run model, involving the expression in brackets, relates the logarithm of the exchange rate to *tbcom* and other long-term exchange rate determinants. By contrast, in earlier work at the Bank of Canada, the exchange rate was related to the logarithm of the price of commodities only through the long-run equation:[13]

$$\Delta e_t = \alpha' X_t - \lambda(e_{t-1} - \theta p_{t-1}^c - \beta' Z_{t-1}) \tag{3}$$

Comparing equations (2) and (3), the new specification differs from the earlier one in two respects:

- First, it relates the short-term rate of change in the exchange rate to the contemporaneous rate of change of commodity prices, rather than only through the error correction mechanism.

- Second, as discussed, the impact of changes in commodity markets in both the short- and long-term depend on the prevailing level of *tbcom*, that is, the ratio of the commodity trade balance to noncommodity imports.

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[12] See Bayoumi, Faruqee, and Lee (2005) for a formal model of this approach.

[13] See Amano and van Norden (1993), Helliwell and others (2005) for estimated exchange rate equations, and Bailliu and King (2005) for a survey of this work.

B. Empirical Results

Differentiating between trade in energy and nonenergy commodities, the estimated model specification becomes:

$$\Delta e_t = \phi_{nec}\Delta p_t^{nec} tbnec_{t-1} + \phi_{enc}\Delta p_t^{enc} tbenc_{t-1} + \alpha_i idiff_{t-1} + \alpha_{exch}\Delta e_{t-1} \\ -\lambda(e_{t-1} - \theta_{nec} tbnec_{t-1} - \theta_{enc} tbenc_{t-1}) + \varepsilon_t. \quad (4)$$

The dependent variable is the CPI-based real exchange rate against the U.S. dollar.[14] The variable p^{nec} refers to the log of nonenergy commodity prices, and *tbnec* to net exports as a ratio of noncommodity imports; p^{enc} and *tbenc* are energy prices and net exports, normalized in the same manner.[15] The dynamic equation includes the short-term interest rate differential between the United States and Canada (*idiff*). As is standard in this work, this was lagged to avoid simultaneity bias. A lagged dependent variable was also added to account for the serial correlation created by time-averaging the real exchange rate.[16] The equation was estimated using quarterly from 1972 onwards, and data construction is described in the Appendix.

The results from the basic specification suggest that energy and nonenergy commodities both play a significant role in explaining exchange rate trends (Table 4). In the dynamic equation, oil and nonoil commodity prices as well as interest rate differentials are correctly signed and significant at the 10 percent level or better, and the lagged dependent variable is around its expected value of 0.25. In the error correction mechanism, the coefficients for the energy and nonenergy commodity trade balance were also significant.

As expected, the long-term coefficients on the trade balances are similar, and also several times larger than their short-term equivalents. A plausible explanation of this difference is that supply responses often reverse movements in real prices over time, and hence short-term price movements are discounted in markets. At -0.12, the coefficient on the error correction mechanism implies that it takes about two years to reduce a deviation from the long-term trend by 50 percent. This half-life estimate is similar to other Canadian exchange rate equations but larger than estimated in many other models (Bayoumi, Faruqee, and Lee, 2005). This is encouraging, as the slow return of real exchange rates to equilibrium (generally defined as a fixed purchasing power parity value) has been an important focus of

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[14] This is the definition of the real exchange rate used in earlier work. The U.S. real exchange rate was preferred over the multilateral real effective exchange rate as, while both series move closely together, data for the U.S. specific series can be more easily constructed back to the 1970s, allowing the analysis to encompass the oil shocks in that decade.

[15] In the case of nonenergy commodities, it proved impossible to match the data on the trade balance with the corresponding price series, as the implied negative correlation between prices and volumes was implausibly high. Based on long-term trends, the ratio of real net nonenergy commodity exports to real noncommodity imports was assumed constant at 22.5 percent.

[16] Time-averaging series that are random walks induces a moving average coefficient in the error term of ¼.

Table 4. Canada: Real Exchange Rate Equations

	General Specifications	Preferred Model
Dynamic Model		
Change in log of energy prices 1/	0.50 (0.19) **	0.37 (0.09) **
Change in log of nonenergy commodity prices 1/	0.20 (0.11) +	
Short-term interest rate differentials	0.57 (0.13) **	0.59 (0.13) **
Lagged dependent variable	0.30 (0.08) **	0.30 (0.07) **
Error Correction Mechanism		
Energy trade balance 2/	0.91 (0.55) +	1.10 (0.21) **
Nonenergy commodity trade balance 2/	1.07 (0.21) **	
Coefficient on error correction mechanism	-0.12 (0.03) **	-0.11 (0.03) **
R^2	0.35	0.34
D-W	2.04	2.04
Schwartz criterion	-4.97	-5.03

Notes: Constant terms not reported. Standard errors are provided in parenthesis, while+, *, and ** represent coefficients that are significant at the 10, 5, and 1 percent significance levels, respectively.

1/ Logarithm of change in prices multiplied by lagged trade balance as a ratio of noncommodity imports.

2/ As a ratio of noncommodity imports. Real nonenergy commodity imports are assumed constant at 22.5 percent of real noncommodity imports.

analysis of exchange rate models after being identified as one of the six puzzles of international economics (Obstfeld and Rogoff, 2000).

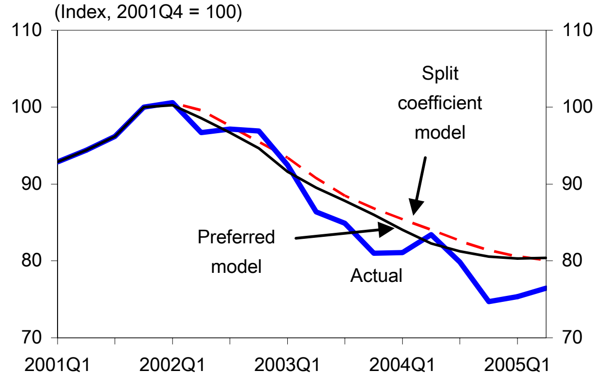
In the preferred specification, the model is made more parsimonious by imposing the same coefficients on shocks to energy and nonenergy commodities. Such a restriction, which is easily accepted by the data, is appropriate because both coefficients are already scaled by their respective trade balances (*tbnec* and *tbenc*) and hence are in the same "units." In the dynamic model, the resulting coefficient of 0.37 on energy and nonenergy prices implies a slightly less than ½ percent increase in the real exchange rate for every one percentage point increase in either price. At 1.1, the error correction coefficient for the commodity trade balance implies that the long-run impact of volume changes is almost three times the short-term effect of price changes. All of the coefficients in this preferred model are significant at the 1 percent level.

C. Interpretation

The results of the exchange rate equation suggest that most of the recent appreciation of the Canadian dollar against its U.S. counterpart reflect underlying factors. A dynamic projection explains over three quarters of the real appreciation of more than 30 percentage points between 2002Q1 and 2005Q2, leaving an unexplained gap of about 5 percentage points that could well reflect generalized U.S. dollar weakness over this period or the anticipation of higher production from tar sands (Figure 8). The estimate of the gap's size is relatively insensitive to varying the starting date of the projection by one or two years.

The model implies a limited exchange rate appreciation due to expected increases volumes of oil exports from Alberta's tar sands. As discussed above, such production is expected to add some 1 percent of GDP to net oil exports over 15 years, increasing net oil exports as a ratio of noncommodity imports by some 4 percentage points. Given the long-run semi-elasticity on this ratio of around unity, this implies a real appreciation of only around 4 percent—much less than the implied appreciation since early 2002 although similar to the unexplained gap over than period.

Figure 8. Dynamic Forecasts of Canadian Real Exchange Rate, 2002:Q1–2005:Q2
(Index, 2001Q4 = 100)



Source: IMF staff estimates.

The new specification compares relatively favorably to a conventional one in which commodity prices are included in the long run model with no adjustment for the commodity trade balance. Table 5 reports results from a conventional equation that drops the contemporaneous changes in commodity prices and includes only the logarithms of energy and nonenergy prices in the error correction mechanism:

$$\Delta e_t = \alpha_i idiff_{t-1} + \alpha_{exch}\Delta e_{t-1} - \lambda(e_{t-1} - \tau_{nec}\, p^{nec}_{t-1} - \tau_{enc}\, p^{enc}_{t-1}) + \varepsilon_t. \quad (5)$$

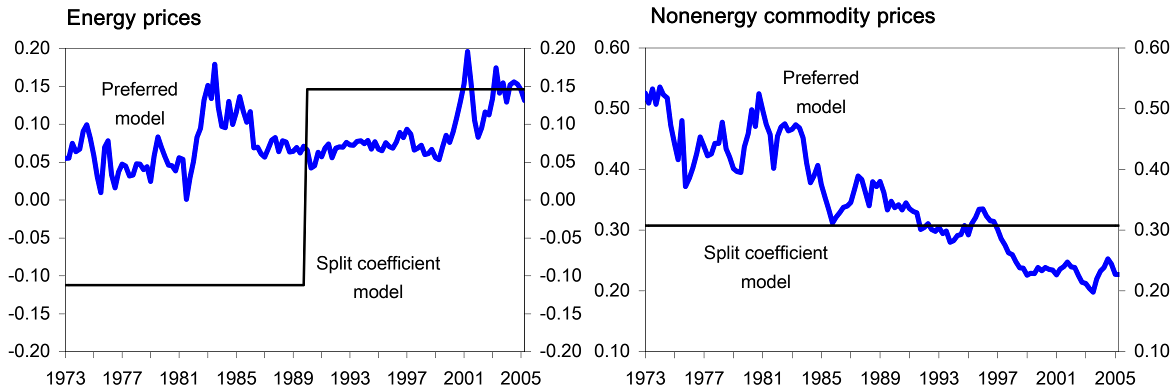
In one regression, all of the coefficients are fixed over time, while in the other the coefficient on energy prices is allowed to change in 1990Q1, to proxy the growing importance of energy exports in Canadian trade (Bailliu and King, 2005, suggest that this modification produces considerably better empirical results). The results confirm that the equation that allows the coefficient on energy prices to change in 1990Q1 fits the data considerably better—all of the

Table 5. Canada: Conventional Real Exchange Rate Equations

	Basic Specifications	Split Energy Coefficient
Dynamic Model		
Short term interest rate differential (α_i)	0.52 (.13) **	0.57 (.14) **
Lagged dependent variable (α_{exch})	0.41 (.08) **	0.30 (.08) **
Error Correction Mechanism		
Coefficient on error correction mechanism (λ)	-0.13 (.03) **	-0.11 (.04) **
Log of non-energy commodity prices (τ_{nec})	0.31 (.06) **	0.31 (.07) **
Log of energy commodity prices (τ_{enc})	-0.05 (.03)	-0.11 (.04) **
Log of energy commodity prices after 1990 ($\tau_{enc,90}$)	--	0.26 (.08) **
R^2	0.26	0.32
D–W	2.02	1.99
Schwartz criterion	-4.91	-4.92

Notes: Constant terms are not reported. Standard errors are provided in parenthesis, while +, *, and ** represent coefficients that are significant at the 10, 5, and 1 percent significance levels, respectively.

Figure 9. Long-Term Impact of Commodity Prices on Exchange Rate 1/



Source: IMF staff estimates.

1/ The charts compare θ multiplied by the ratio of net energy and nonenergy commodity exports to noncommodity imports, respectively, from equation (4), with τ_{enc} from equation (5).

coefficients are significant at the 1 percent level—although the R^2 remains below the preferred specification in Table 4.[17]

As can be seen in Figure 8, the split-coefficient equation implies an appreciation since early 2002 that is almost identical to the specification discussed above. This largely reflects the similarity of the long-run coefficient on energy prices in this specification and the preferred specification reported in Table 4. This likeness in coefficients is not, however, typical. This can be seen in Figure 9, which graphs the long-term coefficients on energy and nonenergy commodity prices in the preferred specification—which vary with the value of the commodity trade balance—and the split-coefficient specification—where the coefficient on energy prices jumps in 1990Q1.

V. Putting It All Together

In addition to any balance of payments benefits, the oil sands impact will be amplified by the large amount of factor inputs needed to support rising production levels. Significant capital equipment as well as energy, transport, and urban infrastructure need to be in place before oil can be produced. Unlike in countries with more conventional energy reserves, the production process itself is also very resource-intensive, reflecting both energy and labor inputs and the need for large replacement investment. Timilsina, Prince, and others (2005) use input-output tables to estimate that each dollar spent on oil sands investment or production yields \$3.35 or \$1.74 of GDP, respectively.[18]

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[17] Root mean squared errors on dynamic projections since 1990 provide a similar ranking of the three models.

[18] Assuming that annual expenditure for investment and production rises to around \$50 billion per year by 2015 (in 2004 prices), their calculation suggests that the level of real GDP would be shifted upward by 7¼ percent.

Oxford Economic Forecasting's global macro model provides a tool for assessing the overall consequences of rising Canadian oil production. The model uses a traditional adaptive-expectations approach with a Cobb-Douglas production function and imperfectly competitive labor markets. Long-term growth is driven by demographics and productivity growth. The model also includes a block of equations for energy production and exports in Canada, which makes modeling the stepped-up production activity relatively straightforward. Two scenarios were studied:

- *Higher oil sands output*. In addition to a stronger oil production forecast, investment and factor input data from Timilsina, LeBlanc and Walden (2005) were added to the forecast for investment and other GDP. In addition, an exogenous path for global oil prices (from the IMF's World Economic Outlook) was provided. The model was calibrated to ensure that the Oxford model's projection of the current balance and exchange rate was consistent with the results of the previous section. The simulations confirm a positive but relatively small impact of oil sands production on Canadian GDP, mainly resulting from the effect of higher export incomes on domestic consumption (Table 6).

- *Higher output and energy prices*. In addition to higher oil sands output, the second scenario assumes an increase in the world oil price to US$110 per barrel by 2020, with a concomitant increase in gas and other energy prices. Although this would yield an additional increase of 1 percent of GDP in the current account balance, the change in both the exchange rate and non-energy exports is more than twice as strong compared to baseline as in the first scenario—in part because of falling demand abroad. With consumption also growing less strongly, the overall impact of higher oil prices on GDP is slightly negative in this simulation.

Both scenarios may be optimistic in that they assume only a gradual buildup of real wages in the face of tight labor markets. The economy's productive capacity initially increases (over baseline) as a result of the shift towards oil sands production, implicitly assuming that sufficient resources can be moved to high-productivity energy activities. Although the effect

Table 6. Impact of Oil Production and Price Increases
(Difference to baseline)

	Higher oil sands output			Higher energy prices		
	2010	2015	2020	2010	2015	2020
GDP (percent)	0.45	0.53	1.07	-0.04	-0.39	-0.53
GDP growth (percentage points)	0.11	0.01	0.08	0.03	-0.08	-0.08
Consumption (percent)	0.27	0.75	1.26	-0.04	0.25	0.70
Real wages (percentage)	0.34	0.65	1.01	0.04	0.15	0.21
Real effective exchange rate (percent)	1.32	2.64	3.97	3.39	6.85	10.40
Export of non-energy goods (percent)	-0.79	-1.74	-1.97	-2.07	-4.12	-6.32
Export of services (percent)	-0.65	-1.21	-1.34	-1.71	-3.34	-5.86
Current account balance (percent of GDP)	0.48	0.38	1.08	1.00	1.17	1.90

Source: Oxford Economic Analysis; IMF staff calculations.

diminishes after oil sands investment is assumed to plateau on a higher level, potential output remains above baseline in both scenarios. Labor pressures are more intense in the first scenario, resulting in a real wage increase of around 1 percent over 15 years. Real wage increases are smaller in the second scenario, as higher energy prices impact negatively on demand.

To test for consistency, the IMF's Global Economic Model (GEM) was used to run a similar exercise.[19] Using the production figures described in Section III as an input, GEM projects that rising oil sands exports could lift GDP by about 4 percent by 2020—a marginally higher but still moderate beneficial effect. Output of the nonoil tradable sector would shrink as expected (by 5 percent relative to baseline) as the real effective exchange rate would appreciate by about 3 percent. The difference may in part reflect the absence of a specific energy sector in GEM—the increase in oil sands output was instead modeled by raising the available supply of land used as a production factor.[20]

VI. Conclusion

The expansion of oil sands production is likely to have a small beneficial impact on the Canadian economy. The potential gains in export revenues could result in some upward pressure on the exchange rate, but this is not expected to be large enough to significantly affect non-energy exporters. Rising factor demand from oil sands exploration and production would also boost domestic output. However, the anticipated production increases are relatively small on a global scale, and even a growing energy sector will remain only one of several pillars in a well diversified Canadian economy.

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[19] See Laxton and Pesenti (2003) and Bayoumi and others (2004) for a description of GEM.

[20] A multilateral exchange rate model applied to Canada by Lee and Mühleisen (2004) also finds that the stronger path for oil exports could increase the exchange rate's sensitivity to energy prices: a 10 percent oil price increase would push up the equilibrium exchange rate by 1.20 percent instead of 1.07 percent.

APPENDIX

I. Data

The data were constructed as follows:

- *Canadian-U.S. dollar real exchange rate*: quarterly averages of the C$/US$ exchange rate divided by the relative GDP deflators.

- *Canada-U.S. interest rate differential*: difference in interest rates on 90-day commercial paper.

- *Canadian net energy (nonenergy) commodity exports as a ratio of noncommodity imports*: difference between exports and imports of energy products (of agricultural and fishing products and forestry products) divided by total goods imports less imports of agricultural and fishing products, energy products, and forestry products (Source: Statistics Canada, Balance of Payments Statistics).

- *Relative price of energy (nonenergy) commodities*: price of Canadian energy (nonenergy) commodities in US$ divided by the U.S. GDP deflator (Source for commodity price series: Bank of Canada).

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