Oil Price Movements and the Global Economy: A Model-Based Assessment

Selim Elekdag, International Monetary Fund

Rene Lalonde, Bank of Canada

Douglas Laxton, International Monetary Fund

Dirk Muir, Bank of Canada

Paolo Pesenti, Federal Reserve Bank of New York, NBER and CEPR

Motivation

This paper introduces a new version of the Global Economy Model (GEM) to deal with oil price shocks. New features include:

- its large scale (5 regions, 4 sectors).
- separate tradable oil and nontradable gasoline sectors.
- ability to deal with short-run vertical supply and demand curves different from long-run curves (that are not as inelastic) in the oil sector.

Motivation (cont'd)

So we want to:

- Highlight the properties and features of the new version of GEM.

- Apply those features to two questions:

  1. What are the underlying causes of the oil price run-up since 2003?

  2. What are some potential policy remedies to reduce oil prices?

Outline of the Presentation

1. Some facts for understanding global growth and the oil market.

2. The analytical framework - Global Economy Model (GEM).

    - Calibrating the model, and caveats about this version.

3. Model properties and how they answer our first question.

4. Using the model for a policy experiment to answer the second question.

Some Facts

Oil prices in the futures market have tripled since the winter of 2003 in nominal terms.

- Roughly 120 percent in real terms.
  - Prices were considered high in 2003 and were expected to fall over time as supply was expected to increase in response (significantly above what was thought to be "the cost of production" in 2003).

- There have been very large revisions in forecasts for oil prices - some forecasters suggest oil prices as high as 80 to 120 US dollars a barrel.

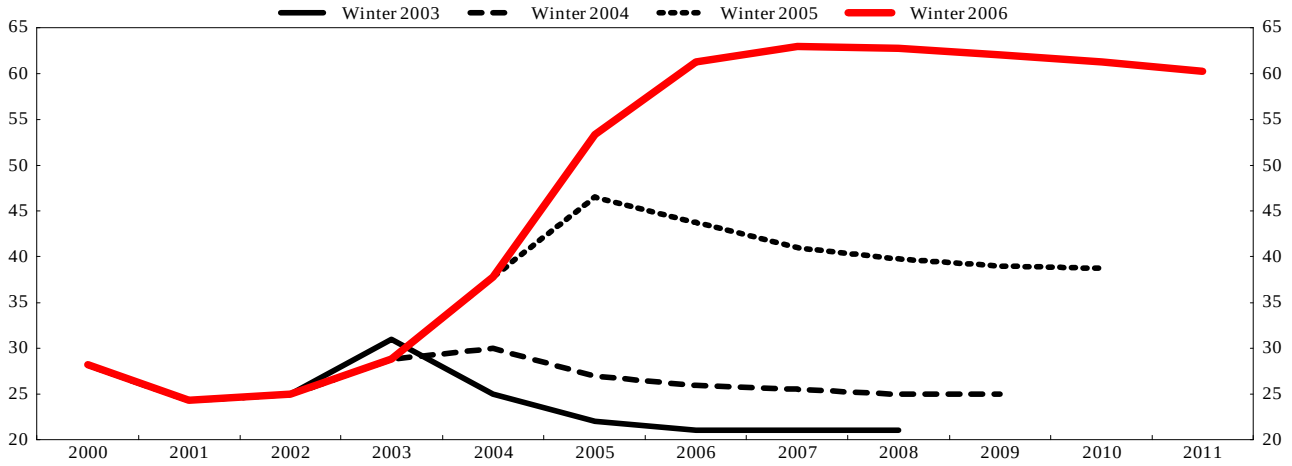
Relating the Oil Market and Global Growth

Upward revisions in current and future output growth seem to have resulted in large and persistent changes in the price of oil and its futures curve.

- Consider forecast revisions from the World Economic Outlook since 2003.
  - World growth in 2006 is expected to exceed 4% for the 4th year in a row.
  - Revised up principally because emerging-market economies $\Longrightarrow$ productivity boom.

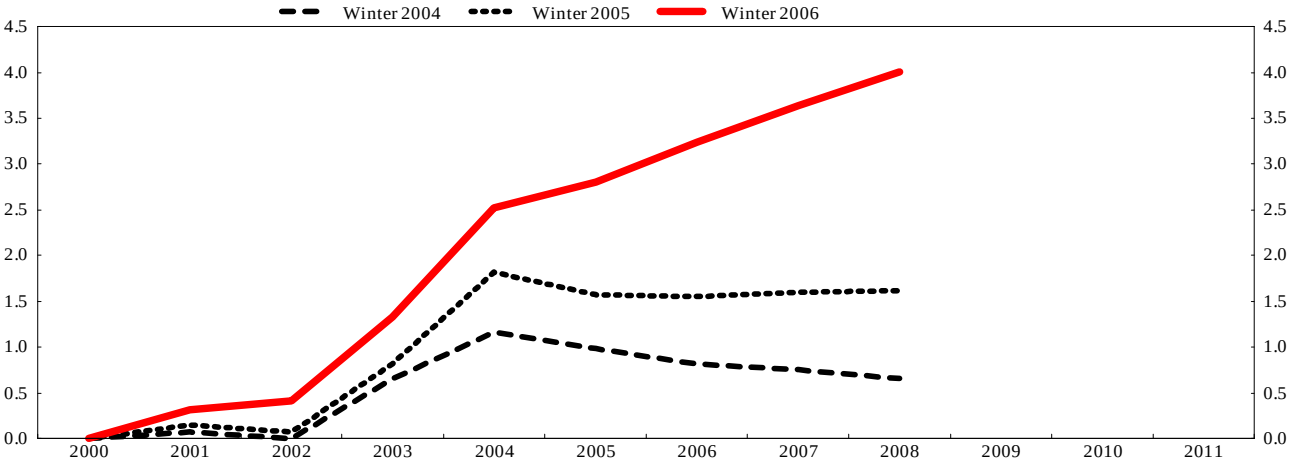
Oil Price Projections From Futures Market

(US Dollars per Barrel)



Revisions in Cumulative World Output Growth Projections

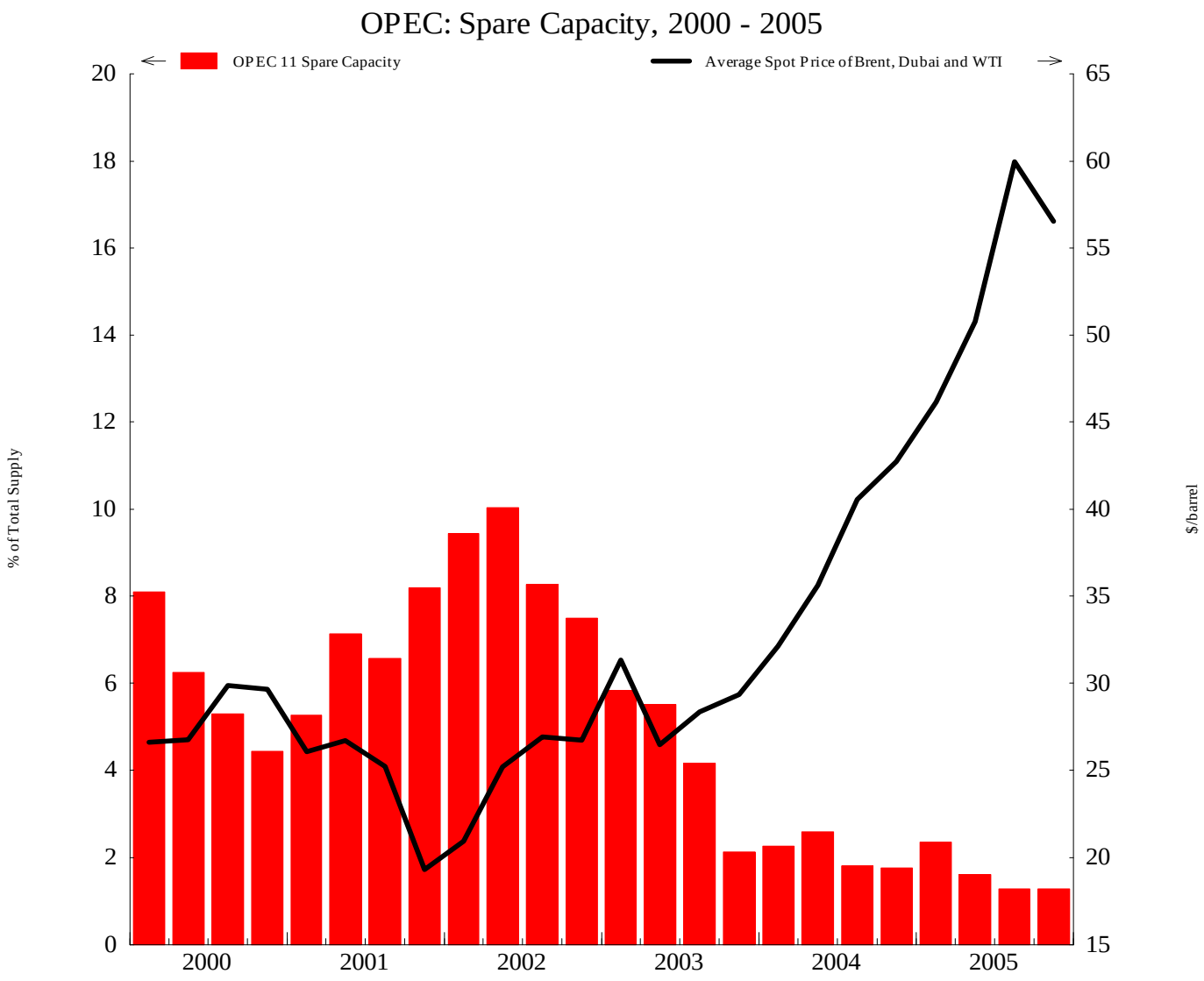
(Percent Deviations from Winter 2003 WEO)



The Effect of Capacity Constraints

World oil supply has not kept up with demand, so the world has moved into a new regime where spare production capacity is at all-time lows and consequently there is considerable variation in future oil prices.

- increased the effective market power of oil producers relative to earlier periods such as in the 1970s, when they had significant spare capacity that had to be held back from the market to maintain high prices.
  - more difficult to maintain prices during these periods as some producers had strong incentives to sell more at existing prices to increase revenues.

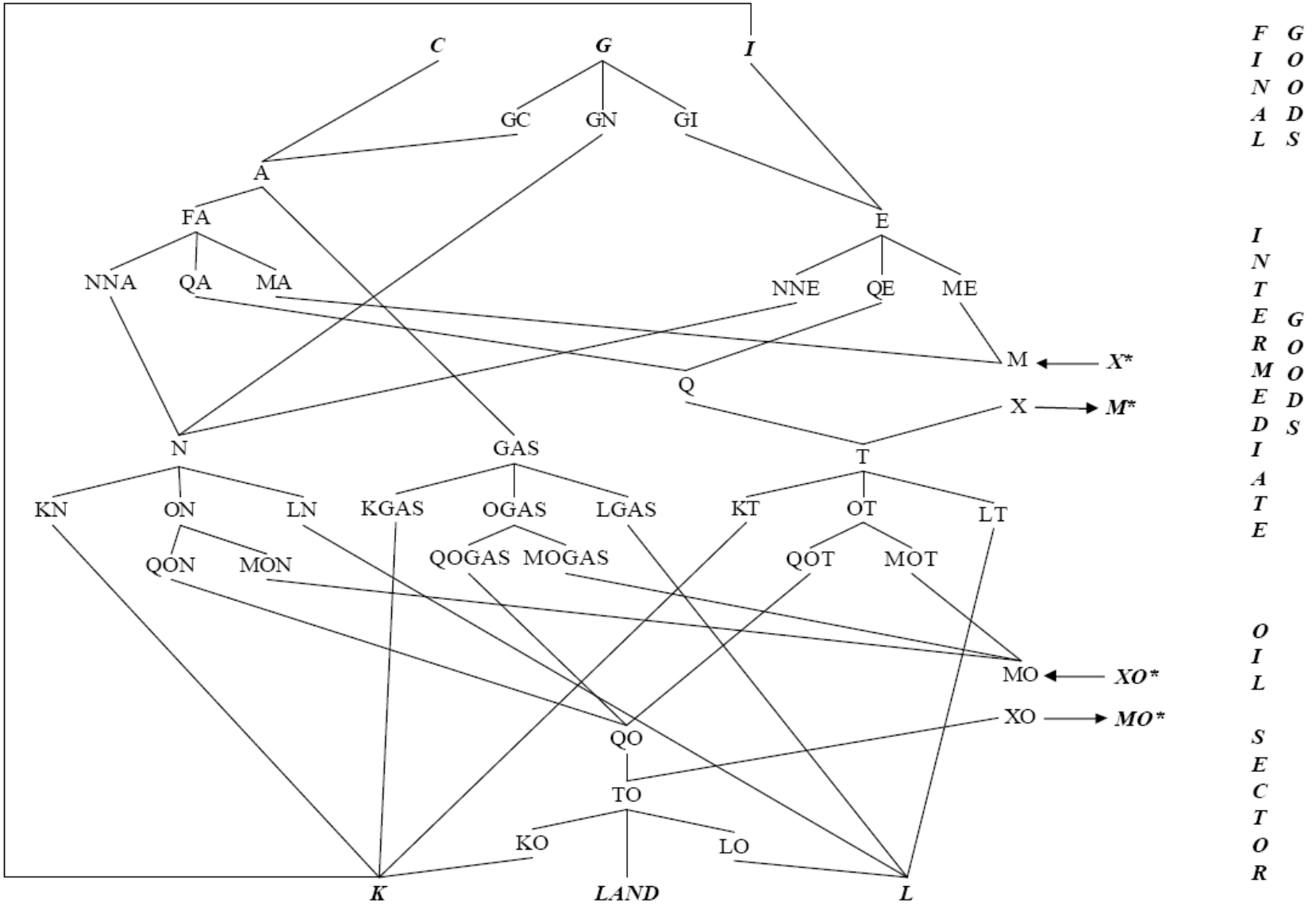

OPEC: Spare Capacity, 2000 - 2005
OPEC 11 Spare Capacity
Average Spot Price of Brent, Dubai and WTI
% of Total Supply
$/barrel
0
2
4
6
8
10
12
14
16
18
20
15
20
25
30
35
40
45
50
55
60
65
2000
2001
2002
2003
2004
2005

The Analytical Framework

We use an extended version of the Global Economy Model where oil production, consumption and trade is modeled from optimizing behavior. There are 5 regional blocs, divided into two groups:

1. Oil-exporting regions = Canada and the group of oil-exporting countries (GOEC). The former has a small effect on the world price of oil and is used to study the effects of world demand and supply on the the terms-of-trade of the Canadian economy.

2. Oil-importing regions = United States, emerging Asia and a remaining countries bloc (driven by Japan and the European Union).


C
G
I
GC
GN
GI
A
FA
E
NNA
QA
MA
NNE
QE
ME
M
X*
Q
X
M*
N
GAS
T
KN
ON
LN
KGAS
OGAS
LGAS
KT
OT
LT
QON
MON
QOGAS
MOGAS
QOT
MOT
MO
XO*
XO
MO*
QO
TO
KO
LO
K
LAND
L
FINAL GOODS
INTERMEDIATE GOODS
OIL SECTOR
FACTORS OF PRODUCTION

The Analytical Framework (cont'd)

- The price of oil is determined by demand and supply. Oil producers are assumed to have market power that can change over time.
  - Oil is used in the production of tradables, nontradables and gasoline.
  - Gasoline is part of the consumption basket of all agents.
- Strong real rigidities in the oil and gasoline sectors = very low short-run elasticities on the demand and supply of oil.
  - Currently these elasticities are much smaller than 30 years ago as there is little spare production capacity.

Important Caveats

- The model does not include oil inventories so oil prices respond too strongly to temporary shocks.

- The value of oil is based entirely on its use value. We do not assume that oil is a storable commodity whose price will be linked to the rates of returns on other assets.

- The model is not meant to explain short-run variation in oil prices because of either actual or potential market disruptions, but has been designed to explain the interaction of oil prices and the world economy over the medium term.

Calibration of the Initial Steady State

Parameterization in line with previous work on GEM for the "deep parameters" (Faruqee, Laxton, Muir and Pesenti (2006)), where all regions are calibrated identically. Parameterization of interest is the oil and gasoline sectors:

- Low elasticities of substitution for capital and labour for production of oil and gasoline.
- Oil sector is subject to diminishing marginal returns in principle because of the fixed factor.
- High degree of substitutability between domestic and imported oil ($= 10$) and region of origin for imported oil ($= 3$).

Calibration of the Initial Steady State (cont'd)

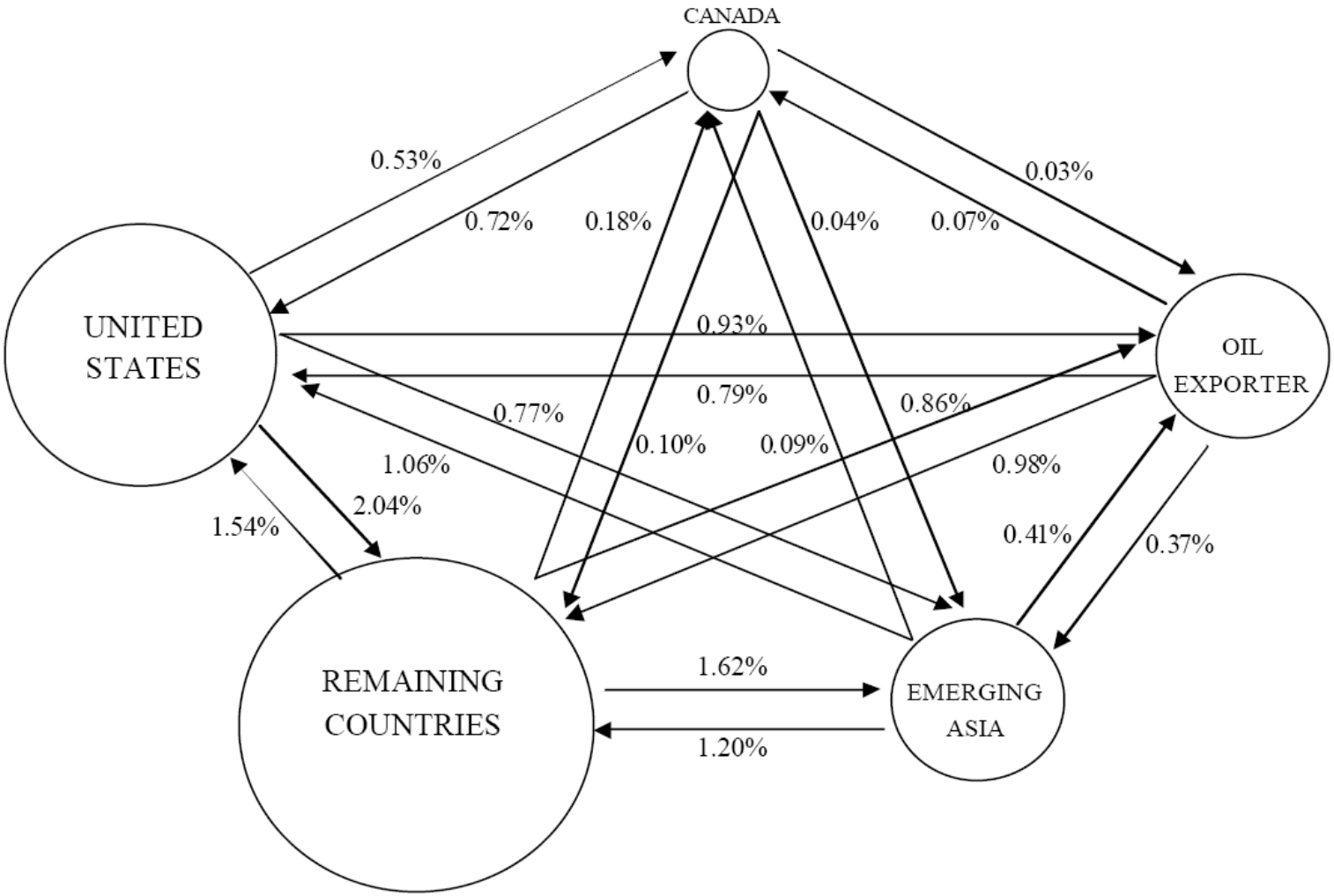
Regions are unique in the following ways:

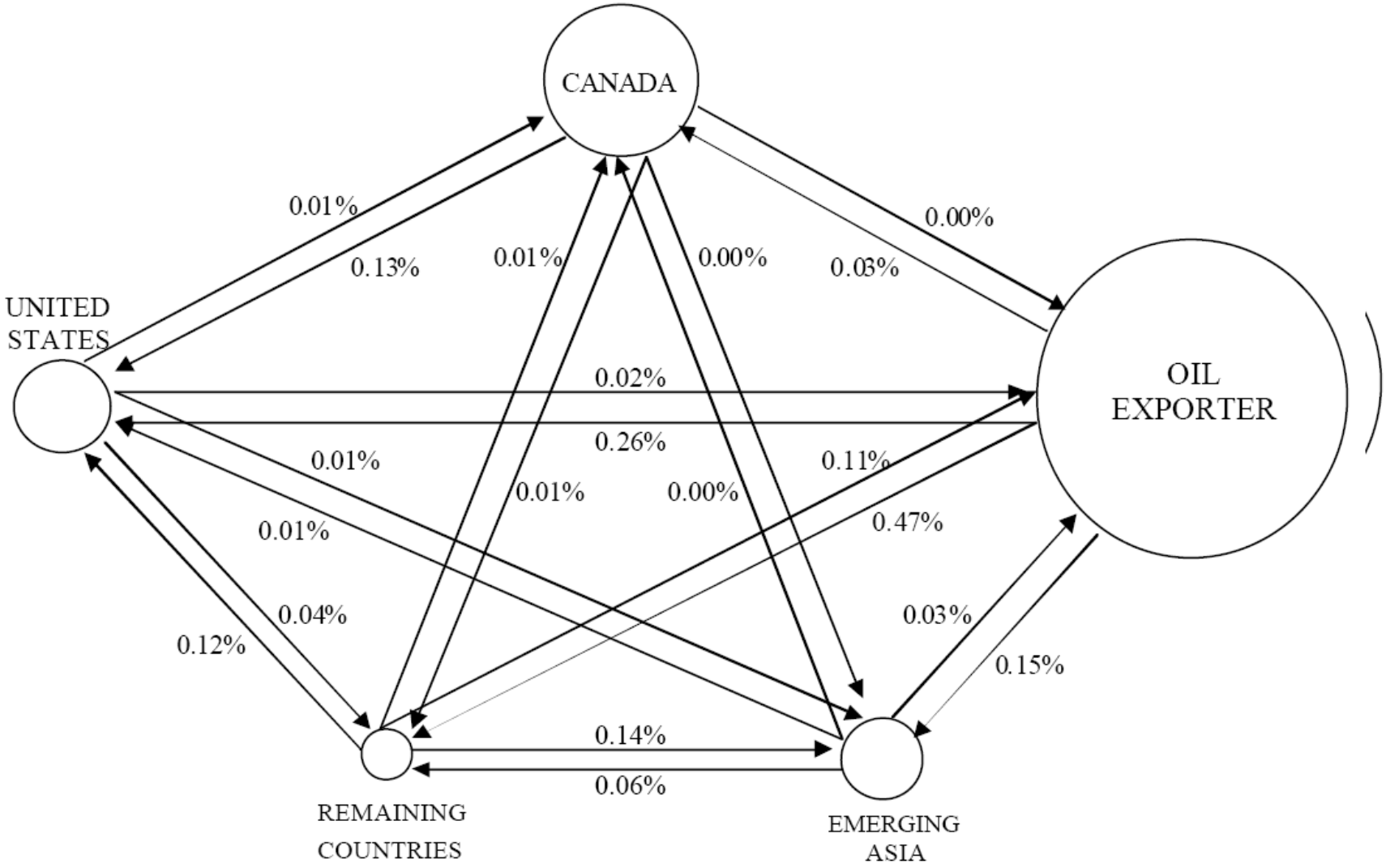
- Roughly match for each region the national accounts composition of output.
- We choose the NFA positions based on current levels and current trends in current account accumulations.
- Government debt is reflective of today's levels, adjusted for fiscal plans going forward.

Calibration of the Initial Steady State (cont'd)

- Trade matrix represents bilateral world patterns as of 2003, cognizant of the long-run wealth distribution.
  - For oil exporters, GOEC exports are dominated by oil; they are significant in Canada but not dominant.
  - Oil imports are very important for emerging Asia.

The bilateral flows are expressed as a percentage of world GDP, in US dollars.


CANADA
UNITED STATES
OIL EXPORTER
REMAINING COUNTRIES
EMERGING ASIA
0.53%
0.72%
0.18%
0.04%
0.07%
0.03%
0.93%
0.79%
0.77%
0.10%
0.09%
0.86%
1.06%
2.04%
1.54%
0.98%
0.41%
0.37%
1.62%
1.20%


CANADA
UNITED STATES
OIL EXPORTER
REMAINING COUNTRIES
EMERGING ASIA
0.01%
0.13%
0.01%
0.00%
0.03%
0.00%
0.02%
0.26%
0.01%
0.01%
0.00%
0.11%
0.01%
0.47%
0.04%
0.12%
0.03%
0.15%
0.14%
0.06%

Calibration of the Dynamics

- Monetary policy - core inflation targeting everywhere in this version.
- Nominal rigidities in prices differ across regions - U.S. has the least, followed by emerging Asia; region with EU has the most.
- In the oil sector, all real rigidities are calibrated close to the same value.
- The real side of the model responds sensibly to standard monetary and business cycle shocks, but the prices respond too much as real rigidities bind (no oil inventories to smooth out responses).

Key Shocks

The model offers a variety of shocks that can help explain what has driven, and will drive, oil prices.

1. Higher productivity growth in oil-importing regions (upward pressure on oil prices)

2. An increase in oil demand in emerging Asia (upward pressure on oil prices)

3. Expected future expansion of oil reserves (downward pressure on oil prices)

4. Supply-induced oil price hike (upward pressure on oil prices).

Higher Productivity Growth in Oil-Importing Regions

- Productivity growth is higher in all the oil importing regions - oil-importing regions at 1 percentage point per year for 20 years.

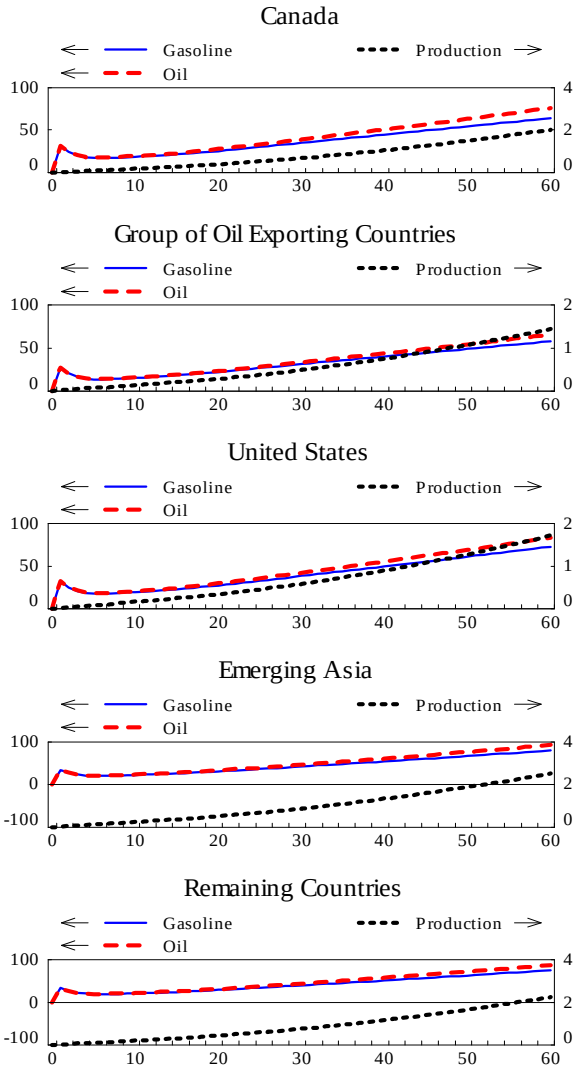
- Oil prices rise initially by about 20% - initial spike is caused by the real rigidities in the oil and gasoline sectors.
  - they decline over time as the rigidities loosen.
  - then trend upwards as there are diminishing returns on the production of oil coupled with continued strong global growth.

Higher Productivity Growth in the Oil-Importing Regions

(Deviation From Control)

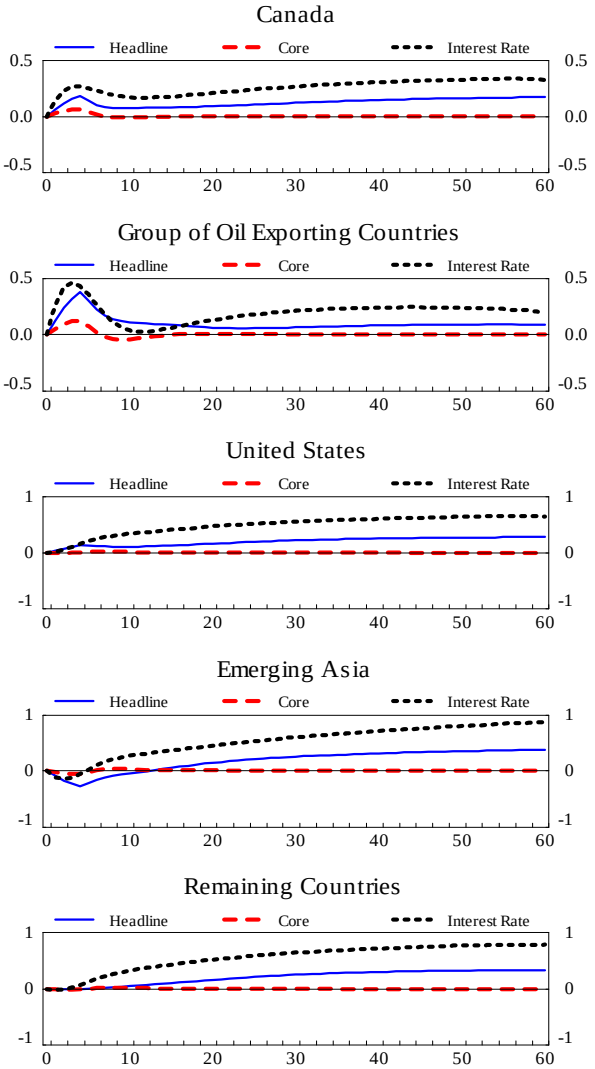
Oil Production and Prices

(Percent, incl. tax)



Inflation and Interest Rate

(Percentage Points)

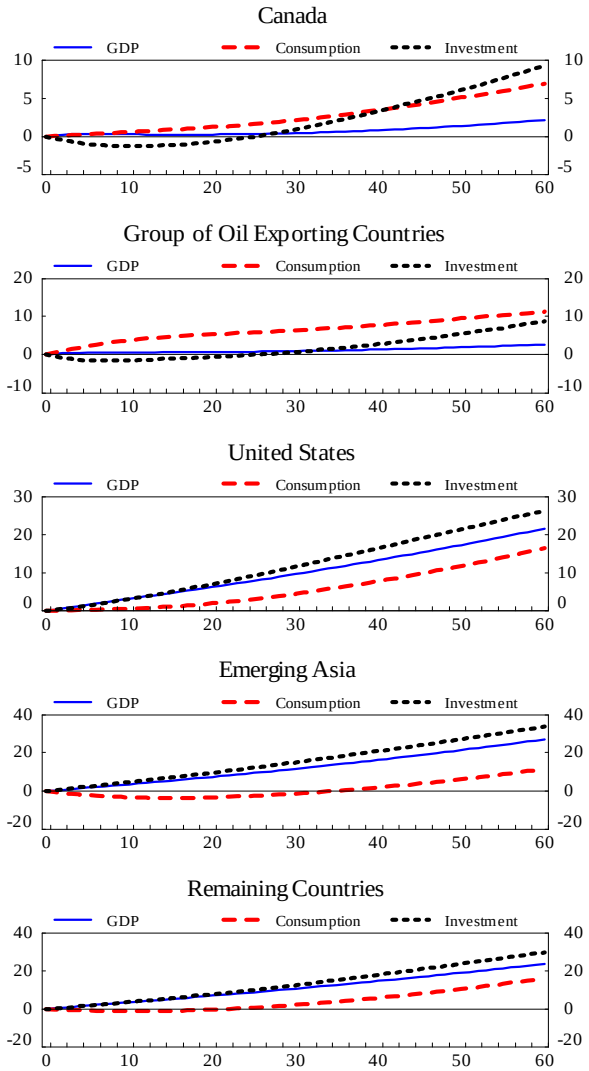


Higher Productivity Growth in Oil-Importing Regions (cont'd)

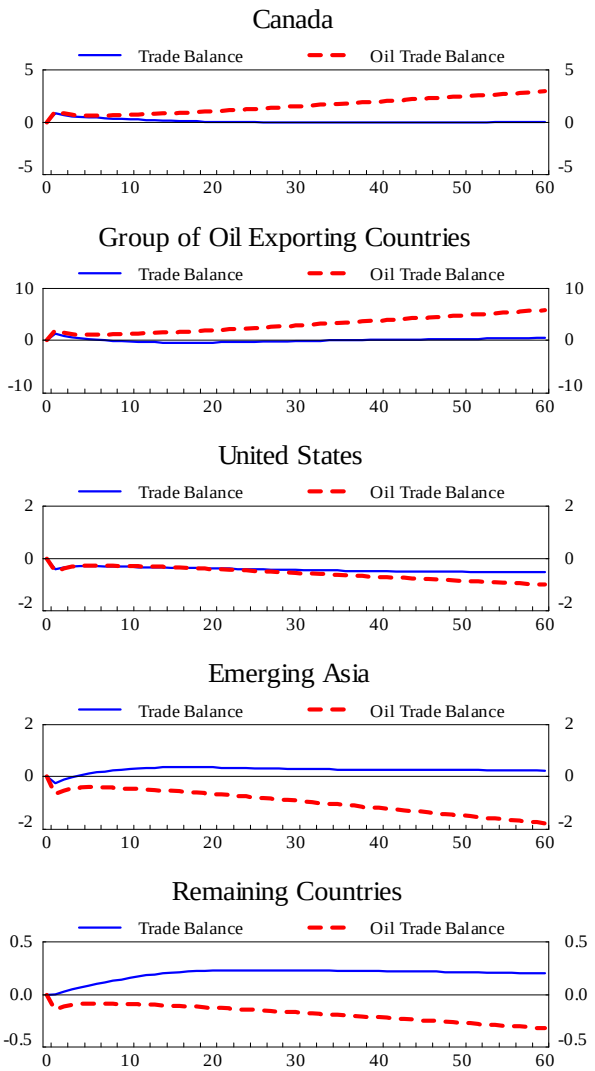
- Oil-exporting regions experience a positive terms-of-trade effect and their trade balances and net foreign asset positions improve.
- Oil importing regions face a general drag on consumption in the short run from higher oil prices but GDP growth is strong.
- U.S. trade deficit worsens almost exclusively because of oil.
- Trade balance in emerging Asia and the remaining countries improves.
  - Despite drags from higher demand for oil. Oil-exporting regions want more of their goods.

Higher Productivity Growth in the Oil-Importing Regions
(Deviation From Control)

GDP, Consumption, and Investment
(Percent)

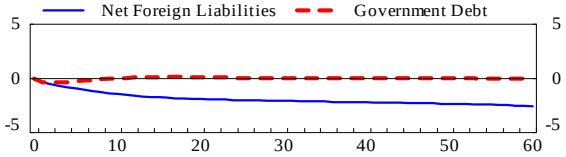


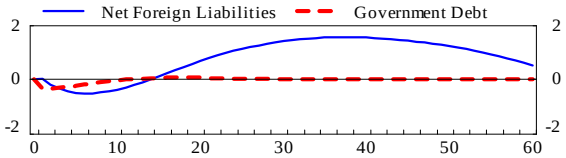
Nominal Trade Balances
(Percent of GDP)

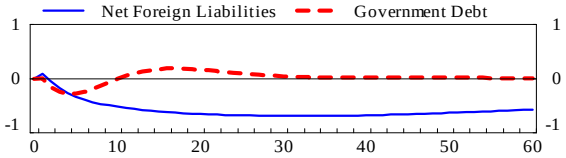


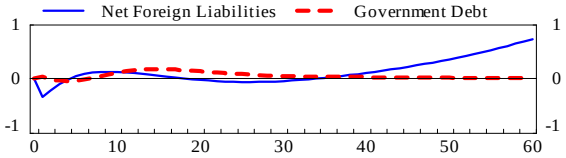
Higher Productivity Growth in the Oil-Importing Regions
(Deviation From Control)

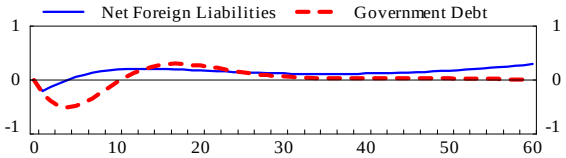
Stocks of Debt Holdings
(Percent of GDP)

Canada


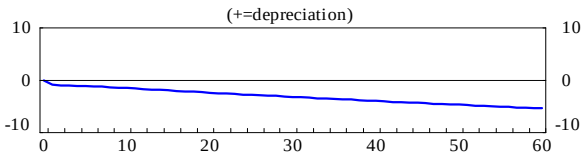
Group of Oil Exporting Countries


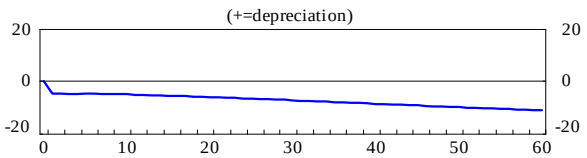
United States


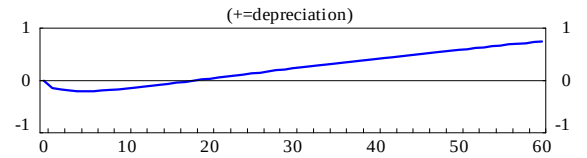
Emerging Asia


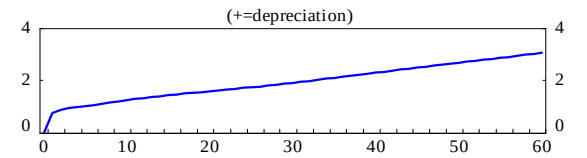
Remaining Countries


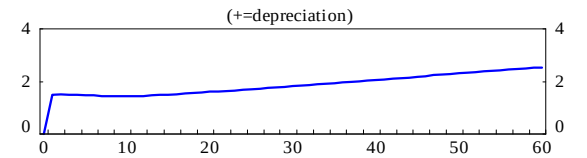
Real Effective Exchange Rate
(Percent)

Canada


Group of Oil Exporting Countries


United States


Emerging Asia


Remaining Countries


Additional Features with the Productivity Shock

Reaction of Oil Reserves

Productivity shock above is not in line with history as there is no growth in oil reserves - high income growth, high oil prices normally spur exploration.

- The model can generate anticipated increase in reserves - 5 years in future $\Longrightarrow$ 10% fall in oil prices; mitigating effects worldwide:
  - Oil importing regions - Terms of trade improve so consumption, output increase in short run.
  - Oil exporting regions - Wealth falls (so does consumption), but more investment for new oil fields.

Additional Features with the Productivity Shock (cont'd)

An Increase in the Demand for Oil in Emerging Asia

- Effects of a productivity shock in emerging Asia is probably intensified:
  - production of goods that are more oil-intensive (i.e. finished goods versus commodities).
  - consumer goods that require higher gasoline consumption (i.e. automobiles versus bicycles).

Additional Features with the Productivity Shock (cont'd)

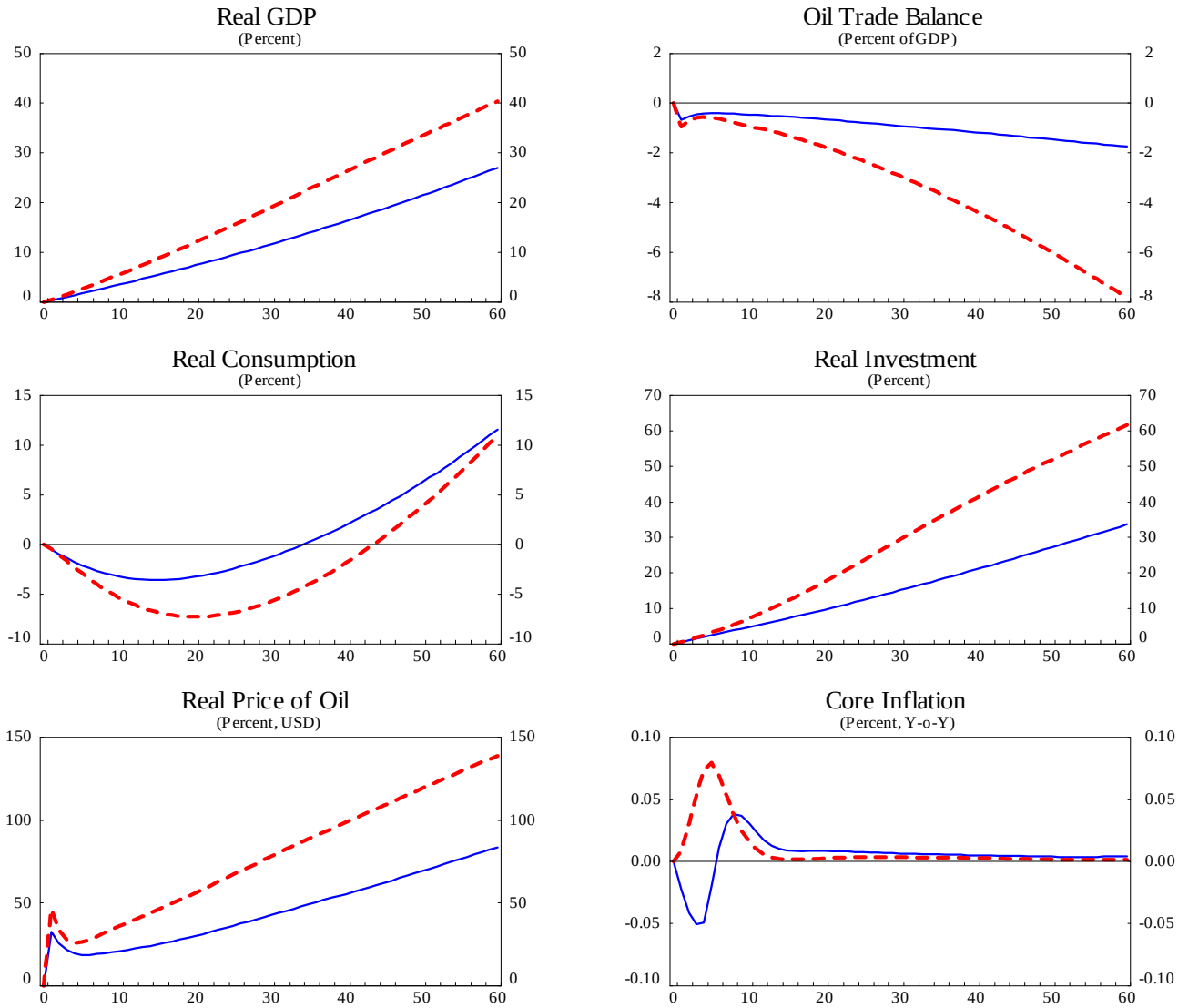
An Increase in the Demand for Oil in Emerging Asia (cont'd)

- Oil consumption increases by roughly 2.5% of GDP in emerging Asia after 15 years.

$\Longrightarrow$ increase in the world price of oil of 10% on impact, 50% in long run.

- All effects are amplified - the demand for oil shock is qualitatively the same as a productivity shock.

Emerging Asia: Increase in Demand for Oil and Higher Productivity Growth in Emerging Asia
(Deviation From Control)
Solid = Productivity Only; Dashed = Combined Shocks



Supply-Induced Oil Price Hike

Oil producers increase their prices as demand grows and excess capacity vanishes. They do this to exploit their market power. Implies two effects:

1. Positive wealth effect from higher oil prices for regions producing oil $\Longrightarrow$ positive terms-of-trade effect, so their trade balance and net foreign asset position improve.

   - They take the peak of their increase in their net foreign assets as permanent. Otherwise, consumption would increase even more in the short run.

Supply-Induced Oil Price Hike (cont'd)

2. Negative effects from higher oil prices for regions consuming oil. This effect happens worldwide, but is most important in the oil-importing regions.

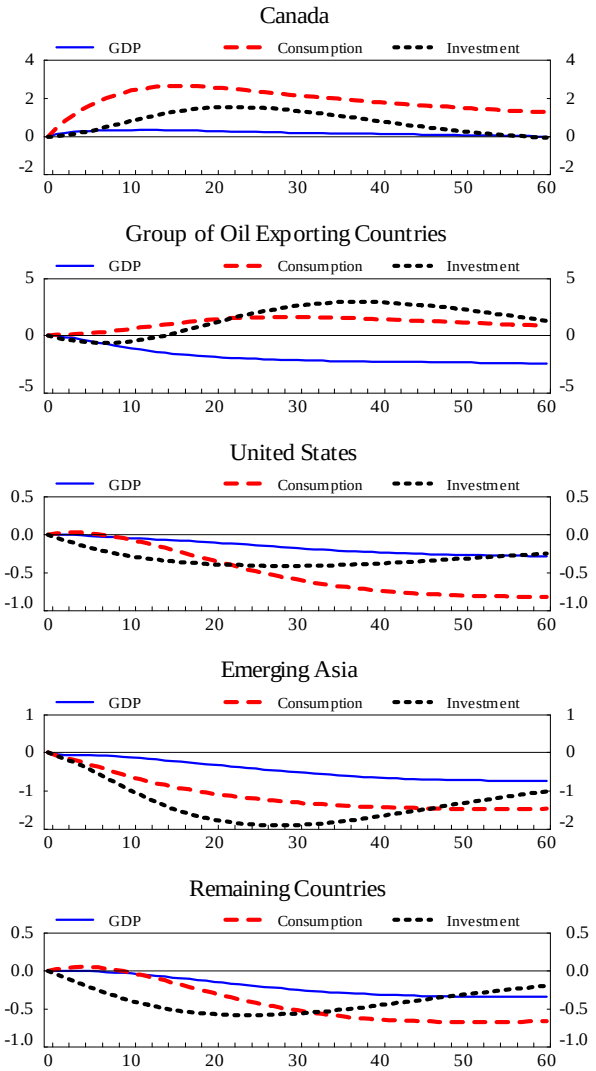
   (a) increased cost of production of tradable and nontradable goods, concurrent falls in consumption and investment.

   (b) extra downward pressure on consumption since gasoline is part of the basket.

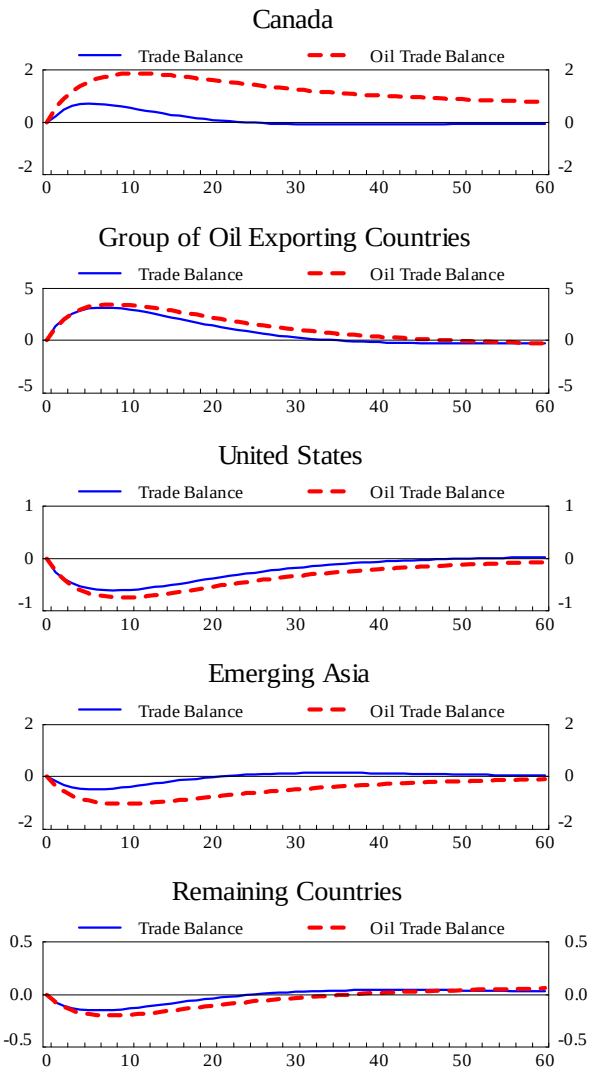
   (c) a real depreciation and a deterioration of their trade balances.

Supply-Induced Oil Price Hike
(Deviation From Control)

GDP, Consumption, and Investment
(Percent)



Nominal Trade Balances
(Percent of GDP)



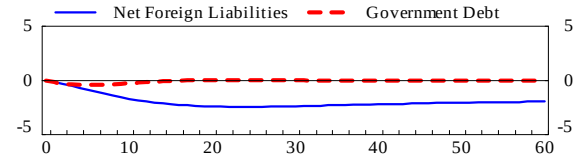
Supply-Induced Oil Price Hike

(Deviation From Control)

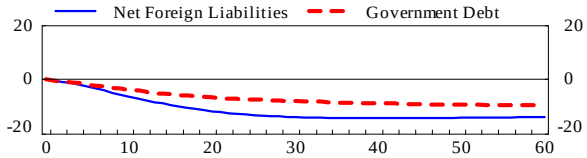
Stocks of Debt Holdings

(Percent of GDP)

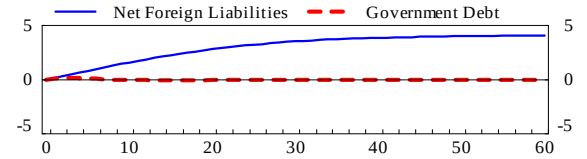
Canada



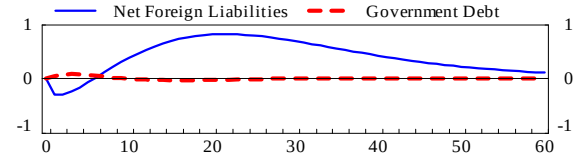
Group of Oil Exporting Countries



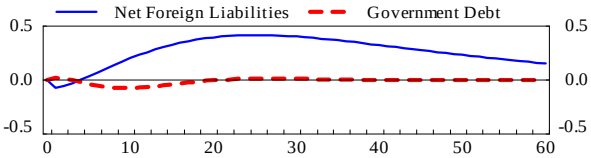
United States



Emerging Asia



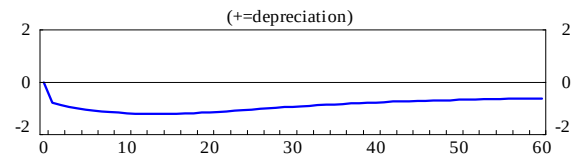
Remaining Countries



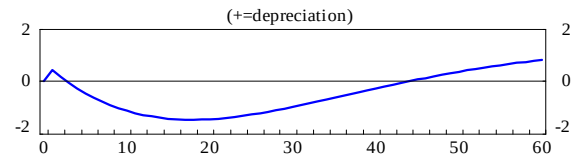
Real Effective Exchange Rate

(Percent)

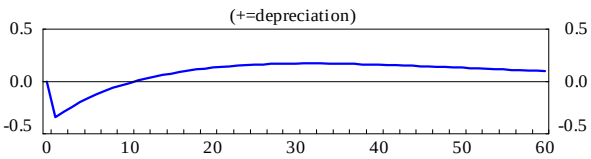
Canada



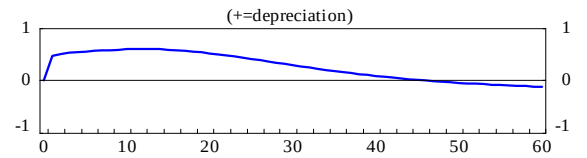
Group of Oil Exporting Countries



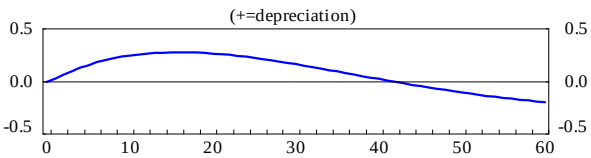
United States



Emerging Asia



Remaining Countries



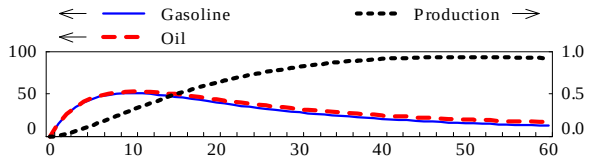
Supply-Induced Oil Price Hike

(Deviation From Control)

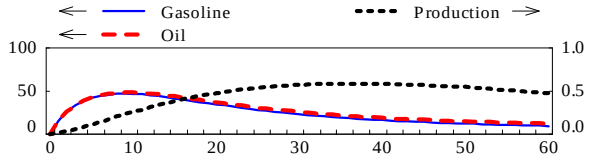
Oil Production and Prices

(Percent, incl. tax)

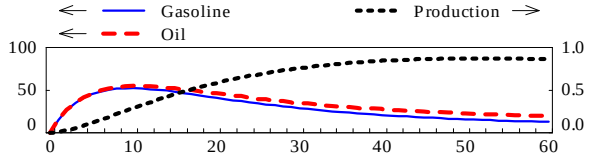
Canada



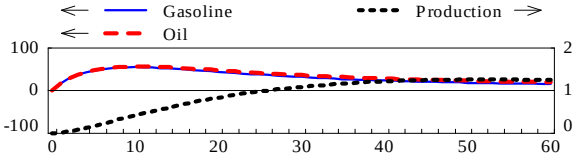
Group of Oil Exporting Countries



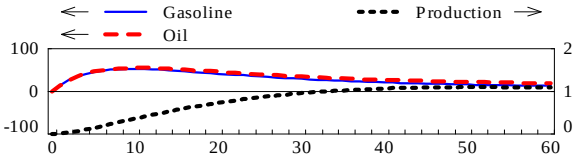
United States



Emerging Asia



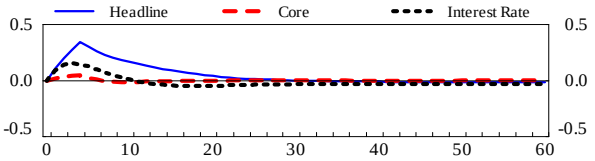
Remaining Countries



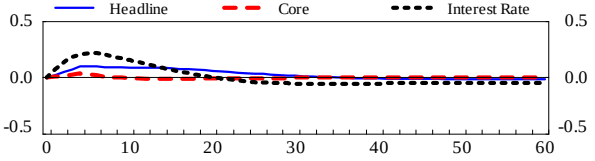
Inflation and Interest Rate

(Percentage Points)

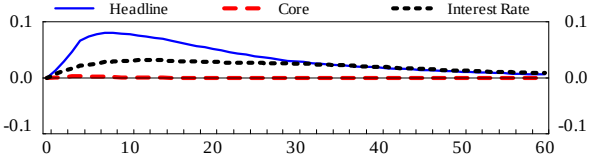
Canada



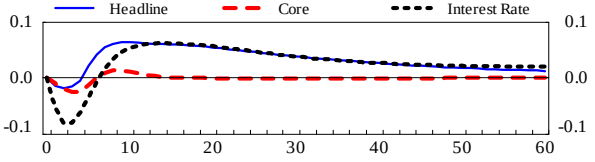
Group of Oil Exporting Countries



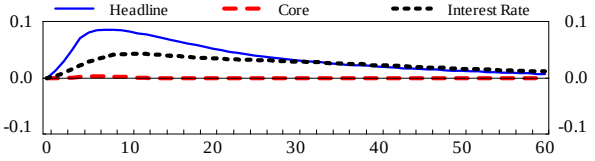
United States



Emerging Asia



Remaining Countries



A Policy Experiment

As well as considering the causes of the oil price increase, we can also consider policy measures to help mitigate it.

- Consider policies with goals such as conservation, or decreasing environmental damage, or moving to renewable energy sources.
  - tax policy is a good example.

A Global Increase in Gasoline Tax Rates

- All regions of the world increase taxes on gasoline by 25 percentage points to encourage conservation - will also reduce the wholesale world price of oil.

- Long-run result - substitute away from gasoline and oil.
  - Very slow process - because of real rigidities in the oil and gasoline sectors.
  - Wealth transfer from oil-exporting regions to oil-importing regions.

A Global Increase in Gasoline Tax Rates (cont'd)

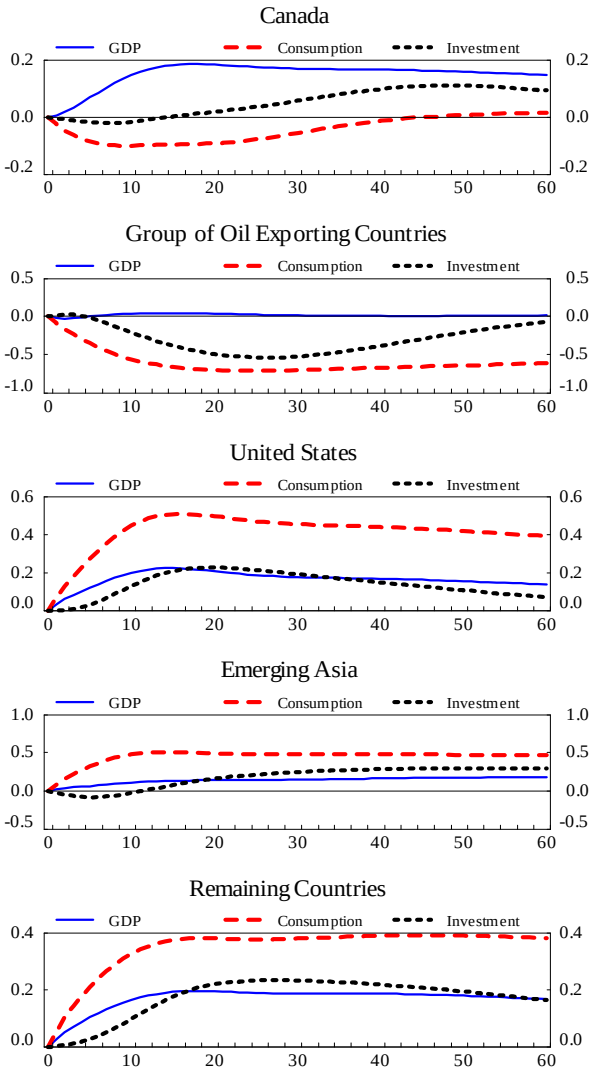
- Oil prices decline five percent; oil trade balance declines in oil exporting regions.
  - Consumption declines in oil exporting regions; increases elsewhere.
- Over all, GDP rises - new source of tax revenues allows cuts in labor taxes in all regions.
  - Stimulates labour supply in the long run, investment in the short run (higher capital stock).
  - This effect mitigates negative effects on Canada much more than in the other oil exporting countries.

A Global Increase in Gasoline Tax Rates

(Deviation From Control)

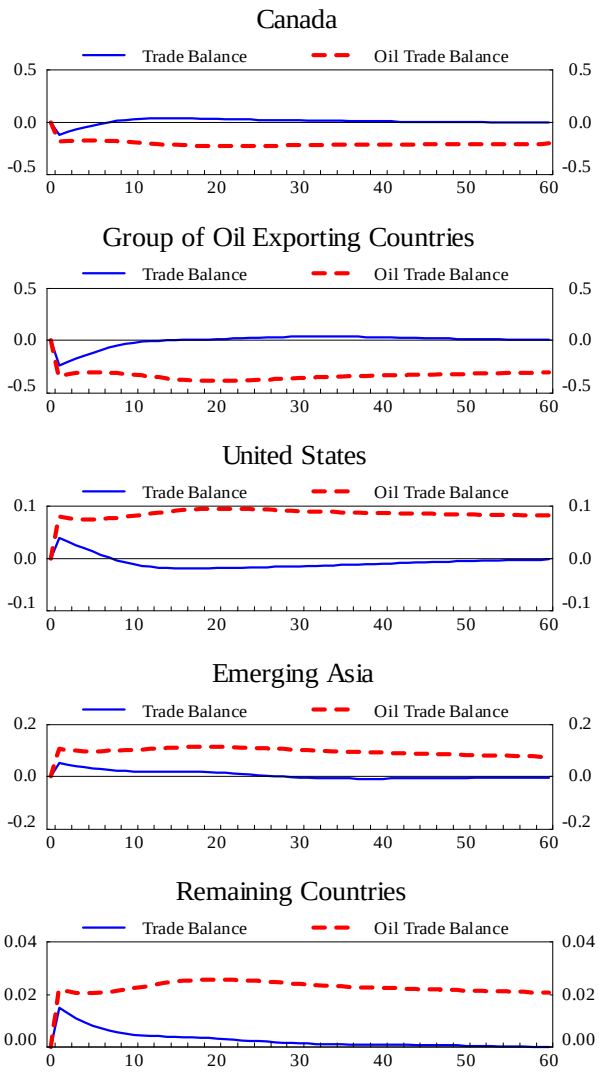
GDP, Consumption, and Investment

(Percent)



Nominal Trade Balances

(Percent of GDP)



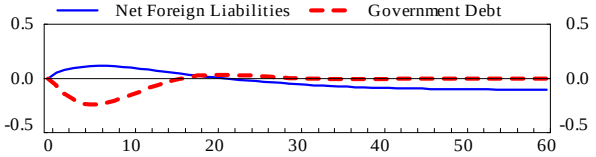
A Global Increase in Gasoline Tax Rates

(Deviation From Control)

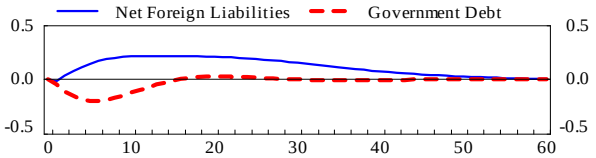
Stocks of Debt Holdings

(Percent of GDP)

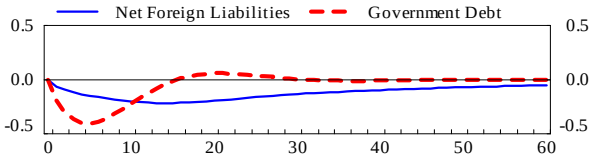
Canada



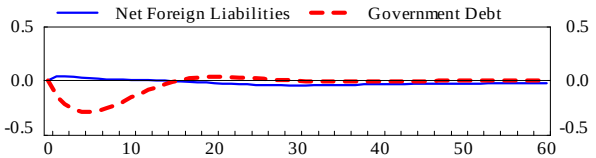
Group of Oil Exporting Countries



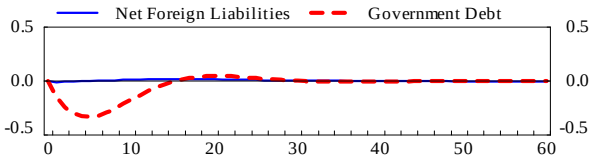
United States



Emerging Asia



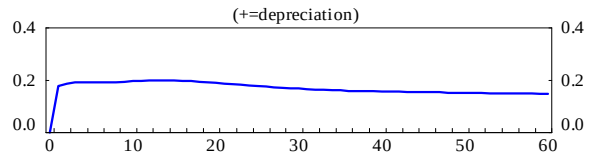
Remaining Countries



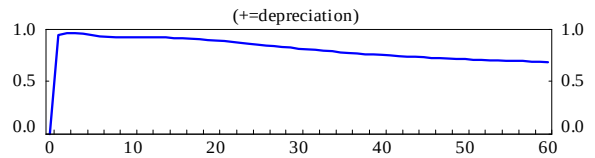
Real Effective Exchange Rate

(Percent)

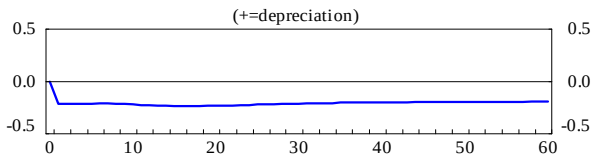
Canada



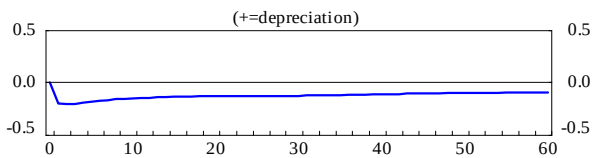
Group of Oil Exporting Countries



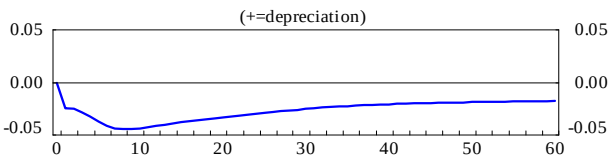
United States



Emerging Asia



Remaining Countries



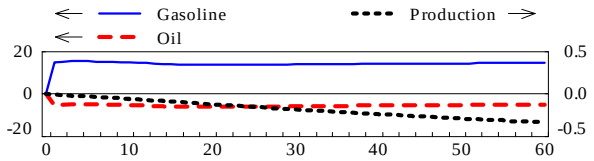
A Global Increase in Gasoline Tax Rates

(Deviation From Control)

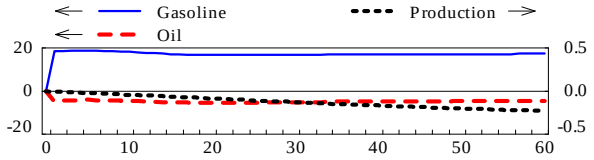
Oil Production and Prices

(Percent, incl. tax)

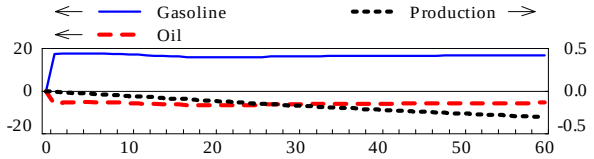
Canada



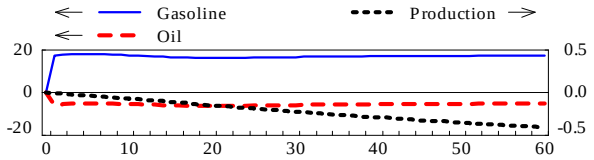
Group of Oil Exporting Countries



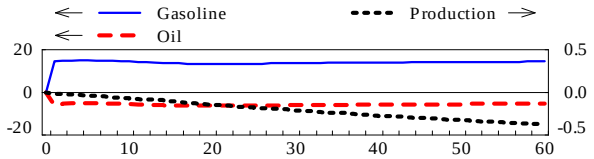
United States



Emerging Asia



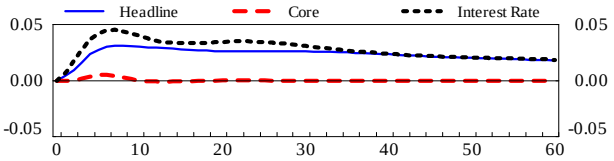
Remaining Countries



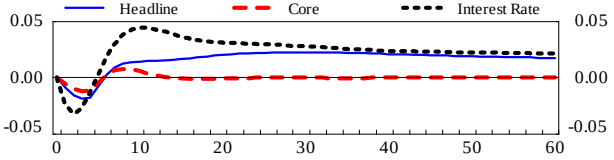
Inflation and Interest Rate

(Percentage Points)

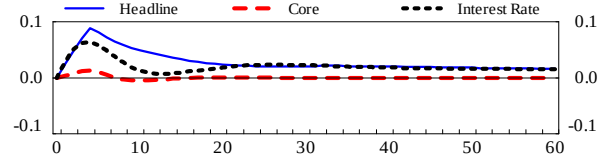
Canada



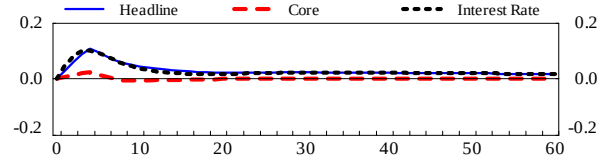
Group of Oil Exporting Countries



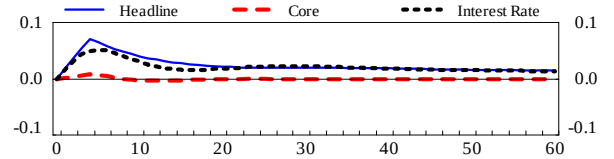
United States



Emerging Asia



Remaining Countries



Conclusions

- New version of GEM is useful to analyze oil price movements.
  - Distinction between oil for production and gasoline for consumers.

- Long-run responses in the oil and gasoline sectors are fairly inelastic, but short-run and medium-run are even more so.
  - = Strong real rigidities in those sectors, as well as low elasticities of substitution.

Conclusions (cont'd)

1. Why did oil prices increase?

   - model properties offer a story based on:

   a. stronger productivity growth in oil importing regions,

   b. coupled with shifts in oil intensity in production (emerging Asia),

   c. as well as pure price increases by producers of oil.

2. What policy measures can can reduce oil demand or prices?

   - We considered an increase in gasoline tax rates by 25% worldwide.

Extensions?

- Extend the baseline of Faruqee *et al*. (2006) to better understand the role of oil prices in global current account imbalances.
  - New benchmark for risk analyses and alternative scenarios for a variety of issues.

- Add non-oil commodities as a separate sector to GEM.