Plausible Quantitative Macroeconomic Effects of the Recent Increase in the Price of Oil and the Appreciation of the Canadian Dollar

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Abstract:

This presentation will develop a model for determining changes in observable macroeconomic variables in the Canadian economy. Specifically, the model demonstrates the effects of shocks to three key variables, first separately, then simultaneously as is the current case for Canada. The shocks are:

1) High energy costs

2) High Canadian dollar

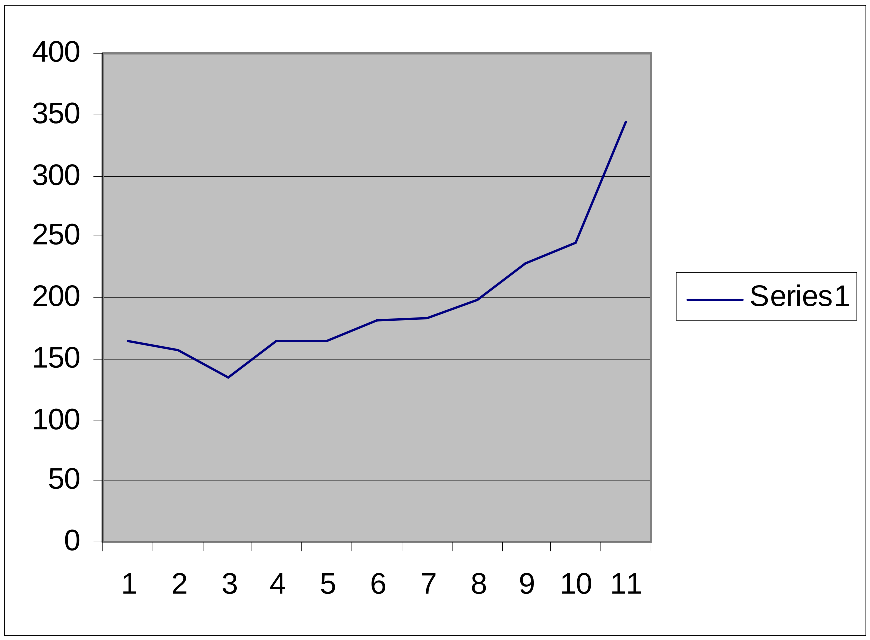
3) Terms of trade

The goal of this is to predict what may potentially happen to the Canadian economy since it has faced these same challenges recently in the near future.

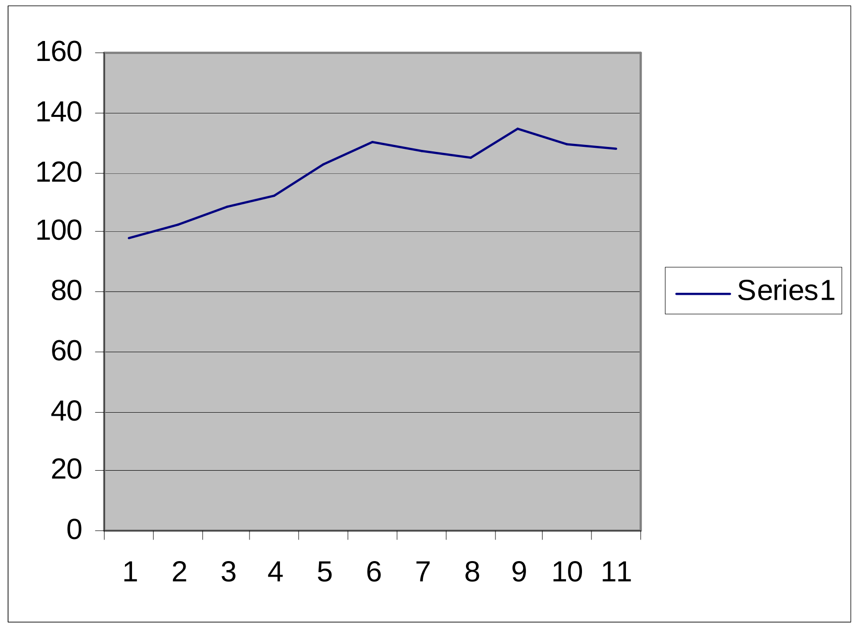
1. I will begin by discussing the current events we are trying to model in section 1
2. I will show some other basic open economy models and their findings before discussing how my model is set up and the equations I use.
3. Section 3 justifies the coefficients I have chosen
4. Separates and analyzes the exchange rate shock and the oil price shock and then analyzes the results when they are run simultaneously
5. Concludes and summarizes the strengths and weaknesses of my model

1: Current Events

Real Oil Prices

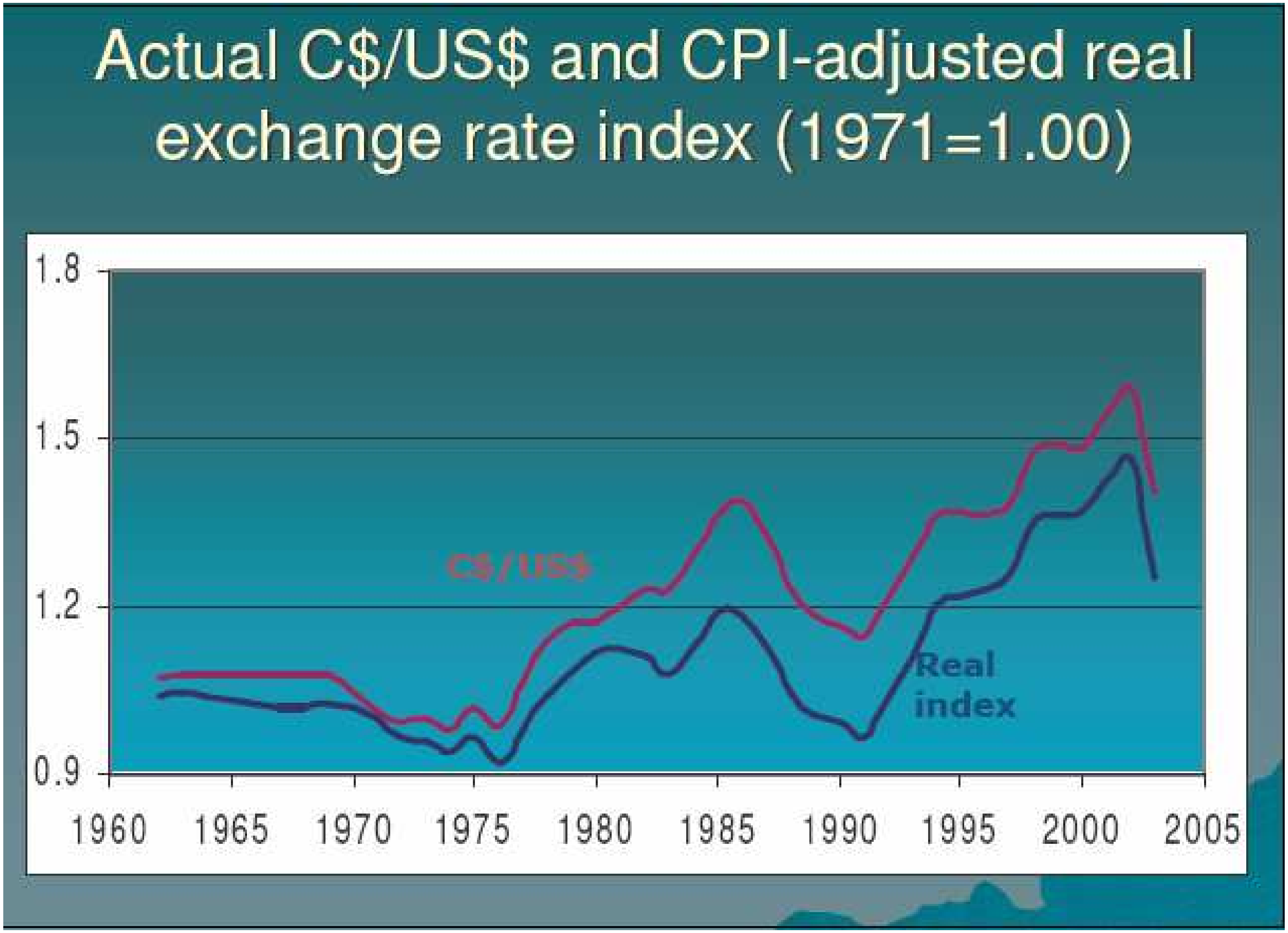


Real Non-Energy Commodity Prices



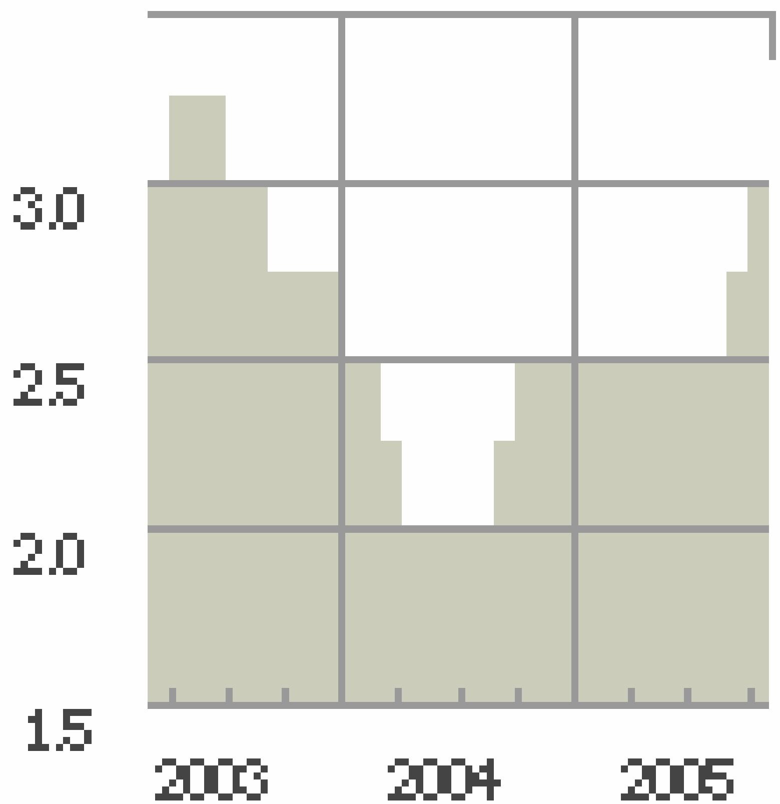
Source: Bank of Canada Real Commodity Price Data

The Real Exchange Rate



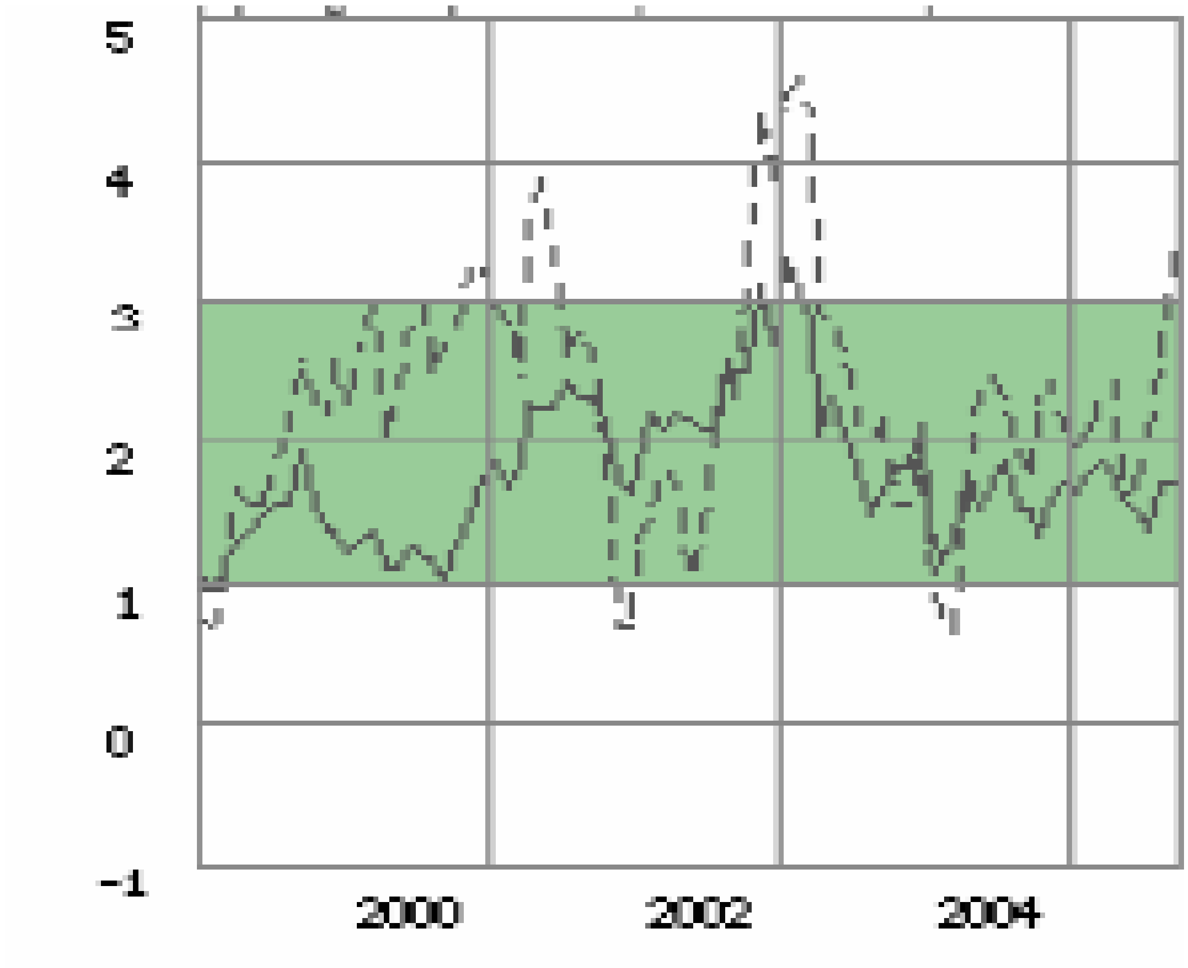
Source: Kevin Clinton, lecture notes online

Canadian Nominal Overnight Interest Rate Target



Source: Bank of Canada website / Jim's presentation

Bank of Canada's Target Rate of Inflation (Including Core Rate and the Aggregate rate



Source: Bank of Canada website / Jim's presentation

Laurence Ball's Open Economy Model

Aggregate Demand:

$Y = \beta r_{-1} - \delta e_{-1} + \lambda y_{-1} + \varepsilon$

Phillips Curve:

$\pi = \pi_{-1} + \alpha y_{-1} - \gamma(e_{-1} - e_{-2}) + \eta$

Exchange Rate:

$e = \theta r + v$

Taylor Rule:

$r = ay + b\,\Delta p + cr-1$

A Taylor Rule is (as Jim mentioned in his presentation) a policy rule adopted by governments that defines how they will act under a given set of circumstances. Specifically this is how they monetary policy will react to changes in inflation and output.

2: My model

- Calculated on a quarterly basis, starting in the 2nd quarter of 2003
- Percentage deviations from mean values
  - I chose Q1 2003 as a base (most shocks seem to originate here)
- 4 quarter rates of change on the price of energy and terms of trade:
  - this reduces the rates of growth from cycling out of control: when the price of energy remains high, its effect begins to diminish in the economy (ie: the effects of the shock are reduced and a new long run equilibrium economy is eventually reached).
  - this enters into the inflation equation (where it is most important) and the output equation
  - eg: y = (usual macroeconomic variables) + $\beta 3(pen - pen_{-4})$
- Assumes only 2 economies: the Canadian and the American.

The Equations:

Aggregate Demand:

$$y = \beta r + \delta e + \lambda y_{-1} + \beta 1 y^* + \beta 2 tot + \beta 3 pen + \varepsilon$$

Output is affected by the interest rate, the exchange rate, output from the previous period, the US economy, terms of trade, and the price of energy (ε is a random error term that we will ignore)

y^* is exogenous, and it has no effect on my equations. Its deviations from mean is assumed to be zero throughout the analysis, however, should we wish to correct for real world effects that the US economy may have on the Canadian economy y^* is still encoded in my aggregate demand equation and thus adjusting its effect is easy.

The endogenous variables are r and e.

Notice that the lags that Ball placed in his aggregate demand equation I am able to remove.

Phillips Curve:

$\Delta p = E\Delta p + \beta 4 y_{-1} + \beta 5 pen + \eta$

Inflation is powered by the price of energy as well as expected inflation and last period output.

Inflation can also be affected by an increase in non-energy commodity prices (Bank of Canada), however, in my model, this effect occurs naturally through the effect that this change has on output

Exchange Rate:

$e = (r - r^*) + \Phi tot + v$

The real exchange rate is the difference of Canadian and US real interest rates plus a terms of trade effect and a random error term.

An increase in e relates to an appreciation of the real Canadian dollar. In other words, e is measured as a percentage deviations from mean of the Canadian dollars that can be purchased with American currency.

Taylor rule:

$r = \gamma \Delta p + \delta 1 y_{-1}$

Canada takes inflation and last periods output into effect when choosing the real interest rate.

Note: The equations use *recursive variables*. That is to say that some equations involve the computation of the variables in the others before they can be computed. The order of computation and matters, which is why some lag periods must exist.

- must compute r and e before y
- setting base equilibrium values of all variables to zero in the base year allows the easy calculation of the inflation deviation from mean
- now we have r
- e follows
- we can compute y

Calculating the Shocks

Exchange Rate:

Exogenous shock to the random error term v

Terms of Trade:

- the terms of trade is the ratio of a country's export prices to its import prices
- Canada's terms of trade with the US has been improving since at least 2003
- in my model, the terms of trade will be an exogenous shock, the variable will be tot
- it will also be specifically non-energy commodity prices that will be of concern
- in order to calculate the magnitude of the shock, I use a commodity price index:

Commodity Price Index 1982-90=100 (U.S. dollars)
Indice des prix des produits de base (dollars É.-U.); 1982-1990#100

	Total *Total*	Excluding Energy *Énergie exclue*	Energy *Énergie*	Food *Alimentation*	Industrial Materials *Matières industrielles*
	V36382	V36383	V36384	V36385	V36386
2003 J	117.99	94.79	157.02	97.02	94.21
F	133.92	98.04	194.53	98.48	98.24
M	122.73	97.64	164.98	99.49	97.23
A	115.23	98.15	143.84	99.38	98.01
M	119.04	99.95	151.07	102.09	99.43
J	122.86	102.58	156.90	102.58	102.98
J	118.71	102.34	146.10	101.87	102.95
A	120.56	104.59	147.24	101.76	106.23
S	118.37	108.31	134.99	102.56	111.22
O	119.64	107.44	139.90	103.72	109.47
N	121.25	110.12	139.67	107.11	111.86
D	131.58	112.03	164.31	105.11	115.46
2004 J	135.22	115.05	169.02	104.67	119.96
F	135.11	119.90	160.43	107.01	125.92
M	138.62	122.87	164.86	113.81	127.26
A	143.12	126.99	169.97	115.67	132.37
M	150.20	128.52	186.48	119.45	132.93
J	148.86	129.74	180.79	121.65	133.73
J	149.26	129.40	182.46	120.22	133.86
A	150.79	130.08	185.42	116.26	136.53
S	147.97	127.21	182.68	114.35	133.24
O	157.99	122.67	217.52	113.68	127.03
N	152.45	122.71	202.49	117.14	125.59
D	152.21	125.12	197.72	113.23	130.73
2005 J	153.80	126.55	199.59	112.85	132.94
F	157.67	131.32	201.90	112.91	139.75
M	169.01	134.37	227.32	116.19	142.72
A	171.80	132.97	237.24	118.18	139.85
M	162.95	128.99	220.12	118.90	133.84
J	171.97	129.12	244.26	119.35	133.83
J	174.62	126.43	256.02	116.60	131.16
A	189.58	126.31	296.65	116.24	131.14
S	207.94	127.98	343.39	115.27	133.95
O	210.37	128.41	349.21	116.33	134.12

Example:

Calculating the non-energy terms of trade deviations from mean for Q1 of 2004:

Q1 2003 as base year

$$\frac{122.87}{97.64} - 1 = .2598$$

We can easily calculate the energy price shock in the same way.

Source: Bank of Canada

The Model

3. Justifying my choices of coefficients

$y = \beta r + \delta e + \lambda y\text{-}1 + \beta 1 y^* + \beta 2 tot + \beta 3 pen + \varepsilon$

β and δ:

A rule of thumb that is widely accepted in current economics is that the effect of a 1% increase in the interest rate on output is generally closely equivalent to three times the effect of a 1% increase in the exchange rate.

thus, $\beta = 3\delta$

The Bank of Canada uses this weight in its monetary conditions index. The MCI is a policy rule it uses to determine the tightness or ease of monetary policy.

In my model, $\beta = -.03$ and $\delta = -.01$ seem to work. This says that a 1% increase in the real interest rate will tend to lower output by .03% and a 1% appreciation of the exchange rate will lower output .01%

Justifying my choices of coefficients

$y = \beta r + \delta e + \lambda y\text{-}1 + \beta 1y^* + \beta 2tot + \beta 3pen + \varepsilon$

λ:

- λ adjusts the length of time that it takes for the economy to get back on track. The larger it is, the longer the lag.
- It also amplifies the magnitude of shocks.
- I found $\lambda = .2$ to be a successful combination. Longer lags are more desirable, however, the way my model is constructed, shocks can easily get amplified to extreme levels if a significant carryover effect is allowed

$\beta 1$:

I went to the StatsCan website and determined what share of GDP was typically accounted for by the size of net exports. For 2004, an expenditure based measure of GDP was 1 290 185 million \$. Exports were 492 580 and imports were 438 436 also in millions of \$. Thus, net exports were 492 580m - 438 436m = 54 144m. This accounts for 54 144m / 1 290 185m = ~.042. Therefore, since I am assuming all exports go to the United States (and about 88% (Jennifer's presentation) actually do), I will take the coefficient β1 to be +.04.

Justifying my choices of coefficients

$y = \beta r + \delta e + \lambda y\text{-}1 + \beta 1 y^* + \beta 2 tot + \beta 3 pen + \varepsilon$

β2:

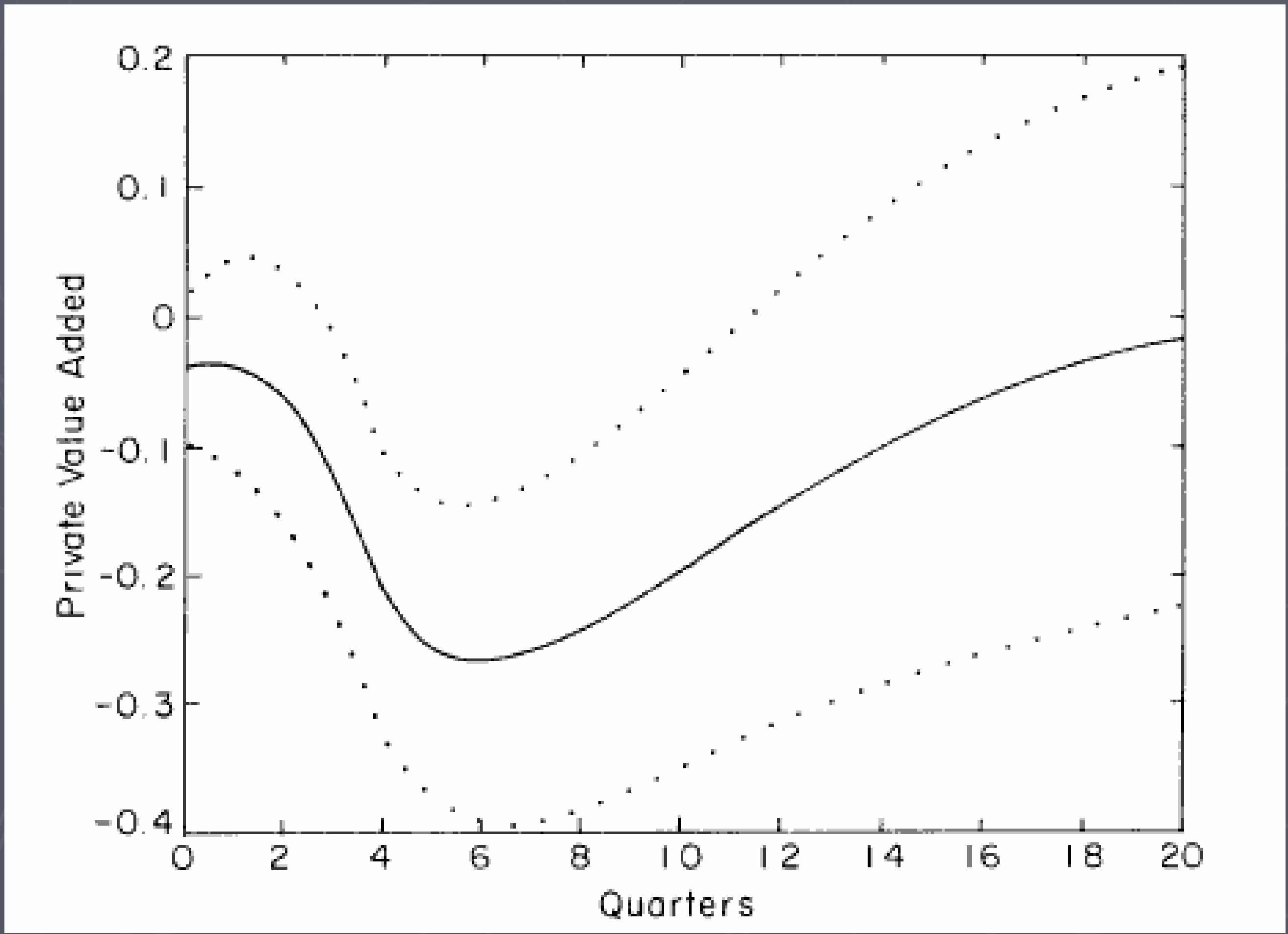
Empirical work (Mendoza, 1995) suggests that terms of trade shocks should obey these guidelines that Mendoza lays out:

1. They are large and persistent.
2. The relation between terms of trade and net exports is small and positive.
3. "Terms of trade shocks account for nearly ½ of actual GDP variability"

β2 = .01 seems to satisfy these properties

Justifying my choices of coefficients

$y = \beta r + \delta e + \lambda y\text{-}1 + \beta 1y^* + \beta 2tot + \beta 3pen + \varepsilon$



β3:

A 10% increase in the real price of oil causes a 2.5% decline in output, 5 or 6 quarters later (Rotemberg and Woodford).

β4 = -.005 works to give this combination because we have observed oil price increases of much greater than 10% since 2003.

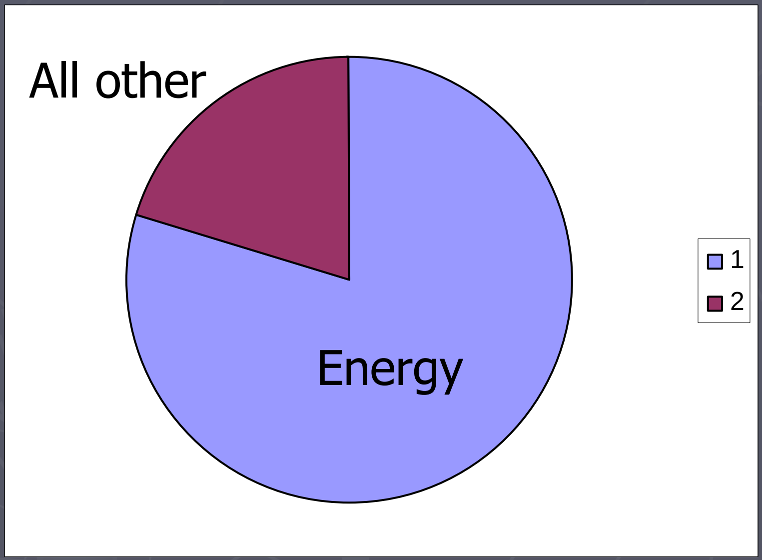
Source: Rotemberg and Woodford

Justifying my choices of coefficients

$y = \beta r + \delta e + \lambda y\text{-}1 + \beta 1 y^* + \beta 2 tot + \beta 3 pen + \varepsilon$

$\beta 3$:

Since Canada is a net exporter of energy (and energy accounts for a very significant portion of Canadian exports, I also considered the positive impact an increase in energy prices might have on the economy.



Energy as a Share of Canadian Net Exports

Energy = ~ 80%

Non-Energy = ~ 20%

Energy Imports = 24,782.5

Energy Exports = 67,956.6

Net Energy Exports = 67,956.6 - 24,782.5 = 43,174

Total Net Exports = 54, 144

Justifying my choices of coefficients

Phillips Curve:

$\Delta p = E\Delta p + \beta 4y\text{-}1 + \beta 5pen + \eta$

Expected inflation:

In my preliminary model, EΔp was an endogenous variable and it was defined :

$$E\Delta p = 1/4(\Delta p\text{-}1 + \Delta p\text{-}2 + \Delta p\text{-}3 + \Delta p\text{-}4)$$

- because of the way the Phillips Curve was designed, EΔp was simply added in. As inflation rose, EΔp rose as well, creating a feedback loop that drove inflation up without end.
- it makes more sense for EΔp to be 0. The Central Bank has a credible inflation target that is rarely far off (as we saw in Jim's presentation)
- so, fluctuations in inflation in my model arise because the Central Bank was unprepared and thus no one expected a rise in inflation.

Justifying my choices of coefficients

$\Delta p = E\Delta p + \beta 4y\text{-}1 + \beta 5pen + \eta$

β4:

$\beta 4 = .1$

β4 should be much greater than β5 because overall output affects inflation (especially core) by much more than the price of energy

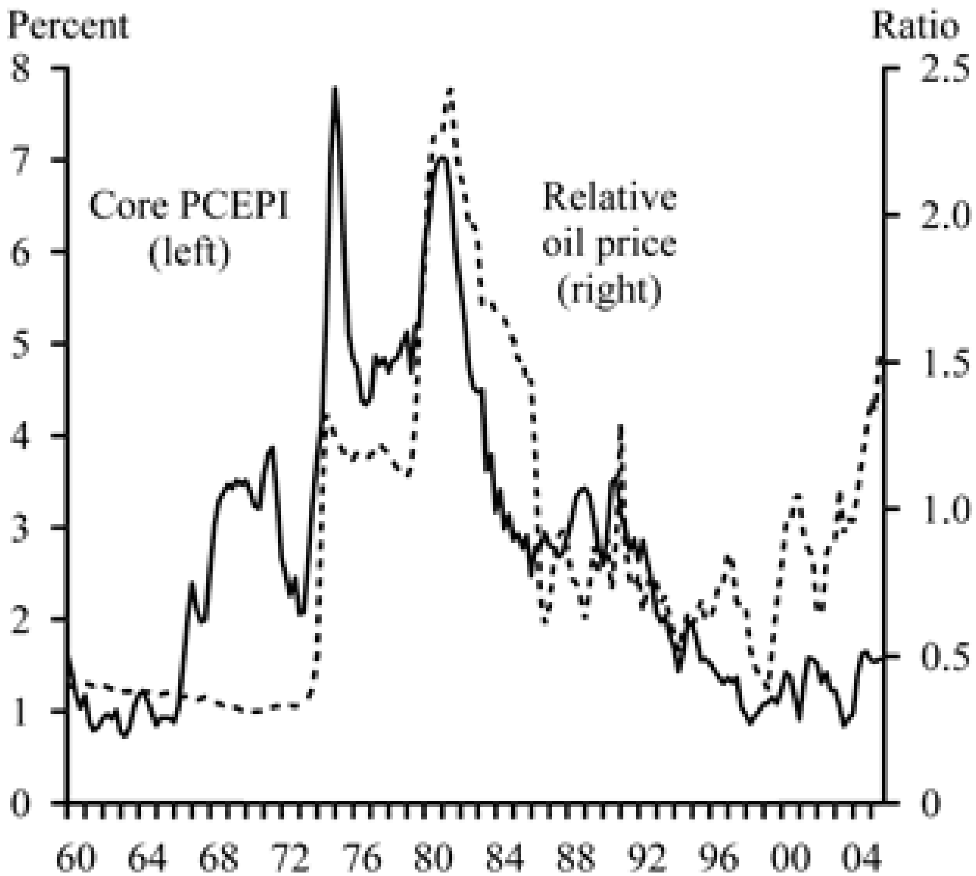
I have decided that a 1% increase in output should raise inflation .1%, which doesn't seem unreasonable.

Justifying my choices of coefficients

$\Delta p = E\Delta p + \beta 4y\text{-}1 + \beta 5pen + \eta$

β5: Inflation and the Relative Price of Oil

Figure 1. Inflation and the relative price of oil



Note: The relative price of oil is the ratio of the price of oil to the core PCEPI.

Inflation seems to be less correlated with the price of oil after the 70s oil shock.

Thus the recent high rates of inflation will most likely not be integrated into core inflation as long as the Central Bank takes the appropriate measures. If the shock is sustained, there may be a small increase in core inflation.

To reflect the high rates of inflation in September especially, β5 = .008

Source: Federal Reserve Bank of San Francisco

Justifying my choices of coefficients

$e = (r - r^*) + \Phi tot + v$

$r - r^*$

- the Bank of Canada has often been known as "the Fed + 15 minutes" (the Star)
    - this is because interest rate adjustments in Canada largely follow what the Fed does: as it should
    - this maintains a stable exchange rate
- Canada has recently chosen pre-specified dates which it will announce changes to the interest rate
- r^* is exogenous in my model. While we can still input it and observe the effects, we will assume that there is no change to $r - r^*$

Justifying my choices of coefficients

$e = (r - r^*) + \Phi tot + v$

Φ:

This is a terms of trade shock: recall that that is the ratio of export prices to import prices. Recalling also Mendoza who notes that ½ of exchange rate fluctuations are caused by terms of trade shocks, Φ should be large. A value of $\Phi = .2$ gives us the scale of exchange rate shocks that we are looking for when:

v:

$v = .05$

In other words, in my model, the Canadian exchange rate has appreciated 5% exogenously since v is a random error term. This can be accounted for by the recent large mergers (Globe and Mail).

Justifying my choices of coefficients

Taylor Rule

$r = \gamma \Delta p + \delta 1 y_{-1}$

- The coefficients γ and δ1 should sum to one.
- The typical Taylor Rule and the one that Taylor originally suggested is:

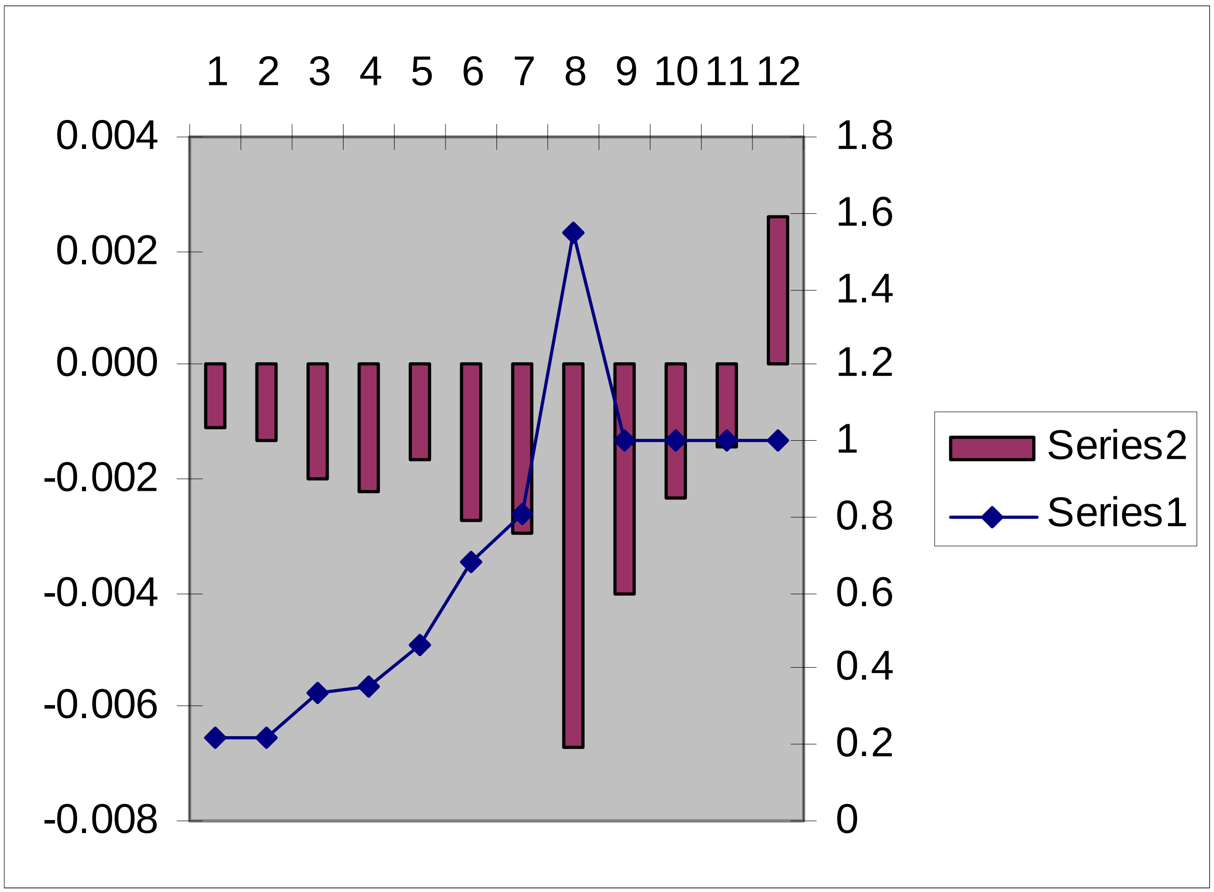
  $\gamma = .5$ and $\delta 1 = .5$

- I chose to follow this standard Taylor Rule because it seems to allow for rational outcomes
- By adjusting the Taylor Rule, we can reverse the direction of the impact of shocks on key variables. Thus the Taylor Rule has an extremely significant effect on the economy.
- The Bank of Canada noted in a its study of 12 different macroeconomic models for the Canadian economy that for Taylor Rules where γ is significantly greater than δ1, most of the models become unstable or fail to predict economic activity effectively

5. Implications

5.1 - Energy Price Effect Alone

Effect of an Increase in the Price of Energy on Output



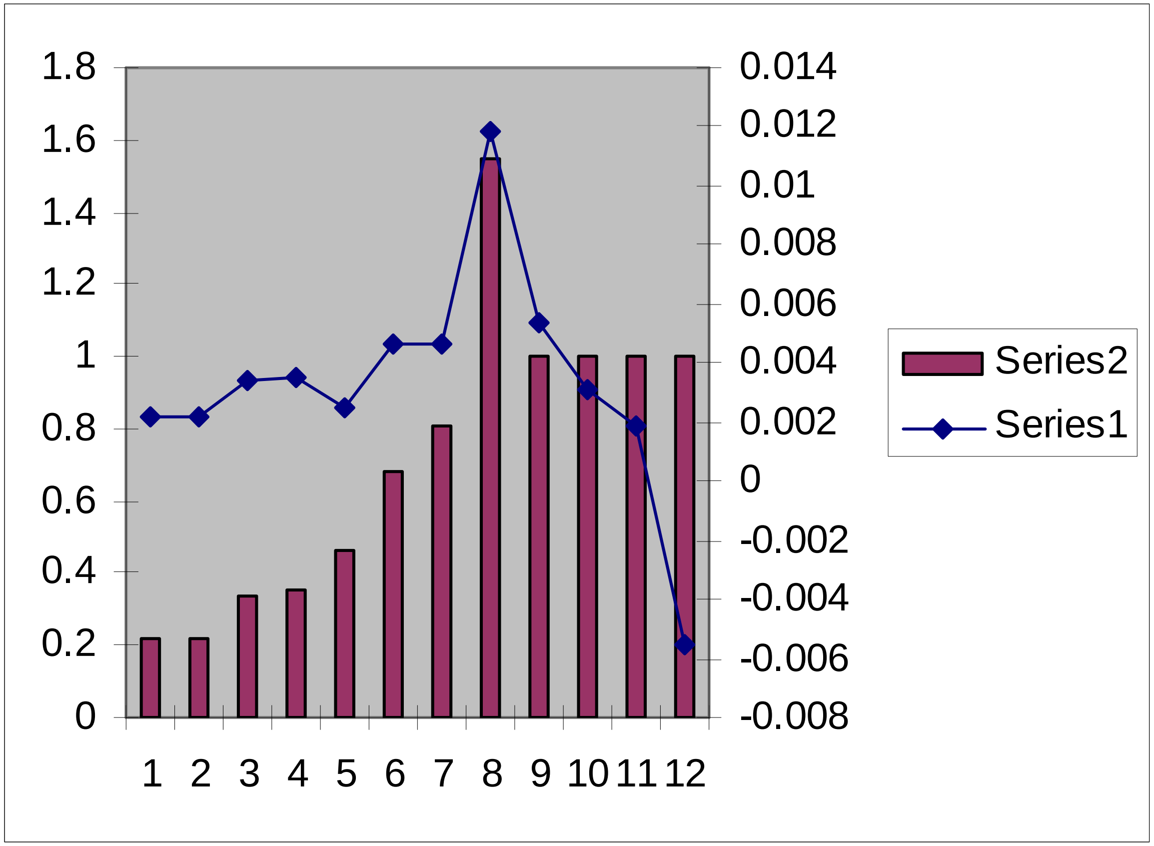
Oil = blue

- energy prices and output are inversely proportional
    - makes good sense: although Canada exports energy and this increases GDP, consumers and firms use energy and this enters as a drag on GDP
- effect of energy price increases have immediate implications for output
    - probably not realistic (Rotemberg and Woodford)
- a steady price of oil allows the economy to grow again
    - realistic: the negative effects of an oil price shock are magnified under unpredicted circumstances in short time spans
    - recovery is too speedy

Implications: Energy Price Effect Alone

Inflation

• despite the evidence to the contrary, I believe oil prices do power inflation, and core inflation if the shock is sustained



• the hurricane shock to oil prices does not seem to have been sustained, and inflation does not rise forever as a result

Oil = red
Inflation = blue

Implications: Energy Price Effect Alone

Exchange Rate

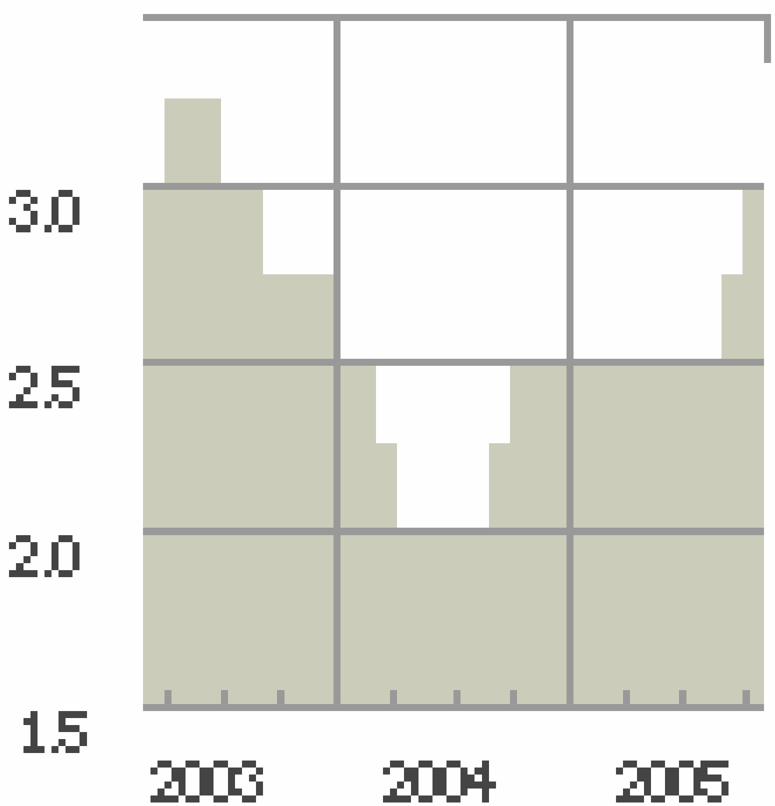
- Canada behaves has a mild increase in the exchange rate because of the increase in the price of oil, at least initially
  - this is entirely because of the choice of weights in the Taylor Rule
  - r is going up powered by inflation while output goes down by less than the increase in r
  - as the shock diminishes, inflation shrinks causing a reduction in the real interest rate in turn reducing the exchange rate

Implications: Energy Price Effect Alone

Interest Rates

- Bank of Canada raises the nominal and real interest rate throughout the shock
  - uncertain: the Bank of Canada often discusses oil prices as a main factor for reducing the real interest rate, which goes up slightly in my model until the shock dissipates—however, my model predicts that the Bank should eventually begin to raise rates
  - the real interest rate can be adjusted through the use of the Taylor Rule (try .3 and .7), however, this will cause the currency to depreciate as well, which loses the "petro-currency" effect my model can capture
    - when gamma = .3 (weight on inflation) and delta1 = .7 (weight on previous quarter's output, the real interest rate will decline, but the effect on inflation is great enough that the nominal interest rate still rises
    - not necessarily bad: some analysts point out other factors that may be causing the rise in the loony:
    1. Recent mergers (and forecast ones)
    2. Weak US dollar against all currencies (because of its CA deficits)
    - might be possible to drop the petro-currency effect and worry about interest rates instead if you agree with Amano and van Norden

Implications: Energy Price Effect Alone



Bank of Canada
Overnight Nominal
Interest Rate

We want to make sure that the nominal rate still rises at least in the overall model because the Bank of Canada has been increasing the overnight rate

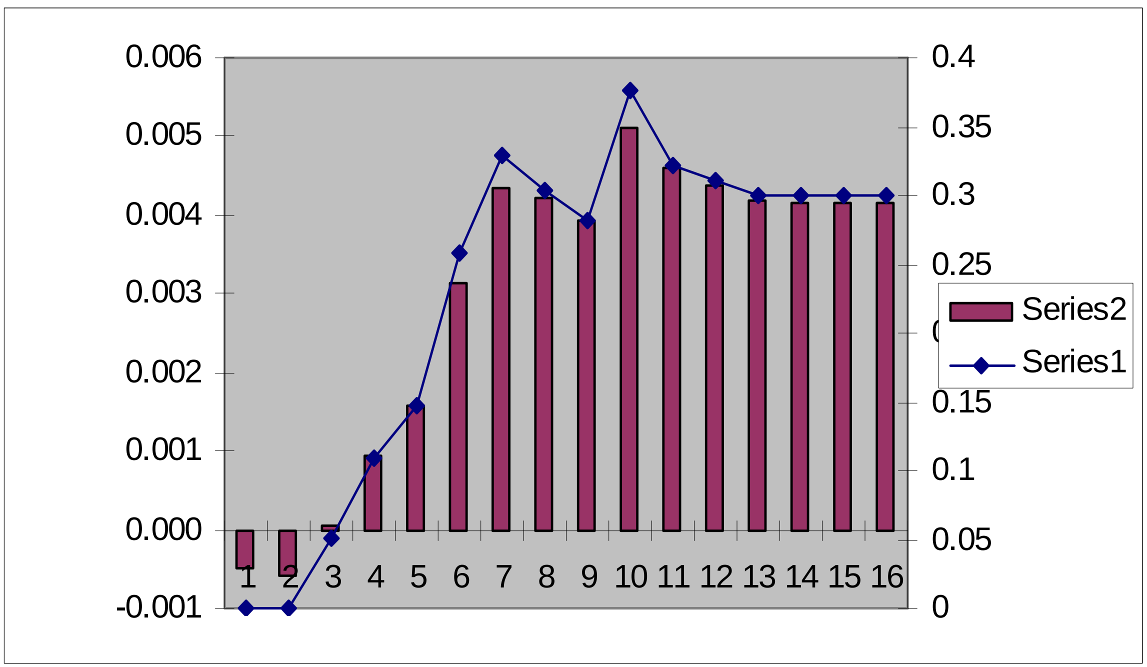
Source: Bank of Canada website / Jim's presentation

Implications: Terms of Trade and Exchange Rate Impact Alone

5.2 - Terms of Trade Impact and Exchange Rate Impact

Increase in Non-Energy Commodity Prices on Output

Commodity prices = blue



- output increases linearly with the linear increase in the terms of trade
  - this is a result of small inflation (as Mendoza predicts)
  - the terms of trade impact on other variables is very small so there is a strong correlation

Implications: Terms of Trade and Exchange Rate Shocks Only

Terms of Trade Impact on Output

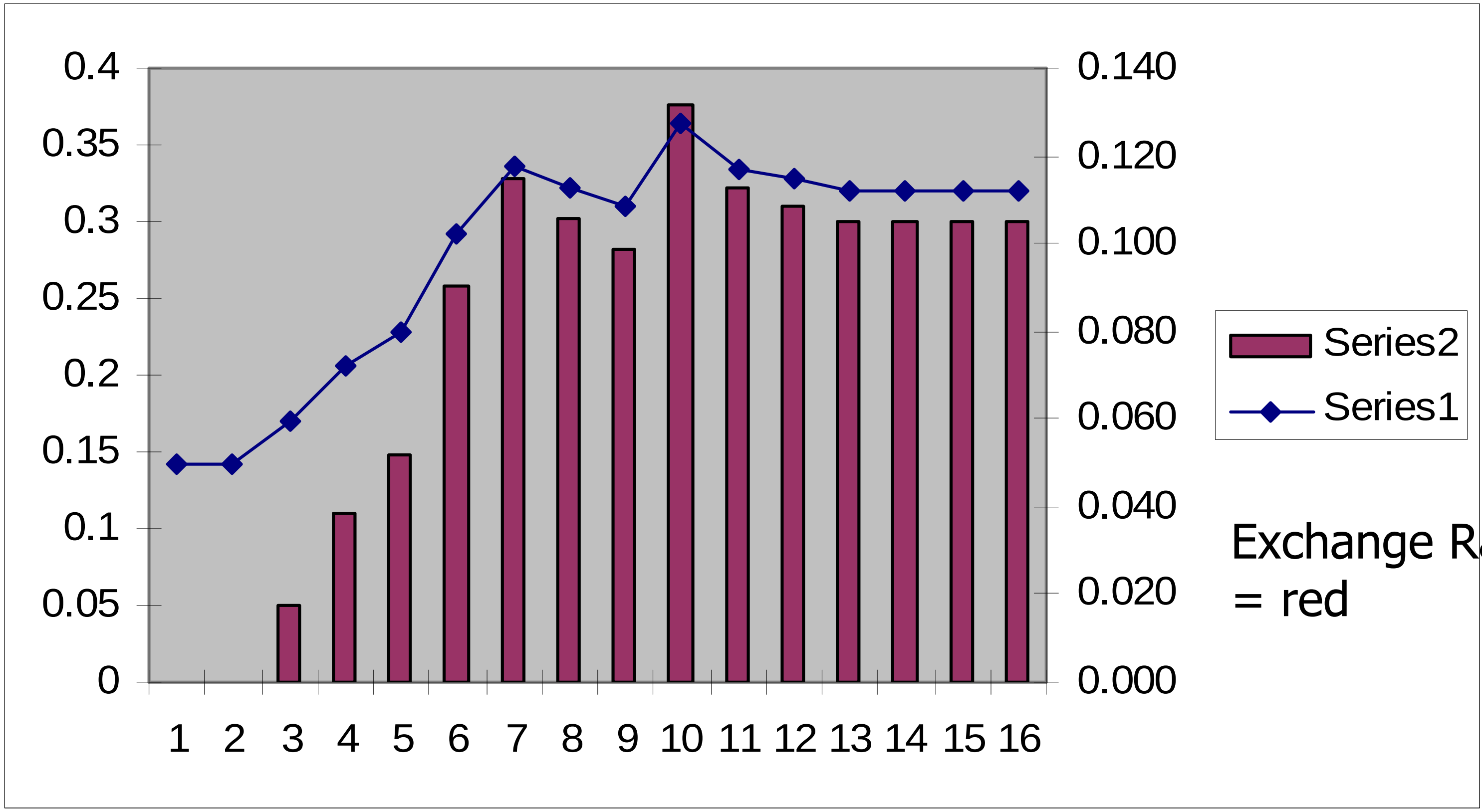
The close correlation follows because the terms of trade effect has been so much smaller than the increase in the price of oil that the inflation rate barely changes. Although it powers the exchange rate, this has a much lower effect than the real interest rate. Thus, output changes mostly in response to direct commodity price impacts.

If I were to enter non-energy commodity prices into the Phillips Curve equation as the price of energy is, then we would see an increase in inflation because of the commodity price impact which would drive the real interest rate, and this would cause output to deviate from its strong correlation.

Implications: Terms of Trade and Exchange Rate Impact Only

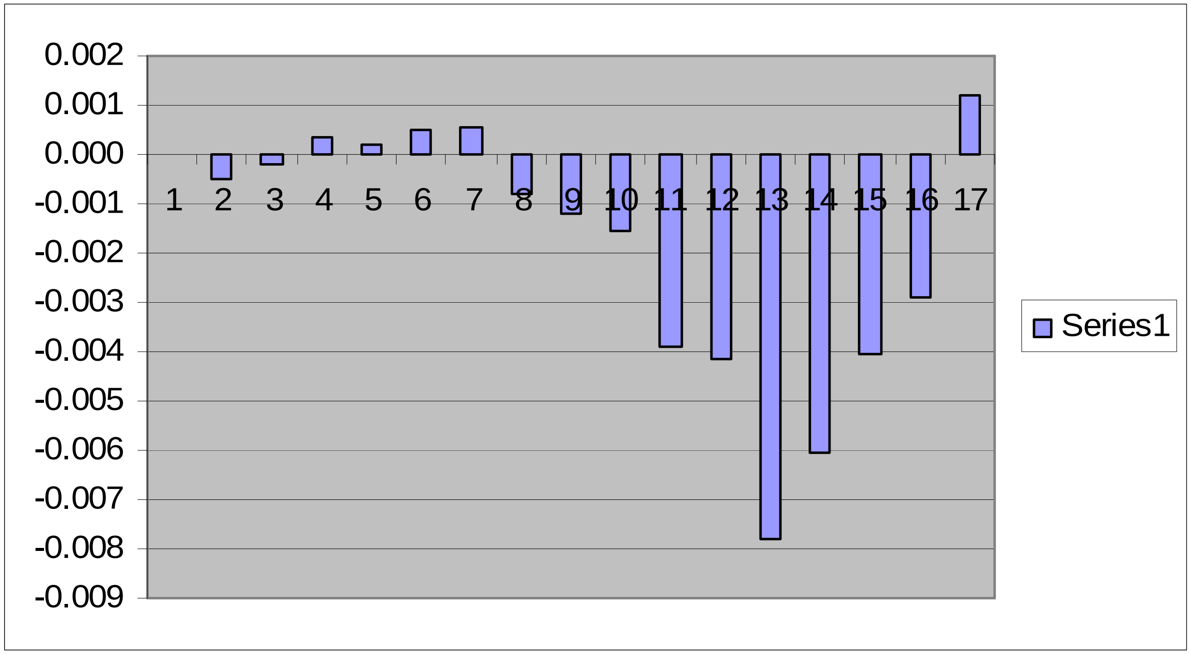
Terms of Trade Impact on The Exchange Rate:

Again we notice very close positive correlation between the exchange rate and the terms of trade shock. There is a lag before the exchange rate catches up.



Exchange Rate = red

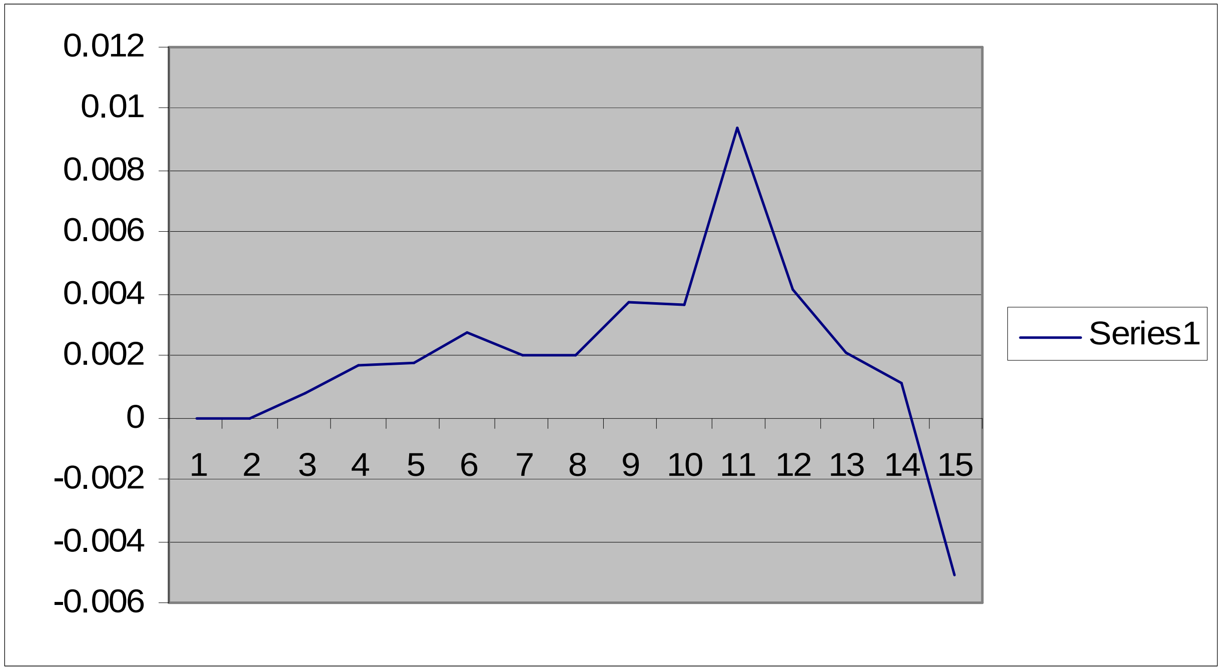
5.3 - Implications: Both High Oil and High Dollar Together



This graph shows output over time. Notice the largest decline is in the quarter of the highest oil prices still because the oil price effect outweighs the terms of trade effect. Again, output will eventually return to positive values as the shock pans out.

Implications: Both High Oil and High Dollar Together

Inflation

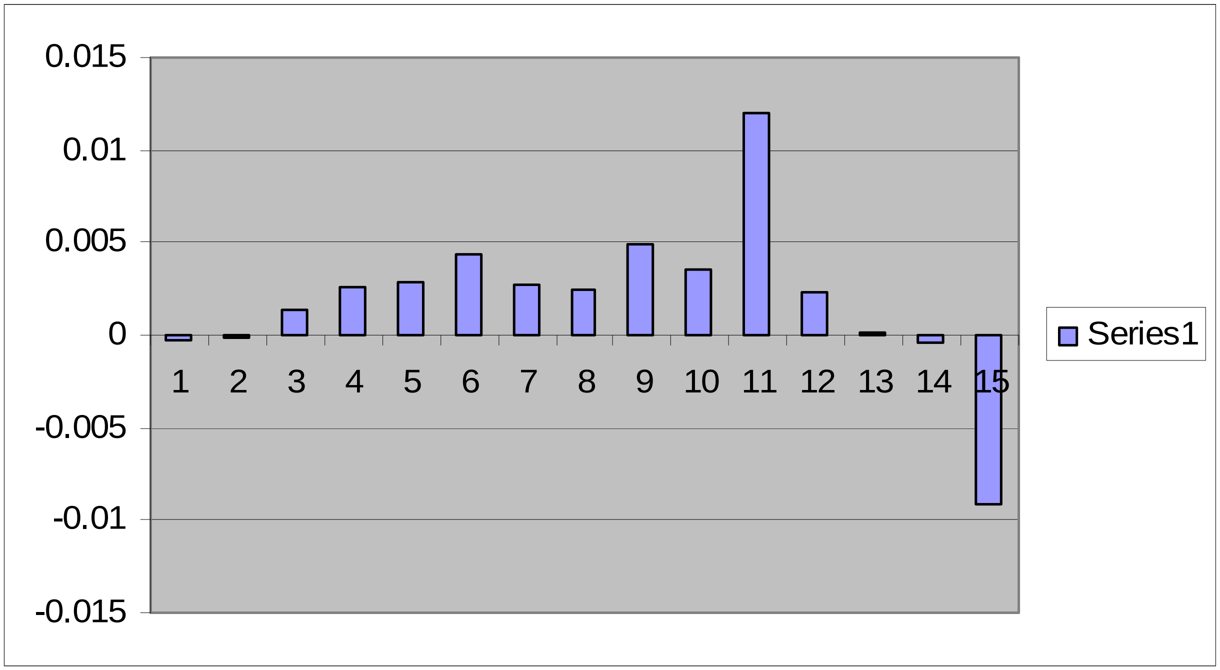


The spike in inflation corresponds to the spike in oil prices

My model predicts stagflation for the Canadian economy.

Implications: Both High Oil and High Dollar Together

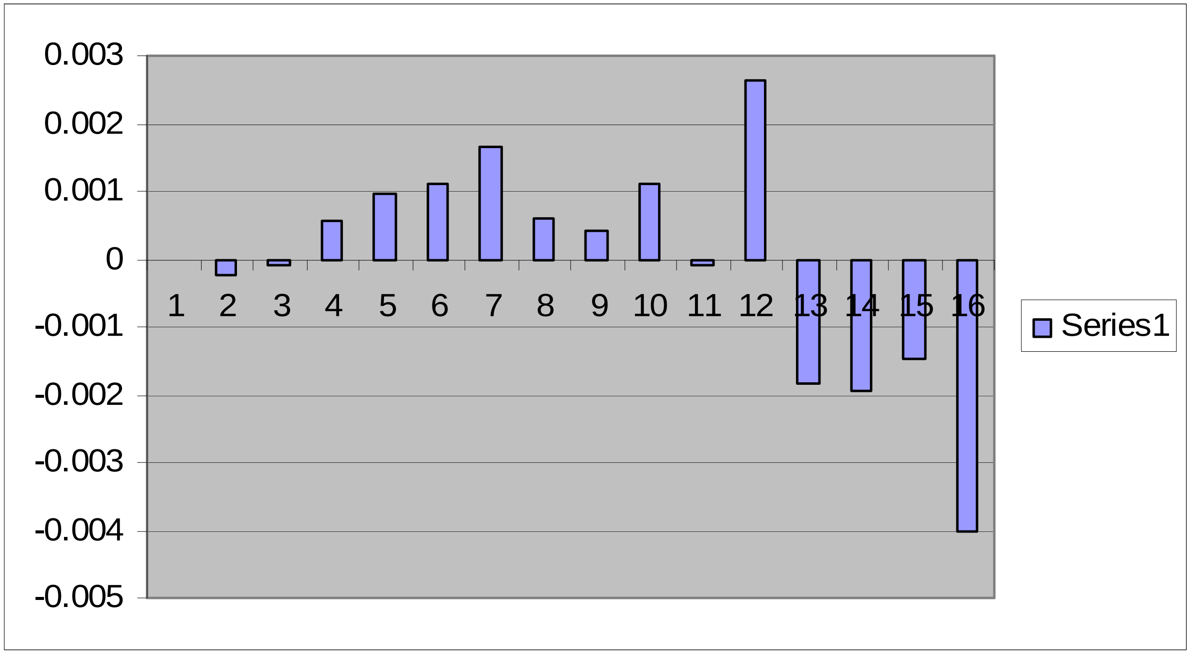
Nominal Interest Rate



1. Because the effect on the real exchange rate is rather small compared to the inflation effect, nominal interest rates tend to follow inflation.

2. As I have mentioned numerous times, the Bank of Canada has been increasing the nominal overnight rate. Thus, seeing increases in the nominal rate reflects reality.

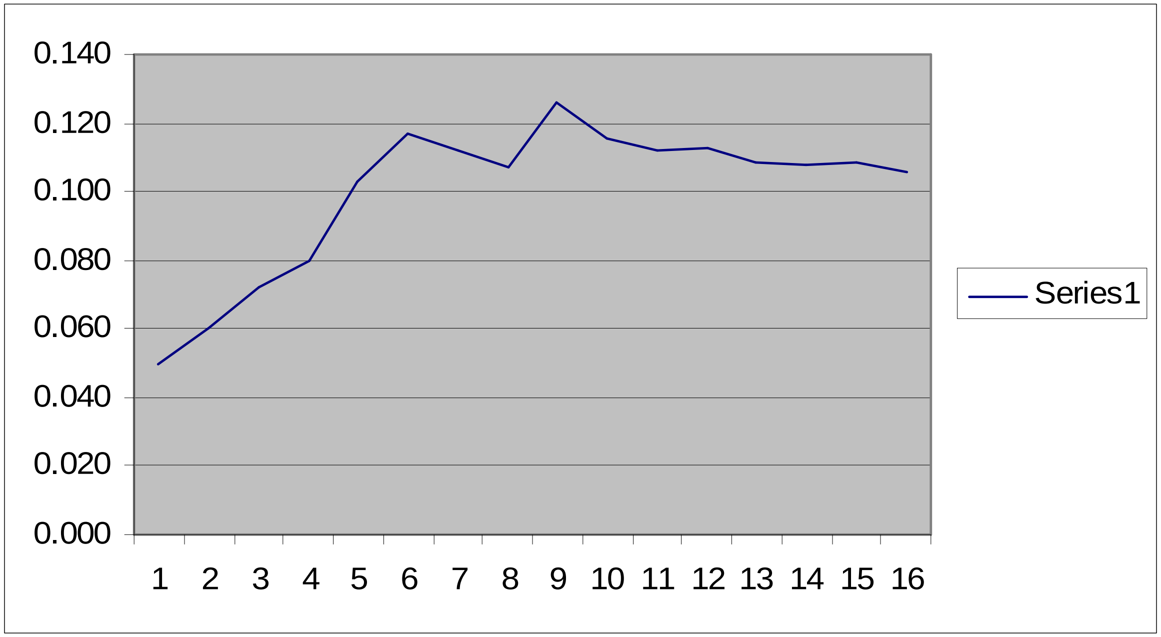
Implications: Both High Oil and High Dollar Together



The main point from this diagram is that the Bank of Canada should lower the real interest rate to stimulate investment in the near future. I think that this prediction will come true.

Implications: Both High Oil and High Dollar Together

Real Exchange Rate



My model predicts that the exchange rate increase has hit its peak. I think this is a fairly realistic assessment. Although some analysts argue that the loony is headed for parity, the Bank of Canada would want to stop the dollar short so exports are still desirable in the US.

However, I assumed that commodity prices have not increased from their last recorded levels. I could try running a regression through the commodity price increase and project further increases to the exchange rate.

Implications: Both High Oil and High Dollar Together

Correlation:

The correlations I have noted in analyses of the separate shocks hold here as well.

- strong negative output – price of oil correlation
- strong dollar – non-energy commodity price correlation

5. Strengths and Weaknesses

Strengths

• my model shows the highest increase in inflation in the Q4 of 2005. It shows a deviations from mean increase of .9%. This may seem high but in September alone, the highest one month increase in inflation since 1991 was observed: an increase of .9%. (Globe and Mail).

• half of the increase in the exchange rate is accounted for by the terms of trade shock as Mendoza suggests it should

• predicts that the Bank of Canada should begin real interest rate cuts soon to stimulate investment and restore growth

Weaknesses

• the nominal interest rate does not follow the Bank of Canada's overnight rate very well. Also, its changes are very small compared to two recent .25% hikes in the overnight rate. I only observe increases of .01% at most

• output declines too much. At most, this effect is -.8% which is very high.

• the exchange rate effect (and terms of trade) effect on output is minimal, contrary to Mendoza`s predictions—however, this may be more realistic than he suggests

A Solution to the Output Problem?

The reason why my model doesn't show growth is because of the set up of the aggregate demand equation:

$$y = \beta r + \delta e + \lambda y\text{-}1 + \beta 1 y^* + \beta 2 tot + \beta 3 pen + \varepsilon$$

Clearly, as I have discussed the price of energy is a negative weight on the economy. This powers output down through all other channels: the real interest rate grows, the exchange rate appreciates so output declines and output from the period before declines.

The US economy has been growing over time and this would serve to lessen the Canadian decline in output. If Canadian exports and terms of trade are growing, perhaps this could at least partially offset the large decline.

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Statcan website

Bank of Canada website

Kevin Clinton lecture notes

The Toronto Star

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