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MONETARY POLICY

## Ripple Effects: Oil Price Shocks and Monetary Policy

by  
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- The effects of large oil price shocks on the Canadian economy are complex, as is the best response of monetary policy.
- Getting monetary policy wrong in response to oil price shocks can be very costly. The Great Inflation of the 1970s can largely be blamed on inappropriate accommodation of the two oil price increases in 1973 and 1979.
- The Bank of Canada is aware of these complexities, but it could make better use of the economic modelling tools it has at its disposal in its analysis of oil price shocks.
- This improved use of modelling tools would also enable the Bank of Canada to communicate its strategy more effectively to the public, thereby enhancing the effectiveness of monetary policy in Canada.

The plunge in the world price of crude oil in December 2014 and January 2015 was the most abrupt movement (up or down) since the drop from over \$140 per barrel to less than \$40 in the second half of 2008 as the world economy entered the Great Recession. The latest oil price shock led to negative GDP growth in the Canadian economy, a lower value for the output of Canada's petroleum industry, reduced investment expenditure in the petroleum sector itself, and reduced demand for intermediate inputs into petroleum production. It has also had cascading adverse effects on other sectors and industries. Overall real GDP growth turned negative in the first quarter

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of 2015, falling by 0.6 percent at annualized rates. Positive GDP growth resumed in June on the back of strong export growth, but growth for the entire second quarter remained negative. The Bank of Canada surprised markets with a 25 basis point rate cut in January 2015, announced as a measure “to provide insurance” against the downside risk to inflation and increased risks to financial stability caused by the drop in the price of oil (Bank of Canada 2015). Continuing economic weakness led the Bank to cut its rate by another 25 basis points in July 2015, a move that was by then widely anticipated by markets.

The effects of an oil price shock, as well as the best monetary policy response, are complex because of the many interactions between the petroleum sector and other sectors of the economy.<sup>1</sup> The Bank of Canada is a flexible inflation targeter, meaning that it mitigates shocks to the economy in the short run while moving inflation toward its target in the medium run.<sup>2</sup> There is a strong consensus in modern macroeconomic theory that the best monetary policy can do to mitigate shocks is to attempt to achieve the economy’s equilibrium through flexible prices and wages. Thus, policy should strive as much as possible to offset the effects of nominal price and wage rigidities.<sup>3</sup>

A first step in coming up with the appropriate monetary policy response to a change in oil prices is for the Bank of Canada to calculate in detail what the effects of the shock would be on employment, output, relative prices, and the sectoral allocation of resources in the absence of nominal rigidities. The Bank has the ideal tool to calculate these effects – its Terms of Trade Economic Model (ToTEM II). I argue in this E-Brief that the Bank should use its main forecasting tools more explicitly in explaining its strategy in responding to oil price shocks. The main elements of this strategy would be as follows:

- use its global forecasting model, BofC-GEM, to forecast jointly the evolution of the world oil price and of world GDP;
- use its main forecasting and policy analysis model, ToTEM II, to forecast the evolution of the Canadian economy under the counter-factual assumption of flexible wages and prices; and
- use these forecasts more explicitly as part of its communication strategy, in particular to explain how monetary policy is offsetting the effects of nominal price and wage rigidities.

## The Qualitative Effects of an Oil Price Shock in General Equilibrium

Taking the world price of oil as given, the effects of a persistent oil price shock on the Canadian economy can be summarized as follows.

- **Fall in potential GDP:** a reduction in the price of oil will lead to a fall in the real value of output produced in the petroleum sector. It will also result in a fall in the quantity of petroleum produced, as marginal wells are shut in and fewer new wells are brought on line.
- **Reduced real incomes:** the decrease in the price of exports relative to imports will cause a negative income effect for workers and owners of capital in the petroleum sector. Real income will decline relative

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1 For a theoretical analysis of optimal monetary policy for an oil-producing economy, see Romero (2008).

2 See Carney (2012).

3 See King and Wolman (1999) and Woodford (2003). Real distortions such as those due to imperfect competition are best left to other policy instruments – for example, taxes and subsidies.

to the standard measure of real GDP. This loss may affect aggregate demand, with a negative impact on the demand even for domestically produced goods.

- **Currency depreciation:** the Canadian economy is a net exporter of oil, so a negative oil price shock will depreciate the currency. That loss will constitute a fall in Canada's terms of trade because a given quantity of exports will buy fewer imports. The currency depreciation will in turn boost demand for non-oil exports. This demand response will be higher in the medium to long run, and it may take time for export industries to increase their productive capacity after having shrunk during the period of higher oil prices. In this way, currency depreciation mitigates the drop in the price of oil, which is fixed on world markets in US dollars.
- **Benefits for domestic suppliers:** the non-oil exporting industries will benefit from the increased demand for Canadian exports.
- **Reallocation of inputs:** both capital and labour will flow from the oil-producing sector to other productive sectors in the economy. This reallocation will not be instantaneous. To the extent that labour reallocation is costly, relative wages may have to fall in the petroleum sector relative to the rest of the economy to encourage this reallocation and to equilibrate labour markets in all sectors during the adjustment process.
- **Loss of skills:** workers leaving the petroleum sector to look for work elsewhere will suffer a loss of sector-specific human capital. As they enter other sectors of the economy, the marginal product of labour in those sectors will fall in the short run. As a result, overall measured labour productivity will fall.
- **Drop in investment demand by the petroleum sector:** the reallocation of capital will mean a drop in demand for equipment by the petroleum sector.
- **Lower prices at the pump and for other industries:** the reduction in the price of oil will be of direct benefit to consumers of petroleum products, freeing up income to spend on other consumer goods (both domestically produced and imported). Other sectors in the economy will benefit from a drop in the price of oil and oil products that are used as intermediate inputs.
- **Lower demand for goods and services by the petroleum sector:** to the extent that output from other sectors is used as an intermediate input by the petroleum sector itself, demand for their products will drop.
- **Lower inflation:** the drop in the price of oil will have a direct impact on headline inflation. This drop constitutes a level effect on prices rather than on the rate of change of prices (inflation). It is a change in a relative price that is determined in world markets. Currency depreciation will offset this effect to some degree as the price of imported goods increases.

These qualitative effects often push in opposite directions. The net quantitative effects of an oil price shock depend on many factors, such as the responses of supply and demand to price changes, the relative importance of the oil sector in the economy, and the strength of the flows of goods and services between the oil sector and the other productive sectors of the economy. Supply and demand responses can vary over time, and the pace of reallocation of capital and labour across sectors is gradual. World demand for non-petroleum exports depends on the evolution of world output. Predicting this demand hinges on identifying the underlying causes of the change in the price of oil.

The last point is critical. The effects of a price change will always depend on the underlying cause and whether the change results from a shift in the supply curve for oil or a shift in the demand curve. A drop in price that is principally demand driven would typically be a sign of slowing world economic growth. In turn,

this decline would strongly affect the degree to which the demand for Canadian non-petroleum exports could take up the slack from the reduced income from petroleum exports. A drop in price that is caused primarily by increased supply from past infrastructure investments coming on line (or from improvements to the technology of oil extraction) is much more positive for the world economy and would help the rotation of demand from petroleum toward other Canadian exports.

Assessments of this issue have been published, including by Bank of Canada researchers.<sup>4</sup> The consensus seems to be that the current drop in oil prices can be explained in large part (but not entirely) by an unexpected slowdown in worldwide economic growth. This conclusion would tend to support the Bank's decision to surprise markets by lowering the overnight rate in January 2015. If lower demand is the cause of the oil price correction, the offsetting positive effects due to increased export demand could be weak. However, because the United States is Canada's main trading partner, the projected growth of that economy will be the determining factor. The part of the oil price movement that was not demand driven came from two main sources: additional US supply came on line, primarily shale oil; and a price war broke out late in 2014 among OPEC producers, with Saudi Arabia no longer willing to restrict supply to maintain prices.<sup>5</sup>

## The Bank of Canada's Tools

The Bank of Canada is aware of these complex interactions and has acknowledged them in its discussions of the effects of the oil price shock.<sup>6</sup> Its public discussion of the interactions has, however, been largely qualitative.<sup>7</sup>

The Bank has a rich set of formal tools to analyze the effects of an oil price shock on the Canadian economy and to simulate the effects of its monetary policy changes. Its main tool for forecasting the Canadian economy is the ToTEM II (Terms-of-Trade Economic Model) model.<sup>8</sup> It also has a tool for forecasting the global economy, called BoC-GEM (Bank of Canada Global Economic Model).<sup>9</sup>

## ToTEM

ToTEM is a "New Keynesian dynamic, stochastic general equilibrium" (DSGE) model. It can be used both for base-line projections and to simulate the effects of different monetary policies. Of all the central bank forecasting models, the current version of ToTEM has the best potential to analyze quantitatively all the factors listed above. It decomposes the Canadian economy into different sectors, including a commodities sector. Commodities are used

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4 See Baumeister and Kilian (2016) and Hamilton (2015). Note that work was done while Baumeister was at the Bank of Canada. She has since moved to the University of Notre Dame.

5 The lifting of sanctions against Iran that accompanied the recent nuclear deal with that country will gradually lead to increased oil exports – another supply-side factor that is politically based. World oil supplies are also tied to Russian foreign policy decisions.

6 See Bank of Canada (2015b, 2015c, 2015d, 2015e, 2016), Duguay (2006), Lane (2015), Mendes (2015), and Patterson (2016), among others.

7 The Bank's January 2015 Monetary Policy Report (2015b) contains a detailed forecast of oil prices but does not outline the assumptions behind these projections in terms of supply versus demand factors.

8 See Dorich et al. (2013) for a detailed summary of ToTEM and its properties.

9 See Lalonde and Muir (2009, 2009b).

as inputs in the production functions of non-commodity industries, but commodities themselves are produced using only labour, capital, and land (Dorich et al. 2013), thereby abstracting from the use by the petroleum sector of intermediate inputs produced by the manufacturing, transportation, and other sectors. Aside from the latter simplification, the interactions between the commodities sector and the rest of the economy in the model are quite rich.

## BoC-GEM

The BoC-GEM model is also a New Keynesian DSGE model. It divides the world economy into five regional blocs (Canada, United States, emerging Asia, commodity exporters, and remaining countries). More importantly, it decomposes economies into five sectors, including oil and natural gas and other commodities.

Oil and gas production is modelled as a function of labour, capital, and crude oil reserves. As in ToTEM, the oil and gas sector does not use intermediate inputs from other sectors, but the interactions between oil and gas and the rest of the economy are fairly rich. Significantly, the equilibrium price of oil and gas is endogenous in the model. It is possible to model the impact of shocks affecting both supply and demand for oil and gas on the equilibrium price and the quantity produced. In principle, BoC-GEM can be used to generate a forecast for the world price of oil and as a measure of world GDP, both of which could be used as inputs to simulations in ToTEM.

## Tools for Analysis and Communication

There are additional, useful ways in which the Bank of Canada could use its available tools to inform policy and communicate its thinking to the public.

## A Model-Based Estimate of Potential Output

As noted above, an oil price shock leads to changes in the equilibrium allocation of labour and capital across sectors. ToTEM itself could be used to calculate this allocation. To do so would require replacing the model's equations for the slow adjustment of wages and prices with conditions equating supply and demand in all labour and goods markets (complete wage and price flexibility). To my knowledge, a solution to the version of the model with flexible prices and wages is not an integral part of the Bank's internal forecasting and policy analysis.

Solving for and reporting ToTEM's flexible-price equilibrium would convey an important advantage. It would generate a model-based estimate and forecast for potential output (the level of output that would prevail if wages and prices were able to adjust freely).<sup>10</sup> Potential output is used to calculate the "output gap" (the difference

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10 Some papers, such as Justiniano and Primiceri (2008), distinguish between natural output (the level that would prevail under flexible prices and wages but in the presence of monopoly distortions) and *potential* output (the level that would prevail with flexible wages and prices but also with monopoly distortions removed). This distinction is ignored here. As noted in the introduction, the consensus in the literature on optimal monetary policy is that the policy should offset as much as possible the distortions from nominal rigidities. Correcting the distortions due to monopoly power is best left for other instruments such as taxes and subsidies.

between actual and potential output), which is a key input into the Bank's monetary policy analysis and an important part of its communication (it is a regular feature of the Bank's Monetary Policy Reports).

Rather than using its main forecasting model to calculate potential output and the output gap, the Bank of Canada currently uses statistical methods that can, potentially, lead to errors in its internal analysis and in its communication with the public. Two different measures of the output gap (statistical and structural) are reported in the Bank's Monetary Policy Reports.<sup>11</sup> Both involve smoothing out abrupt changes in output itself (the statistical measure) or in labour inputs and labour productivity (the structural measure). By ruling out abrupt changes by construction, these methods cannot allow for short-run changes in labour supply due to income or substitution effects or for abrupt fluctuations in either labour productivity or total factor productivity. Oil price shocks act in many ways like productivity shocks. They can therefore affect potential output abruptly in ways that look like productivity shocks (as noted above, they also affect potential output by causing a reallocation of inputs across different sectors of the economy).

The Bank may thereby underestimate short-term fluctuations in potential output and overstate the size of fluctuations in the output gap. As of July 2015, the Bank calculated that the output gap was equal to -1.3 percent according to its statistical measure, and -2.2 percent according to its structural measure (Bank of Canada, 2015c). Both measures could potentially overstate the size of the output gap because they cannot capture the abrupt impact of the recent oil price drop on potential output. This inability could cause the Bank to overestimate the need to cut its target for the overnight rate and to give too pessimistic a view of the medium-term pressure on inflation in its communication with the public.

### **A Flexible-Price Equilibrium Path of Output**

The Bank could also use ToTEM to simulate a path for the economy while allowing for the complete flexibility of prices and wages. By calculating a path for the economy's flexible-price equilibrium, the Bank would be able to calculate and report how changes in its monetary policy affect the distance between the economy's equilibrium and its flexible-price equilibrium. This calculation would include a time path for the output gap that is completely consistent with the model-based estimate of potential output discussed in the previous section.

Given the complexity of ToTEM, the divergence between the economy's equilibrium path with and without flexible prices and wages would necessarily be multidimensional. The projected degree of labour-market slack could, and typically would, differ between the commodity-producing sector and the rest of the economy, and the pressure on output prices could also differ across sectors.

### **The Bank's Communication Process**

The Bank of Canada's communication process would include several elements.<sup>12</sup>

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11 See Pichette et al. (2015) for a detailed explanation of how the measures are constructed.

12 Publishing detailed forecasts along with each policy announcement could be quite costly. The forecasts could be published as part of, or as an annex to, the quarterly Monetary Policy reports. An anonymous referee suggested that the Bank could put its quantitative models in the public domain, allowing academics and private-sector analysts to run their own scenarios and facilitating dialogue with professional practitioners.

- Report the assumptions behind the BoC-GEM forecast of world oil prices and of world GDP along with the forecasts themselves.
- Report conditional forecasts for GDP, sectoral output and employment, and sectoral output prices conditional on the projected time paths for oil prices and world GDP generated by BoC-GEM and also conditional on the Bank's monetary policy.
- Report conditional forecasts for the paths of flexible-price GDP and sectoral output and employment.
- Publish a conditional path for the Bank's overnight rate target, because the projected paths of GNP and sectoral employment, output, and capital stock would all be contingent on the projected path of the interest rate.
- Explain how the projected path of the policy rate is helping to move the economy toward its equilibrium path with flexible prices and wages.
- Because of the complex interactions between the gas and petroleum sector and the rest of the economy, allow for the possibility that monetary policy will involve short-run tradeoffs between moving one or more sectors of the economy closer to their flexible-price equilibrium paths and moving other sectors further away from this ultimate goal. These tradeoffs can be made part of the Bank's communications process.

This level of communication would increase the transparency and predictability of the Bank's monetary policy, as advocated previously by Melino and Parkin (2010, 1). As they write, "More accurate forecasts of the Bank's future policy choices lead to better financial decisions, better price and wage-setting decisions, and the attainment of low and stable inflation with minimum disturbance to the real economy."

More effective communication, by reinforcing the transmission mechanism of monetary policy, should also have the effect of increasing the impact of the Bank's policy announcements on demand and output. It would do so by affecting individuals' expectations for the interest rate at longer horizons. These expectations are important for expenditure decisions such as investment and the purchase of consumer durables. Announcing a policy rate without a conditional path for future policy rates could have negligible macroeconomic effects if it didn't also affect the expectations of future rates. If the Bank were more explicit about the future path of the policy rate, it would reduce individuals' uncertainty about that path, and the heterogeneity of expectations across individuals.<sup>13</sup> These changes would improve the predictability and transparency of the Bank's monetary policy overall, not just in response to major oil price shocks.

## The Role of Judgment

As many authors have pointed out, no central bank is likely to choose a path for its policy rate based entirely on a mechanical rule. Models are necessarily simplifications of reality. The shocks hitting the Canadian economy

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13 For an elaboration of this point, see Clinton et al. (2015). Sweden's Riksbank and Norway's Norges Bank have been publishing conditional policy rate forecasts since 2007 and 2005, respectively. New Zealand's Reserve Bank publishes forecasts of a short-term market interest rate but not of its own policy rate. For a summary of differing views on the usefulness of publishing conditional policy-rate forecasts and an empirical assessment, see Beechey and Österholm (2014).

are more complex than can be accounted for in a model like ToTEM.<sup>14</sup> The interest rate decisions made by the Governing Council of the Bank of Canada are often based on more recent information that has become available after the last forecast generated by ToTEM, which is a quarterly model. The decisions reflect judgments by the staff of the Bank and by members of Governing Council based on more recent information and information that is not part of the Bank's forecasting models. As noted by Melino and Parkin (2010), the forecasts of inflation and output that appear in the Bank's Monetary Policy reports do not necessarily coincide with the forecasts generated by ToTEM.

This kind of decision-making is understandable and normal, but it should also be part of the Bank's communications. By publishing both the Governing Council's final forecasts and the forecasts generated by ToTEM, the Bank can explain the divergences between the two and in particular the information that led to the divergence. This level of communication would help to make the Bank's interest-rate path more predictable and transparent.

The task of explaining the general-equilibrium effects of oil price shocks (or for that matter any other kinds of shocks) would not be an easy one but would be worth the effort. As noted by Cateau and Murchison (2010, 27), "[I]t is in the central bank's own best interest to respond to economic developments in a predictable fashion that is easy to communicate. Not only does this facilitate a better understanding of current policy actions, but it permits markets to better forecast the central bank's future actions."

## Conclusions

The past responses of central banks to major oil price shocks illustrate how difficult it can be to get the policy mix correct and how high the costs of making mistakes can be. The Great Inflation of the 1970s in the United States and in Canada can largely be blamed on inappropriate accommodation of the two major oil price rises at the beginning and the end of that decade. One monetarist interpretation of the Great Recession emphasizes the role played by the US Federal Reserve's inappropriate response to the oil price increase of late 2007 and early 2008. Hetzel (2009, 2012) and Congdon (2009, 2014) are two of the more persuasive advocates of this view.<sup>15</sup>

The Bank already recognizes that responding to real shocks such as oil price shocks is much more difficult than just stabilizing aggregate demand (Bank of Canada 2015b and Poloz 2015). Building on this recognition, the use of formal tools as a more integral part of its communication strategy would increase the transparency and predictability of the Bank's monetary policy. As argued above, this kind of communication would increase its effectiveness and could only be a good thing.

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14 It may also be the case that ToTEM, developed and estimated for a time period with higher average interest rates, is not coping well with the current low-interest-rate environment.

15 Hetzel writes (2009, 4): "[I]n late spring 2008, central banks became increasingly concerned that persistent headline inflation in excess of core inflation would destabilize expected inflation and compromise their inflation objectives . . . . As evidenced by the intensification of recession in summer 2008, central banks caused declines in the real interest rate to lag behind declines in the natural interest rate.

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