Assessing the Spillover Effects of Changes in Bank Capital Regulation Using BoC-GEM-Fin: A Non-Technical Description

Carlos de Resende, Ali Dib, and Nikita Perevalov
International Economic Analysis Department
10 August 2010

1. Introduction and Summary

This note discusses the macroeconomic effects on Canada of changes in bank capital regulation across the world. Using a multi-sector dynamic stochastic general-equilibrium (DSGE) model for the global economy (BoC-GEM-Fin), simulations are conducted to consider the effects of a regulator-imposed *permanent* increase in the minimum capital per unit of risky assets that banks must hold.[1]

More specifically, we use BoC-GEM-Fin to quantify spillover effects from the global adoption of more stringent bank capital requirements. Given a particular scenario for the percentage-point increase in the minimum required bank capital ratio phased in over *T* years, we assume implementation of the change in regulatory policy (i) only in Canada, and (ii) across the world. In both cases, higher regulatory requirements lead to an increase in the marginal economic cost of operations (supply of loans) in the Canadian banking sector. The extra cost is transferred to borrowers through a higher lending rate, which has a negative effect on firms' net worth and leads to an increase in risky spreads, pushing up the firms' external financing costs. This produces a fall in Canadian investment and GDP.

When the change in regulation is global, there are additional channels that exacerbate the negative effects of the change in policy. First, the cost of providing loans increases not only for domestic banks (as is the case when the change in policy is implemented only in Canada), which means that foreign bank lending to Canadian firms also becomes more expensive. Second, the increase in the bank capital requirement in other countries leads to a fall in GDP in those

[1] In the model, the only risky asset held by banks is loans provided to firms.

economies, reduces demand for Canadian exports, and has a negative impact on oil and commodity prices, which compounds the negative effect on the Canadian economy.

The estimate of spillover effects is non-negligible. When a 2-percentage-point rise in minimum bank capital ratio is implemented only in Canada over four years, Canadian GDP is 0.1 per cent below the balanced growth path at the start of 2015, the end of the phase-in period. However, when all countries in the model follow the same policy, Canadian GDP falls by about 0.2 per cent in the same period. On average for this scenario, spillover effects make the loss in output relative to the balanced growth path twice as large during the phase-in period. If the global change in regulatory policy is implemented in a context of a temporarily unresponsive monetary policy, Canadian GDP would be 0.5 per cent below its balanced growth path by 2015Q1.

2. The Model

The Bank of Canada's version of the Global Economy Model (GEM) with financial frictions (BoC-GEM-Fin) is a five-sector, five-region DSGE model.[2] The economy in each of the regional blocks consists of households, a government, a monetary authority that follows a Taylor-type rule on core inflation with interest rate smoothing, heterogeneous monopolistically competitive banks that interact in an interbank market, and a multi-tiered production sector that includes risk-neutral entrepreneurs, capital producers, monopolistically competitive retail firms, and perfectly competitive wholesale firms.

Two key features of the model are its global dimension and the explicit modelling of a banking system. A global model is required to capture spillover effects of shocks originated in one particular economy to other economies. In BoC-GEM-Fin, the different regional blocks are

[2] The five regional blocks in the model, encompassing the entire world economy, are: Canada, the United States, emerging Asia, a block for commodity-exporting countries, and a residual economy to account for the remaining countries in the global economy. A more detailed description of the model and experiments discussed in this note can be found in de Resende, Dib, and Perevalov (2010). A different policy application of BoC-GEM-FIN is described in Beaton et al. (2010).

interconnected by both trade and financial linkages on a bilateral basis. The latter takes the form of lending flows from banks in one region to domestic firms in another region.

The banking sector within BoC-GEM-Fin follows Dib (2010), whereby profit-maximizing banks collect deposits from households and pay a deposit rate optimally set as a markdown over the marginal return of the banks' assets.[3] Banks lend a fraction of the deposits to other banks in the interbank market, while the remaining fraction is used to buy risk-free government bonds. The optimal allocation of deposits between risky interbank loans and government bonds depends on the relative returns (i.e., the interbank rate and the policy rate, respectively). Banks combine borrowed funds from other banks (i.e., a fraction of deposits) with "bank capital" (which they raise from households, paying a risky return) to supply loans to firms.[4] Since banks may default on their interbank borrowing, the equilibrium interbank rate features a spread (relative to both the risk-free rate and the deposit rate). On the other hand, the return received by banks on loans to firms is given by the prime loan rate, which is optimally set as a markup over the "marginal cost of loan supply," plus a risk premium that decreases with the net worth of firms. Moreover, in the process of lending to firms, banks optimally choose their loans-to-capital ratio while satisfying an upper limit (i.e., a minimum capital requirement) set by regulators. One key assumption is that well-capitalized banks, defined in terms of a "capital buffer" above the minimum required, can raise capital at a lower cost.[5]

3. The Channels

An increase in the minimum capital requirement applied only to the *domestic banking system* affects the economy through the marginal cost of loan supply, as banks need more "input" (capital) to produce one unit of "output" (loans). The higher minimum capital requirement

[3] As in Gerali et al. (2010), in a monopolistic competition setup with imperfect substitution between deposit services provided to households, banks face an individual deposit supply function that is increasing in the deposit interest rate relative to the market average, and the total supply of deposits by households.

[4] In addition to government bonds, foreign bonds, and bank deposits, households can also save in bank capital. Since banks are assumed to keep capital in the form of government bonds, the cost of raising bank capital includes the risky return paid to households net of the risk-free rate.

[5] The optimal choice of the leverage ratio directly affects the cost of lending through its impact on the marginal cost of producing loans, given by the sum of the interbank rate with the cost of raising bank capital (including the shadow price of using capital to satisfy the capital requirement) adjusted by the loans-to-capital ratio.

forces banks to deleverage, which they do either by reducing the risky loans made to firms or by raising additional bank capital in the market. How banks actually deleverage (i.e., reduce loans and/or increase capital) depends on the relative opportunity costs: banks weigh the marginal loss in revenues from reducing loans with the marginal increase in costs from raising additional bank capital.[6] When banks deleverage by cutting loans, investment is directly affected and falls, followed by GDP. When deleveraging implies capitalization, the extra cost is transferred to borrowers through a higher lending rate, which has a negative effect on entrepreneurial net worth and leads to an increase in risk premium (spreads), pushing up the firms' external financing costs. This indirect channel also produces a fall in domestic investment and GDP.

When the changes in the bank capital regulation are also implemented in foreign economies, there are spillover effects to the domestic economy. In the BoC-GEM-Fin, the spillovers come from two separate channels. First, the cost of providing loans increases not only for domestic banks (as in the case of changes in policy domestically implemented), which means that foreign bank lending to domestic firms also becomes more expensive. Second, the increase in the bank capital requirement in other countries leads to a fall in economic activity abroad, which reduces the demand for domestic exports and may affect the terms of trade. For instance, economies that export oil and commodities, such as Canada, are negatively affected, since the global fall in output puts downward pressure on the prices of these goods.

4. Policy Experiments and Results

Let the banking system leverage ratio be defined as:

$$k = \text{loans/bank capital},$$

[6] One important element in this trade-off is the rate of return that banks must pay to households when raising bank capital, which depends on the law of motion of the stock of bank capital. In the BoC-GEM-FIN, the supply of bank capital evolves according to the saving decisions by households. When it is costly to adjust their holdings of bank capital, households demand a high return to supply any given amount of capital to banks, reducing the responsiveness of bank capital to exogenous shocks. Thus, if banks face a change in policy that requires a higher capital-to-loans ratio, and bank capital is costly to adjust, the deleveraging process tends to be biased towards the reduction in loans, which amplifies the negative effects on investment and GDP.

such that 1/k is the capital-to-loans ratio. Regulators set the maximum allowed leverage ratio, k_{MAX}, which corresponds to a minimum capital requirement ratio given by:

$$1/k \geq 1/k_{MAX.}$$

The policy experiments consider a 2-percentage-point increase in the minimum required capital-to-loans ratio that banks must satisfy, $1/k_{MAX}$, under different assumptions about where the change in policy will take place (only in Canada vs. globally), the response of monetary policy (endogenous vs. no response for one year), and the phase-in period (two, four, or six years). Table 1 shows the implications for Canadian GDP based on simulations with BoC-GEM-Fin over the period from 2010Q4 to 2018Q4, focusing on only three scenarios:[7]

1. A 2-percentage-point increase in the minimum capital-to-loans ratio, $1/k_{MAX}$, implemented over two years, with a fully responsive monetary authority;
2. A 2-percentage-point increase in $1/k_{MAX}$, implemented over four years, with a fully responsive monetary authority (baseline case);
3. A 2-percentage-point increase in the minimum capital-to-loans ratio, implemented over four years, with an unresponsive monetary authority (policy rates fixed for a year).

For each scenario, two sets of results are discussed in which the change in regulatory policy (increase in the minimum required bank capital ratio) is implemented (i) only in Canada (case A); or (ii) in all regions of the global economy (case B). The implications for Canadian GDP from the simulations are summarized in Table 1. The transition paths for some selected variables are displayed in Charts 1, 2, and 3.

[7] The following assumptions are used in the simulations: (i) the initial value of the minimum capital-to-loans ratio is 10 per cent iin Canada and 8 per cent in the remaining regions; (ii) the change in regulation is implemented linearly, with equal quarterly changes, over the phase-in period; and (iii) the first incremental change in the capital requirement, implemented in 2011Q1, is treated as unexpected but, starting in 2011Q2, any further increment is fully anticipated.

.

Table 1
Effect of an increase of 2 percentage points in the minimum bank capital ratio

Scenario	Phase-in period [1]	Monetary policy	Effect of Canadian GDP by 2015Q1 [2]	
			Change only Canada	With spillover
1	2 years	Fully responsive	-0.10%	-0.44%
2	4 years	Fully responsive	-0.10%	-0.23%
3	4 years	Unresponsive for 1 year	-0.13%	-0.49%

1 Increase in $1/k_{MAX}$ is assumed to be linearly implemented over the phase-in period.
2 In percent deviation from the balanced growth path.

Charts 1 and 2 show the implications of a 2-percentage-point increase in the minimum capital ratio for the following variables in Canada: the excess capital that banks hold as a "buffer" over the minimum required level, bank lending (loans to firms), spreads, consumption, investment, GDP, and the policy rate. In these charts, the green lines represent case A, where the change in the regulation policy is implemented only in Canada (the minimum capital requirement is kept at 8 per cent, the level recommended by the Basel II committee, in all other regions of the global economy). The blue lines represent case B, where all regions increase $1/k_{MAX}$ by 2 percentage points.

As the minimum capital requirement increases, banks need to deleverage either by reducing loans or by increasing their holdings of bank capital. Reducing loans affects banks' revenues, while increasing bank capital holdings affects the marginal costs of supplying loans (since it is costly to raise bank capital in the financial markets).

Focusing on Chart 1, in both cases A and B, banks increase their holdings of capital, which increases the marginal cost of supplying loans. Banks transfer this extra cost to borrowers, and this is reflected in the increase in the spread on the external financing cost to firms over the policy rate (despite the drop in the latter). The increase in borrowing costs explains the decline in investment and GDP.

The differences in the responses of the selected variables between cases A and B is explained by the extent of the drop in entrepreneurial net worth following the increase in the lending rates. In case A, the fall in net worth of Canadian firms is caused only by the increase in the

external financing cost of borrowing from Canadian banks. The cost of borrowing from foreign banks is not affected by the change in Canadian regulatory policy.

On the other hand, in case B, in addition to the increase in the cost of borrowing domestically, the net worth falls by more, owing to two additional reasons. First, since the change in regulation is implemented worldwide, Canadian firms borrowing from foreign banks also pay a higher cost for loans. Second, the fall in foreign output reduces the demand for Canadian exports and negatively affects the price of oil and non-energy commodities.

Chart 1
Effect of an increase in the minimum capital requirement over two years

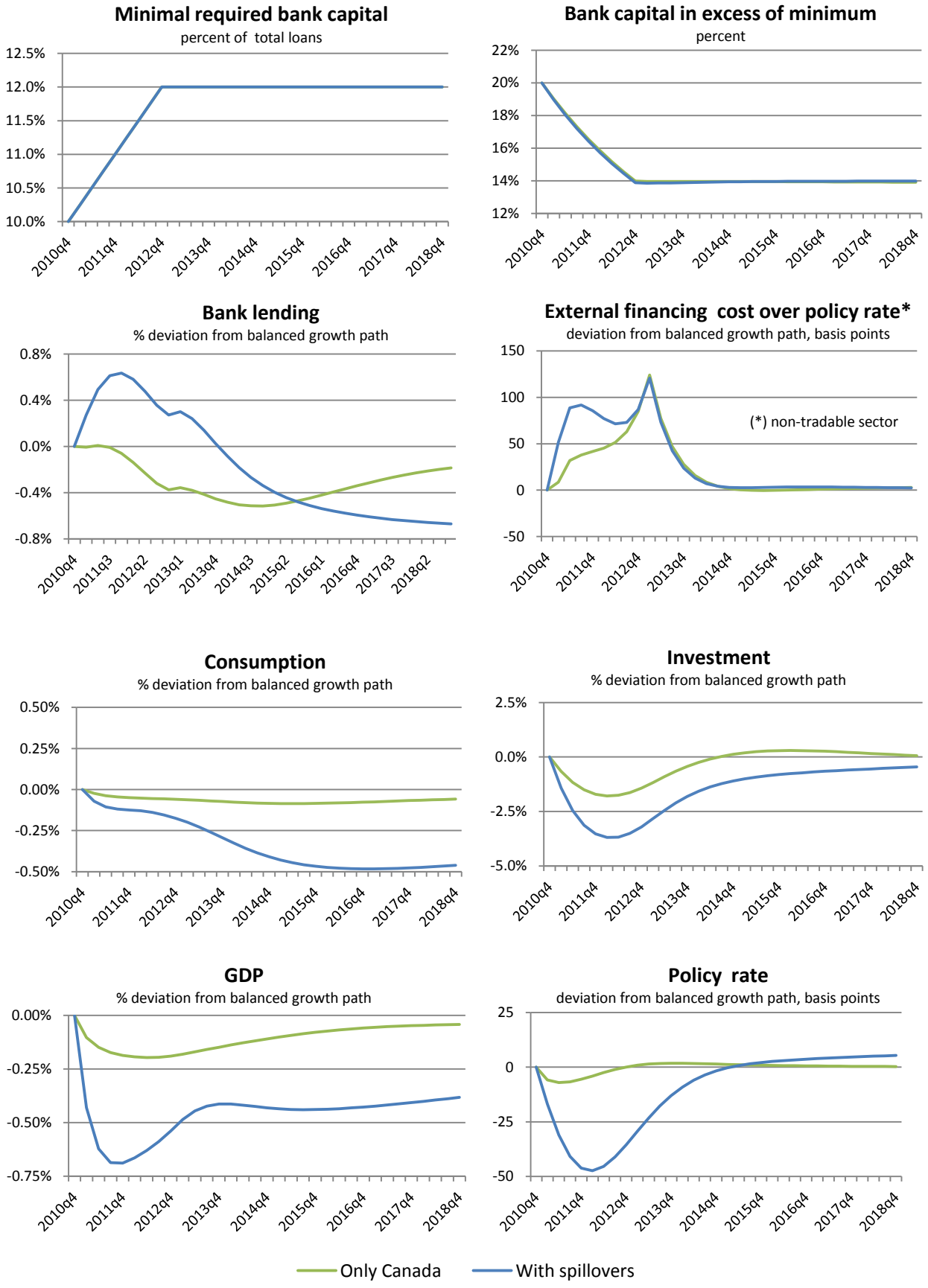
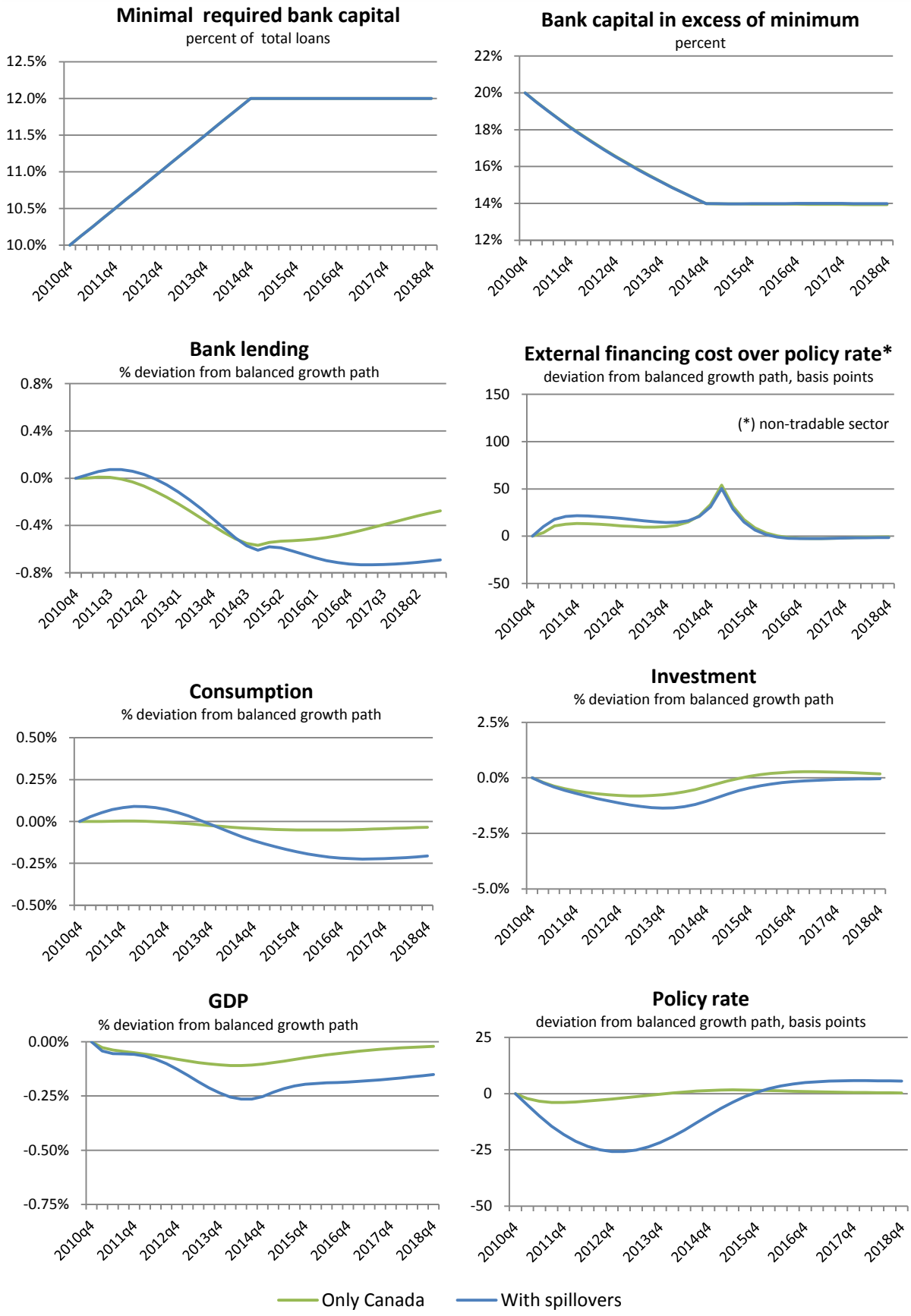


Chart 2
Effect of an increase in the minimum capital requirement over four years



The larger drop in net worth in case B, compared with case A, in the presence of short-run adjustment costs of investment, implies that firms must demand more loans to finance their existing investment plans. This extra demand pull explains why bank lending increases, in case B in the short run, as well as part of the larger increase (compared with case A) in the external financing cost. The latter is also partially explained by a further increase in the risk premium associated with the larger drop in net worth. Finally, in both cases A and B, the drop in consumption is explained by wealth effects caused by the drop in households' income. This is despite the fall in the policy rate in response to the decline in inflation (which, in turn, is caused by the recession).

The effect of keeping the policy rate constant for one year is considered in Chart 3. The green line is exactly the same as in Chart 2 for case B, while the blue line shows the response of the variables to the same change in regulatory policy keeping the policy rate unchanged for one year. Note that the responses of the selected variables are much stronger when monetary policy is temporarily unresponsive.[8] This comparison suggests that "purging" the results from the effects of the monetary policy reaction by fixing the policy rate for some time implies a deeper recession following the change in the regulation policy. Note that the spread of the external financing cost over the policy rate increases by more when the monetary policy response to inflation is reduced. The effect on GDP is also larger in the case of an unresponsive monetary policy. Since the monetary authority does not reduce the nominal interest rate to react to the fall in inflation resulting from the recession, the real interest rate becomes higher than it would be otherwise, which induces a larger fall in GDP, followed by a fall in sales and profits, and reflects negatively in the net worth of entrepreneurs, triggering the so-called "financial accelerator mechanism": increase in the external financial cost of firms, inducing a further decrease in investment, output, and net worth, further rise in the external financial cost, and so on.

[8] This assumption could be interpreted as representing a situation where, at the start of the simulation period, the policy interest rate is already at the effective lower bound and the monetary authority also chooses to not use alternative or "unconventional" instruments. During the recent financial crisis, even though the policy interest rates were reduced to the effective zero lower bound, the Bank of Canada was able to retain considerable flexibility in the conduct of monetary policy. Several instruments other than the interest rates were available to the Bank of Canada, such as a conditional commitment to maintain the overnight rate at 1/4 per cent for a considerable period of time, as well as additional stimulus through quantitative and/or credit easing.

Chart 3
Sensitivity to the Response of Monetary Policy

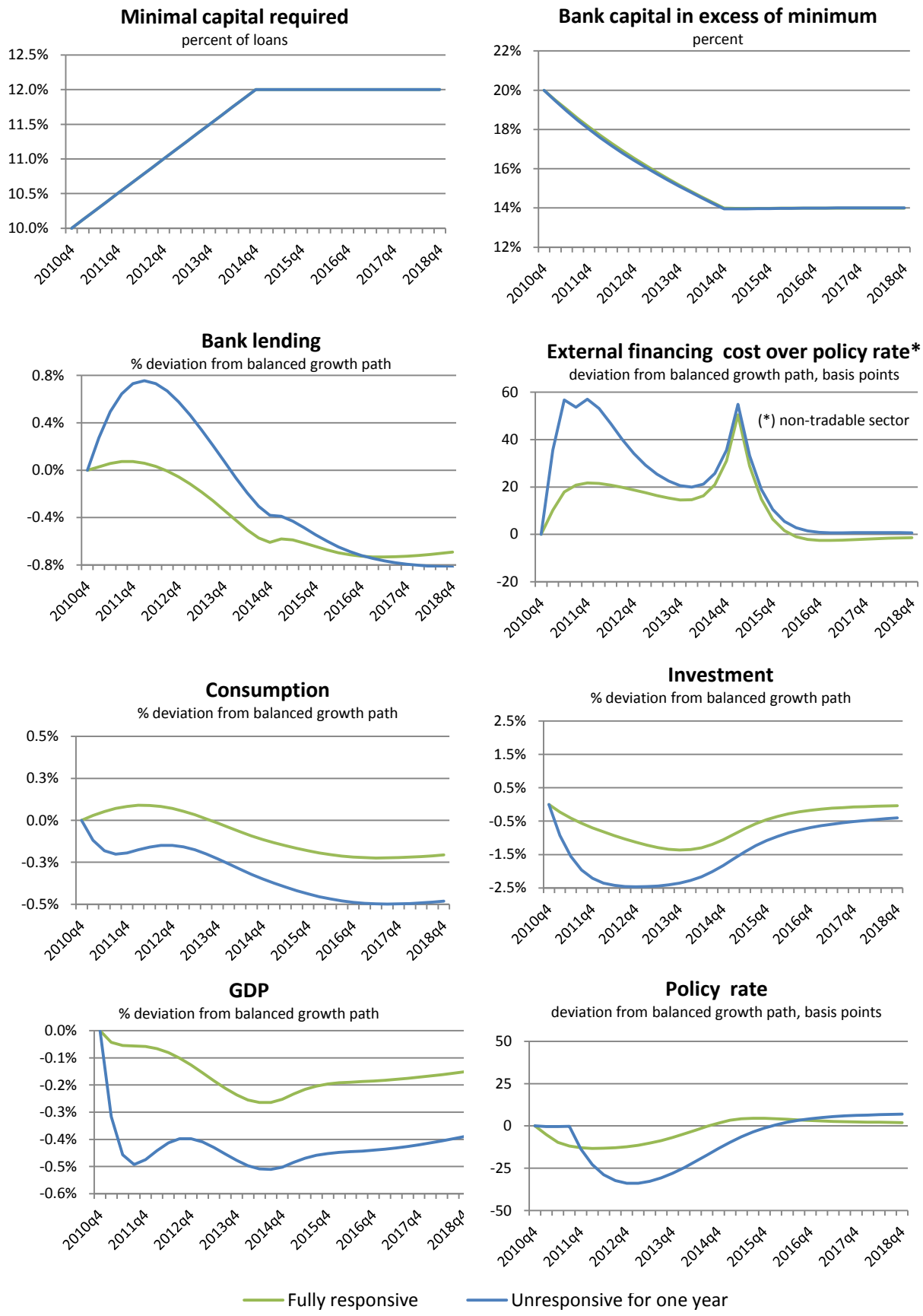


Table 2 shows the implications for Canadian GDP from the simulations with BoC-GEM-Fin over the period 2010Q4 to 2018Q4 for all scenarios considered, including the three scenarios discussed above. The spillover effects are computed in the bottom portion of Table 2, as the difference in the results from the scenarios, where the increase in $1/k_{MAX}$ is implemented globally to those in which the change is implemented only in Canada.

Table 2

Effect of a 2-percentage-point increase in the minimum capital requirement ratio on Canadian GDP [1]

Scenario	Change in capital regulation	Monetary policy [2]	Phase-in	2013Q1	2015Q1	2017Q1	2018Q4	Average 2011-18	Trough
1	only Canada	exogenous	2 years	-0.27%	-0.15%	-0.09%	-0.07%	-0.18%	-0.34%
2	only Canada	exogenous	4 years	-0.16%	-0.13%	-0.07%	-0.04%	-0.12%	-0.18%
3	only Canada	exogenous	6 years	-0.04%	-0.07%	-0.07%	-0.04%	-0.05%	-0.08%
4	only Canada	endogenous	2 years	-0.18%	-0.10%	-0.06%	-0.04%	-0.11%	-0.20%
5	only Canada	endogenous	4 years	-0.09%	-0.10%	-0.04%	-0.02%	-0.06%	-0.11%
6	only Canada	endogenous	6 years	-0.01%	-0.06%	-0.06%	-0.03%	-0.04%	-0.07%
7	global (spillovers)	exogenous	2 years	-0.76%	-0.59%	-0.52%	-0.46%	-0.68%	-1.24%
8	global (spillovers)	exogenous	4 years	-0.41%	-0.49%	-0.44%	-0.39%	-0.44%	-0.51%
9	global (spillovers)	exogenous	6 years	0.04%	-0.09%	-0.15%	-0.11%	-0.06%	-0.17%
10	global (spillovers)	endogenous	2 years	-0.49%	-0.44%	-0.42%	-0.38%	-0.47%	-0.69%
11	global (spillovers)	endogenous	4 years	-0.15%	-0.23%	-0.18%	-0.15%	-0.17%	-0.26%
12	global (spillovers)	endogenous	6 years	0.05%	-0.09%	-0.15%	-0.11%	-0.05%	-0.17%
Spillover effects									
Comparison of scenarios									
1 and 7		exogenous	2 years	-0.49%	-0.44%	-0.43%	-0.39%	-0.50%	-0.90%
2 and 8		exogenous	4 years	-0.25%	-0.35%	-0.37%	-0.35%	-0.32%	-0.33%
3 and 9		exogenous	6 years	0.08%	-0.02%	-0.08%	-0.07%	0.00%	-0.09%
4 and 10		endogenous	2 years	-0.30%	-0.33%	-0.37%	-0.34%	-0.36%	-0.49%
5 and 11		endogenous	4 years	-0.07%	-0.14%	-0.14%	-0.13%	-0.10%	-0.15%
6 and 12		endogenous	6 years	0.06%	-0.03%	-0.09%	-0.08%	-0.01%	-0.10%
			Average across scenarios:	**-0.16%**	**-0.22%**	**-0.24%**	**-0.23%**	**-0.22%**	**-0.34%**

1 Effects are computed as percent deviation of the balanced growth path.

2 Exogenous monetary policy means that the response to inflation has been delayed for one year.

5. Conclusion

The results presented in the previous section suggest that a permanent increase in the minimum capital requirement ratio implies that:

- The transition costs of the change in regulatory policy are modest. These costs include a reduction in Canadian GDP that outlasts the phase-in period, explained by the increase in lending spreads and the resulting drop in investment (see section 3). When one takes scenario 11 (a 2-percentage-point permanent increase in the minimum capital requirement worldwide, implemented over a four-year period) as the baseline case, the transition to a higher capital requirement induces a 50-basis-point (peak) increase in lending spreads, followed by a -1.5 per cent (trough) fall in investment, and a (trough) -0.26 per cent reduction in GDP.[9]
- That spillover effects to Canada from changes in policy in other economies should not be neglected. They may increase the average negative effect of the change in regulation on Canadian GDP by as much as 0.9 percentage point (when comparing scenarios 1 and 7). Considering the average of all scenarios, spillover effects increase the average negative effect on GDP by 0.2 percentage point. Taking scenario 11 as reference, the spillover effects account for an extra -0.1-percentage-point fall on average GDP over 2011-18 (see scenarios 5 and 11).
- The phase-in period for the implementation of the new regulatory policy also matters. When the implementation period increases from two to four years, the responses of the selected variables are much smaller. For example, reducing the implementation period from

[9] Note that the results are conditional on the current calibration of BoC-GEM-FIN and are subject to uncertainty around some of the key parameters. For example, the elasticity of the loan supply to different shocks, including the change in regulatory policy, depends crucially on how costly it is to adjust bank capital. Accordingly, the responsiveness of bank capital to the change in regulatory policy is quantitatively very important for the size of the resulting recession: the more sluggish the response of bank capital to a change in policy, the deeper the recession tends to be, as banks must deleverage by heavily cutting loans made to entrepreneurs. For instance, increasing the adjustment cost of bank capital by a factor of two increases the trough response of GDP in Canada by a factor of more than three.

four to two years implies an extra 0.3-percentagepoint fall in GDP (scenarios 11 and 10), on average (-0.16 percentage point, considering the average of all scenarios). On the other hand, increasing the phase-in period to six from four years reduces the average fall in GDP across scenarios by 0.13 percentage point.

- The response of monetary policy matters greatly for the implications of the changes in capital requirements. If monetary policy does not react to inflation outcomes,[10] the effects of the change in capital regulation policy are much stronger. Considering the average of all scenarios, an unresponsive (exogenous) monetary policy increases the average negative effect on GDP by 0.1 percentage point.
- Taking scenario 11 as reference, an unresponsive monetary policy for one year and a two-year shorter phase-in period amount to additional reductions on average GDP over 2011-18 by 0.27 and 0.3 percentage point, comparing with scenarios 8 and 10, respectively. If the phase-in period is increased to six years (scenario 12), the average reduction in GDP is lowered by 0.12 percentage point.

References

Beaton, K., C. de Resende, R. Lalonde, and S. Snudden. 2010. "Prospects for Current Account Rebalancing." Bank of Canada Discussion Paper No. 2010-4.

de Resende, C., A. Dib, and N. Perevalov. 2010. "The Macroeconomic Implications of Changes in Bank Capital and Liquidity Requirements in Canada: Insights from BoC-GEM-FIin." Bank of Canada. Draft.

Dib, A., 2010. "Banks, Credit Market Frictions, and Business Cycles. " Bank of Canada. Draft.

Gerali, A., S. Neri, S., L. Sessa, and F. M. Signoretti. 2010. "Credit and Banking in a DSGE Model of the Euro Area. " Bank of Italy Working Paper No. 740.

[10] This refers to cases where the policy rate is lowered or quantitative or credit easing instruments are used in response to the fall in inflation resulting from the slowdown in economic activity.