Assessing the Macroeconomic Impact of Stronger Capital and Liquidity Requirements in Canada: Insights from ToTEM*

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Abstract

This paper assesses the macroeconomic impact of higher capital and liquidity requirements for the Canadian banking system. In particular, it quantifies the output losses that the transition towards these higher requirements can cause. We evaluate two different proposals: (i) an increase of a 1-percentage point in the bank capital ratio and ii) an increase of 25 percent in the liquid asset ratio. Our results suggest that a one percentage point increase in the bank capital ratio implemented over four years will cause a decline in output by 0.26 percentage points eight years after the beginning of the implementation. Changes to the liquidity requirements yield very similar quantitative results. Our estimates are based on the assumption that conditions in the rest of the world are fixed. Therefore, they do not take into account the possibility of a global tightening of regulatory requirements that could amplify the effects of the tighter regulatory requirements in Canada. In a companion paper, de Resende et al (2010) discuss the quantitative importance of these additional effects.

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1 Introduction

The recent international banking crisis has raised the issue about how to conduct macroprudential regulation. For instance, the Basel Committee on Banking Supervision has proposed to increase the capital and liquidity requirements of the banking system. The aim of this proposal is to strengthen the banking sector, which generates benefits to society mainly by reducing the probability of a banking crisis in the future. However, there are also some costs that must be incurred in order to get the benefits of a less-leveraged and more liquid banking system. For instance, during the transition towards tighter capital and liquidity requirements, banks could reduce the supply of credit or increase the spreads. The latter would have a negative impact on economic activity, as it implies higher cost of financing for households and firms.

This paper assesses the macroeconomic impact of higher capital and liquidity requirements for the Canadian banking system. In particular, it quantifies the output losses that the transition towards these higher requirements may cause. We evaluate two different proposals: (i) an increase of 1-percentage point in the bank capital ratio and (ii) an increase of 25 per cent in the liquid asset ratio. Each of these proposals is evaluated under different assumptions with respect to the implementation period (two and four years) and the response of monetary policy (an endogenous response vs. no response of monetary policy). Different implementation periods are evaluated to assess how rapidly the new requirements can be achieved without causing a quantitatively important output loss. Regarding monetary policy, the main motivation for studying an endogenous response is that monetary policy is very likely to react to tighter regulation in order to dampen its effects on inflation and output. The case in which monetary policy does not react is evaluated to assess the direct effects of regulation. Moreover, this evaluation is useful in order to explore the scenario in which the policy rate cannot be reduced because it is at the effective zero lower bound.[1]

The methodology followed in this paper to evaluate the two different regulatory proposals is the two-step approach suggested by the Macroeconomic Assessment

[1] Even if the policy rate is at the zero lower bound, a central bank could adopt unconventional monetary policy measures to dampen the macroeconomic impact of tighter regulation.

Group (MAG) of the Basel Committee on Banking Supervision (BCBS) and the Financial Stability Board (FSB). First, we use satellite models to measure the impact of the regulatory policies on interest-rate spreads faced by households and firms in Canada.[2] Second, we use these results to assign a path for the spreads and conduct simulations using a modified version of the Bank of Canada's main macroeconomic policy model for the Canadian economy, ToTEM. This model is a multi-sector, open-economy dynamic stochastic general-equilibrium (DSGE) model that tells coherent and internally consistent stories about the current and expected evolution of the Canadian economy. The modified version allows: (i) imperfect asset substitutability between short-term and long-term securities, (ii) segmented asset markets and (iii) exogenous interest-rate spreads faced by households and firms. Imperfect substitutability allows the model to capture variations in the long-term rates that are not associated with changes in the expected path of future short-term rates. Segmented asset markets generate a meaningful role for long-term interest rates in the expenditure decisions, over and above the traditional role of short-term rates. The introduction of spreads allows the model to capture variations in the effective interest rates faced by households and firms as a consequence of the regulatory changes.

Our results suggest that a 1-percentage point increase in the bank capital ratio implemented over four years will cause a decline in output by 0.26 percentage points eight years after the start of the implementation of the increase. Changes in the liquidity requirements yield very similar quantitative results. The reduction in GDP is mainly driven by the decline in consumption and investment as a consequence of the increase in the interest-rate spreads faced by households and firms. The estimated reduction in economic activity is obtained under the assumption that conditions in the rest of the world are fixed. However, there is a possibility of a global tightening of regulatory requirements that could amplify the effects of the tighter regulatory requirements in Canada. An analysis performed by de Resende et al (2010) quantifies the effects of global tightening of regulatory requirements for Canada using the BoC-GEM-FIN model. They find that tighter regulatory requirements in the rest of the world increase the impact of a 1-percentage point

[2] See Annex 1 in the report "Strengthening International Capital and Liquidity Standards: A Macroeconomic Impact Assessment for Canada"

increase in the capital ratio by 0.05 percentage points (in the case in which the increase in capital is implemented over four years and monetary policy endogenously reacts).

The main focus of this paper is on the effects of the changes in banking regulation on output via their impact on interest-rate spreads. Alternatively, changes in capital and liquidity requirements can affect the economic activity through their impact on lending volumes (credit rationing). In order to explore this possibility, we follow a procedure proposed by MAG, which is based on the idea that credit rationing is a missing variable in the consumption and investment equations. First, we find the relationship between the regulatory changes and lending volumes. Second, we regress the historical residuals in the consumption and investment equations from ToTEM on lending volumes data. We find that the impact of lending volumes on consumption and investment is quantitatively very small, which suggests that the main impact of the regulatory measures would come through their impact on interest-rate spreads.

The remainder of the paper is organized as follows. Section 2 provides a brief description of the modified version of ToTEM that is used to conduct the simulations. Section 3 discusses the calibration of the main parameters of the model. Section 4 explains the different policy experiments. Section 5 presents the results of the different simulations. Section 6 evaluates the potential impact of the regulatory measures through their effects on lending volumes. Section 7 provides a conclusion.

2 The Model

In this section, we present briefly a modified version of ToTEM. In particular, we modify ToTEM by allowing imperfect asset substitution and segmented asset markets, following the framework proposed by Andres et al (2004). Moreover, we introduce exogenous spreads in order to allow the interest rates faced by households and firms to be affected by the implementation of the tighter regulatory requirements. The main goal of this section is to explain the main elements of the modified model and to show the most important log-linearized equations.[3]

The model is an open-economy, dynamic stochastic general-equilibrium (DSGE) model with:

a) Four different financial assets: domestic short-term and long-term bonds; and foreign short-term and long-term bonds.

b) Four agents: households, firms, the central bank, and a representative fiscal authority, or government.

c) Three types of households: they differ in their access to asset markets and in their preferences.

d) Four distinct finished-product sectors: consumption, investment, government and manufactured exports; and one commodity-producing sector.

2.1 Asset Structure

Domestic and foreign short-term bonds are one quarter period bonds. Long-term domestic and foreign bonds are modeled as 5-year period zero-coupon bonds: there are no payments received by the holders until the maturity of these bonds. This assumption is in line with the treatment of long-term bonds in macroeconomic models.[4] Moreover, there is no secondary market for long-term bonds.[5] This introduces a "loss" of liquidity when investing in long-term bonds market, relative to the same investment in short-term bonds, which we assume households dislike.

2.2 Households

The model assumes the existence of three types of consumers. The first type, labelled "unrestricted lifetime-income" consumers, maximize their utility facing a lifetime budget constraint. The functional form for utility is such that consumption and leisure are not additively separable (King, Plosser, and Rebelo 1988),

[3]See Murchison and Rennison (2006) for a full description of ToTEM. See Dorich, Mendes and Zhang (2010) for a full description on how to incorporate imperfect asset substitutability and segmented asset markets in a small open economy. Andres et al (2004) use a closed economy model.

[4]See Svensson (2000).

[5]We follow Andres et al (2004). This assumption helps the model to generate a term premium in a very tractable way.

which ensures that, under any values for the preference parameters, labour supply will be stationary in the presence of trend productivity growth. Their utility function also includes external habit formation. Given that these agents base their consumption decisions on their total expected lifetime income, they choose a very smooth consumption path through time when the real interest rate is constant. Higher (lower) real interest rates will cause these consumers to temporarily increase (reduce) their savings, in order to fully exploit the interest rate change. These agents can borrow or save in any of the four types of financial asset, so as to reallocate consumption across time. However, they face a utility cost when purchasing long-term bonds. The latter assumption tries to incorporate the "loss of liquidity" that these households face when entering in the long-term asset market due to the absence of secondary markets for trading these bonds. Moreover, the latter assumption drives the existence of imperfect asset substitution in the model. These agents are also assumed to own all the domestic firms and are therefore the recipients of any profits.

The second type, labelled "restricted lifetime-income" consumers also maximize their utility facing a lifetime budget constraint. However, these agents have access only to the long-term bonds in order to save or borrow. The functional form for utility for these agents is the same as the one assumed for "unrestricted lifetime-income" consumers, except that these agents do not face any utility cost when investing in long-term bonds. If we relax this assumption, then long-term debt stocks will also matter over and above interest rates in the aggregate demand. Given that the conventional view is that asset quantities do not enter directly the aggregate demand, we decide to keep the previous assumption.

Before presenting the description of the third type of household, it will be helpful to examine the realism of the assumed heterogeneity in lifetime households and discuss the practical implications of the assumptions made for each type. The unrestricted agents in the model can be thought of as standing for that portion of the private sector that save primarily through commercial bank deposits and other highly liquid assets; the restricted households, as those who save heavily through agencies such as pension funds. Commercial banks tend to have self-imposed liquidity requirements; non-bank holders of long-term bonds usually plan to cash them at maturity.[6] Alternatively, the restricted agents can be thought of as investor clienteles with a specific preference for long-term bonds. This alternative interpretation is consistent with the preferred-habitat view, proposed by Culberston (1957) and Modigliani and Sutch (1966).[7] The existence of restricted households allows long-term interest rates to matter over and above short rates in aggregate demand.[8] With only unrestricted households, even if they have access to long-term bonds market, they could always "bypass" this market altogether, and simply implement their consumption plans by trading in sequences of short-term bonds. Imperfect substitutability between short- and long-term bonds allows long-term rates to deviate from the level implied by the strict expectations theory of the term structure.

The third type, labelled "current-income" consumers, face a period-by-period budget constraint that equates their current consumption with their disposable income, including government transfers. In addition to not being able to save or dissave, current-income consumers do not own shares in companies and therefore do not receive dividends. The presence of current-income consumers in the model reflects the simple fact that not all households in the economy can access credit markets, as is typically assumed in DSGE models. In terms of model behavior, the main implication of introducing "current-income" consumers is that changes to taxes and transfers have larger consumption effects.

The evolution of aggregate consumption can be characterized by the following three equations:

$$\frac{-1}{\mu(1-\xi)}\left[\widehat{C_t^l}-\xi\widehat{C_{t-1}^l}\right]+\frac{(1-\mu)}{\mu}\overline{L}^{1+1/\eta}\widehat{L}_t-\widehat{\tau}_t=\frac{-1}{\mu(1-\xi)}E_t\left[\widehat{C_{t+20}^l}-\xi\widehat{C_{t+19}^l}\right] \tag{1}$$

$$+\frac{(1-\mu)}{\mu}\overline{L}^{1+1/\eta}\widehat{L}_{t+20}-\widehat{\tau}_{t+20}+\gamma\sum_{j=0}^{19}\widehat{i}_{t+j}+(1-\gamma)20\widehat{i_t^{20}}-\sum_{j=0}^{19}\left[E_t\widehat{\pi}_{t+j+1}+\xi_{t+j}\right]$$

[6] See Andres et al (2004).

[7] Greenwood and Vayanos (2009) discuss different market episodes supporting the preferred-habitat view.

[8] If restricted households consider money and long-term bonds as imperfect substitutes, the long-term interest rate will matter over and above the short term rate in the IS curve as long as the degree of imperfect substitutability faced by restricted households is lower than the one faced by unrestricted households. See Andres et al (2004) for a detailed explanation of this point.

$$\widehat{C_t^l} = \gamma \widehat{C_t^{ul}} + (1-\gamma)\widehat{C_t^{rl}} \tag{2}$$

$$\widehat{C_t} = (1-\varkappa)\,\widehat{C_t^l} + \varkappa \widehat{C_t^c} \tag{3}$$

where $\widehat{C_t^l}$ is the aggregate consumption of "lifetime income" consumers, $\widehat{L_t}$ is aggregate labour, $\widehat{\tau}_t$ is the income tax rate, $\widehat{i_t}$ and $\widehat{i_t^{20}}$ are the short- and long-term rates faced by households, $\widehat{\pi}_t$ is the inflation rate and ξ_t is a time-preference shock. $\widehat{C_t^{ul}}, \widehat{C_t^{rl}}$ and $\widehat{C_t^c}$ are the aggregate levels of consumption for "unrestricted lifetime", "restricted lifetime" and "current income" consumers respectively.[9] The parameters that appear in this block of equations are the following: μ is the intertemporal elasticity of substitution, ξ is the habit-persistence parameter, $\overline{L}$ is the steady state level of labour, η is the wage elasticity of labour supply, γ is the percentage of "lifetime income" consumers that are "unrestricted" and $\varkappa$ is the fraction of "current income" consumers.

The interest rates faced by households are related to the monetary policy rate and spreads in the following way:

$$\widehat{i_t} = \widehat{i_t^{pol}} + stsp_t \tag{4}$$

$$\widehat{i_t^{20}} = \frac{1}{20}\sum_{j=0}^{19} E_t \widehat{i_{t+j}^{pol}} + tp_t + \frac{1}{20}\sum_{j=0}^{19} E_t stsp_{t+j} + ltsp_t \tag{5}$$

where $\widehat{i_t^{pol}}$ is the policy rate, $stsp_t$ is an exogenous short-term spread faced by households, tp_t is a term premium that is a function of the domestic long-term bond holdings and $ltsp_t$ is an exogenous component of the long-term spread that is not captured by the expected path of the short-term spread.[10] Notice that the long-term spread faced by households in the model is defined as the difference between the long-term rate faced by households and the long-term risk free rate, which includes a term premium.[11] Therefore, we can write the long-term spread

[9]Notice that $\widehat{C_t^c}$ is not determined in this system of equation. This variables is equal to the disposabal income of "current income" consumers.

[10]In the model, it is assumed that the supply of domestic long term bonds follow an exogenous process, so does the term premium.

[11]The long term risk free rate is equal to sum of two components: one that depends on the expected path of the risk free short term, and another one that captures the term premium.

as:

$$longtermspread_t = \frac{1}{20}\sum_{j=0}^{19} E_t stsp_{t+j} + ltsp_t \tag{6}$$

Notice that we will input the expected spread paths associated with each of the regulatory proposals into the model by using $stsp_t$ and $ltsp_t$. In particular, paths for these two variables are generated such that they match the path for the short- and long-term spread. Moreover, the short-term and long-term spreads faced by firms also change with the changes in regulatory requirements. These spreads are analogous to the ones faced by households but can differ in magnitude, given that the short- and long-term rates faced by firms are different from those faced by households.

All types of households sell labour to domestic producers and receive the same hourly wage, which they negotiate with the firm. It is important to note that workers are assumed to possess skills that are partially specific to the individual, thereby implying imperfect substitutability across workers. This assumption about the structure of labour markets is important, because it means that workers have some market power in determining their wage. Workers and firms do not optimally reset the nominal wage every period, but rather do so about once every seven quarters, on average. When a given wage is optimally reset, it is chosen in a forward-looking manner, since workers know that they may not have the opportunity to reset their wage optimally again for several periods. Basically, the optimal wage is a function of the following current and anticipated variables: average real wage, consumption, consumption growth, hours worked and effort. Whenever the workers and firms are not allowed to choose the wage optimally, they choose to index 18 percent of the wage to one quarter lagged wage inflation and 82 percent to the inflation target adjusted for the growth rate of labour productivity. These assumptions imply that part of wage inflation is driven by past wage inflation and the inflation target, and part by the changes in wages performed by those workers choosing their wage optimally. Moreover, the introduction of "sticky" nominal wages plays a crucial role in creating business cycles in the model, while at the same time allowing monetary policy to influence real variables such as GDP in the short run (monetary policy non-neutrality).

Using the previous assumptions and those made for the workers' preferences for consumption and leisure, the following equation describing the wage inflation dynamics can be derived:

$$\widehat{\pi}_{w,t} = (1-\gamma_w)(\overline{\pi}+a)+\gamma_w\widehat{\pi}_{w,t-1} - \frac{\eta}{\eta+\epsilon_w}\frac{1-\theta_w}{\theta_w}\frac{1-\beta\theta_w}{1+\beta\gamma_w}\left\{\widehat{w}_t - \widehat{mrs}_t\right\} + u_{w,t} \quad (7)$$

where $\widehat{\pi}_{w,t}$ is the wage inflation, $\widehat{w}_t$ is the average real wage, $\widehat{mrs}_t$ is the "desired" real wage and $u_{w,t}$ is an exogenous shock to wages, which can be interpreted as a shock to worker's market power or their preference for leisure. The parameters that appear in this equation are the following: γ_w is the degree of indexation, $\overline{\pi}$ is the inflation target, a is the growth rate of productivity, ϵ_w is the elasticity of substitution among labor types, θ_w is the probability of not resetting optimally the wages and β is the discount factor. Notice the presence of the gap between the average real wage and the desired wage as one of the driving forces of wage inflation. This gap arises because the nominal wages of all workers are not optimally reset every period. Given that the coefficient next to this gap is negative, it can be seen that whenever the average wage is below the desired wage, there is a upward pressure on wage inflation. The reason for this is the following: in this situation workers would like to increase their salaries to match the desired wage, thus generating positive wage inflation. The degree of influence of this gap on wage inflation depends positively on the labor supply elasticity, and negatively on the degree of labor market competitiveness and the degree of nominal wage rigidities.

The desired wage is simply the average marginal rate of substitution between consumption and leisure. It is given by:

$$\widehat{mrs}_t = \widehat{C}_t + \frac{\xi}{1-\xi}\Delta\widehat{C}_t + \frac{1+\eta}{\eta}E_t + \frac{1}{\eta}\widehat{H}_t$$

where E_t denotes effort and $\widehat{H}_t$ denotes hours worked.

In determining the desired real wage of households, the assumption that both consumption and leisure are valued by households implies that, when negotiating their wage, they will consider both their current consumption level and the number of hours they are working. All else being equal, higher consumption or higher labour input (either hours worked or effort) will cause households to demand a higher real wage. The former effect occurs because a high consumption level makes leisure relatively more valuable. Thus, the only way to persuade the household to continue working the same number of hours is to offer a higher real wage. Finally, notice that the consumption growth also affects the desired wage due to the existence of habit persistence in the model.

2.3 Firms

Regarding the set of firms in the model, it contains four manufacturing firms of four distinct finished products: consumption goods and services, investment goods, government goods, and export goods. The relative import concentration distinguishes these goods in steady state. Each type of firm combines capital services, labour, commodities, and imports to produce a finished good. Firms choose the optimal mix of inputs by minimizing the total cost of production subject to the production technology, which is characterized by constant elasticity of substitution. Variable capital utilization is possible, but comes at a cost in terms of foregone production; and changes in capital and investment are subject to quadratic adjustment costs. Variable capital utilization smooths the response of marginal cost to movements in production, while adjustment costs on investment allow the model to produce a gradual response of investment to movements in the cost of capital.

In place of the conventional capital rental market assumption, in which capital can be costly reallocated across firms, we assume that capital is firm-specific. In the more typical model of perfect capital mobility, a firm's marginal cost is invariant to the level of demand for its good. By contrast, when capital is owned by the firm and quasi-fixed in the short run, firm-level marginal cost is increasing in its output. Overall, the assumption of firm-specific capital reduces the sensitivity of prices to marginal cost, thereby making the model's predictions consistent with the observed sensitivity of aggregate inflation to demand conditions while at the same time allowing for average price contract durations that accord with micro survey evidence.

In addition to choosing the optimal mix of inputs, firms set a price for their product with the goal of maximizing the net present value of expected profits. The discount rate that firms use is a weighted average of the short- and long-term rates that they face. These rates are analogous to the ones faced by households but with possibly different spreads.

Under the assumption that the elasticity of demand for any particular firm's product is constant, profit maximization corresponds to choosing a price that is a constant markup over marginal cost.[12] However, as with nominal wages, prices are costly for the firm to be fully reoptimized, and therefore firms do so infrequently, and in a staggered fashion. In the model, firms fully reoptimize prices once every three quarters, on average. Those firms that cannot reoptimize follow an indexation rule that update prices according to a weighted average of one lag inflation and the current period expectation of the inflation target.

The equation for core CPI, investment price inflation, government price inflation, and export price inflation all take the following form:

$$\begin{aligned}\widehat{\pi}_t^i &= \frac{\gamma_p}{1+\beta\gamma}\left(\widehat{\pi}_{t-1}^i - \Delta\mathbf{E}_t\overline{\pi}_t\right) + \frac{\beta}{1+\beta\gamma_p}\mathbf{E}_t\widehat{\pi}_{t+1}^i \\ &\quad +\zeta\frac{(1-\theta)(1-\theta\beta)}{\theta\left(1+\beta\gamma_p\right)}\widehat{rmc}_t^i + \varepsilon_t^{pi}, \end{aligned} \tag{8}$$

where i is the sector, $\widehat{\pi}_t^i$ is the difference between actual inflation in sector i and the expected inflation target $\mathbf{E}_t\overline{\pi}_t$. The parameter γ_p measures the degree of indexation to lagged inflation in sector i and reflects the degree of persistence in that measure of inflation after accounting for shifts in the perceived inflation target and persistence in marginal cost. The parameter ζ is governed by the assumption regarding the structure of the capital market. If capital is assumed to be freely tradable among firms in each period, then $\zeta = 1$. If, on the other hand, we make the arguably more plausible assumption that capital is firm owned, specific to that firm, and costly to adjust, then $0 < \zeta < 1$ (Woodford 2005). ζ is a highly non-linear function of several of the model's key structural parameters and is solved for numerically. Finally, the parameter θ measures the probability of not-reoptimizing prices.

Imports are treated as inputs to production, rather than as separate final goods.

[12] As in the labour market, the goods market is assumed to be characterized by imperfect competition, which implies that firms have some power to choose a price that differs from the price of their competitors and still remain in business. Marginal cost refers to the cost to the firm of producing one additional unit of output.

An importing firm buys goods from the foreign economy according to the law of one price, and sells them to manufacturing firms at a price that is also adjusted only periodically. Thus, movements in exchange rates or foreign prices are not fully reflected immediately in the price paid by domestic producers. Furthermore, since the prices of both imported inputs and finished products are sticky, the model includes an element of vertical or supply-chain price staggering, which is crucial in allowing the model to generate realistic exchange rate pass-through to the CPI.

The model also contains a separate commodity-producing sector. Commodities are either used in the production of finished products, purchased directly by households as a separate consumption good, or exported on world markets. The law of one price is assumed to hold for exported commodities, whereas temporary deviations from the law of one price are permitted for commodities that are purchased domestically.

2.4 Monetary Policy

The central bank in the model wishes to maximize the well-being of consumers by minimizing deviations of inflation from the target and output from potential, as well as the variability of interest rates. This optimization problem that the central bank solves is constrained by the structure of the economy and by implementing policy using a standard inflation-forecast based interest rate rule augmented with interest rate smoothing.[13] In particular, the central bank implements its policy by using the following rule:

$$\widehat{i_t^{pol}} = \Theta_R \widehat{i_{t-1}^{pol}} + (1 - \Theta_R)[\overline{r} + \overline{\pi} + \Theta_\pi(\mathbf{E}_t \pi_{t+h}^c - \overline{\pi}) + \Theta_x x_t] \tag{9}$$

where $\overline{r}$ is the steady state real interest rate, $\overline{\pi}$ is the inflation target, π_t^c is the core inflation and x_t is the output gap. The coefficients $\Theta_R, \Theta_\pi, \Theta_y, h$ are chosen to maximize the objective function of the central bank, conditional on the structure of the model and the covariance matrix of structural shocks, which are calculated for the period 1992-2005.

[13] See Cayen et al (2006) for more details.

2.5 Fiscal Policy

The government levies direct and indirect taxes and then spends or transfers to consumers the proceeds of these taxes according to a set of rules that are consistent with achieving a pre-specified ratio of debt to GDP over the medium term.

3 Model Calibration

In this section, we discuss the calibration of the main parameters of the model.[14] We first focus on the parameters associated with nominal price and wage rigidities in the model. The parameter γ_p, which determines the extent to which non-reoptimizing manufacturing firms can index to lagged inflation, is set to 0.18 ($\gamma \in [0, 1]$). This value is somewhat lower than the 0.4 reported in Amano and Murchison (2005). It was chosen primarily to help the model replicate the moderate level of inflation persistence estimated in the data from 1980-2004. Inflation in ToTEM inherits a substantial amount of persistence from real marginal cost, and therefore a high degree of indexation is not required. This setting suggests that the weight on the forward-looking component is quantitatively more important than is the weight on lagged inflation (0.8 versus 0.2). The parameter θ, which determines the proportion of manufacturing firms that are not chosen to reoptimize every period, is 0.7, implying that domestic price contracts are re-optimized, on average, once every three quarters.

For wages, the degree of indexation, γ_w, is 0.18 and the probability of not being picked to reset, θ_w, is 0.85, meaning that wages are reoptimized about every 6.5 quarters, on average. Thus, the main source of nominal rigidity in ToTEM is sticky wages, consistent with the survey evidence presented in Amirault, Kwan, and Wilkinson (2006) for prices, and in Longworth (2002) for wages.

Given the calibrations of the adjustment-cost parameters for capital, investment, and capital utilization, as well as the elasticities of substitution in production, the hazard rate θ, and the elasticity of substitution between finished goods, ζ is equal to 0.25, meaning that aggregate CPIX inflation is four-times less sensitive to real marginal cost than if we were to assume a homogeneous capital market.

[14] See Murchison and Rennison (2006) for a more detailed description of the model calibration.

Taken together, θ and ζ suggest a short-run elasticity of inflation with respect to a real marginal cost of 0.03, which lies between the value of 0.04 reported for the United States in Altig et al (2004), and the value of 0.02 reported for Canada in Gagnon and Khan (2005).[15] Much of the persistence of inflation in ToTEM is generated by the assumption of firm-specific capital that is costly to adjust, in conjunction with a small amount of nominal rigidity in the goods sectors, rather than by nominal rigidities alone.

Household consumption depends positively on lagged consumption according to the habit-persistence parameter, ξ, which we set to 0.65, as in Christiano, Eichenbaun and Evans (2005). We set the intertemporal elasticity of substitution, μ, to 0.9, within the range of 0.5 to 1 made in much of the literature on real business cycles, while the wage elasticity of labour supply, η, is set equal to 0.6. We estimate the parameter γ and find a value of 0.4. This estimate indicates a non-trivial role for long-term rates to explain the evolution of consumption. The share of "current-income" consumers is equal to 20 per cent, which allows the model to generate a reasonable impact of government debt shocks on output.

Finally, the parameters for the optimized inflation-forecast monetary policy rule are given as $\{\Theta_R = 0.95, \Theta_\pi = 20, \Theta_y = 0.35, h = 2\}$, with the short-run response coefficients given as $(1 - \Theta_R)\,\Theta_\pi = 1$ and $(1 - \Theta_R)\,\Theta_y = 0.02$. It is interesting to note the high value for the smoothing parameter $\Theta_R = 0.95$, which is optimized over the range $\Theta_R \in [0, 1)$. This reflects a combination of the crucial role played by the expectations of future outcomes in the model and an assumed desire on the part of the monetary authority in the model to reduce unnecessary instrument volatility. Essentially, because the model is so forward looking, monetary policy can achieve nearly the same output/inflation outcome in response to a shock by moving interest rates by a great deal for a short period of time or by a lesser amount for a long period of time. Given the presence of ΔR_t in the loss function, the latter is the preferred outcome.

[15] These authors also assume CES production with an elasticity of substitution of 0.5 when computing real marginal cost.

4 Policy Experiments

In this section, we explain how we design the policy experiments to evaluate: i) an increase of a 1-percentage point in the bank capital ratio and ii) an increase of 25 per cent in the liquid asset ratio.

Each of the proposals are evaluated under different assumptions about the implementation period (two and four years) and the response of monetary policy (endogenous versus no response of monetary policy). Different implementation periods are evaluated in order to assess how rapidly the new requirements can be achieved without causing a quantitatively important output loss. For each of the implementation periods analyzed, it is assumed that the reform is smoothly implemented with an equal increase of the capital and liquid assets ratios period by period until they reach their permanent level. For modelling purposes, the start date for the simulation exercise is set at the first quarter of 2011 and the end point at the fourth quarter of 2018.

Given that the modified version of ToTEM does not directly incorporate banking sectors, we follow the two step approach proposed by the Macroeconomic Assessment Group of the BIS. First, we estimate the impact of higher capital and liquidity requirements on interest-rate spreads using satellite models.[16] Table 1 presents the impact on interest-rate spreads implied by the changes in the capital and liquid asset ratios for the different implementation period scenarios. Second, both the short- and long-term spreads faced by households and firms are assumed to follow the forecast paths found in step 1 in order to conduct the different simulations.

Regarding monetary policy, the main motivation for studying an endogenous response is that it is very likely that monetary policy will react to the tighter regulation in order to dampen its effects on inflation and output. The case in which monetary policy does not react is evaluated to assess the direct effects of regulation. Moreover, the evaluation of this case can be useful to explore the possibility that the policy rate cannot be reduced because it is at the effective zero

[16] The satellite models have been estimated by the Financial Stability Department of the Bank of Canada using the protocol in the MAG report. The description of the methodology used for this purpose is described in Annex 1 of the report "Strengthening International Capital and Liquidity Standards: A Macroeconomic Impact Assessment for Canada"

Table 1
Impact on Interest Rate Spreads of Regulatory Policies
(Measured in basis points)

Scenario	2013:01	2015:01	2017:01	2018:04
Capital target increases 1 percentage point				
over 2 years	12.18	14.03	14.04	14.04
over 4 years	6.09	13.10	14.03	14.04
over 6 years	4.06	8.74	13.41	14.03
Liquidity ratio increases 25 percent				
over 2 years	12.86	14.84	14.85	14.85
over 4 years	6.43	13.85	14.85	14.85
over 6 years	4.29	9.23	14.18	14.85

lower bound.[17]

5 Results

In this section, we discuss the results for the following regulatory measures: i) the capital ratio increases 1-percentage point over four years and ii)the liquid asset ratio increases 25 per cent over four years. We focus the discussion only on this implementation period because the results are qualitatively similar to those found when the implementation period is two years.[18] Quantitatively, we find that a longer implementation period reduces the impact on the macroeconomic variables. For each of the regulatory measures, we explore the impact under the two alternative monetary policies mentioned before. It is worth mentioning that these results do not take into account potential effects of a global tightening of regulatory requirements.

[17]Even if the policy rate is at the zero lower bound, a central bank could adopt unconventional monetary policy measures to dampen the macroeconomic impact of tighter regulation.

[18]Results when the implementation period is 2 years are presented in Appendix A of this paper.

5.1 Scenario 1: An increase of 1-percentage point in Capital Ratio and Endogenous Monetary Policy

The increase in the capital ratio generates an increase in the spreads of the short- and long-term interest rates faced by households and firms. According to the satellite models, an increase of 1-percentage point in the capital ratio leads to an increase in the spreads of 14 basis points in the long run as banks adjust their lending behavior.

Table 2 present the impact of 1-percentage point increase in the capital ratio on output, consumption, investment, exports, imports, the policy rate and inflation.

Table 2

IMPACT OF A 1 PERCENTAGE POINT INCREASE IN CAPITAL RATIO

Implementation period: 4 years ; Monetary Policy: Endogenous

	2013:01	2015:01	2017:01	2018:04
Output	-0.15	-0.25	-0.28	-0.26
Consumption	-0.56	-0.67	-0.59	-0.43
Investment	-0.61	-0.65	-0.49	-0.30
Exports	0.61	0.39	0.22	0.09
Imports	-0.36	-0.54	-0.43	-0.26
Policy Rate	-0.02	-0.02	-0.05	-0.06
Inflation	0.01	0.00	0.00	0.00

Notes:
1) The interest rate is expressed in annual terms.
2) The inflation rate is measured year over year.
3) All the variables are expressed in percentage points deviations from baseline.

The increase in the spreads causes an increase in the effective interest rates faced by households. The latter gives households an incentive to postpone consumption. This causes a decrease in the demand for consumption goods of 0.67 per cent, relative to its baseline level four years after the start of the implementation.

The increase in spreads affects investment through two alternative channels. First, the effective rate at which firms discount future real profits increases, which means that the net present value of future profits is reduced; and consequently, the demand for investment is reduced. Second, the reduction in consumption reduces the demand for capital by firms that produce consumption goods. These two effects lead to a decline in investment of 0.65 percentage points below its baseline level after four years.

In this scenario, monetary policy reacts by cutting the policy rate in order to stabilize inflation and the output gap. Inflation is back to the target four years after the start of the implementation. It is important to note that during this simulation, the policy rate never hits the zero lower bound, which implies that the reaction of monetary policy is feasible. In particular, the maximum decrease of the policy rate is 6 basis points and takes place at the end of the simulation.

On the trade side, the reduction in the policy rate generates a real exchange rate depreciation that makes Canadian manufactured and commodity exports cheaper for the rest of the world. This leads to an increase of exports by 0.39 percentage points four years after the implementation. Moreover, the real depreciation of the Canadian dollar, combined with the decrease in the demand for finished consumption and investment goods, causes a decrease of imports by 0.54 percentage points.

The decrease in consumption and investment, partially offset by the increase of net exports, leads to a decrease of 0.25 percentage points in GDP below baseline four years after the beginning of implementation.

5.2 Scenario 2: An increase of 1-percentage points in Capital Ratio without a response of Monetary Policy

Table 3 presents the results for this scenario, in which monetary policy keeps the policy rate constant and does not act to mitigate the effects of the regulatory reform.[19] The anticipation of the negative impact of the increase in spreads on economic activity and inflation creates disinflationary expectations in the absence of a stabilizing response of monetary policy. This implies that the effective real interest rate is higher than that in Scenario 1.

[19] Policy normally reacts to anything that affects expected inflation or the output gap. For this reason, we assume that agents expect a policy response and are surprised when it does not materialize.

Table 3
IMPACT OF A 1 PERCENTAGE POINT INCREASE IN CAPITAL RATIO
Implementation period: 4 years ; Monetary Policy: Exogenous

	2013:01	2015:01	2017:01	2018:04
Output	-0.18	-0.27	-0.31	-0.30
Consumption	-0.57	-0.66	-0.58	-0.41
Investment	-0.63	-0.65	-0.49	-0.30
Exports	0.49	0.32	0.09	-0.12
Imports	-0.41	-0.53	-0.45	-0.29
Policy Rate	0.00	0.00	0.00	0.00
Inflation	-0.01	-0.01	-0.03	-0.04

Notes:
1) The inflation rate is measured year over year.
2) All the variables are expressed in percentage points deviations from baseline.

The impact on GDP of the higher real rate in this scenario is slightly negative. In particular, GDP after four years is lower by 0.02 percentage points than the one in Scenario 1. This comes mainly from the lower level of exports (0.07 percentage points lower than in Scenario 1). The lower level of exports is driven by a relatively stronger real exchange rate due to the higher real interest rate in this scenario. It is worth mentioning that consumption slightly increases in this scenario. In order to understand why, it is convenient to notice that not only the level of real interest rate matters for consumption decisions but also the path of real interest rate. In this scenario, the real interest rate is higher but the path of real interest rates is increasing over time. If households expect higher real interest rates in the future, they have an incentive to shift forward consumption. In this simulation, this effect is bigger than the effect of the higher level. This explains why consumption slightly increases. Investment is roughly the same in this scenario because the higher investment demand of the consumption sector is compensated by the lower investment demand of the export sector.

5.3 A 25 per cent increase in the Liquid Asset Ratio under different monetary policies.

The increase in the liquid asset ratio translates into wider interest-rate spreads faced by households and firms. According to the satellite models, an increase of 25 per cent in the liquid asset ratio results in an increase of 15 basis points in spreads in the long run. This magnitude is roughly speaking equal to the impact of stronger capital requirements on spreads. Given that the impact of stronger liquidity requirements has been estimated by translating higher liquid asset holdings into an increase in interest-rate spreads, the estimated macroeconomic impact of stronger liquidity requirements is qualitatively similar to the one of tighter capital requirements. For this reason, in this section we only present the quantitative results. Tables 4 and 5 show the result for an increase of 25 per cent in the liquid asset ratio when monetary policy is endogenous and exogenous respectively.

Table 4

IMPACT OF 25 PERCENT INCREASE IN LIQUID ASSETS RATIO

Implementation period: 4 years ; Monetary Policy: Endogenous

	2013:01	2015:01	2017:01	2018:04
Output	-0.16	-0.27	-0.29	-0.27
Consumption	-0.60	-0.71	-0.62	-0.46
Investment	-0.63	-0.67	-0.52	-0.32
Exports	0.64	0.42	0.24	0.10
Imports	-0.38	-0.57	-0.45	-0.28
Policy Rate	-0.02	-0.02	-0.05	-0.06
Inflation	0.01	0.00	0.00	0.00

Notes:
1) The interest rate is expressed in annual terms.
2) The inflation rate is measured year over year.
3) All the variables are expressed in percentage points deviations from baseline.

Table 5
IMPACT OF 25 PERCENT INCREASE IN LIQUID ASSETS RATIO
Implementation period: 4 years ; Monetary Policy: Exogenous

	2013:01	2015:01	2017:01	2018:04
Output	-0.19	-0.29	-0.32	-0.31
Consumption	-0.60	-0.69	-0.61	-0.43
Investment	-0.64	-0.66	-0.51	-0.32
Exports	0.52	0.32	0.10	-0.12
Imports	-0.42	-0.56	-0.47	-0.31
Policy Rate	0.00	0.00	0.00	0.00
Inflation	-0.01	-0.01	-0.03	-0.04

Notes:
1) The inflation rate is measured year over year.
2) All the variables are expressed in percentage points deviations from baseline.

6 Regulatory Proposals and their Potential Impact on Lending Volumes

Among various consequences of the regulatory reforms, one possibility is that they can affect negatively the economic activity through lower lending volumes (credit rationing). The idea is that in order to meet the stronger capital and liquidity requirements, banks could tighten the flow of credit to households and firms; and therefore, consumption and investment would be reduced.

Since credit constraints are not explicitly modeled in ToTEM, we follow the approach proposed by MAG. In particular, we assess the impact of lending volumes on the residuals in the consumption and investment equations. The idea behind this strategy is that lending volume (or credit rationing) is a missing variable in those equations. Therefore, the residuals there should have some statistical relationship with the credit. We regress the historical residual in the investment equation of ToTEM on business credit growth data and the historical residual in the consumption equation of ToTEM on households credit growth data. Using the estimated relationships, we quantify the implied disturbances to investment and consumption, given the projected credit volume changes induced by the implementation of the higher capital requirements. We then introduce these implied disturbances over the simulation sample to provide the impact of credit quantity constraints on the key macro variables.

Table 10 in the Appendix A of this paper reports the impact of lower lending volumes when 1-percentage point increase of capital requirement is implemented over four years and monetary policy endogenously reacts. The impact on GDP is basically null. Given this result, we conjecture that higher capital requirements would not be affecting the Canadian economic activity through lower lending volumes.

7 Concluding Remarks

This paper studies the macroeconomic impact of changes in bank capital and liquidity requirements by following the two-step approach proposed by the Macroeconomic Assessment Group of the BIS. First, we use satellite models to measure the impact of the regulatory policies on interest-rate spreads. Second, we use these results to assign a path for the spreads and conduct simulations using a modified version of the Bank of Canada's main projection and policy analysis model, ToTEM. Our results suggest that a 1-percentage point increase in the bank capital ratio implemented over four years will cause a decline in output of 0.26 percentage points eight years after the start of the implementation of the increase. Changes in the liquidity requirements yield very similar quantitative results.

There are two issues that have not been explored in this paper regarding the transmission of the regulatory proposals on economic activity. These issues can affect our estimates of the output losses associated with the regulatory proposals. First, the possibility of a global tightening of regulatory requirements could amplify the effects of the regulatory requirements in Canada. The analysis presented in our paper assumes that conditions in the rest of the world are fixed. An analysis performed by de Resende et al (2010) quantifies the effects of global tightening of regulatory requirements for Canada using the BoC-GEM-FIN model. In their model, higher capital ratios in the rest of the world affect Canadian economic activity through both higher costs that domestic firms face when borrowing from foreign banks and the negative effect of the fall in output in the rest of the world. They find that tighter regulatory requirements in the rest of the world increase the impact of a 1-percentage point increase in the capital ratio by 0.05 percentage points (in the case in which the increase in capital is implemented over four years and monetary policy endogenously reacts).

Finally, the availability of alternative sources of financing for non-financial corporations may weaken the impact of changes in the banking sector on economic activity. In this paper, we have assumed that the higher spreads will be passed on to all borrowers. However, large corporate firms could have the scope to obtain their funding from non-banking sources at a lower cost.

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Appendix

Table 6

IMPACT OF A 1 PERCENTAGE POINT INCREASE IN CAPITAL RATIO

Implementation period: 2 years ; Monetary Policy: Endogenous

	2013:01	2015:01	2017:01	2018:04
Output	-0.17	-0.28	-0.29	-0.25
Consumption	-0.66	-0.73	-0.57	-0.40
Investment	-0.65	-0.68	-0.50	-0.28
Exports	0.73	0.43	0.17	0.06
Imports	-0.41	-0.59	-0.43	-0.23
Policy Rate	-0.03	-0.02	-0.05	-0.07
Inflation	0.01	0.01	0.00	0.00

Notes:
1) The interest rate is expressed in annual terms.
2) The inflation rate is measured year over year.
3) All the variables are expressed in percentage points deviations from baseline.

Table 7

IMPACT OF A 1 PERCENTAGE POINT INCREASE IN CAPITAL RATIO

Implementation period: 2 years ; Monetary Policy: Exogenous

	2013:01	2015:01	2017:01	2018:04
Output	-0.20	-0.30	-0.32	-0.30
Consumption	-0.67	-0.72	-0.55	-0.37
Investment	-0.67	-0.69	-0.49	-0.28
Exports	0.60	0.33	0.03	-0.17
Imports	-0.45	-0.59	-0.44	-0.26
Policy Rate	0.00	0.00	0.00	0.00
Inflation	-0.01	-0.01	-0.03	-0.05

Notes:
1) The inflation rate is measured year over year.
2) All the variables are expressed in percentage points deviations from baseline.

Table 8

IMPACT OF 25 PERCENT INCREASE IN LIQUID ASSETS RATIO

Implementation period: 2 years ; Monetary Policy: Endogenous

	2013:01	2015:01	2017:01	2018:04
Output	-0.18	-0.29	-0.30	-0.26
Consumption	-0.70	-0.78	-0.60	-0.42
Investment	-0.67	-0.71	-0.52	-0.29
Exports	0.77	0.45	0.18	0.07
Imports	-0.43	-0.62	-0.45	-0.24
Policy Rate	-0.03	-0.02	-0.05	-0.07
Inflation	0.01	0.00	0.00	0.00

Notes:
1) The interest rate is expressed in annual terms.
2) The inflation rate is measured year over year.
3) All the variables are expressed in percentage points deviations from baseline.

Table 9
IMPACT OF 25 PERCENT INCREASE IN LIQUID ASSETS RATIO
Implementation period: 2 years ; Monetary Policy: Exogenous

	2013:01	2015:01	2017:01	2018:04
Output	-0.21	-0.31	-0.33	-0.31
Consumption	-0.71	-0.76	-0.58	-0.39
Investment	-0.69	-0.71	-0.51	-0.29
Exports	0.64	0.35	0.03	-0.17
Imports	-0.48	-0.62	-0.46	-0.27
Policy Rate	0.00	0.00	0.00	0.00
Inflation	-0.01	-0.01	-0.03	-0.05

Notes:
1) The inflation rate is measured year over year.
2) All the variables are expressed in percentage points deviations from baseline.

Table 10
IMPACT OF A 1 PERCENTAGE POINT INCREASE IN CAPITAL RATIO
Implementation period: 4 years ; Monetary Policy: Endogenous
Lending Volume Approach

	2013:01	2015:01	2017:01	2018:04
Output	-0.01	0.00	0.00	0.00
Consumption	-0.03	0.00	0.01	0.01
Investment	-0.01	-0.02	-0.02	-0.01
Exports	0.03	-0.01	-0.01	-0.01
Imports	-0.01	0.00	0.00	0.00
Policy Rate	0.00	0.00	0.00	0.00
Inflation	0.00	0.00	0.00	0.00

Notes:
1) The interest rate is expressed in annual terms.
2) The inflation rate is measured year over year.
3) All the variables are expressed in percentage points deviations from baseline.