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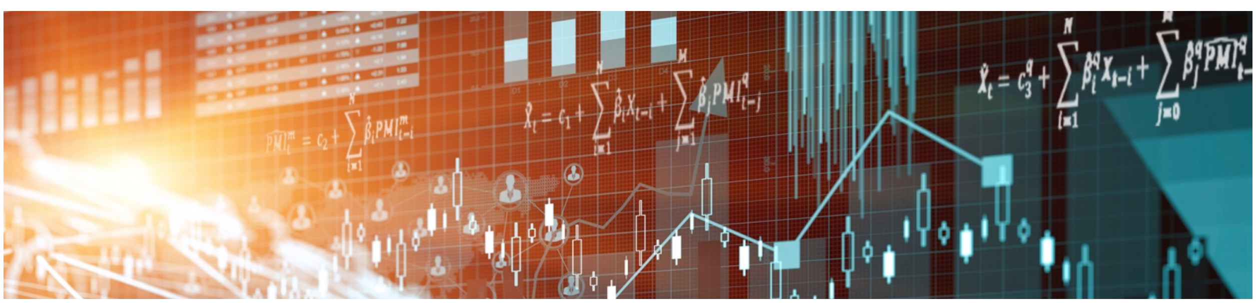
Implementing Cross-Border Interbank Lending in BoC-GEM-FIN



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Implementing Cross-Border Interbank Lending in BoC-GEM-FIN

by

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Abstract

BIS interbank lending data show that the Great Recession generated large and persistent changes in the international interbank lending positions of various countries. The main objective of this study is to understand the role of changes in international interbank credit flows in transmitting shocks across borders. To accomplish this task, we needed a global structural model with an international interbank market. Our search for a suitable structural model revealed that the Bank of Canada version of the global economy model (BoC-GEM-FIN) comes closest to our needs. BoC-GEM-FIN includes region-specific interbank markets, as well as some international borrowing and lending, but abstracts from the international interbank lending. This paper describes the modifications we made in order to introduce the international interbank market into BoC-GEM-FIN. The modified model is calibrated to match the changes in international interbank lending positions and the decline in the business lending of US banks that took place after the fourth quarter of 2008. Our simulations show that the international interbank market amplifies spillover effects of demand shocks but does not systematically alter the effects of supply shocks, including those for commodities.

Bank topic(s): Economic models; International topics; Business fluctuations and cycles
JEL code(s): E27, E37, F47

Résumé

Les données de la Banque des Règlements Internationaux relatives au financement interbancaire montrent que la Grande Récession a changé considérablement et durablement les positions de financement interbancaire internationales de plusieurs pays. La présente étude a pour principal objectif de comprendre l’incidence des changements de flux de crédit interbancaires internationaux sur la transmission transfrontière des chocs. Ainsi, il nous fallait un modèle structurel mondial intégrant un marché interbancaire international. Nous avons trouvé que la version du modèle économique mondial de la Banque du Canada – soit le modèle BoC-GEM-FIN – répondait le mieux à nos besoins. Ce modèle tient compte de marchés interbancaires propres à une région ainsi que de certaines activités internationales d’emprunt et de prêt, mais fait abstraction du financement interbancaire international. Dans les lignes qui suivent, nous décrivons les modifications que nous avons apportées au modèle BoC-GEM-FIN pour y intégrer le marché interbancaire international. Nous avons calibré le modèle modifié pour faire correspondre les changements de positions de financement interbancaire internationales à la diminution du nombre de prêts consentis aux entreprises par les banques américaines qui est survenue après le quatrième trimestre de 2008. D’après nos simulations, le marché interbancaire international amplifie les effets de débordement des chocs de demande, mais ne modifie pas systématiquement les effets des chocs d’offre ni ceux des chocs liés aux produits de base.

Sujet(s) : Modèles économiques; Questions internationales; Cycles et fluctuations économiques
Code(s) JEL : E27, E37, F47

1 Introduction

The recent global economic crisis serves as a forceful reminder that financial and macroeconomic shocks originating in one country can be transmitted to other economies through financial markets and international transactions. What started in 2007 as a subprime credit market shock in the United States became a deep global recession that spread quickly to other advanced and developing economies, causing financial turmoil, elevating national debt burdens, and increasing unemployment in part because of the interconnectedness of financial markets.

The global economy is still going through a painful rebalancing and adjustment process. The recent European debt crisis shows how difficult it can be to resolve debt problems in a group of countries linked through international money and credit markets and bound by a common monetary policy. Creditors became less willing to lend to banks with loans of uncertain quality on their balance sheets and, at times, even banks with strong balance sheets had difficulties obtaining interbank loans, particularly in Spain, Portugal and Greece. But the interbank lending problems were not limited to Europe. Our analysis of BIS interbank lending data shows that the Great Recession also had a profound effect on international interbank lending to other regions. For example, net interbank lending to US banks from international banks declined by about 11 per cent of US GDP between 2008Q4 and 2011Q4. This decline is likely a reflection of lower levels of confidence in the US financial system. For other countries as well, there were large and persistent changes in their international interbank lending positions.

Figure 1 shows the ratio of net interbank lending to GDP for Canada, the United States and the European region. As indicated by the signs of net flows, Canada and Europe are net lenders, while the United States is a net borrower in the cross-border interbank lending market. The yellow line in Figure 1 shows that bank lending from Europe to banks in other regions declined by approximately 8 per cent of Europe's GDP after 2007Q4. In contrast, the blue line shows a substantial rise in interbank loans from Canada to other re-

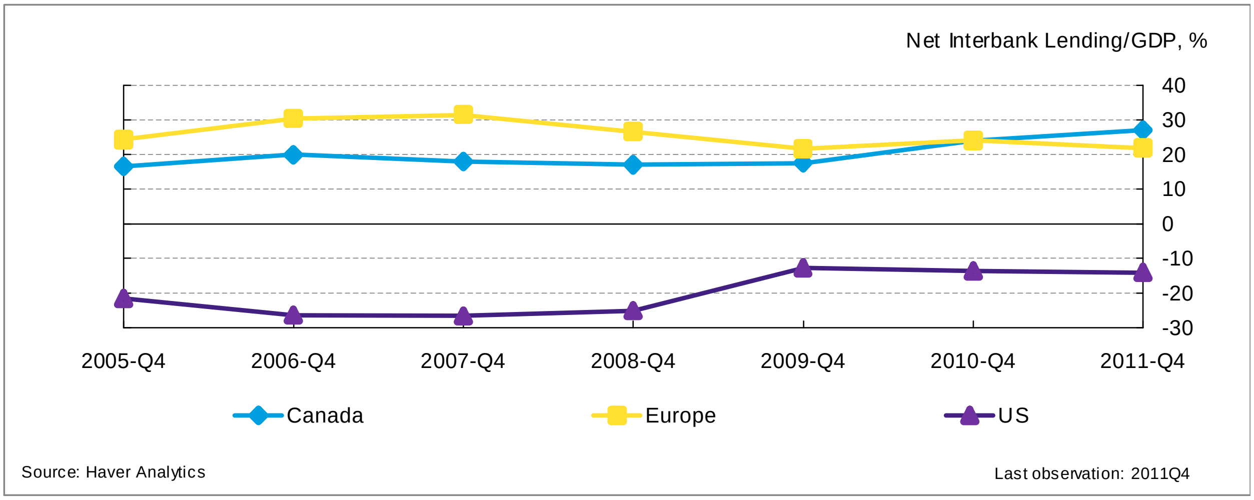

Figure 1: International interbank lending positions relative to respective GDPs

gions, which increased by roughly 7 per cent of Canadian GDP after 2008Q4. As mentioned, the net lending to US banks declined markedly by about 11 per cent of US GDP between 2008Q4 and 2011Q4, as can be seen from the purple line.

These large changes in international interbank lending were likely important contributors to cross-country macroeconomic adjustments.[1] For example, the fall in international interbank lending to US banks closely matches the decline in US banks' total lending by 11 per cent of US GDP between 2008Q4 and 2011Q4. Figure 2 shows that the large fall in US banks' lending took place despite a substantial concurrent increase in US personal deposits.

The main objective of this study is to understand the role changes in international interbank lending plays in transmitting shocks across borders. To accomplish this task, we needed a structural model of the global economy with an international interbank market. Our search for a suitable model revealed that, among a few global structural models with interregional trade and financial links, the Bank of Canada's version of the Global Economy Model, BoC-GEM-FIN (henceforth simply BGF), is the only one that allows for an active, though region-specific, interbank market facilitating borrowing and lending among heterogeneous banks from the same region. Other global models, such as the IMF's Global Integrated Monetary and Fiscal Model (GIMF), do not focus on bank heterogeneity or on interbank

[1] See Terajima et al. (2010) for more details about international lending during the latest financial crisis.

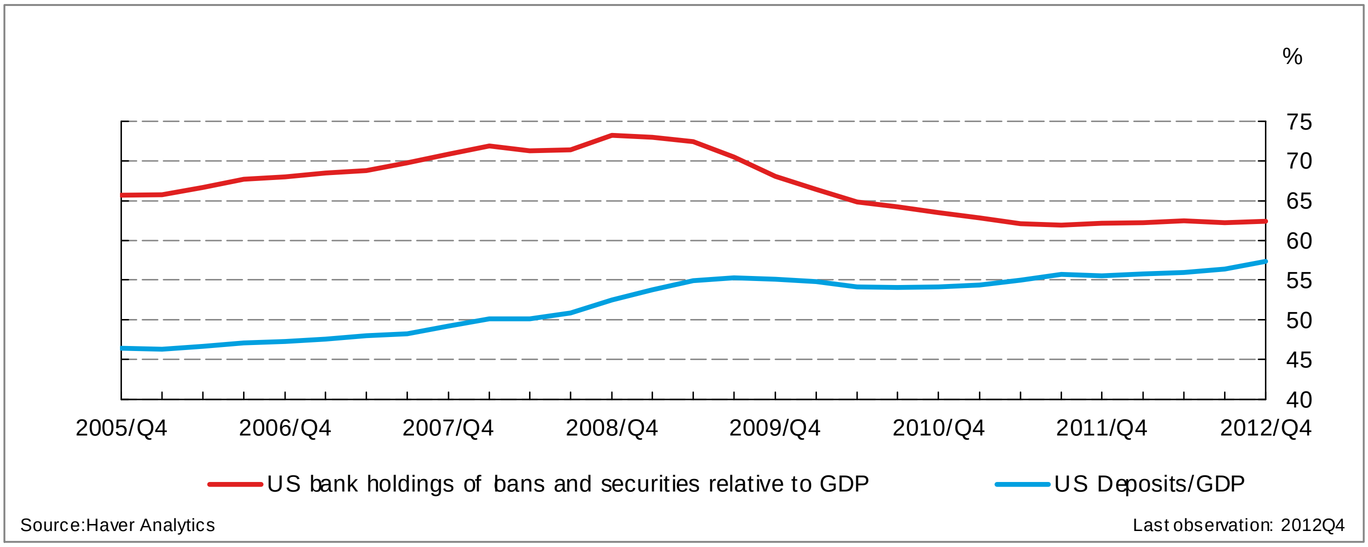

Figure 2: Personal US deposits and banks' loans plus securities relative to GDP

loans. Despite being the model that best met our needs, BGF still required substantial modifications because it did not allow for international interbank borrowing or lending. Enhancing the BGF model by adding a cross-border interbank market provided an appropriate tool for studying the propagation of shocks through international credit market channels.

BGF is a multi-region, multi-sector global economy model. The model has five regions:

- Canada (CA)
- United States (US)
- Commodity Exporters (CX), which is largely represented by the OPEC countries, Russia, Norway and Australia
- Emerging Asia (AS), which includes China, India and other emerging Asian economies
- Remaining Countries (RC), which is effectively represented by Europe and Japan[2]

BGF has two types of optimizing households: forward-looking and liquidity-constrained. There are three levels of production in the model: primary goods production of commodities

[2]See R.Lalonde and D.Muir, Bank of Canada Technical Report No. 98, for precise definitions of the regions.

and oil, production of intermediate goods, and final goods production. Both primary and intermediate goods are traded among regions. The model has fiscal and monetary authorities as well as a banking sector, which includes both deposit-taking and lending banks.[3] The deposit-taking banks lend to lending banks of the same region through region-specific interbank markets.

The size of the model and its complexity created a major challenge for us. We needed to calibrate the new parts of the model in a meaningful way without distorting the model's dynamic responses to shocks, such as commodity price shocks, which have been carefully calibrated in BGF. The modified model is calibrated using changes in international interbank lending positions, and the decline in business lending by US banks that took place after 2008Q4. The effects of the new model features are then evaluated in a series of simulations. These simulations show that the international interbank market amplifies the spillover effects of demand shocks. The effects of supply shocks did not change in a systematic fashion. The effects of commodity shocks remained essentially intact.

Interestingly, the amplification effects of monetary policy shocks on AS depended crucially on the region generating these shocks in the modified model. The effects of US monetary policy shocks on AS were moderated relative to those in the original BGF model, while monetary policy shocks originating in other regions were amplified. We traced the difference in amplification effects to AS monetary policy, which is assumed to follow an exchange rate target relative to the US dollar. When this assumption is relaxed, the effects of US monetary policy shocks are more comparable across the two models.

The remainder of the paper is organized as follows. Section 2 describes the banking sector in the current version of BGF and reviews the changes to the model that were introduced to account for cross-border interbank lending. Section 3 outlines our calibration strategy and its results. Section 4 offers several shock-analysis scenarios comparing the old and the new models. Section 5 concludes.

[3] See de Resende and Lalonde (2011) for a review of the BGF model.

2 Interbank Lending in BoC-GEM-FIN

2.1 Interbank market in the current version of BoC-GEM-FIN

BGF has region-specific interbank markets but no international one. Figure 3 illustrates the region-specific interbank market in BGF, focusing on the banks' balance sheets. There are two types of banks in each region: Deposit-taking banks and lending banks.

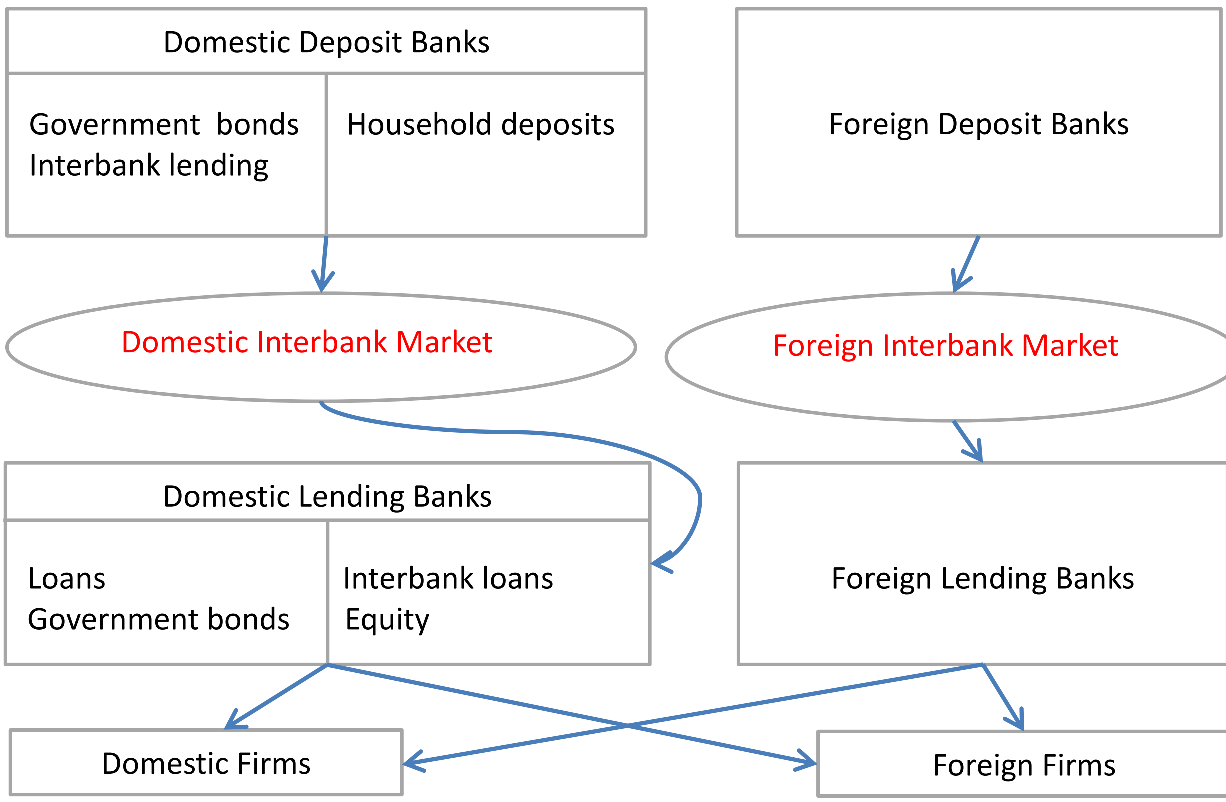

Figure 3: BGF: Region-specific interbank markets

Deposit-taking banks (henceforth simply "deposit banks"), fund themselves by taking deposits from households. On the asset side, deposit banks purchase domestic government bonds and make loans to domestic lending banks through the domestic interbank market.

Lending banks fund themselves by borrowing from domestic deposit banks and by raising equity investment from households. Lending banks then make loans to both domestic and foreign firms, who in turn use these loans to help finance their purchases of capital stock.

This direct lending to foreign firms is the only type of cross-border international lending in BGF, aside from household holdings of international bonds.

Thus, the current modelling structure allows a domestic interbank market, as well as for international credit flows from banks to foreign firms. However, an international interbank market as a propagation mechanism does not exist in the model.

2.2 Introducing cross-border interbank lending to BGF

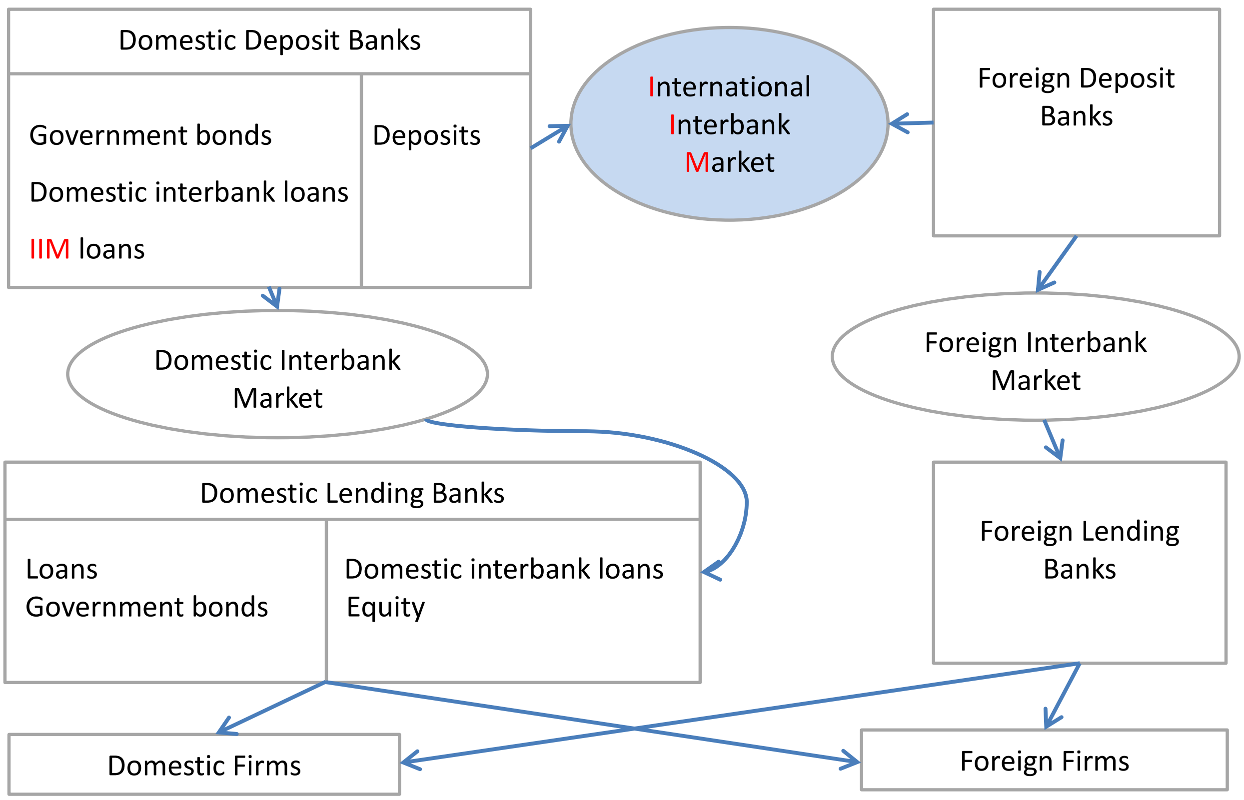

Figure 4: BGF-IIM: Introducing cross-border interbank lending

In this paper, we introduce a modified version of BGF, named here BGF-IIM (or BoC-GEM-FIN with the international interbank market), in which deposit banks from various regions can trade loanable funds among themselves in the global international interbank market. Figure 4 shows how the international interbank market was introduced into BGF. Notice that the figure shows international interbank market loans (IIM loans) on the asset side of the domestic deposit banks' balance sheets. A positive IIM loan position for domestic banks implies that domestic banks lend funds to foreign banks, who borrow to fund investment opportunities abroad. In contrast, if domestic banks have a negative IIM position, then domestic banks borrow from foreign banks to complement their loanable funds for domestic investment opportunities. Thus, domestic deposit banks have the following balance-sheet identity:

$$\left[\begin{array}{c} Domestic\ Interbank\ Loans + Government\ Bonds + \\ International\ Interbank\ Loans \end{array}\right] = [Household\ Deposits]$$

Overall, the international interbank market facilitates the flow of credit funds to regions that have the best investment opportunities.

An important question that we had to address is whether we should model lending banks as also having access to the international interbank market? Mainly for ease of implementation, and somewhat for data availability reasons, we decided not to grant such access to lending banks. Ideally, all banks would have equal access to the IIM or, alternatively, we could let lending banks access regional interbank markets in other countries. Unfortunately, it is quite hard to modify the fairly complex optimization problem of lending banks. These banks are subject to various adjustment costs, and they can choose to default on a fraction of domestic interbank loans. They also operate a complicated Leontief production function for loans and are subject to capital-adequacy constraints. In addition, since data on default rates for international interbank loans are not available, we decided to let deposit banks access the international interbank market because these banks do not default and have a much simpler decision problem in BGF.

We have to make many adjustments to introduce the international interbank market into BGF. Here, we will mainly discuss the key equations determining the interbank market rates. The lending rate charged to banks from a particular region is assumed to be affected by three different spreads. To understand the nature of these spreads, let us use the CA region as an example. Suppose a deposit bank from CA decides to borrow funds from the international interbank market in period t. It does so by selling $B_{t,CA}^{IBF}$ of international interbank bonds. Each bond is denominated in US dollars and promises a gross return of $(1+R_{t,CA}^{IBF})$ in USD at the end of period t. Thus the deposit bank obtains $E_t^{CA,US} \times B_{t,CA}^{IBF}$ of additional loanable funds (in domestic currency) at the beginning of period t and must repay $E_t^{CA,US} \times B_{t,CA}^{IBF} \times (1+R_{t,CA}^{IBF})$ (in domestic currency) at the end of period t. Here, $E_t^{CA,US}$ is the CAD/USD exchange rate in period t, expressed as the number of Canadian dollars per US dollar. The interest rate $(1+R_{t,CA}^{IBF})$ at which the deposit banks in CA can borrow is related to the US rate $(1+R_{t,US}^{IBF})$ using the following parity condition:

$$(1+R_{t,CA}^{IBF}) = \left[\mu^{CA}(1+R_{t,US}^{IBF}) \times \Gamma_{t,CA}\left(\frac{E_t^{CA,US} \times B_t}{GDP_{t,CA}}\right) \times \Gamma_{t,CA}^{IBF}\left(\frac{E_t^{CA,US} \times B_{t,CA}^{IBF}}{GDP_{t,CA}}\right)\right],$$

where μ^{CA} reflects a steady-state risk premium; $\Gamma_{t,CA}\left(\frac{E_t^{CA,US} \times B_t}{GDP_{t,CA}}\right)$ is a risk-premium spread that depends on the level of the net foreign asset positions of CA households (relative to the CA GDP); and $\Gamma_{t,CA}^{IBF}\left(\frac{E_t^{CA,US} \times B_{t,CA}^{IBF}}{GDP_{t,CA}}\right)$ reflects a risk-premium term that is a function of the net international asset positions of the CA deposit banks (relative to the CA GDP again).

An implicit assumption introduced by the two spread functions is that interbank market lenders become more concerned about the solvency of the deposit banks in CA (borrowing region), as households or deposit banks in CA take on higher levels of international debt. As a result, a higher risk premium on loans is charged to highly indebted regions. This assumption is consistent with international practice. Rating agencies often downgrade the commercial banks of countries with high household debt levels.

Note that both risk-premium spread functions,

$$\Gamma_{t,CA}\left(\frac{E_t^{CA,US} \times B_t}{GDP_{t,CA}}\right)$$
$$\text{and } \Gamma_{t,CA}^{IBF}\left(\frac{E_t^{CA,US} \times B_{t,CA}^{IBF}}{GDP_{t,CA}}\right),$$

are equal to unity in the steady state. These spreads only become effective when the economy deviates from the target (steady-state) ratios of household or interbank net foreign asset positions, relative to GDP.[4] The former spread, $\Gamma_{t,CA}\left(\frac{E_t^{CA,US}\times B_t}{GDP_{t,CA}}\right)$, already exists in BGF, determining household international borrowing rates. In BGF-IIM, the former spread affects both household and interbank rates. The latter spread, $\Gamma_{t,CA}^{IBF}\left(\frac{E_t^{CA,US}\times B_{t,CA}^{IBF}}{GDP_{t,CA}}\right)$, is new, but it takes a similar functional form as the household spread. The constant risk premium μ^{CA} allows for a permanent level difference between the CA and US interbank rates.

It is also assumed that the US interbank rate serves as the international benchmark rate, which means that the interbank rates of other regions are set at a premium or discount relative to the US rate. Moreover, the international interbank loans in the model are denominated exclusively in US dollars. Despite that assumption, deposit banks in BGF-IIM do not incur currency risk because interregional loans are assumed to be repaid at the unchanged exchange rate. This feature of the new model is consistent with the prevalence of US-dollar-denominated loans in international lending transactions and also with the fact that most interbank loans are hedged against exchange rate movements.[5]

The interbank rates in different regions adjust to clear the world interbank market. The market-clearing rates assure that cross-region interbank lending and borrowing amounts sum to zero

$$B_{t,AS}^{IBF}+B_{t,CA}^{IBF}+B_{t,CX}^{IBF}+B_{t,RC}^{IBF}+B_{t,US}^{IBF}=0.$$

There is not much difference between the lending banks' problem in BGF-IIM and BGF. Just as in the BGF model, lending banks combine loans received from domestic deposit banks with equity capital raised from households and make loans to domestic or foreign entrepreneurs.

Finally, we also adjusted the current account balance equations by adding international

[4]For notational simplicity, we suppressed the fixed target ratios in the spread formulas above.

[5]Terajima et al. (2010) discuss these details regarding international interbank lending arrangements.

interbank borrowing and lending to the equations. These equations determine current account balances in each period by computing changes in the net foreign asset positions of each region. In BGF, the net foreign asset positions are determined primarily by household holdings of international bonds. We added cross-border interbank loans as an additional foreign asset that is held by deposit banks. Consequently, changes in these loan positions are reflected in the current account balances.

3 Calibration

To calibrate BGF-IIM, we used the BIS[6] data on cross-country international interbank lending positions, as well as data on US bank lending and deposits. The country-level BIS interbank lending positions were aggregated to obtain BGF regional positions.

Equation (1) uses Canada again to provide more details on the parameters that determine the interest rate premium faced by Canadian deposit banks as a function of their international asset positions.

$$(1+R_{t,CA}^{IBF}) = \left[\begin{array}{c} \mu^{CA} \times (1+R_{t,US}^{IBF}) \times \Gamma_{t,CA}\left(\frac{E_t^{CA,US} \times B_t}{GDP_{t,CA}}\right) \times \\ \Gamma_{t,CA}^{IBF}\left(\boldsymbol{\phi}^{\mathbf{CA}}\left(\frac{E_t^{CA,US} \times B_{t,CA}^{IBF}}{GDP_{t,CA}}\right) - \mathbf{B\_SHR_{CA}^{IBF}}\right) \end{array} \right]. \tag{1}$$

The crucial parameters for our calibration are ϕ^{CA} and $B\_SHR_{CA}^{IBF}$. The first parameter defines risk-premium sensitivity to the net foreign asset positions of deposit banks. The second parameter defines the target value of the net international interbank lending positions of deposit banks. For each region of BGF-IIM, these two parameters were calibrated to match two data moments from the BIS data, first the average 2005-11 ratio of the interbank lending position relative to that region's GDP; and second, the change in the same ratio taking place between 2008Q3 and 2009Q4. The following two paragraphs provide further details on our calibration strategy.

[6] Consolidated Banking Statistics, Bank for International Settlements.

Using CA as an example, $B\_SHR_{CA}^{IBF}$ was set equal to the 2005-11 average ratio of the Canadian banks' net international interbank lending position relative to Canadian GDP. This calibration strategy assured that the steady-state ratio of interbank loans from CA banks to other regional banks in the model, divided by CA GDP, matched the average value of this ratio in the BIS data. The same was done for other regions.

Further, we calibrated the parameters ϕ^X ($X = AS,\ CA,\ CX,\ RC$) that control the sensitivity of region-specific interbank market spreads to changes in the ratio of international interbank lending positions to respective GDPs.[7] The parameters were jointly calibrated to match the actual changes in international interbank lending positions after the onset of the global financial crisis at the end of 2008. Before we could do that, we had to create a simulation scenario that would approximate in some sense the latest financial crisis. The change in the interbank lending positions was modelled as the response to the US banking shock. To generate such a shock, we disturbed the US lending banks' productivity (which affects the number of loans producible from a given amount of borrowed funds) to replicate exactly the fall in lending by US banks during the crisis period (after 2008Q3). Of course, all the variables in the model respond to such shocks, but we focused on changes in the net interbank lending position of each region, comparing those changes with the data. We searched for values of ϕ, which minimized the discrepancies between the data and the BGF-IIM model. Thus, to implement this calibration procedure, we needed two data inputs: first, the dynamics of US bank lending after 2008Q3, and second, the changes in the net interbank lending positions of all five regions.

In Figure 5, the red curve shows the decline in US banks' lending after 2008Q3 normalized to 100 per cent at the beginning. The blue line shows the corresponding series from the model. It is at a higher level because it is normalized by the model's steady-state value, but otherwise the series are identical. We can see that during the specified period, the maximum decline in US loans plus securities was approximately 12 per cent of its peak value in 2008Q4.

[7] Notice that there is no IIM premium for US deposit banks because the US rate is the benchmark rate. As a result, there are no ϕ^{US} or $B\_SHR_{US}^{IBF}$ parameters.

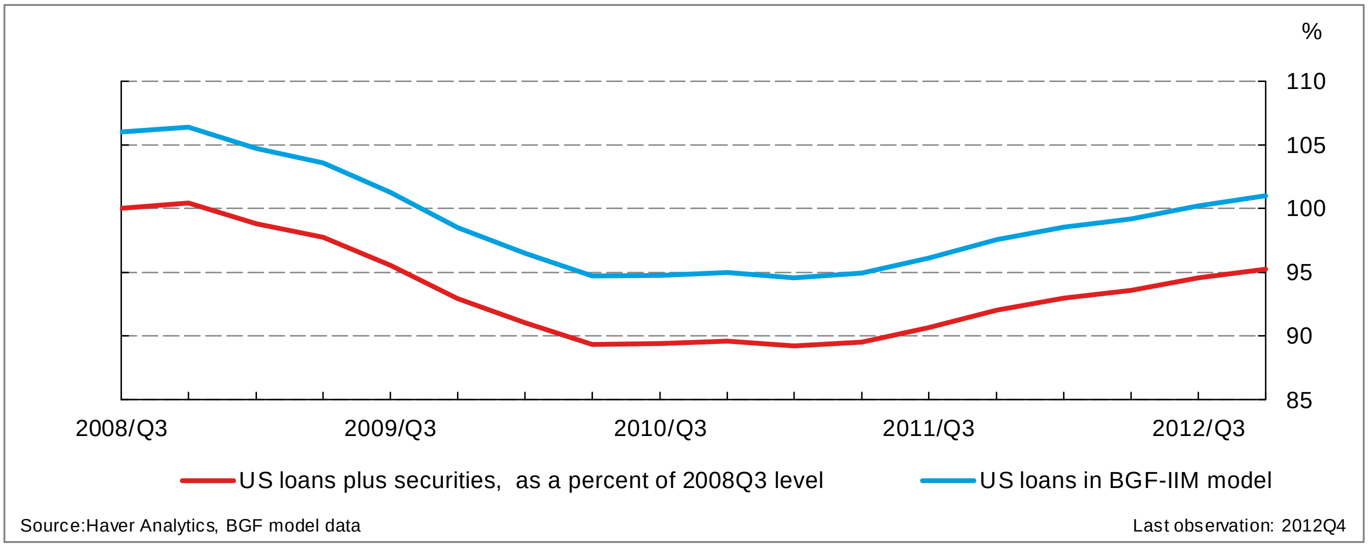

Figure 5: Total lending by US banks

With the shock scenario specified, we could then simulate the implied responses of international interbank lending in all five regions for various combinations of ϕ^X parameters. Our calibration procedure searched for a ϕ^X combination that minimized the discrepancies between the changes in the net international interbank lending positions predicted by the model and those observed in the BIS data. Table 1 compares the changes in the net international interbank lending positions in the data and in the model with ϕ^X $(X = AS,\ CA,\ CX,\ RC)$ parameters identified by our calibration procedure. The middle column in Table 1 shows the actual changes in the international interbank lending positions between 2008Q3 and 2009Q4 normalized by their respective GDP volumes in 2008Q3. The last column of Table 1 shows the corresponding changes in our model with the interbank market.

Table 1: Changes in the ratio of net international interbank lending to respective GDPs, 2008Q3-2009Q4

Region	Data	Model
Emerging Asia (AS)	-0.9	0.5
Canada (CA)	0.3	-1.5
Commodity exporters (CX)	0.7	0.1
Remaining countries (RC)	-9.2	-8.6
US	14.9	15

As can be seen from the last two rows of Table 1, the model matches the changes in the US and RC interbank lending positions quite well. The change in the CX position is substantially underpredicted, however, although the sign of the change is the same as in the data. For the CA and AS regions, even the sign is wrong. Our investigation revealed that the changes in the net interbank lending positions of the AS and CA regions were quite insensitive to a wide variation in the values of ϕ^X. We traced the source of this rigidity to the specification of monetary policy in the AS region, which is assumed to target the real exchange rate against the US dollar. When we changed AS monetary policy to an inflation-targeting rule, as in the other regions, it became much easier to effect a desired change in the net international interbank lending positions of AS and CA. Nevertheless, since the benchmark calibration of BGF assumes exchange-rate targeting in AS, we retained this assumption in BGF-IIM and accepted the imperfect match between the data and the model moments in Table 1.

4 Impulse Responses to Shocks

In this section, we present results for four different shock scenarios: (i) US demand shock, (ii) US and RC monetary policy shocks, (iii) US banking shock, and (iv) an RC risk-premium

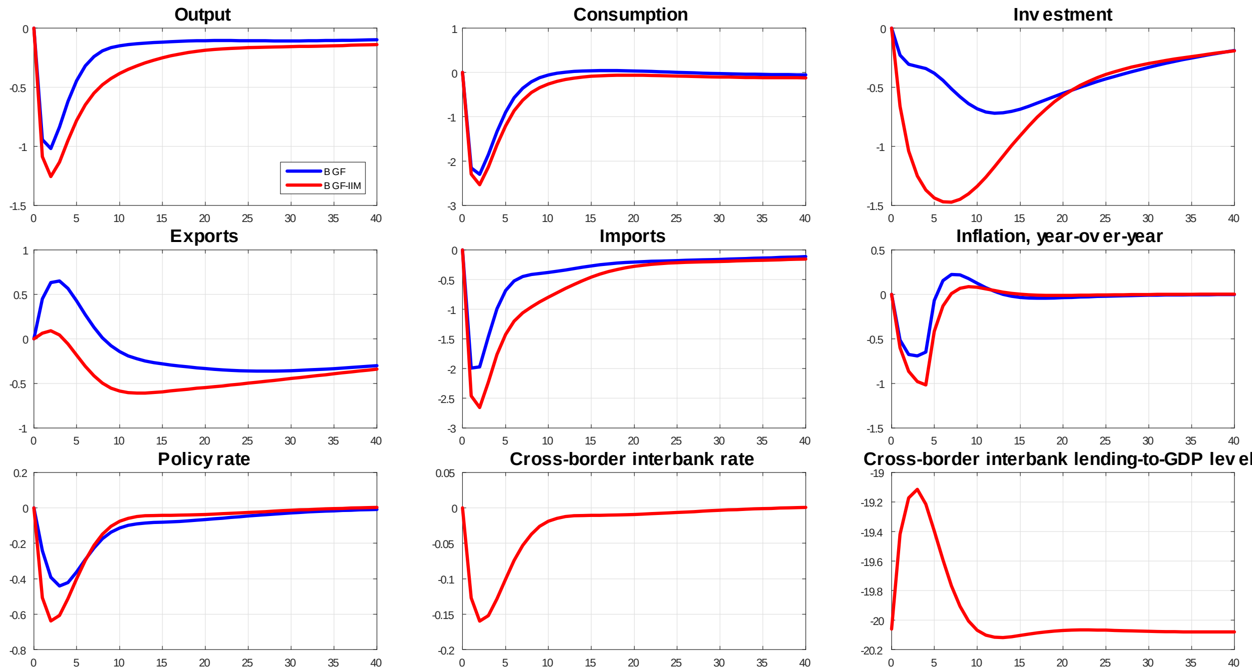

Figure 6: US demand shock: effect on the US region

shock.[8]

As expected, most changes are observed in the financial sector variables because the financial sector is precisely the place where the new interbank loans enter the model.

4.1 US demand shock

Figure 6 depicts the effects of a negative demand shock in the US region, which is modelled as a temporary decrease in the marginal utility of consumption of US households. The size of the shock is calibrated so that US GDP falls by 1 per cent in BGF. The same shock leads to a larger GDP drop of 1.2 per cent in BGF-IIM. The amplification effect of the IIM is also visible for most other variables shown in Figure 6 and is especially strong for investment. Investments in the BGF-IIM model decline more than twice as much as they do in BGF. Exports, imports and inflation also decline to a greater degree in BGF-IIM. The bottom-left chart shows that the response of the policy rate is also stronger in BGF-IIM. The other

[8] We also analyzed an oil supply shock in the oil-exporting region, CX. The impulse responses to that shock look very similar in BGF and BGF-IIM and are not reported here.

two charts in the bottom row show the response of the international interbank rate and the international interbank lending positions. Since these variables do not exist in BGF, there are no BGF curves. All of the charts are in terms of shock minus control, except the very last one for the cross-border interbank lending, which is shown in levels normalized by GDP. Notice that the interbank loans to the US region decline by almost 1 per cent of GDP (they go up closer to zero because the United States is a net borrower).

Why does investment fall so much more in BGF-IIM? In fact, as we can see from Figure 7, bank loans to firms by US banks don't change by much, and household deposits actually grow faster in BGF-IIM than they do BGF. It appears that a decline in net international interbank lending to the United States has the biggest impact on the net worth of firms. When net worth falls, firms face higher risk premiums, owing to a higher loan-to-net-worth ratio. The fall in borrowing by firms results in a decline in investments. So it appears that the greater capital mobility in BGF-IIM makes the BGG accelerator[9] even more powerful. It is well known that an amplification of demand shocks is a common finding for BGG-type financial-accelerator models, which works through a reduction in asset prices and a debt-deflation mechanism.

Next, we investigate whether the effects of a US demand shock on other countries are also amplified in the new model. Figure 8 shows the effects on the RC region, a recipient of the US demand shock.[10] The picture is roughly similar to what we see for the United States: the responses of output, consumption and investment are slightly higher in the new model and so are the responses of exports, imports, inflation and the policy rate. Cross-border interbank lending by RC banks declines by roughly one-half of 1 per cent of the RC GDP (recall that RC is a net lender, so a fall in this variable is a decline in lending.) So in the new model, the IIM amplifies demand shocks, both in the source country of a shock and in countries that are recipients of the shock spillovers. The amplification seems to work using

[9] Bernanke, Gertler and Gilchrist (1999) (BGG) introduced a credit market friction into DSGE models.

[10] See the Appendix for the responses of CA variables to the US demand shock as well as to most other shocks considered in the following subsections.

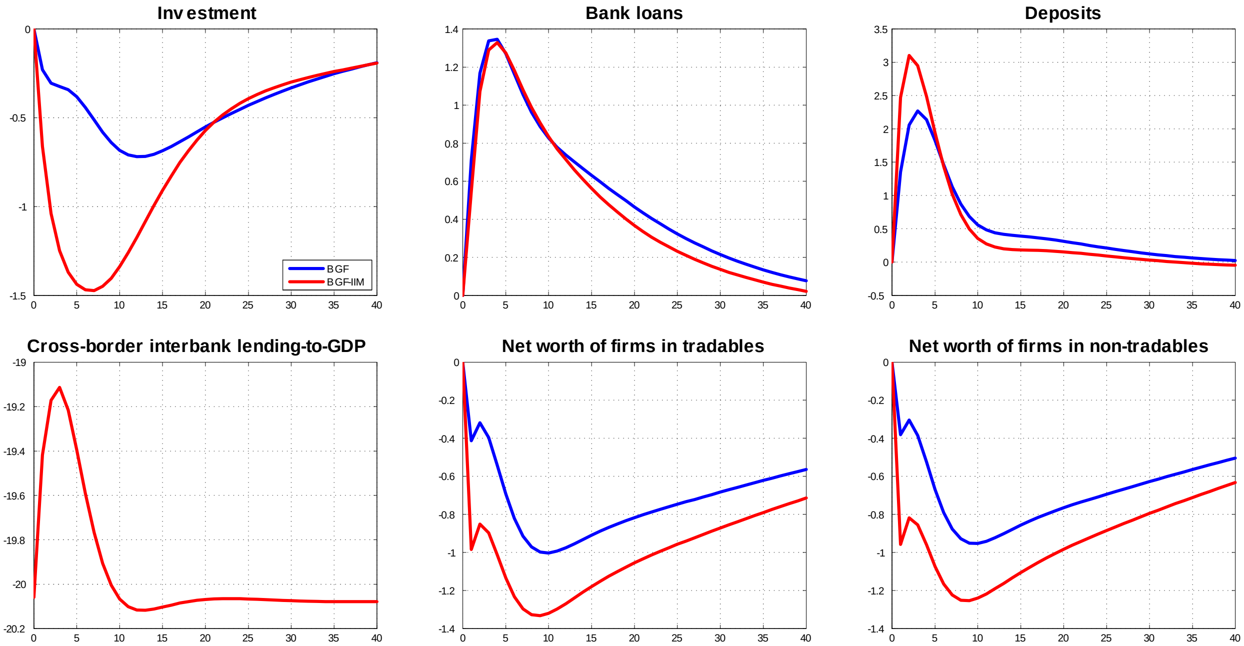

Figure 7: Amplification via BGG accelerator: effect on the US region

the financial-accelerator channel and likely through trade channels as well.

4.2 US and RC monetary policy shocks

We generated a US monetary policy shock by raising the exogenous component of the US monetary policy rule so that the US policy rate rises by 1 per cent in BGF. The same shock leads to a smaller interest rate increase of 0.7 per cent in BGF-IIM.

Figure 9 shows the effects of this shock on AS. There is a marked moderation in output, consumption, and investment in BGF-IIM relative to BGF. The responses of imports and inflation are slightly moderated. The response of exports is slightly amplified in the new model. The moderation of most variables in BGF-IIM happens despite cross-border interbank loans remaining nearly constant, as can be seen from the vertical scale on the bottom right chart. Thus, it appears that in the case of spillovers from US monetary policy shocks, the effect on AS does not work directly through the IIM loans, since AS borrowings from the IIM market barely change. Note that as a result of cross-border capital mobility and

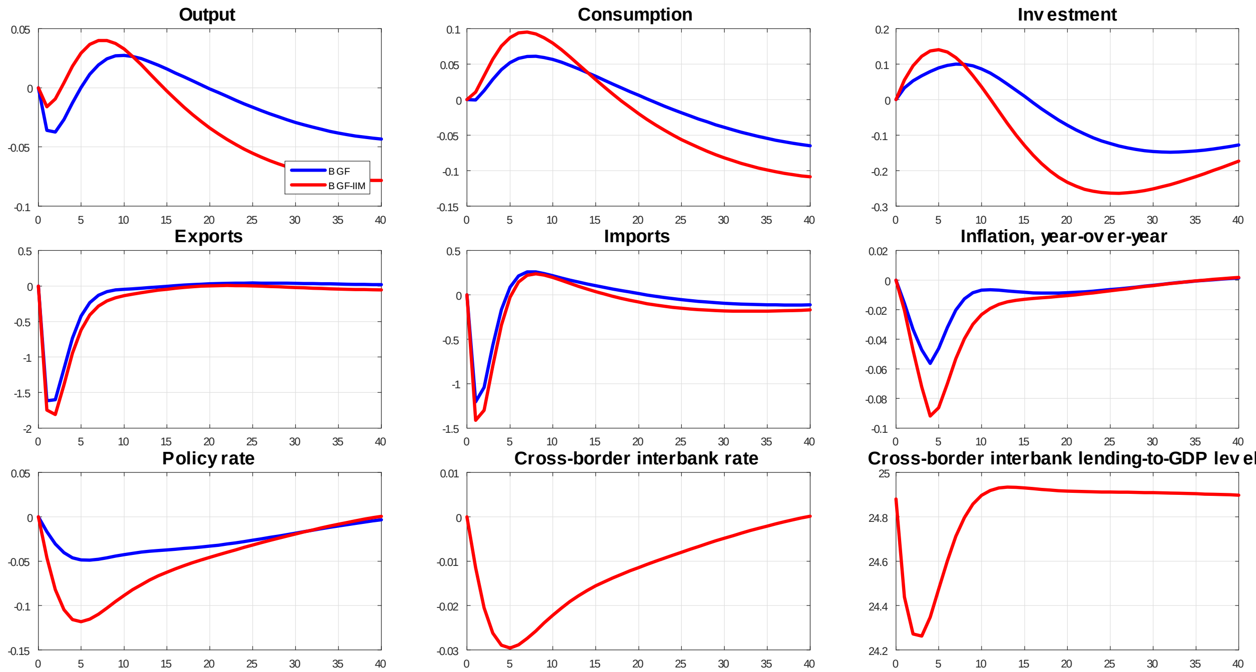

Figure 8: US demand shock: effect on the RC region

the real-exchange-rate targeting against the US dollar, AS does not have an independent interest rate policy. As the United States raises its interest rate, the AS region must also raise its rates, thus inducing an economic contraction in AS.

The moderation of US monetary shock spillovers on AS stands in contrast to the responses of AS variables to an RC monetary policy shock. Figure 10 shows the responses of AS variables to an RC monetary policy shock. We see that the responses of output, consumption and the policy rate are amplified. The responses of exports and investment are quite similar for the two models. The effects on imports and inflation are moderated. So it is not a clear-cut amplification, but at least the responses of output and consumption are amplified.

It is quite likely that the differential impact of the US monetary policy shock on AS is due to the fact that the AS region has a fixed real exchange rate regime against the US dollar. We relaxed the exchange-rate targeting assumption in AS to test this hypothesis.

Figure 11 shows the spillovers of the US monetary policy shock on AS when we change the monetary policy rule in AS from exchange-rate targeting to the same interest rate rule

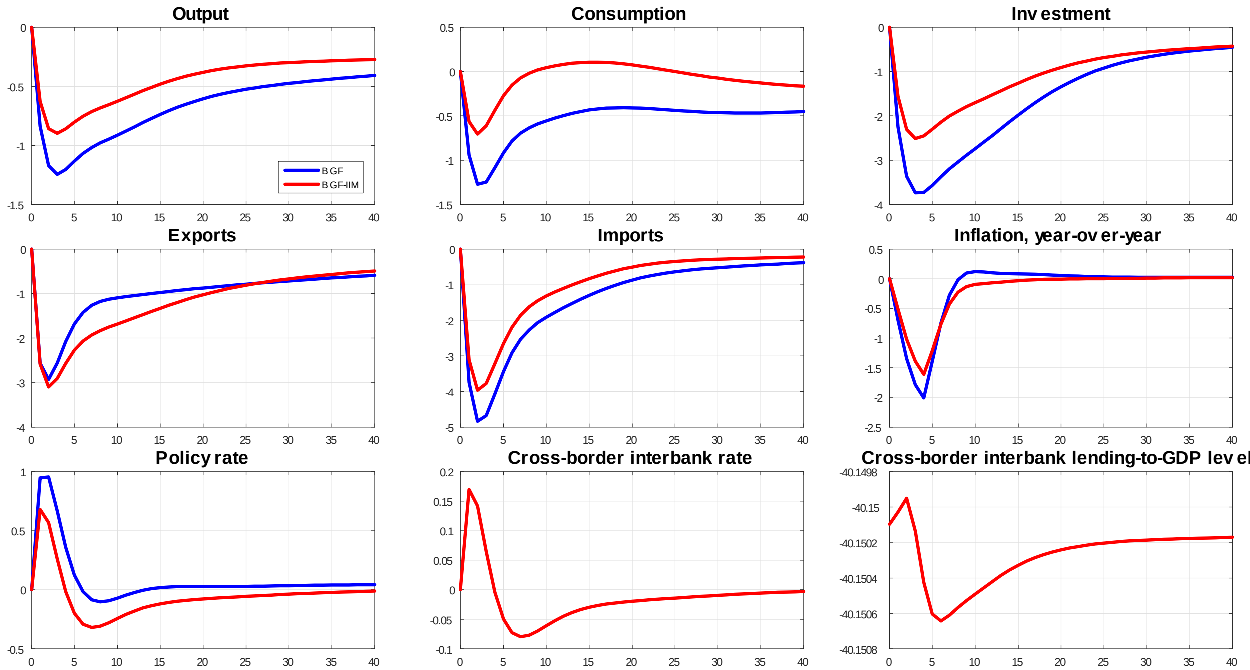

Figure 9: Moderation of the US MP shock spillovers on Asia

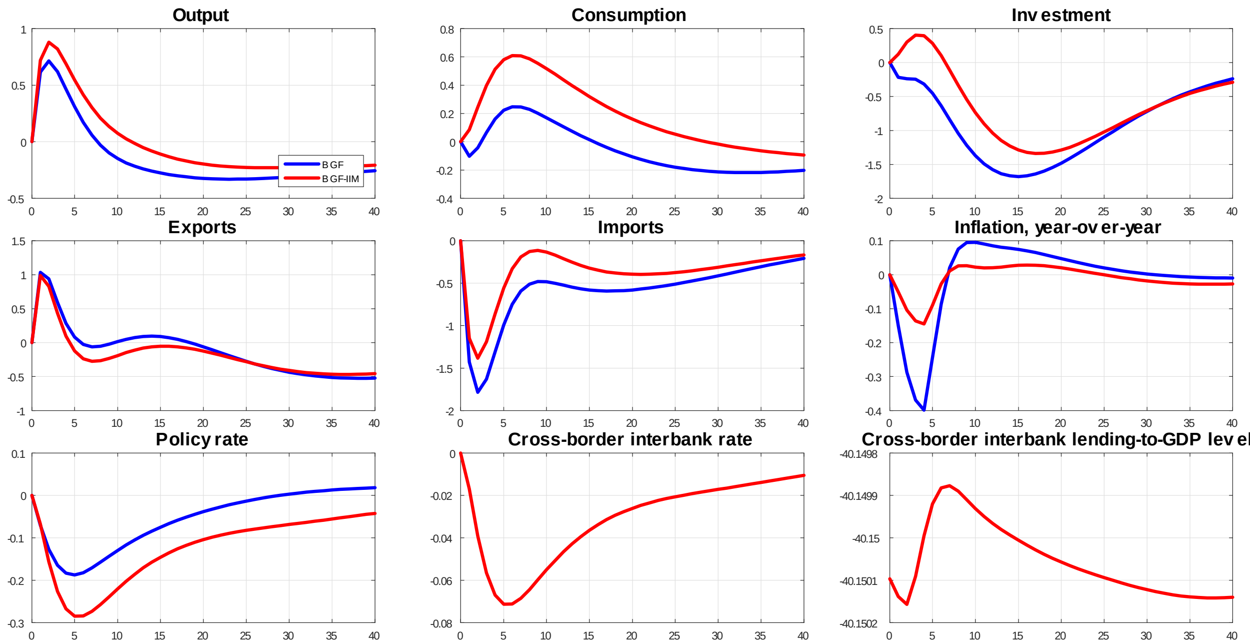

Figure 10: Amplification of the RC MP shock on Asia

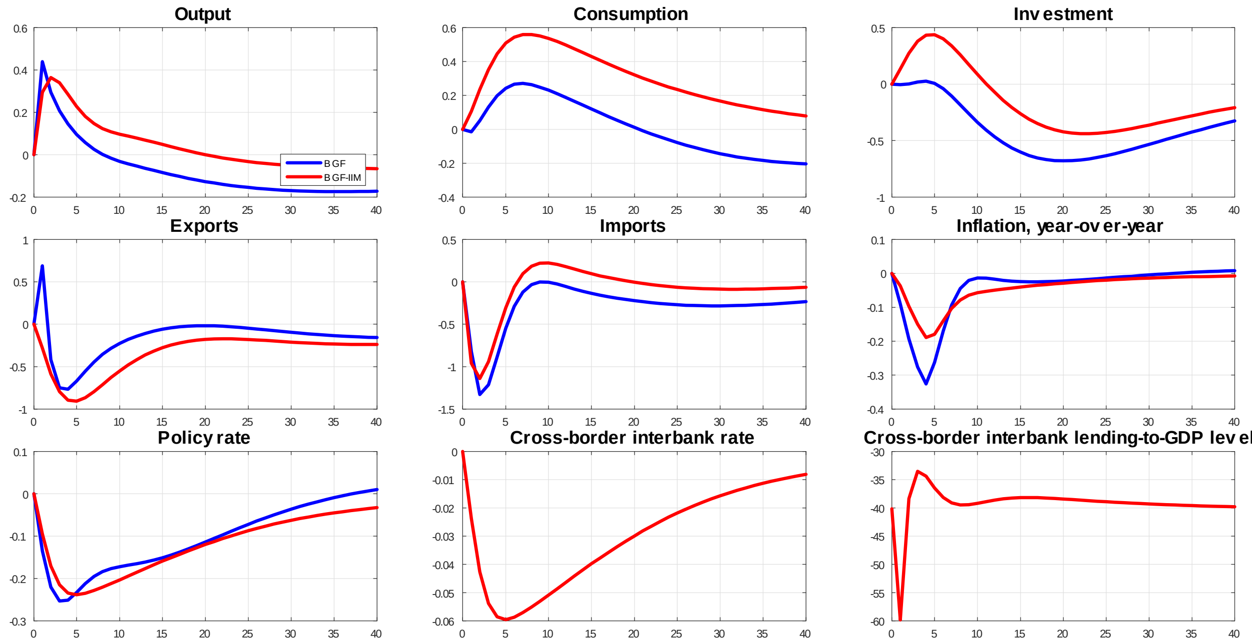

Figure 11: US MP shock spillovers on Asia when Asia's MP follows same rule as the US region

as in the United States. One immediate observation is that there is no apparent moderation for any variable except inflation. As the US policy rate is raised, AS responds by lowering its interest rate to mitigate a fall in exports to United States. Despite the lower interest rates, there is a huge inflow of international interbank loans to AS, roughly equivalent to 20 per cent of the AS GDP (since AS is a net borrower, a downward movement in this variable means an increase in borrowing from abroad). The capital inflow to AS is likely generated by the diversion of IIM loans away from the US region, which experiences an economic contraction induced by its monetary policy tightening. The inflow of international capital to AS is big enough to generate an economic boom, raising AS consumption, investment and output. Admittedly, this response of AS variables to a US monetary policy tightening does not sound very realistic, but it is meant only as a counterfactual experiment.

4.3 US banking shock

Figures 12 and 13 show the effect of a US loan supply shock on the US region and AS. As discussed in the calibration section, the shock was constructed to match the decline in business loans and corporate securities on the balance sheets of US banks.

The first thing to notice in Figure 12 is that for the US banking shock, BGF-IIM has almost no differential impact on US variables relative to BGF. In both models, the US investment and capital stock decline. Firms respond to a lower capital stock by demanding less labour and other factor inputs, resulting in a fall in the real wage and other prices, which in turn leads to a decline in annualized inflation by about 6 per cent. Consumption falls by 3.5 per cent, while investments decrease by about 40 per cent. Overall, US output falls by 7 per cent. The monetary authority responds to the fall in economic activity by lowering the policy rate by 6 percentage points, which leads to reduced capital inflows into the United States and a depreciation of the US dollar. All of these effects on US variables are very similar in BGF and BGF-IIM.

Larger differences are observed in other regions, such as AS and RC, which are on the receiving end of the shock. For example, Asia's GDP declines by 3.3 per cent in BGF-IIM and by 4 per cent in BGF, while AS consumption falls by 1 per cent in BGF-IIM and by 2 per cent in BGF. Thus, the spillover effects are moderated in BGF-IIM compared with BGF. This is expected since other regions benefit from the partial diversion of international interbank loans away from the US banks and toward other regions.

In BGF-IIM, US banks' borrowings from the international interbank market fall by about 12 per cent of US GDP. Household deposits increase after the shock. These results are consistent with the increase in household deposits and a decrease in business loans observed in the US data during the financial crisis (see Figure 2).

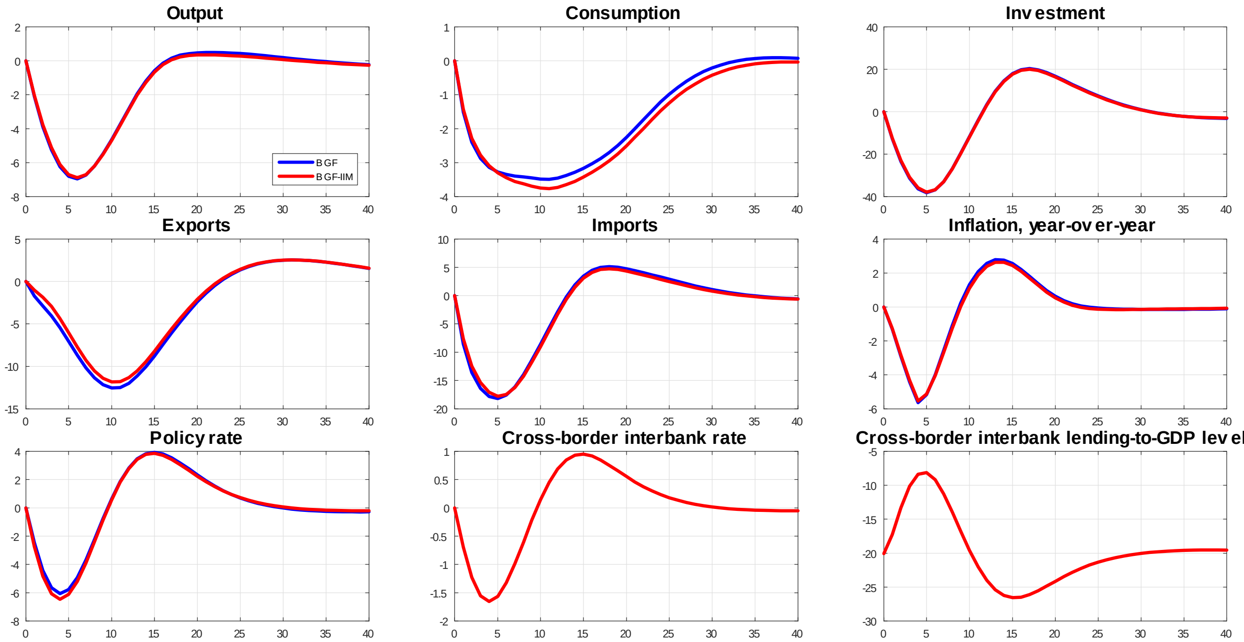

Figure 12: US banking shock: effect on the US region

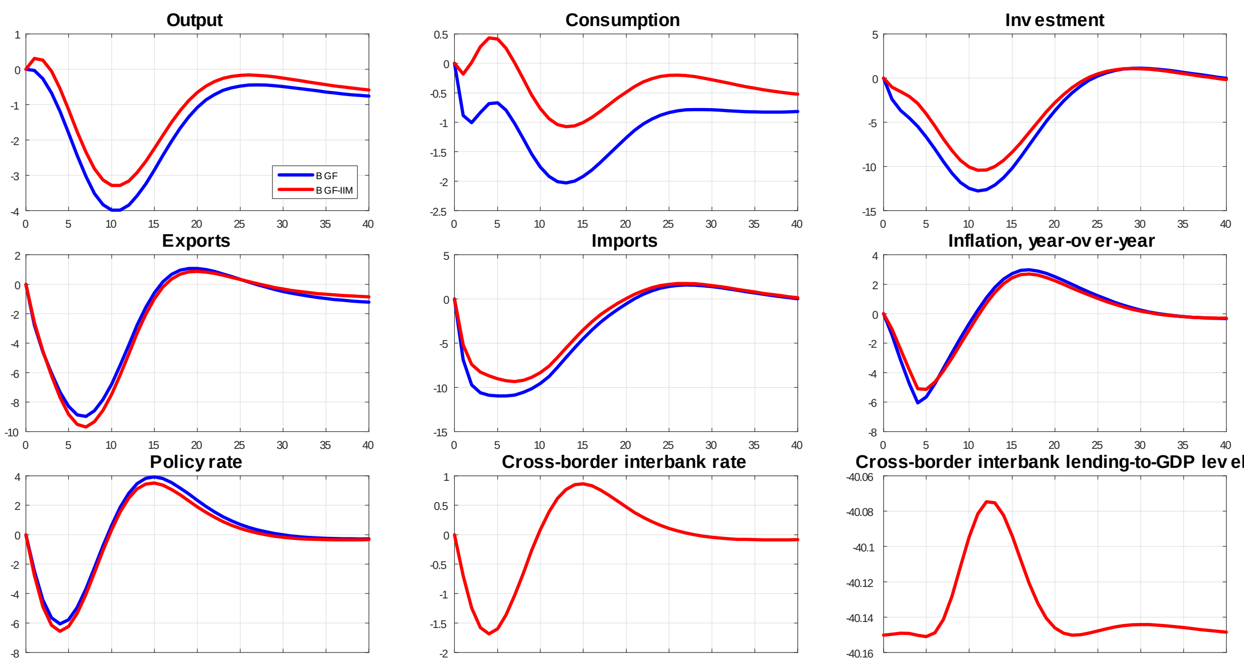

Figure 13: US banking shock: effect on Asia

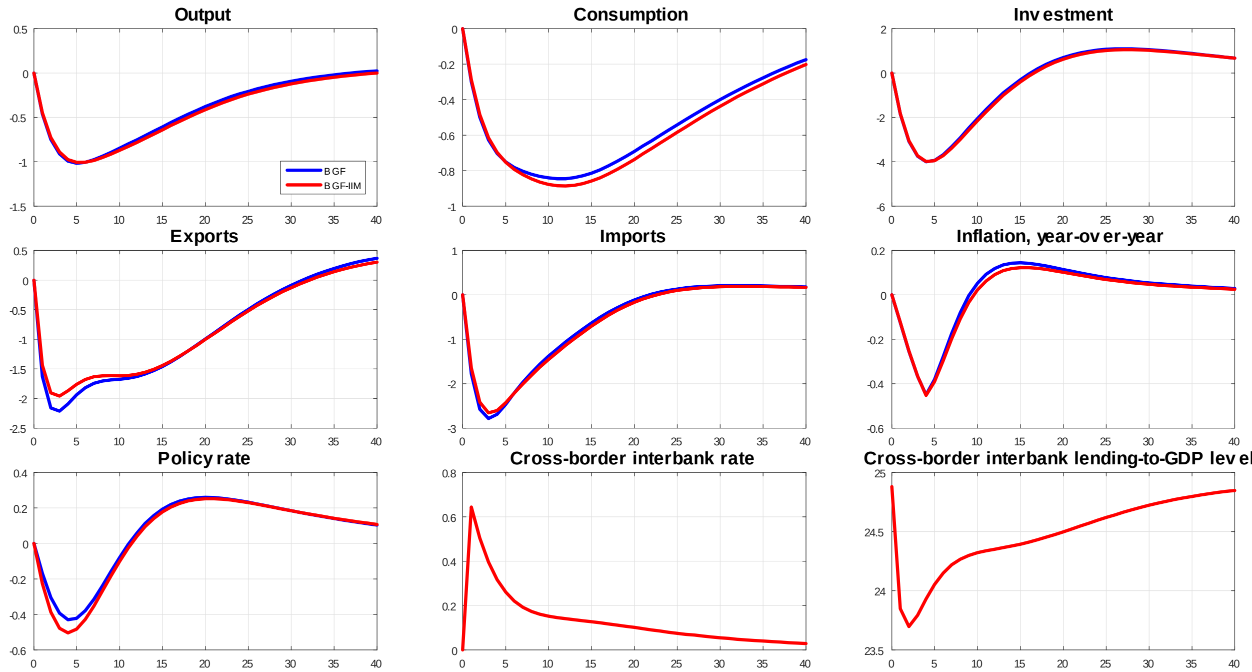

Figure 14: RC risk-premium shock: effect on the RC region

4.4 RC risk-premium shock

Figure 14 shows the effect of an RC risk-premium shock on RC. The shock worsens the financial conditions in RC by increasing the risk-premium spread between the risk-free rate and other rates. As a result of the higher spread, deposit banks reduce their demand for household deposits, which are now more expensive. This reduces the amount of funds available for domestic interbank loans (and for bond purchases by deposit banks), which in turn reduces loanable funds for entrepreneurs, leading to a 4 per cent decline in investment. Consumption of final consumption goods falls by 0.8 per cent as the general level of economic activity moderates. The overall effect is a 1 per cent fall in output in the RC region.

Once again, larger differences between BGF and BGF-IIM macroeconomic variables are observed in some of the regions receiving spillover shocks from RC. For example, AS GDP declines by 0.19 per cent in BGF-IIM, but by 0.27 per cent in BGF (see Appendix).

5 Conclusion

This paper describes the modifications introduced into the Bank of Canada's BoC-GEM-FIN model to improve its ability to analyze the transmission of shocks using international interbank markets. We incorporated cross-border interbank lending as a global market accessible by deposit banks from all regions. This additional feature provides a new channel for the propagation of financial shocks and allows a more detailed study of the banking sector adjustments in times of financial distress. The modified model is calibrated to match the changes in the international interbank lending positions of the world regions and the decline in the US banks' business lending that took place after 2008Q4. Our simulations show that the international interbank market amplifies the spillover effects of demand shocks but does not systematically alter the effects of supply shocks, including those for commodities. We also find that the exchange-rate-targeting monetary policy in emerging Asia moderates the spillover effects of US monetary policy shocks on that region relative to similar monetary policy shocks emanating from other regions.

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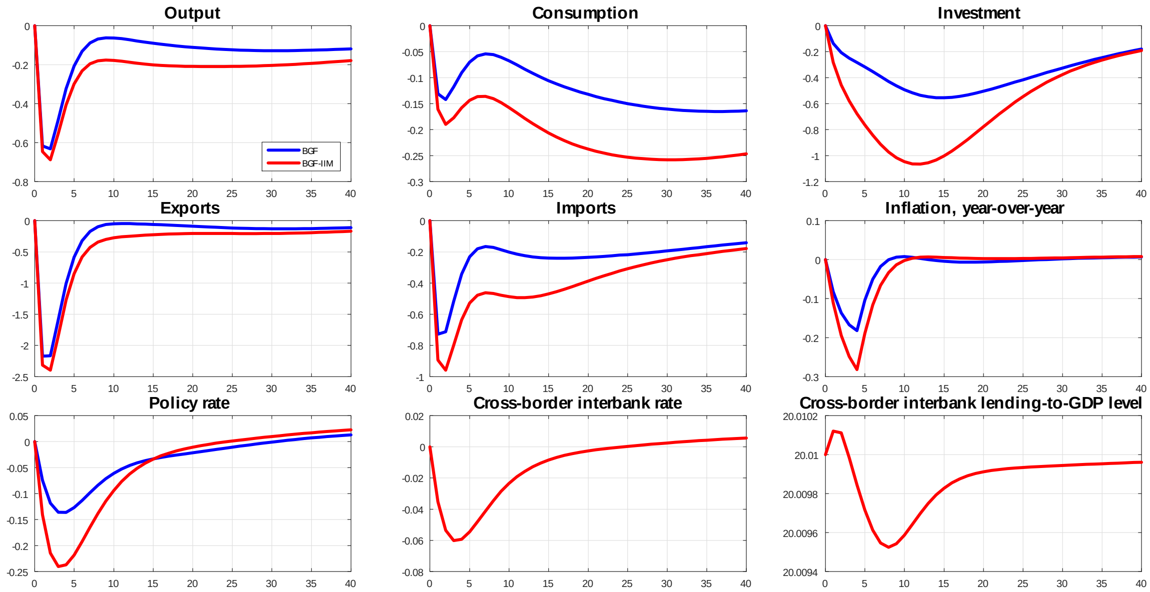
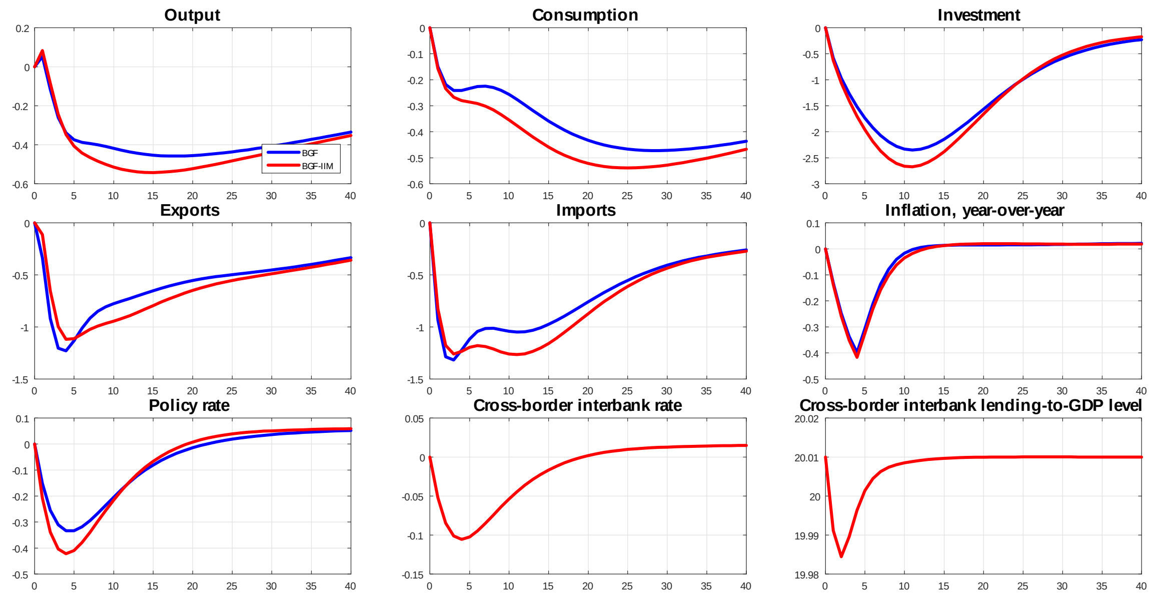
Appendix

A.1 US demand shock

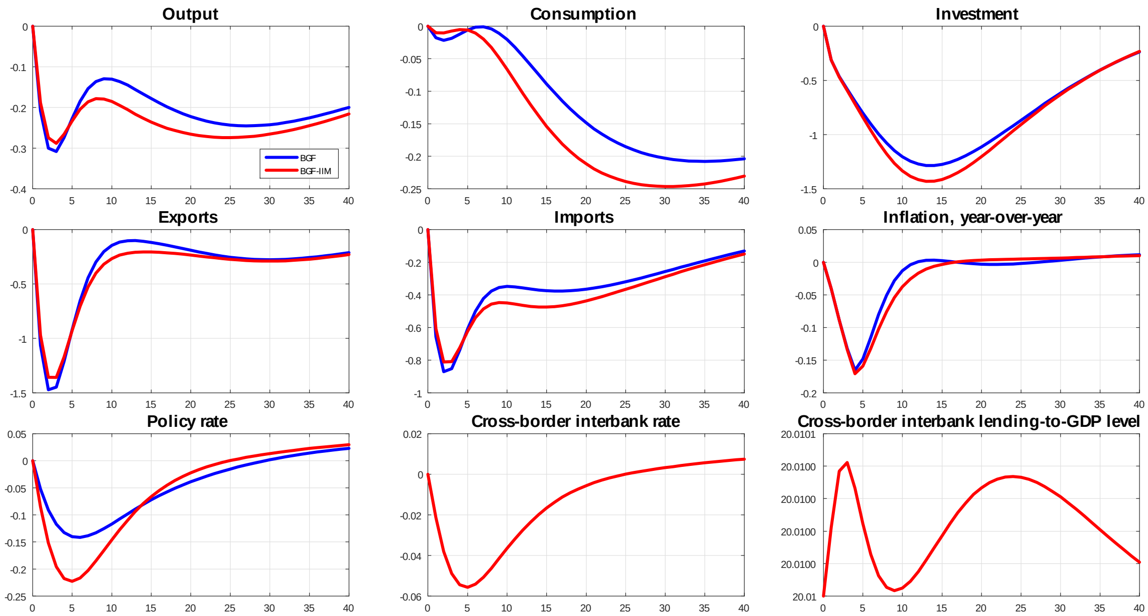


US demand shock: effect on the CA region

A.2 US and RC monetary policy shocks

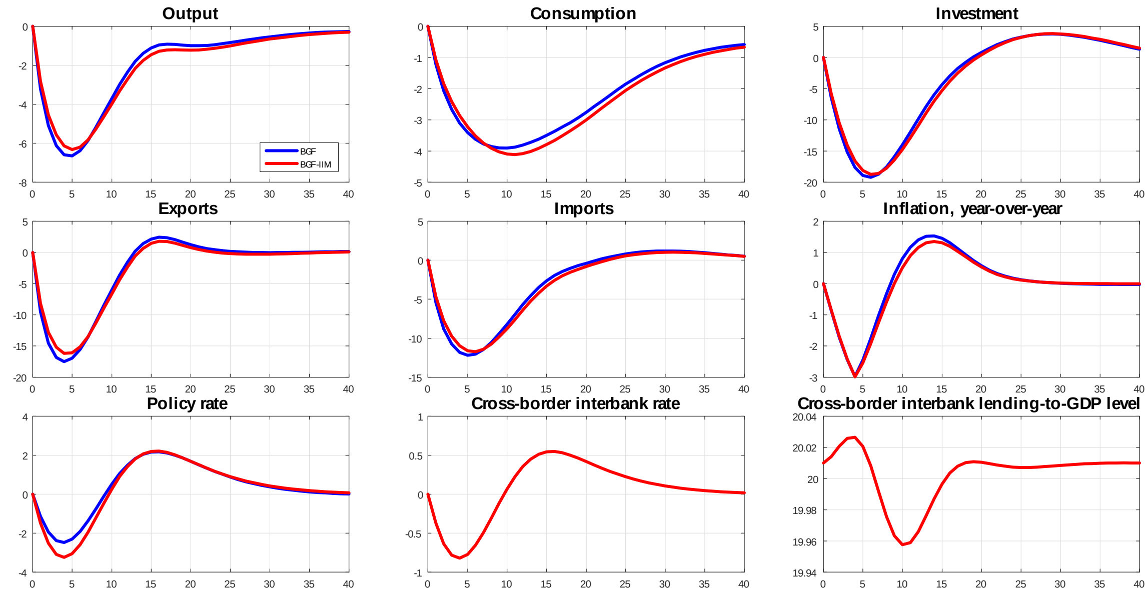


US MP shock: effect on the CA region



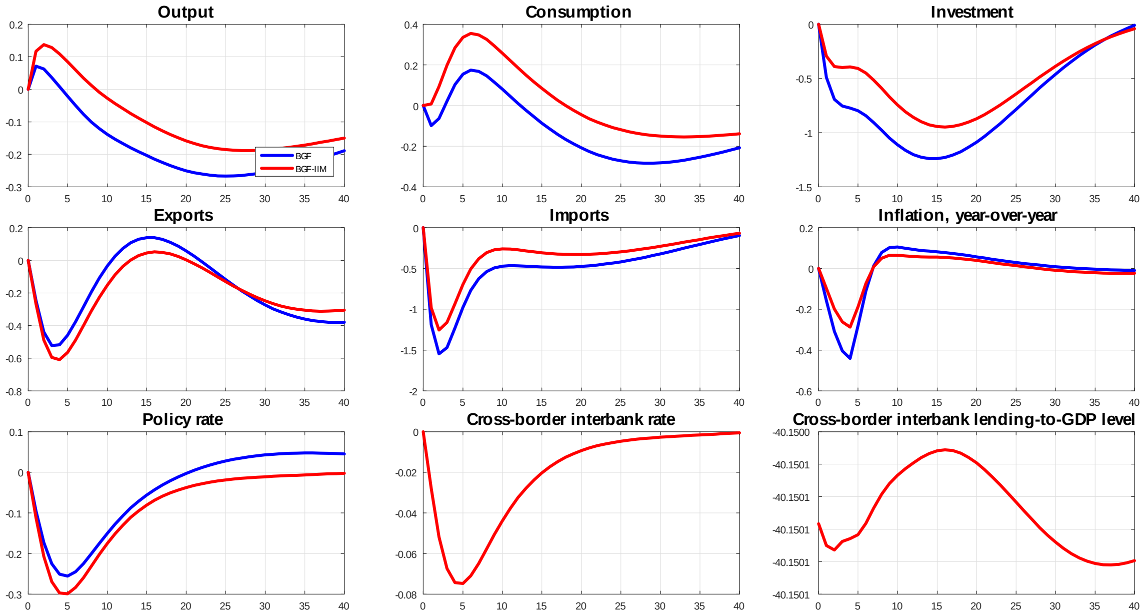
RC MP shock: effect on the CA region

A.3 US banking shock



US banking shock: effect on the CA region

A.4 RC risk-premium shock



RC risk-premium shock: effect on the AS region