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Bad banks choking good banks: simulating balance sheet contagion

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Bad banks choking good banks: simulating balance sheet contagion

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Abstract. We investigate the propagation of contagion through banks' balance sheets in a two-country model. We simulate an increase in non-performing loans in one bank, and study the effects on other banks and the macro economy of each country. We show that credit crunches destabilize each economy in the short run and in the long run reduce potential output. We quantify this loss.

Keywords: Credit crunch, contagion, stock flow consistent models.
JEL classification : E32;E37; E51; G33.

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1. Introduction

The recent crisis has highlighted the role systemic liquidity plays in spreading funding contagion through the web of interlinked banks and other financial institutions. There is a need for models that can identify counterparty risk exposures, shock transmission processes, and other 'fault lines' at the systemic level.

To understand the role liquidity plays within interconnected sets of balance sheets, this paper studies the evolution of an increase in non- performing loans in one bank within a two-country, five-sector model. We find that financial fragility can affect both the short term and long term evolution of the economy.

We define a credit crunch event as a sudden shortage of loanable funds within private banks that results in a decline in lending by those banks. Credit crunches can occur in banks when there is an unexpected decline in the value of their collateral (for example in the case of Ireland's banks (Kinsella and Lyons, 2011)). Credit crunches can occur when reserve or other macro prudential regulatory requirements change, or when governments impose direct credit controls (as in the case of Malaysia in 1998). Credit crunches can, of course, come from an increase in the risk of system-wide insolvency (as witnessed in Ireland, Greece, and Portugal in 2010 and 2011).

Empirically, we can see that loans did indeed increase at a fast pace over this 'bubble' period, and this squares with the credit buildup stories told in the literature (Mizen, 2009). Figure 1 shows the increase in non-performing loans as a percentage of total gross loans in the United States from 2005 to 2010 on the left axis. We see the rise and rise of non-performing loans over this period clearly, from less than 1% of total loans in 2005 to 4.2% in 2009 to 4.7% in 2010. On the right hand axis we see the increase and subsequent decrease in total net lending over the same period from 765 billion dollars in 2005 to -212 billion dollars in 2010.

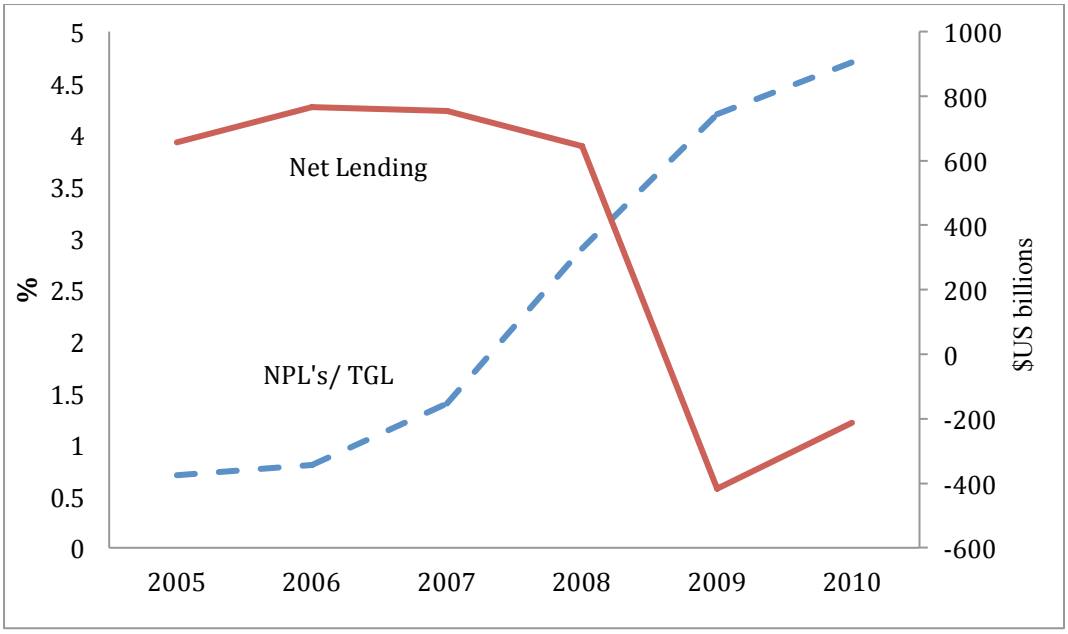


Figure 1:Net lending and non-performing loans as a percentage of total gross loans (left axis). *Sources:* IMF, Financial Soundness Indicators, 2011 and Board of Governors of the Federal Reserve System, 2011.

The causality of a credit crunch event is still not well understood (Gai and Kapadia, 2010; Kindleberger, 1996: Haldane, 2011). Current research focuses on increases in balance sheet connectedness and complexity, viewing the banking system as a directed graph or network (May and Arinaminpathy, 2010; May and Haldane, 2011, Gleeson *et al*, 2011). There is of course a longer thread of literature on these issues. For example, Bernanke *et al* (1991) study leftward shifts in the supply curve of bank loans, holding constant real interest rates and quality of bank borrowers. Kiyotaki and Moore (1997, 2002) study the endogenous generation of temporary liquidity shocks.

The most often-repeated causal story within this literature is that a badly priced asset or asset class (for example, US subprime mortgages) causes a sharp increase in loan defaults which leads to banks provisioning for bad debts, which reduces their equity capital and/or their reserves (Whalen, 2002). The shock increases the cost of interbank funding, causing a reduction in loans into the real economy and a reduction in economic output. The feedback from drops in demand for the original asset to an inability to re-finance that asset due to credit constraints is quite clear in this story. Individual banks can fail, and fail spectacularly, when they demonstrate an inability to meet their short run liabilities, and the impact on the real economy can be profound.

There are competing liquidity crisis stories (Koo, 2009; Eggertson and Krugman, 2010; Minsky, 1986). Each of these stories revolves, in some sense, around a credit buildup within temporarily risk-loving banks enjoying lax regulatory climates, rather than individual householders making poor decisions, but the network of attendant causal linkages is similar to the first set of stories. Many new papers study flows of funds within the financial system empirically (Kastren and Kavonius, 2009; Mian and Sufi, 2010; Billio *et al*, 2011). They find increased levels of interconnection between banks increases the probability of a credit crunch event markedly following a contraction in liquidity in one bank that propagates across the network. This is balance sheet contagion.

Our contribution is motivated by the literature, and is threefold in this paper.

First, we build and solve a large two country, five sector stock flow consistent macroeconomic model in the tradition of Godley and Lavoie (2007)[3]. Rather than focusing just on banks, or on the economy as a whole, we consider the interconnections between the financial and real sides of the economy in explicit detail.

It should be underlined that this is an open-economy model *without* trade but with international flows. In other words, the balance of payments only includes the capital account balance, because we wish to focus on the consequences of interbank loans in a globalized world. There are no exports (although there is a current account balance in each country due to interest payments to and from the other country), and therefore the consequences of the credit crunches we simulate will not take into account the feedback effects on net exports. That important qualification aside, the key advantage of stock flow consistent models is the ability to conduct an analysis of the real and financial flows and stocks at the 'world' level with a comprehensive description of the main agents such as households firms, central banks, private banks, and governments.

Second, we simulate both a one-off increase in non-performing loans, and a multi-period increase in non-performing loans. Many other studies—for example Kiyatoki and Moore's classic (1997) study of credit cycles—look only at a single credit

[3] *Eviews* code for this model is available upon request from the authors.

event, which, while important, tends to underestimate the long run effects of a protracted credit crisis that the world economy is currently experiencing. Our model is careful to correct for this.

Third, we contribute to the literature on imbalances within countries and within its banking institutions, in the hope of a more complete description of these important phenomena.

The rest of this paper is laid out in the standard way. Section 2 describes the main model equations. Section 3 gives the results, graphically and numerically. Section 4 concludes.

2. Model

Before describing the model's balance sheet, transaction matrices and behavioral equations, we first give some intuition for the model's supply shock transmission mechanism through the interbank loan market.

For ease of exposition, rather than calling the countries '1' and '2', we call the two countries 'France' and 'Germany'. Figure 2 shows this mechanism in detail. We assume the private banking sector in this model is made up of two competing banks in each country, regulated by a national central bank.

Running from left to right, we see that bank *A* takes interbank loans from bank *B* and supplies interbank loans to bank *C.* Bank *B* takes interbank loans from bank *D*. Bank *C* a net debtor in this market and takes interbank loans from bank *D*, and thus Bank *D,* as drawn, is a net creditor in this market. Each bank of course has to pay interest on their interbank loans received, and they receive interest on their supplied interbank loans. The banks' profits are made within the differentials between ingoing and outgoing interest rates. Part of the profits will go to households who hold bank shares as dividends. The remainder is held as retained earnings within each bank's capital accounts.

In each period, each bank's capital account contains the change in the bank's assets and liabilities, which gives the new flows of the bank's own funds (or bank equities), retained earnings, and the value of non-performing loans.

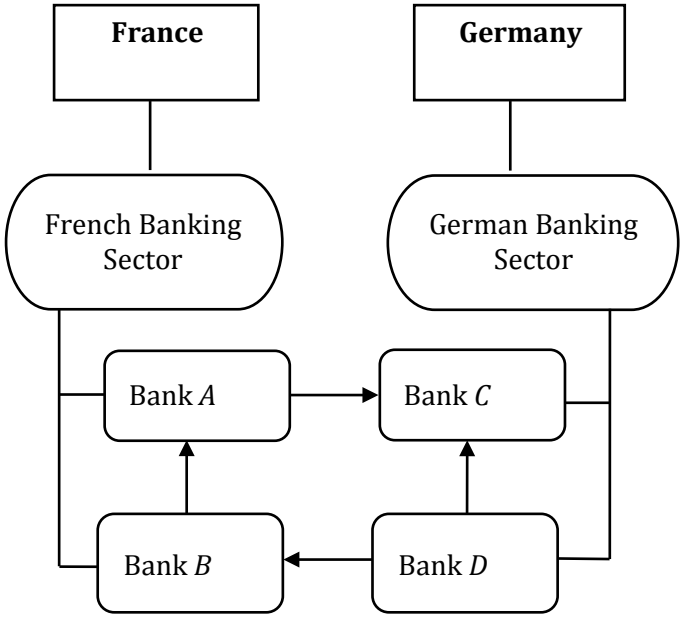


Figure 2. Transmission mechanism through the interbank market.

The model, in general, is laid out as follows. We interact two steady state—almost identical—economies with five sectors in each economy: households, firms (the non-financial sector), government, central bank, and private banks. Each sector acquires assets (+) and incurs liabilities (-).

Again, the objective of the paper is to pull out the effects of a credit supply shock that precipitates a decline in the supply of loans to the other sectors in the economy. To do this, we need to describe the balance sheets of our model, building a relatively elaborate trading schema within the banking sectors as we do so, and keeping the description of the rest of the economy as 'pared down' as possible. Then we introduce revaluation and transactions matrices, and write down the main behavioral equations the model uses before turning to our simulated results in Section 3.

Table 1 shows the balance sheet for our model. Large letters denote the variable under study, for example, high-powered money, *H*. High powered money is just money issued by the central bank and is held by banks as reserves, either in the form of vault cash or as deposits at the central bank, as well as by households. Subscripts within the table show the destination sector of each entry, and whether this sector demands or supplies that quantity. So for example, in France, households ($_h$) have a demand ($_d$) for high-powered money ($+H^{Fra}_{h,d}$), and in Germany,

households ($_h$) have a demand ($_d$) for high powered money ($+H^{Ger}{}_{h,d}$), while the French central bank supplies ($_s$) this money ($-H^{Fra}{}_{s}$).

Please insert table 1 here.

For ease of exposition we suppress subscripts and superscripts within paragraphs.

Running from left to right in the table and by sector, then, in addition to holding high-powered money (+H), households also hold money deposits (+M) in domestic banks, local and foreign government securities (+B), and bank equities (+OF). Households can take loans from domestic banks (-L). The total wealth of the household sector is given by (+V).

Firms own tangible assets in the form of fixed capital (+K). Firms take loans from domestic banks (-L). The sum of their assets and liabilities gives the net worth of the firms at the end of each period (+/-NW).

The government in each country is a passive actor in the system, and must mechanically finance any deficit by selling treasury bills, (B), both at home and abroad. Each government holds treasury bills, as do households and firms.

The central banks of both countries are equally stripped down entities, only issuing money (H) and holding local and foreign treasury bills.

We introduce a necessary complication in the description of private banks to study interbank contagion. Our four private banks demand and supply loans between one another nationally and internationally.

To give a sense of what is happening within the model, we reintroduce the subscript and superscript notation briefly. Bank *A* in France creates a demand for interbank loans from bank *B in* France ($-L^{B}{}_{b\,A\,d}$) and supplies interbank loans to bank *C* in Germany ($+L^{A}{}_{b\,C\,s}$). Bank B in France creates a demand for interbank loans from bank *D* in Germany ($-L^{D}{}_{b\,B\,d}$) and supplies interbank loans to bank *A* in France ($+L^{B}{}_{b\,A\,s}$). Bank *C* in Germany demands interbank loans from bank *A* in France ($-L^{A}{}_{b\,C\,d}$) and from bank *D* in Germany ($-L^{D}{}_{b\,C\,d}$). Bank *D* supplies loans to bank *B* ($+L^{D}{}_{b\,B\,s}$) and to bank *C* ($+L^{D}{}_{b\,C\,s}$).

Table 2 shows the revaluation matrix for this model. We see two revaluations of fixed capital (K) and bank capital (OF). Capital gains accrue to household wealth, whilst banks' own funds are treated as liabilities. The value of the firm's fixed capital is net of price inflation.

Please insert Table 2 here.

Table 3 shows the flows within the sectors and between countries of this module. A plus sign (+) means the sources of fund, and a minus sign (-) denotes a use of those funds.

Firms have both current and capital accounts. In its current account the firm describes its activities in supplying goods and services *(+C)* to households and the government *(+G)*, and providing net investment (+I). The firm pays taxes *(-T)* on its sales, it pays wages to households (-WB) and pays out interest on its loans –(r.L) while taking account of depreciation costs ($-\delta \cdot K$). The difference between sources and uses of funds in the firm's current account is its profits (*-F),* transferred to households that own equity in the firm.

Households earn wages from firms (+WB), they pay income taxes to the government (-T) and they can, from time to time, default on their loans. Households pay interest *r* on their performing loans.

Each government receives taxes (*+T*) from firms and households and central bank's profits ($+F^{j}_{cb}$) and pays interest on treasury bills supplied to the other sectors locally and to the other country (*-r.B*). The sum of these components determines the public sector borrowing requirements (*PSBR*). As mentioned above, governments of both countries meet their public sector borrowing requirement by issuing new treasury bills (*+ΔB)*.

Each central bank receives interest on their holdings of treasury bills from the domestic government and from the other country's government. The sum of these interest payments is the central bank's profits, and the profits of the central bank are transferred completely to the government. The central bank is assumed to cover new flows of domestic and foreign treasury bills by issuing high powered money (-*ΔH*) to households and to private banks.

Please insert table 3 here.

Private banks, in their current account column, receive interest on their loans to households and firms, interest on their holdings of treasury bills, and pay interest to households for money deposits. Banks also receive and pay interest on their interbank loans. We assume that some households will default on their loans, with the difference between outstanding loans (*L*) and non-performing loans (*NPL*) set to 5% initially. Thus banks receive interest just on performing loans ($+r^{j}_{l\text{-}1}\ (L^{i}_{h\ d\text{-}1}\text{-}NPL)$).

2.2 Model equations

Beyond the balance, transaction, and revaluation matrices, the model-proper is a set of behavioral equations governing the motion of the system. For ease of exposition, we place the full model description within an appendix and present a stripped down version here.

The real output in each country is the sum of households' consumption (*c*), government expenditure (*g*), and investment (*i*). This is equal to the real output of the system expressed as sales, (s).

$$y = s = c + g + i \tag{1}$$

Each firm's pricing decision is a constant mark-up (τ) of the unit cost (*UC*), which in turn is equal to the wage bill (WB) paid per unit of sales (*s*).

$$P = (1 + \tau) * UC \tag{2}$$

$$UC = \frac{WB}{s} \tag{3}$$

The investment decision of each firm is given by the accounting identity of the capital account of the firm. The level of employment in each firm depends upon the volume of sales in previous periods and on the productivity of that firm.

Household income is given as the sum of wages, profits, and interest on financial assets held in the previous period. Disposable income is just household income minus taxes on income and interest servicing on loans and capital gains. Importantly, the household must service some part of its non-performing loans also if it is a defaulter.

We model an income distribution by breaking society in each country into three groups. The first group receives 50% of the disposable income of the nation. This group consumes both from their disposable income (*yd*) and from their wealth built up in previous periods (v_{-1}). Call *Sh1* the first group's 'share' of the country's disposable income. Equation (4) shows the consumption function of the first group of households, with α_1 and α_2 denoting the marginal propensities to consume out of disposable income and past wealth, respectively.

$$c1 = \alpha_0 + sh1.\alpha_1.yd + \alpha_2.v_{-1} \quad (4)$$

The second group in society consumes all their share of disposable income plus new loans (*nl*) obtained from banks.

$$c2 = sh2.yd + nl \quad (5)$$

The third group is made up of those households who consume their share of disposable income, so *c3 = sh3.yd*. We vary the shares of income between groups 2 and 3 as households default and transition to group 3. The shares fluctuate according to the following relation:

$$sh3 = sh3_{-1} + \eta.\Delta\left(\frac{\sum_i^x NPL}{\sum_i^x L_{h\,d}}\right) \quad (6)$$

where

$$sh2 = 1 - sh1 - sh3 \quad (7)$$

Here η just transforms the proportion of non-performing loans to a percentage. Each household makes portfolio decisions based on the ratio of the return on those assets[4]. Cash money makes up a potion of households' consumption; households' demand for loans is equal to the supply of loans to households, and flows of bank equities are determined by the differences between banks' retained earnings and their non-performing loans.

As mentioned above, the government of each country is assumed to use treasury bills and taxes to pay for its expenditure and transfers (interest on treasury bills, *r*, supplied for domestic and foreign markets). Where government expenditure is greater than taxation revenue (*T*) plus the profits of the central bank (*F*), the shortfall

[4] That is, incomes obey Haig-Simons conditions (Godley and Lavoie 2007, pg. 137).

is made up using treasury bills, so in each period $\Delta(B_s) = PSBR$. The public sector borrowing requirement (PSBR) of the country is given by

$$PSBR = G + r_{b-1}.B_{s-1} - (T + F_{cb}) \quad (8)$$

Central banks hold high-powered money, which they supply to households and banks. Central banks also hold treasury bills from both countries. The change in demand for domestic bills is dependent on flows of high-powered money and foreign treasury bills. The central banks' profits are generated by interest earned on treasury bills issued.

Private banks supply credit based on their liquidity and leverage ratios in any given period. Each bank also takes the change in debtor banks' liquidity into account when deciding to make a loan. For Bank *A,* for example, the loan equation is

$$L^A = L^A_{s-1} + \zeta^A_{b1}.(BLR^A - BLR^{AT}) + \zeta^A_{b2}.\Delta BLR^C \quad (9)$$

Banks are able to supply more loans if their liquidity ratio is above a target ratio set by the central bank, and they provide less loans if their liquidity ratio is lower than the target liquidity ratio.

Banks acquire vault cash as a portion of money deposits. The change in banks' own funds or existing equities is equal to the retained earnings after subtracting non-performing loans. Banks' demand for treasury bills is an accounting identity determined in each period by the balance sheet of each bank. The redundant, or the hidden, equation in this model is that the central bank of Germany supplies vault cash to bank *D* on demand.

3. Results

After setting-up our model's equations and identities, to start simulations we need to assign values for all model parameters and stocks. Choosing these values, in part, depends on some plausible stock to flow ratios and parameters (Godley and Cripps, 1982).

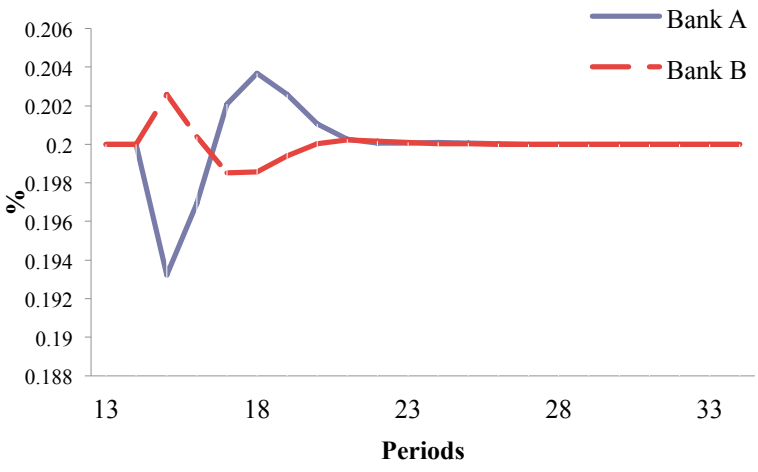
These values must ensure the model convergences, retains its consistency, and is broadly in line with the status quo.

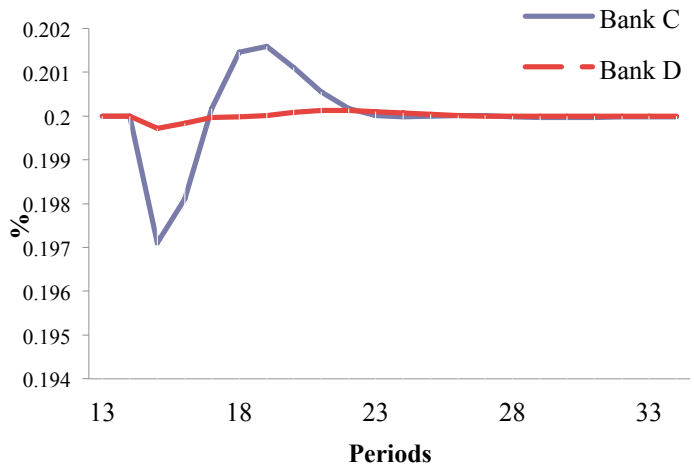
We simulate two different types of shock to the steady state of the system. First, we look at a temporary increase in non-performing loans and the attendant effects on the real economy. Second, we look at a longer run of increasing non-performing loans and the effects it has on the real economy.

3.1 Scenario 1: A temporary increase in non-performing loans

The first scenario assumes a onetime increase in French households' non-performing loans taken from bank *A*. In the baseline scenario it is assumed that the ratio of households default loans forms 5% of the total loans stock. In the first scenario this ratio is assumed to increase in period 15 to reach 10% of total households' loans from bank A.

The charts in Figure 3 tell the story quite well. An increase in non-performing loans leads to an immediate decline in bank *A's* income receipts, which, predictably, effects bank A's own funds negatively. Bank A's demand for treasury bills also suffers, and its liquidity declines, reducing its capability to supply loans to households, firms, and of course to supply loans to the interbank market. The bottom panels in Figure 3 show the evolution of the liquidity ratios of banks *A*, *B*, *C*, and *D* after the increase in non-performing loans in bank *A*.





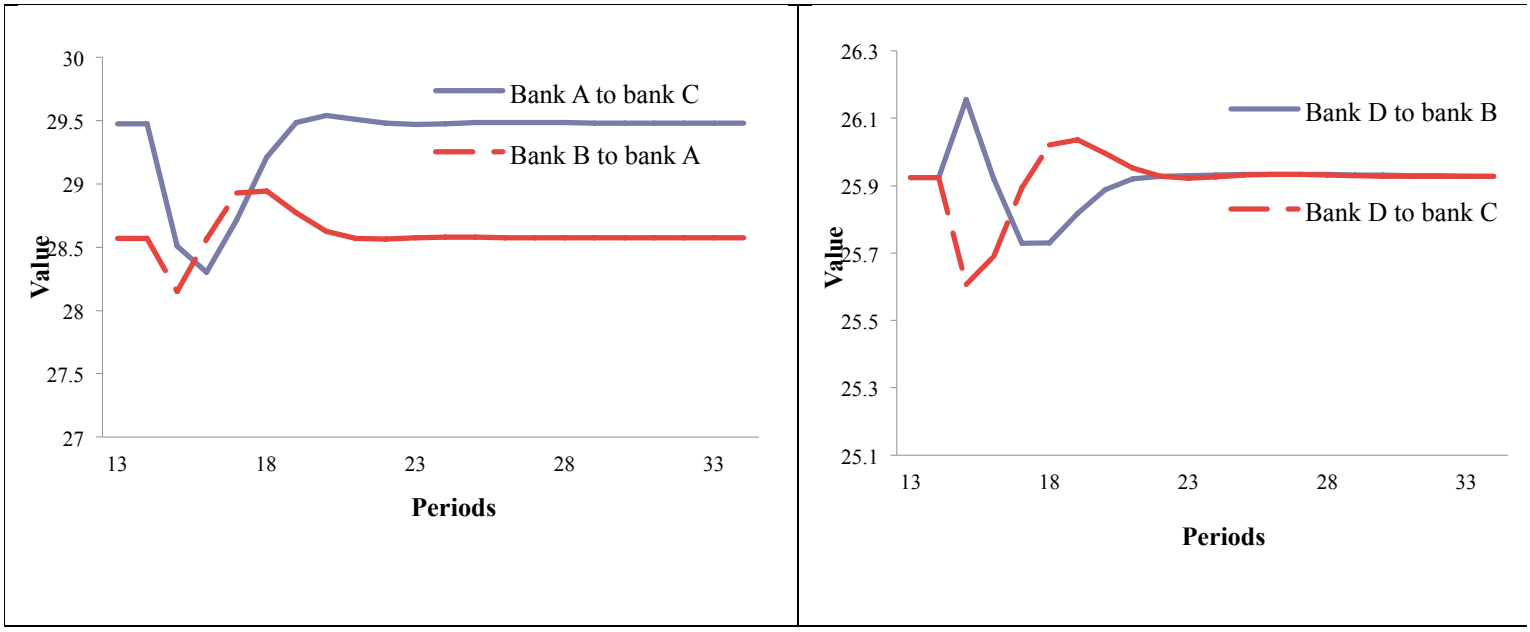


Figure 3: Simulation of a one-time increase in non-performing loans in Bank A in France. Top left panel: evolution of bank liquidity ratios in France. Top right panel: evolution of bank liquidity ratios in Germany. Bottom left panel: *Evolution of interbank loans supply in France. Bottom right panel: evolution of interbank loan supply in Germany.*

We can trace the contagion effects quite clearly. In the interbank loans market, the decline in bank *A's* liquidity ratio forces the bank to reduce the supply of interbank loans to bank *C*. Bank *B* then becomes afraid about bank *A's* solvency, which may affect bank A's capability to fulfill its short and long terms liabilities. Thus bank *B* may be affected. As a consequence, bank *B* decreases its interbank loans supply to bank *A*. To be clear: Bank B's expectations cause the feedback from non-performing loans in Bank A to a further reduction in available credit lines.

We can see the interbank loans supplied in Germany after the increase in bank *A's* non performing loans. The solid line shows the evolution of interbank loans supply of bank *D* to bank *B*. The dash line shows the evolution of interbank loans supply of bank *D* to bank *C*. As shown in the figure, the supply of loans of bank *D* to bank *C* declines due to the decline in bank *C's* liquidity. Bank *C's* liquidity ratio declines due to the decline in the received interbank loans from bank *A*. As a consequence bank *D* decreases its interbank loans to bank *C*. After that, bank *B* decreases interbank loans to bank *A*, its liquidity ratio increases, and due to that interbank loans supplied to bank B by bank *D* increases.

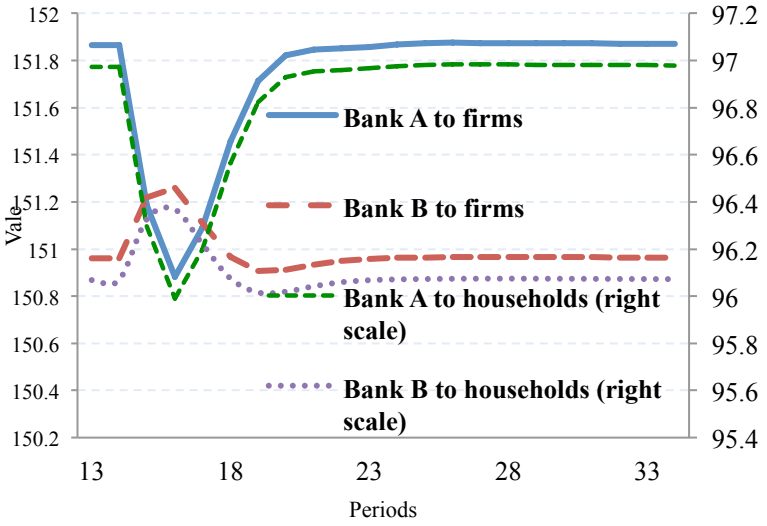
As mentioned above, banks in this model aim to keep their liquidity at a target level set by the central bank. When a bank's liquidity ratio falls below the target, banks decrease loans, causing a credit crunch in the real economy. When a bank's liquidity rises above the target, banks lend more in a credit expansion. In this scenario, decreasing loans supply will lead to an increase in bank liquidity and reach levels above the target. With the increase in bank liquidity, banks start to lend more. After a certain period of time, bank liquidity starts to decline again and thus lending falls, pulling out a rather 'Minskyian' story from this simulation. This process will continue until banks find their liquidity ratio equal to the target liquidity ratio. A credit crunch will affect the domestic economy as well as the foreign economy through the interbank markets in both countries.

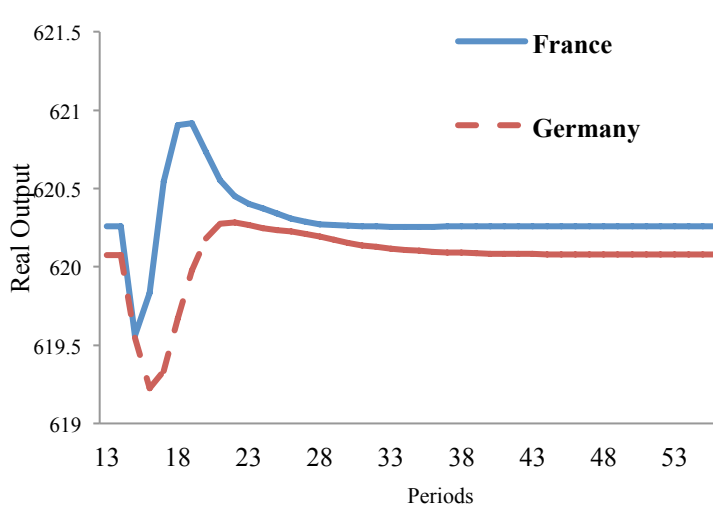
3.1.1 The effects of a credit crunch on the real economy

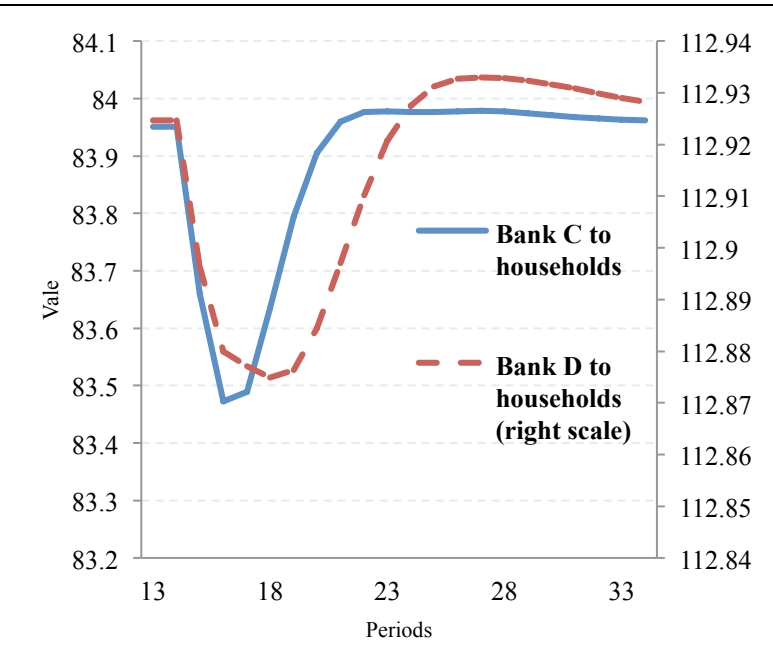
Figure 4 shows the evolution of real output in both countries. We can see that real output declines in both countries immediately after the increase in non-performing loans of bank *A* by households.

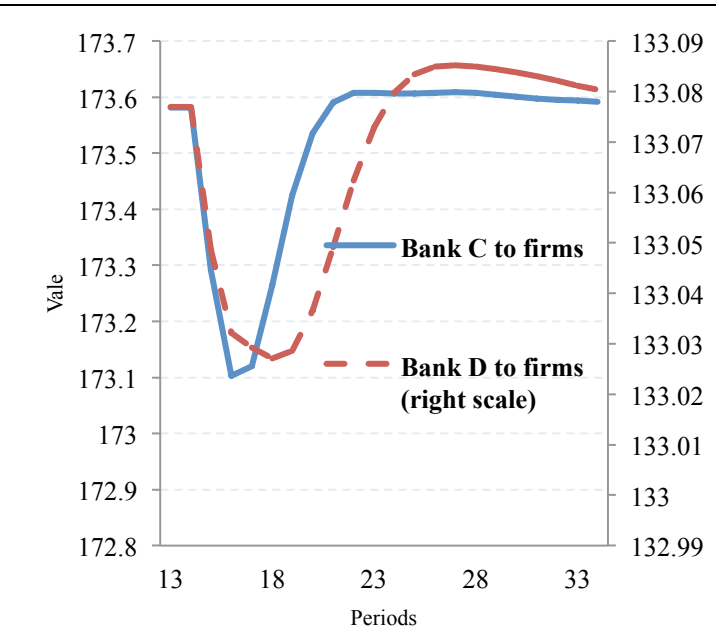
There are two channels through which a credit crunch affects the real economy in both countries in this model. The first is through firms' investments and the second is through households' consumption. The decline in bank *A's* liquidity leads to a decline in its lending to households and firms. The increase in bank *B's* liquidity leads to an increase in its lending to firms and households.

We can also see the evolution of loans supplied by banks *A* and *B* to firms and households in the first country. The solid line in figure 4 is the supply of loans to firms by bank *A*, the dashed line is the supply of loans to firms by bank *B*, the square dotted line is the supply of loans to households by bank *A*, and the round dots line is the supply of loans to households by bank *B*. Clearly once the supply of loans contracts the real economy becomes vulnerable. The lower panel shows the evolution of loans supplied by banks C and D to firms and households in Germany. The rate of increase or decrease in loans supplied clearly follows the liquidity reduction in both countries.


Vale
Periods
Bank A to firms
Bank B to firms
Bank A to households (right scale)
Bank B to households (right scale)


Real Output
Periods
France
Germany


Vale
Periods
Bank C to households
Bank D to households (right scale)


Vale
Periods
Bank C to firms
Bank D to firms (right scale)

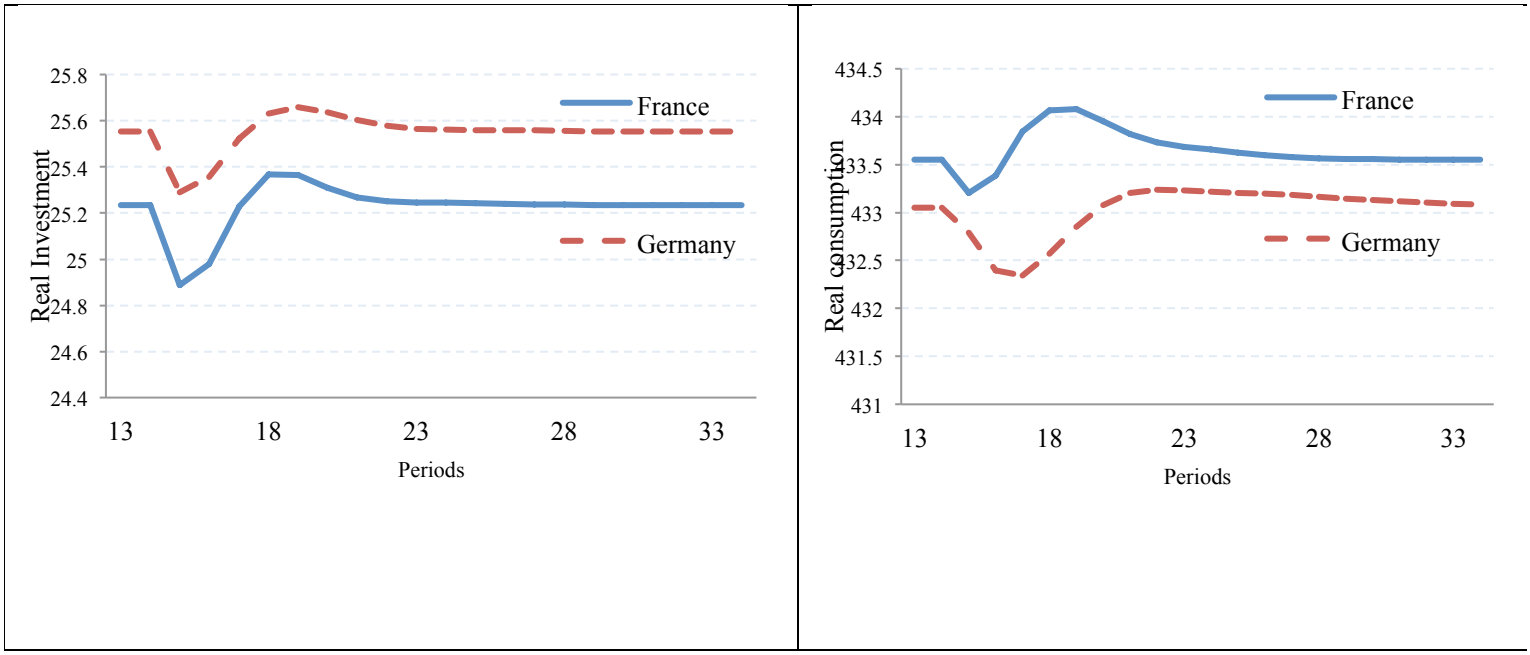


Figure 4. ***Top left panel: loans by Banks A and B to firms and households. Top right panel: evolution of real output in both countries. Middle left panel: lending by banks C and D to households. Middle right panel: lending by banks C and D to firms. Bottom left panel: changes in real investment in both countries. Bottom right panel: changes in consumption in both countries.***

When loans supply to firms decline investment decline and thus output. The other channel that affects real output is household consumption. There are two effects on household consumption, one is direct, the indirect. In this model, income group 2 households are assumed to ask for loans to cover part of their consumption. When loans to households go into decline, the consumption levels of these households will decline too, thus real output falls. This is the direct effect. The indirect effect comes from changes in household disposable income. When loans supplied to firms decline, investment declines and also consumption—a further feedback through the direct effects on consumption. This leads to a decline in firms' sales, which leads to a decline in wages and profits and disposable income. Disposable income declines due to the decline in capital gains—banks' own funds—and increases due to the increase in non-performing loans, but these two elements tend to cancel each other.

These declines in investment, consumption, and output in both continues continue for several periods, then they start to increase again and reach higher levels than the steady state levels following changes in banks' behavior in lending. Subsequently, then, each series starts to decline again towards the steady state levels achieved before the imposition of the shock.

Interest rates in the interbank markets and on loans to firms and to households evolve depending on target bank profits, interest on assets, and stocks of loans supplied. When the rate of non-performing loans increases, banks' own funds tend to decline, so bank liquidity declines, and thus stocks of loans supplied, which leads perforce to a decline in bank profits.

For banks to keep their profits close to their targets, they find themselves needing to increase the interest rates on loans supplied in each period. Figure 5 shows the evolution of interest rates on loans to households and to firms in both countries after a one-time increase in bank *A NPL*.

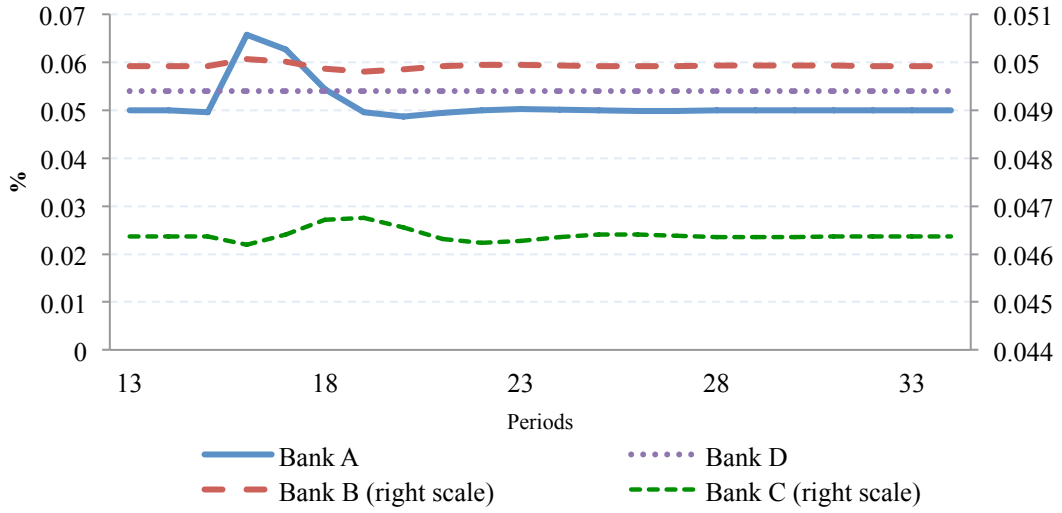


Figure 5: ***Evolution of loans interest rates in both countries.***

As shown in Figure 5, bank *A* increases its interest rates on loans much more compared with the other banks due to the losses that come from the increase in *NPL* non performing loans, besides the change in the stock of loans supplied. The other bank response is mainly due to the change in the stock of loans supplied to the interbank markets and to households and firms. Interest rates on interbank loans follow the same pattern of the interest rates on loans to households and firms.

3.2 The effects of a multi-period increase in non-performing loans

The second scenario assumes an increase in households' non-performing loans from bank *A* for 5 periods starting from period 15. The reason behind this scenario is to see the effect of a several time increase in non-performing loans on the economy, which may allow us to generalize our results. As before, the ratio of non-performing loans as a share of total households demand for loans will increase from 5.0% to 10.0%.

Figure 6 shows the evolution of interbank loans supply in both countries after the increase in non-performing loans of bank *A* (second scenario) compared with an increase in non-performing loans for one time only (our first scenario).

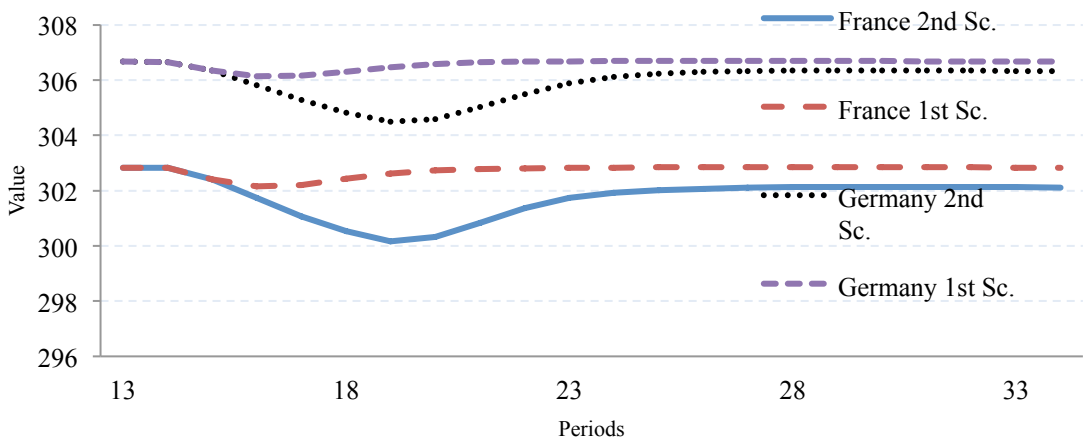


Figure 6. Evolution of loans supplied to firms in both countries in Scenario 1 (single period increase in bad loans) and Scenario 2 (multi-period increase in bad loans).

In this figure, it should be noted that the interbank loan supply is summed for both banks in the country, and not for a specific bank as in figures 4 and 5 above. As shown in figure 6, the effect of a more than one time increase in non-performing loans is pronounced. The credit supply shock has a more negative effect on interbank loans supplied in the second scenario compared with the first scenario in both countries. Thus interbank lending takes more time to return to levels close to the previous levels before the shock in the second scenario compared with the first scenario.

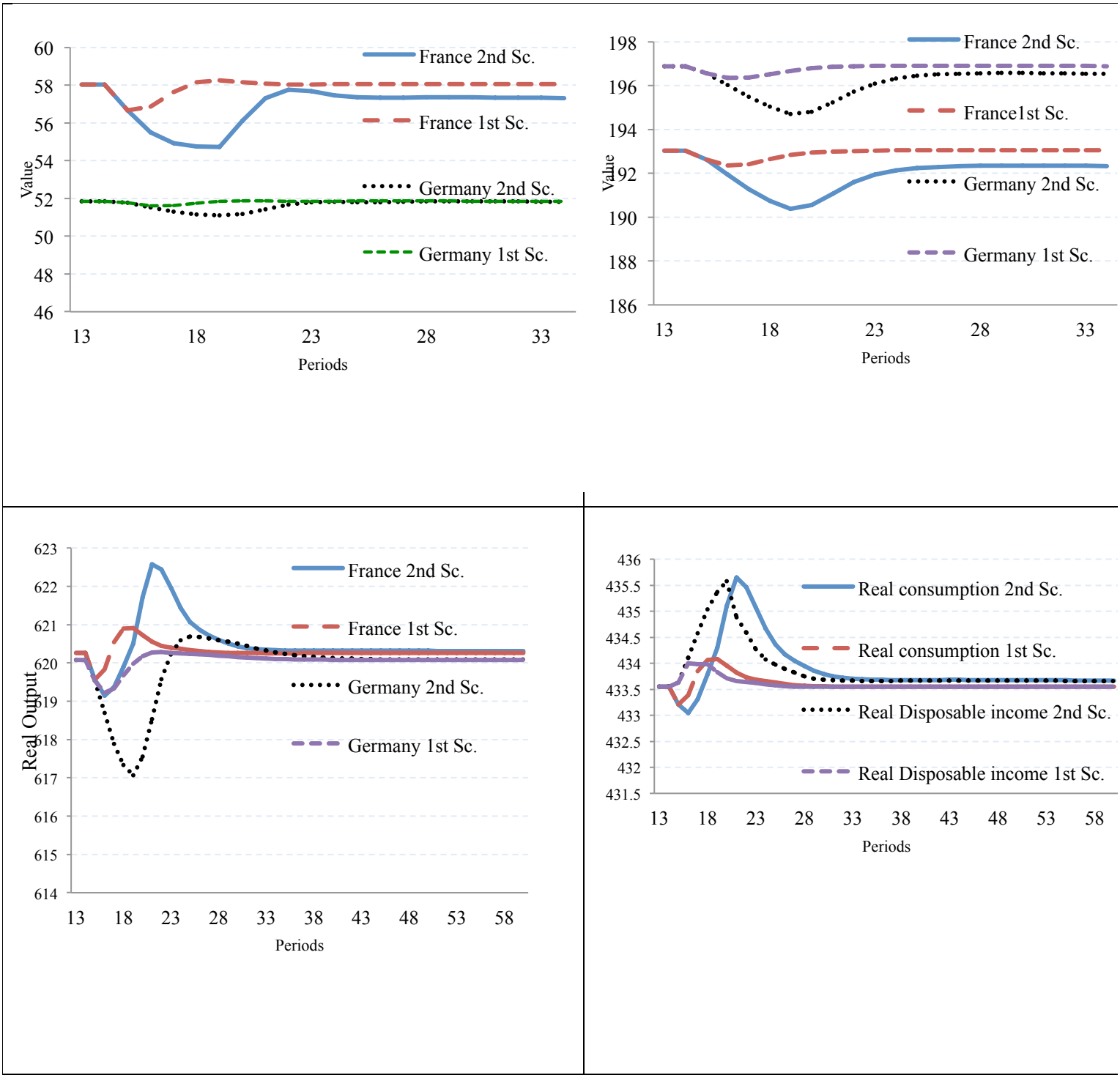


Figure 7. Top left panel: effect of an increase in the non-performing loans of bank *A* on loans supplied to firms in both single and multi-period scenarios. Top right panel: effect of an increase in the non-performing loans of bank *A* on loans supplied to households in both single and multi-period scenarios. Bottom left panel: effect of credit crunch on real output in both single and multi-period scenarios. Bottom right panel: effect of credit crunch on real consumption and disposable income in both scenarios in France.

Figure 7 shows the effect of an increase in the non-performing loans of bank *A* on loans supplied to firms and households in both countries in both scenarios. This increase in non-performing loans in the second scenario has a more negative effect

on loans supply compared with the first scenario in both countries as the case in the interbank lending market.

When non-performing loans increase in bank *A* for more than one period, bank *A* starts facing losses on its own funds. This loss naturally affects bank A's liquidity, which ends up below the target level set by the central bank. This forces bank *A* to decrease loans supplied in the interbank market to households, and to firms to try to regain its liquidity target. The deleveraging attempt causes a marked contraction in real economic output, investment, and consumption, as credit dries up. The continuation of the higher levels of non-performing loans forces bank *A* to continue decreasing loans supplied, period after period. As discussed in the first scenario, bank *A's* credit crunch will spread to the other domestic and foreign banks via the same propagation mechanism.

Figure 7 also shows the real output in both countries in both scenarios. The credit crunch in both countries has bigger effects on real output in the second multi period scenario compared with the first scenario. The evolution of real output follows the evolution of banking behavior in lending both in the interbank lending market and in the domestic market.

We can also show the evolution of real households' consumption and real disposable income in the first country in the case of the second scenario compared with the first scenario. As shown in the figure, real and investment are affected in the second scenario more than in the first scenario. A credit crunch in the first country spreads to the other country, which will have a negative effect on households' real consumption and on real disposable income.

The exchange rate, which mediates between the two economies in the standard fashion, is also adversely affected in the multi-period scenario, as we can see from figure 8.

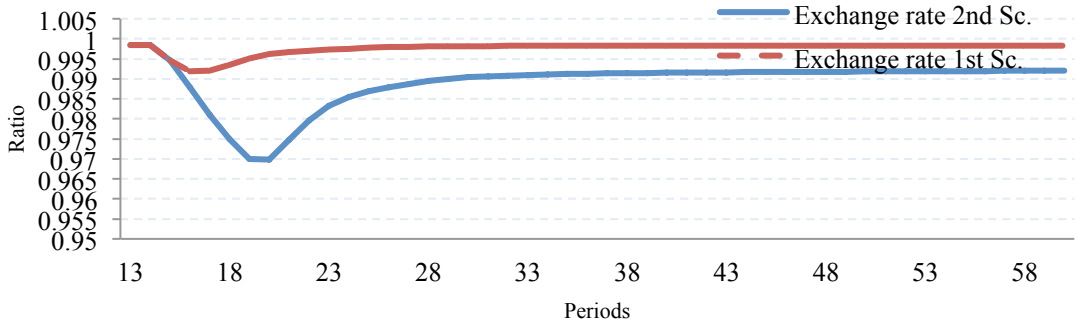


Figure 8. *Evolution of the exchange rate in both scenarios*

4. Conclusion

The aim of this paper is to use simulation to study the effect of a single and multi period increase in non-performing loans in a two-country setting.

The interactions between four private banks are explicitly modeled, as are the effects of two types of credit contraction on the real economy. Through the simulation study, we see the evolution of a series of bad loans on liquidity within banks, between banks, and between the financial and real sectors of the economy.

The model is complex enough to track the flows of liquidity between individual banks, which is the main contribution of the paper.

We find that a single period increase in non performing loans in one bank can be compensated for quite easily by the network of connections represented in this model by the interbank market. When the increase in non-performing loans is long-lived however, interconnection becomes a curse as contagion spreads to undamaged banks. This feeds back into the real economies of both our simulated economies, as a decreased supply of loans, which reduces the real output of each economy in different ways.

In our model we assumed that banks react correctly to the decline in liquidity be squeezing loans supply to keep their liquidity in its target level imposed by the central bank, which led banks to return back to the levels before the shock. This highlights the important role of central banks in regulating and monitoring banks, and provides a direction for future research—what happens when banks do not

react correctly? We will also concentrate on simulating policy responses to the problem of persistent bad debt in bad banks choking good banks.

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Table 1: *Balance Sheet Matrix in France and Germany.*

	Germany						Ex. Rate	France						Sum
	Households	Firms	Gov.	C. Bank	Banks A	Banks B		Households	Firms	Gov.	C. Bank	Banks C	Banks D	
Fixed Capital		$+K^{Ger}$					E_{Ger}		$+K^{Fra}$					ΣK
High Powered Money	$+H^{Ger}{}_{h\,d}$			$-H^{Ger}{}_{s}$	$+H^{A}{}_{b\,d}$	$+H^{B}{}_{b\,d}$		$+H^{Fra}{}_{h\,d}$			$-H^{Fra}{}_{s}$	$+H^{C}{}_{b\,d}$	$+H^{D}{}_{b\,d}$	0
Households Loans	$-L^{A}{}_{h\,d}$				$+L^{A}{}_{h\,s}$			$-L^{C}{}_{h\,d}$				$+L^{C}{}_{h\,s}$		0
	$-L^{B}{}_{h\,d}$					$+L^{B}{}_{h\,s}$		$-L^{D}{}_{h\,d}$					$+L^{D}{}_{h\,s}$	0
Firm Loans		$-L^{A}{}_{f\,d}$			$+L^{A}{}_{f\,s}$				$-L^{C}{}_{f\,d}$			$+L^{C}{}_{f\,s}$		0
		$-L^{B}{}_{f\,d}$				$+L^{B}{}_{f\,s}$			$-L^{D}{}_{f\,d}$				$+L^{II\,2}{}_{f\,s}$	0
Interbank Loans					$-L^{B}{}_{b\,A\,d}$	$+L^{B}{}_{b\,A\,s}$						$-L^{D}{}_{b\,C\,d}$	$+L^{D}{}_{b\,C\,s}$	0
Intrabank loans					$+L^{A}{}_{b\,C\,s}$	$-L^{D}{}_{b\,B\,d}$	E_{Ger}					$-L^{A}{}_{b\,C\,d}$	$+L^{D}{}_{b\,B\,s}$	0
Deposits	$+M^{A}{}_{d}$				$-M^{A}{}_{s}$			$+M^{C}{}_{d}$				$-M^{C}{}_{s}$		0
	$+M^{B}{}_{d}$					$-M^{GerB}{}_{s}$		$+M^{IC}{}_{d}$					$-M^{D}{}_{s}$	0
Bills[1]	$+B^{Ger}{}_{h\,1\,d}$		$-B^{Ger}{}_{s}$	$+B^{Ger}{}_{cb\,1\,d}$	$+B^{I\,1}{}_{b\,d}$	$+B^{B}{}_{b\,d}$	E_{Ger}	$+B^{Ger}{}_{h\,2\,d}$			$+B^{Fra}{}_{cb\,2\,d}$			0
Bills[2]	$+B^{Fra}{}_{h\,1\,d}$			$+B^{Fra}{}_{cb\,1\,d}$			E_{Ger}	$+B^{Fra}{}_{h\,2\,d}$		$-B^{Fra}{}_{s}$	$+B^{Fra}{}_{cb\,2\,d}$	$+B^{C}{}_{b\,d}$	$+B^{D}{}_{b\,d}$	0
Bank Capital	$+OF^{A}$				$-OF^{A}$			$+OF^{C}$				$-OF^{C}$		0
	$+OF^{B}$					$-OF^{B}$		$+OF^{D}$					$-OF^{D}$	0
Balance	$-V^{Ger}$	$-NW^{Ger}{}_{f}$	$-NW^{Ger}{}_{g}$				E_{Ger}	$-V^{Fra}$	$-NW^{Fra}{}_{f}$	$-NW^{Fra}{}_{g}$				ΣK
Sum	***0***	***0***	***0***	***0***	***0***	***0***		***0***	***0***	***0***	***0***	***0***	***0***	***0***

Table 2: *Revaluation Matrix in both economies*

	Germany				France				Sum
	Households	Firms	Banks		Households	Firms	Banks		
			I	II			I	II	
Fixed Capital		$+\Delta p^{Ger}.k^{Ger}_{-1}$				$+\Delta p^{Ger}.k^{Ger}_{-1}$			$\Delta p^{Ger}.k^{Ger}_{-1}.E_1 + \Delta p^{Fra}.k^{Fra}_{-1}$
Bank Capital	$+\Delta OF^{A}$		$-\Delta OF^{A}$		$+\Delta OF^{C}$		$-\Delta OF^{C}$		*0*
	$+\Delta\ OF^{B}$			$-\Delta\ OF^{B}$	$+\Delta\ OF^{D}$			$-\Delta OF^{C}$	*0*

Table 3: *Transactions Flows Matrix in both economies*

Country 1	**Households**	**Firms**		**Gov.**	**C. Bank**	**Banks**				**Ex. Rate**
						A		**B**		
		Current	**Capital**			**Current**	**Capital**	**Current**	**Capital**	
Consumption	$-C^1_d$	$+C^1_s$								
Gov. Expen.		$+G^1_s$		$-G^1_d$						
Investment		$+I^1$	$-I^1$							
Depreciation		$-\delta^1_k . K^1$	$+\delta^1_k . K^1$							
Taxes	$-T^1_h$	$-T^1_f$		$+T^1$						
Wages	$+WB^1$	$-WB^1$								
Entreprene-urial Profits	$+F^1_f$	$-F^1_f$								
Bank Profits	$+FD^A_b$ $+FD^B_b$					$-F^A_b$	$+FU^A_b$	$-F^B_b$	$+FU^B_b$	
CB Profit				$+F^1_{cb}$	$-F^1_{cb}$					
Interest on										
Household Loans	$-r^A_{l-1}.$ $L^A_{h\,d-1}$					$+r^A_{l-1}.$ $L^A_{h\,s-1}$				
	$-r^B_{l-1}.$ $L^B_{h\,d-1}$							$+r^B_{l-1}.$ $L^B_{h\,s-1}$		
Households default loans	$+r^A_{l-1}.$ NPL^A_{-1}					$-r^A_{l-1}.$ NPL^A_{-1}				
	$+r^B_{l-1}.$ NPL^B_{-1}							$-r^B_{l-1}.$ NPL^B_{-1}		
Firm Loans		$-r^A_{l-1}.L^A_{f\,d-1}$				$+r^A_{l-1}.$ $L^A_{f\,s-1}$				
		$-r^B_{l-1}.L^B_{f\,d-1}$						$+r^B_{l-1}.$ $L^B_{f\,s-1}$		
Interbank Loans						$-r^B_{lb-1}.$ $L^B_{b\,A\,d-1}$		$+r^B_{lb-1}.$ $L^B_{b\,A\,s-1}$		
Intrabank Loans						$+r^A_{lb-1}.$		$-r^D_{lb-1}.$		E_1

						$L^{A}_{b\,l\,2\,s-1}$		$L^{D}_{b\,B\,d-1}$		
Deposits	$+r^{A}_{m-1}.M^{A}_{d-1}$					$-r^{l\,1}_{m-1}.$ $M^{l\,1}_{s-1}$				
	$+r^{B}_{m-1}.M^{B}_{d-1}$							$-r^{B}_{m-1}.M^{B}_{s-1}$		
Bills[1]	$+r^{1}_{b-1}.\ B^{1}_{h\,1\,d-1}$			$-r^{1}_{b}.B^{1}_{s-1}$	$+r^{1}_{b-1}.\ B^{1}_{cb\,1\,d-1}$	$+r^{1}_{b-1}.$ $B^{l\,1}_{b\,d-1}$		$+r^{1}_{b-1}.$ $B^{B}_{b\,d-1}$		E_1
Bills[2]	$+r^{2}_{b-1}.\ B^{2}_{h\,1\,d-1}$				$+r^{2}_{b-1}.\ B^{2}_{cb\,1\,d-1}$					E_1
Δ in the stocks of										
Household Loans	$+\Delta L^{A}_{h\ d}$						$-\Delta L^{A}_{h\ s}$			
	$+\Delta L^{B}_{h\ d}$								$-\Delta L^{B}_{h\ s}$	
Firm Loans			$+\Delta L^{A}_{f\ d}$				$-\Delta L^{A}_{f\ s}$			
			$+\Delta L^{B}_{f\ d}$						$-\Delta L^{B}_{f\ s}$	
Interbank Loans							$+\Delta L^{B}_{b\,A\ d}$		$-\Delta L^{B}_{b\,A\ s}$	
Intrabank Loans							$-\Delta L^{A}_{b\,C\,s}$		$+\Delta L^{B}_{b\,D\ d}$	
HPM	$-\Delta H^{1}_{h\,d}$				$+\Delta H^{1}_{s}$		$-\Delta H^{A}_{b\,d}$		$-\Delta H^{B}_{b\,d}$	
Deposits	$-\Delta M^{A}_{d}$						$+\Delta M^{A}_{d}$			
	$-\Delta M^{B}_{d}$								$+\Delta M^{B}_{d}$	
Bills[1]	$-\Delta B^{1}_{h\,1\,d}$			$+\Delta B^{1}_{s}$	$-\Delta B^{1}_{cb\,1\,d}$		$-\Delta B^{A}_{b\,d}$		$-\Delta B^{B}_{b\,d}$	E_1
Bills[2]	$-\Delta B^{2}_{h\,1\,d}$				$-\Delta B^{2}_{cb\,1\,d}$					E_1
Default Loans	$+NPL^{A}$						$-NPL^{A}$			
	$+NPL^{B}$								$-NPL^{B}$	
Σ	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	

Table 3: *Transactions Flows Matrix in both economies (Continued)*

Country 2	Households	Firms		Gov.	C. Banks	Banks				Sum
						C		D		
		Current	Capital			Current	Capital	Current	Capital	
Consumption	$-C^2_d$	$+C^2_s$								0
Gov. Expen.		$+G^2_s$		$-G^2_d$						0
Investment		$+I^2$	$-I^2$							0
Depreciation		$-\delta^2_k . K^2$	$+\delta^2_k . K^2$							
Taxes	$-T^2_h$	$-T^2_f$		$+T^2$						0
Wages	$+WB^2$	$-WB^1$								0
Entreprene-urial Profits	$+F^2_f$	$-F^2_f$								0
Bank Profits	$+FD^C_b$					$-F^C_b$	$+FU^C_b$			0
	$+FD^D_b$							$-F^D_b$	$+FU^D_b$	0
CB Profit				$+F^2_{cb}$	$-F^2_{cb}$					0
Interest on										
Household Loans	$-r^C_{l-1} . L^C_{h\,d-1}$					$+r^C_{l-1} . L^C_{h\,s-1}$				0
	$-r^D_{l-1} L^D_{h\,d-1}$							$+r^D_{l-1} . L^D_{h\,s-1}$		0
Households default loans	$+r^C_{l-1} . NPL^C_{-1}$					$-r^C_{l-1} . NPL^C_{-1}$				0
	$+r^D_{l-1} . NPL^D_{-1}$							$-r^D_{l-1} . NPL^D_{-1}$		0
Firm Loans		$-r^C_{l-1} . L^C_{f\,d-1}$				$+r^C_{l-1} . L^C_{f\,s-1}$				0
		$-r^D_{l-1} . L^D_{f\,d-1}$						$+r^D_{l-1} . L^D_{f\,s-1}$		0
Interbank Loans						$-r^D_{lb-1} . L^D_{b\,C\,d-1}$		$+r^D_{lb-1} . L^D_{b\,C\,s-1}$		0

Intrabank Loans						$-r^{A}_{lb-1}.L^{A}_{b\,C\,d-1}$		$+r^{D}_{lb-1}.L^{D}_{b\,B\,s-1}$		0
Deposits	$+r^{C}_{m-1}.M^{C}_{d-1}$					$-r^{C}_{m-1}.M^{C}_{s-1}$				0
	$+r^{D}_{m-1}.M^{D}_{d-1}$							$-r^{D}_{m-1}.M^{D}_{s-1}$		0
Bills[1]	$+r^{1}_{b-1}.B^{1}_{h\,2\,d-1}$				$+r^{1}_{b-1}.B^{1}_{cb\,2\,d-1}$					0
Bills[2]	$+r^{2}_{b-1}.B^{2}_{h\,2\,d-1}$			$-r^{2}_{b}.B^{2}_{s-1}$	$+r^{2}_{b-1}.B^{2}_{cb\,2\,d-1}$	$+r^{2}_{b-1}.B^{C}_{b\,d-1}$		$+r^{2}_{b-1}.B^{D}_{b\,d-1}$		0
Δ in the stocks of										0
Household Loans	$+\Delta L^{C}_{h\,d}$						$-\Delta L^{C}_{h\,s}$			0
	$+\Delta L^{D}_{h\,d}$								$-\Delta L^{D}_{h\,s}$	0
Firm Loans			$+\Delta L^{C}_{f\,d}$				$-\Delta L^{C}_{f\,s}$			0
			$+\Delta L^{D}_{f\,d}$						$-\Delta L^{D}_{f\,s}$	0
Interbank Loans							$+\Delta L^{D}_{b\,C\,d}$		$-\Delta L^{D}_{b\,C\,s}$	0
Intrabank Loans							$+\Delta L^{A}_{b\,C\,d}$		$-\Delta L^{D}_{b\,B\,s}$	0
HPM	$-\Delta H^{2}_{h\,d}$				$+\Delta H^{1}_{s}$		$-\Delta H^{C}_{b\,d}$		$-\Delta H^{D}_{b\,d}$	0
Deposits	$-\Delta M^{C}_{d}$						$+\Delta M^{C}_{d}$			0
	$-\Delta M^{D}_{d}$								$+\Delta M^{D}_{d}$	0
Bills[1]	$-\Delta B^{1}_{h\,2\,d}$				$-\Delta B^{1}_{cb\,2\,d}$					0
Bills[2]	$-\Delta B^{2}_{h\,2\,d}$			$+\Delta B^{2}_{s}$	$-\Delta B^{2}_{cb\,2\,d}$		$-\Delta B^{C}_{b\,d}$		$-\Delta B^{D}_{b\,d}$	0
Default Loans	$+NPL^{C}$						$-NPL^{C}$			0
	$+NPL^{D}$								$-NPL^{D}$	0
Σ	0	0	0	0	0	0	0	0	0	0