Financial intermediation and the international business cycle *

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Abstract

This paper analyses the role of banks in a small scale flexible price two-country DSGE model. The presence of banks is shown not to alter the standard transmission mechanism by which shocks are transmitted across borders. Banks can have significant effects on the business cycle characteristics of the model when they are an independent source of shocks. A contractionary banking sector shock leads to a depreciation of the terms of trade and an improvement in net trade. The standard transmission mechanism leads to very little cross-country spill-over effects following banking sector shocks that are not internationally correlated. In light of the increased degree of globalization in financial services, we examine the role of bank ownership on the transmission mechanism of banking shocks. Foreign ownership of locally operated banks (where profits flow to the foreign owner) does not increase the international transmission of banking shocks. When foreign ownership implies a common bank capital stock, or a common bank production function for loans, business cycles become highly synchronized following banking sector shocks.

Preliminary and incomplete

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1 Introduction

The recent financial crisis has brought into focus the role of financial shocks as a driver of the business cycle. Christiano *et al.* (2010), Jermann and Quadrini (2009) and Nolan and Thoenissen (2009) have all shown that shocks originating in the financial sector are important and regular drivers of the business cycle. A key feature of the global financial crisis has been the extent to which a shock originated in the US banking sector has affected other major economies.

In this paper, we analyse the effects of introducing a banking sector into an otherwise canonical international real business cycle model (IRBC).

In line with much of the literature, we find that the presence of a banking sector does not significantly amplify or attenuate the transmission of real sector shocks. However, the banking sector plays an important role when it is a source of shocks. In our model, banking shocks are key to understanding the observed cyclical behavior of interest rate spreads. In the IRBC model, the effects of shocks in one country are transmitted to the foreign country via movements in the terms of trade and via the trade balance. We find that a banking sector shock results in a terms of trade depreciation as well as a current account surplus. Importantly, banking sector shocks do not affect the risk sharing properties of the model. As a result, we find that for uncorrelated shocks there are very limited spill-overs from one country to the other. A synchronized decline in economic activity, as observed in the recent financial crisis requires either highly correlated financial sector shocks, or an integrated financial system. We investigate the latter by considering different ownership structures of the financial system. Locally incorporated, but foreign owned banks do not alter the international transmission mechanism. When foreign ownership takes the form of a globally integrated bank, fluctuations arising from banking shocks are showed to be highly correlated between countries. In a related paper, Kollmann et al. (2010) analyze the effect of the presence of a global bank, however, they do not take into account the effects of international relative prices on the transmission mechanism.

The remainder of the paper is organized as follows. Section 2 provides some intuition on how we introduce financial intermediation into the IRBC model. Section 3 describes the model in some detail, while section 4 summarizes our baseline calibration.

Section 5 analyses the dynamic behaviour of the models. Finally, section 6 concludes.

2 Introducing banks into the IRBC model

Our model departs from the canonical IRBC model through the introduction of a competitive banking sector. This section briefly describes how we account for financial intermediation in the IRBC model. As in the standard model, agents (or consumers), who are separate entities from banks, smooth consumption across time by buying and selling deposits in a global market for savings. Banks in both countries have access to this pool of savings and purchase liabilities in order to make loans to firms. In the case where financial intermediation is costless, this framework collapses back to the canonical IRBC model. The net foreign asset position is simply the difference between the amount of savings undertaken by consumers and the amount of borrowing undertaken by banks. When domestic agents have more assets with the global bank than the domestic banking sector has liabilities, the economy as a whole has a positive net foreign asset position.

When financial intermediation uses real resources, competitive banks create a spread between the interest rate they pay on their liabilities and the one they charge on their assets. Banks charge a mark-up over the cost of borrowing from the global market for savings to cover their operating costs. There are several ways of modeling costly financial intermediation but there is no consensus on the matter in the literature. We explore two of them. First we adopt a banking technology model, similar to the ones put forward by Benk et al. (2010). In their approach, deposits are combined with labour effort to produce loans. The spread between loans and deposits is determined by the marginal cost of producing a loan. The second model of banking we analyse is related to the one put forward by Gerali et al. (2010). Here, bank loans are made with both deposits and bank capital. Banks face a cost when the bank capital to loans ratio deviates from some exogenously determined value.

Since borrowing from banks is more expensive then borrowing directly from agents, we have to introduce into the model a mechanism that encourages firms to finance at least part of their capital purchases via the banking sector. This mechanism creates a demand for loanable funds. There are several mechanisms to model the demand for bank loans. In the model presented below, bank loans provide more than just a liquidity service, such that firms choose to finance a proportion of their desired capital stock via the banking sector.

3 The model economy

We adopt a canonical international real business cycle model with banks. There are two countries, of equal size. Consumers in both countries smooth consumption by trading in risk-less, non-state contingent bonds denominated in units of home country produced intermediate goods. Consumers supply labour and are the owners of intermediate and final goods producers; they also own part or all of the banking sector. For expositional purposes, we split up the production side of the economy into final goods producers, who hire labour and rent capital from competitive capital goods producers. Capital goods producers require bank funding to turn purchased investment goods into new capital stock. We analyse two alternative ways of modelling the banking sector. First, we assume that banks face a technology constraint that requires deposits to be combined with labour to produce loans. In this case, the interest rate charged on loans will always exceed that on deposits, and the interest rate spread is a function of, among others, an exogenous banking technology shock. The second way we model financial intermediation assumes that banks have to maintain a stock of capital, accumulated from retained earnings, that is proportionate to the amount of lending undertaken. Deviations from the loans-to-capital ratio are costly. As a direct source of variation in the spread of loans over deposits, we assume the presence of an exogenous shock that affects the loans-to-capital ratio.

3.1 Households

Households in both countries are symmetric, so the exposition below focuses only on the behaviour of home country agents. The representative household owns all the other actors in the economy. Households consume final consumption goods, supply labour to the intermediate good firms and hold deposits in a global bank. The expected utility of the household is defined over consumption and leisure:

$$E_0 \sum_{t=0}^{\infty} \beta^t U(c_t, l_t) \tag{1}$$

and each period the household faces the following budget constraint:

$$c_t + d_t \frac{P_{H,t}}{P_t} = w_t l_t + (1 + r^d_{t-1}) d_{t-1} \frac{P_{H,t}}{P_t} \Psi(d_{t-1} - D_{t-1}) + T_t \tag{2}$$

where c_t is the total consumption of households, d_t are the deposits of households denominated in terms of home produced consumption good, $P_{H,t}$ is the price of home-produced goods and P_t is consumption price index. The term Ψ reflects portfolio adjustment costs and depends on the difference between the total deposits of domestic households to the global bank (d_t) and the domestic bank's borrowing from the global bank (D_t). T_t represents dividend transfers from the household's ownership of the rest of the economy.

3.1.1 Timing assumptions

Note the timing assumption of the interest rate on deposits. The agent's decision on how much to save in period t depends on the interest rate available in the spot market on savings (deposits) in period t. $(1 + r^d_t)$ is the total return to one unit of savings held in the form of deposits between periods t and $t+1$. This timing convention differs slightly from the case where the agent accumulated capital directly, because in that case, what matters for today's savings decision is the return that those savings will yield when the capital becomes productive, which is one period later.

3.2 Goods producers

Goods producers combine rented capital and labour to produce an intermediate output. Profits of the goods producing firm are defined as follows:

$$\pi^G_t = \frac{P_{H,t}}{P_t} y_t - w_t l_t - \rho_t k_t \tag{3}$$

and are maximised subject to the production function:

$$y_t \leq A_t {k_t}^{\alpha} l_t^{1-\alpha} \tag{4}$$

where A_t, is the total factor productivity and k_t is the capital stock.

Home and foreign-produced intermediate goods are combined to produce final consumption and investment goods. Consumers and capital producers in the two countries display home bias in the way they combine home and foreign intermediate goods. The home bias in consumption, causes the consumption-based real exchange rate to deviate from purchasing power parity. Home bias in investment, that differs from home bias in consumption endogenizes the relative price of investment goods, see Basu and Thoenissen (2011).

Home consumption and investment goods are produced according to following CES production function using domestic (c_H) and foreign (c_F) produced intermediate goods:

$$c_t = \left[\gamma^{\frac{1}{\theta}} c_{H,t}^{\frac{\theta-1}{\theta}} + (1-\gamma)^{\frac{1}{\theta}} c_{F,t}^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}} \tag{5}$$

$$x_t = \left[\eta^{\frac{1}{\varepsilon}} x_{H,t}^{\frac{\varepsilon-1}{\varepsilon}} + (1-\eta)^{\frac{1}{\varepsilon}} x_{F,t}^{\frac{\varepsilon-1}{\varepsilon}} \right]^{\frac{\varepsilon}{\varepsilon-1}} \tag{6}$$

where consumption and investment home bias implies that $\gamma > \gamma^*$ and $\eta > \eta^*$

3.3 Capital producers

Capital producers are owned by the agents and are recipients of the agent's savings through the local banks. They turn deposits into capital stock. The representative capital producer maximises cashflow (income less investment expenditures)

$$\pi^K = \rho_t k_t - \frac{P_{x,t}}{P_t} x_t + \frac{P_{H,t}}{P_t} q_t - (1 + r^q_{t-1}) \frac{P_{H,t}}{P_t} q_{t-1} \tag{7}$$

subject to the law of motion of the capital stock, which is subject to adjustment costs and an investment specific technology shock:

$$k_{t+1} = (1-\delta) k_t + \epsilon_t \phi \left(\frac{x_t}{k_t} \right) k_t \tag{8}$$

To motivate the existence of banks, we introduce a constraint that links the amount of borrowing by firms to next period's desired capital stock. Our rationale for this assumption is that banks, in addition to providing funds, provide a service to capital goods producers that is in some way useful. In particular, we assume that borrowing in period t is in proportion to the amount of capital that is produced in period t for use in the following period.

$$q_t = \chi k_{t+1} \tag{9}$$

The representative firm's optimisation exercise yields the following capital-Euler equation:

$$\frac{\beta\lambda_{t+1}}{\lambda_t}\left[\rho_{t+1}+\varphi_{t+1}(1-\delta)-\chi(1+r_t^q)\frac{P_{H,t+1}}{P_{t+1}}\right]=\varphi_t-\chi\frac{P_{H,t}}{P_t} \tag{10}$$

where λ_t is the marginal utility of consumption of the firm's owner (the consumer), φ_t is interpreted as Tobin's q and $(1+r_t^q)$ is the price of loans. As long as financial intermediation is costly and r^q exceeds r^d (the rate at which which the agent can access the bond market), χ exerts a drain on the economy, as the marginal product of capita, ρ, rises with χ.

3.4 Banks with production functions

Following Benk et al. (2010), we put forward a simple model of a bank that requires both liabilities in the form of loans from the global bank as well as domestic labour to produce loans for firms. The cashflow of the representative bank can be expressed as:

$$\pi_t^B=(1+r_{t-1}^q)q_{t-1}\frac{P_{H,t}}{P_t}-q_t\frac{P_{H,t}}{P_t}+D_t\frac{P_{H,t}}{P_t}-(1+r_{t-1}^d)D_{t-1}\frac{P_{H,t}}{P_t}\Psi(d_{t-1}-D_{t-1})-w_tl_{b,t} \tag{11}$$

where w_t is the economy wide wage rate and $l_{b,t}$ is labour effort in banking. Each period, the bank makes loans to firms, q_t, and firms repay these loans with interest r^q on period in arrears. Likewise, banks' borrowing from the capital market in period t is denoted D_t and the repayment of the previous period's borrowing is denoted with $(1+r_{t-1}^d)D_{t-1}$.

Banking technology is captured by a Cobb-Douglas production function defined over bank liabilities, D and bank labour.

$$q_t\leq(A_{b,t}l_{b,t})^{\gamma}D_t^{1-\gamma} \tag{12}$$

Our bank also faces a balance sheet constraint, which equates assets and liabilities:

$$q_t=D_t \tag{13}$$

The bank's optimisation problem yields the following expression for the spread of the loan rate over the capital market rate that the bank charges firms:

$$\frac{\beta\lambda_{t+1}}{\lambda_t}\frac{P_{H,t+1}}{P_{t+1}}\frac{P_t}{P_{H,t}}\left[(1+r_t^q)-(1+r_t^d)\Psi(d_t-D_t)\right]=w_t\frac{l_{b,t}}{q_t} \tag{14}$$

which implies that the discounted spread is a function of the marginal cost of producing a loan. Using the production function along with the constraint, we can express the discounted spread as:

$$\frac{\beta\lambda_{t+1}}{\lambda_t}\frac{P_{H,t+1}}{P_{t+1}}\frac{P_t}{P_{H,t}}\left[(1+r_t^q)-(1+r_t^d)\Psi(d_t-D_t)\right]=w_t\frac{1}{A_{b,t}} \tag{15}$$

The spread increases if there is an increase in the economy-wide wage. This typically implies a a pro-cyclical spread of the loan rate over the rate on bank liabilities and causes the banking sector to act not as a financial accelerator in the Bernanke and Gertler (1989) sense, but as an attenuator, at least when the model is driven by TFP shocks. The spread also increases when there is a decline in banking sector labour productivity. Because of the binding balance sheet constraint, an decrease in the banking sector's labour productivity increases that sector's demand for labour and reduces the amount of labour available in the goods producing sector.

3.5 Banks with capital

Our second model of financial intermediation broadly follows Gerali et al. (2010). Unlike our first model of financial intermediation, banks in this model have to maintain a stock of bank capital.The representative bank's cash flow is:

$$\pi_t^B=\frac{P_{H,t}}{P_t}\left(\begin{array}{c}(1+r_{t-1}^q)q_{t-1}-q_t+D_t-(1+r_{t-1}^d)D_{t-1}\Psi(d_{t-1}-D_{t-1})\\+K_t^b-K_{t-1}^b-\frac{\kappa}{2}\left(\frac{K_t^b}{q_t}-v_t\right)^2K_t^b\end{array}\right) \tag{16}$$

and the its balance sheet constraint:

$$q_t=D_t+K_t \tag{17}$$

which states that in period t, the bank loans cannot exceed the sum of deposits and available bank capital. A cost is incurred if the bank equity share in period t's lending differs from the prescribed ratio, v_t. We treat v_t as a stochastic process that, analogous to $A_{b,t}$ in the the previous subsection, contributes to the volatility of the loan spread.

The bank takes as given the law of motion of the capital stock:

$$K_t = \left(1 - \delta^B\right) K_{t-1} + \omega \pi_t^B \tag{18}$$

where δ^B reflects costs associated with the management of the capital stock. A fraction ω of bank profits is retained and used to augment the capital stock. The remainder is transferred to the owners of the bank as a dividend.

Combining the first order conditions of the bank's problem gives a relationship relating the spread between loan and borrowing (deposits) rates and deviations in the equity to loan ratio.

$$\frac{\beta\lambda_{t+1}}{\lambda_t}\frac{P_{H,t+1}}{P_{t+1}}\frac{P_t}{P_{H,t}}\left((1+r_t^q) - (1+r_t^d)\Psi(B_t)\right) = -\kappa\left(\frac{K_t}{q_t} - v_t\right)\left(\frac{K_t}{q_t}\right)^2 \tag{19}$$

Deviations in the equity to loan ratio of banks affect profits contemporaneously, but do not affect the interest receipts and payments accruing in period t, instead, they affect today's spot market price for loans and deposits, which accrue to the owners of the bank in the following period. Hence, we discount the loan to deposit spread with the stochastic discount factor of the bank's owners which also includes changes in the terms of trade.

3.6 Current account

Substituting the goods, capital and banking sector profits into the consumer's budget constraint yields the standard current account equation and illustrates how the consumer's deposits and the banking sector's borrowing from the capital market are related to the net foreign asset position of our model economy. The agent's budget constraint can be written as:

$$c_t + d_t\frac{P_{H,t}}{P_t} = w_t l_t + (1+r_{t-1}^d)d_{t-1}\frac{P_{H,t}}{P_t}\Psi(d_{t-1} - D_{t-1}) + \pi_t^G + \pi_t^K + \pi_t^B \tag{20}$$

Using (3), (7) and (11) we obtain:

$$c_t + \frac{P_{x,t}}{P_t}x_t + B_t\frac{P_{H,t}}{P_t} = \frac{P_{H,t}}{P_t}y_t + (1+r_{t-1}^d)B_{t-1}\frac{P_{H,t}}{P_t}\Psi(B_{t-1}) \tag{21}$$

where $B_t = d_t - D_t$ is the net foreign asset position of the home country. A country's net foreign asset position is the difference between the consumer's deposits with the global bank and the domestic bank's borrowing from the global bank.

3.7 Market equilibrium

At the equilibrium both home and foreign produced intermediate goods market clear:

$$y_t = c_{H,t} + c^*_{H,t} + x_{H,t} + x^*_{H,t} \tag{22}$$

$$y^*_t = c_{F,t} + c^*_{F,t} + x_{F,t} + x^*_{F,t} \tag{23}$$

The balnce sheet identity for the global bank requires that the total amount of home and foreign houshold's deposits should equate total loans of the global bank to the local banks.

$$d_t + d^*_t = D_t + D^*_t \tag{24}$$

4 Solution and Calibration

In this section we outline our calibration of the structural parameters and shocks processes. We assume that home and foreign countries are of the same size and that both countries are symmetric in terms of their structural parameters. Our time period is one quarter. Table 1 reports the calibrated parameters.

The discount factor is set to 0.99, implying an annual interest rates on deposits of 4% in both countries. We adopt the following functional form for the period utility function:

$$U(c_t, l_t) = \frac{c_t^{1-\sigma}}{1-\sigma} - \eta_l \frac{l^{1+\eta}}{1+\eta} \tag{25}$$

We assume a log-utility function in consumption by setting $\sigma = 1$. The Frisch elasticity of labor supply is set to 1 and we calculate η_l to have households spending 1/3 of their time at work at the steady state. In the model with banks using labour, we follow Goodfriend and McCallum (2007) and impose that 1.9% of total hours are spent in the banking sector.

In our baseline calibration, we assume the same level of home bias in consumption and investment and set the share of home-produced intermediate goods in total consumption and investment to 0.88, the value used in Thoenissen (2011). The intratemporal elasticity of substitution between home and foreign-produced intermediate goods both in consumption and investment, is set to 1. In the production function, the elasticity of output to labor is set to 0.64 while the depreciation rate is set to 0.025, its standard value in the literature. We determine the value of the capital adjustment cost parameter in order to match the observed relative volatility of investment under our baseline calibration. The literature considers a large range of values for the parameters governing the loan to value ratio. In our baseline calibration we set $\varkappa$ to 0.9 and check the sensitivity of our results for alternative values.

For the model with financial intermediaries using labour, we set the steady state of labour productivity in the banking sector so that the yearly steady state spread is 2%. For the model with financial intermediaries using bank capital, we use the US data on total equity to total assets ratio of commercial banks to calibrate the steady state ratio of bank capital to loan ratio. Accordingly, the parameter v is set to 8%, its mean value over 1988-2010 period. Following Gerali et al., we set κ to 10 in our baseline calibration, and check the sensitivity our results to various values of this parameter. Finally we assume that 90% of bank profits are reinvested in bank capital and set ω to 0.9. The value of δ_b is derived from the steady state relationships and equals 0.009 implying that the bank capital depreciates in an annual rate of roughly 4%.

All the exogenous variables in our model are assumed to follow AR(1) processes. We set their persistence and the volatility using quarterly data on US for the sample covering 1986Q1-2009Q4. Accordingly we calculate the persistence of TFP process to be 0.7388 and its volatility to be 0.0056. We construct our data for the relative price of investment for US by dividing the price deflators for durable goods and investment by non-durable goods price deflator. The persistence of linearly detrended relative price of investment is 0.88 and the standard deviation of the shock is 0.0062.

We calibrate banking sector shocks in order to match the observed volatility of interest rate spreads in US. Following Kollmann *et al.* (2010), our measure of spread is the commercial and industrial spreads over the intended federal fund rates for all

Table 1: Calibration

Parameter	Description	Value
β	Discount Factor	0.99
σ	Elasticity of intertemp. substitution	1
η	Labour supply elasticity	1
θ	Elasticity of substitution btw. consumption goods	1
κ	Elasticity of spread to capital to loan ratio	10
γ	Home bias in consumption	0.88
η	Home bias in investment	0.88
v	Steady state capital to loan ratio	0.08
ω	Bank's dividend policy	0.9
δ_b	Bank capital depreciation rate	0.009
l_b	Steady state labour in the banking	1.9%
ρ_A	Persistence: Technology shock	0.7388
σ_A	Standard deviation: Technology shock	0.0056
ρ_i	Persistence : Relative price of investment shock	0.88
σ_i	Standard deviation : Relative price of investment shock	0.0062
ρ_{A_b}	Persistence : Banking labour productivity shock	0.9
σ_{A_b}	Standard deviation : Banking labour productivity shock	0.2
ρ_v	Persistence : Capital to loan ratio shock	0.9
σ_v	Standard deviation : Capital to loan ratio shock	0.2

loans. The relative standard deviation of interest rate spreads with respect to GDP is 0.16. This implies that the standard deviation of our banking shocks is 0.2.

As the main motivation is to investigate the international transmission of shocks, contrary to the standard calibration strategy in the international business cycle literature, we assume that the shocks processes are uncorrelated across countries.

5 Model dynamics

We compare three versions of our model economy: our two banking models as well as the canonical IRBC model (which is nested version of the banking models when χ is zero). Table 2 presents the second moments generated by our models assuming the baseline calibration. Driven by TFP, IST and banking shocks, the models come close to replicating the relative volatility of the financial intermediation margin and generate realistic volatilies for GDP and its components. The models somewhat underpredict the standard deviation of GDP and they are not able to characterize well the cyclical

Table 2: Second Moments (All shocks)

	Data	IRBC	Labour Bank	Capital Bank
Standard deviations				
σ_y	1.15	0.84	0.89	0.86
σ_c/σ_y	0.82	0.61	0.76	0.70
σ_x/σ_y	4.35	4.35	5.85	4.76
σ_n/σ_y	1.59	0.51	0.56	0.57
σ_w/σ_y	0.89	0.63	0.63	0.63
σ_{tot}/σ_y	1.48	0.97	1.13	1.14
σ_{nx}/σ_y	0.24	0.61	0.77	0.73
σ_{sp}/σ_y	0.16	NaN	0.15	0.15
Correlations				
$Corr(c, y)$	0.90	0.30	0.07	0.19
$Corr(x, y)$	0.87	0.84	0.79	0.81
$Corr(n, y)$	0.89	0.77	0.76	0.74
$Corr(w, y)$	-0.17	0.91	0.77	0.87
$Corr(tot, y)$	0.38	0.31	0.17	0.21
$Corr(nx, y)$	-0.41	-0.22	-0.24	-0.21
$Corr(sp, y)$	-0.43	NaN	-0.32	-0.17
Cross Correlations				
$Corr(y, y^*)$	0.66	0.16	0.20	0.18
$Corr(c, c^*)$	0.51	0.04	0.03	0.03
$Corr(rs, c/c^*)$	-.49	0.99	0.99	0.98

characteristics of the labour market. While they slightly underestimate the volatility of terms of trade, the model generated net export dynamics seem to be more volatile.

In terms of correlations, the models underpredict the procyclicality of consumption and completely fail to account for the countercyclicality of real wages. However the models correctly characterise the cyclical behaviour of terms of trade, net foreign assets and spread. Being essentially an IRBC model, the banking sector does not affect the risk sharing properties of the model. Consequently, all models have a unitary correlation between the real exchange rate and relative consumption.

5.1 The role of banks

In order to analyze the effect of introducing a financial sector into a two-country business cycle model, we first simulate our suite of models under TFP shocks and then add more shocks later on. Table 3 displays the second moments of the models

Table 3: Second Moments (Only TFP shocks)

	Data	IRBC	Labour Bank	Capital Bank
Standard deviations				
σ_y	1.15	0.81	0.80	0.81
σ_c/σ_y	0.82	0.33	0.36	0.34
σ_x/σ_y	4.35	3.11	3.30	3.07
σ_n/σ_y	1.59	0.32	0.30	0.31
σ_w/σ_y	0.89	0.63	0.65	0.64
σ_{tot}/σ_y	1.48	0.65	0.70	0.67
σ_{nx}/σ_y	0.24	0.32	0.29	0.31
σ_{sp}/σ_y	0.16	NaN	0.00	0.00
Correlations				
$Corr(c, y)$	0.90	0.97	0.98	0.97
$Corr(x, y)$	0.87	0.99	0.99	0.99
$Corr(n, y)$	0.89	0.99	0.98	0.98
$Corr(w, y)$	-0.17	1.00	1.00	1.00
$Corr(tot, y)$	0.38	0.68	0.68	0.67
$Corr(nx, y)$	-0.41	-0.23	-0.25	-0.24
$Corr(sp, y)$	-0.43	NaN	0.99	0.31
Cross Correlations				
$Corr(y, y^*)$	0.66	0.03	0.05	0.04
$Corr(c, c^*)$	0.51	0.05	0.05	0.05
$Corr(rs, c/c^*)$	-.49	1.00	1.00	1.00

when the only stochastic driving force is the TFP shock. The key finding from this exercise is that the cyclical properties of our banking models are indistinguishable of those generated by the IRBC model. As Figure 1 illustrates, the propagation of uncorrelated productivity shocks is not qualitatively affected by the introduction of a banking sector. Also the international transmission of uncorrelated shocks remains low in all models. Even though, we assume incomplete financial markets, consumption risk sharing, as proxied for by the correlation between relative consumption and the real exchange rate, appears to be perfect.

Moreover, the banking models are not able to generate the observed volatility of the spread. This suggests that the impact of macroeconomic fluctuations on the spread via the banking sector is small. Additionally, when the models are only driven by technology shocks, they imply a procyclical spread.

In the model with banks using labour, the increase in the real wage puts an upward pressure on the marginal cost of producing additional loans which raises the spread (see equation (15)).

In the model with bank capital, the spread is determined by deviations in the loan to equity ratio. As the demand for loans is linked the desired capital stock, a positive productivity shock increases bank lending relative to the existing bank capital stock. This raises the spread. In Figure 1, a TFP shock implies a depreciation of the terms of trade, measured as the price of foreign relative to the home-produced intermediate good. The depreciation of the terms of trade adversely affects the profitability of the banking sector, as bank profits are denominated in terms of units of home-produced intermediate goods, and leads to a decline in bank capital (relative to loans). Combined with the increased demand for loans, the optimal behavior of the bank is to raise the spread.

5.2 The transmission of banking shocks

As the previous section made clear, the banking sector does not provide a strong amplification or indeed attenuation mechanism. This result is in line with the findings from the financial accelerator literature. As the recent Great Recession has shown, the banking sector is not just as conduit, but also as a source of business cycle fluctuations. Accounting for this may bring our model closer to the data. Table 4 shows the simulation results of the banking models when they are only driven by shocks originating in the financial sector. We analyze two different types of banking shocks. In the model with monitoring effort, the shock is defined as a perturbation to the labour productivity in the banking sector (see equation (15)). In the model with bank capital, the shock is defined as a transitory deviation of loan to equity ratio from its target level (see equation (19)).

The banking shock on its own does not generate sufficient volatility in output but comes close to matching the (absolute) volatility of investment. Relative to GDP, all the other key macroeconomic variable seem to be more volatile when the models are simulated with banking shock alone. In particular, the banking shock generates highly volatile spread dynamics.

In terms of correlations, the banking shock induces countercyclical consumption

Table 4: Second Moments (Only banking shocks)

	Data	IRBC	Labour Bank	Capital Bank
Standard deviations				
σ_y	1.15		0.31	0.15
σ_c/σ_y	0.82		1.45	1.90
σ_x/σ_y	4.35		11.16	11.81
σ_n/σ_y	1.59		0.99	1.54
σ_w/σ_y	0.89		0.52	0.53
σ_{tot}/σ_y	1.48		1.91	3.45
σ_{nx}/σ_y	0.24		1.59	2.34
σ_{sp}/σ_y	0.16		0.41	0.88
Correlations				
$Corr(c, y)$	0.90		-0.85	-0.85
$Corr(x, y)$	0.87		0.93	0.94
$Corr(n, y)$	0.89		0.93	0.93
$Corr(w, y)$	-0.17		-0.60	-0.32
$Corr(tot, y)$	0.38		-0.50	-0.64
$Corr(nx, y)$	-0.41		-0.39	-0.29
$Corr(sp, y)$	-0.43		-0.96	-0.98
Cross Correlations				
$Corr(y, y^*)$	0.66		0.24	0.22
$Corr(c, c^*)$	0.51		-0.01	-0.07
$Corr(rs, c/c^*)$	-.49		0.98	0.98

dynamics. Since expansionary banking shocks reduce the spread and cause a large boom in investment, consumption is crowded out while income rises. Like the final consumption good, the final investment good is subject to home bias. Therefore, the boom in domestic investment leads to an increase in the relative price of home-produced good and thus an appreciation of the terms of trade (see figure 3).

The recent financial crisis has been associated with a simultaneous increase in the spread as well as a depreciation of the US terms of trade (see Figure 5). The data also shows (see Figure 6) an improvement in the net exports during the great recession. In the model, net trade improves following a contractionary banking shock.

5.2.1 Banking versus IST shocks

Banking shocks introduce a "wedge" between the savings decision of the household and the investment decision of the firm. An alternative way of modelling this "wedge"

Table 5: Second Moments (Only investment shocks)

	Data	IRBC	Labour Bank	Capital Bank
Standard deviations				
σ_y	1.15	0.23	0.21	0.23
σ_c/σ_y	0.82	1.90	1.88	1.90
σ_x/σ_y	4.35	11.55	13.01	11.46
σ_n/σ_y	1.59	1.49	1.45	1.49
σ_w/σ_y	0.89	0.55	0.59	0.55
σ_{tot}/σ_y	1.48	2.72	2.72	2.67
σ_{nx}/σ_y	0.24	1.95	1.91	1.91
σ_{sp}/σ_y	0.16	NaN	0.00	0.00
Correlations				
$Corr(c,y)$	0.90	-0.80	-0.75	-0.80
$Corr(x,y)$	0.87	0.90	0.88	0.90
$Corr(n,y)$	0.89	0.90	0.88	0.90
$Corr(w,y)$	-0.17	-0.32	-0.23	-0.34
$Corr(tot,y)$	0.38	-0.50	-0.45	-0.49
$Corr(nx,y)$	-0.41	-0.45	-0.48	-0.45
$Corr(sp,y)$	-0.43	NaN	0.57	0.78
Cross Correlations				
$Corr(y,y^*)$	0.66	0.21	0.23	0.21
$Corr(c,c^*)$	0.51	-0.06	-0.05	-0.05
$Corr(rs,c/c^*)$	-.49	0.99	0.99	0.99

is by allowing for investment specific technology (IST) shocks. In equation (26), ϵ_t affects the amount of capital accumulation for given flow of investment. Justiniano et al. (2010) argue that in a model without financial intermediation, this is closely related to interest rate spread and can be seen as a shock to financial intermediation.

$$k_{t+1} = (1-\delta)k_t + \epsilon_t \phi\left(\frac{x_t}{k_t}\right)k_t \tag{26}$$

In Table 5, we analyze the second moment generated by our models when driven solely by IST shocks. In summary, the cyclical properties of macroeconomic variables are very close to those generated by the banking shocks; with one important caveat. The behavior of the spread is at odds with the data. Under IST shocks, the models are unable to generate a sufficiently volatile spread and imply a procyclical spread. This suggests that one way of differentiating between IST shocks and banking sector shocks is via the behaviour of the spread. Figure 7 compares the impulse responses following an IST and a banking shock. In order to make the shocks comparable, we rescale the shocks to have the same initial impact on investment.

5.3 Does ownership matter?

Our results so far suggest only a modest amount of cross country spill-overs of country specific banking shocks. The recent financial crisis was characterized by a synchronized decline in output across countries following what was arguably a banking sector shock. Krugman and Obstfeld (2008) highlight the globalized nature of today's banking system. Hitherto, we have assumed that the banking sector is fully locally owned; domestic banks are owned by domestic agents. In this section, we investigate the effects of relaxing this assumption.

We analyze two forms of globalized banking systems. In the first setup, we assume that the foreign-country labour using bank is owned by domestic households. In this case, the foreign bank's profits are paid to the home household. This in turn implies that the dynamics of spread in the foreign country will be determined by the stochastic discount factor of the domestic household. We call this the "local incorporation" case.

$$\frac{\beta\lambda_{t+1}}{\lambda_t}\frac{P^*_{H,t+1}}{P^*_{t+1}}\frac{P^*_t}{P^*_{H,t}}\left[(1+r^{q*}_t)-(1+r^d_t)\Psi(d^*_t-D^*_t)\right]=w^*_t\frac{1}{A^*_{b,t}} \tag{27}$$

In the second setup, the ownership structure is such that, as before, the home country is assumed to own the banks in both countries. Instead of borrowing from the international capital markets, foreign banks are financed directly via home country banks. Accordingly, domestic banks are the ones that combine bank lialibilities with labour or accumulate the bank capital stock for the combined bank. The market clearing condition for the home bank's loans is now given by:

$$Q_t = q_t + q^*_t = q_t + D^*_t \tag{28}$$

and balance sheet constraints for the labour and capital banks are:

$$Q_t = D_t \tag{29}$$

$$Q_t = D_t + K_t \tag{30}$$

Table 6: Second Moments : Bank ownership

	Bank with Labour			Bank with capital	
	Baseline	Local Incorporation	Foreign ownership	Baseline	Foreign Ownership
Standard deviations					
σ_y	0.31	0.31	0.31	0.15	0.15
σ_c/σ_y	1.45	1.45	1.63	1.90	2.17
σ_x/σ_y	11.16	11.17	9.61	11.81	9.21
σ_n/σ_y	0.99	0.99	1.01	1.54	1.55
σ_w/σ_y	0.52	0.52	0.66	0.53	0.66
σ_{tot}/σ_y	1.91	1.91	0.12	3.45	0.12
σ_{nx}/σ_y	1.59	1.60	0.04	2.34	0.11
σ_{sp}/σ_y	0.41	0.41	0.41	0.88	0.90
Correlations					
$Corr(c, y)$	-0.85	-0.85	-0.88	-0.85	-0.91
$Corr(x, y)$	0.93	0.93	0.96	0.94	0.97
$Corr(n, y)$	0.93	0.93	0.95	0.93	0.96
$Corr(w, y)$	-0.60	-0.60	-0.74	-0.32	-0.75
$Corr(tot, y)$	-0.50	-0.50	1.00	-0.64	0.41
$Corr(nx, y)$	-0.39	-0.39	-0.50	-0.29	-0.14
$Corr(sp, y)$	-0.96	-0.96	-0.97	-0.98	-0.97
Cross Correlations					
$Corr(y, y^*)$	0.24	0.24	0.99	0.22	0.99
$Corr(c, c^*)$	-0.01	-0.01	0.99	-0.07	0.99
$Corr(rs, c/c^*)$	0.98	0.98	0.99	0.98	0.99

respectively, where Q_t is the amount of global loans.

Since we assume that the foreign banks do not accumulate capital and they are not making any profits, the lending rate in the foreign country is equal to the domestic lending rate:

$$r_t^{q*} = r_t^q \tag{31}$$

Table 6 displays the second moments of our models under alternative ownership scenarios with only banking shocks. The first two columns indicate that ownership per se, the local incorporation case, does not matter for the labour bank model. This is because the banking sector makes up only a very small part of the economy under our calibration (we assume a bank labour share of 1.9%.) and because the fluctuations in the stochastic discount factor are highly correlated due to near perfect risk sharing.

The columns labeled "Foreign Ownership" in Table 6 show the second moments of our models under the alternative ownership structure. In this case, a shock to the domestic banking sector leads to highly synchronized movements in financial and macroeconomic variables (see also Figure 4). A contractionary banking shock yields a persistent decline in home output under both ownership scenarios. When banks are locally owned, the recession in the home country coincides with a modest expansion of output in the foreign country. In this case the foreign economy receives a capital inflow as made clear by the positive response of the domestic country's net foreign asset position. When the banking sector is globalized, there is a large and persistent decline in output in both countries. This suggests that for the transmission of banking shock, the ownership structure is key. As the shock is akin to highly correlated country specific shocks, there is little movement in international relative prices and quantities. The terms of trade and net foreign asset position remain largely unaffected.

6 Sensitivity analysis

TBC. See Figure 8 and 9

7 Conclusion

In this paper, we have investigated the role of introducing a banking sector in a two country business cycle model. The banking sector on its own weakly alter the transmission of shocks emanating from the real sector. For example, we found that the international transmission of productivity shocks remains identical independently of the specification of financial sector. On the other hand, disruption to financial intermediation may constitute a strong international propagation of local shocks. In particular, we show that when bank ownership is not equally shared between countries but concentrated in one, shocks spill-over perfectly, making business cycle downturns (upturns) highly synchronized.

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Figure 1: Impulse responses to a unit TFP shock

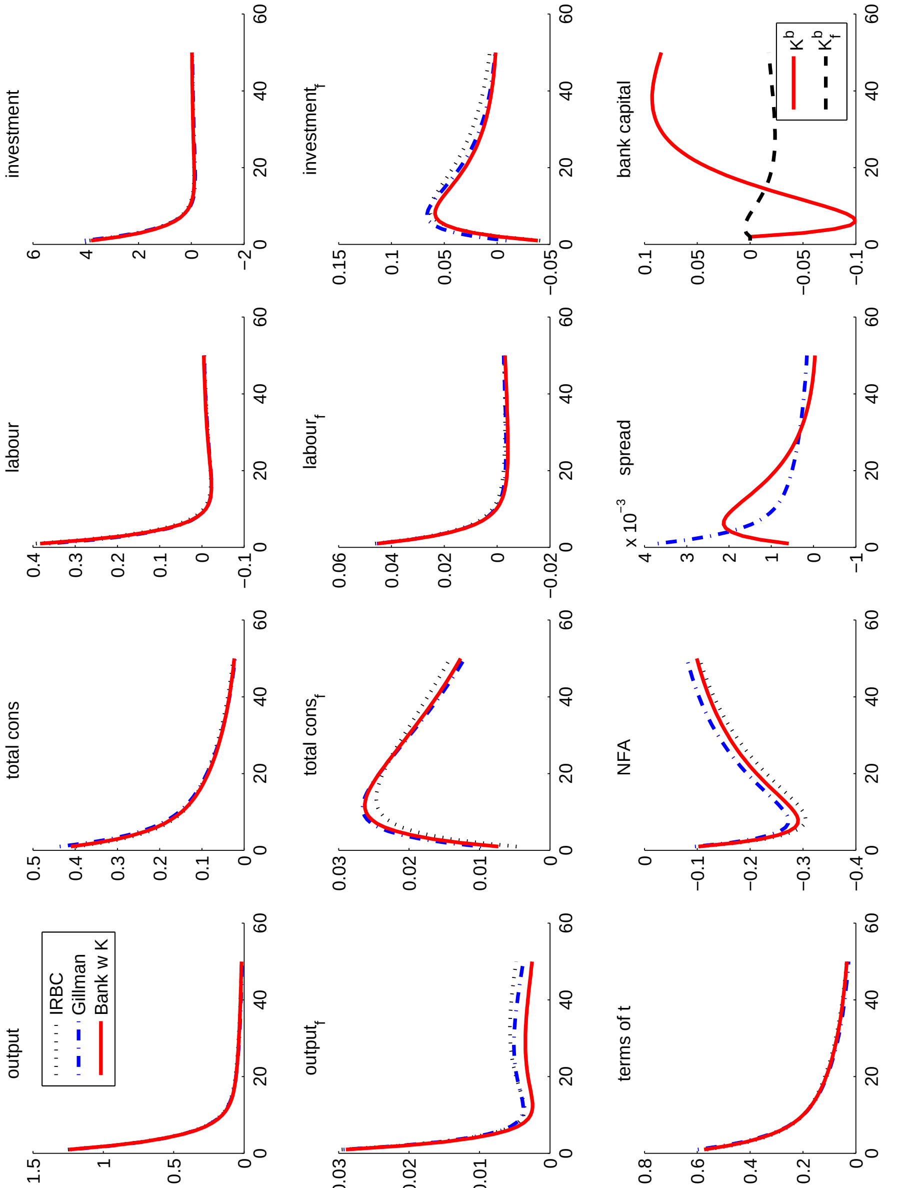

Figure 2: Impulse responses to a unit IST shock

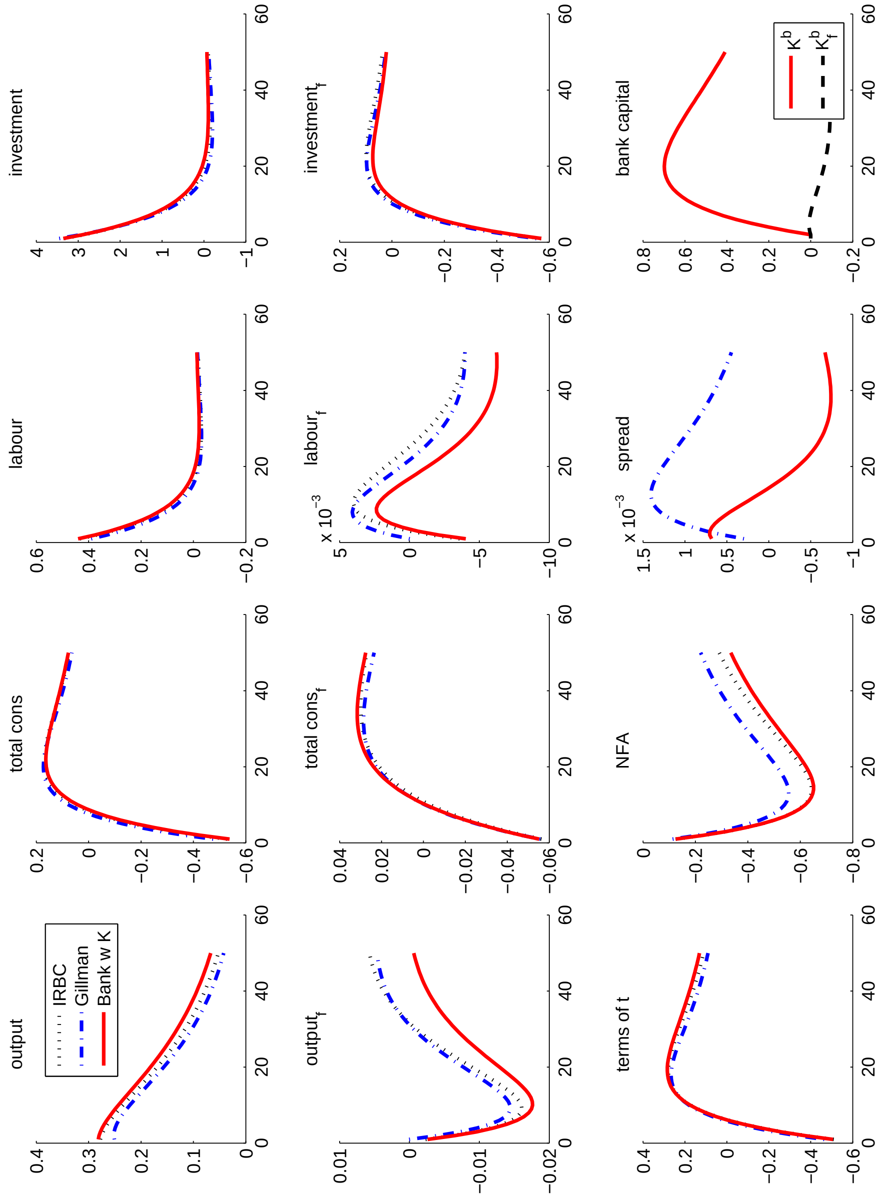

Figure 3: Impulse responses to a unit banking shock

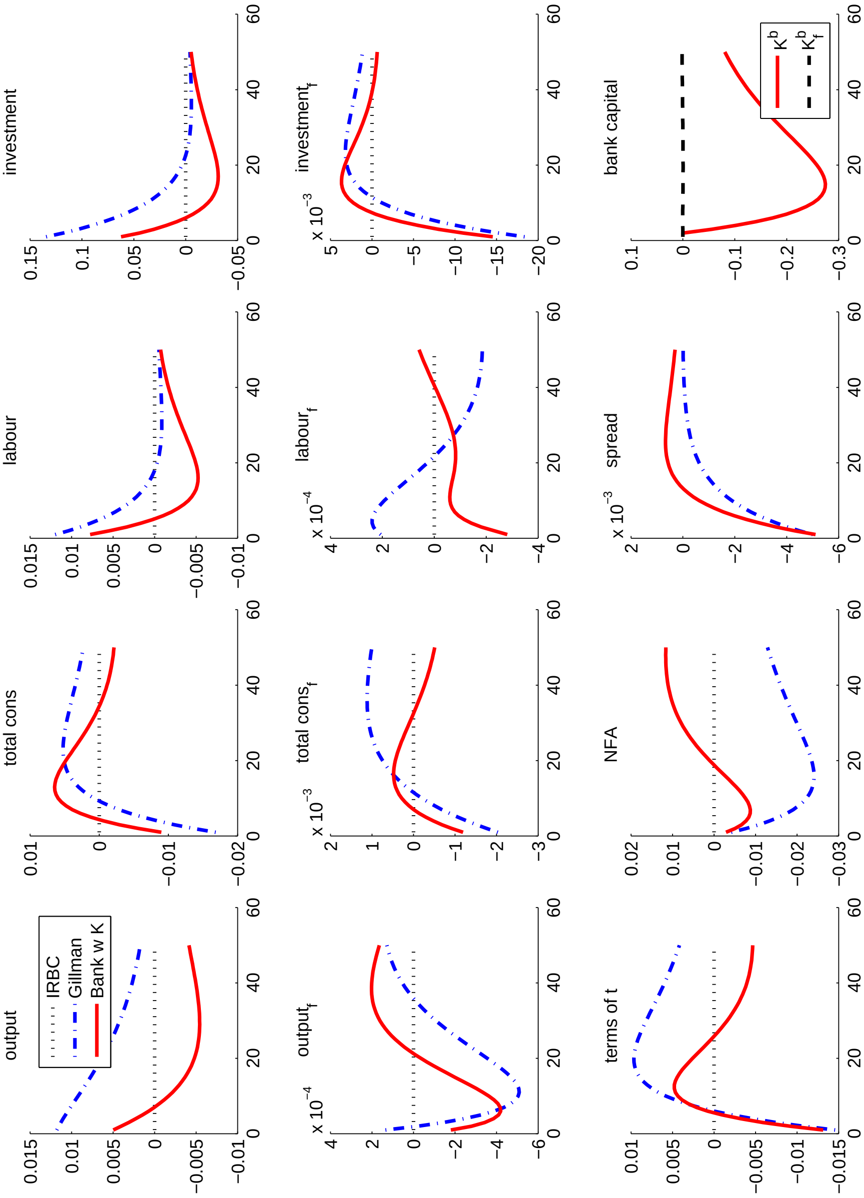

Figure 4: Impulse responses to a banking shock under different ownership assumptions

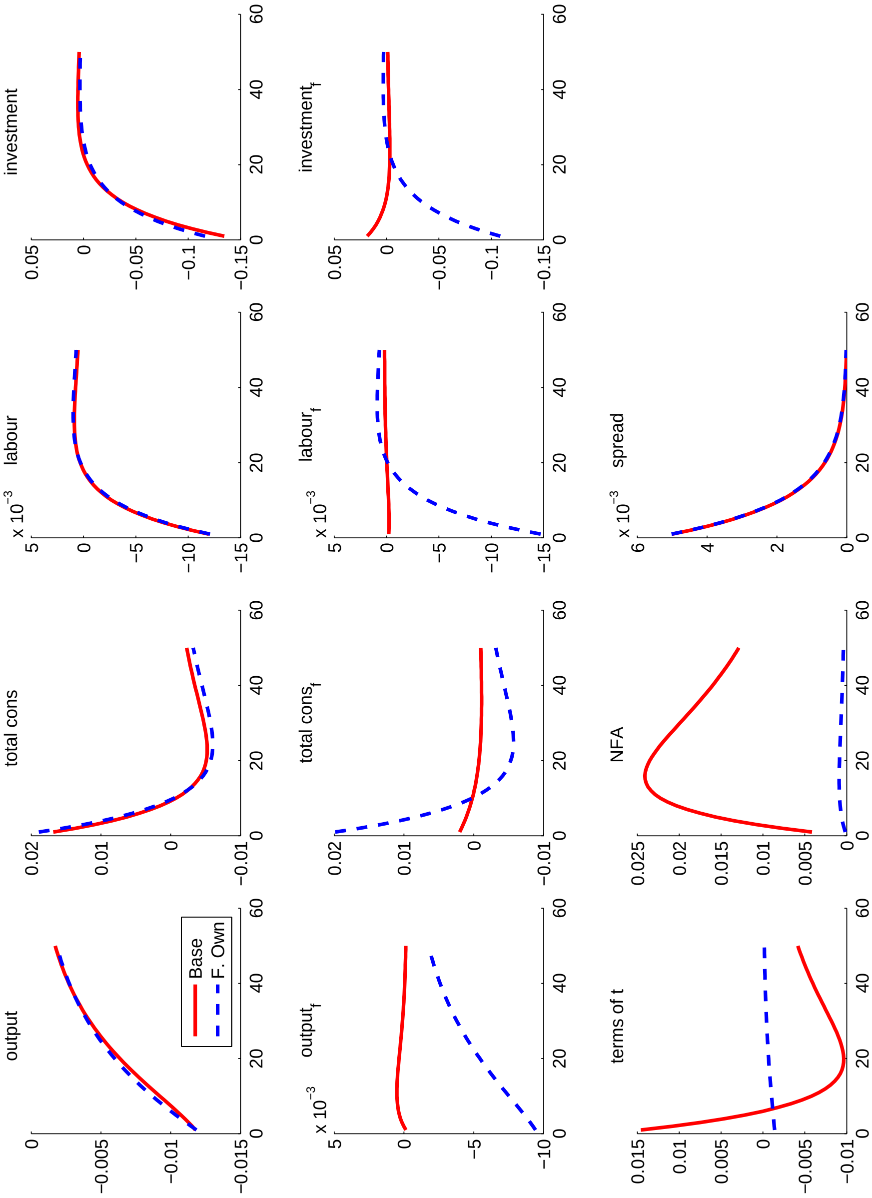

Figure 5: Terms of trade and spread in the last decade

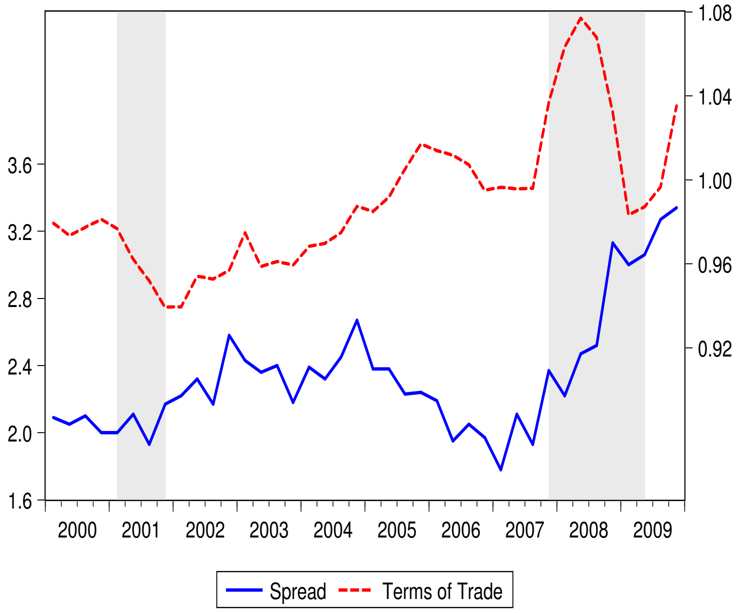

Figure 6: NFA and Spread in the US in the last decade

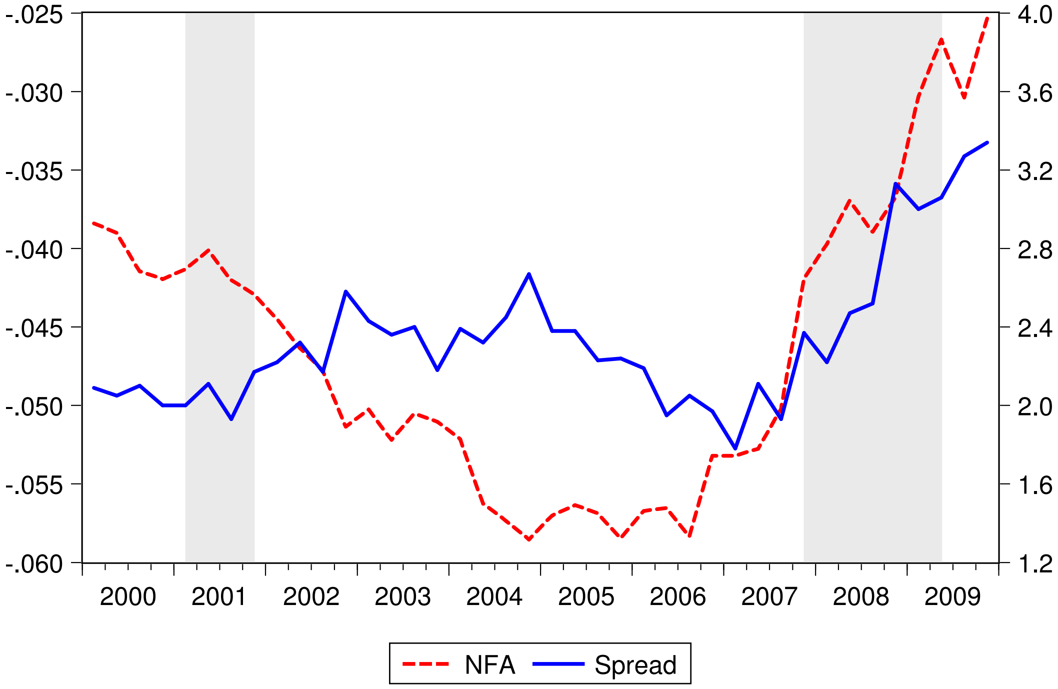

Figure 7: IST vs Banking shocks

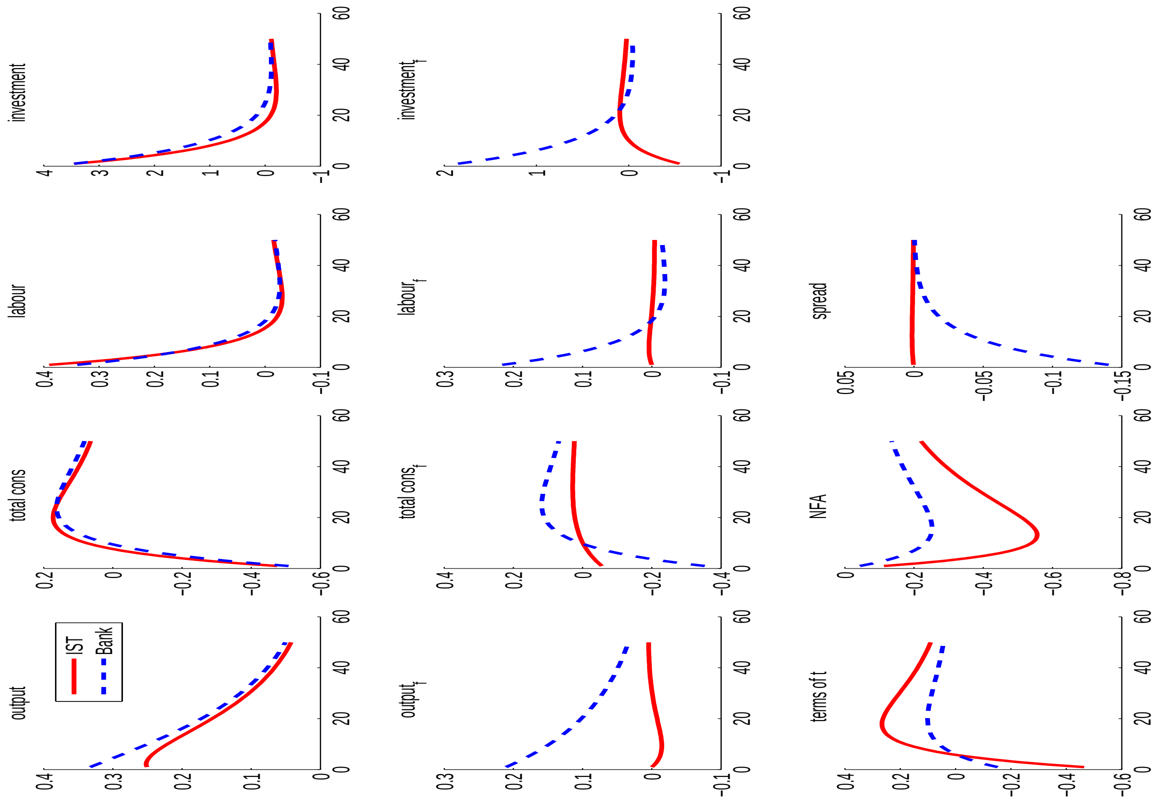

Figure 8: Sensitivity : Standard deviations

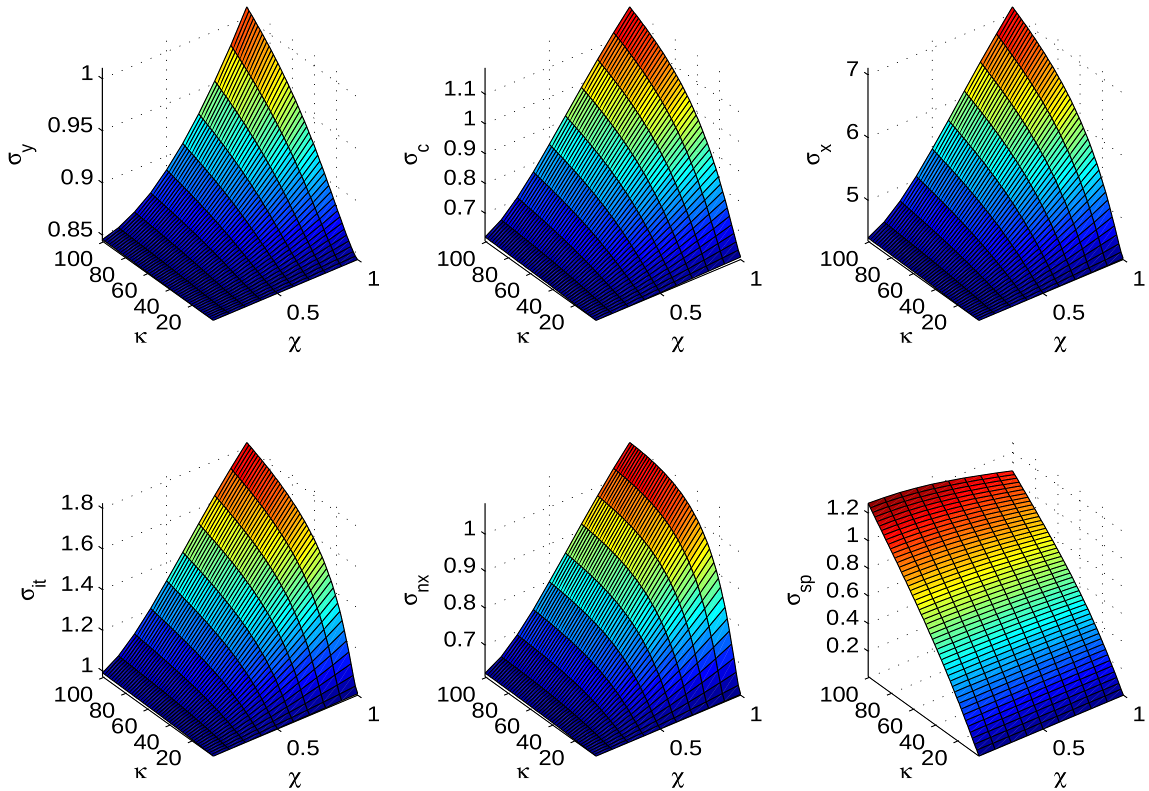

Figure 9: Sensitivity : Correlations