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International Business Cycle and Financial Intermediation

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INSTITUTE OF ECONOMICS, CENTRE FOR ECONOMIC AND REGIONAL STUDIES,
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International Business Cycle and Financial Intermediation

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Abstract

The paper extends a standard two-country international real business cycle model to include financial intermediation by banks of loans and government bonds. Taking in household deposits from home and abroad, the loans are produced by the bank in a Cobb-Douglas production approach such that a bank productivity shock can explain financial data moments. The paper contributes an explanation, for both the US relative to the Euro-area, and the US relative to China, of cross-country correlations of loan rates, deposit rates, and the loan premia. It provides a sense in which financial retrenchment resulted in the US following the 2008 bank crisis, and how the Euro-area and China reacted. The paper contributes evidence of how the Euro-area has been more financially integrated with the US, and China less financially integrated, with the Euro-area becoming more financially integrated after the 2008 crisis, and China becoming less so integrated.

JEL: E13, E32, E44, F41

Keywords: International Real Business Cycles, Financial Intermediation, Credit Spread, Bank Productivity, 2008 Crisis

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September 27, 2018

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The paper extends a standard two-country international real business cycle model to include financial intermediation by banks of loans and government bonds. Taking in household deposits from home and abroad, the loans are produced by the bank in a Cobb-Douglas production approach such that a bank productivity shock can explain financial data moments. The paper contributes an explanation, for both the US relative to the Euro-area, and the US relative to China, of cross-country correlations of loan rates, deposit rates, and the loan premia. It provides a sense in which financial retrenchment resulted in the US following the 2008 bank crisis, and how the Euro-area and China reacted. The paper contributes evidence of how the Euro-area has been more financially integrated with the US, and China less financially integrated, with the Euro-area becoming more financially integrated after the 2008 crisis, and China becoming less so integrated.

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1 Introduction

The paper contributes an explanation of a degree of international business cycle financial synchronization that exists in the data in terms of cross-country correlations. Applied to both the US relative to the Euro-area, and the US relative to China, the paper explains correlations of both bank lending and borrowing rates, and residual "loan premia" spread. This is a challenge in that in recent decades the US loan and deposit rates are positively correlated with the Euro-area, while being negatively correlated with China. Explaining both, the paper contributes how Europe could be viewed as more financially integrated with the US, and China less financially integrated economy with the US. [1] Using a 1996Q1 to 2015Q4 quarterly data period, the paper also contributes a sense of US financial retrenchment after the 2008 US bank crisis.[2]

The paper's model sees a negative bank productivity shock in the Home country (the US) cause a countercyclic increase in the loan premia. In the US - Euro-area, this causes the US elasticity of loans with respect to the loan rate, or equally the loan premium, to become more negative as the bank productivity falls, making the bank sector more "price sensitive" in making loans, and causing domestic loan issuance to fall over time as in a financial retrenchment; concomitant is an aggregate country portfolio shift towards bonds away from risky equity. Breaking the cross-country data correlations into the pre-2007:Q4 subsample and the post 2008:Q1 subsample, the paper contributes a sense in which after the crisis the Euro-area became more financially integrated with the US and China less so integrated.

The paper uses at its basis a standard international real business cycle (RBC) model. Its main extension is to provide a financial intermediation production approach to the provision of loans by banks in each country, while at the same time providing an endogenous portfolio choice between government bonds and loans. It remains consistent with the RBC style emphasizing use of only a small number of shocks, with a productivity shock featuring within Cobb-Douglas goods production functions, as in for example in Chugh (2016) and Kollmann (2017). It adds to this a bank sector productivity shock, in a Cobb-Douglas banking production of loans, as well as a shock to government expenditures as a share of output.[3] These are macroeconomic shocks in the sense of an aggregate, representative agent, notion of such shocks, as Chugh describes and contrasts to his approach using firm-level productivity and micro based "second-moment shocks".[4] Next the model is described, followed by its calibration, moment matching, discussion and conclusions.

[1] Making China less financial integrated is broadly consistent with Song et al. (2011), who explain China's growth and trade surplus as based on lesser access to external finance.

[2] An exception for the data series period is that the loan rate series for the Euro-area is from 2003Q1-2015Q4, making the Euro-area loan premia data the same period.

[3] An assumption used is a non-zero covariance matrix of both real and financial sectoral shocks between the US and Europe, combined with i.i.d Chinese shocks with zero covariance with the US.

[4] Chugh (2016) focuses on explaining countercyclic firm level risk, while we are focusing on countercyclical loan premia in the case of financial crisis led recessions.

2 The Model

In a two country model, the Home country is denoted by H and Foreign by F. Each variable that can be traded across borders is indexed as ij, where $i, j = H, F$, and the ordering ij denotes the direction of the trade (see Collard et al. 2009 for such a notation convention, using equity).[5]

Each country i has a representative infinitely-lived household. The mass of world population is normalized to unity. The Home country household lies on the interval $(0, n)$, where $0 < n < 1$; the Foreign household on the interval $(n, 1)$. For country i, with a_i denoting the leisure preference, σ the elasticity parameter, and $C_{i,t}$ and $x_{i,t}$ consumption and leisure time, respectively, the constant elasticity of substitution (CES) preferences of each household in expected present value terms at time 0 are $E_0 \sum_{t=0}^{\infty} \beta_i^t \frac{\left[C_{i,t} x_{i,t}^{a_i}\right]^{1-\sigma_i}}{1-\sigma_i}$.

The household in each country i allocates its unit time endowment between time spent as leisure, $x_{i,t}$, time working for the intermediate good producer, $l_{i,t}$, and time working in the banking sector, $l_{Qi,t}$: $1 = x_{i,t} + l_{i,t} + l_{Qi,t}$. With $w_{i,t}$ denoting the real wage rate in country i, $P_{Ci,t}$ the price of domestic consumption goods in country i, and $\tau_{i,t}$ a real lump-sum government transfer from its government, wage income is $P_{Ci,t} w_{i,t}(l_{i,t} + l_{Qi,t})$, and in similar terms the transfer is $P_{Ci,t}\tau_{i,t}$. The household chooses the mix of consumption and savings through a portfolio choice of purchasing goods $P_{Ci,t}C_{i,t}$ or investing in bank deposits, Home or Foreign. Let $D_{ij,t+1}$, denote investment in deposits by the country i household in the bank in country j, where j can denote either Home or Foreign countries This makes the sum of country i home bank and foreign bank deposits $P_{CH,t}D_{iH,t+1} + P_{CF,t}D_{iF,t+1}$, for which we use the notation of $\sum_{j=H}^{F} P_{Cj,t}D_{ij,t+1}$. There is an assumed quadratic adjustment cost function of investing in Foreign deposits, but not in Home deposits, denoted by $\Phi_{i,t}$. With the parameter $\chi_{Dij} \in R_+$, and $\frac{P_{Cj,t}}{P_{Ci,t}}$ equaling the real exchange rate (RER; see Kollmann, 2017, for this notation), this cost is given by $\Phi_{i,t} = \frac{\chi_{Dij}}{2}\left(\frac{P_{Cj,t}}{P_{Ci,t}} D_{ij,t+1}\right)^2$.[6] With $R_{Dj,t}$ representing interest paid on deposits by country j, the household receives interest of $\sum_{j=H}^{F}\left[P_{Cj,t}(1 + R_{Dj,t})D_{ij,t}\right]$.[7]

Three random shocks in each country follow first-order autoregressive processes, AR(1), in natural logarithms, with $z_{i,t}$ denoting the intermediate goods production shock, $z_{i,t}^{Q}$ the bank loan production shock, and $z_{i,t}^{gov}$ the shock to the share of government expenditures in total output. The variance-covariance matrix is non-trivial.

Intermediate goods production of $X_{i,t}$ units of a perishable, tradable, good are provided by a perfectly competitive firm in country i using internationally immobile labor $l_{i,t}$ and capital, denoted by $k_{i,t,}$. Given the Cobb-Douglas parameter α_i, the goods production technology is $X_{i,t} = A_i e^{z_{i,t}} k_{i,t}^{\alpha_i} l_{i,t}^{1-\alpha_i}$. These intermediate goods can be sold abroad, at price $P_{Xi,t}$. This means that the total amount produced domes-

[5] As an example, a variable $Z_{HF,t}$ denotes that it moves from country H to country F.

[6] The inclusion of adjustment costs allow a non-symmetric setup of countries and enforce stationarity in the model as suggested by Schmitt-Grohe and Uribe (2003).

[7] The country i household budget constraint is $P_{Ci,t}C_{i,t} = P_{Ci,t}w_i, t(l_{i,t} + l_{Qi,t}) + \sum_{j=H}^{F}\left[P_{Cj,t}(1 + R_{Dj,t})D_{ij,t}\right] + P_{Ci,t}\tau_{i,t} - \sum_{j=H}^{F}\left[P_{Cj,t}D_{ij,t+1} + P_{Ci,t}\frac{\chi_{Dij}}{2}\left(\frac{P_{Cj,t}}{P_{Ci,t}}D_{ij,t+1}\right)^2\right]$.

tically is the sum of those sold at home and abroad, or $X_{i,t} = \sum_{j=H}^{F} X_{ij,t}$. The intermediate goods producer invests in physical capital according to the standard law of motion, with $\delta_i > 0$ denoting the depreciation rate on capital. For this investment, starting at time period 0, the intermediate goods producer must acquire bank loans at time t, as denoted by $Q_{ji,t+1}$, at a loan rate denoted by $R_{Qj,t}$, and with a quadratic adjustment cost on borrowing, where $\chi_{Qji} \in R_+$ and the cost is $\frac{\chi_{Qji}}{2}\left(\frac{P_{Cj,t}}{P_{Ci,t}}Q_{ji,t+1}\right)^2$.[8] The total cost of loans is then $\sum_{j=H}^{F}\left[P_{Cj,t}Q_{ji,t+1} - P_{Ci,t}\frac{\chi_{Qji}}{2}\left(\frac{P_{Cj,t}}{P_{Ci,t}}Q_{ji,t+1}\right)^2\right]$, adding to an otherwise standard profit constraint.[9]

Non-tradable final consumption goods are denoted by $Y_{i,t}$. Given parameters $\gamma_i \in (0,1)$ and $\eta_i > 0$, these goods are competitively produced using domestic and foreign intermediate goods according to the standard CES technology, $Y_{i,t} = \left[\gamma_i^{\frac{1}{\eta_i}}\left(X_{ii,t}\right)^{\frac{\eta_i-1}{\eta_i}} + (1-\gamma_i)^{\frac{1}{\eta_i}}\left(X_{ji,t}\right)^{\frac{\eta_i-1}{\eta_i}}\right]^{\frac{\eta_i}{\eta_i-1}}$. Following De Paoli (2009) and Kamber and Thoenissen (2013), trade openness is denoted by υ, where the parameter specification is $1-\gamma_H = (1-n)\upsilon$ and $\gamma_F = n\upsilon$.

Bank production of loans $Q_{i,t}$ is Cobb-Douglas in labor $l_{Qi,t}$ and deposits used for loans, which are denoted by $D_{i,t}^{Q}$, such that, with $A_{Qi} > 0$ and $\kappa \in [0,1)$, $Q_{i,t} = A_{Qi}e^{z_{i,t}^{Q}}(l_{Qi,t})^{\kappa_i}(D_{Qi,t})^{1-\kappa_i}$. These bank loans can go abroad, so $P_{Ci,t}Q_{i,t} = \sum_{j=H}^{F} P_{Cj,t}Q_{ij,t}$. Also note that by construction $D_{Qi,t} = Q_{i,t}$, so that all deposits $D_{Qi,t}$ become loans in a one-to-one fashion, with a rising marginal cost of loans per deposit.

Since deposits to Home and Foreign banks can come from either country, total country i bank deposits $D_{i,t}$ are given by $P_{Ci,t}D_{i,t} \equiv \sum_{j=H}^{F} P_{Cj,t}D_{ji,t}$. If not used for loans, deposits are used to buy real Home or Foreign bonds, denoted by $B_{ji,t}$, such that bank assets equal liabilities in the sense of: $P_{Ci,t}D_{Qi,t} = \sum_{j=H}^{F} P_{Cj,t}D_{ji,t} - \sum_{j=H}^{F} P_{Cj,t}B_{ji,t}$. Besides the bond purchase cost of $\sum_{j=H}^{F} P_{Cj,t}B_{ji,t}$, there is a bond purchase quadratic adjustment cost. Given $\chi_{Bji} > 0$, this cost is $\frac{\chi_{Bji}}{2}\left(\frac{P_{Cj,t}}{P_{Ci,t}}B_{ji,t+1}\right)^2$, for a total cost of $\sum_{j=H}^{F}\left[P_{Cj,t}B_{ji,t+1} + P_{Ci,t}\frac{\chi_{Bji}}{2}\left(\frac{P_{Cj,t}}{P_{Ci,t}}B_{ji,t+1}\right)^2\right]$. Bonds earn an interest rate $R_{i,t}$.[10]

The government in country i makes purchases, $P_{Ci,t}G_{i,t}$, which are a constant share of output, $G_{i,t} = \left(\gamma_{i,gov}\right)e^{z_{i,t}^{gov}}Y_{i,t}$, and which are financed solely by issuing real bonds, so that $P_{Ci,t}B_{i,t+1} = \sum_{j=H}^{F} P_{Cj,t}B_{ij,t+1}$.[11]

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[8] These Home and Foreign bank loans are then given by the constraint that $\sum_{j=H}^{F} P_{Cj,t}Q_{ji,t+1} = P_{Ci,t}k_{i,t}$.

[9] The profit constraint is given by $0 = P_{Xi,t}X_{i,t} - P_{Ci,t}w_{i,t}l_{i,t} - P_{Ci,t}i_{i,t} + \sum_{j=H}^{F}\left[P_{Cj,t}Q_{ji,t+1} - P_{Ci,t}\frac{\chi_{Qji}}{2}\left(\frac{P_{Cj,t}}{P_{Ci,t}}Q_{ji,t+1}\right)^2\right] - \sum_{j=H}^{F}\left[P_{Cj,t}(1+R_{Qj,t})Q_{ji,t}\right]$.

[10] The bank profit constraint is $0 = -\sum_{j=H}^{F} P_{Cj,t}Q_{ij,t+1} + (1+R_{Qi,t})\sum_{j=H}^{F} P_{Cj,t}Q_{ij,t} + \sum_{j=H}^{F} P_{Cj,t}D_{ji,t+1} - (1+R_{Di,t})\sum_{j=H}^{F} P_{Cj,t}D_{ji,t} - P_{Ci,t}w_{i,t}l_{Qi,t} + \sum_{j=H}^{F}(1+R_{j,t})P_{Cj,t}B_{ji,t} - \sum_{j=H}^{F}\left[P_{Cj,t}B_{ji,t+1} + P_{Ci,t}\frac{\chi_{Bji}}{2}\left(\frac{P_{Cj,t}}{P_{Ci,t}}B_{ji,t+1}\right)^2\right]$.

[11] Govt. constraint: $P_{Ci,t}G_{i,t} = \sum_{j=H}^{F} P_{Cj,t}B_{ij,t+1} - (1+R_{i,t})\sum_{j=H}^{F} P_{Cj,t}B_{ij,t+1} - P_{Ci,t}\tau_{i,t}$.

Along the steady state, it follows that deposits to the foreign bank by country i household are $D_{ij} = \left(\frac{\beta_j - \beta_i}{\beta_i}\right) / \left(\chi_{Dij} RER\right)$; the bank's investment in loans to foreign firms is $Q_{ji} = \left[\frac{\beta_i (R_{Qi} - R_{Qf})}{\chi_{Bji} RER}\right]$; and the bank's foreign government holdings are $B_{ji} = \left[\frac{\beta_i (\beta_j - \beta_i)}{\beta_i \beta_j}\right] / \left(\chi_{Bji} RER\right)$.[12]

3 Calibration

For each country (the US, Euro-area, and China) quarterly lending and deposit rate data is used, from 1996Q1 until 2015Q4 except for the lending rate (and so also the loan premia) for the Euro-area, which is from 2003Q1 until 2015Q4. For the US, the lending and deposit rates are measured using the Bank Prime Loan Rate (US Federal Reserve Board of Governors) and the 3-month Treasury bill rates respectively. For the Euro area, the ECB publishes a Euro-area 1-year loan interest rate on corporate loans, which is used for the loan rate, and the OECD provides a Euro-area 3-month Interbank Rate, which is used for the deposit rate. For China, the People's Bank of China publishes a Policy Lending Rate and Policy Deposit Rate which are used respectively for the loan and deposit rates. Loan premia are calculated as the difference of loan and deposit rates. The US is the Home country, and the Foreign is either the Euro-area or China.

The strategy in calibration is to target financial cross-country correlations, as given below, while using standard parameter choices. For all economies, the subjective discount factor, β_H, is set at 0.99 to match a quarterly 1 percent return on bonds and deposits as in Backus et al. (1994). The weight of leisure in the Home country preferences, A_H, is to 1.8, which is in line with standard values in the US real business cycle literature, such as King and Rebelo (1999) and Gomme and Rupert (2007); the share of capital, α_H, in intermediate good production is 0.36; the quarterly constant rate of depreciation of capital is 0.025; and the productivity parameter in the intermediate goods production A_{GH} is 1.

For the US as Home country, the intertemporal elasticity of substitution, θ_H, is set at 1.51, which corresponds to the value of 1.5 in Kollmann (2017). Similar to Eichenbaum et al. (2017), the size of the Home country n is set at 0.37; the openness parameter υ is 0.25; the residual Home country domestic bias parameter γ_H is 0.84 (as compared to their 0.90); and the substitutability parameter η_H of Home and Foreign goods in the Home country is 0.60 (higher than their value of 0.33, but within a range that goes as high as 1.5). Portfolio adjustment cost parameters for Home assets equal zero ($\chi_{DHH} = \chi_{QHH} = \chi_{BHH} = 0$); these US to Foreign costs equal a small positive level: $\chi_{DHF} = \chi_{QFH} = \chi_{BFH} = 0.01$.[13] The share of government purchases in output $\gamma_{H,gov}$ is 0.20; the share of labor in loan production κ_H is 0.1; and the productivity level in banking A_{QH} is 1.84, with the latter two specified following Benk et al. (2010).

For both the Euro-area and China, the intertemporal elasticity of substitution

[12] In the case of symmetry across countries, not used here, the Foreign country originated holdings of all three assets are zero and only domestic assets are held in the steady state.

[13] Adjustment costs facing foreign asset holdings ensure that portfolio allocations are determinate along the deterministic steady state, as is the case in Eichenbaum et al. (2017).

is $\theta_F = 1$; the share of capital is $\alpha_F = 0.30$; the productivity level in banking is relatively lower at $A_{QH} = 1.50$; the substitutability parameter is $\eta_F = 0.40$; the openness implied domestic bias parameter γ_F is 0.09; and the share of government purchases in output $\gamma_{F,gov}$ is 0.40, larger than for the US. The portfolio adjustment parameters for domestic assets are also set to zero, and the adjustment cost parameter for the Foreign to US deposits is slightly higher at $\chi_{DFH} = 0.012$. For the Euro-area and China respectively, the other financial adjustment cost parameters are $\chi_{BHF} = \chi_{QHF} = 0.0119$ and $\chi_{BHF} = \chi_{QHF} = 0.0121$.

The shock persistence parameters and shock variances, as denoted by $\varepsilon_{i,t}$, $\varepsilon^{Q}_{i,t}$, $\varepsilon^{gov}_{i,t}$, are identical across countries, but the variance-covariance matrix is non-trivial. The goods sector productivity shock persistence parameters and shock variances are set at 0.96 and 0.007, following King and Rebelo (1999), for each country. Using US quarterly data from 1996Q1 - 2015Q4 to estimate the US bank productivity shock persistence and variance, these are found to be 0.963 and 0.00076, respectively;[14] these latter two are also assumed for Euro-area and China. The government expenditure shock persistences and variances are set at 0.80 and 0.01 for all countries. With zero off-diagonal elements for China, the variance-covariance matrix for the US - Euro area, denoted by $\Sigma_{US/EU}$, is calibrated to match moments.[15]

4 Simulation Results and Discussion

The main application of the model is to explain the full sample data correlation of loan and deposit rates and their difference (called the loan premium or spread) for the US as Home country relative to the Euro-area and for the US relative to China. Table 1 displays the data and model simulated moments. The moments match the full sample period data moments in sign and are fairly close in magnitude, with no rejection of the hypothesis that most of the simulated moments are not significantly different from the data moments.[16] For the US - Euro-area, this involves positively correlated loan premia, loan rates and deposit rates. For the US - China case, the loan premia are weakly positively correlated, and the loan rates and deposit rates are

[14] The Federal Reserve Board data series of quarterly total loans and leases, and deposits by all commercial banks, from 1996Q1 until 2015Q4, are the basis of the estimation. The banking productivity shock series is obtained by extracting a Solow-type residual using the production technology of loans, as specified in the model. The obtained residual is then used to estimate the assumed AR1 process parameters using the Maximum Likelihood estimator.

[15] For $\left[\varepsilon_{H,t}, \varepsilon^{Q}_{H,t}, \varepsilon^{gov}_{H,t}, \varepsilon_{F,t}, \varepsilon^{Q}_{F,t}, \varepsilon^{gov}_{F,t}\right]$, $\sum_{US/EU} = \begin{bmatrix} 0.007 & 0 & 0.3 & 0 & 0 & 0 \\ 0 & 0.00076 & 0 & 0.147 & -0.97 & 0 \\ 0.3 & 0 & 0.01 & 0 & 0 & 0 \\ 0 & 0.147 & 0 & 0.007 & 0.52 & -0.19 \\ 0 & -0.97 & 0 & 0.52 & 0.00076 & 0 \\ 0 & 0 & 0 & -0.19 & 0 & 0.01 \end{bmatrix}$

[16] Using the Fisher-z transform test for comparing correlations, the null that data and simulated moments are not different cannot be rejected for the full sample period regarding any of the US-Euro-area comparisons, or for the US-China loan premia. For the pre-2008 data subsample, this null is also not rejected for the US-Euro-area loan and deposit rates; for the post-2008 data, the null is not rejected for the US-Euro-are loan, deposit, and premia, as well as for the US-China loan and deposit rates.

negatively correlated.[17]

		US - Euro Area		US - China	
		Data	Model	Data	Model
$\text{Corr}(R_{Di,t},\ R_{Dj,t})$	Full Sample	0.538	0.621	-0.283	-0.502
	Pre-Crisis	0.552		-0.275	
	Post-Crisis	0.747		-0.362	
$\text{Corr}(R_{Qi,t},\ R_{Qj,t})$	Full Sample	0.279	0.302	-0.315	-0.494
	Pre-Crisis	0.335		-0.299	
	Post-Crisis	0.410		-0.439	
$\text{Corr}(SP_{i,t},\ SP_{j,t})$	Full Sample	0.162	0.162	0.096	0.026
	Pre-Crisis	-0.439		0.390	
	Post-Crisis	0.299		-0.487	

Table 1: Simulated cross-country correlations of financial variables: loan premia is $SP_{i,t} \equiv R_{Qi,t} - R_{Di,t}$; R_Q is loan rate; R_D is deposit rate. Data: 1996Q1 - 2015Q4; except 2003Q1 - 2015Q4 for Euro area lending rate and loan premia. Pre-crisis is 1996Q1 (2003Q1) - 2007Q4; post-crisis 2008Q1-2015Q4.

This model is able to capture both the positively and negatively correlated loan and deposit rates by allowing the Euro-area shocks to be non-trivially correlated with US shocks, as well as having covariance amongst its own shocks. For China, the model fits the data by assuming that the shocks are not correlated with the US and are i.i.d. The Euro-area, in this modelling sense, is more integrated with the US, and between its own sectors, while China is less so integrated internationally and domestically.

These financial data moments also allow investigation into how the US vis a vis the Euro-area and China differed in the pre-2008, US crisis, subperiod versus the post-2008, crisis aftermath, subperiod. For the loan and deposit rates, each the Euro-area and China cross correlations have the same signs during each subperiod as in the full sample, these being positive for the Euro-area and negative for China. For the spread, the US - Euro-area post crisis correlation is the same positive sign as in the full period, while in contrast it is the US - China pre-crisis spread correlation that is the same positive sign as in the full period.

Pre-crisis, the Euro-area spread was negatively correlated with the US, suggesting relatively less financial integration, while after the crisis (and for the whole period) the Euro-area spread is positively correlated with the US, suggesting more integration with the US. This post-crisis greater synchronization seems plausible given that after the crisis, for example, the Euro-area adopted many similar banking and monetary policy measures. In banking, this includes correlated efforts towards higher bank reserve requirements (Basel III capital requirements; these are reflected in the Dodd-Frank 2010 Act), a greater macroprudential stance in both the US and Euro-area (The

[17] Note that all data series for such purposes is filtered with a Hodrick and Prescott (1997) filter at the business cycle frequency to be consistent with the simulation based moment output of Dynare (Adjemian et al. , 2014).

European Banking Authority, EBA, established January 2011; the Dodd-Frank 2010 Act provisions), deposit insurance reform (the Deposit Guarantee Schemes Directive harmonization of EBA deposit insurance at 100,000 Euro, as described in Cerronne, 2018; the US FDIC 2010 multifold increase in its deposit insurance level to $250,000). In monetary policy, low nominal interest rate targets by the central banks and high money supply growth policies were more correlated, as seen for example through relatively stable US-Euro exchange rates.

For the US relative to China, the loan premia went from a positive correlation with the US before the crisis to a negative correlation after the crisis. This suggests that China moved away partly from integration with the US after the crisis. This is a plausible scenario that has been popularized; for example, Glick and Spiegel (2009), summarize that post-crisis "China and India experienced relatively small growth slowdowns (p. 4)" and that "the relative good fortune of China, India, and Indonesia in avoiding recession was partly attributable to their greater reliance on domestic demand, while the more open economies of Asia were harder hit (p. 6.)."

This paper's ability to explain broadly the correlated financial data moments over the whole period is rooted in an elasticity of loan demand with respect to the loan rate, or derived with respect to the loan premium, that rises in magnitude with the price of loans, thereby making for increasingly more price sensitivity as the loan premium rises. Verified through impulse responses, this underlying feature of the model induces less loan demand in the Home country in which a negative bank productivity shocks hits. This causes less loans at Home, a type of financial retrenchment.

For the US as Home in the US - Euro-area, impulse responses to a 1% negative Home bank productivity shock show that financial retrenchment in the Home country occurs in terms of total household deposits falling steadily (starting after 6 quarters), while total bonds rise. Home domestic deposits fall steadily, by 2% after 10 years, while Home foreign deposits also fall over time but by a magnitude less relative to domestic deposits. This retrenchment of mainly lower domestic deposits translates into steadily lower domestic loans, by more that 1%, with a steady increase in foreign loans, by about half the decrease in domestic loans.

The negative bank shock causes the US asset share of Home loans to fall, after a first period rise, for over 10 years, while the share of foreign loans rises, as do the shares of both home and foreign bonds. This is a Home financial retrenchment consisting of a shift from domestic loans towards bonds and foreign loans. It is also characterized as a long lasting decrease in the US total loans to total bonds ratio. This would appear consistent with post 2008 US experience during which US Treasury debt as a fraction of output soared while the aggregate market portfolio has been characterized as moving towards a greater share of risk-free debt holding and lesser share in risky US equity.

Similarly note that, in reverse of a negative bank shock, prior to the crisis it could be said that financial liberalization in the US acted to raise bank productivity, as in Benk et al. (2005). In the two-country framework of the paper, this acts in reverse to financial retrenchment: greater loans, investment and a portfolio shift towards risky equity away from risk free bonds. See also Collard et al. (2007) for pre-crisis integration through the trade channel.

For the Euro-area, in terms of impulse responses, after a US negative bank pro-

ductivity shock, the price elasticity of loans becomes smaller in magnitude, opposite of the US, and its loan premium becomes smaller. This induces the Euro-area to move away from foreign loans and foreign deposits. There are more domestic deposits, domestic loans, and domestic bonds, and less foreign loans, less foreign deposits over time, and initially less foreign bonds. While initially the Euro-area ratio of total loans to total bonds rises, over time, after 5 years, this ratio then falls for the next 5 years. This decrease in total equity loans compared to total bonds is similar to that aspect of financial retrenchment that occurs in the US, although its magnitude for the Euro-area is about half (0.6%) that of the US (1.25%) after 10 years.

For the US as Home in the US-China case, the opposite relative to the Euro-area case occurs in a limited sense. Relative to China, the US has a short-lived increase in the asset share of domestic loans and decrease in the foreign loan asset share, with a like decrease in both foreign and domestic bond asset shares. This is opposite in direction relative to the US as Home in the Euro-area economy, but one lasting only a few periods. But after the first three periods, the US experiences a 1% fall, from the 1% negative bank productivity shock, in its ratio of total equity loans to total government bonds. This shows then a type of financial retrenchment for the US in both the US - Euro-area and the US - China area economies.

For China, a negative US bank productivity shock causes a smaller price elasticity of loans in magnitude, as is the case for the Euro-area and as is opposite of the US. The Chinese loan premium becomes smaller, although with a shorter term effect as compared to the Euro-area and initially with higher loan and deposit rates. Total Chinese deposits and bonds fall, with both domestic and Foreign bonds initially falling. The dominant effect is a very large initial increase in Chinese domestic loans and likewise decrease in Chinese foreign loans. The longer term, 10 year effect is an increase in its ratio of total equity loans to total risk-free bonds. This ratio increase is opposite to the US decrease, and of a smaller magnitude, but it shows China acting in an opposite way relative to financial retrenchment.

In sum, the covariance assumptions combined with the portfolio diversification problem of the bank, allow the model to explain both sets of Foreign economy loan and deposit rate correlations with the US qualitatively over the full sample period. Other approaches include for example adding monopolistic competition in the bank, which would add another degree of freedom. This can be implemented, but the model is rich enough within its competitive structure to explain the financial moments examined here.[18]

5 Conclusion

The paper extends an otherwise standard international business cycle model as in Backus et al. (1994) with a competitive banking sector within each country and a government sector, to explain the cross-country correlations of loan premia, lending

[18] Introducing monopolistic competition can be done for example following Benhabib and Farmer (1994) and Wu and Zhang (2000), by assuming a continuum of monopolistically competitive intermediate loan producers indexed by $j \in (0,1)$ in which case final loans by country i bank are produced by $Q_{i,t} = \left[\int_0^1 Q_i(j)^{\lambda_i} dj\right]^{1/\lambda_i}$; here λ_i measures the degree of monopoly power for intermediate loans.

and deposit rates. The banking sector produces costly savings-investment intermediation between households and the goods producer within and across countries, while providing a portfolio choice between risky loans and bonds. The household chooses between domestic and/or Foreign deposits; the financial intermediary chooses the supply of domestic and/or Foreign loans and the purchase of domestic and/or Foreign government bonds. All assets including deposits, loans, and government bonds are allowed to flow across borders, with cross-country flows facing positive portfolio adjustment costs.

The application shows that the model can qualitatively explain such financial data correlations for both the US relative to the Euro-area, and for the US relative to China, even though the data moment correlations for these two Foreign economies are of opposite signs for the deposit and lending rates. US Home financial retrenchment occurs in the US - Euro-area economy after a negative Home country bank productivity shock, as is likened to the US 2008 bank crisis. The negative Home bank shock raises the loan premia in a countercyclic fashion and causes a more negative price elasticity of loans. This induces a Home portfolio shift away from domestic loans towards foreign loans and towards both domestic and foreign bonds.

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A Appendix

A.1 Calibration Table

Parameters	Description	Country H	Country F	
		US	Euro Area	China
Preferences				
θ_i	Elasticity of substitution	1.51	1	1
A_i	Weight of leisure	1.8	1.8	1.8
β_i	Subjective discount factor	0.99	0.99	0.99
Goods Production				
A_{Gi}	Goods sector productivity level	1	1	1
α_i	Share of capital in output	0.36	0.30	0.30
δ_i	Depreciation rate of capital	0.025	0.025	0.025
ρ_G^i	Persistence of TFP shock	0.96	0.96	0.96
$\sigma_{G,i}^2$	Variance of TFP shock	0.007	0.007	0.007
Banking Sector				
A_{Qi}	Bank sector productivity level	1.84	1.5	1.5
κ_i	Share of labor in loan prod.	0.10	0.10	0.10
ρ_Q^i	Persistence of bank prod. shock	0.963	0.963	0.963
$\sigma_{Q,i}^2$	Variance of bank prod. shock	0.00076	0.00076	0.00076
Open Economy and Gov't				
η_i	CES b/w home and foreign goods	0.60	0.40	0.40
ν_i	Openness parameter	0.25	0.25	0.25
γ_i	Home bias parameter	0.84	0.09	0.09
n	Population parmaeter	0.37	0.63	0.63
χ_{Dij}	Country premium on deposits	0.01	0.012	0.012
χ_{Qij}	Country premium on loans	0.01	0.0119	0.0121
χ_{Bij}	Country premium on bonds	0.01	0.0119	0.0121
$\gamma_{gov,i}$	Share of gov't expenditure	0.20	0.40	0.40
$\rho_{gov,i}^i$	Persistence of gov't exp. shock	0.80	0.80	0.80
$\sigma_{gov,i}^2$	Variance of gov't exp. shock	0.01	0.01	0.01

Table 2: Model calibration parameter values.

A.2 Data Description

All data used in this paper is of quarterly frequency The data covers the period from 1996Q1 until 2015Q4 except for Euro-area loan rates which are 2003Q1-2015Q4. Variables are not seasonally adjusted and are in percents except the deposit and loan series for the US.

US:

Deposits: Deposits, All Commercial Banks (Series ID: DPSACBM027SBOG),from the Board of Governors of the Federal Reserve System; release H.8: Assets and Liabilities of Commercial Banks in the United States (Seasonally adjusted; in billions of US Dollars).

Loans: Loans and Leases in Bank Credit, All Commercial Banks (Series ID: LOANS), from the Board of Governors of the Federal Reserve System; release H.8: Assets and Liabilities of Commercial Banks in the United States (Seasonally adjusted; in billions of US Dollars).

The Lending Rate:.Bank Prime Loan Rate (Series ID: MPRIME) from the Federal Reserve Economic Data (FRED), Federal Reserve Bank of St Louis.

The Deposit Rate:.3-Months Treasury Bill: Secondary Market rate (Series ID: TB3MS), from the Board of Governors of the Federal Reserve System; release H.15: Selected Interest Rates.

Loan Premium: constructed as the difference between the lending and deposit rates.

Euro-area:

The Lending Rate: Bank Interest Rates - Loans to Corporations with an Original Maturity of up to one year - Euro area (Series ID: MIR.M.U2.B.A20.F.R.A.2240.EUR.O), from European Central Bank, Statistical Data Warehouse.

The Deposit Rate: 3-Months or 90-day Rates and Yields: Interbank Rates for the Euro Area (Series ID: IR3TIB01), from OECD, Main Economic Indicators.

Loan Premium: constructed as the difference between the lending and deposit rates.

All data series for calculating cross-country correlations are filtered with a Hodrick and Prescott (1997) filter at the business cycle frequency to be consistent with the simulation based moment output of Dynare (Adjemian et al. , 2014).

China:

Data for the financial variables of China are from the dataset of Chang et al. (2016). The variables used for China are[19]

The Lending Rate: the People's Bank of China benchmark 1-year lending rate.

The Deposit Rate: the People's Bank of China benchmark 1-year deposit rate.

Loan Premium: constructed as the difference between the lending and deposit rates.

[19]The detailed methodology of the construction of the lending and deposit rates are described in Higgins and Zha (2015).

A.3 Impulse Responses

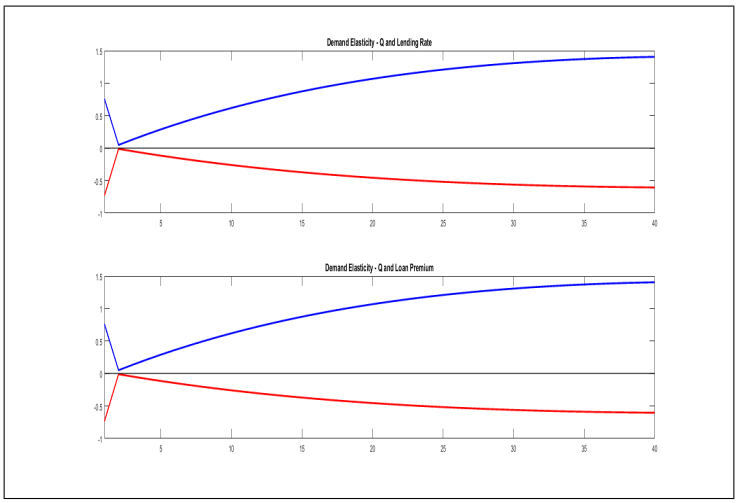


Figure A1. Responses of loan demand elasticity measures for the US (Home country - blue solid) and Euro area (Foreign country red solid) to a 1% positive bank productivity shock in the Home country.

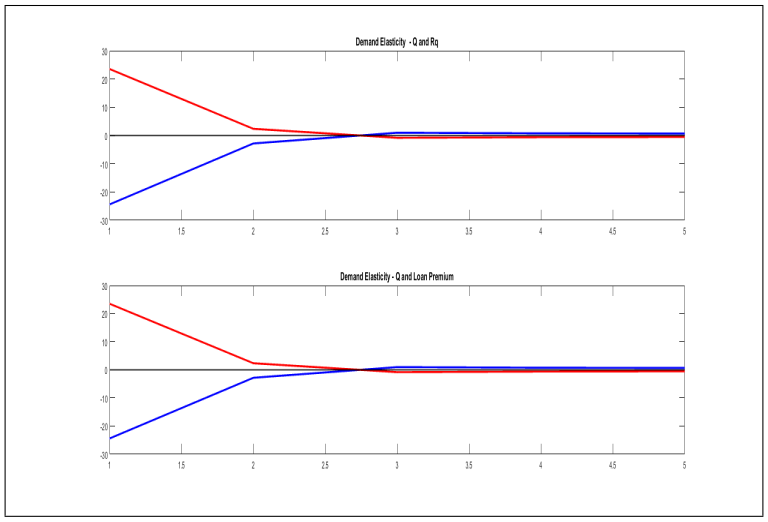


Figure A2. Responses of loan demand elasticity measures for the US (Home country - blue solid) and China (Foreign country red solid) to a 1% positive bank productivity shock in the Home country.

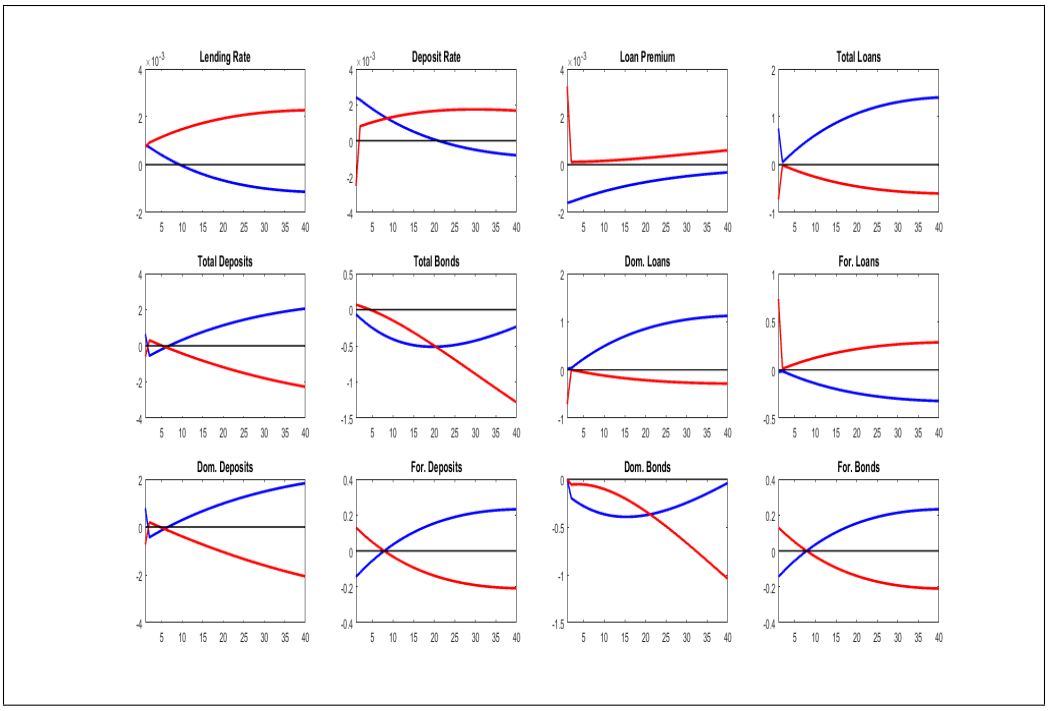


Figure A3. Impulse responses of key financial variables to a 1% positive Home country bank productivity shock for the US (Home country - blue solid) and the Euro area (Foreign country - red solid) calibration.

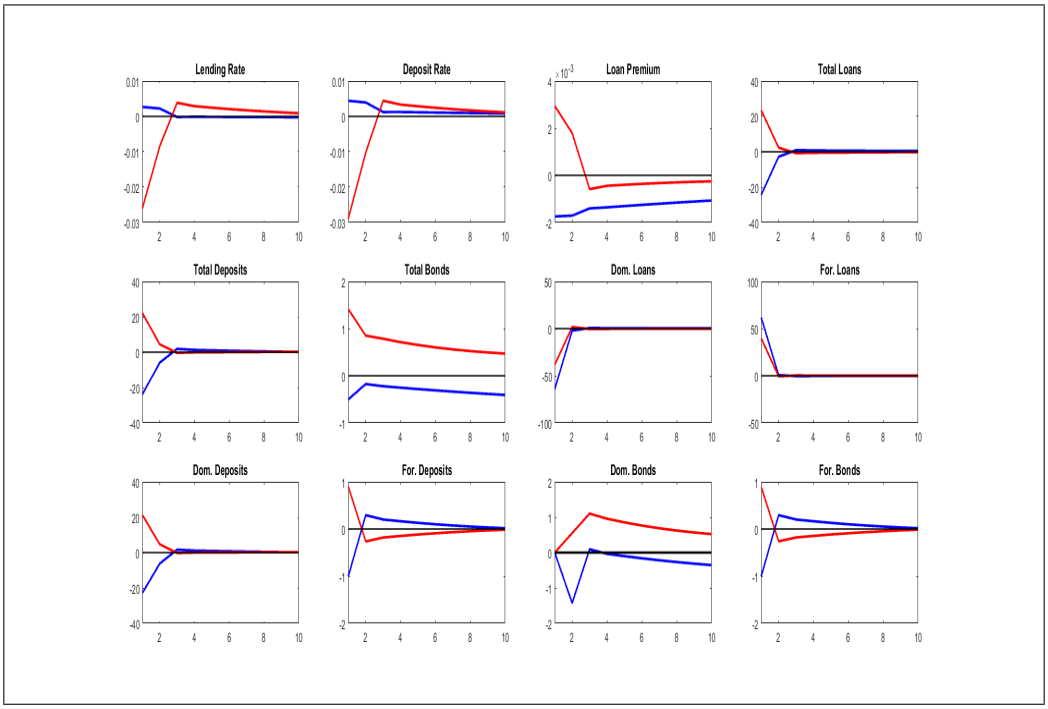


Figure A4. Impulse responses of key financial variables to a 1% positive Home country bank productivity shock for the US (Home country - blue solid) and the China (Foreign country - red solid) calibration.

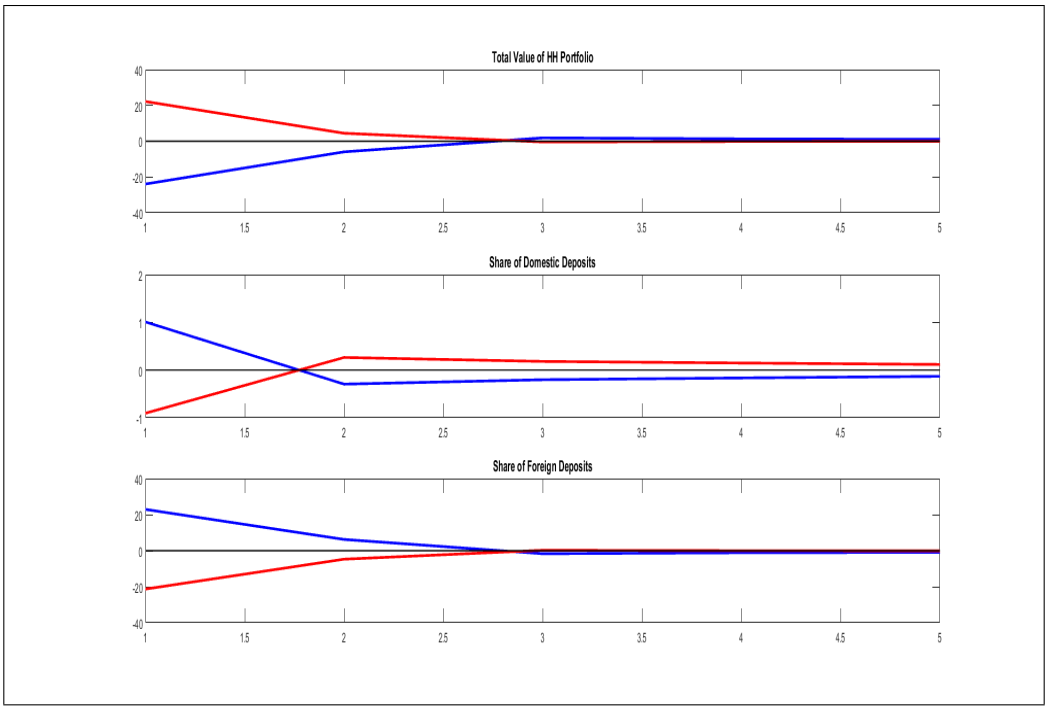


Figure A5. Impulse responses of the total and the shares of domestic and foreign deposits in the household's portfolio for the US (Home country - blue solid) and China (Foreign country red solid) to a 1% positive bank productivity shock in the Home country.

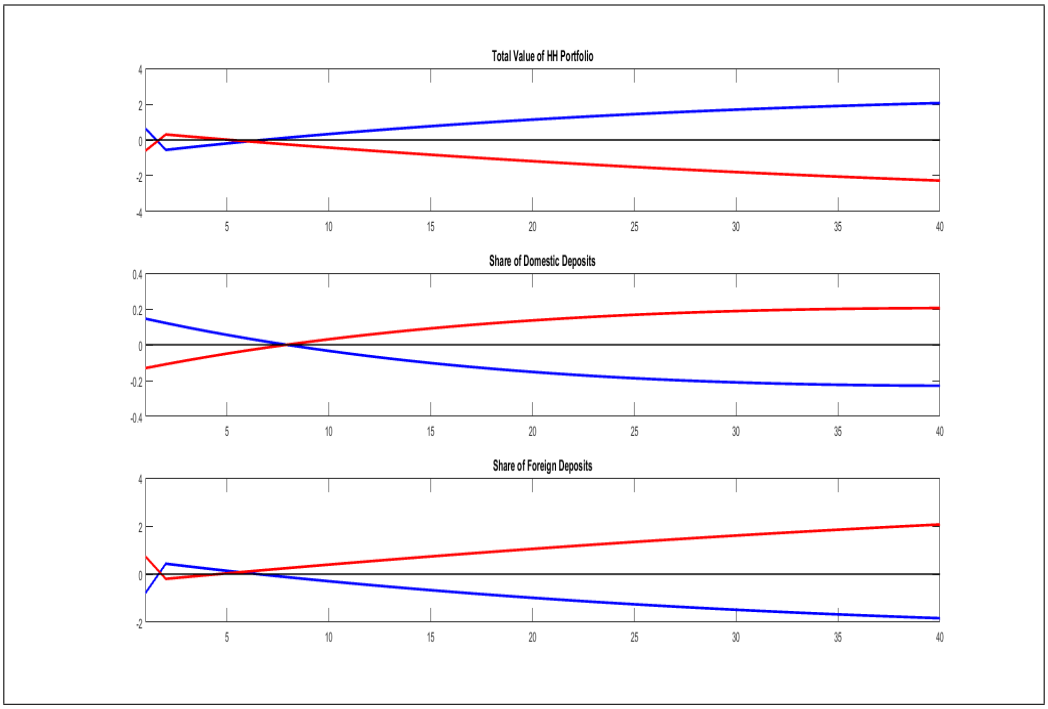


Figure A6. Impulse responses of the total and the shares of domestic and foreign deposits in the household's portfolio for the US (Home country - blue solid) and Euro area (Foreign country red solid) to a 1% positive bank productivity shock in the Home country.

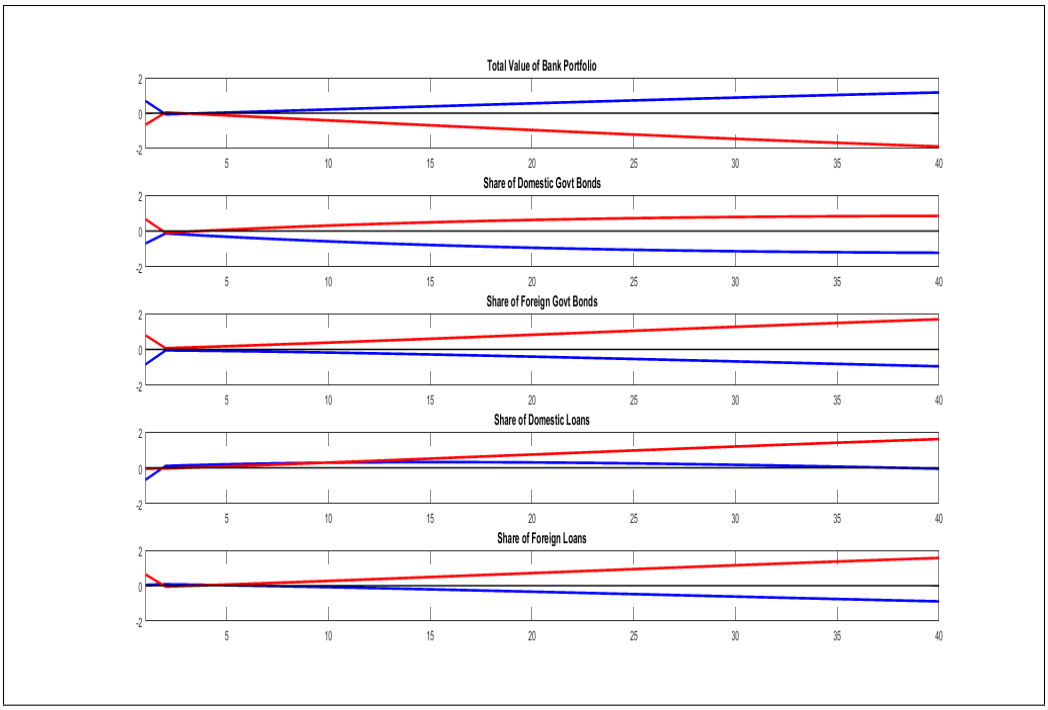


Figure A7. Impulse responses of the total value and the shares of assets in the bank's portfolio for the US (Home country - blue solid) and Euro area (Foreign country red solid) to a 1% positive bank productivity shock in the Home country.

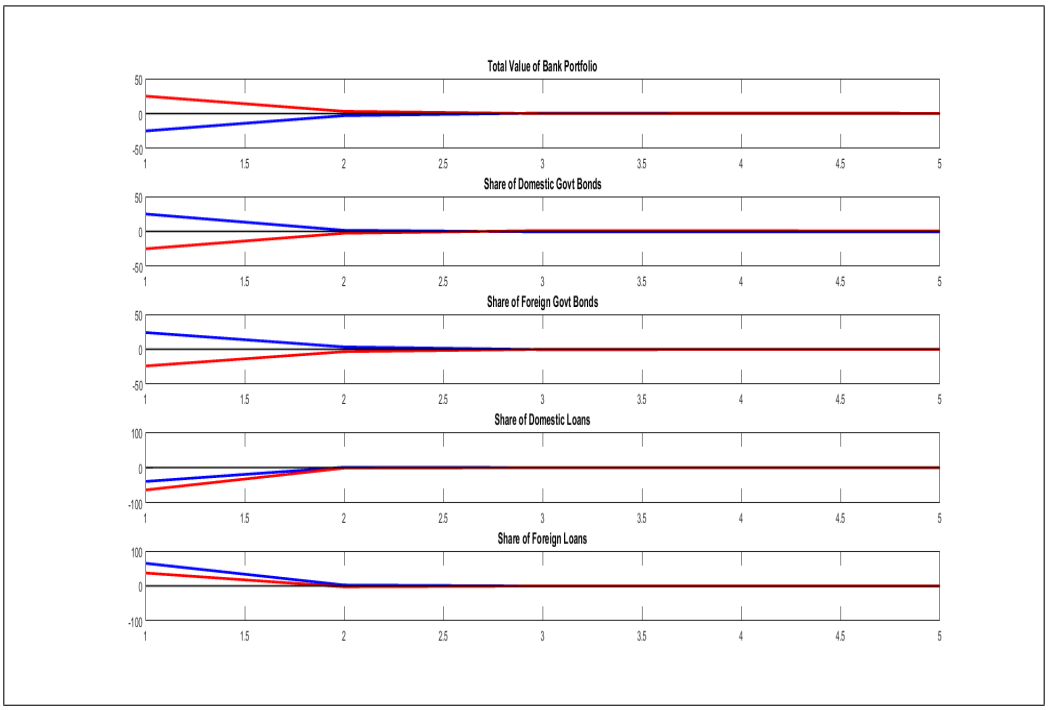
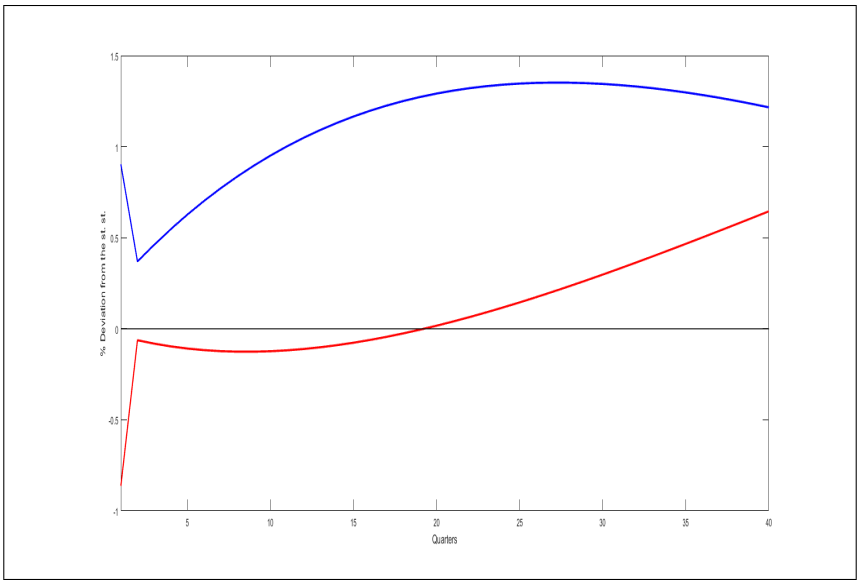
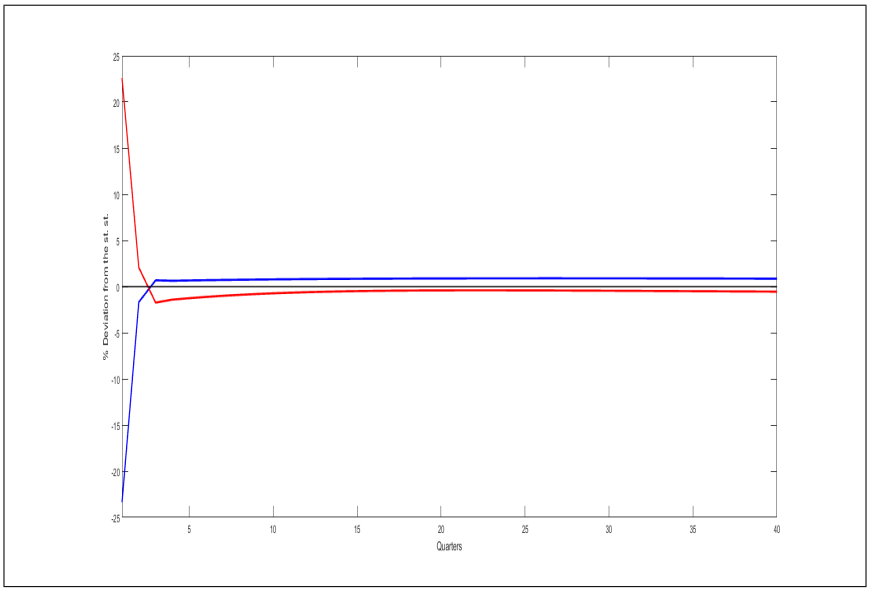


Figure A8. Impulse responses of the total value and the shares of assets in the bank's portfolio for the US (Home country - blue solid) and China (Foreign country red solid) to a 1% positive bank productivity shock in the Home country.



A.9. The impulse responses of the ratio of total loans to total government bond holdings in the bank's portfolio, to 1 percent positive home country banking productivity shock (US - blue solid; Euro area - red solid).



A. 10. The impulse responses of the ratio of total loans to total government bond holdings in the bank's portfolio, to 1 percent positive home country banking productivity shock (US - blue solid; China - red solid).