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Abstract

The world-wide financial crisis of 2007 to 2009 caused bankruptcy and bank failures in the US and many other parts such as Europe. Recent empirical evidence suggests that this simultaneous drop in output was strongest in countries with greater financial ties to the US economy with important cross border deposit and lending. This paper develops a two-country framework to allow for banking structures within an international real business cycle model. The banking structure across countries is modelled using the production approach to financial intermediation. We allow both countries' banks to be able to take deposits both locally and internationally. We analyze the transmission mechanism of both goods and banking sector productivity shocks. We show that goods total factor productivity (TFP) and bank TFP have different effects on the finance premium. Most countries have shown procyclic equity premium over their histories but with evidence that these are countercyclic during the Great Recession especially. The model has the ability to explain the countercyclical movements of credit spreads during major recession and financial crisis when goods TFP also affects banking productivity. This we model as a cross correlation of shocks to replicate the recent events during the crisis period. Importantly, the model can also explain business cycles facts and the countercyclical behaviour of the trade balance.

Keywords: International Business Cycles, Financial Intermediation, Credit Spread

JEL: E13, E32, E44, F41

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1 Introduction

The main idea of analyzing the role of banks in the transmissin of shocks to economies is due to the fact that the synchronized drop in output following the recent financial crisis was strongest in countries with greater financial ties to each other. This paper thus develops a two-country framework to allow for banking structures within a standard international real business cycle model. The banking structure across countries is modelled using the production approach to financial intermediation and is modelled in such a way that the banks collect deposits from households and make loans to firms. To allow for international financial links, we allow banks to be able collect both local and international deposits. We then investigate the impact following both a goods and a banking sector productivity shocks and the extent to which these affect both the local and international transmission of these shocks. We find that, firstly, goods total factor productivity (TFP) and bank TFP have different effects on the finance premium with goods TFP having a procyclical effect on the credit spread due to its accompanying increase in the marginal poduct of capital whereas a positive banking productivity shock will decrease the credit spread given its beneficial effect on banking cost. Most countries have shown procyclic equity premium over their histories but with evidence that these are countercyclic during the Great Recession and during episodes of financial crisis. Hence the model has the ability of explaining such evidence. Furthermore, we show that a cross correlation of goods and banking sector's shocks which could be reflective of major recession and financial crisis has the ability to explain the countercyclical movements of credit spreads. The model is also able to explain one of the key facts in open economy macroeconomics, namely that while on average consumption, investment, exports, and imports are all positively correlated with output, by contrast, the trade balance, the trade-balance-to-output ratio, the current account, and the current-account-to-output ratio are all countercyclical. This means that countries tend to import more than they export during booms and to export more than they import during recessions. This we explain by the presence of the banking sector that allows for bigger domestic absorption following an income increase due to the higher demand for loan and hence deposit.

There are many ways to model financial intermediation and the costly aspect of it. Intermediation creates a friction between savings and loans. For instance, collateral constraint play such key role in Kiyotaki and Moore (1997), Bernanke, Gertler and Gilchrist (1999) use the costly state verification aspect of Townsend (1979) to develop a financial accelerator model, Kiyotaki and Gertler (2012) develop a costly enforcement of contract model using the maturity mismatch of bank runs as in Diamond and Dybvig (1983) and costly banking drives the credit spread in the production approach to financial intermediation as shown by Sealey and Lindley (1977), Clark

(1984), Hancock (1985), Matthews and Thompson (2008) and Gillman (2011). In many of these models, the credit spread plays a key role in reflecting the distortion in the allocation of funds on loans.

There is a large literature on the role of financial integration in the international transmission of real and monetary shocks. For example Heathcote and Perri (2002), Benigno and Thoenissen (2008), Corsetti et al. (2008) and Thoenissen (2011) focus on the role of financial asset market structure and relative price movements in the international transmission of supply shocks and Chari, Kehoe and McGrattan (2002) for instance look at monetary factors in explaining real exchange rate fluctuations. Furthermore, the literature on financially integrated economies has proliferated post 2007 financial crisis with the urge to use explicit financial intermediaries in these models, amongst them Faia (2007, 2010), Kollmann et al. (2011), Kalemli-Ozcan et al. (2012), Dedola and Lombardo (2012), Ueda (2012) and Gamber and Thoenissen (2013). Recently a large literature has emerged using these aspects to also address issues of unconvential monetary policy, viz., Le et al. (2013).

Our approach to bank, or financial intermediary is specified slightly differently and follows from a quite extensive literature. Many partial equilibrium approaches to banking have been used, typically specifying a convex cost function in order to get an upward sloping marginal cost of banking (eg., Berk and Green, 2004, Wang et al., 2009). A way to get a general equilibrium solution is to follow the banking microeconomic literature (see Inklaar and Wang, 2013). Sealey and Lindley (1977) specified a production function for financial intermediation services, followed by a particular constant-returns-to-scale (CRS) function by Clark (1984). Clark made labor and capital inputs but also crucially a third factor, the amount of deposited funds. These deposits can be thought of as financial capital rather than physical capital. Hancock (1985) estimated the Clark function and found that data supported its particular CRS specification in labor, capital and deposits. Since then, this function has been at the basis of standard banking estimated functions, and it is known as the "financial intermediation approach" to modeling banking. This type of modelling for the bank has been well documented in the literature by for instance, Matthews and Thompson (2008) and popularised in dynamic macro models by Gillman (2011). We thus develop a two-country model using the production approach to financial intermediation, furthermore, we allow banks in respective economies to be able to collect both local and international deposits, hence influencing the net foreign asset positions of economies.

The remainder of the paper is structured as follows. Section 2 describes the existing empirical literature on the credit spread and economic activities with a focus on the US and provides some statistical evidence. Section 3 sets out our model, discussing the decentralised problems of the consumer, the bank and the firm. Section 4 provides the calibration of the model's deep parameters and driving forces and examines the international transmission mechanism using impulse response functions and Section 5 concludes.

2 An Overview of the Evidence

In this present section we start by summarizing the existing evidence on credit spread and business cycle fluctuations and provide some evidence of our own. The focus on credit spreads is motivated, in part, by theories of financial market frictions that emphasize linkages between the quality of borrowers' balance sheets and their access to external finance. In most of these models, a deterioration in the capital position of the corporate sector following an economic downturn for instance leads to an increase in the cost of debt finance, i.e., the widening of credit spreads and a subsequent reduction in spending and production. This is in for instance the well known model of the financial accelerator of Bernanke et al. (1996) and the main prediction of these models is that the credit spreads react countercyclically. Empirically, the credit spreads have been shown to be good predictors of economic activity as shown in seminal papers by Stock and Watson (1989), Friedman and Kuttner (1992a,b), Bernanke (1990), and Kashyap, Stein, and Wilcox (1993) and more recently in Philippon (2009) and Gilchrist and Zakrajšek (2012) for instance. They basically confirm the fact that academics, business economists, and policymakers have long relied on credit spreads to gauge the degree of strains in the financial system by showing the ability of the bond market to signal accurately a decline in economic fundamentals prior to a cyclical downturn.

The overwhelming evidence as in for instance Friedman and Kuttner (1992a) and Gilchrist and Zakrajšek (2012) shows that credit spreads widen during deep recessions and are countercyclic. However over the histories of economies, such as the US for instance, Benjamin and Kuttner (1992b) in their extensive statistics, show that the covariance between output and the credit spread is positive.[1] We replicate these two evidences with more recent data showing the countercyclical behaviour of the credit spreads during major recessions and the Great Recession with however procyclic equity premium over most of their histories. These facts we also explain with the use of a model that has the ability to explain the countercyclical movements of credit spreads during major recession and financial crisis but also the procyclic movement in credit spreads during normal times. The main essence of our model is that goods total factor productivity (TFP) and bank TFP have different effects on the finance premium. Basically an increase in output due to a goods total factor

[1] See Table 5.2 to 5.4 of their paper that provides extensive regression of output on credit spreads among other variabls. These results are updated from their (1992a) paper.

productivity increase also calls for an increase in the demand for loans and hence an upward movement in the supply (cost) function of loan and hence causing an increase in the finance premium. On the other hand, an increase in the banking sector's productivity lowers the cost of the bank and hence causes a fall in the credit spread. Hence the model has the ability to explain the countercyclical movements of credit spreads during major recession and financial crisis when goods TFP also affects banking productivity. This we model as a cross correlation of shocks to replicate the recent events during the crisis period.

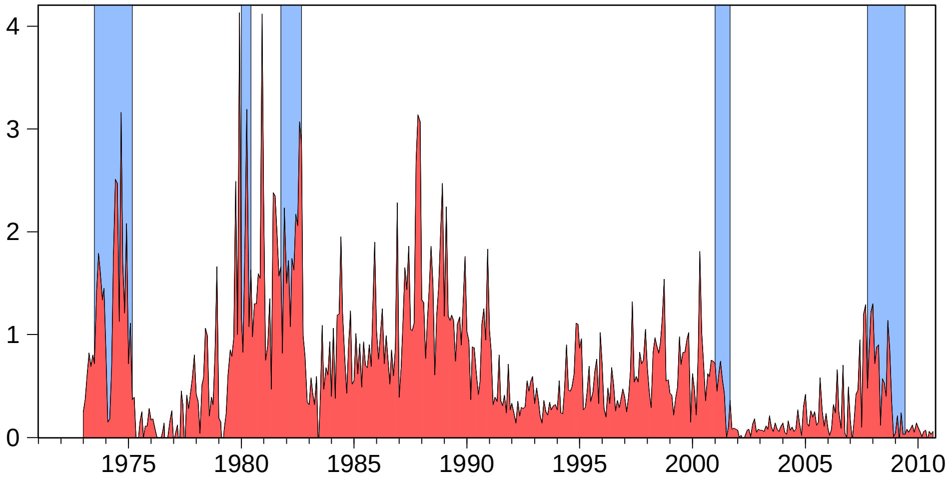
The data comprise monthly observations obtained from the study of Gilchrist and Zakrajšek (2012) who use the proprietary data on the corporate bond market purchased by the Federal Reserve Board over the 1973–2010 period. For the credit spreads measures, we use two widely used default-risk indicators such as the "paper bill" spread and the standard Baa–Aaa corporate bond credit spread. On top of that, we also use the Gilchrist and Zakrajšek (2012) construction of a new credit spread index—the "GZ credit spread"—that has considerable predictive power for economic activity. This spread is constructed using the average (cross-sectional) credit spread on senior unsecured corporate bonds issued by nonfinancial firms measuring essentially the borrowing costs of different firms at the same point in their capital structure in their sample (in percentage points). To compute the spread, they use a hypothetical Treasury security with exactly the same cash flows as the underlying corporate bond. As a measure of business cycle, we use the manufacturing industrial production index (2007=100), using the HP filter as a measure of the trend.[2] Business cycles are then computed as the log difference between the index and the trend.

We first plot the three credit spreads with the NBER-dated recessions in Figures 1, 2 and 3. The figures show the countercyclical behaviour of the credit spreads mainly during deep recessionary times such as the Great Recession.

Table 1 provides some statistics showing the behaviour of the credit spreads. As the table shows, the spread is typically wider not just during but also immediately prior to recessions, in line with the results of Friedman and Kuttner (1992a,b) among others.

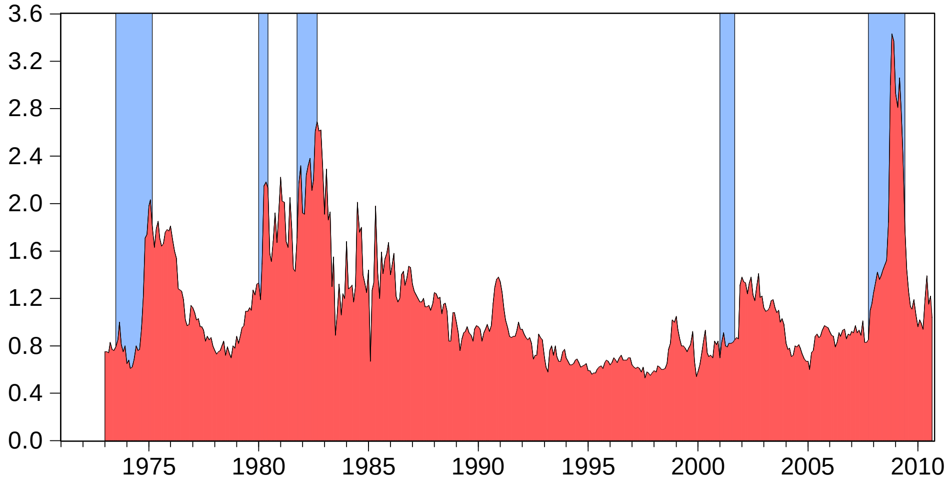
In Table 2, we provide partial regression coefficients of these pair-wise relationships where we select the twelfth lagged values of the credit spread given that one year captures the most interesting predictive ability of this variable to forecast economic

[2]We have also conducted these studies using data set containing the quarterly time series used in the analysis and the results are qualitatively the same and can be obtained upon request from the authors.



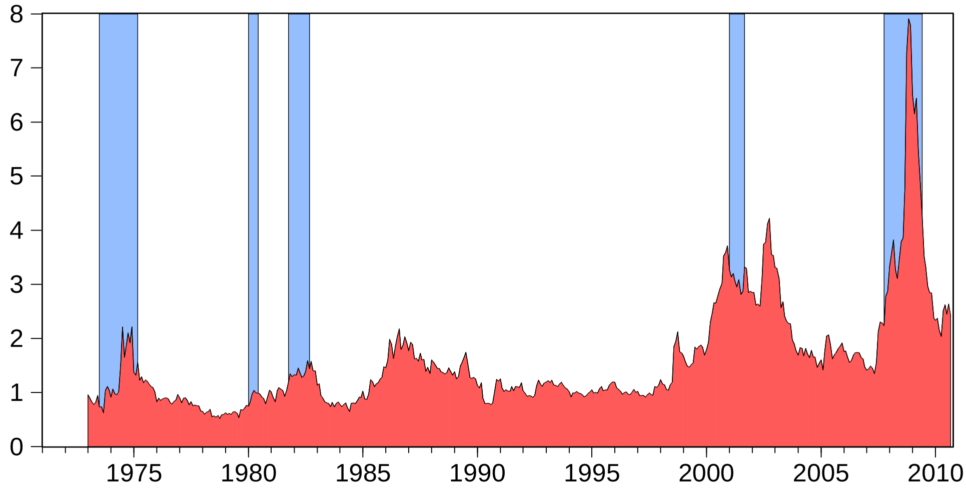
Notes: Sample period: 1973:1–2010:9. The figure depicts the CP–Bill = the spread between the yield on one-month A1/P1 nonfinancial commercial paper and the one-month Treasury yield. The shaded vertical bars represent the NBER-dated recessions.

Figure 1: CP-Bill spread and NBER-dated recessions



Notes: Sample period: 1973:1–2010:9. The figure depicts the Baa–Aaa = the spread between yields on Baa and Aaa rated long-term industrial corporate bonds. The shaded vertical bars represent the NBER-dated recessions.

Figure 2: BAAAAA spread and NBER-dated recessions



Notes: Sample period: 1973:1–2010:9. The figure depicts the GZ spread = the average credit spread on senior unsecured bonds issued by nonfinancial firms in our sample. The shaded vertical bars represent the NBER-dated recessions.

Figure 3: GZ spread and NBER-dated recessions

	CP-Bill (%)	**Baa–Aaa (%)**	**GZ (%)**	**Observations**
Mean over 1973:1 – 2010:10 period	0.69	1.12	1.59	453
Mean during recessions	1.10	1.57	2.53	69
Mean excluding recessions	0.61	1.03	1.41	384
Mean 1-6 months prior to recession	1.07	1.10	1.53	30

Note: Observations are based on Gilchrist and Zakrajšek (2012).

Table 1: Cyclical Behavior of the Credit Spreads

$\Delta Y_t = \beta * Credit\ Spread_{t-12} + \varepsilon_t$						
	Including recessions			Excluding recessions		
Parameter	**CP-Bill**	**Baa-Aaa**	**GZ**	**CP-Bill**	**Baa-Aaa**	**GZ**
β	-0.41	-0.21	-0.21	0.30	0.28	0.15
	(0.001)	(0.04)	(0.002)	(0.006)	(0.001)	(0.014)

Notes: Figures in brackets are p-values.

Table 2: In-sample estimates of relationship between HP-filtered business cycles and credit spreads

activities. We have also tried with 3, 6 and 9 lagged values of the credit spread and the results do not differ qualitatively. Interestingly, one can note that once the deep recessionary periods are removed from the sample, credit spread displays procyclic behaviour. The latter positive covariance have been shown to be stable even after inclusion of other variables such as interest rates or growth of the monetary aggregates, together with lags of the dependent variables as in Friedman and Kuttner (1992a).[3]

Earlier, we mention that the model is able to explain the observed countercyclicality of the trade balance, the current account and the current-account-to-output ratio as documented by Schmitt-Grohé and Uribe (2015) for instance. Two features in dynamic macro models of the open economy are important for making this prediction possible. First, productivity shocks must be sufficiently persistent so that the household does not need to save part of the current increase in output to smooth consumption and secondly, capital adjustment costs must not be too strong so that domestic absorption is big enough. In this paper, the presence of the banking sector helps to explain the countercyclicality of the trade balance and the current account due to the fact that following an increase in banking productivity, loan, deposit and capital increase to provide amplitude to domestic absorption. There is also an accompanying terms of trade and real exchange rate depreciation following a current account deficit, as usually found in factual data.

3 The Model

We model the world economy within an optimizing two-country international business cycle model. The world economy is composed of two countries, the domestic

[3] We restrict our empirical study to these two variables in this paper since inclusion of other variables together with system estimation such as VAR have largely been documented in the literature, viz., Friedman and Kuttner (1992a) among others.

and the foreign economy, and labeled H and F respectively. The mass of world population is normalized to 1. Country H households lie on the interval $[0, n]$, where $0 < n < 1$, while the population on the segment $(n, 1]$ belongs to country F. Moreover variables with an asterisk correspond to the foreign economy. Departing from the standard two-country version found in the literature, a competitive banking sector that stands in between households and goods producers is introduced. Each representative bank combines bank liabilities together with other factor inputs in a costly financial intermediation fashion to make loans to goods producers. Since each bank are allowed to take deposits both locally and internationally, these banks also occupy foreign asset position. The dynamics of the model are driven by aggregate shocks in the goods producing sector. We then let the banking productivity shock react to goods sector productivity shock, the idea here is that the banks have idiosyncratic risk that they can insure against, but they are not so able to insure when there is correlation of the bank productivity shock with the goods sector productivity shock. As the definitions of systemic risk seem to be about the aggregate productivity shock, this correlation will hopefully allow us to capture the aggregate risk impact on the economy.

3.1 Household

Financial intermediation is needed when the consumer cannot directly take savings and turn them into investment of capital. Assume this is the case, that the consumer now cannot invest directly in capital for renting to the firm or in financial markets and instead must invest through the bank. We assume that there are two deposits traded internationally: one is denominated in the consumption index of country H and the other in the consumption index of country F. Denote deposit of the domestic household in country H to country H bank as $d_{H,t}$ (and deposit of the of the (foreign) household in country F to country F bank as $d^*_{F,t}$). Furthermore, let $d^*_{HF,t}$ represents deposit of the domestic household in country H to country F bank (and likewise $d_{FH,t}$ represents deposit of the (foreign) household in country F to country H bank). Note that a d^* represents deposits denominated in the consumption index of country F.

To do this the domestic consumer deposits $d_{H,t}$ into the domestic bank and receives a return of $(1 + R_{d,t})\, d_{H,t}$, where $R_{d,t}$ is the dividend return. The consumer owns the bank so the total dividends received are $R_{d,t} d_{H,t}$, which are the profit of the bank. This dividend is equivalent to interest earned on the dividends. The only difference is the ownership structure. Here the consumer is assumed to own the bank and receives the profit. Alternately it could be assumed that the consumer rents capital to the bank in the form of deposits $d_{H,t}$ and receives the deposits back next period plus the rental cost in the form of interest income; this interest would be equal to $R_{d,t}d_{H,t}$. With the ownership assumption, the way it works is that the consumer gets one share of ownership with each dollar deposited. The price of the share is fixed at one, but variable profits still can result. These are given back to the consumer as dividends per unit of deposited funds, with the dividend rate per unit of deposits $R_{d,t}$. By paying out all profits as these dividends the bank earns no extra profit; profit is zero after paying out dividends. The domestic consumer also deposits $d^*_{HF,t}$ into the foreign bank and receives a return of $\left(1+R^*_{d,t}\right)d^*_{HF,t}$, where $R^*_{d,t}$ is the dividend return.

The framework modifies the baseline dynamic neoclassical model, in which the consumer invests directly in physical capital. The only difference is that now the investment takes the form of choosing $d_{H,t+1}$ and $d^*_{HF,t+1}$, the new deposits to make for next period, while receiving $(1+R_{d,t})\,d_{H,t}$ and $\left(1+R^*_{d,t}\right)d^*_{HF,t}$ in the current period as the return of the deposited funds along with the dividends earned.

The consumer allocates time between working in the goods production sector, $l_{G,t}$ (G subscripts for Goods), in the bank sector, $l_{F,t}$ (F subscripts for Financial Market), and taking leisure x_t. The allocation of time constraint with a time endowment of one is :

$$l_{G,t}+l_{F,t}+x_t = 1 \tag{1}$$

$$\text{where } l_{G,t}+l_{F,t} = l_t \tag{2}$$

Recursive utility is a natural log function of goods C_t and leisure x_t, with $\alpha \geq 0$, and the "state" variable d_t and $d^*_{HF,t}$:

$$V\left(d_{H,t},d^*_{HF,t}\right) = \underset{C_t,x_t,d_{H,t+1},d^*_{HF,t+1}}{Max} \ln C_t + \alpha \ln x_t + \beta V\left(d_{H,t+1},d^*_{HF,t+1}\right). \tag{3}$$

Consumption is equal to wage income, which with w_t (the real wage expressed in terms of the consumption bundle $w_t \equiv W_t/P_{C,t}$) plus the dividend income $R_{d,t}d_{H,t}+R^*_{d,t}d^*_{HF,t}Q_t$ is added to the labor income, and the net increase invested in deposits at the bank, of $(d_{H,t+1}-d_{H,t})+(d^*_{HF,t+1}-d^*_{HF,t})Q_t$, where the consumption based real exchange rate in our model is defined as $Q_t=\frac{P^*_{C,t}}{P_{C,t}}$. $\frac{\chi_B}{2}\left(Q_t d_{H,t+1}\right)^2$ is a portfolio adjustment cost on the foreign asset/debt which generates a country premium when lending/borrowing externally.[4] This makes consumption being equal to income mi-

[4]This assumtion is deemed necessary to close open economy models, see Schmitt-Grohe and Uribe (2003) for an extensive presentation and solutions. Without country premium, the debt dynamic is not stationnary because of an unit root.

nus investment, in the form of the budget constraint

$$C_t = w_t (1 - x_t) + R_{d,t} d_{H,t} + R^*_{d,t} d^*_{HF,t} Q_t - (d_{H,t+1} - d_{H,t}) - (d^*_{HF,t+1} - d^*_{HF,t}) Q_t \tag{4}$$

$$-\frac{\chi_B}{2} \left(Q_t d^*_{HF,t+1}\right)^2 . \tag{5}$$

$$C_t = w_t (1 - x_t) + (1 + R_{d,t}) d_{H,t} + (1 + R^*_{d,t}) d^*_{HF,t} Q_t - d_{H,t+1} - d^*_{HF,t+1} Q_t \tag{6}$$

$$-\frac{\chi_B}{2} \left(Q_t d^*_{HF,t+1}\right)^2 . \tag{7}$$

On the Bellman Equation, we now apply the standard Langrangian method by creating the Lagrange multiplier μ_t which is the shadow value of the constrained variable C_t:

$$\underset{C_t, x_t, d_{H,t+1}, d^*_{HF,t+1}}{Max} L = \ln C_t + \alpha \ln x_t + \beta E_t V\left(d_{H,t+1}, d^*_{HF,t+1}\right) + \tag{8}$$

$$\mu_t \left[\begin{array}{c} w_t (1 - x_t) + (1 + R_{d,t}) d_{H,t} + (1 + R^*_{d,t}) d^*_{HF,t} Q_t - d_{H,t+1} - d^*_{HF,t+1} Q_t \\ -\frac{\chi_B}{2} \left(Q_t d^*_{HF,t+1}\right)^2 - C_t \end{array} \right]$$

The first order equilibrium conditions for labor l_t and deposits $d_{H,t+1}$ are respectively

$$\frac{\alpha C_t}{x_t} = w_t \tag{9}$$

$$\frac{1}{C_t} = \beta \frac{\partial E_t V\left(d_{H,t+1}, d^*_{HF,t+1}\right)}{\partial d_{H,t+1}}, \tag{10}$$

and the envelope condition is

$$\frac{\partial V\left(d_{H,t}, d^*_{HF,t}\right)}{\partial d_{H,t}} = \frac{1}{C_t} (1 + R_{d,t}) . \tag{11}$$

The last two conditions imply that the intertemporal marginal rate of substitution is given by

$$(1 + R_{d,t}) = E_t \frac{1}{\beta} \left(\frac{C_{t+1}}{C_t}\right) \tag{12}$$

The first order equilibrium conditions for $d^*_{HF,t+1}$ is

$$\mu_t Q_t \left(1 + \chi_B Q_t d^*_{HF,t+1}\right) = \beta \frac{\partial E_t V\left(d_{H,t+1}, d^*_{HF,t+1}\right)}{\partial d_{H,t+1}}, \tag{13}$$

and the envelope condition is

$$\frac{\partial V\left(d_{H,t}, d^*_{HF,t}\right)}{\partial d^*_{HF,t}} = \mu_t Q_t \left(1 + R^*_{d,t}\right). \tag{14}$$

Bring forward time index in envelope condition and then substitute in equilibrium condition equation (13)

$$\frac{\mu_t Q_t \left(1 + \chi_B Q_t d^*_{HF,t+1}\right)}{\left(1 + R^*_{d,t}\right)} = \beta E_t \mu_{t+1} Q_{t+1} \tag{15}$$

Substituting equation (12) in equation (15) yields the uncovered interest parity condition in real terms

$$\left(\frac{1 + R_{d,t}}{1 + R^*_{d,t}}\right) \left(1 + \chi_B Q_t d^*_{HF,t+1}\right) = E_t \left(\frac{Q_{t+1}}{Q_t}\right). \tag{16}$$

In logs this yields

$$R_{d,t} = R^*_{d,t} + \log E_t \left(\frac{Q_{t+1}}{Q_t}\right) - \chi_B Q_t d^*_{HF,t+1}. \tag{17}$$

Thus the expected change in the real exchange rate is driven by the difference between the home and the foreign interest rate adjusted by the country risk because of freedom to move deposits in and out into global financial markets in deposits. There is an analogous optimal labour supply and intertemporal consumption allocation for the foreign household.

International risk sharing. One implication under complete markets that assume that agents can trade Arrow-Debreu claims on international assets have implied that the ex-post marginal rates of substitution in consumption should be equalized for residents in different countries. Under the assumption of isoelastic and separable utility, these models imply that consumption growth rates should be equalized across countries and under identical initial consumption levels, consumption are basically equal across countries. This implication has been dramatically rejected by the data and is also as known the Backus and Smith (1993) puzzle which is the lack of correlation between growth rates of relative consumption and the growth rate of the real exchange rate.

Starting from these premises, recent theoretical papers that have attempted to explain such puzzle that has been termed as the 'consumption-real exchange rate anomaly' have either assumed an incomplete financial market structure as a necessary condition for explaining the observed evidence such as in Chari et al. (2002) where domestic and foreign agents are only allowed to trade in a non state-contingent nominal bond, other papers have used both incomplete asset markets in the form of having risk free bond traded together with other features such as nontradables or there are also explanations based on allowing home-bias toward home-produced intermediate or final goods together with explanations based on consumer currency pricing. All these in an attempt to show how the consumption-based real exchange rate deviates from purchasing power parity (PPP). In our study, we follow Gamber and Thoenissen (2011) for instance in assuming that there is heterogeneity in the consumption basket (i.e., $\gamma \neq \gamma^*$) might lead to the real exchange rate deviating from PPP on top of the fact that in our model, the two agents can invest in deposits across countries.

To derive imperfect risk sharing, notice that the home country representative agent Euler equation is given by the following

$$\beta E_t \left(\frac{C_{t+1}}{C_t} \right)^{-1} = \frac{1}{(1 + R_{d,t})} \tag{18}$$

and the foreign country analogue is

$$\beta E_t^* \left(\frac{C_{t+1}^*}{C_t^*} \right)^{-1} = \frac{1}{\left(1 + R_{d,t}^*\right)} \tag{19}$$

Under international tradability of assets (here deposits), which also means that UIP condition in real term holds, then

$$\beta E_t^* \left(\frac{C_{t+1}^*}{C_t^*}\right)^{-1} = \frac{1}{(1+R_{d,t}^*)} \tag{20}$$

$$\beta E_t^* \left(\frac{C_{t+1}^*}{C_t^*}\right)^{-1} = \left(\frac{1}{1+R_{d,t}}\right) \tag{21}$$

$$\left(\frac{1}{(1+\chi_B Q_t d_{HF,t+1}^*)}\right) E_t \left(\frac{Q_{t+1}}{Q_t}\right) \tag{22}$$

$$\beta E_t^* \left\{ \left(\frac{C_{t+1}^*}{C_t^*}\right)^{-1} \left(\frac{Q_t}{Q_{t+1}}\right) (1+\chi_B Q_t d_{HF,t+1}^*) \right\} = \left(\frac{1}{1+R_{d,t}}\right) \tag{23}$$

Assuming that expectations are similar across countries ($E_t^* = E_t$), we have

$$\beta E_t \left\{ \left(\frac{C_{t+1}^*}{C_t^*}\right)^{-1} \left(\frac{Q_t}{Q_{t+1}}\right) (1+\chi_B Q_t d_{HF,t+1}^*) \right\} = \beta E_t \left(\frac{C_{t+1}}{C_t}\right)^{-1} \tag{24}$$

Using the notation $u'(c)$ to denote marginal utility and the fact that the real exchange rate deviates from PPP under heterogeneity of consumption baskets so that $Q_t = \frac{P_{C,t}^*}{P_{C,t}}$, the above equation can be put in the following form

$$E_t \left\{ \left(\frac{u'(C_{t+1})}{u'(C_t)} / \frac{u'(C_{t+1}^*)}{u'(C_t^*)} \right) \right\} = E_t \left(\frac{Q_t}{Q_{t+1}}\right) (1+\chi_B Q_t d_{HF,t+1}^*) \tag{25}$$

Log-linearizing, that gives us

$$E_t(\hat{Q}_{t+1} - \hat{Q}_t) = E_t \left((u'\left(\hat{C}_{t+1}^*\right) - u'\left(\hat{C}_{t+1}\right)) - (u'\left(\hat{C}_t^*\right) - u'\left(\hat{C}_t\right)) + \chi_B Q_t d_{HF,t+1}^* \right) \tag{26}$$

which shows that movements in the real exchange rate, defined as $Q_t = \frac{P_{C,t}^*}{P_{C,t}}$ are related to movements in the relative marginal utilities of consumption and the country's risk via the the standard international risk sharing condition under incomplete markets. Hence under incomplete markets the relation between real exchange rates and consumption growth holds in expected first differences and this weakens the relation between consumption growth across countries and the real exchange rate.

3.2 Demand Aggregation

Let X_t be the final good in the domestic country which is obtained by aggregating over intermediate home produced goods $X_{H,t}$ and imported intermediate goods $X_{F,t}$. The final good X_t is linearly allocated to household's consumption demand and to investment I_t. This composite utility index can be represented as a constant elasticity of substitution (CES) specification

$$X_t = \left[\gamma^{\frac{1}{\eta}}(X_{H,t})^{\frac{\eta-1}{\eta}} + (1-\gamma)^{\frac{1}{\eta}}(X_{F,t})^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}, \tag{27}$$

where η is the elasticity of substitution between H and F goods and $1-\gamma$ represents the share of foreign (imported) intermediate goods in the domestic basket, and is therefore a natural measure of the degree of openness. As γ goes to 1, the home economy becomes closed.

The households and firms in each period maximises this composite utility index given total real expenditure amount $P_{C,t}Z_t$ has been chosen, with respect to its components, $X_{H,t}$ and $X_{F,t}$ subject to

$$P_{C,t}Z_t \equiv P_{H,t}X_{H,t} + P_{F,t}X_{F,t}, \tag{28}$$

where $P_{H,t}$ is the domestic price level and $P_{F,t}$ is the foreign price level. Although we have three prices in the domestic economy, there are only two that are independent in a real economy, since prices are not denominated in terms of a currency as in a nominal economy. For instance, Obstfeld and Rogoff (1996) have all the prices expressed in terms of the foreign good, which is taken to be the numeraire in a real economy. In this paper, we could therefore set the third price to unity. However it is more instructive if we do not add this restriction at this stage. We form the Lagrangean by treating the final good as the numeraire so that all prices are expressed relative to the general price level $P_{C,t}$

$$\underset{X_{H,t},X_{F,t}}{Max}\ L = \left[\gamma^{\frac{1}{\eta}}(X_{H,t})^{\frac{\eta-1}{\eta}} + (1-\gamma)^{\frac{1}{\eta}}(X_{F,t})^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}} + \lambda\left(Z_t - \frac{P_{H,t}}{P_{C,t}}X_{H,t} - \frac{P_{F,t}}{P_{C,t}}X_{F,t}\right) \tag{29}$$

From the conditions for $\partial L/\partial X_{H,t}$ and $\partial L/\partial X_{F,t}$, we obtain the relative consumption of H and F goods as a function of their relative price, the terms of trade $\frac{P_{F,t}}{P_{H,t}}$:

$$\frac{X_{H,t}}{X_{F,t}} = \frac{\gamma}{1-\gamma}\left(\frac{P_{F,t}}{P_{H,t}}\right)^{\eta} \tag{30}$$

Thus an increase in the relative price of H good reduces their consumption relative to the F good. As the elasticity of substitution $\eta \longrightarrow 0$, H and F goods are consumed in fixed proportions, and as $\eta \longrightarrow \infty$, H and F goods become perfect substitutes, the relative price becomes a fixed proportion.

The optimal demand allocation across home and imported intermediate goods for a given level of X_t gives the demand equations (which are obtained by combining the above expenditure switching equation with the budget constraint)

$$X_{H,t} = \gamma\left(\frac{P_{H,t}}{P_{C,t}}\right)^{-\eta} X_t \tag{31}$$

$$X_{F,t} = (1-\gamma)\left(\frac{P_{F,t}}{P_{C,t}}\right)^{-\eta} X_t \tag{32}$$

Thus, the share of home (foreign) produced goods in total demand decreases as the relative price of the H good increases; the size of the response increases with the substitutability of the H good for the F good.

From the optimality conditions, the consumption price index $P_{C,t}$ which measures the least expenditure of foreign goods that buys a unit of the consumption index, on which period utility depends, is given as follows (which is obtained by substituting the individual demand functions into the consumption index and solving for the price level):

$$P_{C,t} = \left[\gamma(P_{H,t})^{1-\eta} + (1-\gamma)(P_{F,t})^{1-\eta}\right]^{\frac{1}{1-\eta}} \tag{33}$$

where the general price level is a function of H and F goods' prices. If instead the home good was chosen as the numeraire as in Obstfeld and Rogoff (1996) so that the home good price was set to unity, then by dividing the above equation by $P_{H,t}$, one obtains the general price in line with the terms of trade $P_{C,t} = [\gamma + (1-\gamma)(\tilde{p}_t)^{1-\eta}]^{\frac{1}{1-\eta}}$, whereby $\tilde{p}_t$ is the terms of trade, i.e., the relative price of the F good in terms of the H good. There is a symmetric optimal demand allocation across home and foreign goods for the foreign country, together with the foreign country price index.

3.3 Bank Maximization Problem

There is one bank residing in each country. These two banks in the world economy take deposits both locally and internationally as suggested above and in Kollman et al. (2011) for instance, and make local loans. We also note that since households across domestic and foreign countries can lend their deposits to either country depending on the demand for capital investment, this effectively allows for international capital flows. With our definition of deposits above in place, let total deposits in the home and foreign banks be given by $\hat{d}_t \equiv d_{H,t} + d_{FH,t}$ and $\hat{d}_t^* \equiv d_{F,t}^* + d_{HF,t}^*$ respectively. Note that $d_{FH,t}$ are defined as deposits that the country H bank takes from country F household and lends to country H firm, thereby increasing country H capital stock and $d_{HF,t}^*$ are defined as deposits that the country F bank takes from country H household and lends to country F firm. If $d_{FH,t} > 0$, then in a two-country model it must be that $d_{HF,t}^* Q_t$ is the negative of $d_{FH,t}$.

In autarky, the capital in the home country $k_t = q_t = d_t$ and the analogue for the foreign country is $k_t^* = q_t^* = d_{F,t}^*$. In the context of capital flows across countries, we instead have $k_t = q_t = d_{H,t} + d_{FH,t}$ and $k_t^* = q_t^* = d_{F,t}^* + d_{HF,t}^*$. In addition, the banks' balance sheet across the two countries are as follows following no capital reserves requirements.[5]

Assets	Liabilities
q_t	$d_{H,t}$
	$d_{FH,t}$
q_t	$\hat{d}_t$
HOME	BANK

Assets	Liabilities
q_t^*	$d_{F,t}^*$
	$d_{HF,t}^*$
q_t^*	$\hat{d}_t^*$
FOREIGN	BANK

Then the production of loans by the home country's bank is subject to the financial intermediation CRS technology that requires labor from the representative agent $l_{F,t}$ and total savings deposits $\hat{d}_t$. With $A_{F,t}$ representing the home banking sector's productivity process later to be defined and $\kappa \in [0, 1]$, the total loans offered by the home bank is

[5] With capital reserves (hat can also be invested in the risk free government bond, this would yield an adhoc setting of $\frac{q_t}{\hat{d}_t} < 1$ and $(\frac{q_t^*}{\hat{d}_t^*} < 1)$.

$$q_t = A_{F,t}(l_{F,t})^{\kappa}(d_{H,t} + d_{FH,t})^{1-\kappa}, \tag{34}$$

$$= A_{F,t}(l_{F,t})^{\kappa}(\hat{d}_t)^{1-\kappa}, \tag{35}$$

$$\frac{q_t}{\hat{d}_t} = A_{F,t}\left(\frac{l_{F,t}}{\hat{d}_t}\right)^{\kappa}. \tag{36}$$

The production function for the financial intermediary, or bank, service is that the loans q_t are produced using the deposited funds $\hat{d}_t$ and the labor $l_{F,t}$, via a Cobb-Douglas production function, just as is used for the production of the consumption good. Here the productivity parameter is $A_{F,t} \geq 0$ (we later specify a functional form for $A_{F,t}$).

Now, it is very easy to see what this production function means by taking the case when κ goes towards 0. At $\kappa = 0$, the function becomes simply

$$q_t = A_{F,t}\hat{d}_t. \tag{37}$$

In this case only deposits are used and no labour is necessary. Further if $A_{F,t} = 1$ (assumed a constant for simplicity), then

$$q_t = \hat{d}_t, \tag{38}$$

and the amount of deposits put in the bank are what get paid out as the output of the bank. As shown in Gillman (2011), if we were operating in a setup whereby the financial intermediary provides insurance across states of nature, this would also be a case of actuarily fair odd price for insurance. This is worth mentioning since if there are costs, then the transferring of funds across time, distance, or states of nature requires that some lesser amount of funds than what was deposited will be available after the transfer. Hence costly banking also takes us away from actuarially fair insurance price.

With $R_{q,t}$ and $R_{d,t}$ denoting respectively the interest rate on loans paid by the goods producer and deposits of households. The home bank time t profit, denoted by $\Pi_{F,t}$, is the net revenue of net loan increases plus net deposit increases, or $-q_{t+1} + (1 + R_{q,t})\, q_t + \hat{d}_{t+1} - \hat{d}_t\, (1 + R_{d,t})$, minus the labor cost $w_t l_{F,t}$.

This makes the profit ex-dividends equal to zero, and it is given by the time t

function $\Pi_{F,t}$:

$$\begin{aligned}\Pi_{F,t} &= -q_{t+1} + (1 + R_{q,t})\, q_t + (d_{H,t+1} + d_{FH,t+1}) - (d_{H,t} + d_{FH,t})\,(1 + R_{d,t}) - w_t l_{F,t} \\ &= -q_{t+1} + (1 + R_{q,t})\, q_t + \hat{d}_{t+1} - \hat{d}_t\,(1 + R_{d,t}) - w_t l_{F,t}\end{aligned}$$

This profit $\Pi_{F,t}$ is maximised subject to the production technology in equation (34). The dynamic home bank problem in recursive form is

$$\begin{aligned}&\Pi_F\left(q_t, \hat{d}_t\right) = \underset{q_{t+1},\hat{d}_{t+1},l_{F,t}}{Max} \\ &\Big\{-q_{t+1} + q_t\,(1 + R_{q,t}) + \hat{d}_{t+1} - \hat{d}_t\,(1 + R_{d,t}) - w_t l_{F,t} \\ &-\lambda_t\left[q_t - A_{F,t}(l_{F,t})^{\kappa}(\hat{d}_t)^{1-\kappa}\right] + z_t \Pi_F\left(q_{t+1}, \hat{d}_{t+1}\right)\Big\}\end{aligned} \tag{39}$$

whereby λ_t has the interpretation of the shadow or marginal cost of output of loans q_t and z_t represent the discount factor in the bank problem.

The equilibrium conditions gives that the ratio of the factor products equal the ratio of the factor costs:

$$\frac{\left[1 - (1-\kappa)\, A_{F,t}\left(\frac{l_{F,t}}{\hat{d}_t}\right)^{\kappa}\right]}{\kappa A_{F,t}\left(\frac{l_{F,t}}{\hat{d}_t}\right)^{\kappa_1 - 1}} = \frac{R_{q,t} - R_{d,t}}{w_t} \tag{40}$$

A particular equilibrium exists under the assumption of no capital reserve requirements and a balance sheet constraint that the change in loans is equal to the change in deposits $q_{t+1} - q_t = \hat{d}_{t+1} - \hat{d}_t$, all deposits get turned into loans such that $\frac{q_t}{\hat{d}_t} = 1$, and $\frac{l_{F,t}}{\hat{d}_t} = \frac{1}{\left(A_{F,t}\right)^{\frac{1}{\kappa}}}$. This gives the loan rate as a competitive equilibrium cost mark-up from the endogenous dividend rate $R_{d,t}$.

$$R_{q,t} - R_{d,t} = \frac{w_t}{(A_{F,t})^{\frac{1}{\kappa}}}. \tag{41}$$

The labour demand in the financial market:

$$\kappa A_{F,t}\left(\frac{l_{F,t}}{\hat{d}_t}\right)^{\kappa-1}=\frac{w_t}{R_{q,t}}, \tag{42}$$

We have the following loan supply function relating relative loan to deposit ratio $\frac{q_t}{\hat{d}_t}$ as a function of the loan rate $R_{q,t}$:

$$R_{q,t}=\frac{w_t}{\kappa\left(A_{Ft}\right)^{\frac{1}{\kappa}}}\left(\frac{\hat{q}_t}{d_t}\right)^{\frac{1-\kappa}{\kappa}} \tag{43}$$

A symmetric set of equations exists for the foreign bank.

3.4 Goods Producer Problem

Intermediate good y_t is produced using capital borrowed from the bank and labour. Intermdiate good is used for consumption and investment in both home and foreign economies. With $R_{q,t}$ the price of loans from the bank to the firm and $P_{h,t}$ (i.e., $P_{h,t}=\frac{P_{H,t}}{P_{C,t}}$) denoting the price of the home-produced intermediate good relative to the home consumption good, the goods producer time t profit denoted by Π_t, is given by

$$\begin{aligned}\Pi_t &= P_{h,t}y_t-w_t l_{G,t}-k_{t+1}+k_t\left(1-\delta_k\right) && (44)\\ &\quad +q_{t+1}-q_t\left(1+R_{q,t}\right) && (45)\end{aligned}$$

subject to the production constraint $y_t=A_{G,t}(l_{G,t})^{\gamma}(k_t)^{1-\gamma}$and the constraint that new investment in capital is paid for by new loans from the bank:

$$i_t=k_{t+1}-k_t=q_{t+1}-q_t \tag{46}$$

This being in place from the beginning of time, say at time $t=0$, it implies that the capital stock k_t^d equals the outstanding loans $\hat{q}_t$, so that

$$k_t=q_t. \tag{47}$$

With this substituted into the goods producer maximization problem, it reduces to a static problem, rather than a dynamic one, given by

$$\underset{l_{G,t},k_t}{Max} : \Pi_t = P_{h,t}A_{G,t}(l_{G,t})^{\gamma}(k_t)^{1-\gamma} - w_t l_{G,t} - k_t^d \left(R_{q,t} + \delta_k\right). \tag{48}$$

The marginal product of capital then just equals the loan interest rate $R_{q,t}$ plus the depreciation rate δ_k :

$$P_{h,t}\left(1-\gamma\right)A_{Gt}\left(\frac{l_{G,t}}{k_t}\right)^{\gamma} = R_{q,t} + \delta_k, \tag{49}$$

while the marginal product of labor equals the real wage

$$P_{h,t}\gamma A_{G,t}\left(\frac{l_{G,t}}{k_t}\right)^{\gamma-1} = w_t \tag{50}$$

A set of symmetric equations exist for the foreign economy.

3.5 Market clearing, current account and net foreign assets

Market clearing for domestic intermediate good must satisfy:

$$y_t = X_{H,t} + X_{H,t}^{*} \tag{51}$$

Market clearing for foreign varieties holds symmetrically for the foreign country. Market clearing in the final good sector in both countries implies:

$$X_t = C_t + I_t \ \text{ and } \ X_t^{*} = C_t^{*} + I_t^{*}. \tag{52}$$

The dynamics of the net foreign asset position of the domestic and foreign economies are derived by consolidating the household's budget constraints. The household owns both the goods producer and the bank and receives any residual profits from these two sectors. Adding these profits to the household's consolidated budget constraint yields:

$$P_{h,t}Y_t - X_t + R_{d,t}^{*}d_{HF,t}^{*}Q_t = Q_t(d_{HF,t+1}^{*} - d_{HF,t}^{*}) \tag{53}$$

The left hand side of the above equation denotes the current account, which is the addition of net trade and interest on income and the right hand side represents the capital account. In a two country setup, the net supply of foreign asset clears

$$d_{FH,t} = -Q_t d^*_{HF,t} \tag{54}$$

and hence the current account, from the home country perspective, is determined by foreign assets variations

$$CA_t = d_{FH,t+1} - d_{FH,t-1} \tag{55}$$

3.6 Openness to trade

In this section, we link the two countries' preferences for the H and the F goods to size of countries and openness to trade. Total consumption in the home and foreign countries is defined as a constant elasticity of substitution (CES) aggregate of home and foreign produced goods for the home and foreign countries respectively $X_t = \left[\gamma^{\frac{1}{\eta}}(X_{H,t})^{\frac{\eta-1}{\eta}} + (1-\gamma)^{\frac{1}{\eta}}(X_{F,t})^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}$ and $X^*_t = \left[\gamma^{*\frac{1}{\eta}}(X^*_{H,t})^{\frac{\eta-1}{\eta}} + (1-\gamma^*)^{\frac{1}{\eta}}(X^*_{F,t})^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}$. Following De Paoli (2009) and later use by Gamber and Thoenissen (2013) for instance, the parameter determining home consumers' preferences for foreign goods, $(1-\gamma)$, is assumed to be a function of the relative size of the foreign economy, $1-n$, and of the degree of openness, λ, more specifically, $1-\gamma = (1-n)\lambda$. Similarly, foreign consumers' preferences for home goods depend on the relative size of the home economy and the degree of openness, $\gamma^* = n\lambda$. Note that, for $\lambda < 1$, the specification of γ and γ^* generates a home bias in consumption.

In the limit, when n approaches zero the share of home-produced goods in foreign consumption tends to zero, $\gamma^* = 0$, and the foreign economy behaves just like a closed economy. In the home economy, the share of home-produced goods in total consumption, γ, becomes a function of the degree of openness of the home economy, $\gamma = 1-\lambda$.

Also note that in linearized form, the terms of trade $T_t = \frac{P_{F,t}}{P_{H,t}}$ and the real exchange rate $Q_t = \frac{S_T P^*_{C,t}}{P_{C,t}}$ are related by the degree of openness $\hat{Q}_t = (1-\lambda)\hat{T}_t$.

3.7 Aggregate Shock and Bank Productivity Shock in the World Economy

The following loglinearized equations for goods sector productivity and banking sector productivity for the home country are posited in this section, with symmetric equations holding in the foreign country. Each economy is buffeted by two sources of shocks, namely the aggregate shock from the goods sector and the shock from the banking sector. We do not allow for a cross correlation between these two types of shocks for simplicity.

The variable $A_{G,t}$ and $A_{F,t}$ denote the goods and bank total factor productivity processes respectively in the home country. The equations summarizing the log-linearized stochastic processes are given by:

$$\ln A_{G,t} = (1-\rho_g)\ln A_G + \rho_g \ln A_{G,t-1} + \varepsilon_{g,t} \tag{56}$$

$$\ln A_{F,t} = (1-\rho_f)\ln A_F + \rho_f \ln A_{F,t-1} + \varepsilon_{f,t} + \rho_{fg}\varepsilon_{g,t} \tag{57}$$

where (ρ_g, ρ_f) $\in$(-1, 1) measures the persistence of these processes and $(\varepsilon_{gt}, \varepsilon_{ft})$ are i.i.d. white noise process with a zero mean and a unit variance. We allow for cross correlation of shocks such that a goods productivity shock also affects banking productivity, the idea here is that the banks have idiosyncratic risk that they can insure against, but they are not so able to insure when there is correlation of the bank productivity shock with the goods sector productivity shock. As the definitions of systemic risk seem to be about the aggregate productivity shock, this correlation will hopefully allow us to capture the aggregate risk impact on the economy of major recessions such as the recent financial crisis.

4 Results and implications

There are two shocks driving our model, the goods total factor productivity shock and banking sectors' productivity shocks. We also discuss the case of a cross correlation of shocks such that a goods productivity shock also affects banking productivity as would be true during a crisis. This section provides the calibrated values of this model and then employs impulse responses to analyze how firstly, we can gauge the impact of a goods total factor productivity shock on the model, secondly, the model's implication when there is a banking sector productivity shock and thirdly, analysing the impact on the economy when the shocks are cross correlated.

4.1 Calibration

Table 3 summarizes our parameter choice and provides a brief rationale, most of the parameter values match those commonly employed in other studies and are closely related to key characteristics of the U.S. economy. A period in the model corresponds to one quarter. The size of the domestic economy is set to $n = 0.37$, which corresponds to the weight of the U.S. economy in the OECD. Calculations are based on OECD Economic Outlook data: GDP is measured in year 2000 USD (PPP). Througout the unit of time is taken to be one quarter. The discount factor for both households is set to 0.99, implying an annual interest rate on deposits held with the banks of 4% in both countries. We set the openness parameter, $\lambda = 0.25$, to match the average import share of consumption and investment goods in the US for instance. We have also varied it to some of the values used in the literature, for instance, Corsetti et al. (2010) use a value of 0.15 but the results are qualitatively the same. The intratemporal elasticity of substitution between home and foreign-produced intermediate goods is set to $\eta = 1.5$, close to Benigno and Thoenissen (2006) value. In the production function, the elasticity of output to capital, is set to 0.34 while the depreciation rate is set to 0.025 implying an annualized depreciation rate of 10%. The elasticity of substitution θ for consumption is set to 1 implying that consumption in the utility function is logarithmic. The disutility to labour supply is set at 1.5. We calculate the share of deposits in loan production using Gillman and Kejak (2011) and set it to 0.9. They calibrate the share parameter using financial industry data. The parameter defining the portfolio adjustment cost χ_B is set to 0.01. We set $\rho_{fg} = 0.5$, assuming that the banking productivity shock responds to goods total factor productivity shock where we follow Smets and Wouters (2007) and Liu et al. (2011) for instance who assume similar behaviour in terms of government spending shock reacting to productivity shocks. We use the posterior mean value for this parameter that these two papers have though they assume a much larger prior distribution and a mean posterior value somewhat higher than the one we choose.[6] We would also like to emphasize at this point that our study focus more on the implicaitons of the model via impulse response functions rather than estimation. The baseline calibration parameters for both countries are given in Table 3.

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[6] Our results do not change qualitatively assuming different values for ρ_{fg}.

Parameters	Description	Country H	Country F (if different)
Preferences			
θ	Relative risk-aversion parameter	1	
α	Leisure weight	1.5	
β	Discount factor	0.99	
Goods production			
γ	Share of capital in output	0.34	
δ_k	Depreciation rate of goods sector	0.025	
ρ_g	Persistence of goods TFP	0.95	
Banking sector			
κ	Labour share in loan production	0.1	
ρ_f	Persistence of bank TFP	0.95	
Open economy			
η	CES btw home and foreign goods	1.5	
λ	Openness	0.25	
n	Population parameter	0.37	0.63
χ_B	Country premium	0.01	
Cross correlation			
ρ_{fg}	Goods and bank TFP corr	0.5	

Note: Baseline calibrated parameters.

Table 3: Baseline Calibrated Parameters

4.2 Transmission mechanism of goods total factor productivity shock

To gain intuition about the model's transmission mechanisms, we analyze impulse responses of selected variables following a goods total factor productivity shock. The productivity process assume persistence of 0.95. Figure 4 shows the impulse responses to a one percent shock to the goods productivity process ($A_{G,t}$).

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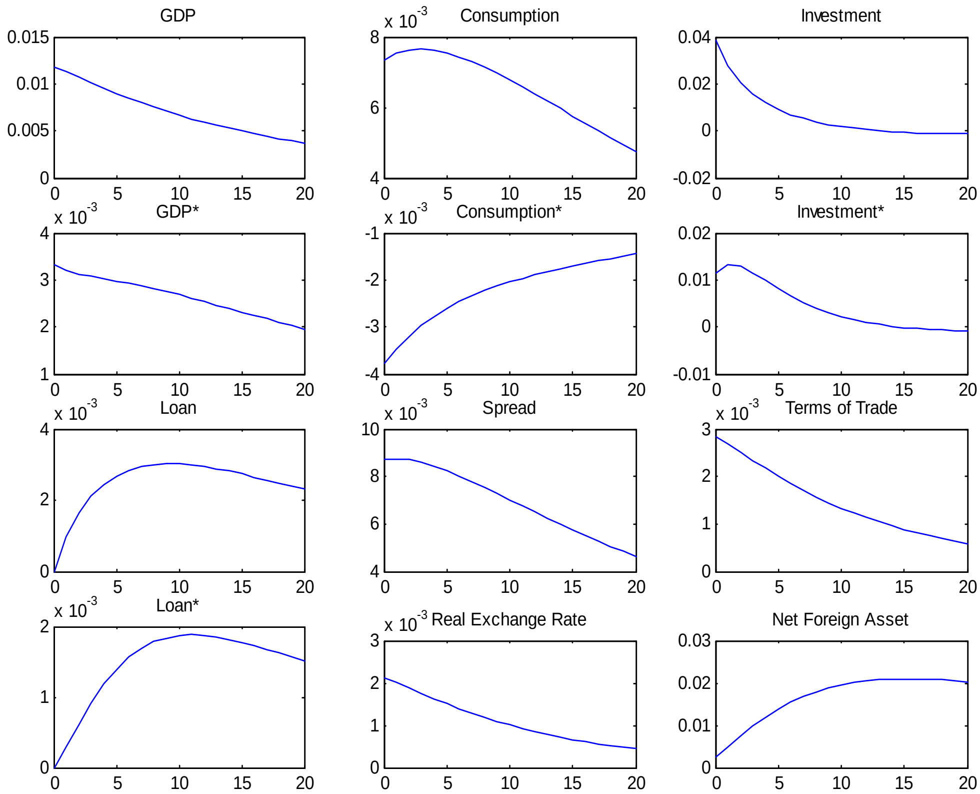
When there is an increase in goods productivity, $A_{G,t}$, the results above show there is an increase in investment following the surge in marginal product of capital. This increases the loan requirement and hence capital stock, so that output and consumption also rise. There is significant positive spillover effects on the foreign country's output though foreign consumption falls and foreign investment increases. This can be attributed to the surge in interest rates that makes foreign consumption expensive together with a real exchange rate appreciation that makes foreign goods expensive. The terms of trade and real exchange rate depreciate since the higher productivity causes a fall in marginal cost and hence in domestic price. The current account (net foreign asset) registers a surplus following a goods total factor productivity



Notes: Variables are expressed in percentage deviation from steady state and interest rates in annual percentage points. Foreign variables are denoted by an asterisk *.

Figure 4: Impulse responses to a one-standard-deviation shock to the good's productivity process

increase since output increase is bigger than domestic absorption. The credit spread increases reflecting the higher return to capital. Likewise, during a downturn, this will result in a fall in the credit spread.

4.3 Transmission mechanism of a bank productivity shock

We analyze impulse responses of selected variables following a bank total factor productivity shock. The productivity process assume persistence of 0.95. Figure 5 shows the impulse responses to a positive one percent shock to the bank productivity process ($A_{F,t}$). The idea is that the interest rate spread that captures the cost of banking increases significantly if there is a fall in bank's productivity as shown in the figure below (note that the figure shows the responses for a positive banking sector shock) and hence the loan rate increases. Hence capital stock shifts out (back) both supply and demand, as output rises (fall). The shift in demand and supply occurs because the capital stock rises (falls). The increase in capital results because the interest rate spread that captures the cost of banking falls significantly as shown in the figure and hence the loan rate falls (increases). In a banking crisis situation, this spread significantly increases and hence loan rate, thus causing capital to fall and hence output, consumption and investment. The banking crisis model of reduced bank productivity therefore offers a way to endogenously generate a crisis type drop in capital and employment without the need to impose fixed prices of labour or capital. All other variables behave pretty much as in the case of a goods total factor productivity shock except that the current account (net foreign asset) registers a deficit in line with the facts discussed in the empirical section. This is due mainly to higher domestic absorption caused by the surge for higher investment need.

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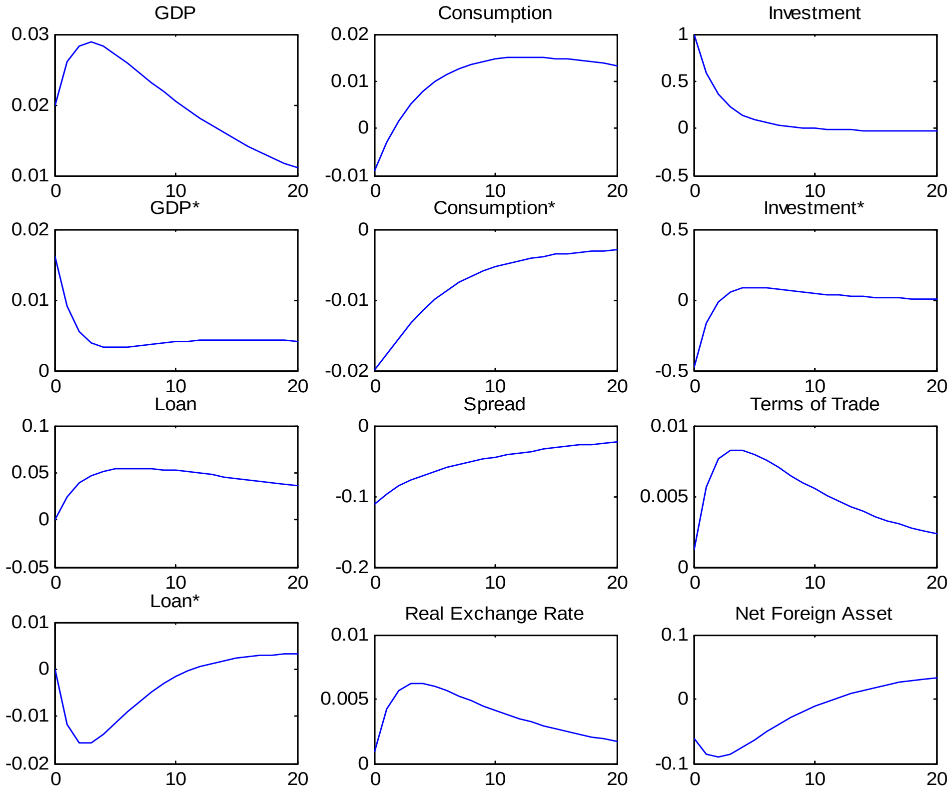
4.4 Transmission mechanism of a cross correlated bank productivity shock with goods total factor productivity

The banking productivity shock responds to the goods technology shock as would be consistent during large bank crises (the 1930s depression and the 2007-2009 recession). These are situtations whereby aggregate risk would affect the banking sector as well. The figure below shows that a cross correlation of goods and banking sector's shocks has the ability to explain the countercyclical movements of credit spreads during major recession and financial crisis. That would trigger the wage rate and the capital stock also to fall significantly, as do consumption, investment and output. Such pervasive changes across the economy are consistent with major



Notes: Variables are expressed in percentage deviation from steady state and interest rates in annual percentage points. Foreign variables are denoted by an asterisk *.

Figure 5: Impulse responses to a one-standard-deviation shock to the banking sector's productivity process

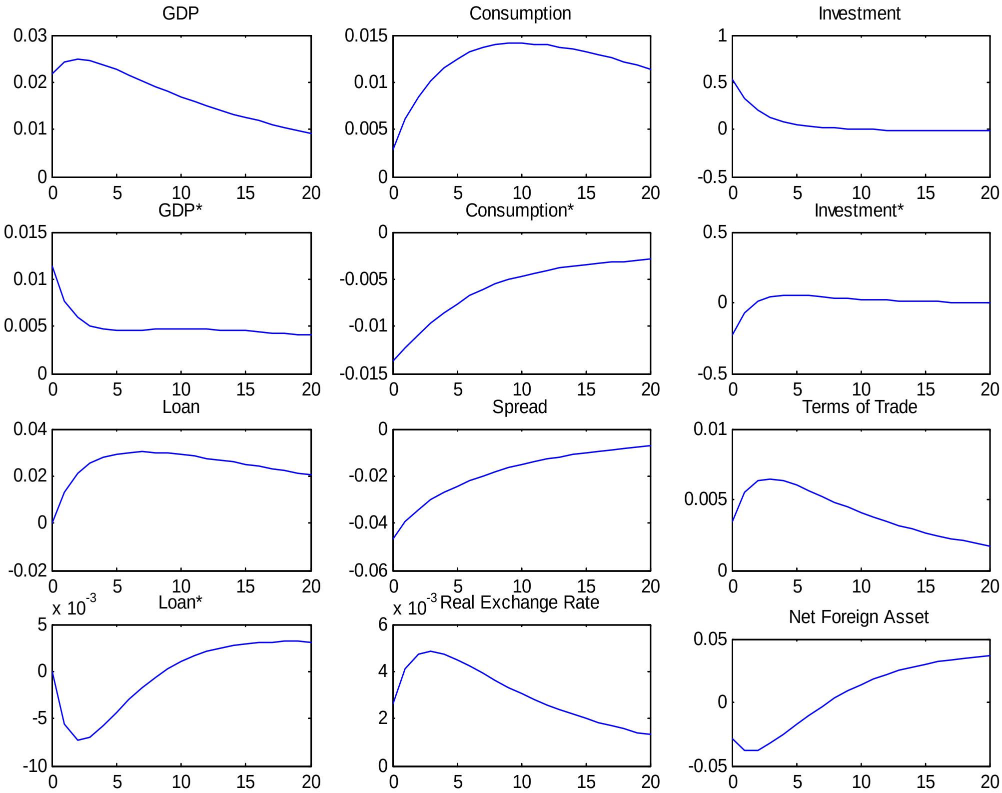


Figure 6: Impulse response function to a cross correlated shock

recessions accompanied with bank crises.

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5 Concluding remarks

This paper analyzes the international transmission of both goods and financial shocks across countries. The main motivation behind the analysis is due to the fact that the synchronized drop in output following the recent financial crisis was greater in countries with greater financial ties as evidence shows and importantly there was a major increase in the credit spread during the recent crisis. This paper thus develops a two-country decentralized framework whereby there is a bank in each country that intermediates between the savings of consumers and the loans to firms. The financial intermediary is modelled using the production approach to financial intermediation whereby the bank combines factor inputs such as labor and importantly deposits to produce loans. It turns out that in this model, the banking costs as represented by labor and banking sector's productivity decline induces the interest rate spread. To allow important international financial linkages, we let banks across countries to be able to collect both local and international deposits. We then investigate the impact following a goods total factor productivity shock, a banking sector's productivity shock and a cross correlated shock. As is consistent in the literature, a negative productivity shock causes the credit spread to significantly increase, thus causing capital to fall together with output, consumption and investment. This we show with a cross correlated shock of the bank with the goods total factor productivity process. The transmission channel we highlight is potentially important, i.e., when banks engage in cross border deposit or loan requirments. We also emphasize that this is not the only channel through which financial shocks can propagate across economies. The literature has highlighted a number of alternative mechanisms, from completely globalized banking through to equalization of banking spreads through arbitrage of risky assets. We plan to investigate these in future research.

Backus, D. K. and Smith, G. W. (1993). Consumption and real exchange rates in dynamic economies with non-traded goods. Journal of International Economics, 35, 297-316.

Benigno, G. and Thoenissen, C. (2008). Consumption and real exchange rates with incomplete markets and non-traded goods. Journal of International Money and Finance, 27(6), 926-948.

Berk, J. and Green, R. (2004). Mutual fund flows and performance in rational markets. Journal of Political Economy, 112(6), 1269–95.

Bernanke, Ben S. (1990). On the predictive power of interest rates and interest rate spreads. New England Economic Review, 5, 1-68.

Bernanke, B., Gertler, M. and Gilchrist, S. (1999). The financial accelerator in a quantitative business cycle framework. Handbook of Macroeconomics 1C, 1341-1393.

Chari, V., Kehoe, P. J., and McGrattan, E. (2002). Can sticky price models generate volatile and persistent real exchange rates? Rev Econ Stud 69(3), 533–563.

Clarida, R., Gali, J., and Gertler, M. (2002). A simple framework for international monetary policy analysis. Journal of Monetary Economics, 49, 879-904.

Clark, J. A. (1984). Estimation of Economies of Scale in Banking Using a Generalized Functional Form, Journal of Money, Credit, and Banking, 16(1), 53–68.

Corsetti, G., L. Dedola, and S. Leduc (2008). International risk sharing and the transmission of productivity shocks. Review of Economic Studies, 75, 443-473.

Corsetti, G., Meier and Müller, J. G. (2010) Cross-Border Spillovers from Fiscal Stimulus, International Journal of Central Banking, International Journal of Central Banking, 6(1), 5-37.

De Paoli, B. (2009). Monetary policy and welfare in a small open economy. Journal of International Economics, 77 (1), 11-22.

Dedola, L. and G. Lombardo (2012). Financial frictions, financial integration and the international propagation of shocks. Economic Policy, 27(70), 319-359.

Diamond, D. W., and Dybvig, P. H. (1983). Bank runs, deposit insurance, and liquidity. Journal of Political Economy, 91(3), 401–419.

Friedman, B. M., and Kuttner, K. N. (1992a). Money, income, prices and interest rates. American Economic Review, 82, 472-92.

Friedman, B. M., and Kuttner, K. N. (1992b). Why Does the Paper-Bill Spread Predict Real Economic Activity? NBER Chapters, in: Business Cycles, Indicators and Forecasting, 213–254 National Bureau of Economic Research, Inc..

Gerali, A., Neri, S., Sessa, L. and Signoretti, F. M. (2010). Credit and banking in a dsge model of the euro area. Journal of Money, Credit and Banking 42 (s1), 107-141.

Gilchrist, S. and Zakrajšek, E. (2012). Credit spreads and business cycle fluctuations. American Economic Review, 102(4), 1692-1720.

Gillman, M. (2011). Advance Modern Macroeconomics, Pearson Edition.

Gillman, M. and Kejak, M. (2009). Inflation, investment and growth: a money and banking approach. Economica, 78(310), 260-282.

Hancock, D. (1985). The financial firm: production with monetary and nonmonetary goods. Journal of Political Economy, 93(5), 859–80.

Heathcote, J. and Perri, F. (2002). Financial autarky and international business cycles. Journal of Monetary Economics 49 (3), 601-627.

Goodfriend, M. and B. McCallum. 2007. Banking and interest rates in monetary policy analysis: A quantitative exploration. NBER Working Papers, Working Paper 13207:1{45.

Inklaar, R. and Wang, C. (2013). Real Output of Bank Services: What Counts Is What Banks Do, Not What They Own. Economica, 80 (317), 96-117.

Kalemli-Ozcan, S., Papaioannou,E. and Perri, F. (2012). Global banks and crisis transmission. Journal of International Economics, 89(2), 495-510.

Kamber, G. and C. Thoenissen (2013). Financial exposure and the international transmission of financial shocks. Journal of Money, Credit and Banking 45 (2), 128-158.

Kashyap, A. K., Stein, J. C. and Wilcox. D. W. (1993). Monetary policy and credit conditions: Evidence from the composition of external finance. American Economic Review, 83, 79-98.

Kiyotaki, N. and J. Moore (1997). Credit cycles. Journal of Political Economy 105 (2), 211-248.

Kiyotaki, N. and J. Moore (2012). Liquidity, Business Cycles, and Monetary Policy. NBER Working Paper No. 17934.

Kollmann, R., Enders, Z. and Muller, G. (2011). Global banking and international business cycles. European Economic Review 55 (3), 407-426.

Le, V.P.M., Meenagh, D., Minford, P., Ou, Z. (2013). What Causes Banking Crises? An Empirical Investigation For the World Economy, Open Economies Review, 21(4), 581–611.

McGuire, P. and G. von Peter (2012). The US dollar shortage in global banking and the international policy response. International Finance, 15 (2), 155-178.

Matthews, K. and Thompson, J. (2008). The Economics of Banking, 2nd edn. Chichester: John Wiley.

Sealey, C. W. and Lindley, J. T. (1977). Inputs, outputs, and a theory of production and cost at depository financial institutions. Journal of Finance, 32(4), 1251–66.

Ueda, K. (2012). Banking globalization and international business cycles: Cross-border chained credit contracts and _nancial accelerators. Journal of International Economics, 86 (1), 1-16.

Wang, J. Christina, and Susanto Basu, and John G. Fernald, 2009. "A General-Equilibrium Asset-Pricing Approach to the Measurement of Nominal and Real Bank Output," NBER Chapters, in: Price Index Concepts and Measurement, pages 273-320 National Bureau of Economic Research, Inc.

Zheng L., Waggoner, D. F. and Zha, T. (2011). Sources of macroeconomic fluctuations: A regime-switching DSGE approach, Quantitative Economics, 2(2), 251-301.