Appendix to

Monetary and Macroprudential Policy in an Estimated DSGE Model of the Euro Area

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1 Introduction

This appendix contains further details on the theoretical model and its estimation. Section 2 describes the derivation of the model in greater detail. Section 3 derives the steady state of the model, while Section 4 provides additional details on the properties of log-normal distributions that are needed to log-linearizing the model. Section 5 provides additional robustness results on the Bayesian estimation of the model.

2 The Model

The model can be summarized as follows:

- Two-country model of the euro area, with a home country H of size n (the core) and foreign country F of size $1-n$ (the periphery). In each country there are two types of agents: savers (of mass λ) and borrowers (of mass $1-\lambda$). There are two sectors in each country: non-durable and durable goods.
- Both types of goods are produced under monopolistic competition and nominal rigidities. The production function is linear in labor in all sectors. Non-durable consumption goods are traded across countries, while durable goods are non-tradable and used to increase the housing stock.
- In each country, savers and borrowers consume non-durable goods, purchase durable goods and provide labor to both sectors. Borrowers are more impatient than savers and have preference for early consumption, which creates the condition for credit to occur in equilibrium.
- Borrowers use their housing stock as collateral to gain access to credit. We adapt the mechanism of Bernanke, Gertler and Gilchrist (1999), henceforth BGG, to the household side and to residential investment. Shocks to the valuation of housing affect the balance sheet of borrowers, which in turn affect the default rate on mortgages and the lending-deposit spread.
- International financial intermediaries channel funds from one country to the other. Savings and (residential) investment need not to be balanced at the country level period by period.

- Monetary policy is conducted by a central bank that targets the union-wide CPI inflation rate, and also reacts to fluctuations in the union-wide real GDP growth.
- Macropudential policy influences credit market conditions by affecting the fraction of liabilities (deposits and loans) that banks can lend. This instrument can be thought of as additional capital requirements, liquidity ratios, reserve requirements or loan-loss provisions that reduce the amount of loanable funds by financial intermediaries and increase credit spreads.
- Macroprudential policy influences credit market conditions above and beyond current regulations. It targets credit spreads by affecting the fraction of liabilities (deposits and bonds) that financial intermediaries can lend. Spreads can be increased by imposing e.g. additional capital surcharges, liquidity ratios, loan-loss provisions, or reserve requirements, whereas the direct provision of liquidity to the banking sector (either through conventional or unconventional policies) can decrease spreads. This could be achieved via measures such as widening of collateral standards, the *Funding for Lending Scheme* launched by the Bank of England in 2012, or even liquidity provision to the real economy as in Gertler and Karadi (2011).

In what follows, we present the home country block of the model, by describing the domestic and international credit markets, households, and firms. The foreign country block has a similar structure and, to save space, is not presented. Unless specified, all shocks follow zero-mean AR(1) processes in logs.

2.1 Credit Markets

We adapt the BGG financial accelerator idea to the housing market, by introducing default risk in the mortgage market, and a lending-deposit spread that depends on housing market conditions. There are two main differences with respect to the BGG mechanism. First, there are no agency problems or asymmetric information in the model, and borrowers will only default if they find themselves underwater: that is, when the value of their outstanding debt is higher than the value of the house they own. Second, unlike the BGG setup, we assume that the one-period lending rate is pre-determined and does not depend on the state of the economy, which seems to be a more realistic assumption.[1]

2.1.1 Domestic Intermediaries

Domestic financial intermediaries collect deposits from savers S_t, for which they pay a deposit rate R_t, and extend loans to borrowers S_t^B for which they charge the lending rate R_t^L. Credit granted to borrowers is backed by the value of the housing stock that they own ($P_t^D D_t^B$), where P_t^D are nominal house prices and D_t^B is the level of the housing stock owned by borrowers. We introduce risk in the credit and housing markets by assuming that each borrower (indexed by j) is subject to an idiosyncratic quality shock to the value of her housing stock, ω_t^j, that is log-normally distributed with CDF $F(\omega)$. We choose the mean and standard deviation so that $E\left[\omega_t^j\right] = 1$. There is idiosyncratic risk but no aggregate risk in the housing market. This assumption implies that $\log(\omega_t^j) \sim N(-\frac{\sigma_{\omega,t}^2}{2}, \sigma_{\omega,t}^2)$, with $\sigma_{\omega,t}$ being the standard deviation characterizing the quality shock. This standard deviation is time-varying, and follows an AR(1) process in logs:

$$\log(\sigma_{\omega,t}) = (1-\rho_{\sigma_\omega})\log(\bar{\sigma}_\omega) + \rho_{\sigma_\omega}\log(\sigma_{\omega,t-1}) + u_{\omega,t},$$

with $u_{\omega,t} \sim N(0, \sigma_{u_\omega})$. The support of the log-normal distribution is $(0,\infty)$, meaning that ω_t^j cannot become negative. Figure (1) plots the log-normal distribution with different values of $\bar{\sigma}_\omega$ (0.25 and 0.33). An increase in $\sigma_{\omega,t}$ is mean-preserving, raising only the skewness of the distribution of ω_t^j. Thus, with a higher standard deviation, more mass of the distribution is concentrated on the left and lower values for ω_t^j become more likely.

The quality shock ω_t^j can lead to mortgage defaults and affects the spread between lending and deposit rates. Borrowers use their housing stock as collateral to gain access to credits. The value of collateral is affected by quality shocks and the realization of these shocks is known at the end of the period (after credits have already been granted and the loan rate has been set). Hence, the value of the housing $\omega_{t-1}^j P_t^D D_t^B$ might not be sufficient to fully repay the loan. With high realizations of ω_{t-1}^j, the value of the housing stock is higher than the outstanding debt ($\omega_{t-1}^j P_t^D D_t^B > R_{t-1}^L S_{t-1}^B$) and households repay the full amount of their outstanding loan $R_{t-1}^L S_{t-1}^B$. Realizations of ω_{t-1}^j that are so low that $\omega_{t-1}^j P_t^D D_t^B < R_{t-1}^L S_{t-1}^B$,

[1] A similar approach is taken by Suh (2012) and Zhang (2009).

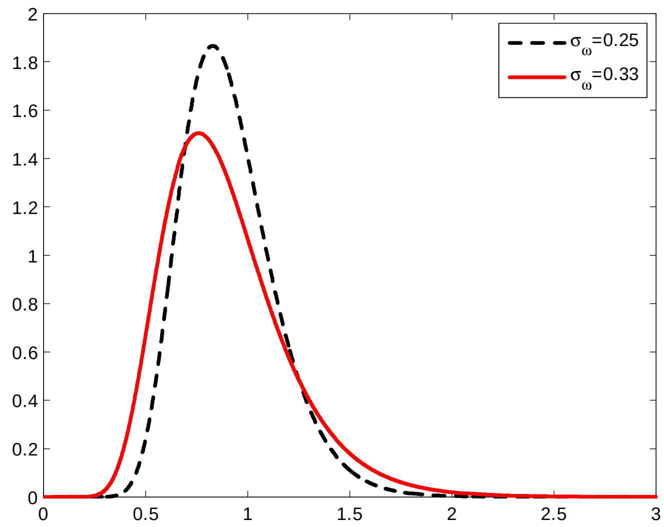

Figure 1: Effect of an Increase in $\sigma_{\omega,t}$ on the Probability Distribution of ω_t^j

however force the household to default on her loan in period t. After the household defaults on its loan, the bank calls a debt collection agency that forces the household to repay the value of the housing stock after the shock has realized, $\omega_{t-1}^j P_t^D D_t^B$. After paying this amount, the household keeps her house. These debt-collection agencies charge banks a fraction μ of the value of the house. The profits of these agencies are transferred to savers, who own them. The value of the idiosyncratic shock is common knowledge, so that households will only default when they are underwater.[2]

When granting credit, financial intermediaries also do not know the threshold $\bar{\omega}_t$ which defines the cut-off value of those households that default and those who do not. The ex-ante threshold value expected by banks is given by:

$$\bar{\omega}_t^a E_t \left[P_{t+1}^D D_{t+1}^B \right] = R_t^L S_t^B. \tag{1}$$

Thus, the threshold $\bar{\omega}_t^a$ is the value of ω_t^j at which borrowers are expected to be indifferent between repaying and defaulting. Notice that $\bar{\omega}_t^a$ is increasing in the

[2]BGG originally assume an agency problem: To observe the final quality of the collateral $\omega_{t-1}^j P_t^D D_t^B$, financial intermediaries must pay a monitoring cost proportional to the collateral $\mu\omega_{t-1}^j P_t^D D_t^B$. Under our assumption however, no fraction of the housing stock is destroyed during the foreclosure process. If, as in BGG, a fraction of the collateral was lost during foreclosure, risk shocks might have unrealistic expansionary effects on housing and residential investment. See Forlati and Lambertini (2011). Suh (2012) also assumes that households that default on their loan pay the value of their house and get to keep it.

expected loan-to-value (LTV) ratio $S_t^B / E_t \left[P_{t+1}^D D_{t+1}^B \right]$.

Given the ex-ante threshold, we can now use the CDF of the quality shock to define the fraction of loans which financial intermediaries expect to be underwater in the next period $t+1$:

$$F\left(\bar{\omega}_t^a, \sigma_{\omega,t}\right) = \int_0^{\bar{\omega}_t^a} dF(\omega; \sigma_{\omega,t}) d\omega, \tag{2}$$

and the fraction of loans which are expected to be repaid:

$$\left[1 - F\left(\bar{\omega}_t^a, \sigma_{\omega,t}\right)\right] = \int_{\bar{\omega}_t^a}^{\infty} dF(\omega; \sigma_{\omega,t}) d\omega. \tag{3}$$

Next, we define

$$G\left(\bar{\omega}_t^a, \sigma_{\omega,t}\right) \equiv \int_0^{\bar{\omega}_t^a} \omega dF(\omega; \sigma_{\omega,t})$$

as the mean value of the quality shock conditional on the shock being less than the threshold $\bar{\omega}_t^a$. We can now also denote the mean value of the housing stock, which financial intermediaries expect to be underwater and will be turned over by borrowers:

$$G\left(\bar{\omega}_t^a, \sigma_{\omega,t}\right) P_{t+1}^D D_{t+1}^B = \int_0^{\bar{\omega}_t^a} \omega P_{t+1}^D D_{t+1}^B dF(\omega; \sigma_{\omega,t}). \tag{4}$$

We introduce a macroprudential instrument η_t that influences credit market conditions by affecting the fraction of liabilities that banks can lend. The balance sheet of financial intermediaries is:

$$n\lambda \frac{1}{\eta_t} \left(S_t - B_t\right) = n\left(1 - \lambda\right) S_t^B, \tag{5}$$

where B_t are claims on financial intermediaries in the foreign country. We assume that this instrument is imposed above and beyond current regulations. Hence, we assume that $\eta_t = 1$ in the estimated version of the model, and that it varies countercyclically in the welfare analysis section. We can think of the macroprudential instrument as additional capital surcharges, loan-loss provisions, or reserve requirements that restrict the amount of loanable funds and affect the spread directly. The macroprudential instrument may also take values smaller than one. In this case, the central bank aims at lowering the spread. This could be implemented e.g. by unconventional monetary policies in the spirit of Gertler and Karadi (2011).

As S_t, B_t and S_t^B are per-capita quantities, we need to multiply them by population size $n\lambda$ and $n\left(1-\lambda\right)$. Intermediaries require the expected return from granting credit to be equal to the funding rate of banks, which equals the deposit rate R_t:

$$
\begin{aligned}
& n\lambda R_t \left(S_t - B_t\right) \\
= \;& n\left(1-\lambda\right) E_t \left\{ (1-\mu) \int_0^{\bar{\omega}_t^a} \omega dF(\omega, \sigma_{\omega,t}) P_{t+1}^D D_{t+1}^B + \left[1 - F\left(\bar{\omega}_t^a, \sigma_{\omega,t}\right)\right] R_t^L S_t^B \right\} \\
= \;& n\left(1-\lambda\right) E_t \left\{ (1-\mu) G\left(\bar{\omega}_t^a, \sigma_{\omega,t}\right) P_{t+1}^D D_{t+1}^B + \left[1 - F\left(\bar{\omega}_t^a, \sigma_{\omega,t}\right)\right] R_t^L S_t^B \right\}. \qquad (6)
\end{aligned}
$$

Equation (6) describes the participation constraint of financial intermediaries. It ensures that their obligations to debtors (left-hand side) are equal to the expected repayment by creditors, which is given by the expected foreclosure settlement (the first term of the right hand side of equation 6) and the expected repayment of households with higher housing values (the second term). Due to the fees paid to debt-collection agencies to make defaulting households pay their debts, financial intermediaries only receive a fraction $(1-\mu)$ of the mortgage settlement. We can use the market clearing condition (5) to rewrite the participation constraint as:

$$
\eta_t R_t = E_t \left\{ (1-\mu) G\left(\bar{\omega}_t^a, \sigma_{\omega,t}\right) \frac{P_{t+1}^D D_{t+1}^B}{S_t^B} + \left[1 - F\left(\bar{\omega}_t^a, \sigma_{\omega,t}\right)\right] R_t^L \right\}. \qquad (7)
$$

For a given demand of credit from borrowers, observed values of risk $\sigma_{\omega,t}$, expected values of the housing stock, and a given macroprudential policy stance η_t, intermediaries passively set the lending rate R_t^L and the expected (ex-ante) threshold $\bar{\omega}_t^a$ so that equation (1) and the participation constraint (7) are fulfilled. Unlike the original BGG set-up, the one-period lending rate R_t^L is determined at time t, and does not depend on the state of the economy at $t+1$. This means that the participation constraint of financial intermediaries delivers ex-ante zero profits. However, it is possible that, ex-post, they make profits or losses. We assume that savers collect profits or recapitalize financial intermediaries as needed.

The participation constraint delivers a positive relationship between the LTV ratio $S_t^B / E_t \left[P_{t+1}^D D_{t+1}^B\right]$ and the spread between the funding and the lending rate, due to the probability of default. This becomes obvious, when we rewrite the participation constraint (7) as:

$$
\frac{R_t^L}{R_t} = E_t \left\{ \frac{\eta_t}{\frac{(1-\mu) G\left(\bar{\omega}_t^a, \sigma_{\omega,t}\right)}{\bar{\omega}_t^a} + \left[1 - F\left(\bar{\omega}_t^a, \sigma_{\omega,t}\right)\right]} \right\}. \qquad (8)
$$

Let's first assume that $\eta_t = \mu = 1$ so that no macroprudential policies are in place and, in case of default, the financial intermediary recovers nothing from the defaulted loan. According to equation (1), the higher is the LTV ratio, the higher is the threshold $\bar{\omega}_t^a$ that leads to default. This shrinks the area of no-default $[1 - F(\bar{\omega}_t^a, \sigma_{\omega,t})]$, and therefore increases the spread between R_t^L and R_t. Similarly, an increase in the standard deviation $\sigma_{\omega,t}$ increases the spread between the lending and the deposit rates. When $\sigma_{\omega,t}$ rises, it leads to a mean-preserving spread for the distribution of ω_t^j: the tails of the distribution become fatter while the mean remains unchanged (as in Figure 1). As a result, lower realizations of ω_t^j are more likely so that more borrowers will default on their loans. More generally, when the financial intermediary is able to recover a fraction $(1-\mu)$ of the collateral value, it can be shown (using the properties of the lognormal distribution when $E[\omega_t] = 1$) that the denominator in the spread equation (8) is always declining in $\bar{\omega}_t^a$, and hence the spread is always an increasing function of the LTV.

Furthermore, a tightening of credit conditions due to macroprudential measures, reflected in a higher η_t, will increase the spread faced by borrowers. As financial intermediaries cannot use the full amount of their liabilities to grant credit but only a fraction $1/\eta_t$, they will pass these costs to their customers.

Finally, we assume that the deposit rate in the home country equals the risk-free rate set by the central bank. In the foreign country, domestic financial intermediaries behave the same way. In their case, they face a deposit rate R_t^* and a lending rate $R_t^{L^*}$, and the spread is determined in an analogous way to equation (7), including a macroprudential instrument η_t^*. We explain below how the deposit rate in the foreign country R_t^* is determined.

2.1.2 International Intermediaries

International financial intermediaries buy and sell bonds issued by domestic intermediaries in both countries. For instance, if the home country domestic intermediaries have an excess B_t of loanable funds, they will sell them to the international intermediaries, who will lend an amount B_t^* to foreign country domestic intermediaries. International intermediaries apply the following formula to the spread they charge between bonds in the home country (issued at an interest rate R_t) and the foreign country (issued at R_t^*):

$$R_t^* = R_t + \left\{ \vartheta_t \exp\left[\kappa_B \left(\frac{B_t}{P_t^C Y^C} \right) \right] - 1 \right\}. \tag{9}$$

The spread depends on the ratio of real net foreign assets B_t/P_t^C to steady state non-durable GDP Y^C in the home country (to be defined below). When home country domestic intermediaries have an excess of funds that they wish to lend to the foreign country domestic intermediaries, then $B_t > 0$. Hence, the foreign country intermediaries will pay a higher interest rate $R_t^* > R_t$. The parameter κ_B denotes the risk premium elasticity and ϑ_t is a risk premium shock, which increases the wedge between the domestic and the foreign deposit rates. International intermediaries are owned by savers in each country and optimality conditions will ensure that the net foreign asset position of both countries is stationary.[3] They always make positive profits $(R_t^* - R_t)\, B_t$, which are equally split across savers of both countries.

2.2 Households

In each country a fraction λ of agents are savers, while the rest $1-\lambda$ are borrowers.

2.2.1 Savers

Savers indexed by $j \in [0, \lambda]$ in the home country maximize the following utility function:

$$E_0 \left\{ \sum_{t=0}^{\infty} \beta^t \left[\gamma \xi_t^C \log(C_t^j - \varepsilon C_{t-1}) + (1-\gamma) \xi_t^D \log(D_t^j) - \frac{\left(L_t^j\right)^{1+\varphi}}{1+\varphi} \right] \right\}, \tag{10}$$

where C_t^j, D_t^j, and L_t^j represent the consumption of the flow of non-durable goods, the stock of durable goods (housing) and the labor disutility of agent j. We assume external habits in non-durable consumption, with ε measuring the influence of past aggregate non-durable consumption C_{t-1} on the current utility level. The utility function is hit by two preference shocks, affecting the marginal utility of either non-durable consumption (ξ_t^C) or housing (ξ_t^D). The parameter β stands for the

[3]Hence, the assumption that international intermediaries trade uncontingent bonds amounts to the same case as allowing savers to trade these bonds. Under market incompleteness, a risk premium function of the type assumed in equation (9) is required for the existence of a well-defined steady state and stationarity of the net foreign asset position. See Schmitt-Grohé and Uribe (2003).

discount factor of savers, γ measures the share of non-durable consumption in the utility function, and φ denotes the inverse elasticity of labor supply. Moreover, non-durable consumption is an index composed of home ($C^j_{H,t}$) and foreign ($C^j_{F,t}$) goods:

$$C^j_t = \left[\tau^{\frac{1}{\iota_C}} \left(C^j_{H,t}\right)^{\frac{\iota_C-1}{\iota_C}} + (1-\tau)^{\frac{1}{\iota_C}} \left(C^j_{F,t}\right)^{\frac{\iota_C-1}{\iota_C}}\right]^{\frac{\iota_C}{\iota_C-1}}, \tag{11}$$

with $\tau \in [0,1]$ governing the preference for domestic over foreign goods and $\iota_C > 0$ being the elasticity of substitution between these two types of goods. In steady state τ will be the fraction of domestically produced non-durables at home, while $1-\tau$ denotes the fraction of imported consumption goods. Goods produced in the home and foreign country are only imperfectly substitutable, only for $\iota_C \to \infty$ they become perfect substitutes. Similarly, we introduce imperfect substitutability between the labor supply to the durable and non-durable sector to explain comovement of hours worked at the sector level:

$$L^j_t = \left[\alpha^{-\iota_L} \left(L^{C,j}_t\right)^{1+\iota_L} + (1-\alpha)^{-\iota_L} \left(L^{D,j}_t\right)^{1+\iota_L}\right]^{\frac{1}{1+\iota_L}}. \tag{12}$$

The labor disutility index consists of hours worked in the non-durable sector $L^{C,j}_t$ and durable sector $L^{D,j}_t$, with α denoting the steady state share of employment in the non-durable sector. Reallocating labor across sectors is costly, and is governed by parameter ι_L. Note that when $\iota_L = 0$ the aggregator is linear in hours worked in each sector and there are no costs of switching between sectors. Wages are flexible and set to equal the marginal rate of substitution between consumption and labor in each sector.[4]

The budget constraint of savers in nominal terms reads:

$$P^C_t C^j_t + P^D_t I^j_t + S^j_t \leq R_{t-1} S^j_{t-1} + W^C_t L^{C,j}_t + W^D_t L^{D,j}_t + \Pi^j_t, \tag{13}$$

where P^C_t and P^D_t are the price indices of non-durable and durable goods, respectively, which are defined below. Nominal wages paid in the two sectors are denoted by W^C_t and W^D_t. Savers allocate their expenditures between non-durable consumption C^j_t and residential investment I^j_t. They have access to deposits in the domestic financial system S^j_t, that pay the deposit interest rate R_t. In addition, savers also receive profits Π^j_t from intermediate goods producers in the durable and the non-

[4] When $\iota_L > 0$, wages can differ across sectors. Only if $\iota_L = 0$ and the elasticity of substitution between the supply of labor to the two sectors becomes infinite, wages are the same in both sectors.

durable sector, from domestic and international financial intermediaries, and from debt-collection agencies that charge fees to domestic financial intermediaries to make defaulting households pay their debts.

Purchases of durable goods (which is the same as residential investment, I_t^j) are used to increase the housing stock D_t^j with a lag, according to the following law of motion:

$$D_t^j = (1-\delta)D_{t-1}^j + \left[1 - \digamma\left(\frac{I_{t-1}^j}{I_{t-2}^j}\right)\right] I_{t-1}^j, \tag{14}$$

where δ denotes the depreciation rate and $\digamma(\cdot)$ reflects an adjustment cost function. This cost function can help the model to replicate hump-shaped responses of residential investment to shocks, and reduce residential investment volatility. To do so, $\digamma(\cdot)$ is a convex function, which in steady state meets the following criteria: $\bar{\digamma} = \bar{\digamma}' = 0$ and $\bar{\digamma}'' > 0$. We discuss below, in the maximization problem of borrowers, the reason why we introduce a lag in the law of motion (14).

The household decision can be separated in two stages. On the first stage, households decide on the allocation of their spending between non-durable and durable goods and the labor supply to the non-durable and durable sector. In a second step, households decide on the allocation of non-durable consumption expenditures between home and foreign goods taking the following budget constraint into account:

$$P_t^C C_t = P_{H,t}C_{H,t} + P_{F,t}C_{F,t},$$

where $P_{H,t}$ stands for the price charged for home non-durabable goods $C_{H,t}$ and $P_{F,t}$ denotes the price for foreign non-durabable goods $C_{F,t}$. Solving the utility maximization problem of savers we get a standard Euler equation for the consumption of non-durable goods:[5]

$$1 = \beta R_t E_t \left[\frac{P_t^C}{P_{t+1}^C}\frac{\xi_{t+1}^C}{\xi_t^C}\frac{C_t - \varepsilon C_{t-1}}{C_{t+1} - \varepsilon C_t}\right], \tag{15}$$

together with the demand for durable goods:

$$(1-\gamma)\frac{\xi_t^D}{D_t} = \varrho_t - \beta(1-\delta)E_t\varrho_{t+1}, \tag{16}$$

where ϱ_t is the Lagrange multiplier associated with the law of motion for the housing

[5] Since all savers behave the same way, we henceforth drop the j subscript.

stock (14). The investment decision (derivative with respect to I_t) is given by:

$$\begin{aligned}\frac{\gamma\xi_t^C}{C_t-\varepsilon C_{t-1}}\frac{P_t^D}{P_t^C} &= \beta E_t\varrho_{t+1}\left[1-F\left(\frac{I_t}{I_{t-1}}\right)-F'\left(\frac{I_t}{I_{t-1}}\right)\frac{I_t}{I_{t-1}}\right] \\ &\quad +\beta^2E_t\left[\varrho_{t+2}F'\left(\frac{I_{t+1}}{I_t}\right)\left(\frac{I_{t+1}}{I_t}\right)^2\right]. \qquad (17)\end{aligned}$$

Equation (16) and (17) determine the allocation of spending between non-durable and durable goods. The decision by savers on how to split their labor supply between the two sectors of the economy is:

$$\begin{aligned}\alpha^{-\iota_L}L_t^{\varphi-\iota_L}\left(L_t^C\right)^{\iota_L} &= \frac{\gamma\xi_t^C W_t^C}{C_t-\varepsilon C_{t-1}}, \\ (1-\alpha)^{-\iota_L}L_t^{\varphi-\iota_L}\left(L_t^D\right)^{\iota_L} &= \frac{\gamma\xi_t^C W_t^D}{C_t-\varepsilon C_{t-1}}, \qquad (18)\end{aligned}$$

taking both wages W_t^C and W_t^D as given.

Given the total amount of non-durable consumption spending C_t households decide on the allocation between home and foreign goods according to:

$$C_{H,t} = \tau\left(\frac{P_{H,t}}{P_t^C}\right)^{-\iota_c}C_t, \qquad (19)$$

$$C_{F,t} = (1-\tau)\left(\frac{P_{F,t}}{P_t^C}\right)^{-\iota_c}C_t, \qquad (20)$$

while the price index for non-durable consumption takes the following form:

$$\left(P_t^C\right)^{1-\iota_C} = \tau\left(P_{H,t}\right)^{1-\iota_C}+(1-\tau)\left(P_{F,t}\right)^{1-\iota_C}. \qquad (21)$$

2.2.2 Borrowers

Borrowers differ from savers along three main dimensions. First, their preferences are different. The discount factor of borrowers is smaller than the respective factor of savers ($\beta^B < \beta$), and we allow for different habit formation coefficients ε^B. Second, borrowers do not earn profits from intermediate goods producers, financial intermediaries, or debt-collection agencies. Finally, as discussed above, borrowers are subject to a quality shock to the value of their housing stock ω_t^j.[6] Since bor-

[6] We could also assume that savers are hit by a housing quality shock. Since they do not borrow and use their housing stock as collateral, this quality shock would not have any macroeconomic

rowers are more impatient, in equilibrium, savers are willing to accumulate assets as deposits, and borrowers are willing to pledge their housing wealth as collateral to gain access to loans. Analogously to savers, the utility function for each borrower $j \in [\lambda, 1]$ reads:

$$E_0 \left\{ \sum_{t=0}^{\infty} \beta^{B,t} \left[\gamma \xi_t^C \log(C_t^{B,j} - \varepsilon^B C_{t-1}^B) + (1-\gamma)\xi_t^D \log(D_t^{B,j}) - \frac{\left(L_t^{B,j}\right)^{1+\varphi}}{1+\varphi} \right] \right\}, \tag{22}$$

where all variables and parameters with the superscript B denote that they are specific to borrowers. The indices of consumption and hours worked, as well as the law of motion of the housing stock have the same functional form as in the case of savers:

$$C_t^{B,j} = \left[\tau^{\frac{1}{\iota_C}} \left(C_{H,t}^{B,j} \right)^{\frac{\iota_C - 1}{\iota_C}} + (1-\tau)^{\frac{1}{\iota_C}} \left(C_{F,t}^{B,j} \right)^{\frac{\iota_C - 1}{\iota_C}} \right]^{\frac{\iota_C}{\iota_C - 1}}, \tag{23}$$

$$L_t^{B,j} = \left[\alpha^{-\iota_L} \left(L_t^{C,B,j} \right)^{1+\iota_L} + (1-\alpha)^{-\iota_L} \left(L_t^{D,B,j} \right)^{1+\iota_L} \right]^{\frac{1}{1+\iota_L}}, \tag{24}$$

$$D_t^{B,j} = (1-\delta) D_{t-1}^{B,j} + \left[1 - F\left(\frac{I_{t-1}^{B,j}}{I_{t-2}^{B,j}} \right) \right] I_{t-1}^{B,j}. \tag{25}$$

Residential investment $I_t^{B,j}$ increases the housing stock with a lag. We make this assumption because an contemporaneous increase would have unrealistic consequences for defaults: borrowers would invest in housing which is already underwater.

The budget constraint for borrowers differs between those who repay their loans in full:

$$P_t^C C_t^{B,j} + P_t^D I_t^{B,j} + R_{t-1}^L S_{t-1}^{B,j} \leq S_t^{B,j} + W_t^C L_t^{C,B,j} + W_t^D L_t^{D,B,j}, \tag{26}$$

and those who default:

$$P_t^C C_t^{B,j} + P_t^D I_t^{B,j} + \omega_{t-1}^j P_t^D D_t^{B,j} \leq S_t^{B,j} + W_t^C L_t^{C,B,j} + W_t^D L_t^{D,B,j}. \tag{27}$$

Independent of the decision to repay or default, borrowers consume non-durables $C_t^{B,j}$, invest in the housing stock $I_t^{B,j}$, supply labor to both sectors ($L_t^{C,B,j}$ and $L_t^{D,B,j}$), and obtain loans $S_t^{B,j}$ from financial intermediaries. Furthermore, savers and borrowers are paid the same wages W_t^C and W_t^D in both sectors, as hiring firms

impact.

are not able to discriminate types of labor depending on whether a household is a saver or a borrower. Borrowers, who decide to repay their loans from last period, pay $R^L_{t-1} S^{B,j}_{t-1}$ with R^L_{t-1} being the lending rate which has been fixed in the previous period. On the contrary, those who default pay an amount $\omega^j_{t-1} P^D_t D^{B,j}_t$ to the bank, after being contacted by a debt-collection agency. This fraction of the housing stock is kept by the households that defaulted on their loans.

We define $\bar{\omega}^p_{t-1}$ as the ex-post threshold value for which a borrower is just willing to repay the loan:

$$\bar{\omega}^p_{t-1} P^D_t D^B_t = R^L_{t-1} S^B_{t-1}. \tag{28}$$

The ex-post threshold $\bar{\omega}^p_{t-1}$ is the de facto cut-off value of those households that default and those who do not after aggregate and idiosyncratic shocks have hit the economy. As financial intermediaries do not know this ex-post threshold when granting credit, they form the expected ex-ante threshold $\bar{\omega}^a_t$ as defined by equation (1). As the housing stock D^B_t together with the lending rate R^L_{t-1} are pre-determined variables and are not a function of the state of the economy, it is possible that $\bar{\omega}^a_t$ and $\bar{\omega}^p_t$ differ. Note, however, that when the loan is signed, $\bar{\omega}^a_t = E_t \bar{\omega}^p_t$. Given the threshold $\bar{\omega}^p_{t-1}$, we can now use the CDF of the quality shock to define the de facto fraction of loans which are underwater:

$$F\left(\bar{\omega}^p_{t-1}, \sigma_{\omega,t-1}\right) = \int_0^{\bar{\omega}^p_{t-1}} dF(\omega; \sigma_{\omega,t-1}) d\omega, \tag{29}$$

the de facto fraction of loans which are repaid by borrowers:

$$\left[1 - F\left(\bar{\omega}^p_{t-1}, \sigma_{\omega,t-1}\right)\right] = \int_{\bar{\omega}^p_{t-1}}^{\infty} dF(\omega; \sigma_{\omega,t-1}) d\omega, \tag{30}$$

together with the de facto mean value of the housing stock, which borrowers pay to financial intermediaries after a debt-collection agency has intervened:

$$P^D_t G\left(\bar{\omega}^p_{t-1}, \sigma_{\omega,t-1}\right) D^B_t = P^D_t \int_0^{\bar{\omega}^p_{t-1}} \omega dF(\omega; \sigma_{\omega,t-1}) D^B_t. \tag{31}$$

Aggregating the borrower's budget constraints (26) and (27), using the expressions (28)-(31), and dropping the j superscripts, we obtain:

$$\begin{aligned} & P^C_t C^B_t + P^D_t \left[I^B_t + G\left(\bar{\omega}^p_{t-1}, \sigma_{\omega,t-1}\right) D^B_t\right] + \left[1 - F\left(\bar{\omega}^p_{t-1}, \sigma_{\omega,t-1}\right)\right] R^L_{t-1} S^B_{t-1} \\ \leq \; & S^B_t + W^C_t L^{C,B}_t + W^D_t L^{D,B}_t. \end{aligned} \tag{32}$$

Before deriving the first order conditions to the borrowers' problem, we rewrite the budget constraint first by introducing the average interest rate of those borrowers who default on their housing stock:

$$R_t^D = \frac{G\left(\bar{\omega}_{t-1}^p, \sigma_{\omega,t-1}\right) P_t^D D_t^B}{S_{t-1}^B}.$$

Note that R_t^D is the ex-post rate of return on defaulted loans (excluding the fraction μ financial intermediaries need to pay to debt-collection agencies). The timing in R_{t-1}^L and R_t^D is thus consistent: the lending rate for those who fully repay is known in advance and is a contractual obligation, while the average return on those loans that default is only known at time t. The budget constraint for borrowers finally takes the following form:

$$\begin{aligned} & P_t^C C_t^B + P_t^D I_t^B + \left\{R_t^D + \left[1 - F\left(\bar{\omega}_{t-1}^p, \sigma_{\omega,t-1}\right)\right] R_{t-1}^L\right\} S_{t-1}^B \\ \leq \; & S_t^B + W_t^C L_t^{B,C} + W_t^D L_t^{B,D}, \end{aligned} \tag{33}$$

leading to an Euler equation for borrowers of the following form:

$$1 = \beta^B E_t \left\{ \left\{\left[1 - F\left(\bar{\omega}_t^p, \sigma_{\omega,t}\right)\right] R_t^L + R_{t+1}^D\right\} \left[\frac{P_t^C}{P_{t+1}^C} \frac{\xi_{t+1}^C}{\xi_t^C} \left(\frac{C_t^B - \varepsilon^B C_{t-1}^B}{C_{t+1}^B - \varepsilon^B C_t^B} \right) \right] \right\}. \tag{34}$$

The demand for durable goods together with the investment decision are given by:

$$\begin{aligned} (1-\gamma) \frac{\xi_t^D}{D_t^B} &= \varrho_t^B - \beta^B (1-\delta) E_t \varrho_{t+1}^B, \qquad (35) \\ \frac{\gamma \xi_t^C}{C_t^B - \varepsilon^B C_{t-1}^B} \frac{P_t^D}{P_t^C} &= \beta^B E_t \varrho_{t+1}^B \left[1 - \digamma\left(\frac{I_t^B}{I_{t-1}^B}\right) - \digamma'\left(\frac{I_t^B}{I_{t-1}^B}\right) \frac{I_t^B}{I_{t-1}^B} \right] \\ &\quad + \left(\beta^B\right)^2 E_t \left[\varrho_{t+2}^B \digamma'\left(\frac{I_{t+1}^B}{I_t^B}\right) \left(\frac{I_{t+1}^B}{I_t^B}\right)^2 \right], \qquad (36) \end{aligned}$$

with ϱ_t^B being the Lagrange multiplier associated with the law of motion for the housing stock of borrowers (25). Impatient households split their labor supply according to:

$$\begin{aligned} \alpha^{-\iota_L} \left(L_t^B\right)^{\varphi - \iota_L} \left(L_t^{C,B}\right)^{\iota_L} &= \frac{\gamma \xi_t^C W_t^C}{C_t^B - \varepsilon^B C_{t-1}^B}, \\ (1-\alpha)^{-\iota_L} \left(L_t^B\right)^{\varphi - \iota_L} \left(L_t^{D,B}\right)^{\iota_L} &= \frac{\gamma \xi_t^C W_t^D}{C_t^B - \varepsilon^B C_{t-1}^B}. \end{aligned} \tag{37}$$

The allocation of non-durable consumption expenditures between home and foreign goods is analogous to the decision by savers:

$$C^B_{H,t} = \tau \left(\frac{P_{H,t}}{P^C_t}\right)^{-\iota_c} C^B_t, \tag{38}$$

$$C^B_{F,t} = (1-\tau) \left(\frac{P_{F,t}}{P^C_t}\right)^{-\iota_c} C^B_t, \tag{39}$$

with the price index for non-durable consumption P^C_t being given by equation (21), which is the Consumer Price Index for the whole country since it is the same for borrowers and savers.

To obtain the total demand for home and foreign non-durable goods $C^{TOT}_{H,t}$ and $C^{TOT}_{F,t}$, respectively, we combine the demand functions (19) with (38) and (20) with (39):

$$C^{TOT}_{H,t} = \tau \left(\frac{P_{H,t}}{P^C_t}\right)^{-\iota_c} C^{TOT}_t, \tag{40}$$

$$C^{TOT}_{F,t} = (1-\tau) \left(\frac{P_{F,t}}{P^C_t}\right)^{-\iota_c} C^{TOT}_t, \tag{41}$$

with $C^{TOT}_t = \lambda C_t + (1-\lambda) C^B_t$ defining total consumption of non-durable goods in the home country.

The maximization problem of savers and borrowers in the foreign country is similar to the problem of these agents in the home country. All functional forms for preferences are the same across countries, we merely allow the parameter value for governing the preference for domestic over foreign goods to be different across countries, i.e. we differentiate between τ and τ^*.

2.3 Firms, Technology, and Nominal Rigidities

In each country, homogeneous final non-durable and durable goods are produced using a continuum of intermediate goods in each sector (indexed by $h \in [0, n]$ in the home, and by $f \in [n, 1]$ in the foreign country). Intermediate goods in each sector are imperfect substitutes of each other, and there is monopolistic competition as well as staggered price setting à la Calvo (1983). Intermediate goods are not traded across countries and are solely bought by domestic final goods producers. In the final goods sector, non-durables are sold to domestic and foreign households.

Thus, for non-durable consumption we need to distinguish between the price level of domestically produced non-durable goods $P_{H,t}$, of non-durable goods produced abroad $P_{F,t}$, and the consumer price index P_t^C, which will be a combination of these two price levels (as given by equation 21).[7] Durable goods are solely sold to domestic households, who use them to increase their housing stock. Both final goods sectors are perfectly competitive, operating under flexible prices.

2.3.1 Final Goods Producers

Final goods producers in both sectors aggregate the intermediate goods they purchase according to the following production function:

$$Y_t^k \equiv \left[\left(\frac{1}{n} \right)^{\frac{1}{\sigma_k}} \int_0^n Y_t^k(h)^{\frac{\sigma_k - 1}{\sigma_k}} dh \right]^{\frac{\sigma_k}{\sigma_k - 1}}, \text{ for } k = C, D, \tag{42}$$

where Y_t^k represents the final goods produced from intermediate goods $Y_t^k(h)$, while σ_k denotes the price elasticity of intermediate goods. Final goods producers purchase non-durable intermediate goods at a price of $P_t^H(h)$ and durable intermediate goods at a price $P_t^D(h)$. Profit maximization leads to the following demand function for individual intermediate goods:

$$Y_t^C(h) = \left(\frac{P_t^H(h)}{P_t^H} \right)^{-\sigma_C} Y_t^H, \text{ and } Y_t^D(h) = \left(\frac{P_t^D(h)}{P_t^D} \right)^{-\sigma_D} Y_t^D. \tag{43}$$

Price levels for domestically produced non-durables P_t^H and durable final goods P_t^D are obtained through the usual zero-profit condition:

$$P_t^H \equiv \left\{ \frac{1}{n} \int_0^n \left[P_t^H(h) \right]^{1-\sigma_C} dh \right\}^{\frac{1}{1-\sigma_C}}, \text{ and } P_t^D \equiv \left\{ \frac{1}{n} \int_0^n \left[P_t^D(h) \right]^{1-\sigma_D} dh \right\}^{\frac{1}{1-\sigma_D}}. \tag{44}$$

[7] The law of one price holds for individual goods and, therefore, $P_{H,t}$ and $P_{F,t}$ are the same in both countries. However, the CPI index in the foreign country differs from the one in the home country due to different preferences for domestic over foreign goods: $\left(P_t^{C*}\right)^{1-\iota_C} = \tau^* \left(P_{F,t}\right)^{1-\iota_C} + (1-\tau^*) \left(P_{H,t}\right)^{1-\iota_C}$.

2.3.2 Intermediate Goods Producers

Intermediate goods are produced under monopolistic competition with producers facing staggered price setting in the spirit of Calvo (1983). In each period, only a fraction $1-\theta_C$ $(1-\theta_D)$ of intermediate goods producers in the non-durable (durable) sector receive a signal to re-optimize their price. For the remaining fraction θ_C (θ_D) we assume that their prices are partially indexed to lagged sector-specific inflation (with a coefficient ϕ_C, ϕ_D in each sector). In both sectors, intermediate goods are produced solely with labor:

$$Y_t^C(h) = A_t Z_t^C L_t^C(h), \quad Y_t^D(h) = A_t Z_t^D L_t^D(h), \quad \text{for all } h \in [0, n]. \tag{45}$$

The production functions include country- and sector-specific stationary technology shocks Z_t^C and Z_t^D, each of which follows a zero mean AR(1)-process in logs. In addition, we introduce a non-stationary union-wide technology shock, which follows a unit root process:

$$\log\left(A_t\right) = \log\left(A_{t-1}\right) + \varepsilon_t^Z.$$

This shock introduces non-stationarity to the model and gives a model-consistent way of detrending the data by taking logs and first differences to the real variables that inherit the random walk behavior. In addition, it adds some correlation of technology shocks across sectors and countries, which is helpful from the empirical point of view because it allows to explain comovement of main real variables. Since labor is the only production input, cost minimization implies that real marginal costs in both sectors are given by:

$$MC_t^C = \frac{W_t^C/P_{H,t}}{A_t Z_t^C}, \quad MC_t^D = \frac{W_t^D/P_t^D}{A_t Z_t^D}. \tag{46}$$

Intermediate goods producers in the durable sector face the following maximization problem:

$$Max_{P_t^D(h)} E_t \sum_{k=0}^{\infty} \theta_D^k \Lambda_{t,t+k} \left\{ \left[\frac{P_t^D(h) \left(\frac{P_{t+k-1}^D}{P_{t-1}^D} \right)^{\phi_D}}{P_{t+k}^D} - MC_{t+k}^D \right] Y_{t+k}^D\left(h\right) \right\}$$

subject to future demand

$$Y^D_{t+k}(h) = \left[\frac{P^D_t(h)}{P^D_{t+k}} \left(\frac{P^D_{t+k-1}}{P^D_{t-1}} \right)^{\phi_D} \right]^{-\sigma_D} Y^D_{t+k},$$

where $\Lambda_{t,t+k} = \beta^k \frac{\lambda_{t+k}}{\lambda_t}$ is the stochastic discount factor, with λ_t being the marginal utility of non-durable consumption of savers (since they are the owner of these firms). The FOC of the optimization problem is given by:

$$\frac{\hat{P}^D_t(h)}{P^D_t} = \frac{\sigma_D}{\sigma_D - 1} E_t \left[\frac{\sum_{k=0}^{\infty} \beta^k \theta^k_D \lambda_{t+k} \left(\prod_{s=1}^{k} \frac{\left(P^D_{t+s-1}/P^D_{t+s-2}\right)^{\phi_D}}{P^D_{t+s}/P^D_{t+s-1}} \right)^{-\sigma_D} MC^D_{t+k} Y^D_{t+k}}{\sum_{k=0}^{\infty} \beta^k \theta^k_D \lambda_{t+k} \left(\prod_{s=1}^{k} \frac{\left(P^D_{t+s-1}/P^D_{t+s-2}\right)^{\phi_D}}{P^D_{t+s}/P^D_{t+s-1}} \right)^{1-\sigma_D} Y^D_{t+k}} \right], \quad (47)$$

where $\hat{P}^D_t(h)$ is the optimal price of durables chosen at time t if the producer can reconsider its price in this period. The fraction $1 - \theta_D$ of producers, which can optimize their prices at time t, face the same decision problem and, therefore, choose the same price $\hat{P}^D_t(h) = \hat{P}^D_t$. Since the remaining fraction θ_D of prices, which are not revised, are partially linked to the past inflation, the evolution of the durable sector price level is given by:

$$P^D_t = \left[\theta_D \left(\hat{P}^D_t \right)^{1-\sigma_D} + (1 - \theta_D)[P^D_{t-1}(P^D_{t-1}/P^D_{t-2})^{\phi_D}]^{1-\sigma_D} \right]^{\frac{1}{1-\sigma_D}}. \quad (48)$$

Producers in the non-durable sector face a similar maximization problem with the appropriate change of notation.

2.4 Closing the Model

2.4.1 Market Clearing Conditions

For intermediate goods, supply equals demand. We write the market clearing conditions in terms of aggregate quantities and, thus, multiply per-capita quantities by population size of each country. In the non-durable sector, production is equal to domestic demand by savers $C_{H,t}$ and borrowers $C^B_{H,t}$ and exports (consisting of demand by savers $C^*_{H,t}$ and borrowers $C^{B*}_{H,t}$ from the foreign country):

$$nY_t^C = n\left[\lambda C_{H,t} + (1-\lambda)\, C^B_{H,t}\right] + (1-n)\left[\lambda^* C^*_{H,t} + (1-\lambda^*)\, C^{B*}_{H,t}\right]. \tag{49}$$

Durable goods are only consumed by domestic households and production in this sector is equal to residential investment for savers and borrowers:

$$nY_t^D = n\left[\lambda I_t + (1-\lambda)\, I_t^B\right]. \tag{50}$$

In the labor market total hours worked has to be equal to the aggregate supply of labor in each sector:

$$\int_0^n L_t^k(h)dh = \lambda \int_0^n L_t^{k,j} dj + (1-\lambda)\int_0^n L_t^{k,B,j} dj, \text{ for } k = C, D. \tag{51}$$

Credit market clearing implies that for domestic credit and international bond markets, the balance sheets of financial intermediaries are satisfied:

$$\begin{aligned} n\lambda(S_t - B_t)/\eta_t &= n(1-\lambda)\, S_t^B, \qquad (52)\\ n\lambda B_t + (1-n)\lambda^* B_t^* &= 0. \end{aligned}$$

Finally, aggregating the resource constraints of borrowers and savers, and the market clearing conditions for goods and financial intermediaries, we obtain the law of motion of bonds issued by the home-country international financial intermediaries. This can also be viewed as the evolution of net foreign assets (NFA) of the home country:

$$\begin{aligned} n\lambda B_t &= n\lambda R_{t-1} B_{t-1} \qquad (53)\\ &\quad + \left\{(1-n)\, P_{H,t}\left[\lambda^* C^*_{H,t} + (1-\lambda^*)\, C^{B*}_{H,t}\right] - nP_{F,t}\left[\lambda C_{F,t} + (1-\lambda)\, C^B_{F,t}\right]\right\}, \end{aligned}$$

which is determined by the aggregate stock of last period's NFA times the interest rate, plus net exports.

2.4.2 Monetary Policy and Interest Rates

Monetary policy is conducted at the currency union level by the central bank with an interest rate rule that targets union-wide CPI inflation and real output growth. The central bank sets the deposit rate in the home country, and the other rates are determined as described in the model. Let $\bar{\Pi}^{EMU}$ be the steady state level of union-wide CPI inflation, $\bar{R}$ the steady state level of the interest rate and ε_t^m an *iid* monetary policy shock, the interest rate rule is given by:

$$R_t = \left[\bar{R} \left(\frac{P_t^{EMU}/P_{t-1}^{EMU}}{\bar{\Pi}^{EMU}} \right)^{\gamma_\pi} \left(Y_t^{EMU}/Y_{t-1}^{EMU} \right)^{\gamma_y} \right]^{1-\gamma_R} R_{t-1}^{\gamma_R} \exp(\varepsilon_t^m). \qquad (54)$$

The euro area CPI P_t^{EMU} and real GDP Y_t^{EMU} are given by geometric averages of the home and foreign country variables, using the country size as a weight:

$$P_t^{EMU} = \left(P_t^C \right)^n \left(P_t^{C*} \right)^{1-n}, \text{ and } Y_t^{EMU} = \left(Y_t \right)^n \left(Y_t^* \right)^{1-n},$$

where the national GDPs are expressed in terms of non-durables:

$$Y_t = Y_t^C + Y_t^D \frac{P_t^D}{P_t^C}, \text{ and } Y_t^* = Y_t^{C*} + Y_t^{D*} \frac{P_t^{D*}}{P_t^{C*}}.$$

2.4.3 Macroprudential Policy

As shown in equations (8) and (52), the macroprudential instrument η_t affects the equilibrium in the domestic credit market and affects the lending-deposit spread in each country. We interpret this macroprudential instrument as being deployed above and beyond current rules, which are static to a large degree. Hence, when we estimate the model, we set η_t to a constant value of one. When we conduct an optimal macroprudential policy exercise, we allow the instrument to be changed in order to maximize the weighted utility of all the citizens in the monetary union. A tightening of macroprudential policies will be reflected in a higher η_t, which will translate into a higher lending-deposit spread. Although we leave it unspecified, this could be implemented via additional capital surcharges, liquidity ratios, loan-loss provisions, or reserve requirements that reduce the amount of loanable funds by financial intermediaries. We assume that the instrument, in principle, can behave symmetrically and it can go below one. In that case, the central bank or any other regulatory agency would provide liquidity to the banking sector to reduce the lending-deposit spread. This could be achieved via (conventional or unconventional) measures like a widening of collateral standards, the *Funding for Lending Scheme* launched by the Bank of England in 2012, or even a direct provision of liquidity to the real economy as in Gertler and Karadi (2011).

In the welfare maximizing exercise, we specify the macroprudential instrument as reacting to an indicator variable (Υ_t):

$$\eta_t = (\Upsilon_t)^{\gamma_\eta}, \quad \eta_t^* = (\Upsilon_t^*)^{\gamma_\eta^*}. \tag{55}$$

We study two main cases. In each country the macroprudential instrument reacts to: (i) nominal credit growth, or (ii) the credit-to-GDP ratio. For both cases, the parameters γ_η and γ_η^* are either allowed to be different, or are forced to be the same in the monetary union. In all cases, the indicator reacts to deviations from steady state values.

3 Steady State

We assume a steady state inflation of zero. The trade balance together with the net international position of both economies are zero. Since we calibrate the two countries symmetrically, all relative prices in all sectors equal to one and all per-capita quantities are the same across countries. Therefore, we only need to solve for the per-capita values of the home country. Given the steady state cut-off point for defaulting on a loan $\bar{\omega}$, the default rate on loans $\bar{F}(\bar{\omega}, \bar{\sigma}_\omega)$ and the fact that $\bar{\mu}_\omega = -\frac{1}{2}\bar{\sigma}_\omega^2$, we use the CDF of the log-normal distribution to obtain a value for the standard deviation of the quality shock ($\bar{\sigma}_\omega$). Using $\bar{\omega}$ together with $\bar{\sigma}_\omega$, we can solve for the mean value of the quality shock conditional on the shock being less than the threshold $\bar{\omega}$:[8]

$$G(\bar{\omega}, \bar{\sigma}_\omega) = \int_0^{\bar{\omega}} \omega F(\omega, \bar{\sigma}_\omega) d\omega = 1 - \Phi\left(\frac{\frac{1}{2}\bar{\sigma}_\omega^2 - \ln\bar{\omega}}{\bar{\sigma}_\omega}\right),$$

with Φ being the CDF of the standard normal distribution. Taking the Euler equation of savers (15), the lending rate in the currency union is given by the discount factor of savers:

$$R = \frac{1}{\beta}.$$

The steady state leverage ratio is determined by the threshold value $\bar{\omega}$ and the lending rate R^L:

$$\frac{\tilde{S}^B}{D^B} = \frac{\bar{\omega}}{R^L},$$

[8]See also Section 4 of this Appendix.

where $\tilde{S}^B$ are outstanding loans in real terms (divided by the CPI). We can now use the participation constraint (7) of financial intermediaries and the fact that $\eta = 1$ to get an expression for the lending rate:

$$R = (1-\mu)G(\bar{\omega}, \bar{\sigma}_\omega)\frac{R^L}{\bar{\omega}} + [1 - F(\bar{\omega}, \bar{\sigma}_\omega)] R^L.$$

The steady state average interest rate of those who default on their housing stock is:

$$R^D = \frac{G(\bar{\omega}, \bar{\sigma}_\omega) R^L}{\bar{\omega}}.$$

From the Euler equation of borrowers (34) we derive the discount factor of impatient consumers:

$$\beta^B = \left\{ \left[1 - F(\bar{\omega}, \bar{\sigma}_\omega) + \frac{G(\bar{\omega}, \bar{\sigma}_\omega)}{\bar{\omega}} \right] R^L \right\}^{-1}.$$

Since in steady state the adjustment costs of investment are zero, the ratio of non-durable to durable consumption for savers and borrowers is given by:

$$\frac{C}{D} = \frac{\gamma [1 - \beta(1-\delta)]}{\beta(1-\gamma)(1-\varepsilon)} \equiv \Upsilon, \tag{56}$$

$$\frac{C^B}{D^B} = \frac{\gamma \left[1 - \beta^B(1-\delta)\right]}{\beta^B(1-\gamma)(1-\varepsilon^B)} \equiv \Upsilon^B, \tag{57}$$

which we obtain by combining equation (16) with equation (17) and equation (35) with equation (36). Since the degree of monopolistic competition is the same in the durable and non-durable good sector ($\sigma_C = \sigma_D = \sigma$), we obtain from the pricing equations (47) the level of real wages as:

$$W \equiv W^C = W^D = \frac{\sigma - 1}{\sigma}. \tag{58}$$

Having equal wages across sectors, the steady state supply of labor for savers is:

$$L^C = \alpha L,$$
$$L^D = (1-\alpha)L,$$

and analogously for borrowers:

$$L^{C,B} = \alpha L^B,$$
$$L^{D,B} = (1-\alpha)L^B.$$

Turning first to the consumption expenditures and total labor supply of borrowers. From the law of motion for the housing stock, we know that $I^B = \delta D^B$ so that the budget constraint (32) can be written as:

$$C^B + [\delta + G(\bar{\omega}, \bar{\sigma}_\omega)] D^B + [1 - F(\bar{\omega}, \bar{\sigma}_\omega)] R^L \tilde{S}^B = \tilde{S}^B + W L^B$$

Together with the labor supply (37):

$$\left(L^B\right)^\varphi C^B = \frac{\gamma}{1 - \varepsilon^B} \frac{\sigma - 1}{\sigma},$$

we solve for L^B:

$$L^B = \left[\frac{\gamma}{1 - \varepsilon^B} \left(1 + \frac{\delta + G(\bar{\omega}, \bar{\sigma}_\omega) + \left[1 - F(\bar{\omega}, \bar{\sigma}_\omega) - \frac{1}{R^L}\right] \bar{\omega}}{\Upsilon^B}\right)\right]^{\frac{1}{1+\varphi}}.$$

The consumption of non-durable goods is then given by:

$$C^B = \frac{\sigma - 1}{\sigma} \left(\frac{\gamma}{1 - \varepsilon^B}\right)^{\frac{1}{1+\varphi}} \left[1 + \frac{\delta + G(\bar{\omega}, \bar{\sigma}_\omega) + \left[1 - F(\bar{\omega}, \bar{\sigma}_\omega) - \frac{1}{R^L}\right] \bar{\omega}}{\Upsilon^B}\right]^{-\frac{\varphi}{1+\varphi}}.$$

Knowing C^B we can use equation (56) to solve for the consumption of durable goods D^B.

Next, we solve for the consumption expenditures and total labor supply of savers. Using the fact that $I = \delta D$ together with the steady state balance sheet identity (5) of financial intermediaries (with $\tilde{S}$ being deposit holdings in real terms and using the fact that $B = 0$):

$$\lambda \tilde{S} = (1 - \lambda) \tilde{S}^B,$$

the budget constraint of savers (13) can be expressed as:

$$C + \delta D + \frac{1 - \lambda}{\lambda} \tilde{S}^B = \frac{1 - \lambda}{\lambda} R \tilde{S}^B + W L + \Pi.$$

Note that aggregate profits are given by:

$$\begin{aligned}
\Pi &= \int_0^n P^H Y^C(h)dh + \int_0^n P^D Y^D(h)dh - W^C \int_0^n \left[\lambda L^C(h) + (1-\lambda)\, L^{B,C}(h)\right] dh \\
&\quad - W^D \int_0^n \left[\lambda L^D(h) + (1-\lambda)\, L^{B,D}(h)\right] dh + n\,(1-\lambda)\,\mu G\left(\bar{\omega}, \bar{\sigma}_\omega\right) D^B \\
&= n(Y^C + Y^D) - \frac{\sigma-1}{\sigma} n \left[\lambda L + (1-\lambda)\, L^B\right] + n\,(1-\lambda)\,\mu G\left(\bar{\omega}, \bar{\sigma}_\omega\right) D^B \\
&= n\left(1 - \frac{\sigma-1}{\sigma}\right) \left[\lambda L + (1-\lambda)\, L^B\right] + n\,(1-\lambda)\,\mu G\left(\bar{\omega}, \bar{\sigma}_\omega\right) D^B.
\end{aligned}$$

Per capita profits are then given by $\frac{\Pi}{\lambda n}$. Plugging this together with equation (58) into the budget constraint leads to:

$$\begin{aligned}
C + \delta D &= \frac{1-\lambda}{\lambda}(R-1)\,\tilde{S}^B + \frac{\sigma-1}{\sigma} L + \left(1 - \frac{\sigma-1}{\sigma}\right)\left[L + \frac{1-\lambda}{\lambda} L^B\right] \\
&\quad + \frac{1-\lambda}{\lambda}\mu G\left(\bar{\omega}, \bar{\sigma}_\omega\right) D^B \\
&= \frac{1-\lambda}{\lambda}(R-1)\,\tilde{S}^B + L + \frac{1-\lambda}{\lambda}\left(1 - \frac{\sigma-1}{\sigma}\right) L^B + \frac{1-\lambda}{\lambda}\mu G\left(\bar{\omega}, \bar{\sigma}_\omega\right) D^B.
\end{aligned}$$

Introducing $\Psi = \frac{1-\lambda}{\lambda}\left[(R-1)\,\tilde{S}^B + \left(1 - \frac{\sigma-1}{\sigma}\right) L^B + \mu G\left(\bar{\omega}, \bar{\sigma}_\omega\right) D^B\right]$ as a parameter which is constant from the perspective of savers, we finally arrive at:

$$C + \delta D - L = \Psi. \tag{59}$$

Bringing together the labor supply of savers (18):

$$L^\varphi C = \frac{\gamma}{1-\varepsilon}\frac{\sigma-1}{\sigma}$$

and equation (59) we obtain the following expression for L:

$$\left(1 + \frac{\delta}{\Upsilon}\right)\frac{\gamma}{1-\varepsilon}\frac{\sigma-1}{\sigma} - \Psi L^\varphi - L^{1+\varphi} = 0.$$

For a given value of L, it is straightforward to obtain C and D. To find a value for γ we use the market clearing condition. The fraction of non-durable production over total production is:

$$\frac{Y^C}{Y^C + Y^D} = \alpha.$$

In steady state this has to be equal to the fraction of spending allocated to non-durable consumption over total spending:

$$\frac{\lambda C + (1-\lambda)C^B}{\lambda(C+\delta D) + (1-\lambda)(C^B + \delta D^B)} = \alpha.$$

Given values for α, δ, λ, χ, σ, β, β^B, ε, ε^B, φ, μ, $\bar{F}(\cdot)$ we can solve for the value of γ. Aggregate expenditures on non-durable consumption is defined as:

$$C^{TOT} = \lambda C + (1-\lambda)C^B,$$

so that aggregate allocation of expenditures between home and foreign-produced goods is:

$$\begin{aligned} C_H &= \tau C^{TOT}, \\ C_F &= (1-\tau)C^{TOT}. \end{aligned}$$

The market clearing conditions for final goods are:

$$\begin{aligned} \bar{Y}^C &= nY^C = nC_H + (1-n)\, C_H^*, \\ \bar{Y}^D &= nY^D = n\left[\lambda\delta D + (1-\lambda)\delta D^B\right], \end{aligned}$$

where $\bar{Y}^C$ and $\bar{Y}^D$ are the steady-state values of Y_t^C and Y_t^D, and Y^C and Y^D are the steady-state individual (per capita) production levels of each firm. Therefore aggregate production levels are given by:

$$\begin{aligned} \bar{Y}^C &= \alpha n\left[\lambda L + (1-\lambda)L^B\right], \\ \bar{Y}^D &= (1-\alpha)n\left[\lambda L + (1-\lambda)L^B\right]. \end{aligned}$$

4 Derivatives of $F(\bar{\omega}, \bar{\sigma}_\omega)$ and $G(\bar{\omega}, \bar{\sigma}_\omega)$

In order to log-linearize the model we need the derivatives of the CDF $F(\bar{\omega}, \bar{\sigma}_\omega)$ and $G(\bar{\omega}, \bar{\sigma}_\omega)$, which denotes the mean value of the quality shock conditional on the shock being less than the threshold. First, we use the properties of the quality shock ω to find expressions for $F(\cdot)$ and $G(\cdot)$. Then, we determine the derivatives with respect to the threshold and the standard deviation. As ω_t follows a log-normal distribution, $E[\omega_t] = e^{\mu_{\omega,t} + \frac{1}{2}\sigma^2_{\omega,t}}$ and since we set $E[\omega_t] = 1$, the steady state of the mean is given by:

$$\bar{\mu}_\omega = -\frac{1}{2}\bar{\sigma}^2_\omega.$$

The CDF of the log-normally distributed quality shock in steady state is defined as:

$$\begin{aligned} F\left(\bar{\omega}, \bar{\sigma}_\omega\right) = \int_0^{\bar{\omega}} dF(\omega) &= \int_0^{\bar{\omega}} \frac{1}{\omega \bar{\sigma}_\omega \sqrt{2\pi}} e^{-\frac{(\ln \omega - \bar{\mu}_\omega)^2}{2\bar{\sigma}^2_\omega}} d\omega \\ &= \int_0^{\bar{\omega}} \frac{1}{\omega \bar{\sigma}_\omega \sqrt{2\pi}} e^{-\frac{\left(\ln \omega + \frac{1}{2}\bar{\sigma}^2_\omega\right)^2}{2\bar{\sigma}^2_\omega}} d\omega, \end{aligned}$$

which can be used to find an expression for the derivative with respect to $\bar{\omega}$:

$$\frac{\partial F(\bar{\omega}; \bar{\sigma}_\omega)}{\partial \bar{\omega}} = \frac{1}{\bar{\omega} \bar{\sigma}_\omega \sqrt{2\pi}} e^{-\frac{\left(\ln \bar{\omega} + \frac{1}{2}\bar{\sigma}^2_\omega\right)^2}{2\bar{\sigma}^2_\omega}},$$

and with respect to the standard deviation $\bar{\sigma}_\omega$:

$$\begin{aligned} \frac{\partial F(\bar{\omega}; \bar{\sigma}_\omega)}{\partial \bar{\sigma}_\omega} &= -\frac{F(\bar{\omega}; \bar{\sigma}_\omega)}{\bar{\sigma}_\omega} + F(\bar{\omega}; \bar{\sigma}_\omega)\left[-\frac{\left(\ln \omega + \frac{1}{2}\bar{\sigma}^2_\omega\right)}{2\bar{\sigma}^2_\omega} + \frac{\left(\ln \omega + \frac{1}{2}\bar{\sigma}^2_\omega\right)^2}{2\bar{\sigma}^4_\omega}\right] 2\bar{\sigma}_\omega \\ &= \frac{F(\bar{\omega}; \bar{\sigma}_\omega)}{\bar{\sigma}_\omega}\left[\frac{\left(\ln \omega + \frac{1}{2}\bar{\sigma}^2_\omega\right)^2}{\bar{\sigma}^2_\omega} - \left(\ln \omega + \frac{1}{2}\bar{\sigma}^2_\omega\right) - 1\right], \end{aligned}$$

where we have used the fact that $\frac{\partial e^{f(x^2)}}{\partial x} = e^{f(x^2)} f'(x^2) 2x$.

Next, we need to find an expression for the mean value of the quality shock conditional on the shock being less than the threshold $G\left(\bar{\omega}, \bar{\sigma}_\omega\right)$. To do so we combine the formula to calculate the expected value with the formula for the partial expectations which are given by:

$$\begin{aligned} E\left[\omega\right] &= \int_0^\infty \omega dF\left(\omega\right) = e^{\bar{\mu}_\omega + \frac{1}{2}\bar{\sigma}^2_\omega}, \\ E\left[\omega \mid \omega > \bar{\omega}\right] &= \int_{\bar{\omega}}^\infty \omega dF\left(\omega\right) = e^{\bar{\mu}_\omega + \frac{1}{2}\bar{\sigma}^2_\omega} \Phi\left(\frac{\bar{\mu}_\omega + \bar{\sigma}^2_\omega - \ln \bar{\omega}}{\bar{\sigma}_\omega}\right), \end{aligned}$$

with Φ being the CDF of the standard normal distribution. We use this to rewrite the expectation $E\left[\omega\right]$ as:

$$\begin{aligned} E\left[\omega\right] = \int_0^\infty \omega dF\left(\omega\right) &= \int_0^{\bar{\omega}} \omega dF\left(\omega\right) + \int_{\bar{\omega}}^\infty \omega dF\left(\omega\right) \\ &= \int_0^{\bar{\omega}} \omega dF\left(\omega\right) + e^{\mu_\omega + \frac{1}{2}\sigma^2_\omega} \Phi\left(\frac{\mu_\omega + \sigma^2_\omega - \ln \bar{\omega}}{\sigma_\omega}\right). \end{aligned}$$

This allows us to find an express for $G(\bar{\omega}, \bar{\sigma}_\omega)$:

$$G(\bar{\omega}, \bar{\sigma}_\omega) = \int_0^{\bar{\omega}} \omega dF(\omega) = E\omega - e^{\bar{\mu}_\omega + \frac{1}{2}\bar{\sigma}_\omega^2} \Phi\left(\frac{\bar{\mu}_\omega + \bar{\sigma}_\omega^2 - \ln \bar{\omega}}{\bar{\sigma}_\omega}\right)$$
$$= e^{\mu_\omega + \frac{1}{2}\sigma_\omega^2}\left[1 - \Phi\left(\frac{\mu_\omega + \sigma_\omega^2 - \ln \bar{\omega}}{\sigma_\omega}\right)\right].$$

Using the fact that $\bar{\mu}_\omega = -\frac{1}{2}\bar{\sigma}_\omega^2$ we can express $G(\bar{\omega}, \bar{\sigma}_\omega)$ as:

$$G(\bar{\omega}, \bar{\sigma}_\omega) = 1 - \Phi\left(\frac{\frac{1}{2}\bar{\sigma}_\omega^2 - \ln \bar{\omega}}{\bar{\sigma}_\omega}\right).$$

The derivative of $G(\cdot)$ with respect to the threshold value $\bar{\omega}$, follows from the definition $G(\cdot) = \int_0^{\bar{\omega}} \omega dF(\omega)$ so that:

$$\frac{\partial G(\bar{\omega}; \bar{\sigma}_\omega)}{\partial \bar{\omega}} = \bar{\omega}\frac{\partial F(\bar{\omega}; \bar{\sigma}_\omega)}{\partial \bar{\omega}}.$$

Turning now to the derivative with respect to the standard deviation $\bar{\sigma}_\omega$. Note that the expression for Φ is given by:

$$\Phi(x) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{x} e^{-t^2/2} dt.$$

Taking derivatives and evaluating at x :

$$\Phi'(x) = \frac{1}{\sqrt{2\pi}} e^{-x^2/2},$$

we arrive at:

$$\frac{\partial G(\bar{\omega}; \bar{\sigma}_\omega)}{\partial \bar{\sigma}_\omega} = -\Phi'\left(\frac{\frac{1}{2}\bar{\sigma}_\omega^2 - \ln \bar{\omega}}{\bar{\sigma}_\omega}\right)\left(\frac{1}{2} + \frac{\ln \bar{\omega}}{\bar{\sigma}_\omega^2}\right).$$

5 Robustness Results on Bayesian Estimation

In section 3.E of the main text we discuss different model comparison exercises that we have undertaken. Our preferred specification is one where there is a common innovation in the technology shock of the non-durable sector and in the preference shock of the durable sector across countries. Also, we found that unlike Christiano, Motto and Rostagno (2013), anticipated ("news") shocks in the standard deviation of the housing quality shock did not improve model fit. Finally, we estimated the model with a targeting rule of the type:

$$\frac{P_t^{EMU}/P_{t-1}^{EMU}}{\bar{\Pi}^{EMU}} + \lambda_p \left(Y_t^{EMU}/Y_{t-1}^{EMU}\right) = 0$$

instead of a Taylor-type rule as equation (54). We also estimated a version of the model where funding costs for financial intermediaries are the same across countries. None of these two extensions improved model fit so they were discarded.

In the following Table 1 we provide the marginal likelihoods for different specifications, while in the following subsections we provide results for the Bayesian parameter estimates.

Table 1: Marginal Likelihoods	
Baseline Model	2575.72
Different AR(1) Coefficients	2563.49
No Common Innovations	2565.99
News shocks in risk, one lag	2569.92
News shocks in risk, two lags	2564.22
News shocks in risk, three lags	2558.21
News shocks in risk,four lags	2556.37
Targeting Rule	2346.52
Same funding costs	2510.48

5.1 Parameter Estimates, Model with Different AR(1) Coefficients

parameters

	prior mean	post. mean	conf. interval		prior	pstdev
theta_c	0.750	0.6291	0.5589	0.6988	beta	0.1500
theta_c_s	0.750	0.7206	0.6747	0.7650	beta	0.1500
theta_d	0.750	0.6404	0.5744	0.7098	beta	0.1500
theta_d_s	0.750	0.5816	0.5065	0.6544	beta	0.1500
phi_c	0.330	0.1474	0.0272	0.2624	beta	0.1500
phi_c_s	0.330	0.1319	0.0233	0.2397	beta	0.1500
phi_d	0.330	0.2682	0.0709	0.4680	beta	0.1500
phi_d_s	0.330	0.4375	0.1997	0.6819	beta	0.1500
epsilon	0.500	0.7156	0.6448	0.7877	beta	0.1500
epsilon_borr	0.500	0.4406	0.2333	0.6433	beta	0.1500
lambda	0.500	0.5968	0.5225	0.6752	beta	0.0500
phi	1.000	0.3466	0.2056	0.4795	gamma	0.5000
iota_C	1.500	1.7977	0.9869	2.5585	gamma	0.5000
iota_L	1.000	0.7853	0.5809	0.9910	gamma	0.5000
psi	2.000	1.4915	0.9952	1.9825	gamma	1.0000
kappa_b	0.005	0.0042	0.0015	0.0071	gamma	0.0020
gamma_pi	1.500	1.5494	1.3912	1.7007	norm	0.1000
gamma_r	0.660	0.8008	0.7668	0.8346	beta	0.1500
gamma_y	0.200	0.2454	0.1605	0.3345	gamma	0.0500
rho_techc	0.700	0.8077	0.7339	0.8747	beta	0.1000
rho_techd	0.700	0.7929	0.7026	0.8909	beta	0.1000
rho_techc_s	0.700	0.7480	0.6224	0.8672	beta	0.1000
rho_techd_s	0.700	0.8384	0.7505	0.9330	beta	0.1000
rho_risk	0.700	0.8321	0.7677	0.8936	beta	0.1000
rho_risk_s	0.700	0.8287	0.7758	0.8839	beta	0.1000
rho_premium	0.700	0.7588	0.6451	0.8744	beta	0.1000
rho_prefc	0.700	0.5563	0.3898	0.7289	beta	0.1000
rho_prefd	0.700	0.9603	0.9395	0.9807	beta	0.1000
rho_prefc_s	0.700	0.8002	0.6964	0.9124	beta	0.1000
rho_prefd_s	0.700	0.9794	0.9689	0.9907	beta	0.1000

standard deviation of shocks

	prior mean	post. mean	conf. interval		prior	pstdev
e_risk_s	0.250	0.2328	0.1724	0.2894	gamma	0.1250
e_risk	0.250	0.1155	0.0830	0.1480	gamma	0.1250
e_m	0.004	0.0011	0.0009	0.0013	gamma	0.0020
e_premium	0.004	0.0021	0.0011	0.0031	gamma	0.0020
e_tech	0.007	0.0073	0.0051	0.0095	gamma	0.0020
e_techc	0.007	0.0061	0.0040	0.0083	gamma	0.0020
e_techc_com	0.007	0.0075	0.0055	0.0095	gamma	0.0020
e_techd	0.007	0.0162	0.0129	0.0196	gamma	0.0020
e_techc_s	0.007	0.0067	0.0041	0.0092	gamma	0.0020
e_techd_s	0.007	0.0138	0.0105	0.0170	gamma	0.0020
e_prefc	0.010	0.0179	0.0130	0.0227	gamma	0.0050
e_prefd	0.010	0.0432	0.0279	0.0574	gamma	0.0050
e_prefc_s	0.010	0.0155	0.0105	0.0207	gamma	0.0050
e_prefd_s	0.010	0.0348	0.0236	0.0459	gamma	0.0050
e_prefd_com	0.010	0.0161	0.0055	0.0258	gamma	0.0050

5.2 Parameter Estimates, Model with No Common Innovations

parameters

	prior mean	post. mean	conf. interval		prior	pstdev
theta_c	0.750	0.6149	0.5374	0.6963	beta	0.1500
theta_c_s	0.750	0.7104	0.6541	0.7643	beta	0.1500
theta_d	0.750	0.6401	0.5685	0.7145	beta	0.1500
theta_d_s	0.750	0.5933	0.5199	0.6686	beta	0.1500
phi_c	0.330	0.1448	0.0211	0.2692	beta	0.1500
phi_c_s	0.330	0.1334	0.0195	0.2380	beta	0.1500
phi_d	0.330	0.2563	0.0593	0.4449	beta	0.1500
phi_d_s	0.330	0.4016	0.1593	0.6307	beta	0.1500
epsilon	0.500	0.6984	0.6222	0.7784	beta	0.1500
epsilon_borr	0.500	0.5028	0.2961	0.7068	beta	0.1500
lambda	0.500	0.6377	0.5673	0.7101	beta	0.0500
phi	1.000	0.3621	0.2173	0.5117	gamma	0.5000
iota_C	1.500	2.3249	1.3436	3.2703	gamma	0.5000
iota_L	1.000	0.7748	0.5498	0.9958	gamma	0.5000
psi	2.000	1.6136	1.0562	2.1557	gamma	1.0000
kappa_b	0.005	0.0047	0.0018	0.0075	gamma	0.0020
gamma_pi	1.500	1.4831	1.3237	1.6378	norm	0.1000
gamma_r	0.660	0.7875	0.7498	0.8245	beta	0.1500
gamma_y	0.200	0.2626	0.1706	0.3534	gamma	0.0500
rho_techc	0.700	0.7967	0.7057	0.8836	beta	0.1000
rho_techd	0.700	0.8588	0.7884	0.9276	beta	0.1000
rho_risk	0.700	0.8491	0.8089	0.8892	beta	0.1000
rho_premium	0.700	0.7721	0.6744	0.8729	beta	0.1000
rho_prefc	0.700	0.7123	0.5901	0.8327	beta	0.1000
rho_prefd	0.700	0.9845	0.9766	0.9930	beta	0.1000

standard deviation of shocks

	prior mean	post. mean	conf. interval		prior	pstdev
e_risk_s	0.250	0.2327	0.1783	0.2874	gamma	0.1250
e_risk	0.250	0.1186	0.0879	0.1505	gamma	0.1250
e_m	0.004	0.0011	0.0009	0.0013	gamma	0.0020
e_premium	0.004	0.0022	0.0012	0.0032	gamma	0.0020
e_tech	0.007	0.0084	0.0063	0.0107	gamma	0.0020
e_techc	0.007	0.0083	0.0062	0.0104	gamma	0.0020
e_techd	0.007	0.0158	0.0122	0.0191	gamma	0.0020
e_techc_s	0.007	0.0079	0.0054	0.0104	gamma	0.0020
e_techd_s	0.007	0.0144	0.0114	0.0176	gamma	0.0020
e_prefc	0.010	0.0185	0.0136	0.0238	gamma	0.0050
e_prefd	0.010	0.0334	0.0250	0.0411	gamma	0.0050
e_prefc_s	0.010	0.0128	0.0079	0.0177	gamma	0.0050
e_prefd_s	0.010	0.0351	0.0269	0.0432	gamma	0.0050

5.3 Parameter Estimates, Model with News in Risk Shock, One Lag

parameters

	prior mean	post. mean	conf. interval		prior	pstdev
theta_c	0.750	0.6504	0.5857	0.7221	beta	0.1500
theta_c_s	0.750	0.7393	0.6930	0.7859	beta	0.1500
theta_d	0.750	0.6423	0.5695	0.7189	beta	0.1500
theta_d_s	0.750	0.5985	0.5244	0.6756	beta	0.1500
phi_c	0.330	0.1489	0.0236	0.2684	beta	0.1500
phi_c_s	0.330	0.1226	0.0227	0.2202	beta	0.1500
phi_d	0.330	0.2492	0.0586	0.4278	beta	0.1500
phi_d_s	0.330	0.4385	0.1981	0.6679	beta	0.1500
epsilon	0.500	0.7147	0.6398	0.7878	beta	0.1500
epsilon_borr	0.500	0.4501	0.2498	0.6558	beta	0.1500
lambda	0.500	0.6171	0.5404	0.6925	beta	0.0500
phi	1.000	0.3787	0.2302	0.5272	gamma	0.5000
iota_C	1.500	1.8637	1.0156	2.6783	gamma	0.5000
iota_L	1.000	0.7109	0.4993	0.9135	gamma	0.5000
psi	2.000	1.7881	1.1807	2.4167	gamma	1.0000
kappa_b	0.005	0.0045	0.0014	0.0074	gamma	0.0020
gamma_pi	1.500	1.5571	1.4060	1.7088	norm	0.1000
gamma_r	0.660	0.8083	0.7756	0.8400	beta	0.1500
gamma_y	0.200	0.2436	0.1489	0.3334	gamma	0.0500
rho_techc	0.700	0.8055	0.7241	0.9002	beta	0.1000
rho_techd	0.700	0.8618	0.7910	0.9323	beta	0.1000
rho_risk	0.700	0.8267	0.7846	0.8705	beta	0.1000
rho_premium	0.700	0.7922	0.6964	0.9008	beta	0.1000
rho_prefc	0.700	0.6647	0.5199	0.8098	beta	0.1000
rho_prefd	0.700	0.9847	0.9762	0.9937	beta	0.1000

standard deviation of shocks

	prior mean	post. mean	conf. interval		prior	pstdev
e_risk_s	0.250	0.2528	0.1982	0.3111	gamma	0.1250
e_risk	0.250	0.1141	0.0827	0.1444	gamma	0.1250
e_risk_s1	0.250	0.0877	0.0302	0.1428	gamma	0.1250
e_risk1	0.250	0.0685	0.0328	0.1031	gamma	0.1250
e_m	0.004	0.0011	0.0009	0.0013	gamma	0.0020
e_premium	0.004	0.0020	0.0010	0.0029	gamma	0.0020
e_tech	0.007	0.0081	0.0058	0.0103	gamma	0.0020
e_techc	0.007	0.0067	0.0045	0.0091	gamma	0.0020
e_techc_com	0.007	0.0077	0.0056	0.0099	gamma	0.0020
e_techd	0.007	0.0159	0.0123	0.0193	gamma	0.0020
e_techc_s	0.007	0.0070	0.0043	0.0096	gamma	0.0020
e_techd_s	0.007	0.0144	0.0108	0.0176	gamma	0.0020
e_prefc	0.010	0.0189	0.0134	0.0241	gamma	0.0050
e_prefd	0.010	0.0314	0.0224	0.0400	gamma	0.0050
e_prefc_s	0.010	0.0141	0.0090	0.0193	gamma	0.0050
e_prefd_s	0.010	0.0327	0.0241	0.0416	gamma	0.0050
e_prefd_com	0.010	0.0147	0.0061	0.0232	gamma	0.0050

5.4 Parameter Estimates, Model with News in Risk Shock, Two Lags

parameters

	prior mean	post. mean	conf. interval		prior	pstdev
theta_c	0.750	0.6486	0.5796	0.7141	beta	0.1500
theta_c_s	0.750	0.7395	0.6922	0.7886	beta	0.1500
theta_d	0.750	0.6457	0.5747	0.7219	beta	0.1500
theta_d_s	0.750	0.5985	0.5247	0.6699	beta	0.1500
phi_c	0.330	0.1502	0.0236	0.2639	beta	0.1500
phi_c_s	0.330	0.1239	0.0224	0.2226	beta	0.1500
phi_d	0.330	0.2436	0.0612	0.4172	beta	0.1500
phi_d_s	0.330	0.4301	0.1904	0.6563	beta	0.1500
epsilon	0.500	0.7149	0.6420	0.7934	beta	0.1500
epsilon_borr	0.500	0.4539	0.2458	0.6552	beta	0.1500
lambda	0.500	0.6152	0.5419	0.6901	beta	0.0500
phi	1.000	0.3970	0.2361	0.5450	gamma	0.5000
iota_C	1.500	1.8572	1.0150	2.6486	gamma	0.5000
iota_L	1.000	0.7134	0.4926	0.9369	gamma	0.5000
psi	2.000	1.7841	1.1033	2.4474	gamma	1.0000
kappa_b	0.005	0.0044	0.0013	0.0070	gamma	0.0020
gamma_pi	1.500	1.5484	1.3978	1.7009	norm	0.1000
gamma_r	0.660	0.8070	0.7716	0.8404	beta	0.1500
gamma_y	0.200	0.2427	0.1538	0.3253	gamma	0.0500
rho_techc	0.700	0.8144	0.7326	0.9051	beta	0.1000
rho_techd	0.700	0.8587	0.7883	0.9299	beta	0.1000
rho_risk	0.700	0.7989	0.7458	0.8526	beta	0.1000
rho_premium	0.700	0.7759	0.6524	0.8973	beta	0.1000
rho_prefc	0.700	0.6659	0.5229	0.8160	beta	0.1000
rho_prefd	0.700	0.9846	0.9758	0.9931	beta	0.1000

standard deviation of shocks

	prior mean	post. mean	conf. interval		prior	pstdev
e_risk_s	0.250	0.2461	0.1771	0.3128	gamma	0.1250
e_risk	0.250	0.1060	0.0683	0.1428	gamma	0.1250
e_risk_s1	0.250	0.1002	0.0298	0.1640	gamma	0.1250
e_risk1	0.250	0.0729	0.0299	0.1128	gamma	0.1250
e_risk_s2	0.250	0.1241	0.0401	0.2067	gamma	0.1250
e_risk2	0.250	0.0719	0.0308	0.1126	gamma	0.1250
e_m	0.004	0.0011	0.0009	0.0013	gamma	0.0020
e_premium	0.004	0.0021	0.0010	0.0032	gamma	0.0020
e_tech	0.007	0.0080	0.0059	0.0102	gamma	0.0020
e_techc	0.007	0.0067	0.0045	0.0089	gamma	0.0020
e_techc_com	0.007	0.0075	0.0053	0.0096	gamma	0.0020
e_techd	0.007	0.0160	0.0125	0.0198	gamma	0.0020
e_techc_s	0.007	0.0069	0.0043	0.0095	gamma	0.0020
e_techd_s	0.007	0.0144	0.0112	0.0176	gamma	0.0020
e_prefc	0.010	0.0188	0.0134	0.0238	gamma	0.0050
e_prefd	0.010	0.0309	0.0213	0.0395	gamma	0.0050
e_prefc_s	0.010	0.0141	0.0089	0.0192	gamma	0.0050
e_prefd_s	0.010	0.0324	0.0241	0.0405	gamma	0.0050
e_prefd_com	0.010	0.0147	0.0060	0.0224	gamma	0.0050

5.5 Parameter Estimates, Model with News in Risk Shock, Three Lags

parameters

	prior mean	post. mean	conf. interval		prior	pstdev
theta_c	0.750	0.6509	0.5832	0.7196	beta	0.1500
theta_c_s	0.750	0.7366	0.6906	0.7852	beta	0.1500
theta_d	0.750	0.6433	0.5754	0.7150	beta	0.1500
theta_d_s	0.750	0.5971	0.5217	0.6707	beta	0.1500
phi_c	0.330	0.1508	0.0295	0.2723	beta	0.1500
phi_c_s	0.330	0.1259	0.0193	0.2204	beta	0.1500
phi_d	0.330	0.2557	0.0727	0.4403	beta	0.1500
phi_d_s	0.330	0.4451	0.2042	0.6823	beta	0.1500
epsilon	0.500	0.7172	0.6430	0.7965	beta	0.1500
epsilon_borr	0.500	0.4414	0.2376	0.6351	beta	0.1500
lambda	0.500	0.6128	0.5407	0.6905	beta	0.0500
phi	1.000	0.4271	0.2569	0.5851	gamma	0.5000
iota_C	1.500	1.9282	1.0474	2.7615	gamma	0.5000
iota_L	1.000	0.7084	0.5010	0.9191	gamma	0.5000
psi	2.000	1.7918	1.1563	2.4173	gamma	1.0000
kappa_b	0.005	0.0043	0.0014	0.0071	gamma	0.0020
gamma_pi	1.500	1.5544	1.4043	1.7055	norm	0.1000
gamma_r	0.660	0.8078	0.7725	0.8428	beta	0.1500
gamma_y	0.200	0.2406	0.1535	0.3275	gamma	0.0500
rho_techc	0.700	0.8217	0.7357	0.9128	beta	0.1000
rho_techd	0.700	0.8612	0.7928	0.9333	beta	0.1000
rho_risk	0.700	0.7654	0.7029	0.8281	beta	0.1000
rho_premium	0.700	0.7627	0.6346	0.8908	beta	0.1000
rho_prefc	0.700	0.6746	0.5286	0.8103	beta	0.1000
rho_prefd	0.700	0.9844	0.9757	0.9935	beta	0.1000

standard deviation of shocks

	prior mean	post. mean	conf. interval		prior	pstdev
e_risk_s	0.250	0.2504	0.1790	0.3250	gamma	0.1250
e_risk	0.250	0.1100	0.0664	0.1522	gamma	0.1250
e_risk_s1	0.250	0.1054	0.0338	0.1745	gamma	0.1250
e_risk1	0.250	0.0754	0.0294	0.1186	gamma	0.1250
e_risk_s2	0.250	0.1361	0.0413	0.2307	gamma	0.1250
e_risk2	0.250	0.0751	0.0286	0.1198	gamma	0.1250
e_risk_s3	0.250	0.1217	0.0451	0.1989	gamma	0.1250
e_risk3	0.250	0.0673	0.0267	0.1064	gamma	0.1250
e_m	0.004	0.0011	0.0009	0.0013	gamma	0.0020
e_premium	0.004	0.0022	0.0010	0.0033	gamma	0.0020
e_tech	0.007	0.0079	0.0057	0.0101	gamma	0.0020
e_techc	0.007	0.0068	0.0045	0.0089	gamma	0.0020
e_techc_com	0.007	0.0074	0.0052	0.0095	gamma	0.0020
e_techd	0.007	0.0158	0.0123	0.0193	gamma	0.0020
e_techc_s	0.007	0.0067	0.0042	0.0092	gamma	0.0020
e_techd_s	0.007	0.0143	0.0110	0.0175	gamma	0.0020
e_prefc	0.010	0.0191	0.0135	0.0248	gamma	0.0050
e_prefd	0.010	0.0309	0.0218	0.0400	gamma	0.0050
e_prefc_s	0.010	0.0145	0.0091	0.0198	gamma	0.0050
e_prefd_s	0.010	0.0328	0.0245	0.0411	gamma	0.0050
e_prefd_com	0.010	0.0144	0.0062	0.0228	gamma	0.0050

5.6 Parameter Estimates, Model with News in Risk Shock, Four Lags

parameters

	prior mean	post. mean	conf. interval		prior	pstdev
theta_c	0.750	0.6448	0.5714	0.7141	beta	0.1500
theta_c_s	0.750	0.7334	0.6825	0.7864	beta	0.1500
theta_d	0.750	0.6418	0.5718	0.7170	beta	0.1500
theta_d_s	0.750	0.5940	0.5224	0.6681	beta	0.1500
phi_c	0.330	0.1596	0.0218	0.2923	beta	0.1500
phi_c_s	0.330	0.1316	0.0197	0.2324	beta	0.1500
phi_d	0.330	0.2564	0.0598	0.4404	beta	0.1500
phi_d_s	0.330	0.4447	0.2102	0.6911	beta	0.1500
epsilon	0.500	0.7170	0.6412	0.7942	beta	0.1500
epsilon_borr	0.500	0.4242	0.2229	0.6201	beta	0.1500
lambda	0.500	0.6003	0.5246	0.6724	beta	0.0500
phi	1.000	0.4412	0.2793	0.6038	gamma	0.5000
iota_C	1.500	2.0240	1.1113	2.9534	gamma	0.5000
iota_L	1.000	0.7075	0.4938	0.9228	gamma	0.5000
psi	2.000	1.7319	1.1169	2.3242	gamma	1.0000
kappa_b	0.005	0.0045	0.0016	0.0076	gamma	0.0020
gamma_pi	1.500	1.5610	1.4204	1.7018	norm	0.1000
gamma_r	0.660	0.8076	0.7750	0.8410	beta	0.1500
gamma_y	0.200	0.2438	0.1520	0.3284	gamma	0.0500
rho_techc	0.700	0.8270	0.7371	0.9196	beta	0.1000
rho_techd	0.700	0.8617	0.7941	0.9302	beta	0.1000
rho_risk	0.700	0.7116	0.6343	0.7903	beta	0.1000
rho_premium	0.700	0.7660	0.6335	0.8954	beta	0.1000
rho_prefc	0.700	0.6684	0.5160	0.8225	beta	0.1000
rho_prefd	0.700	0.9836	0.9746	0.9929	beta	0.1000

standard deviation of shocks

	prior mean	post. mean	conf. interval		prior	pstdev
e_risk_s	0.250	0.2038	0.1009	0.2962	gamma	0.1250
e_risk	0.250	0.0944	0.0443	0.1443	gamma	0.1250
e_risk_s1	0.250	0.1068	0.0376	0.1746	gamma	0.1250
e_risk1	0.250	0.0746	0.0318	0.1177	gamma	0.1250
e_risk_s2	0.250	0.1240	0.0384	0.2079	gamma	0.1250
e_risk2	0.250	0.0721	0.0274	0.1138	gamma	0.1250
e_risk_s3	0.250	0.1172	0.0395	0.1932	gamma	0.1250
e_risk3	0.250	0.0641	0.0223	0.1029	gamma	0.1250
e_risk_s4	0.250	0.2114	0.0892	0.3349	gamma	0.1250
e_risk4	0.250	0.0943	0.0416	0.1445	gamma	0.1250
e_m	0.004	0.0011	0.0009	0.0013	gamma	0.0020
e_premium	0.004	0.0022	0.0009	0.0032	gamma	0.0020
e_tech	0.007	0.0079	0.0058	0.0101	gamma	0.0020
e_techc	0.007	0.0067	0.0043	0.0088	gamma	0.0020
e_techc_com	0.007	0.0073	0.0051	0.0095	gamma	0.0020
e_techd	0.007	0.0158	0.0123	0.0193	gamma	0.0020
e_techc_s	0.007	0.0067	0.0040	0.0092	gamma	0.0020
e_techd_s	0.007	0.0142	0.0109	0.0174	gamma	0.0020
e_prefc	0.010	0.0190	0.0134	0.0241	gamma	0.0050
e_prefd	0.010	0.0305	0.0213	0.0397	gamma	0.0050
e_prefc_s	0.010	0.0142	0.0090	0.0194	gamma	0.0050
e_prefd_s	0.010	0.0329	0.0246	0.0409	gamma	0.0050
e_prefd_com	0.010	0.0140	0.0053	0.0220	gamma	0.0050

5.7 Parameter Estimates, Model with no Financial Frictions, Common Shocks

parameters

	prior mean	post. mean	conf. interval		prior	pstdev
theta_c	0.750	0.6635	0.5814	0.7441	beta	0.1500
theta_c_s	0.750	0.7100	0.6502	0.7744	beta	0.1500
theta_d	0.750	0.6187	0.5382	0.7027	beta	0.1500
theta_d_s	0.750	0.5738	0.4893	0.6563	beta	0.1500
phi_c	0.330	0.1499	0.0247	0.2694	beta	0.1500
phi_c_s	0.330	0.1570	0.0281	0.2813	beta	0.1500
phi_d	0.330	0.2772	0.0660	0.4780	beta	0.1500
phi_d_s	0.330	0.4157	0.1638	0.6531	beta	0.1500
epsilon	0.500	0.6777	0.5856	0.7740	beta	0.1500
phi	1.000	0.8018	0.4667	1.1397	gamma	0.5000
iota_C	1.500	1.8166	0.9582	2.6312	gamma	0.5000
iota_L	1.000	0.8441	0.6546	1.0321	gamma	0.5000
psi	2.000	1.4316	0.9580	1.9263	gamma	1.0000
kappa_b	0.005	0.0045	0.0016	0.0071	gamma	0.0020
gamma_pi	1.500	1.5421	1.3883	1.6942	norm	0.1000
gamma_r	0.660	0.7979	0.7612	0.8355	beta	0.1500
gamma_y	0.200	0.2020	0.1182	0.2821	gamma	0.0500
rho_techc	0.700	0.7223	0.6067	0.8384	beta	0.1000
rho_techd	0.700	0.8523	0.7860	0.9209	beta	0.1000
rho_risk	0.700	0.7013	0.5439	0.8660	beta	0.1000
rho_premium	0.700	0.7035	0.5634	0.8526	beta	0.1000
rho_prefc	0.700	0.7492	0.6348	0.8714	beta	0.1000
rho_prefd	0.700	0.9877	0.9807	0.9949	beta	0.1000

standard deviation of shocks

	prior mean	post. mean	conf. interval		prior	pstdev
e_m	0.004	0.0012	0.0010	0.0014	gamma	0.0020
e_premium	0.004	0.0022	0.0009	0.0034	gamma	0.0020
e_tech	0.007	0.0074	0.0055	0.0093	gamma	0.0020
e_techc	0.007	0.0071	0.0043	0.0099	gamma	0.0020
e_techc_com	0.007	0.0069	0.0045	0.0094	gamma	0.0020
e_techd	0.007	0.0152	0.0119	0.0186	gamma	0.0020
e_techc_s	0.007	0.0063	0.0035	0.0089	gamma	0.0020
e_techd_s	0.007	0.0136	0.0106	0.0167	gamma	0.0020
e_prefc	0.010	0.0175	0.0120	0.0229	gamma	0.0050
e_prefd	0.010	0.0265	0.0188	0.0344	gamma	0.0050
e_prefc_s	0.010	0.0135	0.0084	0.0188	gamma	0.0050
e_prefd_s	0.010	0.0295	0.0220	0.0369	gamma	0.0050
e_prefd_com	0.010	0.0157	0.0074	0.0233	gamma	0.0050

5.8 Parameter Estimates, Model with no Financial Frictions, no Common Shocks

parameters

	prior mean	post. mean	conf. interval		prior	pstdev
theta_c	0.750	0.5962	0.4908	0.7013	beta	0.1500
theta_c_s	0.750	0.6367	0.5515	0.7226	beta	0.1500
theta_d	0.750	0.6167	0.5311	0.7038	beta	0.1500
theta_d_s	0.750	0.5832	0.5008	0.6679	beta	0.1500
phi_c	0.330	0.1687	0.0260	0.3051	beta	0.1500
phi_c_s	0.330	0.1859	0.0348	0.3309	beta	0.1500
phi_d	0.330	0.2713	0.0628	0.4606	beta	0.1500
phi_d_s	0.330	0.3838	0.1423	0.6221	beta	0.1500
epsilon	0.500	0.6476	0.5470	0.7439	beta	0.1500
phi	1.000	0.9806	0.6295	1.3368	gamma	0.5000
iota_C	1.500	2.4395	1.3941	3.4486	gamma	0.5000
iota_L	1.000	0.8633	0.6551	1.0685	gamma	0.5000
psi	2.000	1.4379	0.9393	1.9306	gamma	1.0000
kappa_b	0.005	0.0050	0.0020	0.0078	gamma	0.0020
gamma_pi	1.500	1.5012	1.3438	1.6593	norm	0.1000
gamma_r	0.660	0.7698	0.7260	0.8149	beta	0.1500
gamma_y	0.200	0.2011	0.1197	0.2815	gamma	0.0500
rho_techc	0.700	0.7301	0.6065	0.8577	beta	0.1000
rho_techd	0.700	0.8604	0.7999	0.9237	beta	0.1000
rho_risk	0.700	0.7029	0.5407	0.8612	beta	0.1000
rho_premium	0.700	0.7030	0.5602	0.8451	beta	0.1000
rho_prefc	0.700	0.7900	0.7083	0.8780	beta	0.1000
rho_prefd	0.700	0.9880	0.9812	0.9951	beta	0.1000

standard deviation of shocks

	prior mean	post. mean	conf. interval		prior	pstdev
e_m	0.004	0.0013	0.0010	0.0015	gamma	0.0020
e_premium	0.004	0.0019	0.0008	0.0030	gamma	0.0020
e_tech	0.007	0.0070	0.0053	0.0085	gamma	0.0020
e_techc	0.007	0.0066	0.0041	0.0091	gamma	0.0020
e_techd	0.007	0.0150	0.0115	0.0183	gamma	0.0020
e_techc_s	0.007	0.0053	0.0032	0.0075	gamma	0.0020
e_techd_s	0.007	0.0142	0.0112	0.0173	gamma	0.0020
e_prefc	0.010	0.0166	0.0116	0.0216	gamma	0.0050
e_prefd	0.010	0.0309	0.0233	0.0386	gamma	0.0050
e_prefc_s	0.010	0.0130	0.0081	0.0178	gamma	0.0050
e_prefd_s	0.010	0.0331	0.0257	0.0404	gamma	0.0050

5.9 Parameter Estimates, Model with Targeting Rule

parameters

	prior mean	post. mean	conf. interval		prior	pstdev
theta_c	0.750	0.7717	0.7314	0.8112	beta	0.1500
theta_c_s	0.750	0.8679	0.8454	0.8914	beta	0.1500
theta_d	0.750	0.6639	0.6044	0.7269	beta	0.1500
theta_d_s	0.750	0.6844	0.6346	0.7359	beta	0.1500
phi_c	0.330	0.0394	0.0056	0.0710	beta	0.1500
phi_c_s	0.330	0.0348	0.0051	0.0625	beta	0.1500
phi_d	0.330	0.3468	0.1403	0.5495	beta	0.1500
phi_d_s	0.330	0.4717	0.2374	0.6947	beta	0.1500
epsilon	0.500	0.5115	0.4429	0.5795	beta	0.1500
epsilon_borr	0.500	0.7555	0.6851	0.8255	beta	0.1500
lambda	0.500	0.5017	0.4661	0.5408	beta	0.0500
phi	1.000	0.8876	0.6003	1.1783	gamma	0.5000
iota_C	1.500	2.4915	1.3959	3.5635	gamma	0.5000
iota_L	1.000	0.9173	0.7602	1.0811	gamma	0.5000
psi	2.000	1.3523	0.9758	1.7107	gamma	1.0000
kappa_b	0.005	0.0060	0.0025	0.0094	gamma	0.0020
lambda_p	5.000	11.2743	5.9690	16.4011	gamma	2.5000
rho_techc	0.700	0.4604	0.3351	0.5749	beta	0.1000
rho_techd	0.700	0.7986	0.7309	0.8687	beta	0.1000
rho_risk	0.700	0.8863	0.8487	0.9241	beta	0.1000
rho_premium	0.700	0.7152	0.5079	0.9544	beta	0.1000
rho_prefc	0.700	0.7007	0.6157	0.7900	beta	0.1000
rho_prefd	0.700	0.9814	0.9721	0.9905	beta	0.1000

standard deviation of shocks

	prior mean	post. mean	conf. interval		prior	pstdev
e_risk_s	0.250	0.3640	0.2868	0.4427	gamma	0.1250
e_risk	0.250	0.2473	0.1911	0.3024	gamma	0.1250
e_m	0.004	0.0041	0.0009	0.0071	gamma	0.0020
e_premium	0.004	0.0017	0.0006	0.0028	gamma	0.0020
e_tech	0.007	0.0049	0.0035	0.0062	gamma	0.0020
e_techc	0.007	0.0057	0.0035	0.0079	gamma	0.0020
e_techc_com	0.007	0.0138	0.0111	0.0165	gamma	0.0020
e_techd	0.007	0.0162	0.0130	0.0192	gamma	0.0020
e_techc_s	0.007	0.0117	0.0090	0.0143	gamma	0.0020
e_techd_s	0.007	0.0206	0.0170	0.0241	gamma	0.0020
e_prefc	0.010	0.0125	0.0097	0.0155	gamma	0.0050
e_prefd	0.010	0.0359	0.0264	0.0450	gamma	0.0050
e_prefc_s	0.010	0.0148	0.0111	0.0190	gamma	0.0050
e_prefd_s	0.010	0.0383	0.0281	0.0480	gamma	0.0050
e_prefd_com	0.010	0.0234	0.0139	0.0329	gamma	0.0050

5.10 Parameter Estimates, Model with same Funding Costs across Countries

parameters

	prior mean	post. mean	conf. interval		prior	pstdev
theta_c	0.750	0.5276	0.4381	0.6215	beta	0.1500
theta_c_s	0.750	0.5945	0.5217	0.6648	beta	0.1500
theta_d	0.750	0.6546	0.5850	0.7245	beta	0.1500
theta_d_s	0.750	0.5379	0.4509	0.6226	beta	0.1500
phi_c	0.330	0.1592	0.0226	0.2860	beta	0.1500
phi_c_s	0.330	0.1768	0.0320	0.3105	beta	0.1500
phi_d	0.330	0.1925	0.0300	0.3381	beta	0.1500
phi_d_s	0.330	0.3313	0.0910	0.5426	beta	0.1500
epsilon	0.500	0.7379	0.6640	0.8155	beta	0.1500
epsilon_borr	0.500	0.5150	0.3143	0.7297	beta	0.1500
lambda	0.500	0.5198	0.4417	0.5965	beta	0.0500
phi	1.000	0.0352	0.0181	0.0509	gamma	0.5000
iota_C	1.500	1.6538	0.7812	2.5506	gamma	0.5000
iota_L	1.000	0.9454	0.7284	1.1603	gamma	0.5000
psi	2.000	0.9809	0.6067	1.3238	gamma	1.0000
gamma_pi	1.500	1.3863	1.2136	1.5529	norm	0.1000
gamma_r	0.660	0.7597	0.7208	0.8031	beta	0.1500
gamma_y	0.200	0.2760	0.1646	0.3802	gamma	0.0500
rho_techc	0.700	0.8428	0.7938	0.8941	beta	0.1000
rho_techd	0.700	0.8074	0.7118	0.9019	beta	0.1000
rho_risk	0.700	0.9594	0.9384	0.9819	beta	0.1000
rho_prefc	0.700	0.7237	0.6098	0.8434	beta	0.1000
rho_prefd	0.700	0.9843	0.9758	0.9930	beta	0.1000

standard deviation of shocks

	prior mean	post. mean	conf. interval		prior	pstdev
e_risk_s	0.250	0.0443	0.0365	0.0520	gamma	0.1250
e_risk	0.250	0.0384	0.0311	0.0458	gamma	0.1250
e_m	0.004	0.0012	0.0010	0.0014	gamma	0.0020
e_tech	0.007	0.0072	0.0046	0.0096	gamma	0.0020
e_techc	0.007	0.0057	0.0037	0.0077	gamma	0.0020
e_techc_com	0.007	0.0067	0.0048	0.0085	gamma	0.0020
e_techd	0.007	0.0172	0.0136	0.0208	gamma	0.0020
e_techc_s	0.007	0.0064	0.0044	0.0083	gamma	0.0020
e_techd_s	0.007	0.0135	0.0107	0.0161	gamma	0.0020
e_prefc	0.010	0.0203	0.0140	0.0266	gamma	0.0050
e_prefd	0.010	0.0210	0.0141	0.0282	gamma	0.0050
e_prefc_s	0.010	0.0189	0.0133	0.0245	gamma	0.0050
e_prefd_s	0.010	0.0293	0.0222	0.0362	gamma	0.0050
e_prefd_com	0.010	0.0155	0.0090	0.0225	gamma	0.0050