Banks' balance sheets and the international transmission of shocks

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Abstract

During the last decade the world has experienced a dramatic increase in cross-border holdings of financial assets and liabilities. Exposure to foreign assets in banks' balance sheets is discussed as one of the scapegoats for the rapid spreading of the recent crisis. In this paper, I analyze a two-country New Keynesian model in which leverage constrained financial institutions hold capital in both countries. I show that – depending on the type of shock considered – the degree of balance sheet exposure, i.e., the share of foreign assets in banks' portfolios, can matter quite a lot for the transmission of shocks via financial markets and the international synchronization of business cycles. In particular, after a country-specific shock to the quality of capital, the sign of the cross-country correlation of GDP is turned around by changing the share of foreign assets in banks' portfolios.

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1 Introduction

The recent crisis which had its origins in the U.S. financial sector but quickly spread to other sectors and other economies has been characterized by an unprecedented global comovement in financial and real variables. Given a substantial increase in cross-border financial linkages during the last decades (e.g. Lane and Milesi-Ferretti, 2007), these developments have intensified the interest in the role of financial integration for the international transmission of shocks.

There are many ways in which financial integration, i.e., the opening up of capital and bond markets, has played a role in the recent global financial crisis.[1] A very simplified but widely accepted portrayal of the crisis is centered around balance sheet linkages among highly leveraged (high ratio of assets to underlying capital) investors and financial institutions across countries: a drop in the value of some assets related to the U.S. subprime mortgage market forced balance sheet constrained investors to deleverage by selling assets. This caused a further decline in asset prices, aggravating the initial events. By squeezing lending activity across the board, financial institutions transmitted the shock to the real economy. As financial institutions around the world held portfolios of similar assets, the crisis quickly spread around the globe. This explanation has been dubbed the 'international finance multiplier' by Krugman (2008).

The concept of the 'international finance multiplier' is centered around the existence of balance sheet exposure, i.e., a non-negligable share of assets of financial institutions being held in foreign countries. While much evidence has been brought forward that this channel has played an important role in the financial crises of the nineties, empirical evidence with respect to the direct role of foreign asset holdings during the 'Great Recession' of 2008-2009 is mixed. For instance, using a standard regression methodology, Kamin and DeMarco (2010) find that direct exposure to U.S. mortgage backed securities "fail[s] to explain the lion's share of the deterioration in asset prices [worldwide] that took place during the crisis". Using a cross-country dataset, Rose and Spiegel (2010) come to the conclusion, that exposure to U.S. assets cannot account for the cross-country heterogeneity in contagion. Note, however, that neither of the studies is structural.

This paper is a theoretical contribution to the discussion to which extend the degree of balance sheet exposure matters for the international transmis-

[1] See Kamin and DeMarco (2010) and Devereux and Yu (2015) for good literature overviews.

sion of shocks. I set up a two-country model with balance sheet constrained financial intermediaries. Each economy is modeled as in Gertler and Karadi (2011). I extend their model by introducing international trade in final goods and by allowing intermediaries to purchase financial claims on intermediate goods producing firms at home and abroad, which leads to an equalization of the expected returns to capital at home and abroad. Integration of the asset market gives rise to an international portfolio choice problem which I solve using the method proposed by Devereux and Sutherland (various papers). Bond and deposit markets are domestic. I use the model to analyze a shock which has not been analyzed in an international setting so far[2], a country-specific shock to the quality of capital. This shock directly reduces the value of the corresponding assets in banks' balance sheets producing an enhanced decline in the net worth of these institutions. Gertler and Karadi argue that the effects of this shock broadly capture the dynamics of the subprime crisis. Recently, this shock has been given much attention in the (closed economy) literature, as it can produce a comovement of real variables very close to the one observed since the beginning of the Great Recession' (Furlanetto and Seneca, 2014). Various empirical studies show that this kind of shock can explain a large part of the business cycle fluctuations in recent years (Liu et al., 2011; Sanjani, 2014; Justiniano et al., 2011). I find that a higher share of foreign assets in the portfolio can turn around the sign of the correlation of home and foreign output from negative to positive after a capital quality shock.

Similar theoretical accounts of the role of balance sheet exposure for the international transmission of shocks came to different results. Using a two-country New Keynesian model with leverage constrained investors, Dedola and Lombardo (2012) argue that price equalization in integrated financial markets, in particular the equalization of credit spreads, leads to business cycle comovement "quite independently of the exposure to foreign assets in the balance sheet of leveraged investors". A similar theoretical contribution is the two-country DSGE model with leverage constrained investors by Yao (2012). Setting up a model with integrated equity markets, they come to the conclusion that the degree of balance sheet exposure has a (small) quantitative effect on the cross-country correlation of real variables. Both contributions consider shocks to the net wealth of leverage constrained investors as well as technology shocks.

[2] A notable exception is the model by Dedola et al. (2013). Their model also features a banking sector à la Gertler and Karadi but a reduced international trade sector. In this setting they also analyze the effects of capital quality shocks but they are mainly interested in the question how unconventional monetary policy should be conducted in this context.

In a nutshell, what leads to the differing results is that the capital quality shock directly affects all agents holding the 'bad' assets while net wealth and technology shocks affect asset holders in the country spared by the shock only via price equalization and trade effects.

My results also raise new welfare questions. So far, it has only been shown that financial market integration per se is welfare improving compared to a regime of financial market autarky (e.g. Devereux and Sutherland, 2011). However, if different degrees of portfolio exposure are associated with different degrees of international comovement, do they also yield different welfare? To my knowledge, this paper is the first one to compare welfare under different degrees of balance sheet exposure.[3] In particular, I compare a situation in which banks chose an optimal portfolio (in this model banks chose to hold a balanced portfolio) to a situation in which banks hold only domestic assets. While the first scenario yields the highest welfare, the latter situation is welfare inferior even compared to a regime with financial market autarky. This suggests that any barriers to international financial trade in otherwise open financial markets hinder risk sharing while not being able to shield the economy from contagion effects through price equalization.

Last but not least, the analyses conducted in this paper provide a small but interesting contribution to the literature on international portfolio choice.[4] In all previous contributions (except Dedola et al., 2013) some type of household undertakes the portfolio choice decision. In this case, the optimal portfolio coincides with the portfolio yielding the highest degree of consumption risk sharing. In my model, bankers who have a motive apart from the maximization of lifetime utility undertake the portfolio choice decision. The portfolio they chose is different from the portfolio which yields the highest degree of consumption risk sharing. This an interesting finding with respect to the well known empirical phenomenon that international risk sharing is relatively low despite wide financial market integration.

The paper is organized as follows. The next section develops the model. Section 3 provides the calibration. In section 4, I present and discuss the results. The final section concludes and gives an outlook.

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[3] I would like to thank Giovanni Lombardo for pointing out a way of calculating welfare under ad hoc, i.e., not optimally chosen portfolios in a setting with endogenous portfolio choice.

[4] There is a fairly large number of contributions building on the method proposed by Devereux and Sutherland (various years), some of which have already been mentioned above. Alternative methods to find international portfolios were proposed by Tille and van Wincoop (2010) and Evans and Hnatkovska (2005), among others.

2 Model

Assume that the world consists of two countries with symmetric structures, each inhabited by a continuum of agents of equal size. Each of the economies is modeled isomorphic to the economy in Gertler and Karadi (2011). They introduce financial intermediaries into an otherwise standard New Keynesian Model. The role of intermediaries is to transfer funds between households and intermediate goods producers. Intermediaries face an endogenously determined constraint on their leverage ratio, motivated by a simple agency problem, which drives a wedge between saving and borrowing rates.

The two-country version of the model developed in this paper features final goods market integration as well as asset market integration. Each country produces a differentiated final good which is consumed by households in both countries. Financial markets are integrated only with respect to assets, i.e., I allow intermediaries to purchase financial claims on intermediate goods producing firms at home and abroad. Deposit markets remain national which matches empirical facts according to which households prefer holding deposits nationally, despite large differences in deposit rates. Integration of asset markets introduces an endogenous portfolio choice problem as returns on equity are subject to country-specific risk. In models with endogenous portfolio choice it is common to analyze cross-country positions in equity and bonds. Equity market integration is alway analyzed conditional on bond market integration (see e.g. Dedola and Lombardo, 2012; Devereux and Sutherland, 2011; Devereux et al., 2014). It is known that bonds are mainly used to hedge real exchange rate fluctuations and can indeed ensure a high degree of international consumption risk sharing (Coeurdacier and Rey, 2013). For simplicity, this model abstracts from real exchange rate fluctuations, hence, it seems to be a legitimate modeling choice to abstract from the instrument which is mainly used to provide insurance against this source of risk. Abstracting from bond market integration, can indeed be seen as a highlight of this model, as it allows to single out the effects of cross-border holdings of equity.

As there are eight different sources of risk, home and foreign TFP shocks, home and foreign capital quality shocks, home and foreign shocks to the net wealth of bankers and home and foreign monetary policy shocks, and only two types of assets to provide insurance against country-specific risk (financial claims on home and foreign intermediate goods firms), international consumption risk sharing is incomplete.

For simplicity only home country equations will be displayed. Foreign variables will be denoted with an asterisk.

2.1 Households

Within each household, there are two member types, workers and bankers. While the worker supplies work to intermediate goods firms and deposits to banks, the banker manages a financial intermediary and transfers retained earnings back to her household when the lifetime of the bank ends. Within the family, there is perfect consumption risk sharing, which allows to maintain the representative agent framework. As in Gertler and Karadi (2011), it is assumed that a fraction $1-f$ of household members are depositors, while a fraction f are bankers. Between periods there is a random turnover between the two groups: with probability θ_B a banker will stay a banker and with probability $1-\theta_B$ she will become a depositor. The relative proportions are kept fixed. New bankers are provided with some start-up funds from their respective households.

The lifetime utility of a representative home worker, who draws utility from a consumption aggregate C_t and disutility from labor L_t, is given by

$$E_t \sum_{k=0}^{\infty} \Theta_k \left(\ln C_{t+k} - \chi \frac{L_{t+k}^{1+\phi}}{1+\phi} \right),$$

with χ, $\phi > 0$. Variable Θ_t is the endogenous discount factor of households (see below).

Households save by depositing funds at competitive intermediaries in their country. Deposits held between $t-1$ and t, denoted by D_{t-1}, are equivalent to one-period riskless real bonds paying the gross real rate of return R_t. Furthermore, households provide labor to intermediate goods firms and receive the nominal wage W_t. Hence, the home household's budget constraint in real terms is given by

$$C_t + D_t = R_t D_{t-1} + \frac{W_t}{P_t} L_t + \pi_t,$$

where π_t denotes net profits from the ownership of firms (financial and non-financial).

Households have equal preferences for home and foreign final goods. Hence, C_t, the CES composite of consumption is given by

$$C_t = \left(0.5^{\frac{1}{\iota}} C_{H,t}^{\frac{\iota-1}{\iota}} + 0.5^{\frac{1}{\iota}} C_{F,t}^{\frac{\iota-1}{\iota}} \right)^{\frac{\iota}{\iota-1}},$$

with $\iota > 0$ and $C_{H,t}$ and $C_{F,t}$ denoting consumption of the home and the foreign final goods, respectively. The corresponding consumer price index takes the following form:

$$P_t = \left(0.5 P_{H,t}^{1-\iota} + 0.5 P_{F,t}^{1-\iota}\right)^{\frac{1}{1-\iota}},$$

where $P_{H,t}$ denotes the price of the home good in the home country and $P_{F,t}$ denotes the price of the foreign good in the home country.

Assuming local currency pricing, the law of one price holds, i.e.,

$$\begin{aligned} P_{H,t} &= \epsilon_t P_{H,t}^* \\ P_{F,t} &= \epsilon_t P_{F,t}^*, \end{aligned}$$

where ϵ_t is the nominal exchange rate. As households preferences are identical in the two countries and no home bias is assumed, the consumption baskets are equal, hence, Purchasing Power Parity holds, i.e.,

$$P_t = \epsilon_t P_t^*.$$

Under Purchasing Power Parity, the real exchange rate is constant.

An exogenous discount factor together with incompleteness of financial markets implies a unit root in a first-order approximated open economy model (see e.g. Schmitt-Grohé, S. and Uribe, M., 2003). Hence, an endogenous discount factor is chosen to ensure stationarity in consumption. The discount factor is determined as follows:

$$\begin{aligned} \Theta_{t+1} &= \Theta_t \beta(C_{A,t}), \\ \Theta_0 &= 1, \end{aligned}$$

where $C_{A,t}$ is aggregate home consumption. Using aggregate consumption in the endogenous discount factor ensures that the household does not internalize the effect of her consumption decision on the discount factor, which simplifies calculations considerably. As in Schmitt-Grohé, S. and Uribe, M. (2003) and Devereux and Yetman (2010) the following functional form of the endogenous discount factor is assumed

$$\beta(C_{A,t}) = \omega_c (1 + C_{A,t})^{-\eta_c}.$$

Parameter η_c is chosen to be very small, to keep the effects of this purely technical feature on the results of the model negligibly small.

Accordingly, the households first-order conditions for the optimal choice of labor and consumption are given by

$$\frac{W_t}{P_t} = \chi \frac{L_t^{\phi}}{\lambda_t},$$

and

$$1 = \beta(C_{A,t}) E_t\{\Lambda_{t,t+1}\} R_t,$$

with the marginal utility of consumption being given by

$$\lambda_t = C_t^{-1}$$

and the households real stochastic discount factor being defined as

$$\Lambda_{t,t+1} \equiv \frac{\lambda_{t+1}}{\lambda_t}.$$

2.2 Banks

In the model economy, home financial intermediaries channel funds from home households to home and foreign intermediate goods producers, fulfilling the double role of investment as well as commercial banks.

In addition to obtaining funds from households, banks also raise funds internally by accumulating retained earnings. The balance sheet of home bank i is given by

$$Q_t S_{iH,t} + Q_t^* S_{iF,t} = D_{i,t} + N_{i,t},$$

where Q_t (Q_t^*) denotes the price of the home (foreign) capital asset. Deposits at bank i are denoted by $D_{i,t}$. Variable $S_{iH,t}$ ($S_{iF,t}$) denotes state-contingent claims on future returns of a unit of capital used in intermediate goods production in the home (foreign) country, whose gross rate of return is given by $R_{k,t}$ ($R_{k,t}^*$). Intermediary i's net worth is given by $N_{i,t}$. It evolves according to the following equation:

$$N_{it} = R_{k,t} Q_{t-1} S_{iH,t-1} + R_{kt}^* Q_{t-1}^* S_{iF,t-1} - R_t D_{i,t-1}.$$

Since the banker cannot invest in assets which yield a discounted return smaller than the cost of borrowing, the following inequalities have to be satisfied:

$$E_t\{\Theta_{t+1}\Lambda_{t,t+1}(R_{k,t+1} - R_{t+1})\} \geq 0$$
$$E_t\{\Theta_{t+1}\Lambda_{t,t+1}(R^*_{k,t+1} - R_{t+1})\} \geq 0,$$

With perfect capital markets the above relations would hold with equality. In the presence of financial frictions, however, the premium must be positive. As will be seen later it covaries negatively with GDP as the intermediaries inability to obtain funds increases during bad states of the economy. As long as the banker earns some positive yield on each euro invested, she finds it worthwhile to operate and further accumulate earnings.

As it is assumed that each period a fraction 1-θ_B of bankers exits the business with i.i.d. probability and pays out accumulated earnings to their respective households,[5] a banker maximizes the terminal value of her net worth given by

$$V_t = \max\ E_t \sum_{k=0}^{\infty} (1-\theta_B)\theta_B^k \Theta_k \Lambda_{t,t+k+1} N_{i,t+k+1}.$$

To motivate the requirement to build up net worth, the following moral hazard problem is assumed: at the beginning of each period, before the shocks realize and any other transactions take place, it is assumed that the banker can choose to divert fraction λ of available funds back to the household. The cost associated with this fraud is that the depositors recover the remaining fraction $1-\lambda$ and force the banker into bankruptcy. Due to the moral hazard problem, for creditors to be willing to deposit funds with the bank, the following incentive constraint must hold

$$V_{i,t} \geq \lambda B_{i,t}$$
$$\geq \lambda(D_{i,t} + N_{i,t}),$$

with $B_{i,t} \equiv Q_t S_{iH,t} + Q^*_t S_{iF,t}$ denoting total bank assets. To solve the banker's maximization problem define the objective of the bank recursively as

$$V_{i,t} = \max\ E_t \beta(C_{A,t})\Lambda_{t,t+1}[(1-\theta_B)N_{i,t+1} + \theta_B V_{i,t+1}],$$

[5]This arrangement keeps aggregate bankers' net worth bounded.

and conjecture that the value function is linear in assets and net worth:

$$V_{i,t} = \nu_{iH,t} S_{iH,t} + \nu_{iF,t} S_{iF,t} - \eta_{i,t} N_{i,t}.$$

The solutions for the coefficients are given by

$$\begin{aligned} \nu_{h,t} &= E_t \left\{ \Omega_{t+1} (R_{k,t+1} - R_t) \right\} \\ \nu_{f,t} &= E_t \left\{ \Omega_{t+1} (R^*_{kt+1} - R_t) \right\} \\ \eta_t &= E_t \left\{ \Omega_{t+1} \right\} R_t, \end{aligned}$$

where

$$\Omega_{t+1} = \beta(C_{A,t}) \Lambda_{t,t+1} \left[(1 - \theta_B) + \theta_B \left(\eta_{t+1} + \nu_{t+1} \phi_{t+1} \right) \right],$$

which can be interpreted as the stochastic discount factor of the banker. It differs from the households discount factor due to the presence of financial frictions. The discount factor is a key variable for the determination of international portfolio positions. The difference between the two agents' discount factors is very important for on of the results of this paper: the fact, that in this model the portfolio decision is made by the banker instead of the household leads to inefficiently low insurance of country-specific risk. A further first-order condition is given by

$$\nu_{h,t} = \nu_{f,t} \equiv \nu_t.$$

Note that the subscript i was dropped as the coefficients exclusively depend on aggregate variables.

Assuming that the incentive constraint binds[6], it can be expressed in terms of the coefficients of the value function

$$B_t = \frac{\eta_t}{\lambda - \nu_t} N_t = \phi_t N_t,$$

where ϕ_t is the ratio of intermediated assets to net worth, which can be referred to as the leverage ratio. Note that it is endogenously determined in this model.

[6] Parameters and steady state values are chosen such that it binds in the steady state. Holding the variance of shocks small enough guarantees that the incentive constraint also binds in a stochastic environment.

Finally, the law of motion for aggregate net worth can be derived:

$$N_t = N_{n,t} + N_{e,t}$$
$$N_{e,t} = \theta_B \left[\left((R_{k,t} - R_{t-1}) - \frac{Q^*_{t-1} S_{F,t-1}}{W_{t-1}} (R_{k,t} - R^*_{k,t}) \right) \phi_{t-1} + R_{t-1} \right] N_{t-1}$$
$$N_{n,t} = \omega [Q_{t-1} S_{H,t-1} + Q^*_{t-1} S_{F,t-1}],$$

where $N_{e,t}$ denotes existing bankers' net worth, $N_{n,t}$ denotes new bankers' net worth and ω is the fraction of the assets given to new bankers by their households.

2.3 Intermediate goods firms

Intermediate goods firms produce an intermediate good which is sold to final goods producers in the same country at the real price $P_{m,t}$ for use in the production of the final good. The market for intermediate goods is assumed to be perfectly competitive.

The Cobb-Douglas production function of the representative intermediate goods firm is given by:

$$Y_{m,t} = A_t (U_t \Psi_t K_t)^{\alpha} L_t^{1-\alpha},$$

where $Y_{m,t}$ denotes intermediary output, A_t exogenous technology and U_t the utilization rate of capital. Labor L_t is provided by households in the same country only. Capital K_t was bought from capital goods producers in the same country in the previous period at price Q_t. To finance capital purchases, the firm issues state-contingent securities to obtain funds from home and foreign intermediaries at the same price. Each period, the firm has to pay back capital returns on the securities issued the previous period. As in Gertler and Karadi (2011) we assume a shock to the quality of capital, Ψ_t, to provide a source for exogenous variations in the price of capital. It can be interpreted as the sudden realization that much of the capital installed is of lower quality than previously thought. As capital provides a kind of collateral to banks, banks' balance sheets will be contracted in response to a negative capital quality shock. The law of motion for capital is given by

$$K_{t+1} = I_t + (1 - \delta(U_t)) \Psi_t K_t,$$

where I_t is aggregate investment and $\delta(U_t)$ denotes physical depreciation which depends on the utilization rate of capital.

The first-order conditions of the intermediate goods producers profit maximization problem are given by

$$R_{k,t+1} = \frac{\alpha \frac{P_{m,t+1}Y_{t+1}}{K_{t+1}} + (1-\delta(U_{t+1}))\Psi_{t+1}Q_{t+1}}{Q_t},$$

$$\frac{W_t}{P_t} = (1-\alpha)\frac{P_{m,t}Y_t}{L_t},$$

and

$$\delta'(U_t)\Psi_t K_t = P_{m,t}\alpha\frac{Y_{mt}}{U_t}.$$

The firm earns zero profits state-by-state, hence, it simply pays out the ex post return to capital, $R_{k,t}$, to the financial intermediary.

2.4 Capital goods firms

Competitive capital goods firms produce capital only for the domestic market using national final output as input facing investment adjustment costs (in consumption units). Adjustment costs are assumed to be proportional to the aggregate past capital stock as in Dedola et al. (2013). Their functional form is given by

$$f(\cdot) = \frac{\eta_i}{2}\left(\frac{I_t}{\delta K_t} - 1\right)^2 \frac{I_t}{\delta K_t},$$

with $0 < \eta_i$. The capital goods producer chooses I_t to maximize lifetime profits given by

$$E_t \sum_{k=0}^{\infty} \Theta_k \Lambda_{t,t+k} \left\{Q_{t+k} I_{t+k} - \left[1 + f(\cdot)\right] I_{t+k}\right\}.$$

From the first order conditions, we obtain the real price of one unit of capital

$$Q_t = 1 + \eta_i \left(\frac{I_t}{\delta K_t} - 1\right).$$

Due to flow investment costs, capital goods firms can earn profits outside the steady state. These profits are distributed lump-sum to the households.

2.5 Final goods firms

Final output produced by home firms and purchased by consumers at home and abroad, Y_t, is assumed to be a CES composite of mass unity of differentiated final products.

$$Y_t = \left[\int_0^1 Y_t(h)^{\frac{\epsilon-1}{\epsilon}} dh\right]^{\frac{\epsilon}{\epsilon-1}},$$

with $0 < \epsilon$. $Y_t(h)$ denotes output by retailer h. The corresponding home producer price index is given by

$$P_{H,t} = \left[\int_0^1 P_{H,t}(h)^{1-\epsilon} dh\right]^{\frac{1}{1-\epsilon}}$$

Given that consumers allocate consumption expenditures optimally between varieties, home final goods firm h faces the following demand by home and foreign consumers[7]

$$Y_t(h) = \left(\frac{P_{H,t}(h)}{P_{H,t}}\right)^{-\epsilon} Y_t,$$

i.e., its share in total home final goods production, Y_t, depends on its relative price.

It is assumed that each unit of final output is assembled costlessly from one unit of intermediate output. Real marginal cost is therefore given by the intermediate output price $P_{m,t}$. It is further assumed that firms face a positive probability, θ, each period that they a are not able to reset their price (Calvo-style pricing). Hence, the optimal price of firm h, $\tilde{P}_{H,t}$ is given by

$$\tilde{P}_{H,t} = \frac{\epsilon}{\epsilon-1} \frac{E_t \sum_{k=0}^{\infty} \theta^k \Theta_k C_{t+k}^{-\sigma} \Pi_{H,t,t+k}^{\phi} Y_{t+k}}{E_t \sum_{k=0}^{\infty} \theta^k \Theta_k C_{t+k}^{-\sigma} \Pi_{H,t,t+k}^{\phi-1} Y_{t+k} p_{H,t+k}} P_{H,t},$$

where $\Pi_{H,t} \equiv \frac{P_{H,t}}{P_{H,t-1}}$ denotes home producer price inflation between $t-1$ and t and $p_{H,t} \equiv \frac{P_{H,t}}{P_t}$ is the relative price of home goods. The dynamics of the home price index are given by

$$P_{H,t} = \left(\theta P_{H,t-1}^{1-\epsilon} + (1-\theta)\tilde{P}_{H,t}^{1-\epsilon}\right)^{\frac{1}{1-\epsilon}}.$$

[7]Under the assumption of local currency pricing (which preserves the Law of one Price), a distinction between home and foreign demand is not necessary.

2.6 Monetary policy

Monetary policy is specified by a very simple and standard Taylor rule. It is assumed that the home central bank reacts to variations in the home output gap and home consumer price inflation (CPI). CPI targeting is chosen, because it represents a better description of actual Taylor rules used in central banks following inflation targeting strategies (Devereux et al., 2014, p. 937). The particular Taylor rule of the home country central bank is given by

$$r_t = (\beta^{-1}\Pi_t^{\gamma_\Pi}\hat{y}_t^{\gamma_y})^{(1-\rho_r)} r_{t-1}^{\rho_r}\varepsilon_{i,t},$$

where r_t denotes the nominal rate, $\hat{y}_t$ denotes the output gap, defined as the difference between flexible price output and sticky price output, and $\varepsilon_{i,t}$ is an exogenous disturbance to monetary policy. The output gap is approximated by the inverse of the markup gap. Parameter ρ_r denotes the degree of interest rate smoothing.

The following Fisher equation establishes the link between the policy rate and the real interest rate:

$$r_t = R_t E_t \Pi_{t+1},$$

where $\Pi_{t+1} = \frac{P_{t+1}}{P_t}$ denotes consumer price inflation between periods t and $t+1$.

2.7 Further equilibrium conditions

The model equilibrium is further characterized by the international capital market clearing condition, the home and foreign goods market clearing conditions and the home and foreign aggregate resource constraints.

The capital market clearing condition states that the current value of total capital installed in both countries has to be equal to the total value of state contingent claims on future returns of capital hold by home and foreign banks

$$Q_t K_{t+1} + Q_t^* K_{t+1}^* = Q_t(S_{h,t} + S_{h,t}^*) + Q_t^*(S_{f,t} + S_{f,t}^*).$$

Home goods market clearing is given by

$$Y_t = C_{H,t} + C_{H,t}^* + p_H^{-1}[1 + f(\cdot)]I_t.$$

The home aggregate resource constraint is derived from the aggregation of the budget constraint over home households, considering profits from the ownership of non-financial firms, retained earnings from exiting bankers and the transfer to new bankers

$$\frac{P_{H,t}}{P_t} Y_t + Q^*_{t-1} S_{F,t-1} R^*_{k,t-1} - Q_{t-1} S^*_{H,t-1} R_{k,t-1}$$
$$= C_t + [1 + f(\cdot)] I_t + Q^*_t S_{F,t} - Q_t S^*_{H,t}.$$

Last but not least, the relationship between final goods production and intermediate goods production characterizes the equilibrium:

$$Y_{m,t} = Y_t \Delta_{p,t},$$

with $\Delta_{p,t}$ denoting the price dispersion which arises in a model with a two-stage production process with intermediate and final good producers and sticky prices. It can be written in terms of producer price inflation:

$$\Delta_{p,t} = \theta \Delta_{p,t-1} \Pi^{\epsilon}_{H,t} + (1-\theta) \left(\frac{1 - \theta \Pi^{\epsilon-1}_{H,t}}{(1-\theta)} \right)^{\frac{\epsilon}{\epsilon-1}}.$$

2.8 Portfolio indeterminacy and solution method

Recall home banks first-order condition $\nu_{ht} = \nu_{ft}$ which can be rewritten as

$$\beta E_t \left\{ \Omega_{t+1} R_{k,t+1} \right\} = \beta E_t \left\{ \Omega_{t+1} R^*_{kt+1} \right\}.$$

Evaluated in the the steady state, this equations becomes

$$R_k = R^*_k,$$

and, approximated up to first order,

$$E_t R_{k,t+1} \approx E_t R^*_{k,t+1}.$$

Hence, in the steady state and evaluated up to first-order both assets pay the same return. In economic terms, with equity market integration, expected returns are equalized by arbitrage. This implies that all possible compositions of banks' portfolios, given by $B_t = Q_t S_{H,t} + Q^*_t S_{F,t}$, pay the same return in the non-stochastic steady state and in expectations, evaluated up to a first-order. Therefore, international portfolio choice is indeterminate up to first-order accuracy. The economic intuition behind this indeterminacy problem is the fact that assets are only distinguishable in terms of their risk characteristics which can only be captured with an approximation of second-order or higher (Devereux and Sutherland, 2008, p. 9).

Devereux and Sutherland (various papers) propose a method to determine steady state portfolio holdings, which is based on a second-order approximation of the portfolio equations and a first-order approximation of the non-portfolio parts of the model. Recently, other local and global methods have been proposed by other authors, however, the method used by Devereux and Sutherland is particularly appealing as it uses well-known perturbation techniques and can be quite easily incorporated into otherwise standard programs used to solve DSGE models, e.g. Dynare.

To solve the model by the method proposed by Devereux and Sutherland, it is not necessary to actually conduct the second-order approximation of the portfolio parts of the model. Instead one can use a shortcut. Firstly, it should be noted that to analyze the first-order accurate macroeconomic dynamics of the non-portfolio variables, only steady state portfolio holdings are relevant. Secondly, the equations containing the portfolio shares can be rewritten in a way that portfolio shares only appear in a product with excess returns defined as $R_{x,t} \equiv R_{k,t} - R^*_{k,t}$. From the approximated first-order condition above it follows that up to first-order accuracy this term is equivalent to an exogenous independent mean-zero i.i.d. random variable. Using these insights, the model can be solved using any linear method without knowing the steady state portfolio holdings. This constitutes the first step of the solution procedure.

In a second step, one needs to find the steady state portfolio holdings which make the first-order condition for portfolio choice hold up to second-order. However, a second-order approximation of the whole model is not necessary as second-order accurate solutions to policy functions can be obtained using purely linear solution methods (see e.g. Lombardo and Sutherland, 2007). Hence, to find optimal portfolio holdings one can just extract results for certain policy functions from the first-order approximation of the model described in the previous paragraph and calculate optimal portfolio holdings using a formula given in Devereux and Sutherland .

3 Calibration

Parameter	Description	Value
Households		
χ	utility weight of labor	5.6
ϕ	inverse of Frisch elasticity of labor supply	0.276
η_c	elasticity of the discount factor w.r.t. consumption	0.01
ω_c	parameter from endogenous discount factor	0.9951
Capital producing firms		
η_i	inverse elasticity of net investment to the price of capital	1.728
Intermediate goods firms		
α	capital share	0.33
δ	steady state depreciation rate	0.025
Final goods firms		
θ	probability of not being able to change price	0.75
ϵ	elasticity of substitution between varieties	10
ι	elasticity of substitution between home and foreign goods	1.5
Financial intermediaries		
λ	fraction of divertable assets	0.383
ω	transfer to entering banks	0.003
θ_B	quarterly survival rate of banks	0.972
Taylor rule		
γ_y	feedback coefficient on the output gap	0.125
γ_π	feedback coefficient on inflation	1.5
ρ_r	interest smoothing coefficient	1.5
Exogenous processes		
ρ_ψ	persistence of capital quality shock	0.66
ρ_A	persistence of technology schock	0.95
σ_ψ	standard deviation of capital quality shock	0.05
σ_A	standard deviation of technology shock	0.05
σ_N	standard deviation of net wealth shock	0.05
σ_M	standard deviation of monetary shock	0.01

Table 1: *Parameters*

Table 1 reports the benchmark calibration. Most parameters are quite standard and do not need to be discussed. The parameters of the banking system, λ, the divertable fraction of assets, θ_B, the average lifetime of banks and ω, the transfer to entering bankers are taken from Gertler and Karadi (2011). They choose these values to hit three targets: a steady state interest rate spread of 100 basis points, a steady state leverage ratio of four and an average lifetime of a bank of 10 years. For parameter χ the same value as in Dedola et al. (2013) is used. Parameter ω_c in the endogenous discount factor was chosen as to guarantee a steady state interest rate of 4%, i.e., a steady state value of $\beta(C_A)$ of 0.99. The value for the other parameter in the endogenous discount factor, η_c, which captures the steady state savings propensity, was taken from Devereux and Sutherland (2009). The value chosen for the trade elasticity between home and foreign goods is in line with the values de Walque et al. (2006) estimated for the European Union. The persistence of the capital quality shock is also taken from Gertler and Karadi (2011).

4 Model analysis

4.1 Steady state portfolio holdings and implications for risk sharing

Steady state portfolio holdings in this model are defined as

$$\alpha^P \equiv \frac{Q^* S_f}{Q^* S_f + Q S_h} = \frac{Q S_h^*}{Q^* S_f^* + Q S_h^*},$$

i.e., the share of foreign equity holdings in home banks' portfolio which – due to symmetry – is equal to the share of home equity holdings in foreign banks' portfolio.

Using the benchmark calibration, steady state portfolio holdings amount to 0.54, i.e., financial intermediaries hold a balanced portfolio. Data on international portfolio holdings show that developed countries exhibit an equity home bias (share of domestic equity in portfolio) of 60-80% (see e.g. Coeurdacier and Rey, 2013). The model at hand cannot exactly replicate this feature of international financial markets, however, a value of 0.54 is much closer to realistic portfolio holdings than the values obtained from many other standard open economy models which predict that hedging motives should invoke agents to hold a portfolio consisting mainly of foreign assets. The robustness of steady state portfolio holdings to changes in the parameters was checked. The parameter range for each parameter was chosen such that it covers all values commonly used. The result of a diversified portfolio is fairly robust to varying parameter values. Results are available on request. For a detailed discussion of how different parameter values and model features affect portfolio choice see e.g. Coeurdacier and Rey (2013).

In models with international portfolio choice, agents chose portfolio holdings as to optimally ensure against country-specific risks. A unique feature of my model is that bankers undertake portfolio decisions instead of households.[8] Bankers are owned by households, hence, they internalize the objective of the household which consists in the maximization of lifetime utility. However, they have an additional objective, namely the maximization of terminal net wealth which in the mean time serves as collateral. Therefore, in this setup, the stochastic discount factor relevant for international portfolio choice differs from the households' stochastic discount factor, as long as the incentive constraint is binding, as was already explained in section 2.2.

Figure 1 depicts different second-order properties of the model for varying degrees of balance sheets exposure. The first graph shows the covariance between the difference between stochastic discount factors of bankers, $\Omega_t - \Omega_t^*$, and excess returns on capital, $R_{x,t} = R_{k,t} - R_{k,t}^*$. As explained above, the portfolio allocation chosen optimally by banks is the one which satisfies the equation $E_t\{(\Omega_{t+1} - \Omega_{t+1}^*)R_{x,t}\} = 0$ up to second-order accuracy. Hence, the first graph intersects the x-axis at point 0.54.

If financial frictions were absent, households would undertake the portfolio decision. They would chose a portfolio which satisfies the equation $E_t\{(C_{t+1} - C_{t+1}^*)R_{x,t}\} = 0$ up to second-order accuracy (see e.g. Devereux and Sutherland, 2008). By construction, this portfolio would coincide with the one that maximizes consumption risk sharing. In a two-country model with Purchasing Power Parity, home and foreign households' marginal utilities are equalized under the assumption of perfect consumption risk sharing (see e.g. Nuntramas, 2011). In the model at hand, markets are incomplete and, hence, risk sharing is incomplete. The correlation between home and foreign marginal utilities can serve as proxy for the degree of actual risk sharing. A correlation coefficient of 1 implies perfect risk sharing. As it can be seen in the upper right plot of figure 1, the foreign equity share which maximizes risk sharing is given by approx. 0.7.

[8]The model by Dedola et al. (2013) features the same setup of the banking system as my model, however, they do not analyze the implications of portfolio choice by bankers in detail. In Dedola and Lombardo (2012), Yao (2012) and Devereux and Yetman (2010) so-called 'investors' undertake the portfolio decision, but their objective is also the maximization of lifetime utility, hence, the stochastic discount factor relevant for international portfolio choice is equivalent to the households' one.

It is equal to the portfolio which minimizes consumption volatility, depicted in the lower right graph. The portfolio chosen by banks yields a lower degree of consumption risk sharing and higher consumption volatility and can therefore be considered as a suboptimal portfolio from the viewpoint of the household.

It is a well-known puzzle in international financial macroeconomics, that theoretical models predict a much higher optimal foreign equity share than can be found in the data and – connected to this – that actual international risk sharing is relatively low given a high level of international financial market integration. The results provided in this section suggest that one possible explanation is that in most theoretical models households chose the portfolio which provides the best hedging for income risk, while in the real world, the largest part of portfolio holdings is intermediated by funds, whose objectives most likely differ from those of households (Coeurdacier and Rey, 2013).

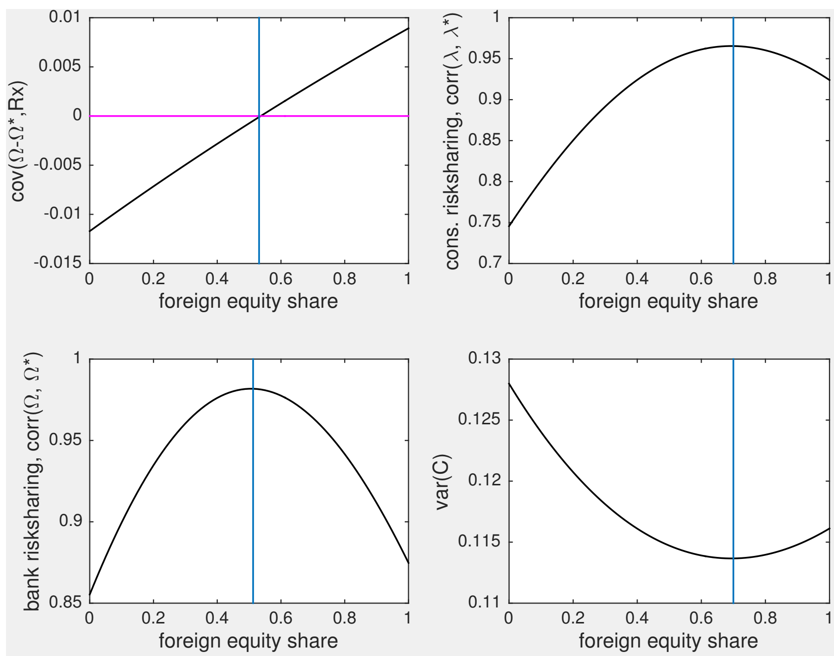

Figure 1: *Some second order properties of the model*

4.2 Impulse response analyses

The purpose of this section is to illustrate and explain the impulse responses of home and foreign variables to a capital quality shock in the home economy for different degrees of financial market integration. As already mentioned in the introduction, international comovement of GDP (and labor) depends very much on the share of foreign assets in banks' portfolios: a higher share turns around the sign of the correlation of home and foreign output from negative to positive after a capital quality shock. This result differs very much from the results of previous contributions which analyzed the implications of technology shocks and net worth shocks for international comovement using similar models (Dedola and Lombardo, 2012; Yao, 2012). Therefore, I will also briefly discuss the impulse responses to technology and net worth shocks, concentrating on the differences between the three shocks.

The technology shock is a negative five percent innovation in home TFP, the net worth shock is a five percent decline in banks' net wealth and the capital quality shock is a five percent decline in the capital stock. All shocks trigger the well-known balance sheet mechanism also known as financial accelerator mechanism: The worsening of economic conditions squeezes banks' balance sheets which increases leverage and forces banks to sell of some of their assets to meet balance sheet constraints. This firesale of assets puts further downward pressure on asset prices and (further) reduces investment, aggravating initial effects of the shock. This is what we *qualitatively* observe in the impulse responses of the home economy for all three types of shocks.

The impulse responses to the *net worth shock* and the *technology shock* can be found in the appendix. The solid blue line and the dashed black line display the impulse responses under financial market integration. The solid blue line gives the impulse responses under full home bias, i.e., $\alpha^P = 0$ and the dashed black line depicts the impulse responses under optimal diversification, i.e., $\alpha^P = 0.54$. My results resemble those of previous contributions in so far that the degree of exposure matters very little for the international transmission of these shocks. The reason is that financial contagion arises through price equalization which takes place regardless of the portfolio composition. Consider the balance sheet of a foreign bank under financial market integration illustrated in figure 3. Given a technology or net worth shock in the home economy, the foreign bank is initially only affected by a decrease in asset prices (Q_t, Q_t^*). As the impulse responses show, home and foreign asset prices are equalized. Hence, the balance sheet of the foreign bank is affected regardless of the share of claims on foreign firms, $S^*_{F,t}$, and claims on home firms, $S^*_{H,t}$, in the balance sheet.

The dotted red line represents the impulse responses under financial autarky, i.e., banks only operate nationally. Note that under this regime, the home net worth shock has only a very small effect on the foreign economy. The reason

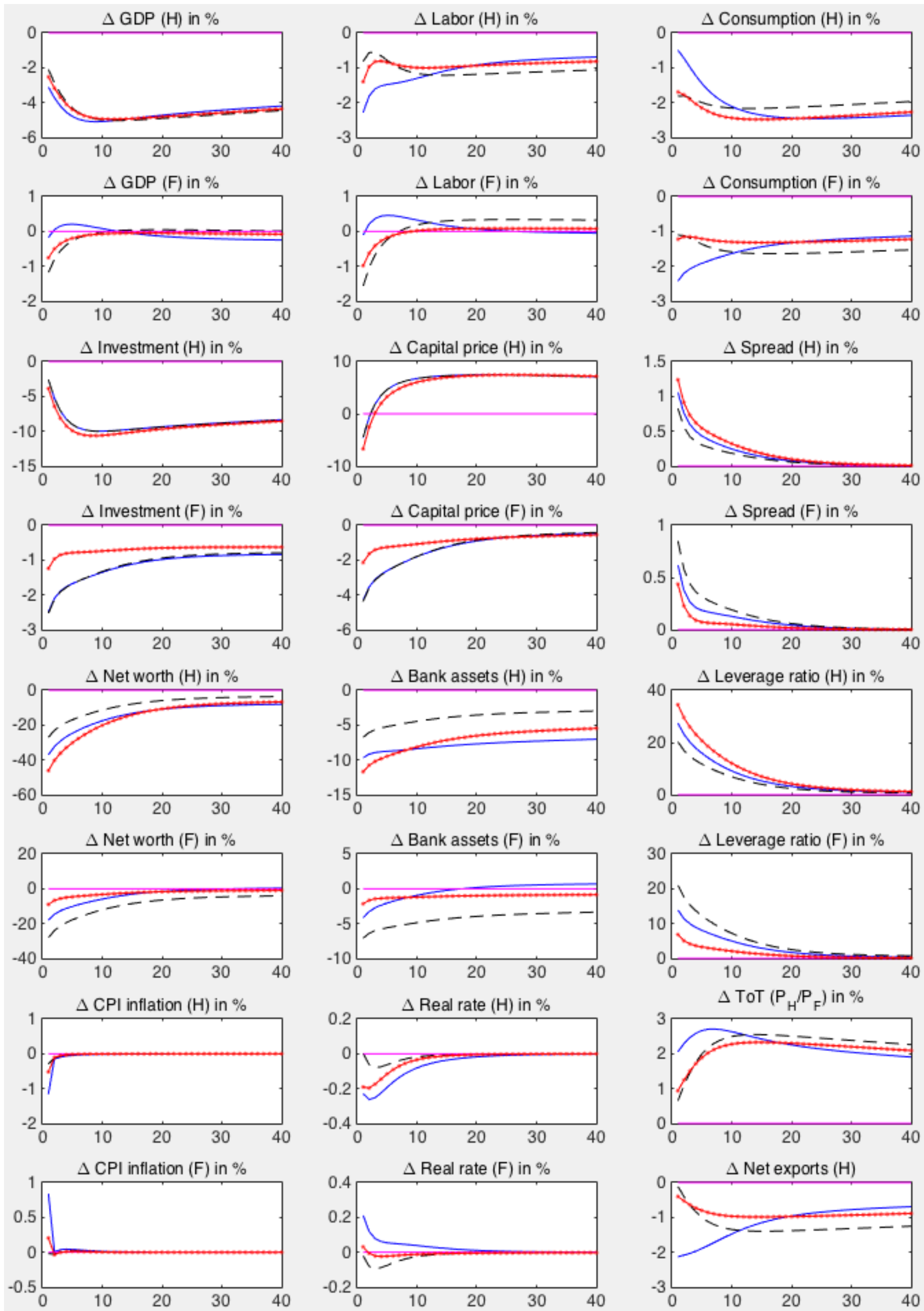

Figure 2: *Impulse responses to a -5% home capital quality shock* (dotted red line: fi. market autarky; solid blue line: full home bias, i.e., $\alpha^P = 0$; dashed black line: optimal portfolio, i.e., $\alpha^P = 0.54$)

is that it does not have a direct impact on production but only affects the real economy via banks' balance sheets. Therefore, the repercussions in the home real economy are very small. Given that under financial market autarky, all international spillover effects happen via the trade sector, the home net worth shock barely affects the foreign real economy. On the other hand, for the technology shock, the impulse responses under financial autarky closely resemble those under integration. The reason is that of all three shocks, the technology shock has the largest direct impact on (home) production, as can be easily seen from the production function. Since the model does not feature home bias in consumption, foreign consumption is negatively affected by the drop in home final goods supply and an increase in consumer prices. Foreign production then suffers from a decrease in total demand and enters a small recession.

Figure 2 shows the impulse responses to a *capital quality shock* in the home country. The response of the foreign economy to a negative home capital quality shock largely depends on the degree of international integration. Recall that the dotted red line represents the impulse responses under financial autarky, i.e., banks only operate nationally. Due to trade integration, the foreign real economy suffers from a decrease in total demand and shows signs of a mild recession. This decline in economic activity then feeds over to the foreign banking sector, triggering the financial accelerator mechanism, however, on a much smaller scale than in the home economy. Compared to the technology shock, the repercussions in the foreign economy under financial autarky are smaller because the initial effects on of this shock on production and demand are smaller.

The solid blue line and the dashed black line display the impulse responses under financial market integration. It can be seen very clearly, that in these setups the shock additionally transmits from the home to the foreign economy via the banking sector: already in the initial period, foreign banks' balance sheets are contracted and investment and asset prices fall. The size of the effects on the foreign banking system depend very much on the share of home assets in foreign banks' portfolios, α^P. The effects on the real economy differ even *qualitatively*: under full home bias ($\alpha^P = 0$), the adverse shock in the home country actually triggers a small boom in the foreign economy, while under optimal diversification ($\alpha^P = 0.54$) the recession is partly synchronized.

The reason for the different transmission of the same shock is that under optimal diversification, foreign banks are affected through a direct devaluation of some of their assets, in particular through a direct devaluation of $S^*_{H,t}$, and through price equalization, while under full home bias only the latter channel plays a role. The price equalization channel works through an equalization of expected returns on capital due to arbitrage. The equalization of returns induces capital prices to develop into similar directions. Furthermore, most of the variation in credit spreads is driven by fluctuations in the expected return to capital, hence, credit spreads develop similarly. Price equalization attenuates the effects of the shock in the home economy while it is a channel of financial contagion for the foreign economy. If only the price equalization effect is at work, which is the case for $\alpha^P = 0$, the foreign economy initially even profits from the shock in the home country. The reason is that it can increase exports to the home economy where demand did not drop as much as under financial autarky because there the financial accelerator was attenuated. If banks hold diversified portfolios, i.e., $\alpha^P = 0.54$, foreign banks are directly affected by the home shock to a similar extend as home banks. This sets of a powerful balance sheet mechanism in the foreign economy. As can be seen in figure 2, the initial increase in leverage ratios and spreads is of similar size in the two countries.

assets	liabilities
$Q_t S^*_{H,t}$	N^*_t
$Q^*_t S^*_{F,t}$	D^*_t

Figure 3: *Foreign bank's balance sheet under financial market integration*

4.3 Welfare analysis

International financial integration helps to ensure against country-specific risks, however, cross-border portfolio holdings also expose the domestic economy to foreign crisis, leading to a high co-movement of real and financial variables. This trade-off inherent in financial market integration had motivated various authors to conduct welfare analysis. Building on a two-country model with financial frictions and endogenous portfolio choice, Devereux and Sutherland (2011) have shown that international financial integration in bond and equity markets is welfare improving despite the fact that it generates high positive co-movement across countries, compared to a setting in which only bond markets are integrated and compared to a regime of financial autarky. Welfare under financial market integration is calculated for optimal portfolio choice only.

In the last section, I showed that conditional on a capital quality shock, balance sheet exposure matters for international comovement. In particular, we can observe 'financial contagion' – the international comovement of real and financial variables after country-specific shocks, made possible by financial interlinkages – if banks hold a large share of foreign assets in their portfolio, whereas the foreign economy does not enter a recession after a home capital quality shock under full home bias. This raises the question whether, given financial market integration, the degree of balance sheet exposure also matters for welfare. I will try to answer this question by calculating welfare for the same three settings I provided impulse responses for: financial autarky, financial market integration and full home bias, i.e., $\alpha^P = 0$ and financial market integration and an optimally chosen portfolio, $\alpha^P = 0.54$.

I evaluate welfare by computing the unconditional expected lifetime utility under each financial market setting, using the same approach as Devereux and Sutherland (2011). Steady state welfare is given by

$$\overline{W} = \frac{U(\overline{C},\overline{L})}{1-\beta(\overline{C})} = \frac{\log(\overline{C}) - \chi\frac{\overline{L}^{1+\phi}}{1+\phi}}{1-\omega(1+\overline{C})^{-\eta}}.$$

Then, unconditional expected lifetime utility, defined as W, is calculated using a second-order approximation to the model, for each setting. The benefit or loss of a particular financial market setting is calculated as the permanent change in steady state consumption, necessary to make agents in the non-stochastic steady state as well off as those in the stochastic economy. I define the necessary permanent change in steady state consumption as g. A positive value of g means that agents in the stochastic setting are better of, whereas a negative value implies that agents in the non-stochastic setting have a higher welfare. The particular value for g is found by solving the following equation:

$$W = \frac{\log((1+g)\overline{C}) - \chi\frac{\overline{L}^{1+\phi}}{1+\phi}}{1-\omega(1+(1+g)\overline{C})^{-\eta}}.$$

Table 2 displays the results for the three different financial market setting. The first part reports the values for the model from the previous sections which features capital quality, TFP, net worth and monetary policy shocks. First of all, the results are in line with the results from Devereux and Sutherland (2011) although my model does not feature bond market integration: if agents are allowed to hold the optimal portfolio, they are better off under financial market integration than under financial autarky. In particular, with integrated financial markets, a 0.66% increase in steady state consumption would be necessary to make agents in the non-stochastic steady state as well off as in the stochastic environment, while under autarky, a 1.43% decrease in permanent consumption would make agents as bad off as in the stochastic regime. As expected, financial market integration increases risksharing. However, it additionally lowers consumption volatility despite being exposed to foreign crisis.

	g (in %)	var(C)	cons. risksharing
1. Benchmark model			
autarky	-1.43	0.1205	0.85
full home bias	-1.82	0.1280	0.75
optimal portfolio	0.66	0.1144	0.95
2. Model without capital quality shocks			
autarky	1.86	0.0173	0.85
full home bias	0.97	0.0173	0.84
optimal portfolio	1.03	0.0171	0.87
3. Model without technology shocks			
autarky	-1.43	0.1205	0.85
full home bias	-1.82	0.1280	0.75
optimal portfolio	0.66	0.1144	0.95

Table 2: *Welfare evaluation*

When we now consider the setting in which financial markets are integrated but portfolios feature full home bias, we see that welfare is even smaller than under autarky. The reason is that price equalization introduces the economy to additional volatility, but there are not any international asset holdings which provide for a better sharing of country-specific consumption risk.

The second and third part of the table show the results for an economy in which either the capital quality shock or the technology shock are turned off. Note that turning off the technology shock does not change the welfare evaluation compared to the benchmark model. That shows, that the welfare effects of the capital quality shock dominate the results. Recall that after a technology shock, balance sheet exposure had only a very small significance for the international transmission of the shock. The second part of the table reflects this result: full home bias and an optimal portfolio yield almost the same welfare. Interestingly, in a version of my model without capital quality shocks, financial autarky is welfare superior to financial market integration, even though risksharing is higher and consumption volatility lower under integration and optimal portfolio choice. It can only be conjectured that the effects of financial market integration on labor lead to this result. However, explaining this finding is beyond the scope of this paper.

5 Conclusion

This paper has shown that in a model featuring leverage constrained intermediaries and international financial markets, balance sheet exposure has an important impact on international business cycle synchronization after capital quality shocks. In fact, moving from a setting with negligibly low cross-border equity holdings to a model with completely diversified portfolios changes the sign of business cycle correlations from negative to positive. This contradicts the results of Dedola and Lombardo (2012), who find that it is price equalization rather than balance sheet exposure which leads to international comovement.

By estimating closed economy DSGE models, various authors have recently shown that capital quality shocks are the "key drivers of business cycle fluctuations" (Justiniano et al., 2011; Liu et al., 2011; Sanjani, 2014, p.23). It is an interesting route to take for further empirical research to find out which shocks are the most important drivers of international business cycles. Finding an answer to this question could then also help to gain more insights into the question which role price equalization and balance sheet exposure have played during the 'Great Recession'. At this point, I can only conclude that the role played by price equalization compared to balance sheet exposure in the cross-country transmission of shocks via financial markets depends on the type of shock we consider.

The welfare analysis in section 4.3 supported the result that the type of shock considered matters for the transmission of shocks via financial markets and the role of balance sheet exposure and price equalization therein. Furthermore, the analysis has shown that given financial market integration, a situation in which agents hold less foreign equity shares than optimal can entail welfare losses, also compared to a setting in which financial markets are closed. A possible implication of this finding is that barriers in international financial markets which deter agents from diversifying optimally can be welfare-reducing.

A unique feature of the model developed in this paper, is that the portfolio choice decision is undertaken by financial intermediaries, not by households. The analysis conducted in section 4.1 provided evidence that this is relevant for international portfolio choice. This feature definitely deserves further attention, as it might help reconciling theory with empirical evidence on home bias in international portfolio holdings and low consumption risk sharing.

Appendix

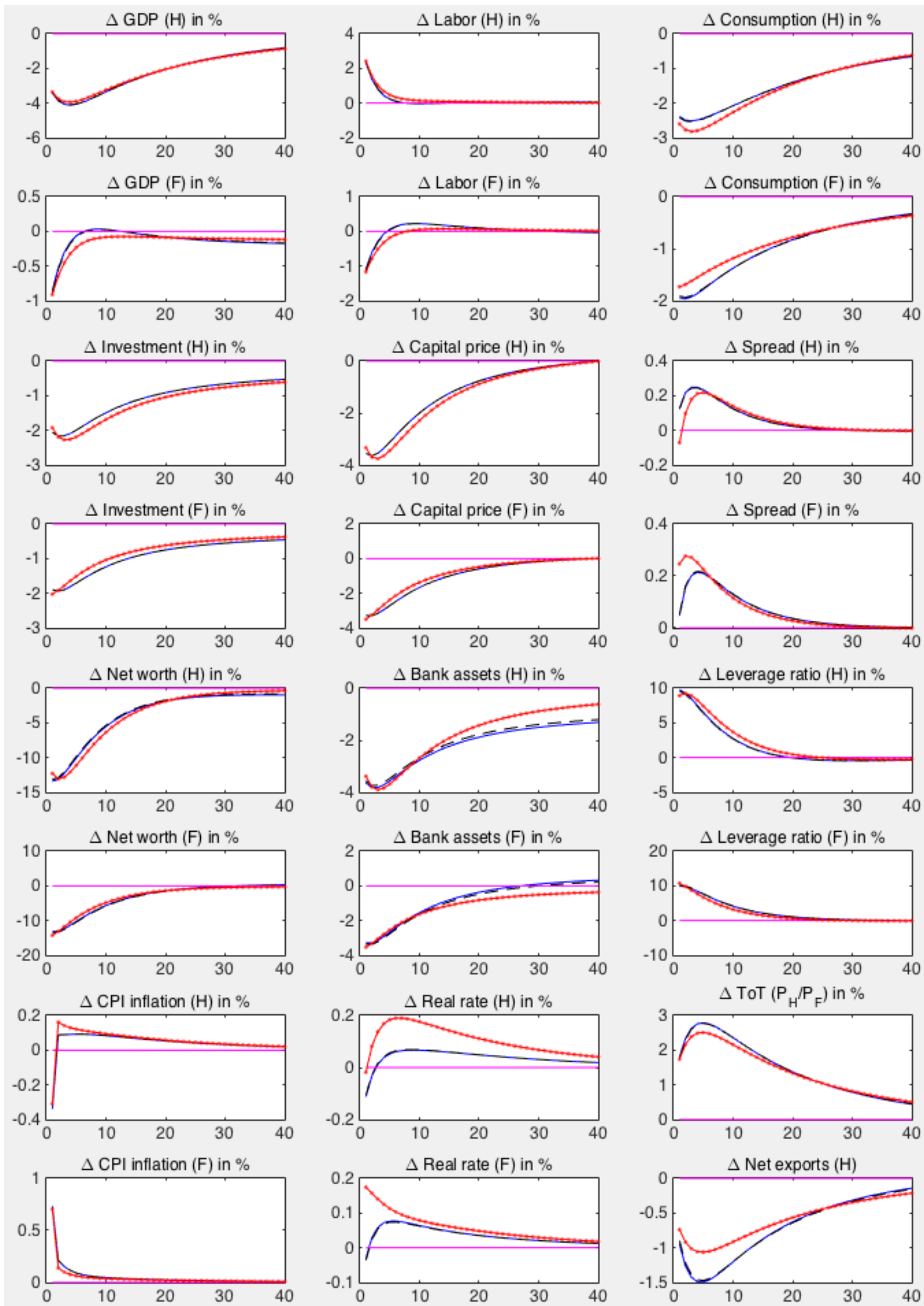

Figure 4: *Impulse responses to a -5% home technology shock* (dotted red line: fi. market autarky; solid blue line: full home bias, i.e., $\alpha^P = 0$; dashed black line: optimal portfolio, i.e., $\alpha^P = 0.54$)

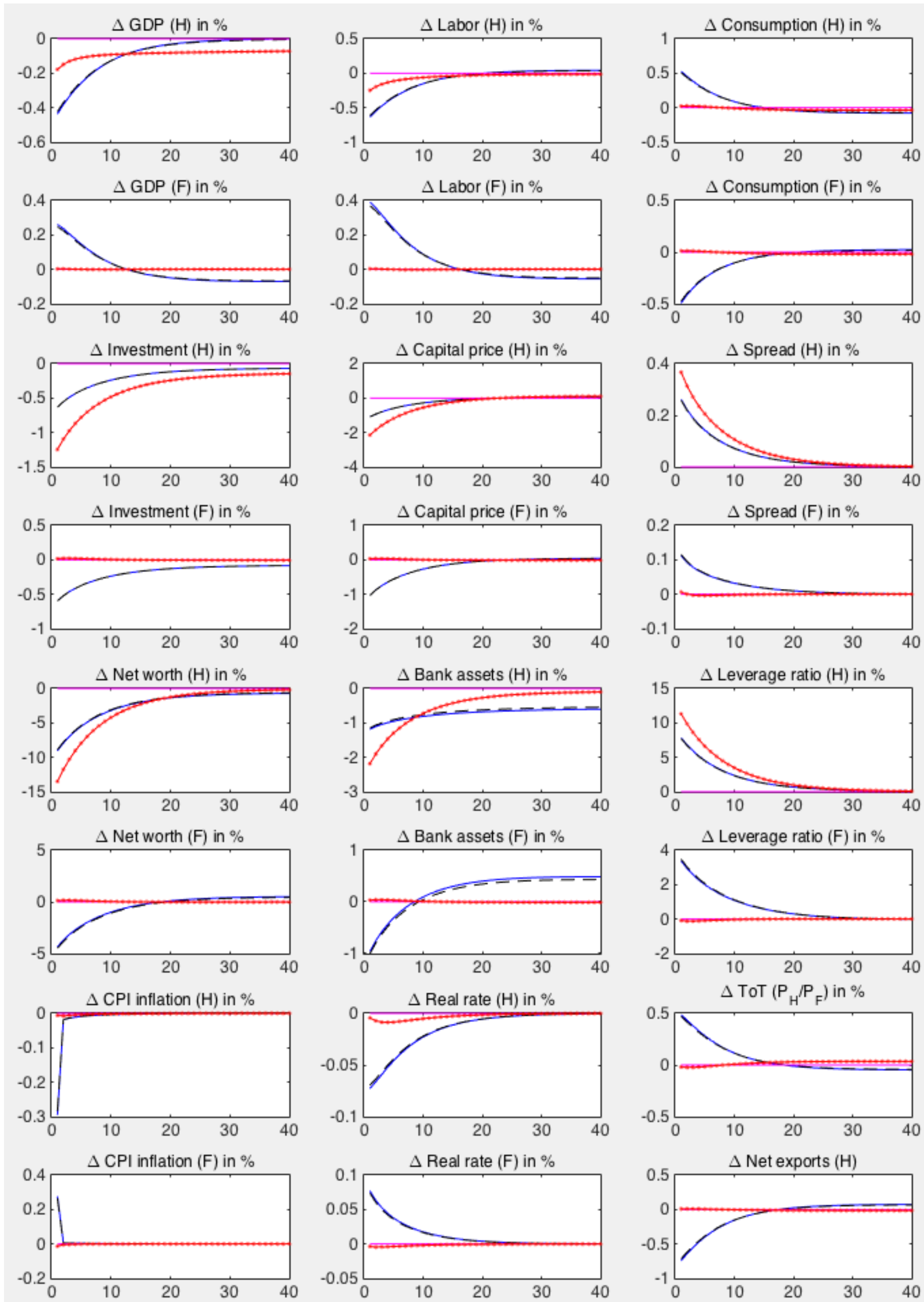

Figure 5: *Impulse responses to a -5% home net wealth shock* (dotted red line: fi. market autarky; solid blue line: full home bias, i.e., $\alpha^P = 0$; dashed black line: optimal portfolio, i.e., $\alpha^P = 0.54$)

References

Coeurdacier, N. and Rey, H. (2013). Home bias in open economy financial macroeconomics. *Journal of Economic Literature*, 51:63–115. 4, 17, 18, 19

de Walque, G., Smets, F., and Wouters, R. (2006). An estimated two-country DSGE model for the Euro area and the US economy. Working paper presented at the 7th EABCN Workshop (Zurich, August 2006), Swiss National Bank. 17

Dedola, L., Karadi, P., and Lombardo, G. (2013). Global implications of national unconventional policies. *Journal of Monetary Economics*, 60:66–85. 2, 3, 11, 17, 18

Dedola, L. and Lombardo, G. (2012). Financial frictions, financial integration and the international propagation of shocks. *Economic Policy*, 27(70):319–359. 2, 4, 18, 20, 26

Devereux, M. B., Senay, O., and Sutherland, A. (2014). Nominal stability and financial globalization. *Journal of Money, Credit and Banking*, 46:921–959. 4, 13

Devereux, M. B. and Sutherland, A. (2008). Country portfolios in open economy macro models. Working Paper Series 14372, NBER. 2, 3, 15, 18

Devereux, M. B. and Sutherland, A. (2009). A portfolio model of capital flows to emerging markets. *Journal of Development Economics*, 89:181–193. 17

Devereux, M. B. and Sutherland, A. (2011). Evaluating international financial integration under leverage constraints. *European Economic Review*, 55(3):427 – 442. 3, 4, 23, 24

Devereux, M. B. and Yetman, J. (2010). Leverage constraints and the international transmission of shocks. *Journal of Money, Credit and Banking*, 42:71–105. 6, 18

Devereux, M. B. and Yu, C. (2015). International financial integration and crisis contagion. Seminar series, National University of Singapore, Department of Economics. 1

Evans, M. D. and Hnatkovska, V. (2005). International capital flows, returns and world financial integration. Working Paper 11701, NBER. 3

Furlanetto, F. and Seneca, M. (2014). New perspectives on depreciation shocks as a source of business cycle fluctuations. *Macroeconomic Dynamics*, 18:1209–1233. 2

Gertler, M. and Karadi, P. (2011). A model of unconventional monetary policy. *Journal of Monetary Economics*, 58:17–34. 2, 4, 5, 10, 16, 17

Justiniano, A., Primiceri, G. E., and Tambalotti, A. (2011). Investment shocks and the relative price of investment. *Review of Economic Dynamics*, 14(1):102 – 121. Special issue: Sources of Business Cycles. 2, 26

Kamin, S. B. and DeMarco, L. P. (2010). How did a domestic housing slump turn into a global financial crisis? International Finance Discussion Papers 994, Board of Governors of the Federal Reserve System. 1

Krugman, P. (2008). *The international finance multiplier.* NY Times Blog. 1

Lane, P. R. and Milesi-Ferretti, G. M. (2007). The external wealth of nations mark II: Revised and extended estimates of foreign assets and liabilities. *Journal of International Economics*, 73:223–250. 1

Liu, Z., Waggoner, D. F., and Zha, T. (2011). Sources of macroeconomic fluctuations: A regime-switching DSGE approach. *Quantitative Economics*, 2(2):251–301. 2, 26

Lombardo, G. and Sutherland, A. (2007). Computing second-order-accurate solutions for rational expectation models using linear solution methods. *Journal of Economic Dynamics and Control*, 31(2):515 – 530. 15

Nuntramas, P. (2011). Revisiting the consumption-real exchange rate anomaly in a model with non-traded goods. *Journal of International Money and Finance*, 30:428–447. 18

Rose, A. K. and Spiegel, M. M. (2010). Cross-country causes and consequences of the 2008 crisis: International linkages and American exposure. *Pacific Economic Review*, 15(3):340–363. 1

Sanjani, M. T. (2014). Financial frictions and sources of business cycle. Working Paper 14/194, IMF. 2, 26

Schmitt-Grohé, S. and Uribe, M. (2003). Closing small open economy models. *Journal of International Economics*, 61:163–185. 6

Tille, C. and van Wincoop, E. (2010). Internation capital flows. *Journal of International Economics*, 80:157–175. 3

Yao, W. (2012). International business cycles and financial frictions. Technical report, Bank of Canada. 2, 18, 20