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Bilateral Trade, Openness and Asset Holdings

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This paper analyzes the relationship between bilateral trade flows, trade openness, and asset holdings in a three-country stochastic general equilibrium model. The three-country model set-up enables me to disentangle and separate the effects bilateral trade flows and trade openness have on bilateral portfolio patterns. I find that both factors independently influence bilateral asset holdings. Higher bilateral trade as well as higher trade openness lead to a higher bilateral foreign asset position. Furthermore, the two factors show an interaction effect, where increasing trade openness diminishes the influence of bilateral trade flows on asset holdings. I provide supporting empirical evidence for these theoretical findings using a data set on the geographical composition of international portfolio holdings.

JEL-Classification: F10, F30, F41
Keywords: International Portfolio Holdings, Bilateral Trade Flows, Trade Openness.

1. Introduction

In recent years, cross-border asset holdings have risen strongly. But despite increasing international financial integration, equity and bond holdings still differ widely across countries. This stands in contrast to economic theory which predicts that in a fully integrated frictionless world cross-border portfolios should be identical across countries,[1] leading to the question which factors determine the size and geographical composition of these varying portfolios. The factors can be grouped along two lines, size of foreign asset position and geographical composition, and have been studied extensively in the literature. The size of the foreign asset position is determined, inter alia, by trade openness. Countries that are more open to trade, measured as total exports plus imports, hold larger foreign asset positions (see, e.g., Lane, 2000; Heathcote and Perri, 2009; Aizenman and Noy, 2009).[2] On

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[1]See, e.g., Lucas (1982).

[2]Other factors that influence the aggregate foreign asset position are economic size and financial development (see Lane, 2000; Lane and Milesi-Ferretti, 2004; Heathcote and Perri, 2009).

the other hand, bilateral trade is one of the factors that govern the geographical composition of the foreign asset position.[3] Both Lane and Milesi-Ferretti (2008) and Aviat and Coeurdacier (2007) report that bilateral trade flows have a positive impact on bilateral asset holdings. However, these studies have either focused solely on trade openness and the size of foreign asset positions or on bilateral trade patterns and the composition of foreign asset positions, but have not looked at the combination of both.

In this paper, I take up this issue and analyze the relationship between bilateral trade, trade openness and asset holdings theoretically, using a three-country model, as well as empirically, providing evidence for the influence of both bilateral trade and trade openness on bilateral asset holdings. To study the effects of trade openness and bilateral trade flows in a unified framework, I build a three-country/three-good general equilibrium model consisting of simple endowment economies with home bias in consumption due to households preferring the home good over foreign goods.[4] The switch to a three-country model is crucial as bilateral trade flows and openness are inseparably intertwined in the two-country case. Higher openness can only be achieved by higher bilateral trade as there are no other trading partners. Conversely, increasing the bilateral trade between the two countries inevitably raises their trade openness. Hence, it is impossible to analyze the individual effects of bilateral and total trade on the foreign portfolio share. This has the consequence that in a two-country set-up the focus has to be either on the effect of trade openness or the effect of bilateral trade. In contrast, with three countries both effects can be studied in a unified framework. I can vary bilateral trade flows while holding the openness of a country constant. That way it is possible to distinguish explicitly between the influence of bilateral trade flows and the influence of openness on the geographical composition of the foreign asset position. In addition, I can identify possible interaction effects between bilateral trade and trade openness.

In order to keep the theoretical model simple and tractable, I follow Lucas (1982), Obstfeld and Rogoff (2001), Kollmann (2006), and Heathcote and Perri (2009) in assuming complete financial markets and full risk-sharing. That way it is possible to first characterize the optimal social planner consumption allocation and then identify the asset allocation that replicates this optimal consumption allocation in a decentralized setting, where only a restricted set of assets is available.

First, my results show that bilateral trade and trade openness both have independent effects on bilateral asset holdings. Holding either one constant, while varying the other one, gives a distinct pattern for the bilateral foreign asset position. The sign of the effect of bilateral trade flows, but also of trade openness, depends on the elasticity of substitution between consumption goods. The elasticity of substitution in combination with the trade pattern drives the responses of international relative prices to endowment shocks and, through this, determines the portfolio allocation. For relatively small values of the elasticity of substitution, higher trade flows between two countries lead, ceteris paribus, to higher asset holdings between these two countries. For higher values of the elasticity of substitution, the opposite pattern emerges: higher trade flows lead to smaller asset holdings of the trade partner's stock. Kollmann (2006) also found the importance of the elasticity

[3] Other factors are, e.g., informational and cultural linkages.

[4] Home bias in consumption is commonly used in the vast literature analyzing portfolio home bias. Consumption home bias is either introduced through preferences (see, e.g., Kollmann, 2006; Coeurdacier, Kollmann, and Martin, 2007) or through trade costs (see, e.g., Obstfeld and Rogoff, 2001; Coeurdacier, 2009).

of substitution in his two-country model. But in using a three-country set-up, I am able to show that bilateral trade flows have an independent effect even when holding openness constant.

Second, my results indicate that, ceteris paribus, bilateral investment positions are larger for higher degrees of openness. In this case, stronger terms-of-trade reactions in response to endowment shocks lead to higher asset holdings through the effects the terms-of-trade have on consumption expenditures. This particular feature of the model emerges for parameter constellations where home and foreign goods are complements.

Third, I find a small interaction effect between bilateral trade and openness. Comparing the influence of bilateral trade flows on asset holdings for different values of openness shows that the effect of bilateral trade flows on equity holdings is smaller for higher trade openness. Intuitively, equity shares of the trading partner are less important for risk sharing if there is a lot of trade with other countries.

Furthermore, I provide empirical evidence that both bilateral trade flows as well as total trade flows influence bilateral asset holdings positively and significantly. For this purpose, I employ a gravity model to estimate the influence of bilateral trade and trade openness on bilateral asset holdings.[5] The basis for this analysis is the Coordinated Portfolio Investment Survey (CPIS) of the International Monetary Fund (IMF) which provides the geographical composition of security investments of up to 74 source countries.[6] I include both bilateral and total trade flows in my analysis of bilateral investment patterns. While bilateral trade flows have been found to be a major determinant of bilateral cross-border asset holdings,[7] total trade flows as a measure for trade openness have only been used to explain aggregate foreign asset positions.

The rest of the paper is organized as follows: Section 2 presents the three-country stochastic general equilibrium model and its solution. In section 3, the resulting optimal portfolios for differing trade patterns are analyzed. Section 4 covers the empirical analysis of bilateral asset holdings, while section 5 concludes.

2. A Three-Country Model

2.1. Model Set-Up

I use a two-period variant of the model by Kollmann (2006) and extend it to a three-country set-up. The three countries are indexed by $i = 1, 2, 3$ and each is exogenously endowed with a distinct national good, Y_i. The economies are linked internationally by trade in goods and equities and exist for two periods ($t = 0, 1$).[8] In the first period ($t = 0$), only equity shares, which are claims to the future endowment of a particular country, are traded. In period $t = 1$, the endowment process is realized and the representative household trades goods, settles the equity claims, and

[5] Gravity models are traditionally used in the international trade literature, but are now also widely used to explain international investment patterns of equity holdings (e.g., Portes and Rey, 2005; Aviat and Coeurdacier, 2007; Sarisoy Guerin, 2006; Lane and Milesi-Ferretti, 2008), bank lending (e.g., Rose and Spiegel, 2004) and foreign direct investment (FDI) (e.g., Mody, Razin, and Sadka, 2002).

[6] Source country residents hold security investments, which are issued by destination country residents, and report these holdings in the CPIS.

[7] See Aviat and Coeurdacier (2007); Lane and Milesi-Ferretti (2008).

[8] Variables without a time subscript correspond to period $t = 1$.

consumes. The only source of uncertainty in this model is the stochastic endowment process. I assume $\mathrm{E}_0[Y_i] = 1$, for $i = 1, 2, 3$, where E_0 is the conditional expectation operator given information at date $t = 0$.

2.1.1. Preferences

Each country i is inhabited by a representative household, who has the following utility function

$$U(C^i) = \mathrm{E}_0 \left[\frac{(C^i)^{1-\rho} - 1}{1-\rho} \right], \quad \rho > 0, \tag{1}$$

where ρ represents the relative risk aversion parameter and C^i is the aggregate consumption index:

$$C^i = \left[(\alpha_1^i)^{\frac{1}{\theta}} (c_1^i)^{\frac{\theta-1}{\theta}} + (\alpha_2^i)^{\frac{1}{\theta}} (c_2^i)^{\frac{\theta-1}{\theta}} + (\alpha_3^i)^{\frac{1}{\theta}} (c_3^i)^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}} \quad \text{for } i = 1, 2, 3. \tag{2}$$

Here, c_j^i denotes consumption in country i of good j and α_j^i is the corresponding weight parameter for that particular good. Note that $\sum_{j=1}^{3} \alpha_j^i = 1$ and a preference for the home good in country i that is $\frac{1}{3} < \alpha_i^i \leq 1$ corresponds to consumption home bias in country i. The elasticity of substitution between any two goods is θ.[9]

Introducing p_j as the price of good j and normalizing p_1 to unity, the consumption based price index for country i is

$$P_i = \left(\alpha_1^i + \alpha_2^i (p_2)^{1-\theta} + \alpha_3^i (p_3)^{1-\theta} \right)^{\frac{1}{1-\theta}} \quad \text{for } i = 1, 2, 3. \tag{3}$$

Since p_1 is normalized to unity, the prices p_2 and p_3 can be interpreted as the terms-of-trade of country 1 vis-à-vis countries 2 and 3, respectively. The real-exchange rate between country i and j, $RER_{ij} = \frac{P_j}{P_i}$, is the price of country j consumption relative to country i consumption.

2.1.2. Financial Markets

There is international trade in equity shares, S_j^i, which are claims of country i to a fraction of the future endowment of country j. Each share of stock j entitles the owner to a dividend payment. The size of this payment is determined by the value of country j's endowment, $p_j Y_j$.

The supply of equity shares is normalized to unity such that market clearing in the asset market requires

$$S_j^1 + S_j^2 + S_j^3 = 1 \quad \text{for } j = 1, 2, 3. \tag{4}$$

At the beginning of period 0, country i has zero foreign assets, $S_{j,0}^i = 0$ $(i \neq j)$, and holds all local shares, $S_{i,0}^i = 1$. With $q_{j,0}$ being the price of stock j in period 0, the budget constraint of country i for period 0 takes the following form:

$$q_{1,0} S_1^i + q_{2,0} S_2^i + q_{3,0} S_3^i = q_{i,0} \quad \text{for } i = 1, 2, 3. \tag{5}$$

[9] Assuming $\theta = 1$, aggregate consumption is of Cobb-Douglas type and α_j^i represents the expenditure share spent for consumption of good j in country i.

In the rest of the paper, the portfolio of country i will be the triple (S_1^i, S_2^i, S_3^i).

2.1.3. Household Maximization

In period 1, after uncertainty has been realized and dividends have been distributed, the representative household in country i decides on consumption, c_j^i, taking as given his portfolio of equity shares. The budget constraint for period 1 is

$$c_1^i + p_2 c_2^i + p_3 c_3^i = S_1^i Y_1 + S_2^i p_2 Y_2 + S_3^i p_3 Y_3 \quad \text{for } i = 1, 2, 3, \tag{6}$$

i.e., consumption expenditures equal portfolio income. Maximizing the utility of country i's representative household, equation (1), subject to the budget constraint for period 1 yields the following first-order conditions for consumption:

$$\left(C^i\right)^{\frac{1-\rho\theta}{\theta}} \left(\frac{c_1^i}{\alpha_1^i}\right)^{-\frac{1}{\theta}} = \lambda^i, \tag{7}$$

$$\left(C^i\right)^{\frac{1-\rho\theta}{\theta}} \left(\frac{c_1^i}{\alpha_1^i}\right)^{-\frac{1}{\theta}} = \lambda^i p_2, \tag{8}$$

$$\left(C^i\right)^{\frac{1-\rho\theta}{\theta}} \left(\frac{c_1^i}{\alpha_1^i}\right)^{-\frac{1}{\theta}} = \lambda^i p_3, \tag{9}$$

where λ^i is the Lagrange multiplier on the period 1 budget constraint of country i. After characterizing how the household income is optimally allocated across consumption goods, the next step is to explore the income side, i.e., the equity portfolio allocation.

In period 0, no production or consumption takes place, but the representative household decides on the amount of equity shares he wants to hold. When deciding on the asset portfolio the agent takes into account his consumption plan for period 1 and that his financial income is uncertain. Let λ_0^i be the Lagrange multiplier on the budget constraint of period 0 in country i. The representative agent of country i maximizes his utility, equation (1), subject to the budget constraints for periods 0 and 1, equations (5) and (6). This gives the following first order conditions for equity shares:

$$\lambda_0^i q_{1,0} = \mathrm{E}_0 \left[\left(C^i\right)^{\frac{1-\rho\theta}{\theta}} \left(\frac{c_1^i}{\alpha_1^i}\right)^{-\frac{1}{\theta}} Y_1 \right], \tag{10}$$

$$\lambda_0^i q_{2,0} = \mathrm{E}_0 \left[\left(C^i\right)^{\frac{1-\rho\theta}{\theta}} \left(\frac{c_1^i}{\alpha_1^i}\right)^{-\frac{1}{\theta}} p_2 Y_2 \right], \tag{11}$$

$$\lambda_0^i q_{3,0} = \mathrm{E}_0 \left[\left(C^i\right)^{\frac{1-\rho\theta}{\theta}} \left(\frac{c_1^i}{\alpha_1^i}\right)^{-\frac{1}{\theta}} p_3 Y_3 \right]. \tag{12}$$

These equations show that the demand for equity shares depends on the purchase price in period 0 and the asset return in period 1.

2.1.4. Equilibrium in the decentralized economy

Having characterized the set-up of the economy and the household maximization, the next step is to define the equilibrium in the decentralized economy. The equilibrium in the decentralized economy is given by a set of quantities c_1^i, c_2^i, c_3^i, S_1^i, S_2^i, S_3^i, $i = 1, 2, 3$, and prices p_2, p_3, $q_{1,0}$, $q_{2,0}$, $q_{3,0}$, such that

1. the FOCs for consumption, equations (7)-(9),
2. the FOCs for equity shares, equations (10)-(12), and
3. the budget constraint, equation (6), hold and
4. asset markets, equation (4), and goods markets, $c_j^1 + c_j^2 + c_j^3 = Y_j$, $j = 1, 2, 3$, clear.

2.2. Equilibrium with full risk-sharing

As in Lucas (1982), Obstfeld and Rogoff (2001), Kollmann (2006) and Heathcote and Perri (2009), I focus on equilibria with full risk-sharing, i.e., Pareto efficient equilibria. Therefore, I first solve the central planner's problem to obtain the efficient consumption allocation. In a next step, I characterize the asset portfolio in a decentralized economy that supports the efficient consumption allocation. In the decentralized economy, the number of assets is restricted to three equities. Coeurdacier and Gourinchas (2009) show that such a portfolio can replicate the full risk-sharing allocation up to first order, if the number of shocks equals the number of assets and the asset pay-offs react to shocks. While the first condition is fulfilled in my model with three endowment shocks and three assets, I will later encounter some model calibrations for which the second condition is not fulfilled.

2.2.1. Efficient Consumption Allocation

The efficient allocation is attained through a social planner maximizing the sum of the countries' utility functions, where the planner problem is static since consumption only takes place in period 1:

$$\max_{\{c_j^1,\, c_j^2,\, c_j^3\}} \frac{\left(C^1\right)^{1-\rho} - 1}{1-\rho} + \frac{\left(C^2\right)^{1-\rho} - 1}{1-\rho} + \frac{\left(C^3\right)^{1-\rho} - 1}{1-\rho} \tag{13}$$

subject to the resource constraints

$$c_j^1 + c_j^2 + c_j^3 = Y_j \quad \text{for } j = 1, 2, 3, \tag{14}$$

and C^1, C^2, C^3 given by equation (2).

The first order conditions for consumption of good j ($j = 1, 2, 3$) are

$$\left(C^1\right)^{\frac{1}{\theta}-\rho} \left(\frac{c_j^1}{\alpha_j^1}\right)^{-\frac{1}{\theta}} = \left(C^2\right)^{\frac{1}{\theta}-\rho} \left(\frac{c_j^2}{\alpha_j^2}\right)^{-\frac{1}{\theta}}, \tag{15}$$

$$\left(C^1\right)^{\frac{1}{\theta}-\rho} \left(\frac{c_j^1}{\alpha_j^1}\right)^{-\frac{1}{\theta}} = \left(C^3\right)^{\frac{1}{\theta}-\rho} \left(\frac{c_j^3}{\alpha_j^3}\right)^{-\frac{1}{\theta}}. \tag{16}$$

These conditions imply that the marginal utilities from consuming good j are perfectly positively correlated across countries. From these risk-sharing conditions and the resource constraints, I can compute the efficient consumption allocation, $c_1^i,\ c_2^i,\ c_3^i$, for $i = 1, 2, 3$.

Before decentralizing the efficient consumption allocation, let us look at the properties of the consumption allocation and, in particular, its response to endowment shocks. For this purpose, it is convenient to define $\mu_j^i \equiv c_j^i / Y_j$ as the efficient share of good j that is consumed by the representative agent of country i. The response of this efficient consumption share to an endowment shock shows whether consumption changes proportionally to an endowment shock or not. The reaction depends on the relationship between the elasticity of substitution, θ, and the risk aversion parameter, ρ.[10]

Case 1: $\frac{1}{\rho} = \theta$

If $\frac{1}{\rho} = \theta$, the utility function is additively separable in the three goods. The risk-sharing conditions then imply that marginal utilities of good j are perfectly correlated across all countries, if consumption of good j changes by the same amount in all countries. Linearizing the risk-sharing conditions shows this: $\hat{c}_j^1 = \hat{c}_j^2$ and $\hat{c}_j^1 = \hat{c}_j^3$ (see Appendix A). Efficient risk-sharing thus prescribes, that, after an increase of the endowment of good j, consumption of good j increases proportional to the endowment shock in all three countries. Consumption of the other two goods remains unchanged in all countries. Thus, all consumption shares remain unaltered after an endowment shock.

Case 2: $\frac{1}{\rho} \lesseqgtr \theta$

If $\frac{1}{\rho} \neq \theta$, the response of consumption shares depends on the relation $\frac{1}{\rho} \lesseqgtr \theta$, which determines whether the goods are complements or substitutes (see Kollmann, 2006).

Assume $\frac{1}{\rho} > \theta$. In this parameter region the three goods are complements, as a higher consumption of one good increases the marginal utilities of the other goods. Full risk-sharing prescribes that marginal utilities should equalize across countries after a shock. However, if, after a positive endowment shock to good 1, agents in all countries increase consumption of good 1 proportional to the endowment shock and leave consumption of the other two goods unchanged, marginal utilities from consuming any good do not equalize. Marginal utility from consuming good 1 falls less in country 1 than in country 2 or 3 because marginal utility increases with aggregate consumption. Aggregate consumption in turn rises more in country 1 than in the other ones. On the other hand, marginal utility from consuming good 2 or 3 increases more in country 1 than in the other two countries. Hence, for marginal utilities to equalize, consumption of good 1 in country 1 has to rise more than the endowment shock, while consumption of good 1 in the other countries has to rise less than the endowment shock. Furthermore, consumption of goods 2 and 3 must increase in country 1, while it falls in country 2 and 3.

To summarize, consumption shares of a country increase for a positive endowment shock in the same country, while they fall for a positive endowment shock in one of the other countries. Due to

[10] In a dynamic model the risk aversion parameter, ρ, is related to the intertemporal elasticity of substitution, σ, in the following way: $\sigma = \frac{1}{\rho}$. However, in this model consumption takes place only in period 1.

complementarities and home bias, the country experiencing the positive endowment shock has to consume proportionally more of all goods.

For $\frac{1}{\rho} < \theta$, consumption shares react the opposite way. A country's consumption shares fall for a positive endowment shock to its own good, while they increase for an endowment shock to one of the other goods.

Note the important role of home bias. Without the assumption of home bias in consumption, but with identical preferences for all three goods, consumption shares would be constant no matter what the relationship between $\frac{1}{\rho}$ and θ is.

2.2.2. Decentralizing the Efficient Allocation

Having computed the efficient consumption allocation from the social planner solution, I can now identify the portfolio allocation that supports this efficient consumption allocation. To this end, I have to find a set of prices and portfolios, p_2, p_3, S_1^i, S_2^i, S_3^i, for $i = 1, 2, 3$, that together with the efficient allocation, c_1^i, c_2^i, c_3^i, for $i = 1, 2, 3$, constitutes an equilibrium.

Substituting the efficient consumption allocation into the first order conditions for consumption, equations (7)-(9), yields the relative prices p_2 and p_3 that pertain to the efficient consumption allocation:

$$p_2 = \left(\frac{\alpha_1^i}{\alpha_2^i} \frac{c_2^i}{c_1^i} \right)^{-\frac{1}{\theta}}, \tag{17}$$

$$p_3 = \left(\frac{\alpha_1^i}{\alpha_3^i} \frac{c_3^i}{c_1^i} \right)^{-\frac{1}{\theta}} \qquad \text{for } i = 1, 2, 3. \tag{18}$$

The next step is to find the portfolio allocation, S_1^i, S_2^i, S_3^i, for $i = 1, 2, 3$, that supports the efficient allocation. Since the budget constraint for each country has to hold for the portfolio allocation, I can use these constraints to compute the optimal equity shares. However, to find this portfolio, I have to resort to a linear approximation since the first order conditions are nonlinear. This is done in the next section.

2.3. Linear Approximation

The model equations are linearized around a symmetric equilibrium where endowments and prices are equal and trade is balanced. Here, $\hat{x} = \frac{x - \bar{x}}{\bar{x}}$ denotes percentage deviations from the symmetric equilibrium, $\bar{x}$.

Linearizing the period 1 budget constraint for country 1, equation (6), and using the definition for consumption shares, μ_j^i, leads to:

$$\bar{\mu}_1^1(\hat{\mu}_1^1 + \hat{Y}_1) + \bar{\mu}_2^1(\hat{\mu}_2^1 + \hat{p}_2 + \hat{Y}_2) + \bar{\mu}_3^1(\hat{\mu}_3^1 + \hat{p}_3 + \hat{Y}_3) = S_1^1\hat{Y}_1 + S_2^1(\hat{p}_2 + \hat{Y}_2) + S_3^1(\hat{p}_3 + \hat{Y}_3). \tag{19}$$

This expression shows that the change in total consumption expenditures in response to an endowment shock has to be accounted for by a reaction of the portfolio income. Rearranging equation (19) yields:

$$\bar{\mu}_1^1\hat{\mu}_1^1 + \bar{\mu}_2^1\hat{\mu}_2^1 + \bar{\mu}_3^1\hat{\mu}_3^1 = (S_1^1 - \bar{\mu}_1^1)\hat{Y}_1 + (S_2^1 - \bar{\mu}_2^1)(\hat{p}_2 + \hat{Y}_2) + (S_3^1 - \bar{\mu}_3^1)(\hat{p}_3 + \hat{Y}_3). \tag{20}$$

On the left hand side, I have isolated the change in consumption expenditures in response to an endowment shock that is due to changes of consumption shares. These are changes of the efficient consumption allocation that are not proportional to an endowment shock. The right hand side shows the change in total expenditures that is due to changes of relative prices and it shows the change in portfolio income. In order to analyze the implications of relative price and consumption share responses (discussed above) for the portfolio allocation, next I examine how endowment shocks affect relative prices.

The terms-of-trade of country 1 correspond to the relative prices p_2 and p_3. Linearizing equations (17) and (18) and again using the definition for consumption shares yields:

$$\hat{p}_2 = -\frac{1}{\theta}\left(\hat{\mu}_2^i + \hat{Y}_2 - \hat{\mu}_1^i - \hat{Y}_1\right), \tag{21}$$

$$\hat{p}_3 = -\frac{1}{\theta}\left(\hat{\mu}_3^i + \hat{Y}_3 - \hat{\mu}_1^i - \hat{Y}_1\right) \quad \text{for } i = 1, 2, 3. \tag{22}$$

With the assumption of efficient risk-sharing, the terms-of-trade of country 1 always fall in response to a positive home endowment shock (see Corsetti, Dedola, and Leduc, 2008). The terms-of-trade of country 2 and country 3 behave in the same way and fall in response to a positive endowment shock to good 2 and good 3, respectively. Equations (21) and (22) further show that the terms-of-trade between two countries can also change in response to an endowment shock in the third country. For example, assume a higher endowment in country 3, $\hat{Y}_3 > 0$, while $\hat{Y}_1 = \hat{Y}_2 = 0$. If consumption shares of good 1 and good 2 do not respond in an identical way to this endowment shock, i.e., $\hat{\mu}_1^i \neq \hat{\mu}_2^i$, the terms-of-trade between country 1 and 2 change, $\hat{p}_2 \neq 0$.

2.4. Equity Portfolios

In a next step, I solve for equity shares, that replicate the efficient consumption allocation. That means, I compute the portfolio of country 1, S_1^1, S_2^1, S_3^1, such that its budget constraint, equation (20), holds for arbitrary realizations of $\hat{Y}_1$, $\hat{Y}_2$, $\hat{Y}_3$. Country 1's portfolio then has the following form:

$$S_1^1 = \alpha_1^1 + \Delta_1^1 - \frac{\Gamma_{p2}^1\left(\Delta_1^2(\Gamma_{p3}^3 + 1) - \Delta_1^3\Gamma_{p3}^2\right) + \Gamma_{p3}^1\left(\Delta_1^3(\Gamma_{p2}^2 + 1) - \Delta_1^2\Gamma_{p2}^3\right)}{(\Gamma_{p2}^2 + 1)(\Gamma_{p3}^3 + 1) - \Gamma_{p2}^3\Gamma_{p3}^2}, \tag{23}$$

$$S_2^1 = \alpha_2^1 + \frac{\Delta_1^2(\Gamma_{p3}^3 + 1) - \Delta_1^3\Gamma_{p3}^2}{(\Gamma_{p2}^2 + 1)(\Gamma_{p3}^3 + 1) - \Gamma_{p2}^3\Gamma_{p3}^2}, \tag{24}$$

$$S_3^1 = \alpha_3^1 + \frac{\Delta_1^3(\Gamma_{p2}^2 + 1) - \Delta_1^2\Gamma_{p2}^3}{(\Gamma_{p2}^2 + 1)(\Gamma_{p3}^3 + 1) - \Gamma_{p2}^3\Gamma_{p3}^2}, \tag{25}$$

where Δ_1^i summarizes the response of consumption shares in country 1 to an endowment shock in country i and $\Gamma_{p_j}^i$ shows the response of p_j to an endowment shock in country i.[11] The portfolios

[11] For the calculation of Δ_1^i and $\Gamma_{p_j}^i$, see appendix A.

of the other countries can be derived in a similar manner.

However, there are two cases where it is not possible to derive equilibrium asset shares. In the first case, portfolio holdings are indeterminate. This case occurs for two parameter combinations. If the elasticity of substitution is equal to one, $\theta = 1$, and either the utility function is logarithmic, $\rho = 1$, or preferences do not exhibit home bias, $\alpha^i_j = 1/3$, consumption shares are constant in response to an endowment shock ($\Delta^i_1 = 0$) and the terms-of-trade fully offset endowment shocks ($\Gamma^2_{p2} = \Gamma^3_{p3} = -1$, see appendix A). Thus, terms-of-trade changes fully insure against output fluctuations and financial autarky is efficient (see also Cole and Obstfeld, 1991).

In the second case, for some parameter combinations, the given asset structure cannot replicate the efficient allocation since asset pay-offs are unaffected by endowment shocks ($\Gamma^2_{p2} - 1 = \Gamma^3_{p3} - 1 = \Gamma^3_{p2} = \Gamma^2_{p3} = 0$). The equity pay-offs are not state-contingent and it is not possible to generate a pay-off structure that replicates the one for Arrow-Debreu securities.

Apart from the two cases just discussed, equations (23)-(25) specify the equity portfolio of country 1. The equity shares generate the financial income for arbitrary realizations of endowment shocks that induce the households to consume according to the efficient consumption allocation. Therefore, they incorporate the responses of consumption shares and relative prices to endowment shocks, as these indicate how the efficient consumption allocation and the dividends look like for different endowment realizations.

The first term in S^1_j indicates the level of asset holdings, if consumption shares are constant for all endowment realizations. In this case, the asset share of stock j corresponds to the share agent 1 consumes of good j (at the point of linearization) which is equal to the preference weight for good j. Thus, financial income from these asset holdings suffices for consumption expenditures for good j, because both endowment shock responses are the same. If, however, not only relative prices but also consumption shares react to endowment shocks, equity shares have to be higher or lower than the consumption weight. Higher asset holdings of a stock, whose dividend is higher relative to the other stocks, would induce the representative agent of country 1 to consume a higher output share as prescribed by efficient risk-sharing. However, I cannot state general conclusions about the consumption share and terms-of-trade responses and their co-movement, since they specifically depend on the chosen parameters.

3. Results from a Calibrated Model

3.1. Calibration

My model is parsimonious in the number of parameters. The parameter for risk aversion is set to $\rho = 2$, a standard value in the literature (see, e.g., Backus, Kehoe, and Kydland, 1994). There is no consensus on the value of the elasticity of substitution between home and imported goods, θ, with estimates being highly dependent on the data used. Studies using disaggregated sectoral data usually find higher estimates of $3 - 6$ (e.g. Baier and Bergstrand, 2001; Hummels, 2001), while studies using macro data find lower estimates of $0.23 - 2$. The estimates of Enders and Müller (2009) and Lubik and Schorfheide (2005) are at the lower end with values of 0.23 and 0.3, respectively, while Corsetti, Dedola, and Leduc (2008) find a value of 0.85 and Backus, Kehoe, and

Kydland (1994) use one of 1.5. The parameter θ plays a key role for the division of the portfolio between home and foreign assets. Therefore, I will first analyze the equilibrium portfolios for a given trade pattern and $\theta \in [0, 5]$. However, when analyzing the effects of bilateral trade flows, I will set $\theta = 0.3$. At this value of θ, the influence of bilateral trade flows on asset holdings best fits the empirical evidence presented by Lane and Milesi-Ferretti (2008) and Aviat and Coeurdacier (2007).

Since the main objective of this paper is to analyze the effects of bilateral trade and openness, it is natural to consider different values for the consumption preference parameters that govern trade flows. The values of the α_j^is are chosen to pin down the import share in country 1, $\alpha_j^1 + \alpha_k^1, j \neq k$, at 30% of GDP. The exact specifications for all α_j^is depend on the prespecified trade pattern and will be given in subsequent sections.

3.2. The Portfolios' Dependence on the Elasticity of Substitution

In this section, I analyze how the portfolio allocation depends on the substitution elasticity, θ, given a specific trade pattern. I study the portfolio composition for two different trade patterns. In case 1, all countries have symmetric preferences, such that trade flows between all countries are identical (see table (1), case 1).

In the second case, country 1 and 2 have asymmetric preferences for the respective foreign goods, but otherwise they are symmetric. I interpret country 3 as the rest of the world, such that the import share from country 3 is higher than the one from the other trading partner. In other words, the consumption preference parameters are set, such that α_2^1 (α_1^2) is smaller than α_3^1 (α_3^2). Table (1) (case 2) gives the specification for the consumption preference parameters. Note that country 3 has symmetric preferences for good 1 and 2, and that due to the assumption of overall and bilateral balanced trade the import share of country 3 has to be reduced.

Table 1: Trade Flow Matrix

		Case 1: Sym. Pref.			Case 2: Asym. Pref.		
Import Country i		1	2	3	1	2	3
	1	0.7	0.15	0.15	0.7	0.1	0.2
Export Country j	2	0.15	0.7	0.15	0.1	0.7	0.2
	3	0.15	0.15	0.7	0.2	0.2	0.6

Note: The table reports the share α_j^i that country i imports from export country j for symmetric and asymmetric preferences regarding the two foreign goods.

3.2.1. Symmetric Preferences

For symmetric preferences, the portfolio allocation is identical in all three countries and I focus on the portfolio allocation of country 1. Figure 1 shows the portfolio of country 1 as a function of the elasticity of substitution, θ. Due to the symmetric preference structure, asset holdings of stocks 2 and 3 are identical. As mentioned, θ plays a key role for the composition of the portfolio. There exists a critical value of θ, $\tilde{\theta}_s = 1.22$, for which dividends are unaffected by endowment shocks and the efficient consumption allocation cannot be supported under the existing asset structure.[12] For values of θ smaller than this threshold, the portfolio of country 1 exhibits home bias, while for values higher than $\tilde{\theta}_s$ the portfolio mainly contains foreign shares. For values of θ near the threshold point, the portfolio exhibits extreme home or foreign bias. As noted by Coeurdacier and Gourinchas (2009), the portfolio responds very sensitively to preference parameter changes. A small shift of θ can have huge effects on the optimal asset holdings if close to the pole.

Households hold equity shares to hedge their consumption risk. The portfolio allocation can therefore be explained through the abilities of different stocks to hedge consumption risk. The hedging ability of an equity is determined by the response of its dividend in comparison to the response of consumption shares and relative to the dividend response of other stocks. As shown in the last section, consumption shares in country 1 fall in response to a positive endowment shock to good 2 or 3, if $\theta < 1/2$ (since $\rho = 2$) and rise otherwise. An endowment shock to good j has two effects on the dividend of stock j, a volume effect, through a higher or lower endowment, and a value effect, determined by the terms-of-trade response. The two effects influence the dividend response in opposite directions. At the critical value $\tilde{\theta}_s$ the two effects fully offset each other. For values of θ smaller than $\tilde{\theta}_s$, the value effect prevails, since terms-of-trade move stronger if the substitution elasticity is lower. In this case, the terms-of-trade and dividend response are positively correlated. On the other hand, for $\theta > \tilde{\theta}_s$, the volume effect dominates and a positive endowment shock leads to a positive dividend reaction. Thus, terms-of-trade and dividend response are negatively correlated for this parameter region.

Taken together the responses of consumption shares and dividends explain the portfolio allocation. Assume a positive endowment shock to good 2. For $\theta < 1/2$, consumption shares in country 1 fall. At the same time, the dividend of stock 2 falls as well. Therefore, S_2^1 has to be higher than α_2^1 (see equation (20)). However, the relative value of stock 1 is higher, therefore the home stock prevails in the portfolio.

For $1/2 < \theta < \tilde{\theta}_s$, consumption shares rise, while the dividend of stock 2 still falls. Thus, the relative hedging ability of stock 2 is smaller than for the case discussed before and S_2^1 is smaller than α_2^1. For values of θ near $\tilde{\theta}_s$, country 1 even goes short in assets of country 2 and 3. The dividend changes become smaller and to hedge consumption risk agents have to hold more and more shares of the preferred stock. For full risk-sharing, country 1 would need to hold a larger share of its own stock than it initially has in period 0. To finance this leveraged position it has to go short in foreign assets, i.e., country 1 sells claims to the endowment of good 2 and 3. Since country 1 does not own these claims in period 0, this is only possible if country 2 and 3 also want to hold a leveraged position of their own stock and therefore go short in assets of country 1. In period 1, after the endowment has been distributed, the following chain of events occurs: All three countries hold a leveraged position of their own stock, i.e., more than 100%. But the distributed endowment is only 100% of a country's goods as it cannot violate the resource constraint. Country 1, in order to serve the claims it has shortened the period before, now buys the respective amounts of endowment from countries 2 and 3 and then hands them back to them. Country 2 and 3 do the same, making it possible to have a leveraged position of ones own stock.

[12] Baxter, Jermann, and King (1998) find a similar effect in a portfolio model with traded and nontraded goods for the substitution elasticity between traded and nontraded goods.

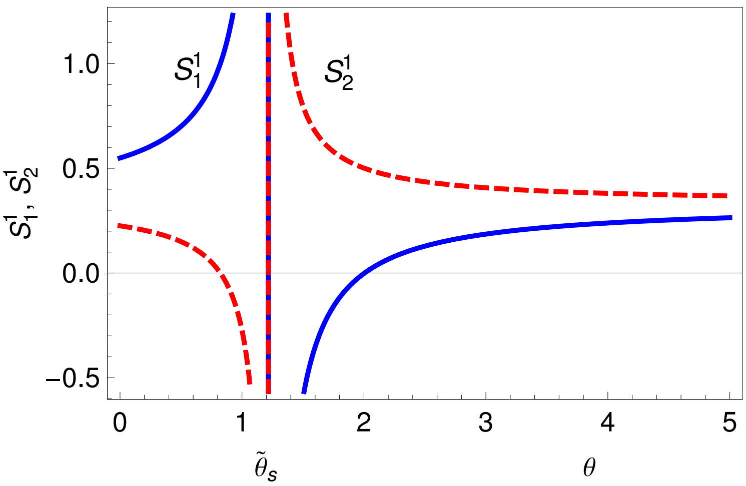

Figure 1: Equity Portfolio of Country 1 with Symmetric Preferences.
Note: The figure shows the shares country 1 holds of stock 1 (S_1^1, solid line) and of stock 2 (S_2^1, dashed line) as a function of the elasticity of substitution θ. For symmetric preferences $S_2^1 = S_3^1$. The asset structure cannot replicate the efficient consumption allocation for $\theta = \tilde{\theta}_s = 1.22$.

Once $\theta > \tilde{\theta}_s$, the dividend of stock 2 rises after an endowment shock in country 2 and holdings of stock 2 can hedge consumption risk (consumption shares in country 1 are positively correlated with an endowment shock to good 2) relatively better than holdings of stock 1. The portfolio now contains a higher proportion of foreign shares than of home shares.

In summary, if consumption shares and the relative dividend value of the home asset co-move positively, the portfolio exhibits home bias, while a negative co-movement leads to foreign bias. These results are the same as in a standard two-country model (see Kollmann, 2006). Coeurdacier (2009) also finds a foreign bias for a high substitution elasticity. In his model, the covariance between the home real exchange rate and home equity returns matters for the composition of the portfolio. A positive covariance leads to a home bias, while for a negative covariance the foreign share in the portfolio prevails.

3.2.2. Asymmetric Preferences

Next, I interpret country 3 as the rest of the world and assume the trade pattern outlined in table (1) for asymmetric preferences (case 2). Again I focus on the portfolio allocation of country 1. Figure 2 displays the portfolio of country 1 as a function of θ. In comparison to the case with symmetric preferences, asset holdings of stock 2 and 3 now differ. Another difference relative to the symmetric case is that for asset holdings of stock 1 and 2 there are now two values of θ where the efficient consumption allocation cannot be supported. However, the composition of the portfolio has again a pole at $\theta = \tilde{\theta}_a$.[13] For $\theta < \tilde{\theta}_a$, the portfolio contains mainly the local asset, while for $\theta > \tilde{\theta}_a$ foreign assets prevail.

In this setting, it is interesting to compare the two foreign shares, S_2^1 and S_3^1. When $\theta < \tilde{\theta}_a$, asset holdings of stock 3 are higher than holdings of stock 2 except for values of θ that are close

[13] In what follows, I will focus for convenience on the portfolio where $\theta < \tilde{\theta}_{a1} = 1.10$ and $\theta > \tilde{\theta}_{a2} = 1.28$, denoting the critical value of θ with $\tilde{\theta}_a$. I make this assumption because the asset holdings between these two points show strongly leveraged positions and thus are hard to interpret.

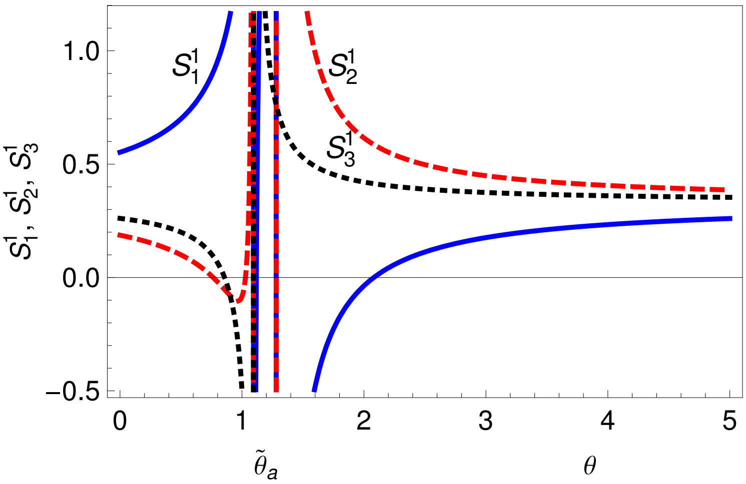

Figure 2: Equity Portfolio of Country 1 with Asymmetric Preferences.
Note: The figure shows the shares country 1 holds of stock 1 (S_1^1, solid line), of stock 2 (S_2^1, dashed line) and of stock 3 (S_3^1, dotted line) as a function of the elasticity of substitution θ. The asset structure cannot replicate the efficient consumption allocation for $\theta = \tilde{\theta}_{a1} = 1.10$ and $\theta = \tilde{\theta}_{a2} = 1.28$.

to $\tilde{\theta}_a$, while for $\theta > \tilde{\theta}_a$ the opposite holds true. In the simple case where consumption shares are constant, $1/\rho = \theta$, S_3^1 is higher than S_2^1 due to the fact that the representative household in country 1 prefers good 3 over good 2 ($\alpha_3^1 > \alpha_2^1$). Apart from this special case, differences in the responses of consumption expenditures and relative prices, dependending on whether an endowment shock affects good 2 or 3, further contribute to $S_2^1 \neq S_3^1$. For the symmetric case, on the other hand, it does not matter for consumption share and relative price responses whether the endowment shock affects good 2 or 3.

Trade flows between country 1 and 3 are assumed to be higher than between country 1 and 2 ($\alpha_3^1 = 0.2 > \alpha_2^1 = 0.1$). Hence, these results show a (mostly) positive influence of bilateral trade flows on asset holdings for $\theta < \tilde{\theta}_a$, while for $\theta > \tilde{\theta}_a$ the influence is negative. These results also suggest that the influence of bilateral trade flows is closely related to the portfolio composition regarding home and foreign assets.

3.3. How Bilateral Trade Flows affect the Foreign Portfolio Share

One major advantage of the three country model developed in this paper is that it enables me to analyze the effects of bilateral trade flows on asset holdings independently of trade openness. Let us focus on country 1's equity holdings of stock 2. An increase in the parameter α_2^1 leads to a rise in trade flows between country 1 and 2. At the same time, the import share of country 1, $\alpha_2^1 + \alpha_3^1$, stays constant due to the presence of country 3. Of course, trade flows between country 1 and country 3 decrease, when α_2^1 increases.

I fix the import share at 30% of output and assume that country 1 trades less with country 2 than with the rest of the world, i.e., $\alpha_2^1 \in (0, 0.15)$, where preferences are symmetric if $\alpha_2^1 = 0.15$. Furthermore, the substitution elasticity, θ, is set to 0.3 as the results in section 3.2.2 imply a relatively low value of θ to generate the empirically identified positive effect of bilateral trade on bilateral equity holdings (see the evidence in Lane and Milesi-Ferretti, 2008; Aviat and Coeurdacier,

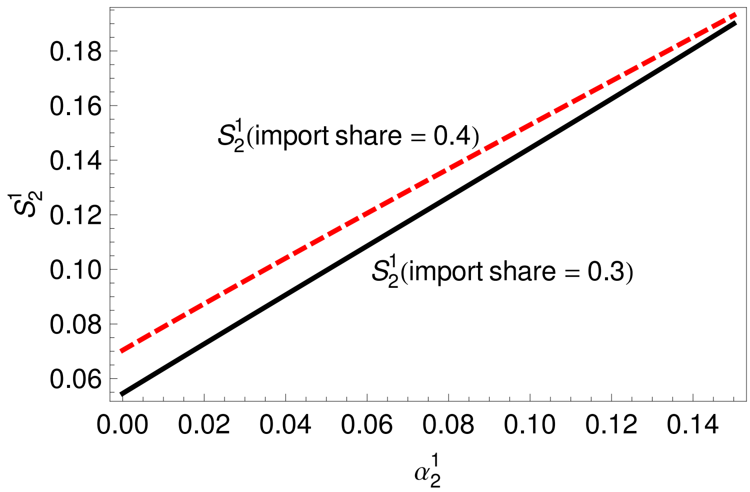

Figure 3: Country 1 Holdings of Stock 2 for Increasing Trade Flows between Country 1 and 2. *Note:* The figure shows S_2^1 for a bilateral import share α_2^1 between 0 and 0.15. The total import share is 0.3 (solid line) and 0.4 (dashed line), such that $\alpha_3^1 = 0.3 - \alpha_2^1$ and $\alpha_3^1 = 0.4 - \alpha_2^1$, respectively. The elasticity of substitution is set to $\theta = 0.3$.

2007).[14] Figure 3 displays the share of stock 2 in country 1's portfolio as a function of α_2^1 (solid line). It shows that bilateral trade flows have a positive effect on asset holdings. Importantly, this effect is independent of the general openness to trade. When country 1 and 2 trade more with each other, the ability of stock 2 to hedge consumption risk increases and country 1 holds more of stock 2.

Consider the following example of a negative endowment shock to good 2. The first effect is a positive response of stock 2's dividend through an terms-of-trade increase. In addition, consumption expenditures rise due to the increases in terms-of-trade and consumption shares. On the one hand, the increase in the dividend of stock 2 is stronger for higher imports from country 2 (α_2^1 increases), since the rise in the terms-of-trade is stronger in this case. This by itself would lead to lower asset holdings. On the other hand, consumption expenditures react stronger to the endowment shock if imports from country 2 are higher, thus calling for higher asset holdings of stock 2. Since the latter effect is more pronounced, shares of stock 2 are higher for higher α_2^1 to generate the adequate financial income.

I am also interested in the effect of trade openness on asset shares when controlling for the effect of bilateral trade flows. To this end, I choose a higher import share of 40% and repeat the experiment of computing the portfolio share of stock 2 as a function of α_2^1. Figure 3 plots the graphs for the two experiments. The solid line depicts holdings of stock 2 for an import share of 30% and the dashed line shows holdings of stock 2 for an import share of 40%. Comparing the asset holdings for the two import shares shows that openness exerts an independent effect on bilateral investment patterns. Although bilateral trade flows are the same, bilateral asset holdings vary with the degree of trade openness. The influence of openness is positive as country 1 holds a higher share of stock 2 for an import share of 40% than for one of 30%. The explanation runs along similar lines as for the effect of α_2^1 on S_2^1. Consumption expenditures and the dividend of

[14]Note that a value of, e.g., $\theta = 0.8$ would also generate a positive effect of bilateral trade flows on bilateral asset holdings. However, foreign asset holdings are mainly negative in this case.

stock 2 fall stronger in response to an endowment shock to good 2 if trade openness is higher. The dividend of stock 2 falls stronger since the relative price of good 2 in terms of good 1 falls stronger due to consumption of good 1 being higher. The stronger response of stock 2's dividend would lead the representative agent to hold a lower share of stock 2 regardless of the consumption expenditure response. To generate a certain amount of financial income, lower asset holdings are needed if their value changes stronger. However, consumption expenditures also react stronger to an endowment shock if trade openness is higher. This response calls for a higher financial income and outweighs the dividend effect. Hence, S_2^1 is higher for higher trade openness.

Given this comparison between asset holdings for different import shares, I can analyze possible interaction effects between bilateral trade flows and trade openness. An interaction effect would show up through an influence of openness on the effect bilateral trade has on stock holdings. For my calibration, I find a small interaction effect. The influence of bilateral trade flows on the portfolio share is smaller for higher openness, i.e., S_2^1 has a smaller slope for $\alpha_2^1 + \alpha_3^1 = 0.4$. The intuitive explanation is that once a country has a lot of overall trade, the trade with one single country becomes less important for risk-sharing.

4. Empirical Evidence

4.1. Data and Econometric Specification

In this section, I provide empirical evidence on the effects of bilateral and total trade flows on the bilateral foreign asset position. For this analysis, I use a data-set that breaks international security holdings down by the residence of the security issuer, the *Coordinated Portfolio Investment Survey* (CPIS) provided by the IMF. The CPIS reports data on year-end cross-border security holdings, where security holdings include holdings of equity, long-term and short-term debt securities, i.e., claims to a country's output. In using this broad definition of portfolio investment, my analysis is comparable to Lane and Milesi-Ferretti (2008). Annual data starting in 2001 is available for up to 74 source and 236 destination countries and territories. Although in principle I could employ panel data methods, the low time-variation (high correlation over time) in bilateral asset holdings leads me to consider only cross-sections without losing too much sample information. To estimate my model, I use the 2001 cross-section, which was also used by Lane and Milesi-Ferretti (2008),[15] and the 2007 cross-section, which is the latest available year and has the broadest country coverage.[16]

Specifically, my econometric analysis is based on the following gravity model:[17]

$$\log(assets_{ij}) = d_j + \beta_1 \log(biltrade_{ij}) + \beta Z_{ij} + \gamma_1 \log(tottrade_i) + \gamma C_i + \epsilon_{ij} \ , \qquad (26)$$

where $assets_{ij}$ is the level of portfolio investment in host country j by source country i[18], $biltrade_{ij}$ measures trade between source country i and host country j, $tottrade_i$ is total trade of source country i, all three measured in millions of US Dollars, d_j is a host country dummy, and ϵ_{ij} is an

[15] For a detailed discussion of the shortcomings of the CPIS data regarding country coverage and asset reporting, see Lane and Milesi-Ferretti (2008).

[16] The data for 2008 is only preliminary.

[17] For a complete list of data sources and variable definitions, see appendix B.

[18]

error term. I also include a set of bilaterally varying control variables, Z_{ij}, and a set of controls for source country characteristics, C_i. While Lane and Milesi-Ferretti (2008) employ a double fixed effects specification with host and source country dummies, I cannot use source country dummies as they would absorb the effect of total trade.

I follow the literature and specify the dependent variable in natural logarithms.[19] In addition, I exclude source and host countries that mainly act as financial offshore centers.[20] The reasons why these countries hold cross-border asset holdings might differ systematically from other source countries since financial offshore centers are mostly intermediaries (see the discussion in Lane and Milesi-Ferretti, 2008). Similarly, the motives why source countries hold assets of financial offshore centers might be different as well.

Z_{ij} consists of variables that have been previously found to influence bilateral investment patterns. First, these include the geographical distance and the time-zone difference between two countries, which could possibly have a negative impact on information flows and communication.[21] Second, I include dummies for common language, past colonial relationship, and currency unions, which are measures for cultural and financial proximity that could help overcome information barriers. Furthermore, I include a dummy for the existence of a tax treaty and control for a possible diversification motive by including the correlation between GDP growth rates of source and host country.

The source country control variables, C_i, include country specific characteristics that influence its propensity to hold outward investments. The factors I control for are the size of the source country (measured by population), and economic and financial development (measured by GDP per capita and stock market capitalization). Richer countries and those with a better developed financial market might have higher incentives to invest in securities of other countries (Lane and Milesi-Ferretti, 2004).

4.2. Estimation Results

The first two columns of table (2) present OLS estimates for the 2001 cross-section not including (column 1) and including (column 2) total trade as a regressor, respectively. The results show that bilateral trade and total trade both have a significant positive impact on bilateral asset holdings, even when controlling for informational frictions and source country characteristics. Once I include total trade in the regression, the influence of bilateral trade decreases slightly. The effect of total trade is similar in magnitude to the effect of bilateral trade. Other significant factors are bilateral distance (with the expected negative influence), common language and being in a currency union (both raising bilateral asset holdings). Economic and financial development seems to have a positive

[19] While this forces me to exclude all observations that are equal to zero, Lane and Milesi-Ferretti (2008) argue that this specification is justified on the grounds that the main focus is on variables explaining the specific magnitude of investments. Including zero observations would put a higher emphasis on regressors explaining the difference between zero and non-zero asset holdings. A way to include zero observations would be to add a small "epsilon" to the dependent variable before taking logs, i.e., $\log(assets + \varepsilon)$.

[20] See appendix C for a list of excluded countries.

[21] While the negative impact of distance on trade in goods can be justified by transportation costs, this does not apply to "weightless" equities. Distance is thus interpreted as a barrier to information flows. The time difference between countries hinders communication directly (see Aviat and Coeurdacier, 2007; Portes and Rey, 2005; Stein and Daude, 2007).

influence on a country's bilateral investment, GDP per capita and stock market capitalization both have significant positive coefficients. A country's population, apart from the role it plays in GDP per capita, is not significant in itself. Including total trade in the regression leads to marginally smaller coefficients for the regressors that control for source country characteristics.

Using the cross-section for 2007 changes the OLS estimates only slightly, as columns 1 and 2 of table (3) show. However, some differences are noteworthy. First, there are more observations. Interestingly, only a small share of the higher amount of non-zero observations are due to the additional countries reporting to the CPIS in 2007.[22] One potential explanation for the higher number of observations might be a higher worldwide financial integration.

Second, the effects of some regressors have become stronger, while others have become smaller. The coefficient for total trade is slightly smaller than in 2001. The effect of the currency union is stronger in 2007, which might be driven by the European Monetary Union. The coefficient for the time zone difference is now significant. However, it is positive and very small, making an interpretation difficult. The coefficient of per capita GDP is higher, while the one for stock market capitalization is smaller.

Aviat and Coeurdacier (2007) point to an endogeneity problem that renders OLS estimates biased and inconsistent. Not only does trade in goods affect asset holdings, the reverse is also possible. Therefore, I use instrumental variables to check the robustness of the results. The possibly endogenous regressors that I instrument are bilateral and total trade, the correlation of GDP growth rates, GDP per capita, and stock market capitalization. As instruments I use variables that are known to be correlated with trade: the product of the land area of the two countries, a common border dummy, a dummy for being in a free-trade-agreement, a dummy for the number of landlocked countries in the country pair[23], and a dummy for a common colonial ruler after 1945.[24] I also use the colonial dummy as an instrument (excluding this dummy as an independent regressor). Furthermore, I include lagged GDP per capita, lagged stock market capitalization and the lagged correlation of GDP growth rates in my list of instruments.

Column 3 of table (2) and column 3 of table (3) show the results for the IV estimation. The results are mostly unchanged in comparison to the OLS estimates. All regressors that were significant before are still significant with similarly sized coefficients. One exception applies to the IV results for 2007. Total trade does not have a significant effect anymore. Thus, the effect of total trade on bilateral asset holdings might not be as robust as the effect of bilateral trade. Considering that the OLS-results show a smaller coefficient for total trade, a possible conclusion might be that the effect of total trade has decreased with increasing financial linkages.

[22] Countries that report their security holdings for the first time after 2001 include Pakistan (2002), Barbados (2003), Kuwait (2003), Mexico (2003), Gibraltar (2004), India (2004), and Latvia (2006). The number in parentheses is the first year these countries report their data in the CPIS.

[23] Takes values 0, 1 or 2.

[24] The dummy takes the value 1, if the two countries were colonies after 1945 and had the same colonial ruler, e.g., Singapore and Sri Lanka.

5. Conclusion

Using a three-country stochastic general equilibrium model, I have shown in this paper that bilateral trade and trade openness both have an independent and positive effect on bilateral cross-country asset holdings. To my knowledge, this is the first attempt at a unified framework for these two effects as the separation of the effects of bilateral trade and trade openness is impossible in a two-country model.

My calibration experiments provided evidence that bilateral trade flows have a positive impact on the bilateral foreign asset position. This means that two countries which trade more with each other also hold higher shares of each others' equities. The reason is that the equities of the trade partners provide a better hedge for output risks. Similarly, a higher trade openness leads to higher bilateral asset holdings. Furthermore, I have identified interaction effects between the two trade measures. A higher trade openness dampens the effect bilateral trade flows have on bilateral asset holdings. My empirical findings supported the theoretical results. Analyzing the geographically categorized asset holdings of 74 countries, showed that bilateral and total trade both have a positive effect on bilateral portfolio holdings. Nevertheless, the influence of total trade is less robust and seems to fall over time.

It would be interesting to relax some of the simplifying assumptions in future work. E.g., in a framework with incomplete markets the correlation and size of endowment shocks would influence the asset portfolios.

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A. Derivation of Consumption and Terms-of-Trade Responses to Endowment Shocks

In this appendix, I derive the responses of consumption shares and the terms-of-trade to endowment shocks. The model is linearized around a symmetric equilibrium, where endowments and prices are equal and trade is balanced. $\hat{x}$ denotes percentage deviations from the symmetric equilibrium $\bar{x}$.

In a first step, I linearize the risk-sharing conditions, equations (15) and (16):

$$\left(\frac{1}{\theta} - \rho\right)\hat{C}^1 - \frac{1}{\theta}\hat{c}_j^1 = \left(\frac{1}{\theta} - \rho\right)\hat{C}^2 - \frac{1}{\theta}\hat{c}_j^2, \tag{27}$$

$$\left(\frac{1}{\theta} - \rho\right)\hat{C}^1 - \frac{1}{\theta}\hat{c}_j^1 = \left(\frac{1}{\theta} - \rho\right)\hat{C}^3 - \frac{1}{\theta}\hat{c}_j^3 \quad \text{for } j = 1, 2, 3. \tag{28}$$

If $\frac{1}{\theta} = \rho$, these equations become $\hat{c}_j^1 = \hat{c}_j^2$ and $\hat{c}_j^1 = \hat{c}_j^3$.

Using the definition $\mu_j^i \equiv c_j^i / Y_j$, the linearized risk sharing conditions, and the resource constraints (equation (14)), I can show that endowment shocks affect consumption shares μ_1^1 and μ_2^2 in the following way:

$$\hat{\mu}_1^1 = \Sigma_1\hat{Y}_1 + \Sigma_2\hat{Y}_2 + \Sigma_3\hat{Y}_3, \tag{29}$$

$$\hat{\mu}_2^2 = \Psi_1\hat{Y}_1 + \Psi_2\hat{Y}_2 + \Psi_3\hat{Y}_3, \tag{30}$$

where Σ_i and Ψ_i are functions of the structural parameters θ, ρ and α_i^j. For all other consumption shares, the following holds: $\hat{\mu}_j^i = \gamma_j^i\hat{\mu}_1^1 + \chi_j^i\hat{\mu}_2^2$, where γ_j^i and χ_j^i are combinations of $\bar{\mu}_j^i$s.[25] The signs of Σ_i and Ψ_i are driven by the relationship between ρ and θ (see the discussion in the main text), such that for $\theta = \frac{1}{\rho}$ consumption shares remain constant, i.e. $\Sigma_i = \Psi_i = 0$, and for $\theta < \frac{1}{\rho}$ consumption shares in country i increase for a positive endowment shock in country i, while they fall for a positive endowment shock in one of the other countries.

In a second step, I substitute the consumption share responses in the linearized equations for relative prices, (21) and (22). The relative price responses can then be summarized in the following way:

$$\hat{p}_2 = \Gamma_{p2}^1 Y_1 + \Gamma_{p2}^2 Y_2 + \Gamma_{p2}^3 Y_3, \tag{31}$$

$$\hat{p}_3 = \Gamma_{p3}^1 Y_1 + \Gamma_{p3}^2 Y_2 + \Gamma_{p3}^3 Y_3, \tag{32}$$

where

$$\Gamma_{pj}^1 = -\frac{1}{\theta}\left((\gamma_2^1 - 1)\Sigma_1 + \chi_2^1\Psi_1 - 1\right) \quad \text{for } j = 2, 3,$$

$$\Gamma_{pi}^i = -\frac{1}{\theta}\left((\gamma_2^1 - 1)\Sigma_i + \chi_2^1\Psi_i + 1\right) \quad \text{for } i = 2, 3,$$

$$\Gamma_{pj}^i = -\frac{1}{\theta}\left((\gamma_2^1 - 1)\Sigma_i + \chi_2^1\Psi_i\right) \quad \text{for } i \neq j,\ i = 2, 3,\ j = 2, 3.$$

Substituting the foregoing equations into the budget constraint, equation (20), and using the

[25] E.g.,

$$\gamma_2^1 = \frac{\bar{\mu}_2^3}{\bar{\mu}_1^3(1 - \bar{\mu}_2^2) + \bar{\mu}_1^2\bar{\mu}_2^3} \quad \text{and} \quad \chi_2^1 = \frac{\bar{\mu}_1^2\bar{\mu}_2^3 - \bar{\mu}_2^2\bar{\mu}_1^3}{\bar{\mu}_1^3(1 - \bar{\mu}_2^2) + \bar{\mu}_1^2\bar{\mu}_2^3}.$$

assumption $\bar{\mu}_j^i = \alpha_j^i$ (see Kollmann, 2006) results in:

$$\begin{aligned}
\hat{Y}_1 &\left\{\Delta_1^1 - (S_1^1 - \alpha_1^1) - (S_2^1 - \alpha_2^1)\Gamma_{p2}^1 - (S_3^1 - \alpha_3^1)\Gamma_{p3}^1\right\} \\
+\hat{Y}_2 &\left\{\Delta_1^2 - (S_2^1 - \alpha_2^1)(\Gamma_{p2}^2 + 1) - (S_3^1 - \alpha_3^1)\Gamma_{p3}^2\right\} \\
+\hat{Y}_3 &\left\{\Delta_1^3 - (S_2^1 - \alpha_2^1)\Gamma_{p2}^3 - (S_3^1 - \alpha_3^1)(\Gamma_{p3}^3 + 1)\right\} \\
&= 0 \ ,
\end{aligned} \tag{33}$$

where $\Delta_1^i = (\alpha_1^1 + \alpha_2^1\gamma_2^1 + \alpha_3^1\gamma_3^1)\Sigma_i + (\alpha_2^1\chi_2^1 + \alpha_3^1\chi_3^1)\Psi_i$. I solve this equation for S_1^1, S_2^1, S_3^1 such that it holds for arbitrary realizations of $\hat{Y}_1$, $\hat{Y}_2$, $\hat{Y}_3$, which yields equations (23)-(25) in the main text.

B. Data: Definitions and Sources

- **Bilateral Portfolio Asset Holdings**: Portfolio investment assets (equity securities, long-term and short-term debt securities) held by source country residents and issued by destination country residents. Asset holdings are end of 2001 (2007) holdings measured in millions of current US dollars. *Source*: Coordinated Portfolio Investment Survey, International Monetary Fund, `http://www.imf.org/external/np/sta/pi/datarsl.htm`.

- **Bilateral Trade**: Sum of exports and imports between source and host country. Annual data averaged over the period 1997-2001 and 1997-2007, respectively, in millions of current US dollars. *Source*: Direction of Trade Statistics, International Monetary Fund.

- **Total Trade**: Sum of exports and imports of the source country for a given year. Annual data averaged over the period 1997-2001 and 1997-2007, respectively, in millions of current US dollars. *Source*: Direction of Trade Statistics, International Monetary Fund.

- **Distance**: Great-circle distance in miles between the approximate geographic centers of source and host country taken from the CIA "World Factbook" (`https://www.cia.gov/library/publications/the-world-factbook/index.html`). *Source*: Rose and Spiegel (2004); Subramanian and Wei (2007).

- **Common Language Dummy**: Dummy variable, that is 1 if source and host country have the same language. Constructed using country-specific information from the CIA "World Factbook". *Source*: Rose and Spiegel (2004); Subramanian and Wei (2007).

- **Colony Dummy**: Dummy variable, that is 1 if source and host country have ever been in a colonial relationship. Constructed using country-specific information from the CIA "World Factbook". *Source*: Rose and Spiegel (2004); Subramanian and Wei (2007).

- **Time Difference**: Absolute value of the time difference between source and host country (ranging from 0 to 12). *Source*: `http://timeanddate.com`.

- **Tax Treaty Dummy**: Dummy variable, that is 1 if the source and host country have a double taxation treaty prior to 1999. *Source*: Treaty data from `http://www.unctad.org`.

- **Population**: Source country population in thousands. *Source*: World Development Indicators, World Bank.

- **GDP per capita**: Source country GDP in current US dollars per capita. *Source*: World Development Indicators, World Bank.

- **GDP growth rate correlation**: Correlation between the annual nominal GDP growth rates of source country i and host country j using growth rates from 1981-2000. For the IV-estimation I use the correlation between growth rates for the period 1981-1990 as the lagged variable. *Source*: Calculations based on World Development Indicators, World Bank.
- **Stock Market Capitalization**: Market capitalization of the companies, listed on the source country's stock exchange in millions of current US dollars. *Source*: World Development Indicators, World Bank.

C. List of Excluded Offshore Financial Centers

The following list contains the countries and territories I have excluded in my empirical analysis. These countries and territories are classified as offshore financial centers by the IMF (see Zorome, 2007). If a country or territory is an offshore financial center according to the IMF, but was not excluded by Lane and Milesi-Ferretti (2008), I follow Lane and Milesi-Ferretti (2008) and do not exclude that country either.
Andorra, Anguilla, Antigua and Barbuda, Aruba, the Bahamas, Bahrain, Barbados, Belize, Bermuda, British Virgin Islands, Cayman Islands, Cook Islands, Cyprus, Dominica, Gibraltar, Grenada, Guernsey, Isle of Man, Jersey, Lebanon, Liechtenstein, Luxembourg, Macao SAR, Malta, Marshall Islands, Mauritius, Monaco, Montserrat, Nauru, Netherlands Antilles, Niue, Palau, Panama, Samoa, Seychelles, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Turks and Caicos Islands, Vanuatu.

Table 2: Regression Results for 2001

	(1)	(2)	(3)
Dependent variable	Log(assets)	Log(assets)	Log(assets)
Estimation method	OLS	OLS	IV
Log bilateral trade	0.46	0.36	0.28
	(8.95)***	(6.51)***	(1.69)*
Log total trade		0.42	0.75
		(5.02)***	(4.04)***
Log distance	-0.41	-0.45	-0.48
	(-4.00)***	(-4.41)***	(-2.58)***
Common language dummy	0.76	0.84	0.94
	(6.56)***	(7.32)***	(6.88)***
Colony dummy	0.23	0.29	
	(1.19)	(1.49)	
Currency union dummy	1.25	1.20	1.12
	(8.44)***	(8.25)***	(7.22)***
Time zone difference	0.03	0.02	0.01
	(1.26)	(0.71)	(0.43)
Correlation in growth rates	0.15	0.15	0.30
	(1.00)	(1.01)	(1.21)
Tax treaty dummy	-0.02	-0.07	-0.11
	(-0.19)	(-0.77)	(-1.24)
Log GDP per capita	1.35	1.14	0.88
	(13.83)***	(10.82)***	(7.40)***
Log market capitalization	0.28	0.23	0.25
	(4.82)***	(3.97)***	(3.36)***
Log Population	0.15	-0.00	-0.19
	(2.06)**	(-0.05)	(-2.09)**
N	1725	1725	1725
Adjusted $\bar{R}^2$	0.77	0.77	0.77

Note: Asset holdings are end of 2001 holdings measured in millions of U.S. dollars. Regressions include fixed host country effects. t-statistics are reported in parentheses. ***, ** and * denote statistical significance at 1%, 5% and 10% levels, respectively.

Table 3: Regression Results for 2007

	(1)	(2)	(3)
Dependent variable	Log(assets)	Log(assets)	Log(assets)
Estimation method	OLS	OLS	IV
Log bilateral trade	0.49	0.43	0.69
	(10.69)***	(8.27)***	(4.68)***
Log total trade		0.23	-0.03
		(2.98)***	(-0.18)
Log distance	-0.41	-0.44	-0.21
	(-4.72)***	(-5.01)***	(-1.29)
Common language dummy	0.88	0.91	0.73
	(8.08)***	(8.26)***	(5.34)***
Colony dummy	-0.09	-0.02	
	(-0.43)	(-0.10)	
Currency union dummy	1.47	1.43	1.50
	(10.46)***	(10.19)***	(9.68)***
Time zone difference	0.06	0.05	0.06
	(3.12)***	(2.72)***	(2.99)***
Correlation in growth rates	0.06	0.07	0.05
	(0.48)	(0.55)	(0.23)
Tax treaty dummy	0.02	0.01	-0.00
	(0.22)	(0.10)	(-0.01)
Log GDP per capita	1.50	1.37	1.34
	(19.25)***	(15.85)***	(13.56)***
Log market capitalization	0.14	0.11	0.16
	(3.47)***	(2.63)***	(3.40)***
Log Population	0.15	0.07	-0.02
	(2.59)***	(1.10)	(-0.27)
N	2417	2417	2417
Adjusted $\bar{R}^2$	0.74	0.74	0.74

Note: Asset holdings are end of 2007 holdings measured in millions of U.S. dollars. Regressions include fixed host country effects. t-statistics are reported in parentheses. ***, ** and * denote statistical significance at 1%, 5% and 10% levels, respectively.