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# COUNTRY SIZE, CURRENCY UNIONS, AND INTERNATIONAL ASSET RETURNS

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## ABSTRACT

Differences in real interest rates across developed economies are puzzlingly large and persistent. I propose a simple explanation: Bonds issued in the currencies of larger economies are expensive because they insure against shocks that affect a larger fraction of the world economy. I show that differences in the size of economies indeed explain a large fraction of the cross-sectional variation in currency returns. The data also support a number of additional implications of the model: The introduction of a currency union lowers interest rates in participating countries and stocks in the non-traded sector of larger economies pay lower expected returns.

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# 1 Introduction

International investors earn high expected returns by borrowing in low interest rate currencies and lending in high interest rate currencies. I propose a simple explanation for this fact: Bonds issued in the currencies of economies that account for a larger share of world wealth are a better hedge against consumption risk. As a consequence, larger economies have permanently lower real and nominal interest rates than smaller economies, resulting in persistent violations of uncovered interest parity.

Consider a world in which there are two countries, call them the US and Denmark (where the US accounts for most of the world's wealth). Households in both countries consume a mixture of traded and non-traded goods. In this world bonds are country-specific consumption insurance: The US risk-free bond promises to deliver one unit of the US consumption bundle while the Danish risk-free bond promises to deliver one unit of the Danish consumption bundle. Intuitively, it has to be cheaper to provide this insurance to Danish consumers. It takes a tiny fraction of the world's supply of traded goods to make up for any shortage of Danish non-traded goods. In contrast, a relative shortage of US non-traded goods automatically creates a world-wide shortage of traded goods. The US risk-free bond must therefore be more expensive than the Danish risk-free bond and the US must have lower risk-free interest rate in equilibrium.

I show that differences in the size of economies indeed explain a large fraction of the cross-sectional variation in currency returns. Moreover, the data also support a number of additional implications of the model: Stocks in the non-traded sector of larger economies pay lower expected returns and the introduction of the Euro lowered default-free interest rates and stock returns in the non-traded sector of participating countries. Moreover, bonds denominated in currencies of larger economies appear to be a better hedge against long-run consumption risk of US investors.

Sections 2 and 3 develop the theoretical part of the paper. In section 2, I derive the main theoretical results in a simplified model in which asset markets are complete and the world is populated by a continuum of households that receive stochastic endowments of a traded and of a non-traded consumption good. All households within a given country receive the same per capita endowments, where a large country accounts for a larger share of world wealth (it has more households or richer households). Households share all the risk from their traded endowment and some of the risk from their non-traded endowment by shipping traded goods across countries. Assets are priced with the marginal utility from traded goods, which is the same for all households in equilibrium. Households demand a lower expected return on assets that pay off well when this marginal utility is high, i.e. when the world endowments of traded and non-traded goods are low.

When a country has a relatively low per capita endowment in the non-traded sector its non-traded good becomes relatively more expensive and its real exchange rate appreciates. However, a low endowment in the non-traded sector of a large country simultaneously triggers a large rise in the marginal utility from traded goods, while a low endowment in the non-traded sector of a small country does not. As a consequence, a larger country's consumption bundle tends to appreciate when marginal utility from traded goods is high. Any asset which makes a payment that is partially fixed in terms of a larger country's consumption bundle is therefore a better hedge against consumption risk and must pay lower expected returns. One such asset is a risk-free bond (think of an inflation indexed bond) which promises to pay one unit of a country's consumption bundle. Another is the ownership claim (stock) to the endowment in the non-traded sector which, under mild restrictions on the parameter space, increases in value when a country's consumption bundle appreciates. Larger countries should thus have lower risk-free interest rates and stocks in their non-traded sector should pay lower expected returns.[1]

Section 3 introduces the full model in which the economy is affected by monetary shocks in addition to endowment shocks. Introducing money is important for two reasons. First, it provides us with a meaningful way of thinking about currency areas which are distinct from countries. Second, it breaks the tight link between exchange rates and aggregate consumption growth, which is a famously counterfactual prediction of real models of exchange rate determination.

In the full model households must hold currency to settle their transactions and a subset of households in each currency area are precluded from trading in asset markets. These "inactive" households must rely on the nominal money balances carried over from the previous period when purchasing consumption goods. When inflation rises, they pay an "inflation tax" which goes to the benefit of "active" households in equilibrium who consume proportionately more whenever inflation is high.

Strikingly, this process again induces a positive correlation between the real exchange rate of larger currency areas and the marginal utility from traded goods of active households: Following a rise in inflation in a given currency area active households have more consumption goods available. International risk-sharing requires them to share some of these gains with active households in other currency areas by shipping traded goods to the rest of the world. As a consequence, the relative price of non-traded goods falls and the domestic currency depreciates in both real and nominal terms.

However, active households' marginal utility from traded goods falls proportionately more following inflation in a larger currency area as it triggers a relatively larger shipment of traded goods to the rest of the world. As a consequence, a larger currency area tends to appreciate when marginal utility from traded goods is high. It follows that all assets which make payments that are partially fixed in terms of a larger currency area's currency are better hedges against consumption risk. These include risk-free and nominal bonds as well as stocks in the non-traded sector. The introduction of a currency union should thus lower risk-free and nominal interest rates as well as expected returns on stocks in the non-traded sector within participating countries.

The theoretical part of the paper thus yields four testable predictions that link differences in expected returns to differences in the size of economies and currency areas: (1) real and nominal bonds issued in the currencies of larger countries pay lower expected returns; (2) the introduction of a currency union lowers expected returns on bonds within the union; (3) stocks in the non-traded sector of larger countries pay lower expected returns than those of smaller countries; and (4) the introduction of a currency union lowers expected returns on stocks in the non-traded sector of participating countries.

Sections 5 and 6 test these four predictions using a panel dataset of developed economies 1984-2007. Figure 1 shows the raw data. The left hand side of the figure plots the average forward premium of the currencies of 27 OECD countries against the US dollar over a simple measure of the relative

[1] These statements are subject to a slight restriction on the parameter space and to the assumption that differences in the variances of countries' endowments adhere to a regularity condition. The monetary model yields the same predictions without restrictions on the parameter space.

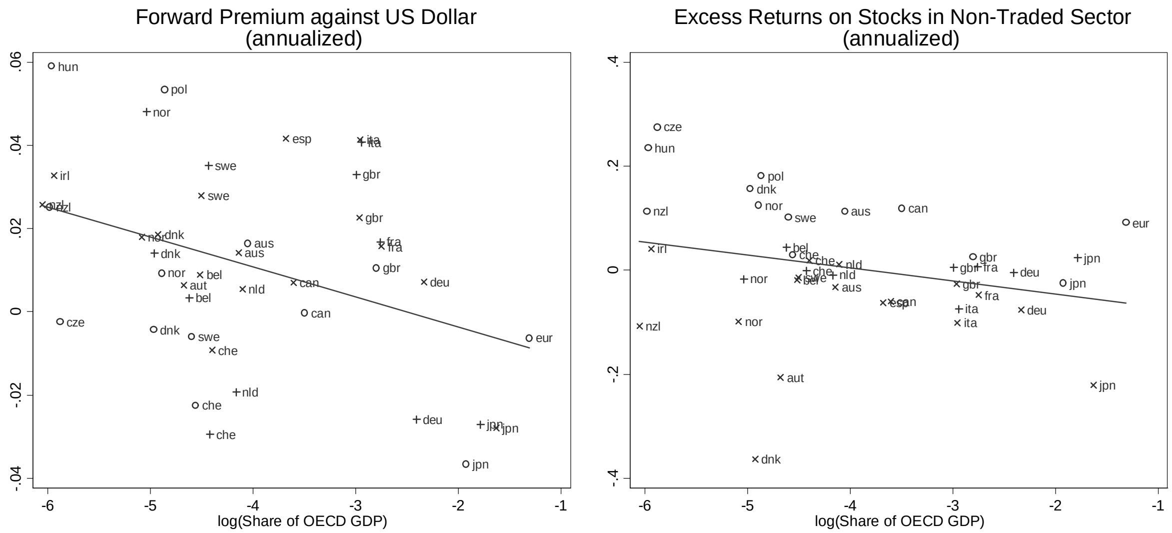


Figure 1: Unconditional scatterplots of annualized forward premia against the US Dollar (left panel) and annualized excess returns to US investors of investing in the non-traded sector of 27 OECD countries vs. the US non-traded sector (right panel) plotted over the log of the share that each country contributes to total OECD output. Each observation in the graph is an average for the years 1984-1990 (+), 1991-1998 (x), and 1998-2007 (○).

size of their economies – the log of the share that each country contributes to total OECD output. Each observation in the graph is an average over the years 1984-1990, 1990-1998, and 1998-2007. We see an economically large negative correlation between this simple measure of country size and forward premia. It implies that a country that contributes 10% of OECD output (such as Germany) on average tends to have a 1.40 percentage points lower (annualized) interest rate than a country that contributes only a negligible share of OECD output. These persistent interest rate differentials translate into persistent violations of uncovered interest parity: US investors earn lower expected returns when investing in bonds denominated in the currencies of larger economies. This pattern cannot be explained by likely alternate channels, such as default risk premia; liquidity premia; or the variance of the bilateral exchange rate. Moreover, I document this effect for the entire yield curve, ranging from 3-month currency forwards to 5-year government bonds. The estimation is robust to dropping different countries and groups of countries from the sample and to using base countries other than the US. I also show that excess returns to US investors from investing in bonds of EMU member countries fell by an average of 2.1 percentage points after European monetary integration. This drop again cannot be explained by improvements in credit default risk due to the accession to the Euro.

The right hand side of Figure 1 shows excess returns to a US investor on a portfolio of industry return indices that proxy for returns in the non-traded sector of the countries in my sample. The negative slope implies that US investors earn systematically lower excess returns in the non-traded sector of larger countries. Moreover, the data show that returns on stocks in the non-traded sector of EMU member countries fell after European monetary integration. All four predictions of the model are thus supported by the data.

Section 7 examines the narrower prediction of the model, that differences in country size indeed explain differences in the covariances of the returns on international bonds with the marginal utility of households who trade in financial markets. It shows that differences in country size indeed explain differences in covariance with long-run consumption growth of US investors and that this variation is priced in the cross-section of currency returns.

To my knowledge, this paper is the first to address the relevance of asymmetries in country size within a standard international asset pricing model and to systematically document the empirical relationship between country size and international returns on stocks and bonds.

The standard approach in international economics is to model variation in exchange rates as the result of either real (Lucas (1982); Stulz (1987)) or monetary shocks (Alvarez, Atkeson, and Kehoe (2002, 2009)).[2] The main theoretical insight of this paper is that both approaches imply a robust relationship between the size of any given economy, its interest rate, and expected stock returns in its non-traded sector. Considering asymmetries in country size within a model that endogenizes the correlation structure of real exchange rates thus offers a simple explanation for persistent deviations from uncovered interest parity.

Parallel literatures study international asset prices in an environment in which the correlation structure of real exchange rates is exogenously specified (Solnik (1974), Adler and Dumas (1983)) and in which the real exchange rate is fixed at one (Cochrane, Longstaff, and Santa-Clara (2008), Menzly, Santos, and Veronesi (2004) and Martin (2007, 2010)).[3]

The model also provides a natural way of thinking about currency areas and about why large currency areas are special. In this sense the paper relates to a literature that centers on the notion of "reserve currencies" (Martin and Rey (2004)) and to the literature on optimal currency areas (Frankel and Rose (2002) and Alesina and Barro (2002)).

The empirical finding that differences in country size indeed explain a significant fraction of the cross sectional variation in interest rates and currency returns is directly relevant for the literature that documents deviations from uncovered interest parity (the carry trade), including Lustig, Roussanov, and Verdelhan (2010) and Menkhoff et al. (2012). Since this finding offers a potential explanation for the persistently low real interest rates in the US it also relates to an emerging literature focusing on the US current account deficit and the role of international return differentials in stabilizing it (Gourinchas and Rey (2005) and Caballero, Farhi, and Gourinchas (2006)). Contrary to the dominant view in this literature, US interest rates do not appear to be exceptionally low once I control for the size of the US economy.

The empirical finding that bonds denominated in currencies of larger economies appear to be better insurance against the consumption risk faced by US investors is in line with Campbell, de Medeiros, and Viceira (2007) who find that the Euro and the dollar are good hedges against the risk faced by a global equity investor, and with Lustig and Verdelhan (2007) who argue that portfolios of bonds

[2] Other real models of exchange rate determination include Stockman and Dellas (1989), Tesar (1993), Stockman and Tesar (1995), Baxter, Jerman, and King (1998), and Collard et al. (2007).

[3] Although there is a tradition of referring to the relative price between different goods as "exchange rates" in these models, that terminology is slightly misleading.

denominated in low interest-rate currencies tend to be good hedges against US consumption risk.

# 2 Complete Markets Model

I begin by setting up a standard "Lucas-tree" endowment economy with complete asset markets. Households consume a bundle of a freely traded good and a country-specific non-traded good. The non-traded component in consumption allows the consumption price index to differ across countries; and the real exchange rate between any two countries is the ratio of their consumption price indices. The only respect in which I depart from the standard real model of exchange rate determination is that I allow for countries to differ in the size of their economies.

In order to provide closed-form solutions, I assume that households receive transfer payments before trading in complete asset markets commences so that the initial distribution of wealth exactly decentralizes a Social Planner's problem with unit Pareto weights. In the main part of the paper I therefore do not consider the effects that asymmetries in country size may have on the distribution of initial wealth across countries. Moreover, I log-linearize the model. Appendix E gives a numerical solution of the model and demonstrates that neither of these two simplifications matter for the results in a meaningful way.

In order to keep the exposition simple, the main text focuses on the case in which the traded consumption good endowed in all countries is the same, and endowments are uncorrelated internationally and between tradables and non-tradables. The Appendix gives parallel results for the case in which households in each country receive endowments of a differentiated traded good (Appendix A sets up the generalized model). I refer to these results in the main text when they are relevant. Section 3.3 discusses extensions of the model that allow for correlated endowments, endogenous production, and capital accumulation.

## 2.1 Economic Environment

The model economy exists at two discrete periods of time $t = 1, 2$. It is populated with a set of identical households on the interval $[0, 1]$. The set of households is partitioned into $N$ subsets $\Theta^n$ of measure $\theta^n$, $n = 1, ..., N$. Each subset represents the constituent households of a country $n$.

At the beginning of the second period, households receive a stochastic endowment of a homogenous traded and of a country-specific non-traded good. Shocks to endowments are common within each country such that all households within a country $n$ receive the same amount, $Y^n_{T2}$, of the traded good and the same amount, $Y^n_{N2}$, of their country-specific non-traded good. Endowments are log-normally distributed

$$y^n_{T2}, y^n_{N2} \sim N\left(-\frac{1}{2}\sigma^2_n, \sigma^2_n\right) \ \forall n, \tag{1}$$

where the variance of endowments, $\sigma^2_n$, may differ across countries and I assume that $\sigma^2_n$ is the same for traded and non-traded goods within each country (this is not crucial). Throughout the paper, lowercase variables stand for logs and uppercase variables stand for levels. In order to simplify notation, call $\omega$ the configuration of second period endowments and let $g(\omega)$ be the associated density. For simplicity, the endowments in the first-period are not stochastic and households receive exactly one unit of the traded and one unit of the non-traded consumption good. Furthermore, endowments cannot be stored but must be consumed in the period in which they were received. International trade in the traded consumption good is costless. Throughout the paper I use the traded consumption good as the numéraire, such that all prices are accounted for in terms of the same units.

**Households** exhibit constant relative risk aversion according to

$$U(i) = \frac{1}{1-\gamma} C_1(i)^{1-\gamma} + e^{-\delta} \frac{1}{1-\gamma} E\left[C_2(i)^{1-\gamma}\right], \tag{2}$$

where $E$ is the rational expectations operator conditional on all information available in period 1, $\delta$ is the time preference rate, and $C_t(i)$ is a consumption index for household $i$ at time $t$. I assume that households are risk-averse with $\gamma > 0$. The consumption index is defined as

$$C_t(i) = \left[\tau C_{T,t}(i)^{\alpha} + (1-\tau) C_{N,t}(i)^{\alpha}\right]^{\frac{1}{\alpha}}, \ \alpha < 1, \tag{3}$$

where $C_N$ is consumption of the country-specific non-traded good, $C_T$ stands for consumption of the traded good, and $\tau \in (0,1)$ is the weight of the traded good in the consumption index.[4]

## 2.2 Market structure and equilibrium

At the beginning of the first period, households may trade a complete set of state-contingent securities. Before trading commences, individuals receive a country-specific transfer that de-centralizes the Social Planner's allocation with unit Pareto weights.

Households take prices as given and maximize their lifetime utility (2) subject to their intertemporal budget constraint

$$C_{T1}(i) + P^n_{N1} C_{N1}(i) + \int_{\omega} Q(\omega)\left(C_{T2}(\omega,i) + P^n_{N2}(\omega) C_{N2}(\omega,i)\right) d\omega = W_1(i), \tag{4}$$

where $Q(\omega)$ is the first period price of a state-contingent security that pays one unit of the traded good if state $\omega$ occurs in the second period. $P^n_N$ denotes the spot price of the non-traded good in country $n$, and $W_1(i)$ stands for the net present value of household $i$'s endowments, net of the country-specific transfer.

The economy is at an equilibrium when all economic actors behave according to their optimal program and goods markets clear.[5]

[4] Note that the full model with differentiated traded goods has the natural implication that larger countries have a lower trade to GDP ratio in equilibrium, even though households in all countries have the same preference parameter $\tau$.

[5] Formally, $W_1(i) = Y^n_{T1} + P^n_{N1} Y^n_{N1} + \int_{\omega} Q(\omega)\left(Y^n_{T2}(\omega) + P^n_{N2}(i,\omega) Y^n_{N2}(\omega)\right) d\omega + \kappa^n$, where $\kappa^n$ is the country specific transfer in period one and $\sum_{n=1}^{N} \theta^n \kappa^n = 0$. The market clearing conditions are

$$\int_{i\in[0,1]} Y^n_T di = \int_{i\in[0,1]} C_T(i)\, di \quad \text{and} \tag{5}$$

$$\int_{i\in\Theta^n} Y^n_N di = \int_{i\in\Theta^n} C_N(i)\, di, \ n = 1, ...N. \tag{6}$$

## 2.3 Optimal Behavior and International Spreads

Households' optimal behavior is characterized by the Euler equation

$$Q(\omega) = e^{-\delta} \frac{\Lambda_{T2}(\omega)}{\Lambda_{T1}} g(\omega) \quad \forall \omega, \tag{7}$$

where $\Lambda_{T,t} = C_t(i)^{1-\gamma-\alpha} C_{T,t}(i)^{\alpha-1}$ is the marginal utility from tradable consumption at time $t$. In equilibrium, this marginal utility is equalized across all households in all countries. Thus, all households price assets using the ratio of marginal utilities from *tradable* consumption as the unique stochastic discount factor. (This is due to the fact that we chose the traded good as the numéraire. Any other choice of units would result in a different stochastic discount factor for residents of each country.) Based on this result, we can make a general statement about the spread on any two international assets (recall that lowercase letters stand for logs, $\lambda_T = \log \Lambda_T$):

**Lemma 1** *The difference in log expected returns between two arbitrary assets with log-normally distributed payouts $X$ and $Z$ equals the covariance of the difference of their log payouts with the log of the marginal utility of tradable consumption.*

$$\log ER[X] - \log ER[Z] = cov(\lambda_{T2}, z - x), \tag{8}$$

*where $\lambda_{T2}$ is normally distributed and $R[\bullet]$ refers to the gross return (in terms of traded goods) of an asset paying $\bullet$.*

**Proof.** See Appendix A.1. ■

Households thus prefer assets that pay off well when the marginal utility from tradable consumption is high. Whichever asset has the higher covariance with the marginal utility of tradable consumption must therefore pay a lower expected return in equilibrium. Importantly, the left hand side of (8) is the log of a ratio of two returns and therefore has no units. The results on international spreads which I derive below are thus invariant to the numéraire chosen. Throughout the paper I work with differences in log expected returns to economize on notation; all results for differences in expected returns are qualitatively the same and quantitatively identical up to a correction for Jensen's inequality.

## 2.4 Allocation

As asset markets are complete in this economy, we can obtain the equilibrium allocation by solving the Social Planner's problem. Given that endowments cannot be carried over from the first period to the second, the Social Planner's problem is the same in each period and invariant to the state of the world. I therefore concentrate on the second period and omit the time subscript from here on. Moreover, since all households within a given country are identical and receive the same endowments, they must also consume the same bundle $(C_T^n(\omega), C_N^n(\omega))$ in equilibrium.

The Social Planner's problem can therefore be written as

$$\max \sum_{n=1}^{N} \theta^n \frac{1}{1-\gamma} \left[\tau (C_T^n)^\alpha + (1-\tau)(C_N^n)^\alpha\right]^{\frac{1-\gamma}{\alpha}} \tag{9}$$

subject to the economy's resource constraints (5) and (6). I log-linearize the first-order conditions and resource constraints around the point at which $[y_T, y_N]' = 0$ in order to provide closed-form solutions.[6]

Equation (10) gives intuition for how households share risk in this economy. It shows the equilibrium consumption of the traded good in an arbitrary country $h$, which we may think of as the home country (recall that lowercase variables indicate logs):

$$c_T^h = \bar{y}_T + \frac{(\gamma - \varepsilon_\alpha^{-1})(1-\tau)}{\varepsilon_\alpha^{-1}(1-\tau) + \tau\gamma}\left(\bar{y}_N - y_N^h\right), \tag{10}$$

where $\bar{y}_N = \sum_{n=1}^N \theta^n y_N^n$ is the average of log endowments of non-tradables across countries, and $\bar{y}_T$ is the log world endowment of tradables. As one may expect, home consumption of the traded good moves one for one with the world supply. Since the traded good can be freely shipped around the globe, it is inconsequential which country has a better or worse endowment of tradables, as long as $\bar{y}_T$ is constant. Households thus perfectly share risk when it comes to endowments of the traded good. However, the second term of (10) shows that they also use the traded good in order to insure against risk in their non-tradable endowments. Although non-tradables cannot be shipped, households purchase insurance in world markets in the form of compensating deliveries of traded goods if the following condition holds:

**Condition 1** *Households are sufficiently risk-averse such that $\gamma\varepsilon_\alpha > 1$.*

This condition ensures that the cross-partial of marginal utility from tradable consumption with respect to the non-traded good is negative, i.e. that the relative price of a country's non-traded good falls when its supply increases. As most empirical applications of the standard international asset pricing model find a relative risk aversion significantly larger than one and an elasticity of substitution around one, I follow the literature in assuming that this condition is met, but refer to it whenever it is relevant (see Coeurdacier (2006) for a detailed discussion). If relative risk aversion is sufficiently high, households in the home country thus receive additional tradables whenever they have a lower than average endowment of non-tradables.

This risk-sharing behavior is reflected in the equilibrium marginal utility from tradable consumption,

$$\lambda_T = -((1-\tau)\varepsilon_\alpha^{-1} + \tau\gamma)\sum_{n=1}^N \theta^n y_T^n - (1-\tau)(\gamma - \varepsilon_\alpha^{-1})\sum_{n=1}^N \theta^n y_N^n + \log(\tau). \tag{11}$$

The first term on the right hand side shows that marginal utility from tradable consumption unambiguously falls with the world supply of tradable goods. The second term states that the same is true for the average non-tradable endowment, as long as condition 1 holds. Thus $\lambda_T$ tends to be low in "good" states of the world. Note, however, that not every shock to endowments has the same influence on $\lambda_T$. Since larger countries account for a larger share of the world endowment, they have a larger influence on the marginal utility from tradable consumption – it takes a larger share of the world

[6] See Appendix A.2 and A.3 for details on the social planner's problem. Appendix B.4 shows the log-linearized system of equations. This log-linearized solution is identical to the solution obtained with a second-order perturbation around the same point (see Appendix D).

endowment of traded goods to compensate for a bad endowment in the non-traded sector of a larger economy. *Bad times in a large economy are thus likely bad times for the average world investor.*

## 2.5 Prices and Exchange Rates

Now that we know the price of risk in this economy we need only to understand the behavior of relative prices and exchange rates before we can work out the spreads on international assets. From the Lagrange multipliers associated with the Social Planner's problem we can obtain equilibrium prices of the goods traded in this economy.

The number of traded goods needed to purchase one unit of country $n$'s equilibrium consumption bundle is

$$p^n = \lambda^n - \lambda_T = \log\left(\frac{(1-\tau)^{\tau-1}}{\tau^\tau}\right) + (1-\tau)\, p_N^n, \tag{12}$$

where $\lambda^n = -\gamma c^n$ is the marginal utility of households in country $n$ and $p_N^n$ is the relative price of country $n$'s non-traded goods.

Keeping in mind that we use the traded good as numéraire, the equilibrium price of the non-traded good is:

$$p_N^h = \varepsilon_\alpha^{-1}\bar{y}_T + \frac{\varepsilon_\alpha^{-1}(1-\tau)\left(\gamma - \varepsilon_\alpha^{-1}\right)}{\varepsilon_\alpha^{-1}(1-\tau)+\tau\gamma}\bar{y}_N - \frac{\varepsilon_\alpha^{-1}\gamma}{\varepsilon_\alpha^{-1}(1-\tau)+\tau\gamma}y_N^h - \log(\frac{\tau}{1-\tau}) \tag{13}$$

The first two terms on the right hand side are functions of world endowments and thus common to all countries. Only the third term is specific to each country and thus relevant for international return differentials: It shows that the higher the endowment of the non-traded good in the home country, the lower is its relative price.

If we think of each country as using its own currency, then $p^n$ is the value of one real unit of country $n$'s currency in terms of traded goods. In contrast, the real exchange rate between two countries, call them $f$ and $h$, measures how expensive consumption is in one country relative to consumption in the other country:

$$s^{f,h} = \lambda^f - \lambda^h = (1-\tau)\left(p_N^f - p_N^h\right), \tag{14}$$

The real exchange rate between two countries depends only on the difference between their relative prices of non-tradables, and this difference in turn depends solely on the relative endowment of non-traded goods in the two countries: If the home country has a relatively large endowment of the non-traded good, $p_N^h$ falls relative to $p_N^f$ and the domestic consumption bundle depreciates relative to the foreign consumption bundle. Note also that endowments in the traded sector have no bearing on the real exchange rate since changes in the relative scarcity of the traded good affect the price of consumption of all countries in the same way.

## 2.6 Spread on International Bonds

From lemma 1 we know that determining the spread between any two assets is a matter of determining how their second period payoffs co-vary with $\lambda_T$.

**Definition 1** *A country n risk-free bond is an asset which is risk-free in terms of the utility of the residents of country n. It pays $p^n$ traded goods in the second period.*

From the perspective of the households of each country there is only one asset which is risk-free, and this asset pays the exact amount of units of the traded good required to buy one unit of the country-specific final consumption bundle, $p^n$.[7] While this payoff is riskless from the perspective of households in the home country, its value in terms of traded goods depends on the state of the world which is realized ex-post: When the domestic endowment of non-tradables is high, the home consumption bundle depreciates and the payoff of the risk-free bond is low (in terms of traded goods). Conversely, the payoff from the risk-free bond is high when the non-tradable endowment is low.

These movements in the relative price of domestic consumption are independent of country size as the real exchange rate is fully determined by the *relative* (per household) endowment of non-tradables and independent of $\theta$ (see equations (12) and (13)). For a given percentage fall in the non-tradable endowment, a small country appreciates just as much as a large country, but $\lambda_T$ rises more sharply if the fall is in the endowment of a larger country. The consumption bundles of large countries thus tend to appreciate when marginal utility is high. For the case in which the variance of endowment shocks is the same in all countries, it follows immediately that large-country bonds are better hedges against consumption risk: Their payoffs have a larger covariance with $\lambda_T$ than small-country bonds. More generally, this is the case if the following regularity condition holds:

**Condition 2** *The variance adjusted measure of differences in country size $\sigma_h^2\theta^h - \sigma_f^2\theta^f$ is monotonic in the actual difference in country size $\left(\theta^h - \theta^f\right)$, i.e. $\sigma_h^2\theta^h > \sigma_f^2\theta^f$ iff $\theta^h > \theta^f$ for any country pair $h, f$.*

This condition on the variances of endowments is very mild. It means that $\sigma^2$ must decrease less than linearly with country size. For example, such a linear relationship would arise in a model in which there are no country-specific shocks and endowments to each individual are i.i.d. As long as there is some country-specific element to shocks faced by households, condition 2 will thus typically hold.

**Proposition 1** *The difference in log expected returns of two countries' risk-free bonds is given by*

$$r^f + \Delta E s_2^{f,h} - r^h = cov\left(\lambda_{T2}, \lambda^h - \lambda^f\right) = \frac{\varepsilon_\alpha^{-1}(\gamma - \varepsilon_\alpha^{-1})}{\varepsilon_\alpha^{-1}(1-\tau) + \tau\gamma}\gamma(1-\tau)^2\left(\sigma_h^2\theta^h - \sigma_f^2\theta^f\right), \qquad (15)$$

*where $r^n$ is the country n risk-free interest rate and $\Delta E s_2^{f,h} = \log\left(Ep_2^f / Ep_2^h\right) - s_1^{f,h}$ is the expected change in the real exchange between countries f and h net of the correction for Jensen's inequality. Given conditions 1 and 2, the larger country's risk-free bond pays lower expected returns.*

**Proof.** Use lemma 1 together with $X = P^f$, $Y = P^h$, (13) and (12). The left hand side of (15) follows from the fact that $\log ER\left[P^f\right] - \log ER\left[P^h\right] = r^f + \Delta E s_2^{f,h} - r^h$, where $R[\bullet]$ is the gross return (in

[7] We can re-derive (12) by minimizing the expenditure required to obtain one unit of $C$. The consumer price index thus pays a fixed number of utils. See Appendix A.4 for details.

terms of traded goods) on an asset that pays $\bullet$.[8] ■

Proposition 1 states that the marginal utility of consumption of households in larger countries is more volatile and more correlated with the marginal utility from traded consumption than that of households in smaller countries. As a consequence, uncovered interest parity (UIP) fails between countries that are not of the same size. This departure from UIP results from the fact that larger countries have lower risk-free interest rates. A carry trade strategy shorting a larger country's risk-free bond and going long a smaller country's risk-free bond yields positive expected returns. These positive expected returns are a compensation for consumption risk as the larger country's consumption bundle tends to appreciate in states of the world in which $\lambda_T$ is high. The difference in log expected returns rises unambiguously with the difference in size, with relative risk aversion, $\gamma$, and with the weight of non-tradables in households' consumption bundles $(1-\tau)$.

On the surface, proposition 1 also reflects a well-known and undesirable property of real models of exchange rate determination; exchange rates are perfectly correlated with differences in aggregate consumption growth across countries and, as a consequence, countries with lower risk-free interest rates have more volatile aggregate consumption growth. However, neither of these properties are central to the deeper logic that larger countries' bonds are better hedges against consumption risk. We will return to this issue in section 3.

### 2.7 Spread on International Stocks

The fact that larger countries' consumption bundles tend to appreciate when marginal utility from traded goods is high has implications for the risk premia on all assets which pay off in proportion to these country-specific consumption bundles. A portfolio of assets which is mean-variance efficient from the perspective of households in country $i$ pays multiples of $\lambda^i$. Multiples of the covariance $cov\left(\lambda_{T2}, \lambda^h - \lambda^f\right)$ thus give the difference in log expected returns between two portfolios which are mean-variance efficient from the perspective of households in the two countries. Proposition 1 is therefore part of a broader result which states that a portfolio which pays a positive multiple of a larger country's marginal utility pays a lower expected return than a (corresponding) portfolio which pays the same positive multiple of a smaller country's marginal utility. As long as $\gamma > 1$, one of this set of corresponding mean-variance efficient portfolios is the equilibrium portfolio held by households in each country, which pays $c^i + p^i = \left(1 - \frac{1}{\gamma}\right)\lambda^i - \lambda_T$ units of the traded good.[9]

While we cannot easily observe the set of portfolios that are mean-variance efficient from the perspective of households in different countries we can use the structure of the model to map the differences in expected returns between these portfolios into differences in expected returns between assets which we observe in the data.

[8] An alternative derivation of the same result uses the familiar condition $r^f + Es_2^{f,h} - s_1^{f,h} - r^h = 0.5\left(var\left(\lambda^h\right) - var\left(\lambda^f\right)\right)$. I do not emphasize this approach as it is significantly more cumbersome when pricing assets that are not risk-free in terms of consumption, such as nominal bonds and stocks.

[9] By the two-fund separation theorem portfolios that pay a convex combination of the country $i$ risk-free bond and a portfolio paying the equilibrium consumption of country $i$ are mean-variance efficient from the perspective of country $i$ and pay $(1-w)P^i + wC^iP^i$ traded goods, where $w \geq 0$. The log-linear approximation to this payoff is $\left(1 - \frac{w}{\gamma}\right)\lambda^i - \lambda_T$, where $w \in (0, \gamma]$ traces out the set of mean-variance efficient portfolios which pay positive mulitples of $\lambda^i$.

**Definition 2** *Country n stock in the non-traded (traded) sector is a claim to one household's second period endowment of the non-traded (traded) good.*

Appendix A.5 shows a natural de-centralization of the model in which households can trade stocks in the traded and non-traded sectors. In this de-centralization the mean-variance efficient portfolios of all countries are identical in their loadings on stock in the traded sector and differ only in their loadings on stock in the non-traded sector. The intuition for this result is again that differences in endowments in the traded sector have no impact on differences in consumption, and consequently have no impact on differences in returns between portfolios which pay a given multiple of marginal utility in different countries. Any differences in expected returns between two corresponding mean-variance efficient portfolios of different countries must therefore result from differences in expected returns on stocks in the non-traded sector.

Stock in the **non-traded sector** of country $n$ pays off $P_N^n Y_N^n$.

**Condition 3** *The elasticity of $P_N^f / P_N^h$ with respect to $Y_N^h$ is greater than one, $\gamma + \tau > \tau\gamma\varepsilon_\alpha + 1$.*

**Proposition 2** *The difference in log expected returns of two countries' stocks in the non-traded sector is given by*

$$\rho_N^{h,f} = \frac{(1-\tau)(\gamma\varepsilon_\alpha - 1)(\gamma + \tau - \tau\gamma\varepsilon_\alpha - 1)}{\varepsilon_\alpha (1 - \tau + \tau\gamma\varepsilon_\alpha)} \left(\sigma_h^2 \theta^h - \sigma_f^2 \theta^f\right), \tag{16}$$

*where $\rho_N^{h,f}$ is a shorthand for* $\log ER\left[P_N^f Y_N^f\right] - \log ER\left[P_N^h Y_N^h\right]$.
*Given conditions 1, 2, and 3, stock in the larger country's non-traded sector pays lower log expected returns.*

**Proof.** Lemma 1 implies $\rho_N^{h,f} = cov\left(\lambda_T, \left(p_N^h + y_N^h\right) - \left(p_N^f + y_N^f\right)\right)$. Using (12) and (13) we can write $p_N^f + y_N^f - \left(p_N^h + y_N^h\right) = \frac{(\gamma+\tau-\tau\gamma\varepsilon_\alpha - 1)}{\gamma(1-\tau)}\left(\lambda^h - \lambda^f\right)$ and $\rho_N^{h,f} = \frac{(\gamma+\tau-\tau\gamma\varepsilon_\alpha - 1)}{\gamma(1-\tau)} cov\left(\lambda_T, \lambda^h - \lambda^f\right)$. The difference in log expected returns of two countries' stocks in the non-traded sector is thus a positive multiple of the difference in log expected returns on their risk-free bonds if condition 3 holds. Proposition 2 then follows directly from Proposition 1. ■

Condition 3 requires that a country's endowment in the non-traded sector becomes more valuable relative to that of other countries when its non-traded good is relatively scarce. (This means that the country's "currency" appreciates enough for the endowment to become relatively more valuable from the perspective of an international investor.) The same condition ensures that households hold home-biased equity portfolios in equilibrium if $\gamma > 1$.[10] It therefore holds in any reasonable calibration of the model. Given this condition, stock in the non-traded sector of larger countries must pay lower expected returns and, as a consequence, the same is true for all corresponding mean-variance efficient portfolios of larger countries which are skewed towards these assets.

This tight link between country size and expected returns on risk-free bonds and stocks in the non-traded sector arises because differences in the payoffs of both assets across countries are proportional to

[10] See Appendix A.5 for a formal proof and Appendix A.6 for a more detailed discussion of conditions 1 and 3. Coerdacier and Rey (2011) provide a a recent survey of the literature on home bias in equity.

differences $\lambda^i$, i.e. to the part of consumption risk which cannot be shared internationally. In contrast, differences in the payoffs of stocks in the traded sector are unrelated to this country-specific part of consumption risk as traded goods can be freely shipped across countries. As a result, any spread on stocks in the **traded sector** is unrelated to differences in risk-free interest rates across countries. The model therefore makes an ambiguous prediction for the relationship between country size and expected returns on stocks in the traded sector. The difference in log expected returns on two countries' stock in the traded sector is given as

$$\rho_T^{h,f} = \left(\varepsilon_\xi^{-1} - 1\right)\left((1-\tau)\varepsilon_\alpha^{-1} + \tau\gamma\right)\left(\sigma_h^2\theta^h - \sigma_f^2\theta^f\right), \tag{17}$$

where $\varepsilon_\xi$ is the elasticity of substitution between varieties of the traded good. (As this is the only result for which this parameter is relevant I have abstracted from it in the main text by setting $\varepsilon_\xi = \infty$, see Appendix A for the full notation.) The sign of the spread on stocks in the traded sector depends only on $\varepsilon_\xi$. If $\varepsilon_\xi > 1$, the relative price of a variety does not move enough to offset the gains from a larger endowment and stocks pay off well whenever the endowment of the variety in question is large. Since a larger country's endowment is more negatively correlated with $\lambda_T$, stock in a larger country's traded sector is then a bad hedge against consumption risk and it must pay a *higher* expected return in equilibrium. (This finding is similar to that in Cochrane, Longstaff, and Santa-Clara (2008), where tradable varieties of two countries are perfect substitutes, $\varepsilon_\xi = \infty$.) If $\varepsilon_\xi < 1$, these dynamics reverse, and stock in a larger country's traded sector is a better hedge against consumption risk.

# 3 Incomplete Markets Model and Monetary Shocks

In the previous section we have established two central implications of country size for international return differentials under complete asset markets. While the complete-markets model is an important benchmark, it predicts a counterfactually tight link between exchange rates and aggregate consumption growth, and allows no role for monetary shocks to influence the equilibrium allocation. It thus makes the question of which currency is used in which part of the world almost meaningless.

In this section, I relax the complete markets assumption, which allows me to address both of these issues and also shed some light on the link between the size of currency areas and international return differentials. The extension of the model follows Alvarez, Atkeson, and Kehoe (2002) in assuming that only a subset of households within each country have access to international asset markets and that households are required to hold currency in order to undertake economic transactions.

## 3.1 Extending the Model

Each country has a central bank which issues a national currency. Central banks introduce fresh liquidity through open market operations in a complete set of state contingent bonds denominated in their respective currencies. Within each country, a fixed proportion $\phi$ of ("active") households has access to world asset markets where households and central banks trade the state contingent bonds. The complementary proportion of ("inactive") households has no access to asset markets. All goods must be exchanged for cash. More specifically, I assume that all goods must be paid for in the home currency of the country from which they originate (the reverse assumption generates identical results). Currencies are freely convertible without restriction and all households within a given country start the first period with identical cash holdings.

I assume that the central banks target inflation between the first and second period at some positive level $\mu$, but generate net monetary shocks, such that realized inflation, $\tilde{\mu}_2^n$, is normally distributed around its target level $\mu$ with variance $\tilde{\sigma}_n^2$. For simplicity, I further assume that this target level is sufficiently high so that inactive households' cash in advance constraint always binds in the first period, $\mu > \delta/(\gamma - 1)$ (see Appendix B.2 for details).

The following discussion focuses on the impact of monetary shocks by showing analytical results for the special case in which there are no endowment shocks, $[y_{T,2}, y_{N,2}]' = 0$. Appendix B gives all the formal details on the extended model and unabridged analytical solutions. Section 3.3 discusses the case in which real and monetary shocks are correlated.

### 3.2 Monetary Shocks and International Spreads

Since active households have access to complete asset markets they are never nominally cash constrained and are able to hedge their portfolio against inflation. Inactive households on the other hand are nominally cash constrained and vulnerable to inflation. By solving for both active and inactive households' policies we can show the following result:

**Lemma 2** *In the second period, all active households within a given country $n$ consume the same bundle $\left(C_{T2}^n(\omega), C_{N2}^n(\omega)\right)$, and all inactive households consume the bundle*

$$\hat{C}_{T2}^n = \frac{\exp\left(-\tilde{\mu}^n\right)}{\tau\left(1 + \left(P_{N2}^n\right)^{\frac{-\alpha}{1-\alpha}}\left(\frac{1-\tau}{\tau}\right)^{\frac{1}{1-\alpha}}\right)}, \quad \hat{C}_{N2}^n = \frac{\exp\left(-\tilde{\mu}^n\right)}{\tau P_{N2}^n\left(\left(\frac{1-\tau}{\tau}\right)^{\frac{-1}{1-\alpha}}\left(P_{N2}^n\right)^{\frac{\alpha}{1-\alpha}} + 1\right)}. \tag{18}$$

**Proof.** See Appendix B.2. ■

Equations (18) show that a monetary expansion acts as an "inflation tax" on inactive households. The higher inflation, the less their money holdings are worth and the less they are able to consume. However, since monetary shocks have no bearing on the real endowments available for consumption, this reduction of consumption on the part of the inactive households must go to the benefit of the active households in equilibrium. Since only a fraction $\phi$ of households trade with central banks in their open market operations, the securities that insure against inflationary shocks trade below their actuarially fair price, thus re-distributing the inflation tax from inactive to active households via the marketplace. This shift in consumption has important implications for asset prices. Since only active households trade in asset markets, it is their marginal utility that determines asset prices,

$$\lambda_T = -\frac{1-\phi}{\phi}\gamma\sum_{n=1}^{N}\theta^n\tilde{\mu}^n, \tag{19}$$

where $\lambda_T$ is now *active households'* marginal utility from tradable consumption. This expression is similar to (11) in that inflationary shocks unambiguously lower $\lambda_T$, but their impact is proportional to the size of the country in which they originate. Inflationary shocks in larger countries thus have a larger impact on marginal utility than inflationary shocks in smaller countries.

Active households' equilibrium consumption of tradables is

$$c_T^h = \frac{1-\phi}{\phi}\tilde{\mu}^h + \frac{(1-\phi)\,\gamma\left[\varepsilon_\alpha + \frac{1-\phi}{\phi}\left(1-\tau\left(1-\varepsilon_\alpha\right)\right)\right]}{\left(1-\tau\left(1-\varepsilon_\alpha\right)\right)\gamma - (\gamma-1)\,(1-\tau)\,\phi}\left(\bar{\mu}^n - \tilde{\mu}^h\right), \tag{20}$$

where $\bar{\mu} = \sum_{n=1}^{N} \theta^n \tilde{\mu}^n$ is the weighted average inflation rate across all countries. The first term on the right hand side reflects the immediate rise in active households' consumption which is proportional to the number of inactive households per active household. However, risk-sharing among active households of different countries requires that some of the initial rise in consumption is shared internationally, which is reflected in the second term on the right hand side (the fraction is unambiguously positive). Whenever domestic inflation exceeds weighted average inflation $\bar{\mu}$, the home country ships traded goods to the rest of the world, lowering the relative price of domestic non-traded goods:

$$p_N^h = \frac{\gamma\,(1-\phi)}{\left(1-(1-\varepsilon_\alpha)\,\tau\right)\gamma - (\gamma-1)\,(1-\tau)\,\phi}\left(\bar{\mu} - \tilde{\mu}^h\right). \tag{21}$$

As a result, the domestic currency *depreciates* in real terms whenever inflation is high, and this depreciation again happens regardless of the size of the country in question.[11]

It immediately follows that a larger country's risk-free bond is a better hedge against consumption risk. It tends to pay off badly when $\lambda_T$ is low and it tends to pay off well when $\lambda_T$ is high. Moreover, the same is true for stocks in the non-traded sector. Since monetary shocks move only the price of non-tradables and have no impact on $Y_N^h$, stocks in the non-traded sector pay off proportionally to the relative price of non-tradables. Both larger countries' risk-free bonds and larger countries' stocks in the non-traded sector must therefore pay lower expected returns in equilibrium. Proposition 3 formalizes these findings.

**Proposition 3** *In the presence of only monetary shocks, the difference in log expected returns on two countries' stocks in the non-traded sector is given by*

$$\rho_N^{h,f} = \frac{\gamma^2(1-\phi)^2}{\left(\left(1-(1-\varepsilon_\alpha)\,\tau\right)\gamma - (\gamma-1)\,(1-\tau)\,\phi\right)\phi}\left(\tilde{\sigma}_h^2\theta^h - \tilde{\sigma}_f^2\theta^f\right). \tag{22}$$

*Moreover, the difference in log expected returns on risk-free bonds is* $\rho^{h,f} = (1-\tau)\,\rho_N^{h,f}$.
*Given that condition 2 holds for the variances of monetary shocks, both risk-free bonds and stocks in the non-traded sector of larger countries pay lower log expected returns.*

**Proof.** Use (19), (21) and follow the proof of Proposition 1. ■

It is striking that these conclusions are not only qualitatively the same as in the purely real model, but that they are actually slightly stronger. Unlike in Propositions 1 and 2 we require no restrictions

[11] $\bar{\mu}$, the only argument in (21) that depends on $\theta$, is common to all countries and thus has no impact on the real exchange rate in (14).

on the parameter space to find that larger countries' bonds and stocks in the non-traded sector pay lower expected returns.[12]

Since we now have a well-defined notion of currency in our model, we may also solve for the equilibrium spread on nominal bonds, which have a real (log) payoff of $p^n - \tilde{p}_T^n$, where $\tilde{p}_T^n$ is the (log of) the nominal price of the traded good in country $n$. When inflation is high, $p^n$ falls as the domestic currency depreciates and $\tilde{p}_T^n$ rises. The nominal component of the payoff therefore merely reinforces the correlation between the risk-free component and $\lambda_T$. The spread between nominal bonds of different countries must thus always be larger than the spread between their risk-free bonds.[13] Finally, note that monetary shocks have no implications for the spread on stocks in the traded sector as their ex-post payoff is not affected by inflation.

## 3.3 International Spreads with Real and Monetary Shocks

Appendix B gives solutions for the case in which the economy is affected both by real and monetary shocks. The analytical expressions detailing the impact of the endowments on the equilibrium are now slightly more involved. However, the economic mechanisms are identical to those discussed in the complete markets model. The only relevant difference is that conditions 1 and 3 are modified slightly. We may thus conclude that (with the exception of parameter combinations for which the modified conditions 1 or 3 are violated) both real and monetary shocks induce correlations that make bonds and stocks in the non-traded sector of larger countries better hedges against consumption risk than those of smaller countries.[14]

While allowing for market segmentation reinforces the central economic insight from section 2 it simultaneously addresses the main empirical failure of real models of exchange rate determination (Backus and Smith (1993)) by breaking the link between exchange rates and aggregate consumption growth. While real shocks induce a (counterfactual) negative correlation between exchange rates and differences in aggregate consumption growth (a high endowment in the non-traded sector leads to a rise in aggregate consumption and a depreciation of the domestic consumption bundle), monetary shocks induce the opposite. A rise in inflation leads to a depreciation but triggers an outflow of traded goods and thus *lowers* aggregate consumption. The full model therefore allows for positive as well as negative correlations between exchange rates and aggregate consumption growth and, as a consequence, also makes no prediction about the relationship between country size and the volatility of aggregate consumption growth. (See Appendix B.5 for a formal proof of these statements.)

**Correlated Real and Monetary Shocks** The model generalizes easily to the case in which

[12] In the purely real model, we needed condition 1 to ensure that households are sufficiently risk averse relative to the elasticity of substitution between tradable and non-tradable consumption, such that an increase in non-tradable endowment would lower the marginal utility of tradable consumption. But since inflation directly affects the amount of tradables available to active households, it must always lower marginal utility, regardless of the relationship between $\gamma$ and $\varepsilon_\alpha$.

[13] Formally, it is given by

$$\rho^{h,f}_{\text{nominal}} = \frac{\gamma(1-\phi)\left((1-\phi)\left[(1-\tau)\gamma + (\gamma-1)(1-\tau)\right] + (1-\tau(1-\gamma\varepsilon_\alpha))\right)}{((1-(1-\varepsilon_\alpha)\tau)\gamma - (\gamma-1)(1-\tau)\phi)\phi}\left(\tilde{\sigma}_h^2\theta^h - \tilde{\sigma}_f^2\theta^f\right).$$

[14] The modified conditions are $\gamma > \varepsilon_\alpha^{-1}\frac{\phi}{1-\varepsilon_\alpha^{-1}(1-\phi)}$ and $\gamma(\varepsilon_\alpha^{-1}(1-(1-\phi)(1-\tau)) - \tau) > \phi\varepsilon_\alpha^{-1}(1-\tau)$, respectively.

endowments and monetary shocks are correlated within each country. For example, one may expect monetary expansions to occur in states of the world in which $y_T$ is large, $corr\left(\tilde{\mu}, y_T\right) > 0$. In this case, a given depreciation of the domestic currency due to a high $\tilde{\mu}$ is associated with a larger movement in $\lambda_T$, which (in proportion to country size) now drops for two reasons: The shift in consumption from inactive to active households, and the higher availability of traded goods in equilibrium. Larger countries' bonds and stocks in the non-traded sector are therefore even better hedges against consumption risk if $corr\left(\tilde{\mu}, y_T\right) > 0$. A similar logic also holds for the correlation between monetary expansions and the endowment of the non-traded good, as well as for the correlation between domestic endowments $y_T$ and $y_N$. In fact, Appendix C shows that:

*Given conditions 1, 2, and 3, international spreads on bonds and stocks in the non-traded sector increase linearly with the within-country correlation between endowments and monetary expansions, as well as with the within-country correlation between endowments in the traded and non-traded sectors.*

**Endogenous Production** Moreover, none of these conclusions rely on endowments in the non-traded sector being determined exogenously. If we allow for endogenous capital accumulation larger countries accumulate a larger per capita capital stock in their non-traded sectors. However, this effect cannot wipe out the initial differences in both risk-free rates and in expected returns in the non-traded sector as long as returns to capital are decreasing. Appendix D shows formally that the differences in (log) expected returns on both assets have the same sign under endogenous capital accumulation as in the model in the main text.

### 3.4 Monetary Unions

So far we have assumed that all transactions in the goods market are settled in the seller's domestic currency. In this sense, we have not drawn a distinction between the size of a country and the size of its currency area. However, there are many examples of countries in which households de facto settle their transactions using a foreign country's currency. The US dollar for example is used extensively outside the US. Similarly, a number of smaller countries might form currency unions, such as the Euro Zone. A simple application of our model highlights the implications of such policies for asset returns. Consider the full model in which endowments and monetary shocks are uncorrelated. If a number of countries form a currency union in the first period, they subsequently experience the same monetary shock. It follows immediately from Proposition 3 that expected returns on risk-free and nominal bonds, as well as on stocks in the non-traded sector of the participating countries, must fall.

**Corollary 1** *Given that condition 2 holds for the variances of monetary shocks of individual countries as well as for the currency union, the formation of a currency union lowers the expected returns on (a) risk-free and nominal bonds as well as on (b) stocks in the non-traded sector of all participating countries.*[15]

Bonds denominated in the currencies of larger currency areas are thus better hedges against consumption risk. Note that this finding is independent of any possible harmonization of real shocks

[15] The former statement is just a generalization of condition 2. Formally, $\tilde{\sigma}_U^2 \left(\sum_{j \in U} \theta^j\right) > \tilde{\sigma}_f^2 \theta^f$ iff $\left(\sum_{j \in U} \theta^j\right) > \theta^f$ for arbitrary $U, f$, where $\tilde{\sigma}_U^2$ is the variance of monetary shocks within the currency union and $U$ is the set of countries participating in the union.

among the countries participating in the currency union. If real shocks were indeed to harmonize due to the introduction of a common currency, expected returns on the three types of assets would fall further, as suggested by Propositions 1 and 2.

## 4 Empirical Analysis and Data

The theoretical part of the paper started with the basic prediction of the consumption-based asset pricing model which states that differences in expected returns on international bonds should be explained by differences in the covariances of the returns on these assets with the marginal utility of households who trade in financial markets. We then used the model to show that these differences in covariances are a function of differences in country size, in the size of currency areas, and in the volatility shocks affecting each country.

The model yields four testable predictions that link differences in expected returns directly to these three variables: (1) real and nominal bonds issued in the currencies of larger countries pay lower expected returns (Propositions 1 and 3); (2) the introduction of a currency union lowers expected returns on bonds within the union (Corollary 1a); (3) stocks in the non-traded sector of larger countries pay lower expected returns than those of smaller countries (Propositions 2 and 3); and (4) the introduction of a currency union lowers expected returns on stocks in the non-traded sector of participating countries (Corollary 1b). In the following sections I test each of these predictions in turn. In addition, I also examine directly the prediction that differences in country size indeed explain differences in the covariances of the returns on international bonds with the consumption growth of US households who trade in financial markets.

The sample consists of quarterly data for OECD countries ranging from 1980 to 2007. Countries enter the sample upon joining the OECD or when data becomes available. I deliberately focus on developed countries as, almost by definition, developing countries account only for a small share of the world wealth. The relevant variation in the size of economies is thus among OECD members. Moreover, OECD countries have reasonably open financial markets throughout the period and good quality data is available.[16] Since the model developed in this paper has only two time periods, I interpret the panel as a series of cross-sections and make the appropriate econometric adjustments. As is customary in the literature, I choose the perspective of a US investor when calculating excess returns and use the US dollar as the base currency.

The main independent variables are proxies for the size of a country's economy, for the size of its currency area, and for the volatility of shocks that affect its economy. I measure the size of a country's economy using its share in OECD GDP:

$$\hat{\theta}_t^j = \frac{GDP_t^j}{\sum_{n=1}^N GDP_t^n}, \tag{23}$$

where $GDP_t^j$ is country $j$'s Gross Domestic Product in quarter $t$ in terms of US dollars as sourced from

[16] I exclude Turkey and Mexico from the sample as their level of financial development and GDP per capita are significantly lower than those of the other member countries throughout the sample period.

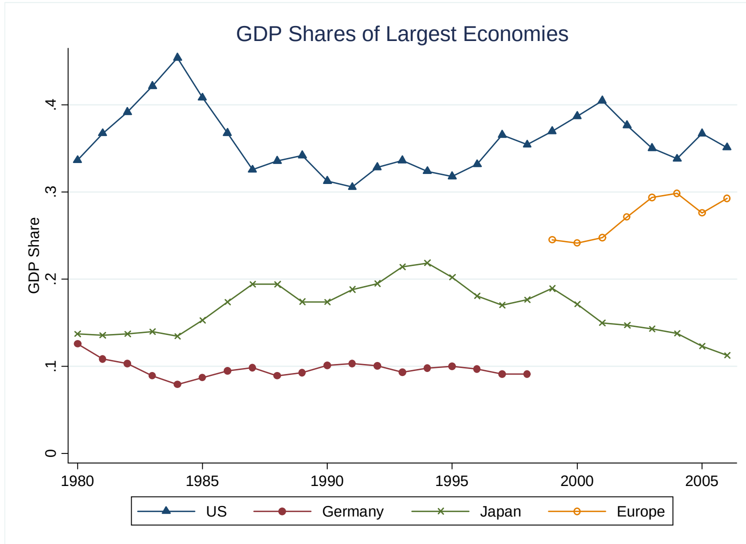


Figure 2: Shares of OECD GDP 1980-2007 for United States, Germany, Japan and the Euro Area (after 1998) at annual frequency.

Global Financial Data (GFD). Table 1 gives summary statistics for this and all other main variables used. The average GDP Share in the sample is 3.6%, where the smallest observation is Iceland in 2004 with 0.04%. Figure 2 gives the evolution of this variable over time for the largest economies in the sample. In this figure I treat the Euro Zone as a single economy after the introduction of the Euro in 1998. However, in some specifications that explicitly distinguish between the size of a country's economy and the size of its currency area, I retain the individual member countries in the sample, assigning them their national GDP Shares and the Euro Area's M1 Share. M1 Share is a country's share in the total OECD M1 money aggregate in terms of US dollars. It is calculated in the same way as GDP Share. The data on monetary aggregates is sourced from the IMF's International Financial Statistics (IFS). I use M1 because internationally harmonized measures of money are not available for broader aggregates. Both M1 Share and GDP Share are adjusted for imbalances in the panel, where countries that enter the sample late are assigned their 1992 shares before they enter. I use the variance of the bilateral exchange rate to the US dollar as my main proxy for the volatility of shocks affecting different countries.

The main dependent variables are annualized excess returns to a US investor on bonds of different maturities and on portfolios of stock return indices. I calculate the former using forward and spot exchange rates against the US dollar sourced from Thompson Financial Datastream (DS)

$$\hat{\rho}^j_{d,t+d} = f^j_{d,t} - s^j_{t+d} \overset{CIP}{=} \tilde{r}^j_{d,t} - \Delta\tilde{s}^j_{t+d} - \tilde{r}^{US}_{d,t}\,, \tag{24}$$

where $s^j_{t+d}$ is the log spot exchange rate between the foreign currency $j$ and the US dollar at time $t+d$ and $f^j_{d,t}$ and is the corresponding log forward exchange rate at time $t$ and maturity $d$. Under covered interest parity ($CIP$) this excess return is equal to the difference in the nominal interest rates between the foreign country and the US at maturity $d$ plus the ex-post realized change (log difference) in the nominal exchange rate ($\Delta\tilde{s}^j_{t+d}$). For simplicity, I do not adjust these excess returns for Jensen's inequality. However, doing so has no significant bearing on the empirical results.

I use data on forward premia rather than data on interbank rates because forward contracts are not affected by potential variation in sovereign default risk across countries. While the forward exchange rates from DS may potentially incorporate a counterparty risk premium (the data refer to over-the-counter forward contracts), such a risk premium would be specific to the counterparty, not to the currency which is the object of the contract and should thus not affect the analysis. Moreover, any such counterparty risk premia appear to be vanishingly small. The forward rates from DS are for all practical purposes identical to the rates on default-free currency futures contracts, which I was able to obtain from the Chicago Mercantile Exchange, for a subset of the countries in my sample (see Appendix G.6 for a detailed comparison). The main specifications focus on forward contracts at the 3-month horizon. In robustness checks I also construct excess returns using 6-month and 1-year forward rates, and government yields at the 3 year and 5 year horizon.

Similarly, I calculate annualized excess returns on portfolios of stock return indices in the traded and non-traded sectors as

$$\hat{\rho}^j_{m,t+1} = dr^j_{m,t+1} + \Delta\tilde{s}^j_{t+1} - dr^{US}_{m,t+1},$$

where $m = T, N$ indicates the sector and $dr^j_{m,t+1}$ is the value-weighted domestic-currency return of the portfolio in sector $m$ between $t$ and $t+1$. I construct these portfolios from industry stock return indices provided by DS. These indices cover all countries in the sample except Iceland, Luxembourg, and the Slovak Republic. I subsume the 'Health Care', 'Consumer Services', and 'Financials' industries under the non-traded sector ($N$) as these can broadly be seen to provide localized services; and I take the 'Basic Materials', 'Consumer Goods', and 'Industrials' industries to represent the traded sector ($T$).[17] This very high-level division between sectors is necessarily imperfect, where many firms in the non-traded sector also produce tradable output and vice versa. However, it is likely that any errors in this sorting should go against finding patterns in the data. The portfolios of traded and non-traded industries on average pay quarterly returns of 3.0% and 3.5%.

As an additional dependent variable I also calculate the covariance of monthly excess returns on international currency forwards with the consumption growth of US stockholders provided by Malloy, Moskowitz, and Vissing-Jorgensen (2009). I use this variable as a proxy for the covariance of returns on international bonds with the marginal utility of (active) households who trade in financial markets. I discuss its construction in detail in section 7.

Throughout the empirical analysis, I control for the liquidity of assets denominated in different currencies as investors might ask a liquidity premium for holding assets denominated in the currencies of smaller countries. Following Burnside et al. (2006), I proxy for differences in liquidity with the difference of the bid and offer rates against the British Pound in the London market (DS), where the liquidity of the British Pound is measured with the bid-ask spread against the US dollar. Further details on the dataset are in Appendix G.

[17] Additional indices for the telecommunications industry, utilities, and the high-technology sectors are also available, but I do not use them as these are more recent and have very limited coverage. Moreover, I exclude the 'Oil and Gas' index as most countries in my sample do not produce significant amounts of fossil fuels.

## 5 Country Size, Currency Unions and International Bond Returns

I first examine the relationship between country size and international bond returns. I begin with the most parsimonious specifications relating excess returns to country size, and later show that results are very similar when interacting country size with different measures of the volatility of endowment and monetary shocks. The basic econometric model can be written as

$$\hat{\rho}^{j}_{d,t+d} = \kappa + \delta_t + \beta \hat{\theta}^{j,US}_t + X'_{jt}\varsigma + \epsilon_{j,t}, \tag{25}$$

where $\hat{\rho}^{j}_{d,t+d}$ are the realized excess returns to a US investor on bonds of country $j$ and maturity $d$ as defined in (24), $\kappa$ is a constant term, $\delta_t$ is a complete set of time fixed effects, which are constrained to sum to zero over time, $\hat{\theta}^{j,US}_t = \hat{\theta}^{j}_t - \bar{\theta}^{US}$ is country $j$'s GDP Share normalized with the average US GDP Share over the sample period ($\bar{\theta}^{US}$), and $X'_{jt}$ is a vector of controls. The error term $\epsilon_{j,t}$ captures all omitted influences. Since the United States is the largest economy in the world it is of special interest how well the model fits the experience of the base-country. The coefficient $\kappa$ can be interpreted as a measure of how far the US real interest rate is off the regression line. In some specifications I also impose $\kappa = 0$, which is equivalent to forcing the specification to perfectly fit the US experience. However, the main coefficient of interest is $\beta$, which captures the relationship between country size and excess returns to a US investor. Throughout, I use OLS estimators and adjust standard errors where appropriate. All of the main empirical findings of the paper are robust to various alternative methods of computing standard errors which are reported in Appendix Table 4.[18]

Panel A of Table 2 gives results for $d = 3$ *months*. The specifications in columns 1-3 do not contain time fixed effects but cluster standard errors by time. The specifications in all other columns contain time fixed effects and report robust standard errors. Column 1 gives the raw correlation in the data between excess returns and GDP Share. The estimated coefficient is -0.157 (s.e.=0.075) suggesting a negative and significant relationship between the two variables. The (adjusted) $R^2$ of this regression is quite low, at 0.1%, which is common in applications in which the dependent variable is a function of exchange rate movements (note that the model explains variation in expected returns, not in realized returns).

The specification in column 2 controls for the variance of the bilateral exchange rate against the US dollar as a proxy for the volatility of shocks affecting different countries. Adjusting for differences in the volatility of shocks affecting different countries does not appear to affect the basic correlation between country size and expected returns. In column 3, I control for the liquidity of the national currency. As expected, the coefficient on this variable is positive but not statistically significant. Throughout, the coefficient of interest is almost unchanged at -0.161 (s.e.=0.074).

The specification in column 4 adds time fixed effects. For the remainder of the paper, I take this specification as the *standard specification*. The coefficient on GDP Share drops only slightly to -0.187 (s.e.=0.069). It points to an economically large effect which suggests that US investors tend to earn 1.87 percentage points less on bonds of a country that produces 10% of OECD output (such as Germany) than they earn in a country that has almost no economic mass (such as New Zealand).

[18] I largely follow the advice of Petersen (2009) for the standard errors reported in the main part of the paper.

Panel A of Appendix Table 4 replicates the same results using a range of alternative methods for computing standard errors.

In columns 5 and 6, I include GDP per Capita and the variance of each country's inflation respectively. Neither of the two variables change the coefficient of interest significantly. In column 7, I impose $\kappa = 0$ and the estimated coefficient drops to -0.120 (s.e.=0.031) but remains statistically significant at the 1% level. The quantitative implications of these estimates thus depend somewhat on whether we force the specification to fit the US data. The econometric reason for this is simple: Although the United States tends to have low interest rates, Japan, which is significantly smaller in terms of GDP, tends to have even lower interest rates during the sample period. If we force the regression line to fit the US, Japan plays little role in identifying $\beta$.

Panels B and C re-run the specifications from Panel A while collapsing the entire dataset to averages of the years 1984-1990, 1991-1998, and 1999-2007, reducing the sample to 41 observations. The dependent variable in Panel B is the decade average of realized excess returns to a US investor of investing in 3-month forwards. Throughout, the coefficient estimates are negative and close to the ones in Panel A. As expected, the standard errors tend to be somewhat larger, but all estimates remain statistically significant at the 5% level except the ones in columns 5 and 6 which are significant at the 10% level. These results suggest that almost all of the identification is coming from the cross-section of countries, rather than from the time series of the panel.

The dependent variable in Panel C is the average forward premium to the US dollar which is displayed at the very beginning of the paper (the left panel of Figure 1). The coefficient estimates are all negative and only slightly smaller than those in Panels A and B. All estimates are statistically significant at the 1% level. While the model refers to differentials in expected returns, which are the sum of interest rate differentials and expected changes in exchange rates, it is comforting to know that the driving force behind the identification of $\beta$ are persistent interest rate differentials between countries, rather than systematic trends in exchange rates, which is in line with the conventional view that exchange rates are highly unpredictable.

The coefficient $\beta$ has a structural interpretation in terms of the model for the case in which the variances of both endowment and monetary shocks are identical across countries (see Appendix B.6 for analytical details). To give an idea of the quantitative implications of the model, we can calculate the level of relative risk aversion, $\gamma$, implied by the estimates in this table for a given set of parameters. As a numerical example, consider the case in which $\tau = 0.3$, $\varepsilon_\alpha = 1$, $\sigma = 0.05$, and $\tilde{\sigma}$ and $\phi$ are chosen to match the average standard deviation of the nominal and real exchange rates with the US dollar in the data (these are 0.1178 and 0.1286, respectively).[19] Under these parameters, the estimate of $\beta$ from the standard specification in column 4 of Table 2 corresponds to $\gamma = 14.23$, whilst the lowest estimate in Table 2 corresponds to $\gamma = 8.46$. The model can thus replicate the spreads observed in the data within a range of reasonable parameters.

Table 3 implements a simple trading strategy based on the relationship between country size and expected returns on international bonds: At the beginning of every quarter I sort all available currency

[19]Burstein, Neves, and Rebelo (2001) and Goldberg and Campa (2008) emphasize that a large share of consumption is non-tradable, since a significant proportion of the price of tradables accrues to non-tradable retail services. I therefore pick a relatively low value of $\tau = 0.3$ in this numerical example.

forwards into five (equally weighted), portfolios where the first portfolio contains the currency forwards of the smallest economies and the fifth portfolio contains those of the largest economies. Panel B lists the excess return to a US investor of buying and holding these portfolios until the maturity of the forward contracts. The excess return falls monotonically from the first portfolio (5.8%) to the fifth portfolio (2.0%), with the exception of the third portfolio which pays 1.3%. When I take into account bid-ask spreads on forward and spot exchange rates, a strategy of borrowing in large economies and lending in small economies pays an annualized excess return of 2.8% with a Sharpe ratio of .215.

### 5.1 Alternative Specifications

In Table 4, I explore a number of alternative specifications which use cross-country differences in the variances of shocks for identification, rather than just controlling for these differences. Throughout, all specifications contain a full set of time fixed effects and control for Variance of Exchange Rate and Bid-Ask Spread on Currency. In column 1, GDP Share is interacted with Variance of Exchange Rate. This interaction yields a highly significant coefficient of -15.685 (s.e.=6.043), while the coefficient on Variance of Exchange Rate remains statistically insignificant. The specification in column 2 includes the interaction as well as GDP Share un-interacted. This specification has a structural interpretation in terms of the model, which can be derived under the assumption that the ratio of the variance of real and monetary shocks is identical across all countries, $\sigma_i^2/\tilde{\sigma}_i^2 = const$. For this case the model predicts a negative sign for the coefficient on the interaction and a positive sign for the coefficient on GDP Share. Indeed, the data support exactly this prediction. However, both coefficients remain statistically insignificant. The specifications in columns 3 and 4 take a slightly different approach by interacting GDP Share with the variance of real GDP growth and variance of inflation (as measured by CPI), respectively. The implicit assumption in the former case is that the variance of GDP growth accurately captures the variance of endowment shocks in the non-traded sector, and both specifications can be interpreted structurally if $\sigma_i^2 = \tilde{\sigma}_i^2$.

While the interaction between the variance of shocks and country size seems to add a moderate amount of explanatory power, I nevertheless continue to focus on the simpler standard specification, which is considerably easier to interpret.

### 5.2 Robustness Checks

Appendix Tables 1, 2, and 3 report a wide range of robustness checks. Throughout, all specifications mirror the standard specification in Table 2 column 4: They contain time fixed effects and control for the variance of the bilateral exchange rate to the US dollar as well as the bid-ask spread on the currency. In all tables the specifications in Panel A contain a constant term and those in Panel B do not, where only the coefficients of interest are reported.

Appendix Table 1 controls for a set of country characteristics, such as stock market capitalization and the skewness of the exchange rate. Appendix Table 2 replicates the standard specification at different ends of the yield curve using excess returns on 3, 6, and 12 month forward contracts as well as on 3 and 5 year government bonds. The conclusion from these tables is that the coefficient of interest remains stable and statistically significant throughout the yield curve, and even when I control for a set of country characteristics which may themselves be alternative proxies for the covariance of currency returns with consumption risk. The coefficient of interest consistently remains in a tight range and loses significance only in one out of the 24 specifications (when I include a constant and simultaneously control for life expectancy, but even there the coefficient of interest is back to -0.112 (s.e.= 0.034) and significant at 1% in the parallel specification which drops the constant term).

Appendix Table 3 shows that the negative association between country size and expected returns persists even when I drop Japan, the Euro Zone, EMU member countries, or a set of resource dependent economies from the sample. The most striking result from the table is in Panel A of column (3). The specification contains a constant term and thus does not use the US for identification and simultaneously drops the Euro Zone and Japan, leaving Germany as the largest economy driving the identification of $\beta$ as -0.175 (s.e.= 0.122). The slope of the regression line among this subset of "small" economies is thus almost identical to the slope of the regression line in the full sample (-0.187, s.e.=0.069), although excluding all three large economies widens the standard error of the estimation. The conclusion from Appendix Table 3 is that no single country or group of countries appears to be driving the results and that a negative relationship between country size and excess returns exists throughout the subsamples of countries.

### 5.3 Currency Areas and Bond Returns

Up to this point the empirical investigation has focused on the link between excess returns on bonds and country size (Propositions 1 and 3). However, the model also predicts that excess returns on bonds should fall after the introduction of a currency union (Corollary 1a). This prediction can be tested for the case of European Monetary integration. To this end I now replace the countries in my sample which form the Euro Zone in 1999 with a single time series of the returns on an equally weighted portfolio of their currency forwards. This portfolio contains forwards of 10 individual currencies prior to 1999 (I drop Greece as it joins only in 2001) and the Euro currency forward thereafter. The GDP Share of this portfolio of currencies is the mean of the GDP shares of its constituent countries, while its M1 Share is the mean of the M1 Shares of the currencies of member countries prior to 1999 but the M1 Share of the Euro thereafter. Expected returns on this portfolio of European currencies should thus decrease after the introduction of the common currency in 1999. The main specification is

$$\hat{\rho}^{j}_{d,t+d} = \kappa + \delta_t + \beta\hat{\theta}^{j,US}_t + \upsilon Euro \times \left(\hat{M}^{j,US}_t - \hat{\theta}^{j,US}_t\right) + X'_{jt}\varsigma + \epsilon_{j,t}, \tag{26}$$

where $Euro$ is a fixed effect for EMU member countries post 1998, $\hat{M}^{j,US}_t = \hat{M}^{j}_t - \bar{M}^{US}_t$ stands for country $j$'s share of total OECD M1 money balances normalized with the average US M1 Share throughout the sample, $\bar{M}^{US}_t$. The model predicts that $\beta < 0$ and $\upsilon < 0$.[20]

Column 1 of Panel A in Table 5 begins by introducing the $Euro$ fixed effect into the standard specification, which is now estimated on the sample that contains a single time series for the Euro Zone pre and post 1999. $\beta$ is estimated as -0.264 (s.e.=0.138) and the coefficient on the $Euro$ fixed effect is

[20] Note that the purpose of interacting $\left(\hat{M}^{j,US}_t - \hat{\theta}^{j,US}_t\right)$ with the $Euro$ fixed effect in (26) is not to estimate a differential effect. The interaction reflects an implicit assumption that only countries within the EMU have a currency area that is larger than their domestic economy.

negative and statistically significant at the 10% level. It indicates that expected excess returns to US investors from investing in Euro Zone forwards are 2.1 percentage points lower after the introduction of the common currency than they would have been if each member country had continued to use its own currency. Importantly, changes in country default risk cannot explain this result as currency forward contracts are arguably unaffected by government default risk. Moreover, all specifications continue to control for the variance of the bilateral exchange rate and for the bid-ask spread, such that any change in these variables due to accession to the Euro is already accounted for. Column 2 interacts the *Euro* fixed effect with the difference in M1 and GDP Shares as in (26). The estimate of $\upsilon$ is -0.035 (s.e.=0.019), which suggests a negative and significant effect as predicted by the model. Column 3 includes the difference between M1 Share and GDP Share, regardless of whether or not the country is an EMU member. The coefficient on this variable is -0.075 (s.e.=0.035) and $\beta$ is estimated at -0.206 (s.e.=0.153). Finally, column 5 drops the constant term, where both coefficients remain negative and are statistically significant at the 5% level. Panel B repeats the same specifications with the forward premia on the left hand side showing that, again, the differences in expected returns appear to result directly from differences in forward premia, rather than from systematic changes in exchange rates.

The conclusion from Table 6 is that the evidence supports the prediction that excess returns to US investors on bonds denominated in Euro Zone currencies fell after 1998 even when measured using currency forward premia, which are unaffected by changes in investors' assessments of individual country default risk. In fact, a simple differences in differences specification (not shown) suggests that the expected returns on *all* EMU member currency forwards (even those denominated in German Marks) were higher than the expected returns on Euro currency forwards which replaced them in 1999. Beyond the specific historical context of European monetary integration, the data support the view that countries generally appear to pay lower excess returns on their foreign lending if their currency area (as measured by their M1 Share) exceeds the size of their economy (as measured by their GDP Share).

# 6 Country Size, Currency Areas, and Stock Returns

The model predicts that stocks in a larger country's non-traded sector pay lower expected returns (Propositions 2 and 3) and that the introduction of a currency union lowers expected returns in the non-traded, but not in the traded sector, of participating countries (Corollary 1b). While we can test the first prediction exclusively with cross-country data, the second prediction has implications for both the variation across countries and for the variation within countries. After the introduction of the Euro, domestic returns in the non-traded sector of participating countries should have fallen relative to domestic returns in the traded sector. Both predictions are to my knowledge new to the literature and can therefore be seen as a good test of the mechanism in the model.

## 6.1 Cross-Country Return Differentials

I first focus on the cross-country variation by mirroring specification (26), with the excess return to a US investor from investing in the non-traded sector of country $j$, $\hat{\rho}^j_{N,t+1}$, as dependent variable. Since we have stock return data for each individual country both pre and post 1999, all individual EMU member countries remain in the sample and are assigned their own-country GDP Share and the M1 Share of the Euro Zone post 1998.

$$\hat{\rho}^{j}_{N,t+1} = \kappa_N + \delta_t + \beta_N \hat{\theta}^{j,US}_t + \upsilon_N Euro \times \left( \hat{M}^{j,US}_t - \hat{\theta}^{j,US}_t \right) + X'_{jt}\varsigma + \epsilon^{N}_{j,t}, \tag{27}$$

where the vector $X'_{jt}$ now contains controls for the variance of the bilateral exchange rate with the US dollar and the (domestic) variance of returns in the non-traded sector.

The specification in column 1 of Table 7 returns an estimate for $\beta_N$ of -0.585. This coefficient is economically large indicating that stocks in the non-traded sector of a country that contributes 10% of OECD GDP tend to pay 5.85 percentage points lower returns on an annual basis than stocks in the non-traded sector of countries with almost no economic mass. However, this coefficient is also relatively imprecisely estimated with a standard error of 0.256. Column 2 shows that excess returns in the non-traded sector of EMU member countries are on average 3.9 percentage points lower after the introduction of the Euro than predicted by the sizes of their economies, while the estimate of $\beta_N$ remains almost unchanged at -0.594 (s.e.=0.255). Column 3 introduces the interaction with $\left( \hat{M}^{j,US}_t - \hat{\theta}^{j,US}_t \right)$ suggested by the model, which gives an estimate for $\upsilon_N$ of -0.067 (s.e.=0.037). The specification in column 4 drops the interactions and estimates a unified effect of the difference in M1 Share and GDP Share. It returns a negative coefficient of -0.125 (s.e.=0.066). Finally, column 5 replicates this specification but drops the constant term. In this case, the estimate for $\beta_N$ is -0.136 but statistically insignificant. However, the coefficient on the difference between M1 Share and GDP Share remains significant at -0.171 (s.e.=0.066).

The conclusion from Table 6 is that the data are consistent with both the prediction that stocks in the non-traded sector of larger countries pay lower excess returns and the prediction that the introduction of the Euro would lower returns in the non-traded sector of participating countries. Appendix Table 2 replicates all specifications of Table 7, but with excess returns in the *traded* sector as the left hand side variable. Interestingly, none of the coefficients of interest are statistically distinguishable from zero in this case, which again is in line with the predictions of the model.

## 6.2 Within-Country Return Differentials

In Table 7 I focus on the following econometric model:

$$dr^{j}_{N,t+1} - dr^{j}_{T,t+1} = \kappa_\Delta + \upsilon_\Delta Euro \times \left( \hat{M}^{j,US}_t - \hat{\theta}^{j,US}_t \right) + \beta_\Delta \hat{\theta}^{j,US}_t + X^{\Delta\prime}_{jt}\varsigma_\Delta + \epsilon^{\Delta}_{j,t}, \tag{28}$$

It is derived by differencing specifications (27) for excess returns in the non-traded and traded sectors, $\hat{\rho}^{j}_{N,t+1} - \hat{\rho}^{j}_{T,t+1}$. The new left hand side variable, $dr^{j}_{N,t+1} - dr^{j}_{T,t+1}$ is the domestic return differential between the portfolios of stock return indices in the traded and non-traded sectors. The vector of controls $X^{\Delta\prime}_{jt}$ contains only the domestic variances of the returns on the portfolios in the two sectors as all other controls, as well as the time fixed effects, difference out of the equation. The coefficient of interest is $\upsilon_\Delta$, the differential impact of European monetary integration on returns in the two sectors. The model predicts $\upsilon_\Delta < 0$. Note, however, that the model has no implications for $\beta_\Delta$, as the spread on international stocks in the traded sector is indeterminate.

Column 1 of Table 7 shows a regression of the domestic return differential on the *Euro* fixed effect and a constant. The estimated coefficient on the fixed effect is -0.016 (s.e.=0.005). Domestic returns in the non-traded sector of EMU member countries thus tended to fall by 1.6 percentage points relative to those in the traded sector after the introduction of the Euro. Column 2 adds the control variables, with little impact on the coefficient of interest. Column 3 estimates the full model (28). The estimate of $\upsilon_\Delta$ is -0.059 (s.e.=0.015), which suggests a negative and significant effect as predicted by the model. The estimate of $\beta_\Delta$ is -0.078, but statistically indistinguishable from zero with a standard error of 0.050. Column 4 allows for a more general relationship between the size of currency areas and the domestic return differential. The estimated coefficient is -0.061 (s.e.=0.016). It suggests that stocks in the non-traded sector of a hypothetical country which is associated with a currency area that contributes 10% to OECD M1 money balances, but has no economic mass, would on average pay 0.61 percentage points lower returns than stocks in the same country's traded sector. Finally, column 5 re-estimates the same equation while including the US in the sample. The coefficient remains almost unchanged at -0.055 (s.e.=0.015).

The conclusion from Table 7 is that European monetary integration seems to have indeed lowered expected returns in the non-traded sector relative to expected returns in the traded sector of participating countries.

# 7 Country Size and US Consumption Growth Risk

While the empirical analysis in the previous sections established a direct link between country size and international return differentials, I now turn to the narrower prediction of the model that the returns on larger countries' bonds should have a lower covariance with the consumption growth of households who trade in financial markets. Empirically, it is difficult to distinguish between households who do and do not trade in financial markets. Nevertheless, this distinction is crucial since the model makes no prediction about the covariance of currency returns with aggregate consumption growth.

The only publicly available time series of consumption growth that allows a distinction between households who do and do not trade in financial markets is the one provided by Malloy, Moskowitz, and Vissing-Jorgensen (2009) who use data from the Consumer Expenditure Survey to measure the consumption growth of US stockholders in every month between 1982 and 2004. The conclusion from their paper and some of the broader literature on consumption-based asset pricing (Parker and Julliard (2005)) is that the covariance of asset returns with consumption growth over longer periods ranging from 8 to 24 quarters can explain the the expected returns on US financial assets, but that the covariance of asset returns with contemporaneous consumption growth cannot. While factors driving the dynamic relationship between asset returns and consumption growth are beyond the scope of the two-period model in this paper I nevertheless follow this literature in examining the covariance of asset returns with consumption growth at various time horizons.[21]

Following the methodology of Malloy et al. (2009) I use (overlapping) monthly data to calculate

[21] A fully dynamic version of the model might for example include a time lag in household consumption decisions or recursive preferences.

the covariance of quarterly excess returns on international bonds as defined in (24) with stockholder consumption growth in the same quarter and at a horizon of $S = 2, 4, 8, 12, 16, 20$, and 24 quarters.[22] There are two added difficulties for my application of the Malloy et al. (2009) data to currency forwards. First, the GDP Share of the US changes over time, which means that the covariance of US active households' consumption growth with returns on all foreign currency forwards should change over time. Second, the set of international currencies for which I have data changes over time. To deal with both of these difficulties I allow currencies to enter the sample in the years 1984, 1991, and 1999 and calculate a separate set of covariances for the three sub-periods 1984-1990, 1991-1998, and 2000-2004.

In Panel A of Table 8, I regress these covariances on a constant term and the country average GDP Share for each sub-period (while weighting each observation with the number of observations used to estimate the corresponding covariance). Column 1 shows that the returns on larger countries' currency forwards indeed have a lower covariance with contemporaneous ($S = 1$) consumption growth of US stockholders, although this association is not statistically significant at conventional levels (standard errors are clustered at the country level). The following columns show the same specification, but use the covariance of returns on currency forwards with consumption growth over longer horizons as dependent variable. The results are striking: All coefficients are negative and those at longer horizons (at $S = 2$, 12, 16, 20 and 24 quarters) are statistically significant at conventional levels. It thus appears that larger countries' bonds are indeed a better hedge against long-run consumption risk of US stockholders.

In Panel B I take this insight one step further and regress the sub-period mean excess return to a US investor on a given currency forward on its covariance with US stockholder consumption growth and a constant term. We can interpret this specification as an Euler equation test, where the coefficient on the covariance with stockholder consumption is an estimate of the relative risk aversion of households. Throughout, this estimate is positive and in a reasonable range between 4.7 and 9.6. Moreover, all estimates except the one for $S = 1$ are statistically significant at the 5% level, where I cluster standard errors at the country level and use the Shanken (1992) correction to account for the fact that the right hand side variables are estimated. Although the constant term is significantly different form zero in all specifications (and the model is thus rejected), the consumption-based asset pricing model appears to account for a significant fraction in the variation of expected returns and thus fares surprisingly well in this application.

In Panel C I take the analysis to its logical conclusion by using GDP Share as an instrument for US stockholder consumption growth. The estimated coefficients are positive and statistically significant at the $S = 2$, 12, 16, 20, and 24 quarter horizons (standard errors are again clustered at the country level, where the IV standard errors account for the fact that the right hand side variable is estimated). The results therefore suggest that the part of the variation in US stockholder consumption risk which is explained by differences in country size is indeed priced in international forward markets.

[22] The series is identical to the one on Annette Vissing-Jorgensen's webpage, except that the authors kindly provided me with a version of their series in which the discount rate is set to one, such that it literally describes the growth rates of stockholder consumption.

# 8 Conclusion

This paper presented an international asset pricing model which endogenizes the stochastic properties of real exchange rates. It offers a strikingly simple explanation for violations of uncovered interest parity: The currencies of economies that account for a larger share of world wealth tend to appreciate in bad times (when traded goods are scarce around the world). As a result, larger economies have persistently lower real and nominal interest rates than smaller economies and pay lower expected returns on stocks in their non-traded sector. The model also provides a natural notion of a 'currency area' and predicts that an expansion in the use of a currency beyond national borders lowers real and nominal interest rates in the affected economies.

The empirical part of the paper gives strong support for the predictions of the model along various dimensions. Most importantly, it shows that differences in the size of economies and in the size of currency areas indeed explain a significant fraction of the variation in currency returns across developed economies. Contrary to the conventional view, US interest rates do not appear to be significantly lower than those of other countries once the size of its economy is controlled for.

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**Table 1**
**Descriptive Statistics**

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| | *Obs.* | *Mean* | *Std.Dev.* | *Min* | *Max* |
| GDP Share | 1538 | 0.036 | (0.056) | 0.000 | 0.301 |
| M1 Share | 1141 | 0.061 | (0.101) | 0.001 | 0.413 |
| Annualized Forward Premium (3-month contracts) | 1538 | 0.015 | (0.039) | -0.078 | 0.331 |
| Annualized Yield on 5-Year Bond (gov. debt) | 1397 | 0.071 | (0.033) | 0.002 | 0.198 |
| Annualized Yield on 10-Year Bond (gov. debt) | 1458 | 0.074 | (0.031) | 0.007 | 0.189 |
| Qtrly Domestic Rtrn on Portfolio of 'Traded' Industries | 1329 | 0.028 | (0.135) | -0.674 | 0.509 |
| Qtrly Domestic Rtrn on Portfolio of 'Non-Traded' Industries | 1383 | 0.033 | (0.114) | -0.631 | 0.476 |
| Qtrly Growth in Nominal Exchange Rate to US-Dollar | 1538 | -0.005 | (0.056) | -0.190 | 0.291 |
| Qtrly Inflation | 1531 | 0.007 | (0.009) | -0.018 | 0.084 |
| Bid Ask Spread on Currency | 1488 | 0.001 | (0.001) | 0.000 | 0.009 |
| Variance of Exchange Rate | 1538 | 0.013 | (0.005) | 0.003 | 0.049 |
| Domestic Variance of 'Traded' Portfolio Returns | 1500 | 0.017 | (0.007) | 0.009 | 0.052 |
| Domestic Variance of 'Non-traded' portfolio returns | 1500 | 0.013 | (0.008) | 0.007 | 0.064 |

Note: The sample consists of quarterly data for 27 OECD countries 1983-2007. Countries enter the sample upon joining the OECD or when data becomes available. After 1998 countries that joined the European Monetary Union are dropped from the sample and replaced by a single observation for the Euro Zone. GDP Share is countries' share in total OECD output at each point in time, and M1 Share is countries' share in total OECD M1 money balances at each point in time. Both series are adjusted for fluctuations in the sample. Annualized Forward Premium (3-month contracts) is the annualized difference between the three-month forward and spot exchange rates against the US Dollar. Annualized Yield on 5-Year Bond is the annualized yield to maturity on government debt at the 5 year horizon. Qtrly Domestic Rtrn on Portfolio of 'Traded' ('Non-Traded') Industries is the quarterly domestic currency return on a value-weighted portfolio of industry return indices which are taken to produce mainly tradable (non-tradable) output, where the 'Basic Materials'; 'Consumer Goods'; and 'Industrials' industries are classified as producing mainly tradable output and the 'Health Care'; 'Consumer Services'; and 'Financials' industries are classified as producing mainly non-tradable output. Qtrly Growth in Nominal Exchange Rate to US Dollar is the quarterly growth in the price of one US Dollar in terms of the national currency. Quarterly Inflation is the quarterly growth of the national consumption price index. Bid-Ask Spread on Currency is the offer rate minus the bid rate on the national currency in the London market. Variance of Exchange Rate is the variance of the bilateral nominal exchange rate of the national currency against the US Dollar. Domestic Variance of 'Traded' ('Non-Traded') Portfolio Returns is the variance of the Qtrly Domestic Rtrn on Portfolio of 'Traded' ('Non-Traded') Industries variable. See data appendix for details.

**Table 2**
**GDP Shares and Excess Returns (Prediction 1)**

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|---|
| Panel A | *Excess return on 3-month forwards* | | | | | | |
| GDP Share | -0.157** | -0.155** | -0.161** | -0.187*** | -0.132** | -0.176** | -0.120*** |
| | (0.075) | (0.075) | (0.074) | (0.069) | (0.066) | (0.069) | (0.031) |
| Variance of Exchange Rate | | 0.537 | 0.440 | -0.511 | -0.535 | -0.634 | -0.740 |
| | | (0.740) | (0.722) | (0.750) | (0.757) | (0.741) | (0.719) |
| Bid-Ask Spread on Currency | | | 3.986 | 7.635* | 5.958 | 8.026* | 6.789 |
| | | | (7.246) | (4.418) | (4.423) | (4.419) | (4.460) |
| GDP per Capita | | | | | -0.002*** | | |
| | | | | | (0.000) | | |
| Variance of Inflation | | | | | | 35.116 | |
| | | | | | | (27.183) | |
| Constant | -0.018 | -0.024 | -0.028 | -0.028 | -0.018 | -0.026 | |
| | (0.031) | (0.029) | (0.028) | (0.024) | (0.024) | (0.024) | |
| $R^2$ | 0.001 | 0.000 | -0.000 | 0.642 | 0.647 | 0.643 | |
| N | 1489 | 1489 | 1489 | 1489 | 1485 | 1489 | 1489 |
| Panel B | *Excess return on 3-month forwards (decade averages)* | | | | | | |
| GDP Share | -0.268** | -0.268** | -0.269** | -0.163** | -0.129* | -0.162* | -0.159*** |
| | (0.100) | (0.100) | (0.103) | (0.078) | (0.073) | (0.082) | (0.056) |
| $R^2$ | 0.181 | 0.162 | 0.139 | 0.530 | 0.651 | 0.547 | |
| N | 41 | 41 | 41 | 41 | 41 | 41 | 41 |
| Panel C | *Forward premium against US dollar (decade averages)* | | | | | | |
| GDP Share | -0.140*** | -0.142*** | -0.126*** | -0.151*** | -0.120*** | -0.149*** | -0.134*** |
| | (0.054) | (0.045) | (0.048) | (0.052) | (0.040) | (0.062) | (0.048) |
| $R^2$ | 0.105 | 0.196 | 0.267 | 0.294 | 0.525 | 0.504 | |
| N | 41 | 41 | 41 | 41 | 41 | 41 | 41 |
| Time fixed effects | no | no | no | yes | yes | yes | yes |

Note: OLS regressions with robust standard errors in parentheses. In columns 1-3 of Panel A standard errors are clustered by time. All specifications in columns 4-7 contain time fixed effects, which are not reported and are constrained to sum to zero, $\sum_t \delta_t = 0$. Columns 1-6 contain a constant term, whereas the specification in column 7 does not. The dependent variable in Panels A and B is the (annualized) log difference of the 3-month forward rate and the spot exchange rate against the US Dollar at the time of maturity of the forward contract. Dependent variable in Panel C is the annualized forward premium against the US Dollar (i.e. the annualized log difference of the 3-month forward rate and the spot exchange rate at the time at which the forward contract is issued). The sample consists of quarterly data for 27 OECD countries 1983-2007. After 1998 countries that joined the European Monetary Union are dropped from the sample and replaced by a single observation for the Euro Zone. Panels B and C use period averages 1983-1990, 1991-1998, 1999-2007 of the same sample and include the same covariates as in Panel A (not reported). GDP Share is countries' share in total OECD output at each point in time, adjusted for fluctuations in the sample. Variance of Exchange Rate is the variance of the bilateral nominal exchange rate of the national currency with the US Dollar. Bid-Ask Spread on Currency is the offer rate minus the bid rate on the national currency. GDP per Capita is GDP per capita in US Dollars. Variance of Inflation is the variance of the national inflation rate as measured by the consumer price index. See data appendix for details. All independent variables are differenced with the US sample average in Panel A and the US decade average in Panels B and C.

**Table 3**
**Currency Portfolios formed on GDP Share (Prediction 1)**

| Portfolio | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| Panel A | *Average GDP Share* | | | | |
| Mean | .004 | .009 | .016 | .038 | .138 |
| Panel B | *Excess return on 3-month forwards* | | | | |
| Mean | .058 | .041 | .013 | .033 | .02 |
| Std. Dev. | .198 | .22 | .197 | .167 | .21 |
| Sharpe Ratio | .295 | .186 | .068 | .194 | .094 |
| Panel C | *Excess return (including bid-ask spread)* | | | | |
| Mean | .051 | .034 | .008 | .028 | .017 |
| Std. Dev. | .198 | .22 | .197 | .168 | .21 |
| Sharpe Ratio | .256 | .154 | .042 | .166 | .08 |
| Panel D | *High-minus-Low (including bid-ask spread)* | | | | |
| Mean | .028 | .011 | -.015 | .005 | |
| Std. Dev. | .129 | .108 | .117 | .139 | |
| Sharpe Ratio | .215 | .102 | -.125 | .035 | |

Note: This table describes five portfolios of currency forward contracts. At the beginning of each quarter all available currencies are sorted into quintiles according to the GDP Share of the issuing country. Portfolio (1) contains forward contracts of the smallest countries, portfolio (5) contains the forward contracts of the largest countries. Panels B and C give the annualized mean excess return, the annualized standard deviation of excess returns, and the annualized Sharpe Ratio of each portfolio. Excess returns are calculated as the log difference of the 3-month forward rate and the spot exchange rate against the US Dollar at the time of maturity of the forward contract. Panel B gives log excess returns using mid quotes (without taking into account bid-ask spreads). Panel C takes into account bid-ask spreads faced by a US investor. Panel C, gives the same statistics for a "High-minus-Low" strategy in which a US investor shorts portfolio (5) and goes long the indicated portfolio. Quarterly data, 1983-2007.

**Table 4**
**Alternative Specifications (Prediction 1)**

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | *Excess return on 3-month forwards* | | | |
| GDP Share * Variance Exchange Rate | -15.685*** | -27.919 | | |
| | (6.043) | (36.719) | | |
| GDP Share * Variance GDP | | | -7.379** | |
| | | | (3.164) | |
| GDP Share * Variance Inflation | | | | -11.713** |
| | | | | (5.353) |
| GDP Share | | 0.152 | | |
| | | (0.408) | | |
| Variance of GDP | | | 0.682* | |
| | | | (0.372) | |
| Variance of Inflation | | | | 40.230 |
| | | | | (27.149) |
| Variance of Exchange Rate | -0.148 | 0.138 | -0.522 | -0.672 |
| | (0.750) | (1.129) | (0.745) | (0.746) |
| $R^2$ | 0.642 | 0.642 | 0.642 | 0.643 |
| N | 1489 | 1489 | 1489 | 1489 |
| Time fixed effects | yes | yes | yes | yes |
| Constant term included | yes | yes | yes | yes |

Note: This table explores a number of specifications which control for differences in the variance of real and nominal shocks in a more structural manner. OLS regressions with robust standard errors in parentheses. All specifications are analogous to the standard specification in column 4 of Table 2: They contain controls for Variance of Exchange Rate and Bid-Ask Spread on Currency. They also contain a complete set of time fixed effects, which are constrained to sum to zero, $\sum_t \delta_t = 0$ (see the caption of Table 1 and the data appendix for details). All specifications contain a constant term. Dependent variable is the (annualized) log difference of the 3-month forward rate and the spot exchange rate against the US Dollar at the time of maturity of the forward contract. The sample consists of quarterly data for 27 OECD countries 1983-2007. After 1998 countries that joined the European Monetary Union are dropped from the sample and replaced by a single observation for the Euro Zone. GDP Share is countries' share in total OECD output at each point in time, adjusted for fluctuations in the sample. Variance of Exchange Rate is the variance of the bilateral nominal exchange rate of the national currency with the US Dollar. Variance of GDP is the variance of real GDP growth, deflated with the national consumer price index. Variance of Inflation is the variance of the national inflation rate as measured by the consumer price index. All independent variables are differenced with the US value.

**Table 5**
**Currency Unions and Use of Currency Abroad (Prediction 2)**

| | (1) | (2) | (3) | (4)5 |
|---|---|---|---|---|
| Panel A | *Excess return on 3-month forwards* | | | |
| GDP Share | -0.269* | -0.276* | -0.206 | -0.136** |
| | (0.138) | (0.146) | (0.153) | (0.064) |
| Euro Zone Post '98 | -0.021* | | | |
| | (0.011) | | | |
| (M1 Share - GDP Share) * Euro Zone Post '98 | | -0.035* | | |
| | | (0.019) | | |
| (M1 Share - GDP Share) | | | -0.075** | -0.084** |
| | | | (0.035) | (0.034) |
| Constant | -0.045 | -0.057 | -0.026 | |
| | (0.047) | (0.051) | (0.054) | |
| $R^2$ | 0.718 | 0.736 | 0.737 | |
| N | 1061 | 802 | 802 | 802 |
| Panel B | *3-month forward premia against US Dollar* | | | |
| GDP Share | -0.300*** | -0.275*** | -0.235*** | -0.135* |
| | (0.053) | (0.059) | (0.039) | (0.071) |
| Euro Zone Post '98 | -0.017** | | | |
| | (0.007) | | | |
| (M1 Share - GDP Share) * Euro Zone Post '98 | | -0.023 | | |
| | | (0.015) | | |
| (M1 Share - GDP Share) | | | -0.042* | -0.054* |
| | | | (0.024) | (0.029) |
| Euro Zone | | | | |
| Constant | -0.081*** | -0.058 | -0.040 | |
| | (0.019) | (0.034) | (0.029) | |
| $R^2$ | 0.450 | 0.480 | 0.480 | |
| N | 1061 | 802 | 802 | 802 |
| Time fixed effects | yes | yes | yes | yes |

Note: Weighted least squares regressions with robust standard errors in parentheses. All specifications contain but do not report controls for Variance of Exchange Rate and time fixed effects which are constrained to sum to zero, $\sum_t \delta_t = 0$. The specifications in columns 1-3 contain a constant term, whereas the specification in column 4 does not. Dependent variable in Panel A is the annualized log excess return to maturity to a US investor on 3-month currency forwards. Dependent variable in Panel B is the annualized forward premium against the US Dollar (i.e. the annualized log difference of the 3-month forward and spot exchange rate at the time at which the forward contract is issued). The sample consists of quarterly data for OECD countries 1983-2007. M1 Share is the national currency's share in total OECD money balances, adjusted for fluctuations in the sample. M1 Share - GDP Share is the difference between countries' share in total OECD money balances and their share in total OECD GDP. The countries that accede to the the EMU in 1999 are treated as a single entity throughout the sample, where returns on Euro currency forwards are replaced with returns on an equally weighted portfolio of currency forwards of participating countries prior to 1999. Excess returns on Euro currency forward contracts are used when they become available in 1999. Throughout the sample, the GDP Share of the Euro Zone is the average size of participating countries. M1 Share of the Euro Zone is the average M1 share of participating countries prior to accession and the Euro Zone's M1 Share post accession. Euro Zone Post 1998 is a fixed effect for Euro Zone after 1998. In the estimation the Euro Zone has a weight that corresponds to the number of constituent countries for which we have data pre and post 1999 (10). Greece is dropped from the sample as it accedes after 1999. All independent variables are differenced with the US value.

**Table 6**
**Stocks in 'Non-Traded' Industries (Predictions 3 & 4)**

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| | *Excess return on portfolio of 'non-traded' industries* | | | | |
| GDP Share | -0.585** | -0.594** | -0.598** | -0.508** | -0.136 |
| | (0.256) | (0.255) | (0.256) | (0.258) | (0.091) |
| Euro Zone Post '98 | | -0.039* | | | |
| | | (0.020) | | | |
| (M1 Share - GDP Share) * Euro Zone Post '98 | | | -0.067* | | |
| | | | (0.037) | | |
| (M1 Share - GDP Share) | | | | -0.125* | -0.171*** |
| | | | | (0.066) | (0.066) |
| Domestic Variance of 'Non-Trad.' Portfolio | 2.266 | 2.371 | 2.384 | 2.501 | 2.659 |
| | (2.645) | (2.649) | (2.652) | (2.665) | (2.661) |
| Constant | -0.181** | -0.182** | -0.183** | -0.139 | |
| | (0.087) | (0.087) | (0.087) | (0.090) | |
| $R^2$ | 0.371 | 0.372 | 0.372 | 0.372 | |
| N | 1537 | 1537 | 1537 | 1537 | 1537 |
| Constant term included | yes | yes | yes | yes | no |
| Time fixed effects | yes | yes | yes | yes | yes |

Note: OLS regressions with robust standard errors in parentheses. All specifications contain but do not report controls for Variance of Exchange Rate and time fixed effects, which are constrained to sum to zero, $\sum_t \delta_t = 0$. The specifications in columns 1-4 contain a constant term, whereas the specification in column 5 does not. Dependent variable is the annualized log excess return to a US investor of investing in a value-weighted portfolio of three industry stock return indices of other OECD countries versus the corresponding US portfolio of indices. These industries can broadly be interpreted as providing non-traded goods and services: Health Care; Consumer Services; and Financials (Indices for the telecommunications industry and for utilities are also available for some countries but are not used due to their limited coverage). All indices are sourced from Thompson Financial Datastream. The sample consists of quarterly data for the 24 OECD countries that are covered by the Datastream indices, 1980-2007. Euro Zone countries remain in the sample after 1998. They are assigned their national GDP Share and the M1 Share of the Euro. M1 Share is the national currency's share in total OECD money balances at each point in time, adjusted for fluctuations in the sample. M1 Share - GDP Share is the difference between countries' share in total OECD money balances and their share in total OECD GDP. Domestic Variance of Non-Trad. Portfolio is the local-currency variance of returns of the portfolio of indices. Euro Zone Post 1998 is a fixed effect for Euro Zone countries after 1998. All independent variables are differenced with the US value.

**Table 7**
**Domestic Return Differential between Traded and Non-Traded Sectors (Prediction 4)**

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| Panel A | *Domestic return differential, 'non-traded' - 'traded'* | | | | |
| Euro Zone Post '98 | -0.016*** | -0.018*** | | | |
| | (0.005) | (0.005) | | | |
| (M1 Share - GDP Share) * Euro Zone Post '98 | | | -0.059*** | | |
| | | | (0.015) | | |
| (M1 Share - GDP Share) | | | | -0.061*** | -0.055*** |
| | | | | (0.016) | (0.015) |
| GDP Share | | -0.072 | -0.078 | -0.029 | -0.019 |
| | | (0.050) | (0.050) | (0.050) | (0.019) |
| Domestic Variance of 'Trad.' Portfolio | | -0.232 | -0.247 | -0.234 | -0.181 |
| | | (0.605) | (0.604) | (0.605) | (0.573) |
| Domestic Variance of 'Non-Trad.' Portfolio | | 0.558 | 0.592 | 0.642 | 0.580 |
| | | (0.908) | (0.909) | (0.912) | (0.895) |
| $R^2$ | 0.007 | 0.006 | 0.007 | 0.007 | 0.006 |
| N | 1421 | 1421 | 1421 | 1421 | 1532 |
| USA included | no | no | no | no | yes |

Note: OLS regressions with robust standard errors in parentheses. Dependent variable is the quarterly log return differential measured in local currency between a portfolio of industry stock return indices in the non-traded sector and a portfolio of industry stock return indices in the traded sector. The former is constructed from return indices for Health Care; Consumer Services; and Financials and the latter from return indices for Basic Materials; Consumer Goods; and Industrials. Both portfolios are value-weighted and all indices are sourced from Thompson Financial Datastream. The sample consists of quarterly data for the 24 OECD countries that are covered by the Datastream indices, 1980-2007. Euro Zone countries remain in the sample after 1998. They are assigned their national GDP Share and the M1 Share of the Euro. M1 Share is the national currency's share in total OECD money balances at each point in time, adjusted for fluctuations in the sample. M1 Share - GDP Share is the difference between countries' share in total OECD money balances and their share in total OECD GDP. Euro Zone Post '98 is a fixed effect for Euro Zone countries after 1998. Domestic Variance of Trad. (Non-Trad.) Portfolio is the local-currency variance of log returns of the portfolio of indices in the traded (non-traded) sector.

**Table 8**
**Country Size and Covariance with US Stockholder Consumption Growth**

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| $S =$ | 1 | 2 | 4 | 8 | 12 | 16 | 20 | 24 |
| Panel A: | *Cov with US stockholder Consumption* | | | | | | | |
| GDP Share | -0.001 | -0.002** | -0.002 | -0.002 | -0.003* | -0.004** | -0.006** | -0.007** |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.002) | (0.002) | (0.002) | (0.003) |
| N | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 29 |
| Panel B: | *Expected excess return on 3 month forwards (WLS)* | | | | | | | |
| Covariance US Cons | 6.133 | 9.685** | 4.718** | 7.924** | 9.115** | 8.137** | 7.333** | 8.407** |
| | (3.771) | (2.621) | (1.626) | (2.063) | (1.348) | (1.742) | (1.346) | (2.053) |
| Constant | 0.010** | 0.009** | 0.009** | 0.011** | 0.011** | 0.009** | 0.009** | 0.009** |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| $R^2$ | 0.065 | 0.238 | 0.162 | 0.265 | 0.479 | 0.427 | 0.521 | 0.530 |
| N | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 29 |
| Panel C: IV | *Expected excess return on 3 month forwards (IV)* | | | | | | | |
| Covariance US Cons | 64.850 | 31.222** | 28.315 | 39.542 | 22.015** | 16.219** | 12.260** | 11.804** |
| | (58.633) | (12.480) | (20.280) | (28.046) | (7.569) | (5.289) | (2.720) | (3.017) |
| Constant | 0.010** | 0.008** | 0.006** | 0.017** | 0.013** | 0.008** | 0.009** | 0.009** |
| | (0.003) | (0.002) | (0.003) | (0.007) | (0.002) | (0.001) | (0.001) | (0.001) |
| N | 42 | 42 | 42 | 42 | 42 | 42 | 42 | 29 |

Note: Dependent variable in Panel A is the covariance of annualized log excess returns to maturity to a US investor on 3-month currency forwards of 21 OECD countries with quarterly US stockholder consumption growth in the same quarter ($S = 1$) and at a horizon of $S = 2, 4, 8, 12, 16, 20$ and 24 quarters (Covariance US Cons). A separate set of covariances is calculated for each of the sub-periods 1984-1990, 1991-1998, and 2000-2004 to allow entry and exit of currencies. All specifications in Panel A include but do not report a constant term. Panels B and C show specifications in which the average annualized log excess return to a US investor on 3-month currency forwards over each of the sub-periods 1984-1990, 1991-1998, and 2000-2004 is regressed on Covariance US Cons and a constant term, where in Panel C Covariance US Cons is instrumented with GDP Share. GDP Share is countries' average share in total OECD output in each sub-period, adjusted for fluctuations in the sample. In all panels observations are weighted with the number of quarters used to estimate the Covariance US Cons of the appropriate horizon. Standard errors are clustered by country.

# Online Appendix
(Not for Publication)

## A Details on the Complete Markets Model

All results in this Appendix are given for the full model in which households are endowed with varieties of a tradable intermediate input. The traded consumption good is then produced from intermediate inputs, which are freely traded. Varieties of the intermediate are specific to households and not countries such that each individual variety is in the same supply in expectation.

A **representative firm** has access to a technology which transforms the tradable intermediates into the traded consumption good according to

$$\bar{Y}_T = \left[\int_0^1 I_T(j)^{\xi}\, dj\right]^{\frac{1}{\xi}},\ \xi \leq 1, \tag{29}$$

where $I_T(j)$ stands for the input of the tradable intermediate $j \in [0,1]$ and $\bar{Y}_T$ denotes world output of the traded good.[23] The elasticity of substitution between any two tradable intermediates is $\varepsilon_\xi = (1-\xi)^{-1}$. The model in the main text is nested by setting $\varepsilon_\xi = \infty$. The representative firm takes prices as given and chooses quantities of inputs $\{I_T(j)\}_j$ to maximize profits.

The market clearing conditions for intermediate inputs are

$$I_T(j) = Y_T^n \quad \forall j \in \Theta^n,\ n = 1, ...N; \tag{30}$$

and (5) becomes

$$\bar{Y}_T = \int_{i\in[0,1]} C_T(i)\, di; \tag{31}$$

In equilibrium, the price of all tradable intermediate varieties originating in country $h$ is given by

$$p_T^h = \varepsilon_\xi^{-1}\left(\bar{y}_T - y_T^h\right). \tag{32}$$

Varieties that are in relatively short supply fetch a higher price and vice versa and the degree to which input prices respond to variations in relative supply depends inversely on the elasticity of substitution between intermediate varieties.

### A.1 Proof of Lemma 1

Consider an arbitrary asset with a stochastic payout of $X$ units of the traded consumption good in period 2 and a period 1 price of $V_X$. Summing up the prices of state-contingent securities from

[23] This representative firm is introduced mainly for notational convenience. Alternatively, one might interpret equation (29) as a definition of a country-specific tradable consumption index. See Grossman and Helpman (1991) for a discussion of these alternative interpretations.

households' first order conditions (7) yields

$$V_X = e^{-\delta} E \left[ \frac{\Lambda_{T2}}{\Lambda_{T1}} X \right].$$

Taking logs on both sides gives

$$v_X = -\delta + \log E \left[ \Lambda_{T2} X \right] - \lambda_{T1}.$$

If asset returns and marginal utilities are log-normal,

$$v_X = -\delta + E\lambda_{T2} + Ex + \frac{1}{2} var\left(\lambda_{T2}\right) + \frac{1}{2} var\left(x\right) + cov\left(\lambda_{T2}, x\right) - \lambda_{T1}$$

and therefore

$$\log ER\left[X\right] = \delta\lambda_{T1} - E\lambda_{T2} - \frac{1}{2} var\left(\lambda_{T2}\right) - cov\left(\lambda_{T2}, x\right). \tag{33}$$

Any other asset with payout $Z$:

$$\log ER\left[Z\right] = \delta\lambda_{T1} - E\lambda_{T2} - \frac{1}{2} var\left(\lambda_{T2}\right) - cov\left(\lambda_{T2}, z\right).$$

Differencing and re-arranging yields

$$\log ER\left[X\right] - \log ER\left[Z\right] = cov\left(\lambda_{T2}, z\right) - cov\left(\lambda_{T2}, x\right),$$

where $R\left[\bullet\right]$ is the gross return (in terms of traded goods) on an asset that pays $\bullet$.

## A.2 Proof of Lemma 3

**Lemma 3** *All households within a given country $n$ consume the same bundle $\left(C^n_{T2}\left(\omega\right), C^n_{N2}\left(\omega\right)\right)$ in the second period.*

**Proof.** The representative firm chooses a quantity of inputs $\left\{I_T\left(j\right)\right\}_j$ to solve

$$\max_{\left\{I_T(j)\right\}_j} \left[\int_0^1 I_T\left(j\right)^{\xi} dj\right]^{\frac{1}{\xi}} - \int_0^1 P_T\left(j\right) I_T\left(j\right) dj$$

The first order conditions associated with this problem state that the price of each tradable variety must equal its marginal product in the production of the traded good:

$$\left[\int_0^1 I_T\left(j\right)^{\xi} dj\right]^{\frac{1}{\xi}-1} I_T\left(j\right)^{\xi-1} = P_T\left(j\right) \quad \forall j \tag{34}$$

Combining the first order conditions (34), with the market clearing conditions for tradable varieties (30) we get that all intermediate varieties originating within one country fetch the same real price on the world market.

Moreover, solving the households' problem (maximizing (2) subject to (4)) yields the Euler equations

(7) as well as the following condition of optimality governing the ratio of tradable to non-tradable consumption:

$$P_{Nt} = \frac{(1-\tau)\, C_{Nt}\,(i)^{\alpha-1}}{\tau C_{Tt}\,(i)^{\alpha-1}}, \quad t = 1, 2. \tag{35}$$

It follows that the optimal behavior of all households within a given country is characterized by the same first order conditions as well as identical budget constraints. In the monetary model the same applies to the subset of all active households, $\Phi^n$:

$$C_{T2}\,(\omega, i) = C_{T2}^n\,(\omega) \quad \forall i \in \Phi^n,\ n = 1, ...N$$

and

$$C_{N2}\,(\omega, i) = C_{N2}^n\,(\omega) \quad \forall i \in \Phi^n,\ n = 1, ...N.$$

The proof of the same Lemma for the model given in the main text follows directly from setting $\xi = 1$ below. ■

### A.3 Details on the Social Planner's Problem

Applying lemma 3 to the economy's resource constraints (30), (5), and (6), yields the following simplified expressions:

$$\theta^n C_N^n = \theta^n Y_N^n \ \ \forall n,$$

$$\left[\sum_{n=1}^{N} \theta^n C_T^n\right] = \left[\sum_{n=1}^{N} \theta^n \left(Y_T^n\right)^{\xi}\right]^{\frac{1}{\xi}}.$$

Maximization of (9) subject to these constraints yields $3n$ first order conditions which characterize the equilibrium allocation.

$$\left[\tau \left(C_T^n\right)^{\alpha} + (1-\tau)\left(C_N^n\right)^{\alpha}\right]^{\frac{1-\gamma}{\alpha}-1} (1-\tau)\left(C_N^n\right)^{\alpha-1} = \Lambda_N^n \quad \forall n,$$

$$\left[\tau \left(C_T^n\right)^{\alpha} + (1-\tau)\left(C_N^n\right)^{\alpha}\right]^{\frac{1-\gamma}{\alpha}-1} \tau \left(C_T^n\right)^{\alpha-1} = \Lambda_T \quad \forall n,$$

$$\Lambda_T \left[\sum_{n=1}^{N} \theta^n \left(I_T\right)^{\xi} dj\right]^{\frac{1}{\xi}-1} \left(I_T\right)^{\xi-1} = \Lambda_T^n \quad \forall n$$

where $\Lambda_N^n$, $\Lambda_T^n$, and $\Lambda_T$, are Lagrange multipliers associated with the corresponding constraints.

### A.4 Deriving the price index

The cost of one unit of consumption in country $n$ is defined as

$$P^n = \arg\min C_T\,(i) + P_N C_N\,(i) \ \text{ s.t. } \ C\,(i) = 1,\ i \in \Theta^n.$$

First-order conditions imply

$$C_N(i)^* = \left(\frac{P_N}{1}\right)^{\frac{1}{\alpha-1}} \left(\frac{\tau}{1-\tau}\right)^{\frac{1}{\alpha-1}} C_T(i)^*,$$

where the optimized consumption bundle is denominated with an asterisk. The objective function and the constraint, combined with equation (3) imply that

$$P^n = \frac{C_T(i)^* + P_N C_N(i)^*}{\left[\tau C_T(i)^{*\alpha} + (1-\tau) C_N(i)^{*\alpha}\right]^{\frac{1}{\alpha}}}.$$

Now combine the two expressions to find that $C_T(i)^*$ cancels out of the fraction, multiply the numerator and the denominator with $\tau^{\frac{1}{1-\alpha}}$, plug in the definition $\varepsilon_\alpha = (1-\alpha)^{-1}$, and simplify to get

$$P_t^n = \frac{\Lambda^n}{\Lambda_T} = \left(\tau^{\varepsilon_\alpha} + (1-\tau)^{\varepsilon_\alpha} \left(P_{N,t}^n\right)^{1-\varepsilon_\alpha}\right)^{\frac{1}{1-\varepsilon_\alpha}}. \tag{36}$$

Log-linearizing this expression yields (12).

## A.5 Equilibrium Portfolio Holdings

**Proposition 4** *In a de-centralization of the model in which households trade stocks in the traded and non-traded sectors, the mean-variance efficient portfolios of all countries are identical in their loadings on stock in the traded sector and differ only in their loadings on stock in the non-traded sector.*

**Proof.** Portfolios that are mean-variance efficient from the perspective of a household in country $i$ make payments in terms of the country-specific consumption bundle that are perfectly correlated with marginal utility of consumption in country $i$. This amounts to payments of $\exp\left[x\lambda^i\right]$ units of the country-specific consumption bundle or $MV^i = \exp\left[x\lambda^i + p^i\right] = \exp\left[(x+1)\lambda^i - \lambda_T\right]$ units of traded goods, where values of $x \geq 0$ trace out the entire mean-variance frontier.
A portfolio of stocks in the traded and non-traded sectors held by households in country $i$ pays

$$Q^i = \sum_j W_{jT}^i \exp\left[p_T^j + y_T^j\right] + \sum_j W_{jN}^i \exp\left[p_N^j + y_N^j\right],$$

where $W_{jS}^i$,is the number of stocks held in sector $S = T, N$ of country $j$.
We solve for the number of stocks held in mean-variance efficient portfolios of households in country $i$ by equating the first derivatives of $MV^i$ and $Q^i$ with respect to the vector of endowments at the point $[y_T, y_N]' = 0$.

$$W_{jT}^i = \theta^j \frac{1 + x\gamma + \tau(-x\gamma\varepsilon_\alpha - 1)}{\tau(\varepsilon_\alpha - 1)} \forall j$$

$$W_{jN}^i = \theta^j \frac{(\gamma\varepsilon_\alpha - 1)(1 + x\gamma + \tau(-x\gamma\varepsilon_\alpha - 1))}{(\varepsilon_\alpha - 1)(1 - \gamma - \tau + \gamma\tau\varepsilon_a)}) \forall j \neq i \tag{37}$$

$$W_{iN}^i = \theta^i \left(\frac{1 + x\gamma}{1 - \varepsilon_\alpha} - x\gamma\right) + \left(\theta^i - 1\right) \frac{(1+x)\gamma}{(1 - \gamma - \tau + \gamma\tau\varepsilon_a)} \tag{38}$$

It follows trivially that $W^i_{jT} - W^i_{kT} = 0 \; \forall j, k$. ■

**Corollary 2** *In a de-centralization of the model in which households trade stocks in the traded and non-traded sectors households hold home-biased portfolios iff condition 3 holds.*

**Proof.** A direct implication of Proposition 4 is that any home bias in equity holdings can only result from home bias in stocks in the non-traded sector. The equilibrium portfolio of households held in country $i$ pays $\exp\left[-\frac{1}{\gamma}\lambda^i + p^i\right] = \exp\left[c^i + p^i\right]$ traded goods. We can thus obtain equilibrium holdings of stocks in the non-traded sector by substituting $x = -\frac{1}{\gamma}$ into equations (37) and (38). Portfolio holdings are thus home biased iff

$$\left(W^i_{iN} - W^i_{jN}\right)|_{x=-\frac{1}{\gamma}} > 0.$$

Manipulating this expression yields condition 3. ■

### A.6 Details on Conditions 1 and 3

Figure 3 plots the restrictions on the parameter space required in Proposition 2 for $\tau = 0.3$. All combinations north-east of the broken line satisfy condition 1 and the combinations above the solid line satisfy condition 3. If either relative risk aversion or the elasticity of substitution between tradables and non-tradables are large enough, both conditions typically hold. While Proposition 2 refers to the areas A and B, stocks in the non-traded sector of larger countries also pay lower expected returns if both conditions are simultaneously violated, as in area C.

Note that parallel results in the monetary model do not depend on any restrictions on the parameter space, such that regions A and B in Figure 3 expand further when the economy is affected by both real and monetary shocks simultaneously.

## B Details on the Incomplete Markets Model

### B.1 Details on the Setup

In the second period, the cash in advance constraint for active households is

$$\tilde{P}^n_{T2}\left(C_{T2}(i) + P^n_{N2}C_{N2}(i)\right) \leq \tilde{M}^n_1(i) + \tilde{P}^n_{T2}B(\omega, i) \quad \forall \omega, i \in \{\Phi^n\}, \; n = 1, ...N, \tag{39}$$

where $\Phi^n$ denotes the subset of active households in country $n$, $\tilde{P}^n_T$ is the nominal price of the traded good in country $n$, $\tilde{M}^n_1(i)$ are the nominal money holdings of a household $i$ carried over from period 1 in terms of the currency of its home country $n$, and $B(\omega, i)$ is the quantity of state-contingent bonds that pay one unit of the traded good in state $\omega$ held by the household. Since inactive households are precluded from trading in asset markets, their cash in advance constraint in both periods is simply

$$\tilde{P}^n_{T,t}\left(C_{T,t}(i) + P^n_{N,t}C_{N,t}(i)\right) \leq \tilde{M}^n_{t-1}(i) \quad , i \in \{\Theta^n \cap \backslash \Phi^n\}, \; n = 1, ...N. \tag{40}$$

All households within a given country start the first period with identical cash holdings, $\tilde{M}^n_0$, where the appropriate transfers required to de-centralize the allocation resulting from a utilitarian welfare

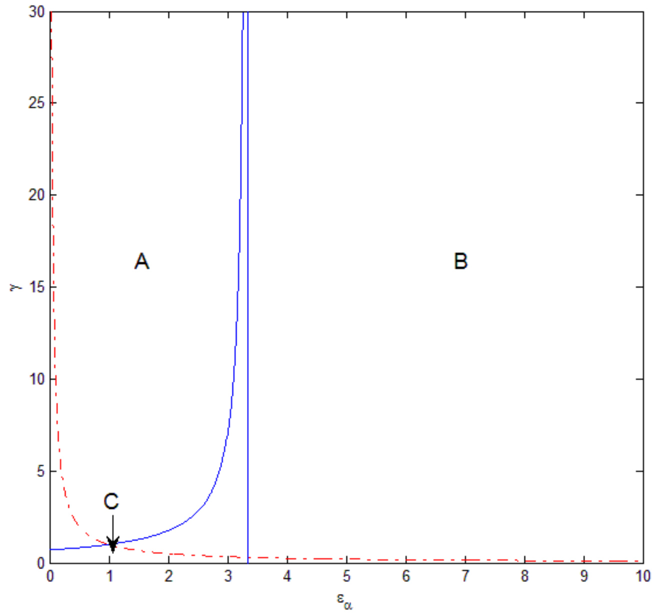


Figure 3: This figure plots the restrictions on the parameter space required in propositions 1 and 2 for $\tau = 0.3$. All combinations north-east of the broken line satisfy condition 1 which is required for both propositions 1 and 2. The combinations above the solid line satisfy condition 3 which is required only by proposition 2.

function are made between active households.[24]

The market clearing conditions for the goods markets remain unchanged, while the money market clearing conditions are given by

$$\int_{i \in \Theta^n} \tilde{P}^n_{T,t} \left( P_{T,t}(i) Y^n_{T,t} + P^n_{N,t} Y^n_{N,t} \right) di = \bar{M}^n_t, \quad \forall n, t \tag{42}$$

where $\bar{M}^n_t = \int_i \tilde{M}^n_t(i) \, di$. The central bank may change the monetary base in the second period through open market operations

$$\tilde{P}^n_2(\omega) B^n_2(\omega) = \bar{M}^n_2 - \bar{M}^n_1,$$

where $B^n_2(\omega)$ is the total payout of tradables in state $\omega$ from bonds issued by central bank $n$. The central banks' budget constraint is

$$0 = \int Q(\omega) B^n_2(\omega) \, d\omega.$$

[24] The first period constraint for active households is therefore given by

$$\tilde{P}^n_{T1} \left( C_{T1}(i) + P^n_{N1} C_{N1}(i) + \int_\omega Q(\omega) B(\omega, i) \right) \leq \tilde{M}^n_0(i) + \tilde{P}^n_{T1} \kappa^n , \tag{41}$$

where $\tilde{P}^n_{T1} \kappa^n$ reflects the nominal value of transfers of claims to tradable output between active households of different countries.

## B.2 Proof of Lemma 2

For the first part of the statement, note that the problem of the representative firm (see Appendix A) remains unchanged. We can thus apply the first step of the proof of lemma 3 to find that all tradable varieties originating within one country continue to fetch the same real and nominal price on the world market. It follows that all households (both active and inactive) within a given country enter the second period with the same amount of cash.

$$\tilde{M}_1^n(i) = \tilde{P}_{T1}^n\left(P_{T1}^n Y_{T1}^n + P_{N1}^n Y_{N1}^n\right) \equiv \tilde{M}_1^n \ ; \ \forall i \in \Theta^n, n = 1, ...N \tag{43}$$

It immediately follows that active households within each country consume identical bundles. Moreover, note that the condition ruling out that inactive households save by holding cash between the first and second period is sufficient to ensure that active households never do so, because active households have the option to save by purchasing state-contingent bonds in the first period. Then, an active household's problem is to maximize (2) subject to (39) and (41), yielding the conditions of optimality (7) and (35). Proof of the first part of the statement thus follows from the fact that the optimal behavior of all active households within a given country is characterized by the same first order conditions under identical constraints. It follows immediately that

$$C_{T2}(\omega, i) = C_{T2}^n(\omega) \quad \forall i \in \Phi^n, \ n = 1, ...N$$

$$C_{N2}(\omega, i) = C_{N2}^n(\omega) \quad \forall i \in \Phi^n, \ n = 1, ...N$$

For the second part of the lemma, I first show that the condition $\mu > \delta/(\gamma - 1)$ is sufficient to ensure that inactive households do not carry over cash from the first to the second period. We can re-write inactive households' problem in the following way:

$$\max U(i) = \frac{1}{1-\gamma} C_1(i)^{1-\gamma} + e^{-\delta} \frac{1}{1-\gamma} E\left[C_2(i)^{1-\gamma}\right]$$

subject to

$$C_1(i) = \frac{\tilde{M}_0^n(i) - H(i)}{P_1^n \tilde{P}_{T1}^n} \text{ and } C_2(i) = \frac{\tilde{M}_1^n(i) + H(i)}{P_2^n \tilde{P}_{T2}^n},$$

where $H(i) \geq 0$ are the savings in cash carried over from the first to the second period. Maximization of the problem yields

$$\left(\frac{\tilde{M}_0^n(i) - H(i)}{P_1^n \tilde{p}_{T1}^n}\right)^{-\gamma} \frac{1}{P_1^n \tilde{P}_{T1}^n} = e^{-\delta} E\left[\left(\frac{\tilde{M}_1^n(i) + H(i)}{P_2^n \tilde{P}_{T2}^n}\right)^{-\gamma} \frac{1}{P_2^n \tilde{P}_{T2}^n}\right],$$

where households choose not carry over cash between the two periods if

$$\left(\frac{M_0^n(i)}{P_1^n \tilde{p}_{T1}^n}\right)^{-\gamma} \frac{1}{P_1^n \tilde{P}_{T1}^n} > e^{-\delta} E\left[\left(\frac{M_1^n(i)}{P_2^n \tilde{P}_{T2}^n}\right)^{-\gamma} \frac{1}{P_2^n \tilde{P}_{T2}^n}\right].$$

Given that $[y_{T,1}, y_{N,1}, \tilde{\mu}_1] = 0$ and (1), this expression collapses to

$$\mu > \frac{\delta}{(\gamma - 1)}.$$

Under this condition, inactive households thus face a stationary problem. This can be written as

$$\max \frac{1}{1-\gamma} \left[\tau \left(C_{T,t}\left(i\right)\right)^{\alpha} + \left(1-\tau\right)\left(C_{N,t}\left(i\right)\right)^{\alpha}\right]^{\frac{1-\gamma}{\alpha}}$$

subject to (40). Maximization of this problem yields (35) as the single condition of optimality. Since (43) applies to the cash holdings of both active and inactive households, it immediately follows that all inactive households within a given country must consume identical bundles $\left(\hat{C}^n_{T,t}, \hat{C}^n_{N,t}\right)$.

From (40) and (35), this bundle is given as

$$\hat{C}^n_{T,t} = \frac{\tilde{M}^n_{t-1}}{\tilde{P}^n_{T,t}\left(1 + \left(P^n_{N,t}\right)^{\frac{-\alpha}{1-\alpha}} \left(\frac{1-\tau}{\tau}\right)^{\frac{1}{1-\alpha}}\right)},\ \hat{C}^n_{N,t} = \frac{\tilde{M}^n_{t-1}}{\tilde{P}^n_{T,t} P^n_{N,t}\left(\left(\frac{1-\tau}{\tau}\right)^{\frac{-1}{1-\alpha}} \left(P^n_{N,t}\right)^{\frac{\alpha}{1-\alpha}} + 1\right)}. \quad (44)$$

The money market clearing condition (35) implies

$$\tilde{P}^n_{T,t} = \frac{\bar{M}^n_t}{\theta^n \left(P^n_{T,t} Y^n_{T,t} + P^n_{N,t} Y^n_{N,t}\right)} = \frac{\tilde{M}^n_t}{\left(P^n_{T,t} Y^n_{T,t} + P^n_{N,t} Y^n_{N,t}\right)}.$$

Monetary policy aims to stabilize the price level, such that

$$\frac{\tilde{P}^n_{T,t}}{\tilde{P}^n_{T,t-1}} = \frac{\bar{M}^n_t}{\bar{M}^n_{t-1}} \frac{P^n_{T,t-1} Y^n_{T,t-1} + P^n_{N,t-1} Y^n_{N,t-1}}{P^n_{T,t} Y^n_{T,t} + P^n_{N,t} Y^n_{N,t}} = \exp\left(\tilde{\mu}_t\right).$$

Combining these two conditions yields

$$\frac{\tilde{M}^n_{t-1}}{\tilde{P}^n_{T,t}} = \left(P^n_{T,t-1} Y^n_{T,t-1} + P^n_{N,t-1} Y^n_{N,t-1}\right) \exp\left(-\tilde{\mu}_t\right).$$

Plugging in the endowments in the first period and combining this expression with (44) yields (18) and concludes the proof of the lemma.

## B.3 Details on the Social Planner's Problem under Segmented Markets

Although the first theorem of welfare economics fails in this economy, we may nevertheless obtain the equilibrium allocation by solving a Social Planner's problem for the active subset of households, subject to the constraint that the inactive households follow their own optimal program. Applying lemma 2, we can write this Social Planner's problem as

$$\max \phi \sum_{n=1}^{N} \theta^n \frac{1}{1-\gamma} \left[\tau \left(C_T^n\right)^\alpha + (1-\tau)\left(C_N^n\right)^\alpha\right]^{\frac{1-\gamma}{\alpha}}$$

subject to the economy's resource constraints (30), (5), and (6), as well as to the behavior of inactive households from (18). As before, the problem is now time-separable and we can henceforth omit the time subscripts.

I obtain closed-form solutions by log-linearizing the model around the point at which $[y_{T,2}, y_{N,2}, \tilde{\mu}_2]' = 0$. Applying lemma 2 to the economy's resource constraints (30), (5), and (6), yields the following simplified expressions:

$$\theta^n \left(\phi C_N^n + (1-\phi)\hat{C}_N^n\right) = \theta^n Y_N^n \quad \forall n,$$

$$\phi \left[\sum_{n=1}^{N} \theta^n C_T^n\right] + (1-\phi)\left[\sum_{n=1}^{N} \theta^n \hat{C}_T^n\right] = \left[\sum_{n=1}^{N} \theta^n \left(I_T^n\right)^\xi dj\right]^{\frac{1}{\xi}},$$

and $Y_T^n = I_T^n$. The associated Lagrangian is

$$\begin{aligned} L &= \phi \sum_{n=1}^{N} \theta^n \frac{1}{1-\gamma} \left[\tau \left(C_T^n\right)^\alpha + (1-\tau)\left(C_N^n\right)^\alpha\right]^{\frac{1-\gamma}{\alpha}} \\ &\quad -\Lambda_T \left(\phi \left[\sum_{n=1}^{N} \theta^n C_T^n\right] + (1-\phi)\left[\sum_{n=1}^{N} \theta^n \hat{C}_T^n\right] - \left[\sum_{n=1}^{N} \theta^n \left(I_T^n\right)^\xi dj\right]^{\frac{1}{\xi}}\right) \\ &\quad -\sum_{n=1}^{N} \theta^n \Lambda_N^n \left(\phi C_N^n + (1-\phi)\hat{C}_N^n - Y_N^n\right) - \sum_{n=1}^{N} \theta^n \Lambda_T^n \left(I_T - Y_T^n\right) \end{aligned}$$

which yields $3n$ first order conditions

$$\left[\tau \left(C_T^n\right)^\alpha + (1-\tau)\left(C_N^n\right)^\alpha\right]^{\frac{1-\gamma}{\alpha}-1} \tau \left(C_T^n\right)^{\alpha-1} = \Lambda_T \quad \forall n,$$

$$\left[\tau \left(C_T^n\right)^\alpha + (1-\tau)\left(C_N^n\right)^\alpha\right]^{\frac{1-\gamma}{\alpha}-1} (1-\tau)\left(C_N^n\right)^{\alpha-1} = \Lambda_N^n \quad \forall n,$$

and

$$\Lambda_T \left[\sum_{n=1}^{N} \theta^n \left(I_T^n\right)^\xi dj\right]^{\frac{1}{\xi}-1} \left(I_T^n\right)^{\xi-1} = \Lambda_T^n \quad \forall n.$$

## B.4 System of Log-Linearized Equations

Log-linearizing the first order conditions and resource constraints around the point at which $[y_T, y_N, \tilde{\mu}]' = 0$ yields

$$(1-\gamma-\alpha)\left(\tau c_T^n + (1-\tau)\, c_N^n\right) + \log \tau + (\alpha - 1)\, c_T^n = \lambda_T \quad \forall n,$$

$$(1-\gamma-\alpha)\left(\tau c_T^n+(1-\tau)\,c_N^n\right)+\log\left(1-\tau\right)+(\alpha-1)\,c_N^n=\lambda_N^n\quad\forall n,$$

$$\lambda_T+(1-\xi)\left(\sum_{n=1}^{N}\theta^n y_T^n\right)+(\xi-1)\,y_T^n=\lambda_T^n\quad\forall n,$$

$$\phi c_N^n+(1-\phi)\left(-\tilde{\mu}^n-\tau\left(\frac{1}{1-\alpha}+\frac{1-\tau}{\tau}\right)\left(p_N^n-\log\left(\frac{1-\tau}{\tau}\right)\right)\right)=y_N^n\quad\forall n,$$

and

$$\phi\sum_{n=1}^{N}\theta^n c_T^n+(1-\phi)\sum_{n=1}^{N}\theta^n\left(-\tilde{\mu}^n-\frac{\alpha}{1-\alpha}\left(1-\tau\right)\left(p_N^n-\log\left(\frac{1-\tau}{\tau}\right)\right)\right)=\sum_{n=1}^{N}\theta^n y_T^n.$$

The equivalent expressions for the model with complete asset markets can be obtained by setting $\phi=1$ in the expressions above.

### B.5 Volatility of Aggregate Consumption and the Backus-Smith Puzzle

I first show formally that the volatility of aggregate consumption growth of larger countries is lower than that of smaller countries if the economy is affected only by monetary shocks and real endowments are constant.

Plug the equilibrium consumption of traded and non-traded goods of inactive households (18) into (3) and manipulate the right hand side of the equation to get

$$\hat{C}_2^n=\frac{1}{\tau}\exp\left(-\tilde{\mu}^n\right)\left[\tau^{\frac{1}{1-\alpha}}+\left(P_{N2}^n\right)^{\frac{-\alpha}{1-\alpha}}\left(1-\tau\right)^{\frac{1}{1-\alpha}}\right]^{\frac{1-\alpha}{\alpha}}=\frac{1}{\tau}\exp\left(-\tilde{\mu}^n-p_2^n\right),$$

where the second equality follows from (36). Aggregate consumption of country $n$ is defined as the integral over the consumption of all households in the country, denoted as $\bar{C}$ :

$$\bar{C}_2^n=\phi C_2^n+(1-\phi)\,\hat{C}_2^n=\exp\left(c_2^n\right)+\frac{1}{\tau}\exp\left(-\tilde{\mu}^n-p_2^n\right).$$

I then plug the equilibrium allocation into this expression (using the fact that $c_2^n=\left(\tau c_T^n+(1-\tau)\,c_N^n\right)$ as well as (12), (21), and (20)) and log-linearize the expression around the point at which $[y_T,y_N,\tilde{\mu}]'=0=0$.

With the log-linear solution for $c_2^n$ and $\bar{c}_2^n$ in hand I can then solve for their variances and show that

$$Var\left(\bar{c}_2^h\right)-Var\left(\bar{c}_2^f\right)=\frac{2\gamma^2\tau^2(1-\phi)^2\epsilon_\alpha^2}{\left(\gamma\left(1-\tau\left(1-\epsilon_\alpha\right)\right)-\left(\gamma-1\right)\phi(1-\tau)\right)^2}(\theta^f\tilde{\sigma}_f^2-\theta^h\tilde{\sigma}_h^2)$$

and

$$Var\left(c_2^h\right)-Var\left(c_2^f\right)=-\frac{2\gamma(1-\tau)(1-\phi)^2\left((1-\tau)(1-\phi)+\tau\epsilon_\alpha\right)}{\phi\left(\gamma\left(1-\tau\left(1-\epsilon_\alpha\right)\right)-\left(\gamma-1\right)\phi(1-\tau)\right)^2}(\theta^f\tilde{\sigma}_f^2-\theta^h\tilde{\sigma}_h^2).$$

The fractions on the right hand side of both equations are strictly greater than zero. For $\theta^f\tilde{\sigma}_f^2>\theta^h\tilde{\sigma}_h^2$ it follows that $Var\left(c_2^h\right)<Var\left(c_2^f\right)$ but $Var\left(\bar{c}_2^h\right)>Var\left(\bar{c}_2^f\right)$.

Moreover, the covariance between the exchange rate and aggregate consumption growth is positive:

$$cov\left(s_2^{f,h}, \bar{c}_2^f - \bar{c}_2^h\right) = \frac{\gamma^2 (1-\tau)\tau(1-\phi)^2 \varepsilon_\alpha}{\left((1-\tau)(\phi+\gamma(1-\phi)) + \gamma\tau\varepsilon_\alpha\right)^2}(\tilde{\sigma}_f^2 + \tilde{\sigma}_h^2).$$

It follows that in the full model in which households are affected by both real and monetary shocks the volatility of aggregate consumption growth in larger countries may be higher or lower, depending on the relative size of real and monetary shocks and on the parameters of the model.

## B.6 Full Analytical Results under Market Segmentation

This section lists full solutions for the case in which markets are segmented and the economy experiences both real and monetary shocks. The relative price of non-traded goods in an arbitrary country $h$ is given as

$$\begin{aligned} p_N^h &= \varepsilon_\alpha^{-1}\sum_{n=1}^N \theta^n y_T^h - \frac{\gamma y_N^h}{(1-(1-\varepsilon_\alpha)\tau)\gamma - (\gamma-1)(1-\tau)\phi} \\ &+ \frac{(1-\tau)\left[\gamma - \gamma\varepsilon_\alpha^{-1}(1-\phi) - \varepsilon_\alpha^{-1}\phi\right]}{(1-(1-\varepsilon_\alpha)\tau)\gamma - (\gamma-1)(1-\tau)\phi}\sum_{n=1}^N \theta^n y_n^n - \frac{\gamma(1-\phi)}{(1-(1-\varepsilon_\alpha)\tau)\gamma - (\gamma-1)(1-\tau)\phi}\tilde{\mu}^h \\ &+ \sum_{n=1}^N \frac{\gamma\theta^n(1-\phi)}{(1-(1-\varepsilon_\alpha)\tau)\gamma - (\gamma-1)(1-\tau)\phi}\tilde{\mu}^n - \log\left(\frac{\tau}{1-\tau}\right). \end{aligned}$$

Marginal utility of active households from tradable consumption is

$$\begin{aligned} \lambda_T &= -\left((1-\tau)\varepsilon_\alpha^{-1} + \frac{\tau\gamma}{\phi} + (1-\tau)\gamma\varepsilon_\alpha^{-1}\frac{1-\phi}{\phi}\right)\sum_{n=1}^N \theta^n y_T^n \\ &\quad -(1-\tau)\left[\frac{\gamma}{\phi} - \varepsilon_\alpha^{-1} - \gamma\varepsilon_\alpha^{-1}\frac{1-\phi}{\phi}\right]\sum_{n=1}^N \theta^n y_N^n - \frac{1-\phi}{\phi}\gamma\sum_{n=1}^N \theta^n \tilde{\mu}^n + \log(\tau), \end{aligned}$$

the real exchange rate is given as

$$s^{h,f} = \frac{\gamma(1-\tau)}{(1-(1-\varepsilon_\alpha)\tau)\gamma - (\gamma-1)(1-\tau)\phi}\left[(1-\phi)\left(\tilde{\mu}^h - \tilde{\mu}^f\right) + y_N^h - y_N^f\right],$$

and the nominal exchange rate becomes

$$\begin{aligned} \tilde{s}^{h,f} &= \left(\frac{\gamma(1-\tau)}{((1-(1-\varepsilon_\alpha)\tau)\gamma - (1-\tau)(\gamma-1)\phi)}(1-\phi) - 1\right)\left(\tilde{\mu}^h - \tilde{\mu}^f\right) \\ &+ \frac{\gamma(1-\tau)}{((1-(1-\varepsilon_\alpha)\tau)\gamma - (1-\tau)(\gamma-1)\phi)}\left(y_N^h - y_N^f\right). \end{aligned}$$

International spreads on stocks in the traded sector, on stocks in the non-traded sector, and on risk-free bonds are

$$\rho_T^{h,f} = ((1-\tau)\phi\varepsilon_\alpha^{-1} + (1-\phi)\gamma(1-\tau)\varepsilon_\alpha^{-1} + \gamma\tau)(\varepsilon_\xi^{-1} - 1)/\phi\left(\sigma_h^2\theta^h - \sigma_f^2\theta^f\right),$$

$$\rho_N^{h,f} = \frac{\gamma^2(\phi-1)^2}{((1-(1-\varepsilon_\alpha)\tau)\gamma-(\gamma-1)(1-\tau)\phi)\phi}\left(\tilde{\sigma}_h^2\theta^h-\tilde{\sigma}_f^2\theta^f\right) + \frac{[(\gamma-1)\phi+(\varepsilon_\alpha-1)\gamma](1-\tau)[(1-\tau)(\gamma-1)\phi-\tau\gamma(\varepsilon_\alpha-1)]}{((1-(1-\varepsilon_\alpha)\tau)\gamma-(\gamma-1)(1-\tau)\phi)\phi\varepsilon_\alpha}\left(\sigma_h^2\theta^h-\sigma_f^2\theta^f\right),$$

and

$$\rho^{h,f} = (1-\tau)\frac{\gamma^2(\phi-1)^2}{((1-(1-\varepsilon_\alpha)\tau)\gamma-(\gamma-1)(1-\tau)\phi)\phi}\left(\tilde{\sigma}_h^2\theta^h-\tilde{\sigma}_f^2\theta^f\right) + (1-\tau)\frac{(1-(1-\varepsilon_\alpha)\tau)\gamma-(1-\tau)(\gamma-1)\phi-\gamma\varepsilon_\alpha}{(1-(1-\varepsilon_\alpha)\tau)\gamma-(1-\tau)(\gamma-1)\phi}\frac{\gamma}{\varepsilon_\alpha\phi}\left(\sigma_h^2\theta^h-\sigma_f^2\theta^f\right)$$

respectively. Conditions 1 and 3 are

$$\gamma > \frac{\phi}{\varepsilon_\alpha-(1-\phi)}$$

and

$$\gamma > \frac{\phi(1-\tau)}{(\phi+((1-\phi)-\varepsilon_\alpha)\tau)}.$$

The calibration for the numerical example in section 5 is based on the following calculations: First, the predicted spread on nominal bonds is

$$\rho_{\text{nominal}}^{h,f} = \frac{\gamma\varepsilon_\alpha-(1-(1-\varepsilon_\alpha)\tau)\gamma+(1-\tau)(\gamma-1)\phi}{(1-(1-\varepsilon_\alpha)\tau)\gamma-(1-\tau)(\gamma-1)\phi}\frac{\gamma(1-\tau)}{\varepsilon_\alpha\phi}\left(\sigma_h^2\theta^h-\sigma_f^2\theta^f\right) + \frac{(1-\tau)\gamma^2(1-\phi)^2+\gamma(1-\phi)[(\gamma-1)(1-\tau)(1-\phi)+(1-\tau+\tau\gamma\varepsilon_\alpha)]}{((1-(1-\varepsilon_\alpha)\tau)\gamma-(\gamma-1)(1-\tau)\phi)\phi}\left(\tilde{\sigma}_h^2\theta^h-\tilde{\sigma}_f^2\theta^f\right). \tag{45}$$

Under the assumption the variance of endowment and monetary shocks is identical across countries, the variance of the real exchange rate is

$$var(\Delta s) = 2\frac{(\gamma(1-\tau))^2}{((1-(1-\varepsilon_\alpha)\tau)\gamma-(\gamma-1)(1-\tau)\phi)^2}\left[(1-\phi)^2\tilde{\sigma}^2+\sigma^2\right] \tag{46}$$

and the variance of the nominal exchange rate is given as

$$var(\Delta\tilde{s}) = 2\left(\frac{\gamma(1-\tau)}{((1-(1-\varepsilon_\alpha)\tau)\gamma-(1-\tau)(\gamma-1)\phi)}(1-\phi)-1\right)^2\tilde{\sigma}^2 + 2\left(\frac{\gamma(1-\tau)}{((1-(1-\varepsilon_\alpha)\tau)\gamma-(1-\tau)(\gamma-1)\phi)}\right)^2\sigma^2. \tag{47}$$

Substitute $\tilde{\sigma}_h = \tilde{\sigma}_f$ and $\phi$ out of (45) with (46) and (47) and plug in the values for the remaining parameters given in the text to obtain the implied estimates of $\gamma$.

# C Within-Country Correlations

**Proposition 5** *Given conditions 1 and 2, the difference in log expected returns between larger and smaller countries' risk-free and nominal bonds increases monotonically with the within-country covariance between endowments and monetary shocks, as well as with the within-country covariance between endowments in the traded and non-traded sectors.*
*Given conditions 1, 2, and 3 the same is true for the difference in log expected returns between larger and smaller countries' stocks in the non-traded sector.*

**Proof.** The difference in log expected returns between two countries' risk-free bonds is given as

$$\begin{aligned}
\rho^{h,f} \quad = \quad & (1-\tau)\frac{\gamma^2(\phi-1)^2}{((1-(1-\varepsilon_\alpha)\tau)\gamma-(\gamma-1)(1-\tau)\phi)\phi}\left(\tilde{\sigma}_h^2\theta^h-\tilde{\sigma}_f^2\theta^f\right) \\
& +(1-\tau)\frac{(1-(1-\varepsilon_\alpha)\tau)\gamma-(1-\tau)(\gamma-1)\phi-\gamma\varepsilon_\alpha}{(1-(1-\varepsilon_\alpha)\tau)\gamma-(1-\tau)(\gamma-1)\phi}\frac{\gamma}{\varepsilon_\alpha\phi}\left(\sigma_h^2\theta^h-\sigma_f^2\theta^f\right) \\
& +(1-\tau)\varepsilon_\alpha^{-1}\gamma\frac{(1-\phi)}{\phi}corr\left(\tilde{\mu},y_T\right)\left(\tilde{\sigma}_h\sigma_h\theta^h-\tilde{\sigma}_f\sigma_f\theta^f\right) \\
& +(1-\tau)\varepsilon_\alpha^{-1}\gamma\frac{(1-\phi)}{\phi}\frac{((2-\tau)\varepsilon_\alpha\gamma-[(1-\phi)\gamma+\phi](1-\tau))}{((1-\tau(1-\varepsilon_\alpha))\gamma-(1-\tau)\phi(\gamma-1))}corr\left(\tilde{\mu},y_N\right)\left(\tilde{\sigma}_h\sigma_h\theta^h-\tilde{\sigma}_f\sigma_f\theta^f\right) \\
& +(1-\tau)\varepsilon_\alpha^{-1}\gamma\frac{1}{\phi}corr\left(y_T,y_N\right)\left(\sigma_h^2\theta^h-\sigma_f^2\theta^f\right).
\end{aligned}$$

Proof of the first part of the statement thus amounts to observing that 1 and 2 are sufficient to ensure that the sign of each term is the sign of $\left(\theta^h-\theta^f\right)$.
The difference in log expected returns between two countries stocks in the non-traded sector is given as

$$\begin{aligned}
\rho_N^{h,f} \quad = \quad & \frac{\gamma^2(\phi-1)^2}{((1-(1-\varepsilon_\alpha)\tau)\gamma-(\gamma-1)(1-\tau)\phi)\phi}\left(\tilde{\sigma}_h^2\theta^h-\tilde{\sigma}_f^2\theta^f\right) \\
& +\frac{[(\gamma-1)\phi+(\varepsilon_\alpha-1)\gamma](1-\tau)[(1-\tau)(\gamma-1)\phi-\tau\gamma(\varepsilon_\alpha-1)]}{((1-(1-\varepsilon_\alpha)\tau)\gamma-(\gamma-1)(1-\tau)\phi)\phi\varepsilon_\alpha}\left(\sigma_h^2\theta^h-\sigma_f^2\theta^f\right) \\
& +\varepsilon_\alpha^{-1}\gamma\frac{(1-\phi)}{\phi}corr\left(\tilde{\mu},y_T\right)\left(\tilde{\sigma}_h^2\theta^h-\tilde{\sigma}_f^2\theta^f\right) \\
& +\gamma\frac{(1-\phi)}{\phi}\left[\varepsilon_\alpha^{-1}\frac{((2-\tau)\varepsilon_\alpha\gamma-[(1-\phi)\gamma+\phi](1-\tau))}{((1-\tau(1-\varepsilon_\alpha))\gamma-(1-\tau)\phi(\gamma-1))}-1\right]corr\left(\tilde{\mu},y_N\right)\left(\tilde{\sigma}_h^2\theta^h-\tilde{\sigma}_f^2\theta^f\right) \\
& +\varepsilon_\alpha^{-1}\frac{(\phi(1-\tau)(\gamma-1)-(\varepsilon_\alpha-1)\gamma\tau)}{\phi}corr\left(y_N,y_T\right)\left(\sigma_h^2\theta^h-\sigma_f^2\theta^f\right),
\end{aligned}$$

where again conditions 1, 2, and 3 are sufficient to ensure that each term has the same sign as $\left(\theta^h-\theta^f\right)$. The proof for nominal bonds is analogous. ■

# D Endogenous capital accumulation

In this section I extend the model in section 2 to allow for endogenous capital accumulation. As only differences in the endowment in the non-traded sector matter for exchange rates and spreads on bonds

I focus on endogenous production and capital accumulation in the non-traded sector and continue to assume exogenous endowments of the traded good. In particular, output of the non-traded good in each country is produced using a Cobb-Douglas technology. Output per capita of the non-traded good in (1) becomes

$$Y_{N2}^{n} = \exp\left[\eta^{n}\right]\left(\frac{K^{n}}{\theta^{n}}\right)^{v}, \tag{48}$$

where $0 < \nu < 1$ and each household is endowed with one unit of labor such that the total supply of labor per country is $\theta^n$. Each country experiences a shock to total factor productivity in the second period,

$$\eta^{n} \sim N\left(-\frac{1}{2}\sigma_{n}^{2}, \sigma_{n}^{2}\right) \forall n.$$

While trading in complete asset markets in period one, households now additionally face a choice of which fraction of its first-period endowment to consume and which fraction to invest into the capital stock. Capital accumulates according to

$$\theta^{n} Y_{1} - \int_{i\in\Theta^{n}} C_{1}\left(i\right) di = K^{n}, \tag{49}$$

where $Y_1$ is the deterministic per-capita endowment of each country's final consumption bundle in period one. After production takes place in the second period the accumulated capital fully depreciates.

I solve the model using perturbation methods. Perturbation methods deliver the coefficients to a Taylor series that approximates the non-linear equilibrium variables. The goal of the exercise is to write all equilibrium variables as a Taylor series in the state variables. In order to show tractable analytical expressions I focus on the case of two countries ($n = h, f$), complete markets ($\phi = 1$) and an elasticity of substitution between traded and non-traded goods of one ($\alpha = 0$). Analytical expressions exist for the general case but they are too complex to display here. A numerical solution for the full model is straight-forward and available upon request.

Applying lemma 2 to the social planner's problem gives

$$\max E_{1} \sum_{n=h,f} \theta^{n} \frac{1}{1-\gamma}\left[\left(C_{1}^{n}\right)^{1-\gamma} + e^{-\delta}\left(C_{2}^{n}\right)^{1-\gamma}\right] \tag{50}$$

subject to the economy's resource constraints (3), (5), (6), (30), (48), and (49). Plugging these constraints into the objective function and maximizing yields three equilibrium conditions.

The first relates the allocation of traded goods across the two countries to the realization of endowments and the level of capital accumulation, $f\left(\eta^{h}, \eta^{f}, y_{T}^{h}, y_{T}^{f}, K_{N}^{h}, K_{N}^{f}\right) = 0$. This condition implicitly defines the equilibrium allocation of traded goods across the two countries, $C_{T2}^{h}\left(\eta^{h}, \eta^{f}, y_{T}^{h}, y_{T}^{f}, K_{N}^{h}, K_{N}^{f}\right)$. Via the set of constraints to the optimization this policy function determines all other endogenous variables in the second period.

The remaining two conditions relate the level of capital accumulation in the first period to the expected allocation in the second period:

$$\left(Y_1-\frac{K^n}{\theta^n}\right)^{-\gamma}=E\left[e^{-\delta}(1-\tau)\nu\frac{\theta^n}{K^n}\left(\left(\left(\frac{K^n}{\theta^n}\right)^{\nu}\eta^n\right)^{1-\tau}(C^n_{T2})^{\tau}\right)^{1-\gamma}\right],\ n=h,f. \tag{51}$$

They implicitly define the policy functions of each of the two countries governing the accumulation of capital, $K^h_N(\sigma_h,\sigma_f)$ and $K^f_N(\sigma_h,\sigma_f)$. The latter two policy functions are independent of the realization of endowments and shocks as households decide about capital accumulation in period one, before these are realized.

I choose the endowment in the first period as

$$Y_1=1+(\exp[[-\delta]\,(1-\tau)\,\nu)^{-\frac{1}{\gamma}},$$

such that the deterministic solution of the model coincides with the deterministic solution of the model in the main part of the paper:

$$DS:=\{C^h_{T2}\left(0,0,0,0,K^h_N(0,0),K^h_N(0,0)\right)=1,\ K^h_N(0,0)=\theta^h,\ K^h_N(0,0)=\theta^f\}.$$

I then take a series of derivatives of the condition $f\left(\eta^h,\eta^f,y^h_T,y^f_T,K^h_N,K^f_N\right)=0$ and solve for the coefficients in a Taylor expansion of $C^h_{T2}\left(\eta^h,\eta^f,y^h_T,y^f_T,K^h_N,K^f_N\right)$ around the deterministic solution of the model. For example, the equation $\frac{\partial f\left(\eta^h,\eta^f,y^h_T,y^f_T,K^h_N,K^f_N\right)}{\partial\eta^h}=0$ allows me to solve explicitly for the coefficient $\frac{\partial C^h_{T2}\left(\eta^h,\eta^f,y^h_T,y^f_T,K^h_N,K^f_N\right)}{\partial\eta^h}|_{DS}$, and so on. Using this procedure we can furnish all coefficients of the Taylor expansion

$$\begin{aligned}C^h_{T2}\left(\eta^h,\eta^f,y^h_T,y^f_T,K^h_N,K^f_N\right)\approx&\sum_{i_1,\dots,i_6}\frac{1}{(i_1+\dots+i_6)!}\frac{\partial^{i_1+\dots+i_6}C^h_{T2}\left(\eta^h,\eta^f,y^h_T,y^f_T,K^h_N,K^f_N\right)}{\partial^{i_1}\eta^h\partial^{i_2}\eta^f\partial^{i_3}y^h_T\partial^{i_4}y^f_T\partial^{i_5}K^h_N\partial^{i_6}K^f_N}|_{DS}\\&\cdot\left(\eta^h\right)^{i_1}\left(\eta^f\right)^{i_2}\left(y^h_T\right)^{i_3}\left(y^f_T\right)^{i_4}\left(K^h_N-\theta^h\right)^{i_5}\left(K^f_N-\theta^f\right)^{i_6},\end{aligned} \tag{52}$$

and thus come arbitrarily close to the exact solution of the model by adding higher and higher expansions.

The next step is to use this solution for the allocation prevailing in period 2 to solve the stochastic model. To this end, we take the remaining two equilibrium conditions (51), substitute in (48) and replace both the left hand side of the equation and the term in the square brackets with their Taylor expansions in the vector of realizations, $\left(\eta^h,\eta^f,y^h_T,y^f_T,K^h_N,K^f_N\right)$. We can then substitute in the implicit functions $K^h_N=K^h_N(\sigma_h,\sigma_f)$ and $K^f_N=K^f_N(\sigma_h,\sigma_f)$ and , without loss of generality, re-define

$$\sigma_n=\varpi_n\sigma,\ \eta^n=\tilde{\eta}^n\varpi_n\sigma,\text{ and } y^n_T=\tilde{y}^n_T\varpi_n\sigma;\ n=h,f \tag{53}$$

where $\varpi_n$ are positive constants and $\tilde{\eta}^n,\tilde{y}^n_T\sim N(0,1)$. We can solve for $\frac{K^n_N(\sigma)}{\partial^{i_7}\sigma}$ in two steps. First, take the partial derivative of (51) on both sides of the equation. What we are left with is a deterministic function of $\frac{K^n_N(\sigma)}{\partial^{i_7}\sigma}$ on the left hand side and the expectation of a stochastic function of $\frac{K^n_N(\sigma)}{\partial^{i_7}\sigma}$ on the right hand side. Second, we take expectations of the right hand side by integrating over the shocks. This is particularly easy as all (re-defined) shocks have a standard normal distribution: $E[\tilde{\eta}^n] = E[\tilde{y}_T^n] = E[\tilde{\eta}^n \tilde{y}_T^n] = 0$, $E\left[(\tilde{\eta}^n)^2\right] = E\left[(\tilde{y}_T^n)^2\right] = 1$, and so on. We can then repeat this procedure for all terms in the Taylor expansion

$$K_N^n(\sigma) \approx \sum_{i_7} \frac{1}{i_7!} \frac{K_N^n(\sigma)}{\partial^{i_7}\sigma}|_{DS} \cdot \sigma^{i_7},\ n = h, f \tag{54}$$

by taking higher-order derivatives of both sides of (51), integrating over the right hand side, and solving for the implicitly defined coefficients.

We can now solve for the realization of any period-two variable by substituting (52) and (54). Moreover, we can solve for the first-period expectation of each of these variables by applying (53) and performing a non-linear change of variables. For example, we get the expected payoff of the country $n$ risk-free bond by plugging (52) into (36), such that the relative price of country $n$ non-traded goods is a non-linear function of the vector of realizations:

$$EP_t^n = E\left[\left(\tau^{\varepsilon_\alpha} + (1-\tau)^{\varepsilon_\alpha}\left(P_{N,t}^n\left(\eta^h, \eta^f, y_T^h, y_T^f, K_N^h, K_N^f\right)\right)^{1-\varepsilon_\alpha}\right)^{\frac{1}{1-\varepsilon_\alpha}}\right]. \tag{55}$$

We then replace the expression in the square brackets with its Taylor expansion, plug in (54) and (53), and integrate over the shocks. Using this procedure we can solve for all endogenous variables of the model.

For all analytical solutions below I use a second order expansion as, for the case of an exogenously given capital stock, $(K_N^n = \theta^n)$, this second order expansion exactly coincides with the log-linearized solutions given in the main text.

**Proposition 6** *Given conditions 1 and 2 the larger country accumulates more capital per capita in the non-traded sector.*

**Proof.** Dividing the second-order Taylor expansion (54) with $\theta^n$ and differencing between the home and foreign country yields ■

$$\frac{K_N^h(\sigma)}{\theta^h} - \frac{K_N^f(\sigma)}{\theta^f} = \frac{-(\gamma-1)^2\tau}{\left(1+\gamma(e^{-\delta}(1-\tau)\nu)^{\frac{1}{\gamma}} + (\gamma-1)\left(\tau\left(1-\nu+\gamma(e^{-\delta}(1-\tau)\nu)^{\frac{1}{\gamma}}\right)+\nu\right)\right)}\rho^{h,f},$$

where $\rho^{h,f}$ is the difference in log expected returns of the two countries' risk-free bonds from equation (15) that arises under an exogenous capital stock. The denominator on the right hand side of the equation is strictly larger than zero and the numerator is negative.

This result makes intuitive sense. The larger country faces a lower risk-free interest rate and thus accumulates more capital. However, labor is immobile between the two countries and the marginal product of capital is therefore decreasing in $K_N^n$. The higher investment in the non-traded sector of the larger country can therefore never be large enough to eliminate the difference in risk-free interest rates that triggered it.

**Proposition 7** *The difference in log expected returns of two countries' risk-free bonds under endogenous capital accumulation has the same sign as the difference in log expected returns under* $K_N^n = \theta^n$.

**Proof.** The difference in log expected returns of two countries' risk-free bonds under endogenous capital accumulation is

$$r^f + \Delta E s_2^{h,f} - r^h = \frac{1 + (\gamma-1)\nu + \gamma(e^{-\delta}(1-\tau)\nu)^{\frac{1}{\gamma}} + (\gamma-1)\tau\left(1 - \nu + (e^{-\delta}(1-\tau)\nu)^{\frac{1}{\gamma}}\right)}{1 + (\gamma-1)\nu + \gamma(e^{-\delta}(1-\tau)\nu)^{\frac{1}{\gamma}} + (\gamma-1)\tau\left(1 - \nu + \gamma(e^{-\delta}(1-\tau)\nu)^{\frac{1}{\gamma}}\right)}\rho^{h,f},$$

where the fraction on the right hand side is $\in [0,1]$ and $\rho^{h,f}$ is again the difference in log expected returns of the two countries' risk-free bonds from equation (15) that arises under an exogenous capital stock. ■

The introduction of capital accumulation thus changes the size of the spread on international bonds but has no effect on the qualitative prediction. We can show a parallel result for the spread on stocks in the non-traded sector, which can be shown to be

$$\log ER\left[P_N^f Y_N^f\right] - \log ER\left[P_N^f Y_N^f\right] = \frac{\frac{(\gamma-1)}{\gamma}\left(1 + (\gamma-1)\nu + \gamma(e^{-\delta}(1-\tau)\nu)^{\frac{1}{\gamma}} + (\gamma-1)\,\tau(1-\nu)\right)}{1 + (\gamma-1)\nu + \gamma(e^{-\delta}(1-\tau)\nu)^{\frac{1}{\gamma}} + (\gamma-1)\tau\left(1 - \nu + \gamma(e^{-\delta}(1-\tau)\nu)^{\frac{1}{\gamma}}\right)}\rho_N^{h,f},$$

where $\rho_N^{h,f}$ is again the difference in log expected returns of the two countries' stocks in the non-traded sector from equation (16) that arises under an exogenous capital stock and the fraction on the right hand side strictly larger than zero and smaller than one.

# E Numerical Solution

In the main part of the paper I employ two simplifying devices that enable me to provide closed-form analytical solutions: (1) I assume that active households receive transfers in the first period that de-centralize the allocation corresponding to the utilitarian welfare function, and (2) I log-linearize the model around the point at which $[y_T, y_N, \tilde{\mu}]' = 0$. This section gives a numerical solution to the model, demonstrating that neither of these two simplifying devices seem to matter for the results in any meaningful way.

The numerical algorithm used is a standard Gauss-Hermite quadrature (see Judd (1998)). I solve for the case in which the world economy consists of two countries. I choose the same combination of parameters used for the calibrated numerical example in section 5; $\tau = 0.3$, $\varepsilon_\alpha = 1$, $\sigma = 0.05$, and $\tilde{\sigma}$ and $\phi$ are chosen to match the average standard deviation of the nominal and real exchange rates to the US dollar in the data (these are 0.1145 and 0.1170, respectively). I set $e^{-\delta} = 0.95$ and choose $\mu$ such that the net present value of consumption is equalized between active and inactive households within each country. For an easy comparison with the coefficients given in the main part of the paper I solve for the case in which $\theta^h - \theta^f = 0.1$. I choose 5 points approximating the log-normal distributions of each of the real and monetary shocks. The state-space thus consists of $5^6 = 15625$

possible combinations of these shocks.[25]

I first quantify the inaccuracies stemming from the log-linearization. Column 1 of Panel A in Appendix Table 3 lists the international spreads on all four types of assets using the closed-form solutions derived in the main part of the paper. Column 2 gives the corresponding exact numerical solution. The log-approximation comes very close to the exact solutions in each case. For example, the log-approximated spread on nominal bonds is -0.0298 and the exact spread is -0.0306. Generally, the log-approximation seems to underestimate the spreads slightly. Both the solution in column 1 and the solution in column 2 solve for the allocation corresponding to unit Pareto-Negishi weights. The transfer that de-centralizes this allocation is a payment of 0.1% of the total wealth of active households in the home country to those in the foreign country.

If no transfers are made, households' initial wealth is a function of the first-period value of the claims to the endowments they receive in the second period. By numerically solving a fixed point problem between equilibrium spreads and the net present value of these endowments we can identify the Social Planner's problem that corresponds to this allocation. For the numerical example in Panel A, this problem gives home households Pareto-Negishi weights that exceed those of foreign households by a factor of 1.008 in order to account for the endogenous differences in wealth between the residents of both countries. Column 3 gives the spreads on the four types of international assets for this allocation. The values in columns 2 and 3 are almost exactly identical. Panels B and C repeat the same analysis for different elasticities of substitution between traded and non-traded goods, in each case with very similar results.

The conclusion from this table is that while the log-approximation generates small quantitative inaccuracies, the assumption of first-period transfers that de-centralize the allocation corresponding to unit Pareto-Negishi weights seems to be almost completely innocuous.

# F Evidence on Inflation Protected Securities

The model in the paper predicts that large countries should have both lower risk-free and lower nominal interest rates in equilibrium. For reasons of data availability the empirical analysis focuses exclusively on the latter. Nevertheless there are a few countries for which we observe risk-free interest rates, i.e. yields to maturity on inflation-indexed bonds. Figure 4 plots the average annualized yield spread on inflation-indexed securities of seven countries to US TIPS over the log of their GDP Share. The figure shows a clear negative association between country size and the yields on risk-free bonds that mirrors the one documented for nominal securities. The data in this picture are sourced from Global Financial Data (mnemonic IG*ccd*ID_Close) and Datastream.

# G Data Appendix

This section gives details on the sources of the data series used.

[25] The algorithm is available from the author upon request.

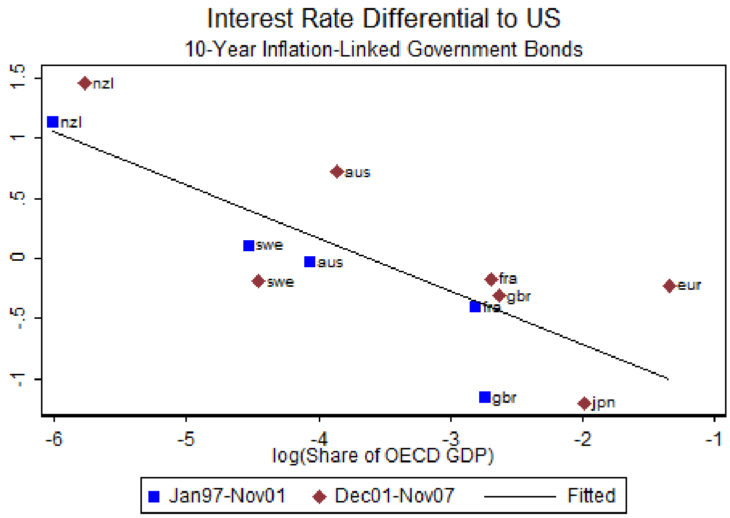


Figure 4: Unconditional scatterplot of average differences in annualized yields on inflation-linked bonds of various countries to US TIPS for the time periods Jan 1997-Nov 2001 and Dec 2001-Nov 2007 plotted over the log of the share that each country contributes to total OECD output.

### G.1 Forward Premia and Currency Returns

I use data on dollar-based spot and forward exchange rates from Datastream (DS) to construct currency returns, the main variable of interest. Within Datastream there are four sources of these data: World Markets PLC/Reuters (WM/R), Thomson/Reuters (T/R), HSBC, and Barclays Bank PLC (BB). The most comprehensive in terms of currencies is WM/R. However, this series only begins in December 1996. T/R goes back to May 1990. Both HSBC and BB are not available for recent years but have data back to October 1983 (BB) and October 1986 (HSBC) for some currencies. All providers also offer spot exchange rates corresponding to their forward rates. The mnemonics for these series are: *dsiso*SP for spot and *dsiso*1F, -3F, -6F, and -1Y or -YF for 1, 3, 6, and 12 month maturity forwards. *ds* corresponds to the dataset mnemonic: *TD* for Thomson/Reuters, *BB* for Barclays Bank and *MB* for HSBC. WM/R has a different structure for spot and forward rates. The spot rates don't have a clear pattern other than some abbreviation of the currency name and the dollar sign in the end (e.g. *AUSTDO$* for the Australian Dollar quote). The forward rates follow the pattern given above for the other sources with mnemonic *US*. Datastream uses the *iso* codes as country codes. To check ISO codes specified by the International Organization for Standardization (ISO) go to: *http://www.oanda.com/help/currency-iso-code-country.*

There are some exceptions to the general rules for mnemonics (e.g. departures from ISO codes). In addition to mid rates, bid and offer quotes are also available. To distinguish between these three, DS codes have a suffix -E$x$ where $x$ is B, R, or O respectively for bid, mid, and offer quotes. See the data provider's website for details on respective detailed methodology.

In time periods in which they overlap the data from the different providers are very similar. I assemble them into a comprehensive panel of dollar-based forward premia and currency returns in three steps. First, I use forward and spot rates from the same source to construct a panel of forward premia and currency returns from each provider. (The data providers vary on the fixing time. Using a forward rate from one source with a spot from another could therefore lead to inaccuracies.) Second, I combine the panels in the following order: When available I use WM/R data, which appears to be the most recent and most accurate source. I fill in missing observations using the Thomson/Reuters, HSBC and Barclays Bank datasets in that order. In a final step, I check the consistency of the data using the following algorithm:

For observations for which I have information on a single forward premium I compare the forward premia to differentials in the interbank rates at the one-month horizon. If the interest rate differential in the Global Financial Data (GFD) data is within 20bps of the interest differential sourced from DS I exclude the observation if the 1-month forward premium deviates from the 1-month GFD interest differential by more than 50bps (a dramatic violation of uncovered interest parity). By this criterion I exclude Italy 2/1985 and 3/1985; Switzerland 2/1985; Germany 2/1985; and United Kingdom 3/1985.

For observations for which I have information on the forward premium from multiple sources and information on interest differentials from one source, I again check if the 1-month forward premium deviates from the interest differential by more than 50bps. If it does I check the forward premium from the alternative sources. If the forward premia from one other source deviates from the interest differential by less than 50bps I substitute this observation. By this criterion I replace Switzerland 1/1989; Germany 5/1988; Norway 5/1988; Sweden 5/1988; France 1/1989; Italy 5/1988; Netherlands 5/1988; United Kingdom 1/1989, and Belgium 10/1987 and 5/1988 with data from BB.

### G.2 Interest Rates

I use interbank interest rates and government bond yields for robustness checks in the paper. I source interbank interest rates at the 1-month horizon and government bond yields at the 5-year horizon from the Global Financial Data online database (GFD), as well as 1-month interbank rates and 3-year government bond yields from Thompson Financial Datastream (DS). Yields on Government bonds of a particular maturity refer to the average yield on a basket of traded government bonds within a certain band around the desired maturity. See the data providers' websites for details on their respective methodologies. The series in detail are:

- **1-month interbank rates**: Series symbols in GFD are IB*ccg*1D and IB*ccg*1D and EC*iso*1m in DS. After 1998, interbank rates are not available for individual EMU member countries
- **Yields on 5-year government bonds** (GFD): Series symbols are IG*ccg*5D.
- **Yields on 3 year government bonds** (DS): Series mnemonics are BM*ccd*03Y(RA).

*ccg* and *ccd* refer to the country codes used by GFD and DS respectively. In each case, the data refers to the last trading day of the quarter.

## G.3 Industry Stock Return Indices

The industry stock return indices are sourced from Thompson Financial Datastream (DS).The mnemonics of the series used for the construction of

- **stock returns in the non-traded sector** are $mv/ri$FINAN$ccd$, $mv/ri$CNSMS$ccd$, and $mv/ri$HLTHC$ccd$,
- **stock returns in the traded sector** are $mv/ri$INDUS$ccd$, $mv/ri$CNSMG$ccd$, and $mv/ri$BMATR$ccd$.

$mv/ri$ =RI gives the mnemonic for the stock return index of the sector in question, $mv/ri$ =MV gives the mnemonic for the total market valuation of the stocks in the index, and $ccd$ refers to the country code used by DS. The domestic return in the non-traded sector used in the text is calculated as

$$dr^j_{N,t} = \log \left( \frac{\frac{RICNSMS^j_{t+1}}{RICNSMS^j_t} MVCNSMS_t + \frac{RIFINAN^j_{t+1}}{RIFINAN^j_t} MVFINAN_t + \frac{RIHLTHC^j_{t+1}}{RIHLTHC^j_t} MVHLTHC_t}{MVCNSMS_t + MVFINAN_t + MVHLTHC_t} \right)$$

and the domestic return in the traded sector is calculated as

$$dr^j_{T,t} = \log \left( \frac{\frac{RIINDUS^j_{t+1}}{RIINDUS^j_t} MVINDUS_t + \frac{RICNSMG^j_{t+1}}{RICNSMG^j_t} MVCNSMG_t + \frac{RIBMATR^j_{t+1}}{RIBMATR^j_t} MVBMATR_t}{MVINDUS_t + MVCNSMG_t + MVBMATR_t} \right),$$

where the variables in the formula refer directly to the mnemonic of the series.

## G.4 Exchange Rates

When calculating the variance of the nominal exchange rate and when calculating returns to a US investor on stocks in the traded and non-traded sectors of foreign countries, I use end of quarter nominal exchange rates to the US dollar obtained from the International Financial Statistics online database (IFS).

In the construction of bid-ask spreads I use the same series used by Burnside et al. (2006), which are from DS. I copy their procedure in using the difference between bid and ask interbank spot exchange rates in the London market against the British Pound, where I take the UK bid-ask spread to be the British Pound against US dollar spread. The series in detail are:

- **Nominal spot exchange rate to US dollar** (IFS): Series symbols are $cci$..AE.ZF.
- **Bid and ask spot exchange rate to British Pound** (DS): Series symbols are UKDOLLR(E$b/o$), AUSTDOL(E$b/o$), AUSTSCH(E$b/o$), BELGLUX(E$b/o$), CNDOLLR(E$b/o$), CZECHCM(E$b/o$), DANISHK(E$b/o$), ECURRSP(E$b/o$), FINMARK(E$b/o$), FRENFRA(E$b/o$), DMARKER(E$b/o$), GREDRAC(E$b/o$), HUNFORT(E$b/o$), ICEKRON(E$b/o$), IPUNTER(E$b/o$), ITALIRE(E$b/o$), JAPAYEN(E$b/o$), FINLUXF(E$b/o$), GUILDER(E$b/o$), NZDOLLR(E$b/o$), NORKRON(E$b/o$), POLZLOT(E$b/o$), PORTESC(E$b/o$), SLOVKOR(E$b/o$), SPANPES(E$b/o$), SWEKRON(E$b/o$), SWISSFR(E$b/o$), USDOLLR(E$b/o$), KORSWON(E$b/o$).

$cci$ refers to the country codes in the IFS database. Bid rates are obtained with mnemonics in which $b/o$ =B and ask rates are obtained with mnemonics in which $b/o$ =O.

### G.5 Macroeconomic Data

Data on quarterly GDP in terms of US dollars, consumer prices, and population are from Global Financial Data. The series in detail are

- **GDP** (GFD): Series symbols are GDP*ccg*M, where the data for Japan, Italy, and South Korea are given in billions rather than millions.
- **Population** (GFD): Series symbols are POP*ccg*.
- **Consumer Price Indices** (GFD): Series symbols are CP*ccg*M, where the series symbol for the UK and the Euro area are CPGBRCM and CPEUR12 respectively.
- **M1 Money Balances** (IFS): Series symbols are *cci*59MA, where money balances for Australia, New Zealand, Slovak Republic, and Poland are listed in millions of the national currency. Money balances for Japan are listed in trillions of Yen, and the data for all other countries are in billions of the national currency.

*ccg* and *cci* refer to the country codes used by GFD and IFS respectively.

### G.6 Comparing Currency Futures and Forwards

This section constructs a time series of currency futures that is comparable to the time series of forward data in Datastream and compares the two.

#### G.6.1 Futures Data

I obtained futures data from the Chicago Mercantile Exchange. Quotes are organized by settlement date, e.g. in 011387, there were 2 quotes for the Australian dollar, one for contracts expiring in March 1987 and another for contracts expiring in June 1987. The dataset lists low, high, close and settlement prices (the latter are an average price of the contracts traded in a given day). I use the settlement price as the price for each given day.

The currencies covered in the sample are Australian dollar (aud), Canadian dollar (cad), Euro (eur), Japanese Yen (jpy), Swiss Franc (chf), British Pound (uk), Czech Koruna (czk), Hungarian Forint (huf), Mexican Peso (mxn), New Zealand dollar (nzd), Polish Zloty (pln), South African Rand (zar), Swedish Krone (sek), Korean Won (krw), Norwegian Krone (nok), and Turkish Lira (try). The codes listed after each currency are the ones used by Datastream, except for the British Pound which is simply "uk". I will use these codes to refer to the currencies throughout this section. All currencies are listed in terms of dollars per foreign currency unit.

The coverage of currencies varies widely. For cad, jpy, chf, huf, and uk, price quotes start in January 1982. eur data starts in January 1986 and aud data starts a year later in January 1987. Data for mxn starts in April 1995 and both nzd and zar in May 1997. nok and sek data starts in May 2002. pln data starts in July 2004 and czk in December of the same year. krw starts in September 2006 and try in January 2009.

The CME futures contracts have a standardized settlement date, which is the third Wednesday of the month listed in the contract (except for Canadian dollar denominated contracts which are settled on Tuesdays). The forwards expire on the preceding Monday. Most quotes are for contracts expiring in March, June, September, or December.

Some of the earlier futures quotes for aud, cad, chf and jpy have an extra zero to the right of the dot in their quotes before January 1996 (I multiply by 10 to correct for this). I exclude the eur quotes before December 1998, the date at which the euro was officially introduced. I also exclude the huf before August 2004 as the data appear to imply forward exchange rates that are factor three above their spot exchange rates.

#### G.6.2 Construction of a Futures Index

The forward data used in the paper are end of month quotes for a fixed maturity of 1 to 12 months, whereas the futures data from CME are for a fixed expiration date and thus vary in their time to maturity. Moreover, the futures do not expire at the end of the month but between the 15th and 21st of any given month (depending on the month and year). None of the quotes from the two sources are therefore directly comparable.

In order to obtain a comparable series of futures I follow the same approximate methodology that Datastream uses to construct its forward quotes. I first create a variable measuring the number of days to settlement of each observed futures quote. I then create an indices of futures quotes by bundling contracts with maturities close to 1, 2, 3, 6, and 12 months. For the 1-month index I average futures prices of contracts with maturities between 30 and 20 days, for the 2-month index contracts between 60 and 50 days, for the 3-month index contracts between 90 and 80 days, and so on.

#### G.6.3 Comparing Forward and Future Prices

The futures prices thus constructed are virtually identical to the forward quotes from Datastream. The figure below plots the futures and forward prices for 1-month contracts for the 16 countries which are covered in the CME data. The two series are virtually on top of each other. Regressing forward prices on futures prices yields an $R^2$ of 99.9%.

For longer maturities the pictures is similar, although fewer futures data is available for contracts with maturities of more than 3 months. In conclusion, forward and futures prices are virtually identical such that any counterparty default risk premia in the currency forward rates would have to be vanishingly small.

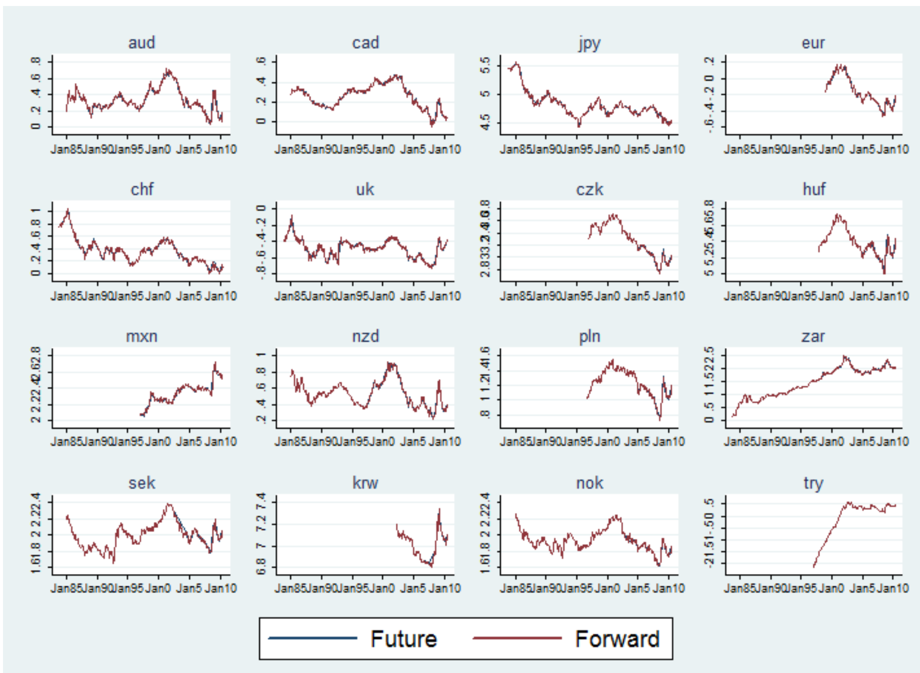


Figure 5: Forward prices from the Chicago Mercantile Exchange and over-the-counter forward prices of 16 currencies against the US dollar.

## Appendix Table 1
## Alternative Controls

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|---|
| Panel A | *Excess return on 3-month forwards* | | | | | | |
| GDP Share | -0.187*** | -0.185*** | -0.212*** | -0.194*** | -0.096 | -0.195*** | -0.180*** |
| | (0.069) | (0.069) | (0.070) | (0.068) | (0.068) | (0.074) | (0.068) |
| Government Consumption (% GDP) | | 0.000 | | | | | |
| | | (0.001) | | | | | |
| Secondary School Enrollment | | | -0.000* | | | | |
| | | | (0.000) | | | | |
| Population Growth | | | | -0.010 | | | |
| | | | | (0.010) | | | |
| Life Expectancy | | | | | -0.008*** | | |
| | | | | | (0.002) | | |
| Market Capitalization (% GDP) | | | | | | -0.000** | |
| | | | | | | (0.000) | |
| Skewness of Exchange Rate | | | | | | | 0.003 |
| | | | | | | | (0.009) |
| Constant | -0.028 | -0.030 | 0.018 | -0.024 | 0.610*** | -0.029 | -0.023 |
| | (0.024) | (0.032) | (0.035) | (0.025) | (0.155) | (0.026) | (0.025) |
| $R^2$ | 0.642 | 0.642 | 0.645 | 0.642 | 0.646 | 0.598 | 0.642 |
| N | 1489 | 1489 | 1412 | 1489 | 1489 | 1259 | 1489 |
| Time fixed effects | yes | yes | yes | yes | yes | yes | yes |
| Panel B | *Excess return on 3-month forwards* | | | | | | |
| GDP Share | -0.120*** | -0.120*** | -0.204*** | -0.112*** | -0.129*** | -0.195*** | -0.129*** |
| | (0.031) | (0.037) | (0.072) | (0.034) | (0.031) | (0.075) | (0.034) |
| $R^2$ | | | | | | | |
| N | 1489 | 1489 | 1171 | 1489 | 1489 | 1259 | 1489 |
| Time fixed effects | yes | yes | yes | yes | yes | yes | yes |

Note: OLS regressions with robust standard errors in parentheses. All specifications are analogous to the standard specification in column 4 of Table 2: They contain but do not report controls for Variance of Exchange Rate and Bid-Ask Spread on Currency as well as a complete set of time fixed effects which are constrained to sum to zero, $\sum_t \delta_t = 0$. Dependent variable in both panels is the (annualized) log difference of the 3-month forward rate and the spot exchange rate against the US Dollar at the time of maturity of the forward contract. All specifications in Panel B are identical to those in Panel A but do not include a constant term. The sample consists of quarterly data for 27 OECD countries 1983-2007. After 1998 countries that joined the European Monetary Union are dropped from the sample and replaced by a single observation for the Euro Zone. GDP Share is countries' share in total OECD output at each point in time, adjusted for fluctuations in the sample. Additional control variables in columns 2-6 are the following series from World Development Indicators: General government final consumption expenditure (% of GDP); School enrollment, secondary (% gross); Population growth (annual %); Life expectancy at birth, total (years); Market capitalization of listed companies (% of GDP). Skewness of Exchange Rate is the skewness of the quarterly growth rate (log difference) of the bilateral exchange rate against the US dollar. See data appendix for details. All independent variables are differenced with the US sample average.

**Appendix Table 2**
**Yield Curve (Prediction 1)**

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| | | *Forwards* | | *Gov. Bonds* | |
| *Maturity* | *3mo* | *6mo* | *1y* | *3y* | *5y* |
| Panel A | | | *Excess returns* | | |
| GDP Share | -0.183*** | -0.176** | -0.171** | -0.182*** | -0.167** |
| | (0.068) | (0.076) | (0.077) | (0.056) | (0.061) |
| Constant | -0.026 | -0.020 | -0.014 | -0.024 | -0.035 |
| | (0.023) | (0.028) | (0.028) | (0.027) | (0.023) |
| $R^2$ | 0.644 | 0.656 | 0.654 | 0.710 | 0.732 |
| N | 1446 | 1446 | 1446 | 992 | 1045 |
| Panel B | | | *Excess returns* | | |
| GDP Share | -0.118*** | -0.125*** | -0.137*** | -0.182*** | -0.167*** |
| | (0.031) | (0.030) | (0.030) | (0.057) | (0.062) |
| $R^2$ | | | | | |
| N | 1446 | 1446 | 1446 | 992 | 1045 |
| Time fixed effects | yes | yes | yes | yes | yes |
| S.E. clustered by country | no | yes | yes | yes | yes |

Note: OLS regressions with robust standard errors in parentheses. In columns 2-5 standard errors are clustered by country. All specifications are analogous to the standard specification in column 4 of Table 2: They contain but do not report controls for Variance of Exchange Rate and Bid-Ask Spread on Currency (see the caption of table 1 and the data appendix for details). All specifications contain time fixed effects, which are constrained to sum to zero, $\sum_t \delta_t = 0$. The specifications in Panel A contain a constant term, whereas the specifications in Panel B do not. Dependent variable in both panels is the annualized log excess return to maturity to a US investor on currency forwards and bonds of different maturities. Columns 1-3 use forward rates, while columns 4 and 5 use government bonds. After 1998 countries that joined the European Monetary Union are dropped from the sample and replaced by a single observation for the Euro Zone. GDP Share, is countries' share in total OECD output at each point in time, adjusted for fluctuations in the sample. All independent variables are differenced with the US value.

**Appendix Table 3**
**Subsets of Countries (Prediction 1)**

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Panel A | *Excess return on 3-month forwards* | | | | | |
| GDP Share | -0.187*** | -0.272** | -0.119** | -0.175 | -0.327** | -0.199*** |
| | (0.069) | (0.113) | (0.052) | (0.122) | (0.134) | (0.070) |
| Constant | -0.026 | -0.056 | -0.002 | -0.021 | -0.073 | -0.016 |
| | (0.024) | (0.039) | (0.018) | (0.041) | (0.047) | (0.023) |
| $R^2$ | 0.642 | 0.638 | 0.666 | 0.661 | 0.512 | 0.714 |
| N | 1489 | 1453 | 1393 | 1357 | 978 | 1238 |
| Panel B | *Excess return on 3-month forwards* | | | | | |
| GDP Share | -0.121*** | -0.122*** | -0.115*** | -0.116*** | -0.109*** | -0.164*** |
| | (0.031) | (0.032) | (0.032) | (0.032) | (0.032) | (0.035) |
| $R^2$ | | | | | | |
| N | 1489 | 1453 | 1393 | 1357 | 978 | 1238 |
| Time fixed effects | yes | yes | yes | yes | yes | yes |
| Sample Excludes | | Euro Zone | Japan | Euro Zone, Japan | Euro Zone, EMU countries pre 1998 | Resource dependent countries |

Note: OLS regressions with robust standard errors in parentheses. All specifications are analogous to the standard specification in column 4 of Table 2: They contain but do not report controls for Variance of Exchange Rate and Bid-Ask Spread on Currency (see the caption of table 1 and the data appendix for details). All specifications contain time fixed effects, which are constrained to sum to zero, $\sum_t \delta_t = 0$. The specifications in Panel A contain a constant term, whereas the specifications in Panel B do not. Dependent variable in both panels is the annualized log excess return to maturity to a US investor on 3-month currency forwards. The sample consists of quarterly data for 27 OECD countries 1983-2007. Countries enter the sample upon joining the OECD or when data becomes available. After 1998, countries that joined the European Monetary Union are dropped from the sample and replaced by a single observation for the Euro Zone. Column 1 uses the entire sample. Columns 2 and 3 drop the Euro Zone and Japan respectively. Column 4 drops the Euro Zone and Japan simultaneously. Column 5 drops all Euro Zone countries pre and post the establishment of the currency union. Column 6 drops highly resource dependent economies: Australia; Canada; and Norway. GDP Share is countries' share in total OECD output at each point in time, adjusted for fluctuations in the sample. All independent variables are differenced with the US value.

**Appendix Table 4**
**Alternative Standard Errors**

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| *Standard Errors* | *White* | *Roger (by Time)* | *Roger (by Country)* | *Thompson (by Time & Country)* | *Newey-West* |
| Panel A | *Excess return on 3-month forwards (Table 2)* | | | | |
| GDP Share | -0.187*** | -0.187** | -0.187** | -0.187** | -0.187** |
| | (0.069) | (0.072) | (0.076) | (0.079) | (0.075) |
| Panel B | *Excess return on 3-month forwards (Table 5)* | | | | |
| GDP Share | -0.269* | -0.269* | -0.269*** | | -0.683*** |
| | (0.138) | (0.148) | (0.050) | | (0.240) |
| Euro Zone Post '98 | -0.021* | -0.021 | -0.021** | | -0.026 |
| | (0.011) | (0.014) | (0.009) | | (0.041) |
| Panel C | *Excess return on portfolio of 'non-traded' industries (Table 6)* | | | | |
| GDP Share | -0.649*** | -0.649** | -0.649*** | -0.649*** | -0.649** |
| | (0.249) | (0.249) | (0.120) | (0.120) | (0.254) |
| Euro Zone Post '98 | -0.038* | -0.038 | -0.038 | -0.038 | -0.038* |
| | (0.021) | (0.030) | (0.024) | (0.033) | (0.021) |
| Panel D | *Domestic return differential, 'non-traded' - 'traded' (Table 7)* | | | | |
| Euro Zone Post '98 | -0.018*** | -0.018*** | -0.018*** | -0.018*** | -0.018*** |
| | (0.005) | (0.006) | (0.003) | (0.005) | (0.005) |

Note: This table presents alternative standard errors for the standard specifications of Tables 2, 5, 6, and 7. Column 1 reports White (heteroskedasticity robust) standard errors. Columns 2 and 3 report Roger standard errors clustered by time and country respectively. Column 4 reports Thompson (2006) standard errors which are clustered by both time and country. Column 5 reports Newey-West standard errors allowing for 3 lags of autocorrelation. Panel A replicates the specification in Table 2 Column 4; Panel B replicates the one in Table 5 Column 1; Panel C replicates the one in Table 6 Column 2; and Panel D replicates the one in Table 7 Column 2. In each case only the coefficients of interest are reported. Column 4 in Panel C is left blank as Thompson standard errors as implemented in STATA are incompatible with a weighted least squares regression.

**Appendix Table 5**
**Stocks in 'Traded' Industries**

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| Panel A | *Excess return on portfolio of 'traded' industries* | | | | |
| GDP Share | -0.257 | -0.276 | -0.279 | -0.204 | 0.045 |
| | (0.242) | (0.243) | (0.243) | (0.245) | (0.092) |
| Euro Zone Post '98 | | -0.031 | | | |
| | | (0.025) | | | |
| (M1 Share - GDP Share) * Euro Zone Post '98 | | | -0.054 | | |
| | | | (0.045) | | |
| (M1 Share - GDP Share) | | | | -0.113 | -0.134* |
| | | | | (0.081) | (0.080) |
| Domestic Variance of 'Trad.' Portfolio | 0.624 | 0.546 | 0.544 | 0.548 | 1.064 |
| | (1.897) | (1.887) | (1.888) | (1.889) | (1.793) |
| Constant | -0.122 | -0.126 | -0.127 | -0.088 | |
| | (0.085) | (0.085) | (0.085) | (0.088) | |
| $R^2$ | 0.332 | 0.333 | 0.333 | 0.333 | |
| N | 1535 | 1535 | 1535 | 1535 | 1535 |
| Constant term included | yes | yes | yes | yes | no |
| Time fixed effects | yes | yes | yes | yes | yes |

Note: OLS regressions with robust standard errors in parentheses. All specifications contain but do not report controls for Variance of Exchange Rate and time fixed effects, which are constrained to sum to zero, $\sum_t \delta_t = 0$. The specifications in columns 1-4 contain a constant term, whereas the specification in column 5 does not. Dependent variable is the annualized log excess return to a US investor of investing in a value-weighted portfolio of three industry stock return indices of other OECD countries versus the corresponding US portfolio of indices. These industries can broadly be interpreted as producing tradable output: Basic Materials; Consumer Goods; and Industrials (An index for the high technology sector is also available for some countries but is not used due to its limited coverage). All indices are sourced from Thompson Financial Datastream. The sample consists of quarterly data for the 24 OECD countries that are covered by the Datastream indices, 1980-2007. Euro Zone countries remain in the sample after 1998. They are assigned their national GDP Share and the M1 Share of the Euro. M1 Share is the national currency's share in total OECD money balances at each point in time, adjusted for fluctuations in the sample. M1 Share - GDP Share is the difference between countries' share in total OECD money balances and their share in total OECD GDP. Domestic Variance of Non-Trad. Portfolio is the local-currency variance of returns of the portfolio of indices. Euro Zone Post 1998 is a fixed effect for Euro Zone countries after 1998. All independent variables are differenced with the US value.

**Appendix Table 6**
**Numerical Integration**

| | (1) | (2) | (3) |
|---|---|---|---|
| | *Spreads Between Home and Foreign Assets* | | |
| | *Utilitarian Weights* | | *Endogenous Weights* |
| | *log-approximation* | *exact solution* | *exact solution* |
| *Panel A:* $\epsilon_\alpha = 0$ | | | |
| Risk-free bond | -0.0115 | -0.0120 | -0.0119 |
| Nominal bond | -0.0298 | -0.0306 | -0.0306 |
| Stock in non-traded sector | -0.0142 | -0.0147 | -0.0147 |
| Stock in traded sector | 0.0000 | 0.0000 | 0.0000 |
| *Panel B:* $\epsilon_\alpha = 2$ | | | |
| approx exact endogenous weight Risk-free bond | 0.0088 | 0.0092 | 0.0093 |
| Nominal bond | 0.0271 | 0.0279 | 0.0279 |
| Stock in non-traded sector | 0.0091 | 0.0096 | 0.0097 |
| Stock in traded sector | 0.0000 | 0.0000 | 0.0000 |
| *Panel C:* $\epsilon_\alpha = 5$ | | | |
| Risk-free bond | 0.0048 | 0.0051 | 0.0051 |
| Nominal bond | 0.0231 | 0.0239 | 0.0239 |
| Stock in non-traded sector | 0.0027 | 0.0030 | 0.0030 |
| Stock in traded sector | 0.0000 | 0.0000 | 0.0000 |

Note: This table compares the spreads computed using the log-approximated analytical solutions in the text with an exact numerical solution, and with the (exact) spreads corresponding to an allocation in which Pareto-Negishi weights are endogenous to the value of endowments received by households. In this numerical example, the world economy consists of two countries, where the home country is 10 percentage points larger than the foreign country. The values given in the table are log expected returns on home assets minus log expected returns on foreign assets. Panel A: The parameters used for this numerical example are: $\gamma = 14.19$, $\tau = 0.3$, $\epsilon_\alpha = 1$, $\sigma = 0.05$, and $e^{-\delta} = 0.95$. $\phi$ and $\tilde{\sigma}$ are chosen to match the average standard deviation of the nominal and real exchange rates to the US Dollar in the data, and $\mu$ is chosen such that the net present value of consumption is equalized between active and inactive households within each country. Panels B and C use the same numerical example but set $\epsilon_\alpha = 2$ and $\epsilon_\alpha = 5$, respectively.