Implications of Infrequent Portfolio Adjustment for International Portfolio Choices

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Abstract

This paper helps unravel the long-standing equity home bias puzzle by building a model in which an agent infrequently adjusts her portfolio holdings of home and foreign equities. As real exchange rate returns are volatile, an investor who invests in foreign equities and holds on to her portfolio holdings for a long duration is likely to drift away from an optimal allocation. The agent, taking infrequent adjustment into account ex-ante, lowers her demand for foreign equities, generating home bias in equities. The introduction of the euro into various European countries and the enlargement of euro area in subsequent years provide a natural environment in which to validate the implications of the model. We empirically document that European countries experience lower equity home bias after adopting the euro as cross-border equity investment within the euro area entails no nominal exchange rate risk. When the levels of real exchange rate volatility are calibrated to match the average levels for European countries in the euro area and outside the euro area, the model can match the difference in levels of equity home bias between European countries experienced after the introduction of the euro.

JEL classification: F30, F31, G11, G15

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1 Introduction

Strong preference for domestic equities has been a longstanding puzzle in international finance. Since the 1970s, economists have noticed that *given the return distributions of domestic and foreign equities*, a domestic investor holds a disproportionately high level of domestic assets relative to the prediction of standard portfolio theory (for instance, Levy and Sarnat (1970)). This prominent feature of international equity portfolio allocations, coined as the "home bias puzzle", has been documented by many international macroeconomists. Some of the seminal papers are: French and Poterba (1991), Cooper and Kaplanis (1994) and Tesar and Werner (1995).

The discrepancy between what a standard portfolio model predicts and what is observed in the data has sparked a large literature devoted to explaining the home bias in equities. The main strands of explanations are: information asymmetries and behavior explanations, transaction costs with small diversification benefits, hedging motives, and price stickiness. Recently, some papers incorporate international portfolio choices into the standard DSGE open economy model and generate home bias in equities. Dynamic general equilibrium models of portfolio choice match the aggregate pattern of international portfolio choice, but fall short of generating reasonable asset return distributions, thus failing to explain other puzzles such as the equity premium puzzle and the volatility of asset prices and the exchange rates. Rather than solving one puzzle while producing another one, this paper – given the estimated return processes of equities and the exchange rates – revisits the home bias puzzle explaining why an investor is holding few foreign equities.

This paper presents a model with infrequent portfolio adjustment that successfully generates the home bias in equities. Taking the distributions of equity and exchange rate returns as given, the optimal portfolio allocations between home and foreign equities are derived in a model with portfolio stickiness. The model has a distinctive feature where an agent faces a constant probability p of sticking to the previous period's portfolio allocations and $1-p$ of adjusting her holdings.[1] Since an investor on average holds on to her portfolio holdings for a longer duration, with volatile real exchange rate returns, her foreign equity holdings are likely to deviate more from the optimal than domestic equity holdings. The agent, taking this account ex-ante, lowers her demand for foreign equities. The deviation is more pronounced when the exchange rate volatility is higher, and therefore the weight on foreign equities is much lower with higher exchange rate volatility. In a way, a higher probability of sticking with the portfolio holdings that an agent chooses increases her aversion towards risk. When there is *no* stickiness in the portfolio allocation (i.e., when $p = 0$ in the model), a level of real exchange rate volatility consistent the data cannot generate a disproportionately high portfolio weight on the domestic equities. With a reasonable level of risk aversion, our model can generate a high weight on the domestic equities, quantitatively close to the level that we see from

[1] There will be changes to the actual amount of holdings due to the realized returns in equities and exchange rates.

that data offering some resolution to the home bias puzzle in equities.

In the model, the key structural assumption pertains to the incomplete foreign exchange rate risk trading, i.e., home investors cannot hedge their exchange rate risk. Some survey evidence shows that investors rarely hedge their exchange rate risk when investing in foreign equities. Levich et al. (1999) present their survey of 298 U.S. institutional investors and find that more than 20% are prohibited to trade derivatives. Moreover, they find another 25% are not prohibited but do not trade in derivatives. The rest of 55% hedge only a small proportion of their exchange rate risk. According to their calculation, in the whole sample, only 8% of the total foreign equity investment is hedged. According to Hau and Rey (2006), the lack of trading in foreign exchange rate derivatives is due to public perception, regulation, monitoring problems, and lack of knowledge. One thing worth noting is that the presented evidence is from the survey of institutional investors, who face comparably lower costs in exchange rate hedging and have a higher level of financial competency, and therefore, will be more prone to engage in exchange rate hedging compared to individual investors. Hence, the evidence strongly suggests that a very small portion of the exchange rate risk of the total foreign equity investment by institutional and individual investors is in fact hedged: an average investor, who invests in foreign equities, faces foreign equity price volatility and exchange rate volatility, justifying our assumption.

Our model with infrequent portfolio choices, moreover, matches the heterogeneity in home bias among countries in Europe. The introduction of the euro in 1999 resulted in exogenous variation in exchange rate risk: countries in the euro area face zero nominal exchange rate risk.[2] More interestingly, two groups of countries – those in the eurozone and those not – have shown diverging patterns in the degrees of home bias since the introduction of euro. The countries who have adopted the euro have shown a lower level of home bias in equities. The model is able to match the difference in those two groups' weights on domestic equities, when the model is simulated with two different levels of real exchange rate risk that each group of countries faces.

Figure 1 illustrates how elimination of currency risk due to the introduction of the euro may have shaped the international portfolio allocations across countries. Following the literature, the degree of equity home bias is defined for country i at year t:

$$\text{ACT}_{i,t} = \frac{\text{Foreign Equity Asset}_{i,t}}{\text{Foreign Equity Asset}_{i,t} + \text{Market Capitalization}_{i,t} - \text{Foreign Equity Liability}_{i,t}}$$

$$\text{OPT}_{i,t} = 1 - \frac{\text{Market Capitalization}_{i,t}}{\text{World Market Capitalization}_{t}}$$

$$\text{Home Bias}_{i,t} = 1 - \frac{\text{ACT}_{i,t}}{\text{OPT}_{i,t}}$$

[2]Other countries adopted the euro at the later phases when they satisfied certain convergence criteria.

$\mathrm{ACT}_{i,t}$ denotes the actual share of foreign equities in country i's equity holdings and hence, the weight on domestic equities is $1 - \mathrm{ACT}_{i,t}$. $\mathrm{OPT}_{i,t}$ is the optimal share of foreign equities in country i's equity holdings under the ICAPM framework.[3] The home bias measure quantifies how much the actual holdings of foreign equities deviates from the optimal: the level of home bias equal to zero means there is no discrepancy between the optimal and the actual holding of foreign equities. The mean of each individual country's level of home bias is computed when calculating each group's level of home bias.[4]

Figure 1 depicts the time-series of the degree of home bias for the two groups of countries in Europe, *Euro* and *Non-Euro* in 1994–2017. Before 1999, countries who adopted the euro in 1999 are in the group *Euro* and the rest in the *Non-Euro*.[5] After 1999, since some countries joined the euro area later, the groups of *Euro* and *Non-Euro* are defined as those who use the euro and those who do not at a given point of year. This classification allows countries to move from *Non-Euro* to *Euro* over time if they have adopted the euro in a later phase. For instance, Greece adopted the euro in 2001; Slovenia, Cyprus, Malta and Slovakia adopted the euro in late 2000s. In Figure 1, it is observed that the home bias in *Euro* has been systematically lower than that in *Non-Euro*. The average levels of both groups have fallen over time, but the gap between *Euro* and *Non-Euro* has not been falling, but rather widens slightly in recent years.[6]

We observe a distinctively lower level of home bias in equities among those who use the euro, compared to those who do not use the euro. In subsequent studies in Section 3, the effect of common currency, thereby eliminating the nominal exchange rate risk among member countries, on the level of home bias is empirically studied. Then, we see that the model with portfolio stickiness is able to generate the levels of the weight on domestic equities, 0.58 for euro-adopted countries and 0.80 for non-euro adopted countries, when the difference of the two groups, in the model, is only captured by the real exchange rate risk that they face when investing abroad.

Section 2 reviews the related literature. Section 3 focuses on the empirical studies of how real exchange rate volatility has shaped the international equity portfolio allocations. Section 4 introduces the main features of the model and Section 6 elaborates on the main results from the

[3]The data are from two sources: IMF and the data set constructed by Lane and Milesi-Ferretti (2007). Whenever possible, the IMF data is used and then supplemented it with the data set of Lane and Milesi-Ferretti (2007). The market capitalization of each country is collected from the World Bank database.

[4]Computing the weighted average with the weight of each country's market capitalization generates similar results. A simple average is computed instead, however, so that large countries are not over-represented. The same qualitative pattern is observed when we use the model-free measure of the home bias, the actual weight on the domestic equities: $1 - \mathrm{ACT}$.

[5]Denmark is included in the group *Euro* even though it did not adopt the euro due to its opt-out right. It has been in the ERM II so it is more natural to put Denmark in *Euro*. The result is robust to the classification of Denmark.

[6]The data before 1995 are not readily available for many countries. With limited sample of countries, we investigate the home bias patterns from 1980. In Figure 12 in the Appendix, we can see that there is no evidence that countries that adopted the euro in 1999 had lower levels of home bias before the euro was introduced. In fact, they had higher levels of home bias for around ten years, before the euro adoption was announced in 1995.

numerical exercise. Then, concluding remarks will follow in Section 7.

2 Literature Review

Since French and Poterba (1991) empirically found that there is a substantial level of home bias in equities, there has been a great volume of studies trying to explain the reasons behind the bias.[7] The explanations put forward in the literature are: information asymmetries and behavior explanations, transaction costs with small diversification benefits, hedging motives, and price stickiness.

The effect of information asymmetries on portfolio choice is widely studied in the finance literature. In this literature, investors have more precise information about the future return of domestic equities compared to that of foreign. For instance, Gehrig (1993) and Gordon and Bovenberg (1996) derive the equity home bias from a model where an agent receives a more precise signal on the future returns for domestic equities. Empirically, many papers use the proxy for information asymmetries such as physical distance to study the impact of information asymmetries on portfolio decisions. Coval and Moskowitz (1999) use data on US mutual fund managers' investment patterns and Tesar and Werner (1995) use the international investment positions of five OECD countries to advocate the role of information asymmetries in international diversification. Portes and Rey (2005) also empirically examine the role of distance in the geography of equity flows between 14 countries under a gravity specification. More recently, in line with Open Economy DSGE approach, Carlos Hatchondo (2008) studies a two country model with two assets per country. Two assumptions in the model generate a high level of equity home bias: first, only local investors receive informative signals about the ranking of local assets and secondly, short-selling is costly. A high cost of short-selling renders an agent to reduce her holdings of foreign stocks to buy "good" local stocks rather than short-selling "bad" local stocks.

Other papers focus on hedging motives against non-tradable risks to explain equity home bias. Neoclassical models such as that in Baxter and Jermann (1997) result in a negative covariance between non-tradable labor income and domestic equity returns and hence suggest that "the international diversification is worse than you think." The empirical evidence on this is debatable: Bretscher et al. (2016) show that with a sample of four large countries - the USA, the UK, Japan and Germany - labor income shocks are less correlated with domestic equity returns than with foreign equity returns, opposing Baxter and Jermann's claim. Moreover, Engel and Matsumoto (2009) develop a two-country DSGE model with sticky price and show that a high degree of price stickiness can generate home bias in equity portfolios. A higher weight on domestic equity is optimal in this set-up as domestic returns to human wealth and local equity returns are negatively correlated, con-

[7]Many others include Lewis (1999), Tesar and Werner (1995), and Cooper and Kaplanis (1994). For a recent survey, see Coeurdacier and Rey (2013).

ditional on nominal exchange rate changes. The conclusion, however, requires agents fully hedge foreign exchange rate risk. In line with this argument, Coeurdacier and Gourinchas (2016) develop a model of international equity portfolio choices with bonds and equities and show that home equity bias arises when non-financial returns are negatively correlated with equity returns conditional on bond returns. They empirically show that the covariance between returns on equity and returns on nontradable wealth is positive but the conditional covariance is negative (or insignificant).

Each paper offers some resolution to the lasting puzzle but many fall short of matching the *degree* of home bias in equities. Furthermore, even if some of the general equilibrium models replicate, to some extent successfully, the degree of equity home bias, they fail to match realistic moments of asset returns and exchange rates. Whilst solving one puzzle, other puzzles in finance- the equity premium puzzle and excess volatility of asset prices - then remain unsolved.

This paper, taking the return distribution as given, offers a new resolution to the existing literature on equity home bias. Moreover, our model with slow portfolio adjustment aims not only to generate a home bias in equities but also to match quantitatively the actual weight on the domestic equities. The model implication will be tested qualitatively but also quantitatively.

This article is also related to a large volume of research documenting micro-level evidence on how infrequently households adjust their portfolio and examine its impact on the asset prices. Some look for household/brokerage level evidence, while others look at asset returns data and concentrate on how these features may hint the limited portfolio adjustment. For instance, Ameriks and Zeldes (2004) report that over a 10-year period, 44% of households in a TIAA-CREF panel do not change their portfolio allocations and 17% of these investors only make a single re-allocation during this period. Brunnermeier and Nagel (2008) use the PSID data on purchases and sales of risky assets on the two interview dates and reconstruct the approximate portfolio allocation assuming investors did not adjust their risky asset holdings between the two interview dates and with the ex-post realized returns between the two interview dates. They find that that the constructed and the actual allocations are quite similar. This result implies that many households do not adjust their portfolios at all during these two interview dates, evidence of portfolio stickiness. Bilias et al. (2010) document that conditional on owning stocks at the start or at the end of the period, more than 50% of agents did not trade stocks over this period. Others look at asset returns' data to look for the evidence of infrequent trading: Duffie (2010), Bogousslavsky (2016) and Chien et al. (2012). Also, in the intentional context, Bacchetta and Van Wincoop (2010) explain the forward premium puzzle with a model featuring infrequent trading.

However, there is certainly a lack of studies exploring the implication of infrequent portfolio adjustment on actual portfolio allocations. A notable exception is Bacchetta and Van Wincoop (2017). Bacchetta and Van Wincoop (2017), *taking the equity home bias as given*, study the implications of a model with infrequent portfolio adjustment on various moments of asset returns and equity portfolio weight.[8] Conditional on a reasonable level of risk aversion (less than 50), they conclude that data patterns are consistent with a high level of sluggishness in the portfolio adjustment- with a frequency of *at most* once in 15 months on average.[9] With a similar type of set-up, we explore the implications of portfolio stickiness to the international portfolio allocation between home and foreign equities to resolve the equity home bias puzzle.

There are few studies exploring the role of real exchange rate volatility in shaping portfolio allocations: Cooper and Kaplanis (1994) and Fidora et al. (2007). Cooper and Kaplanis (1994) examine whether domestic inflation risk can rationalize the observed degree of home bias in equities, looking at the correlation between domestic inflation and domestic equity returns. They conclude that uncertainty in inflation cannot justify a high level of home bias in equities. This is, in fact, not a direct analysis of the effect of real exchange rate volatility on the level of home bias in equities. Fidora et al. (2007) explicitly study the role of real exchange rate volatility in explaining a different degree of home bias in equities, using the International Monetary Fund (IMF)'s Coordinated Portfolio Investment Survey (CPIS) data of 40 investor countries and up to 120 destination countries in 2001–2003.[10] The authors find that the real exchange rate volatility increases the home bias and the impact varies across the asset classes, bonds and equities, suggesting a larger impact on bond holdings. Complementing the above research, this paper closely examines the role of currency union and real exchange rate volatility on the home bias measure and bilateral equity holdings among the country pair in the European Union. Documenting differing degrees of home bias in equities among countries in Europe after an introduction of the euro, we show that a model with infrequent portfolio adjustment is able to explain a high level of home bias in equities among those who have not adopted the euro, whilst addressing a lower but still substantial level of equity home bias among those who adopted the euro.

3 Empirical Analysis

In this section, we investigate how the adoption of euro – a complete elimination of nominal exchange rate risk – has shaped international equity portfolio holdings among 28 countries in the European Union and Switzerland.[11] First, to reinforce our argument that the euro has brought a divergence in the levels of home bias among countries in Europe, we estimate the dynamic effects

[8]The standard deviations and autocorrelations of returns and equity portfolio weights (sometimes changes over a period of time) and the contemporaneous correlation between asset returns and portfolio changes are considered. For more information, look at the result summarized in Table 2 of Bacchetta and Van Wincoop (2017).

[9]In their model of Bacchetta and Van Wincoop (2017), the market is segmented. There are frequent vs. infrequent traders. For the infrequent traders, periods of inaction that the authors have considered are 2 to 8 years, and they account for more than 99% of the population in their estimated models.

[10]The paper uses averaged data over this period.

[11]Excluding Switzerland does not change any of the results qualitatively.

of the euro adoption before and after a country adopts the euro. The second part of the anlaysis then focuses on the effect of euro adoption on the level of the equity home bias, highlighting that the euro adoption has brought a fall in the real exchange rate volatility, which in turn has lowered the level of the home bias. Lastly, focusing on the equity investment between pairs of countries, we further examine how a fall in the *bilateral* real exchange rate volatility due to the adoption of euro has shaped the *bilateral* real equity holdings.

The analyses elaborate more on the patterns shown in Figure 1, explaining whether there is indeed a statistically significant difference in the levels of home bias between countries who face varying degrees of the real exchange rate volatility, due to the introduction of the euro. As of 2017, 19 out of 28 member states use the euro, of which 8 countries joined the euro area after 1999. The cross-sectional and time variation in exchange rate volatility due to the adoption of euro allows us to see its impact on the geography of international equity investments in Europe.

3.1 Dynamic Effects of Euro Adoption

Following Gourinchas and Obstfeld (2012), we estimate the dynamic effects of the euro on the level of home bias and the weight on domestic equities before and after a country adopts the euro. The degree of home bias is calculated as described in the introduction. The IMF International Financial Statistics and the panel data of Lane and Milesi-Ferretti (2007) are used for foreign equity assets and liabilities and the market capitalization is from the World Bank's World Development Indicator (WDI) database.[12] The following specification is estimated:

$$(1):\ y_{it} = \alpha + \sum_{x=-5}^{18} \beta_x D^i_{x,t} + \epsilon_{it}$$

$$\text{where}\ \ y_{it} = \{\text{Home Bias}_{it}, \text{Weight on Domestic Equity}_{it}\}$$

$D^i_{x,t}$ is equal to one in year t when a country i has adopted the euro at year $t-x$. The coefficients of interest are $\{\beta_x\}_{x\in[-5,18]}$.[13] Since the later analysis focuses on the period 1994-2017 due to the data availability of the exchange rate, the same sample period is adopted.

Figure 2 depicts the β coefficients when y is the level of home bias. It shows the point estimates of the coefficients with the 95% confidence interval estimates. 0 is the time when a country adopts the euro. It is shown that before a country adopts the euro, virtually there is no difference in the degrees of home bias from the average of those who do not adopt the euro in our sample. After a

[12]The updated and extended version of the data set constructed by Lane and Milesi-Ferretti (2007)

[13]The results are still qualitatively the same when the country fixed effects are included. The main focus of the section is the divergence in the cross-sectional averages between the euro and non-euro groups, and hence the baseline specification doesn't include the country fixed effects.

country adopts the euro, it has been exhibiting a systemically lower level of home bias, and the euro adoption has a permanent impact on the level of home bias. The estimates are around -0.2 and slightly larger in size in the recent period but not statistically different. This finding confirms our argument that the adoption of the euro has changed the geography of foreign portfolio investment. Since the degree of home bias is not model-free, we use the weight on the domestic equity as a dependent variable, and a similar set of estimation results is found. Figure 13 in the Appendix shows the estimated coefficients.

3.2 Home bias and REER volatility

In this section, we analyze the impact of changes in real exchange rate volatility via the euro adoption on home bias in equities. We first compute real effective exchange rate volatility. To compute real effective exchange rate volatility, we use the *monthly* real effective exchange rates (REER) in 1994-2017 of 29 countries from the Bank of International Settlement (BIS) database.[14] The volatility of the real effective exchange rate of each country i at year t is computed as the standard deviation of monthly REER returns (i) in the same contemporaneous year t, and (ii) in the past five years preceding year t (in other words from year $t-5$ to year $t-1$).[15] Each of the volatility measures for country i's REER, from now on, will be denoted as $\sigma_{i,contemp}$ and $\sigma_{i,five}$ respectively. For the robustness check, the conditional REER volatility measure is estimated with GARCH(2,2), denoted as $\sigma_{i,GARCH}$. The effect of the constructed REER volatility measures on the level of home bias are analyzed. The degree of home bias is calculated as described in the introduction. The IMF International Financial Statistics and the panel data of Lane and Milesi-Ferretti (2007) are used for foreign equity assets and liabilities, and the market capitalization is from the World Bank's World Development Indicator (WDI) database.

First, we see if the adoption of the euro has brought a fall in the levels of home bias and weight on domestic equities. We also control various other channels that the euro may have indirectly influenced a country's home bias in equities other than a complete elimination of nominal exchange rate risk. Secondly, we directly test if there is an indeed a fall in the level of REER volatility after a country adopts the euro, and use this variation to see how this effect has shaped a country's level of home bias. We run a two-stage regression for this estimation. The below is the set of empirical specifications:

[14] The list of countries is summarized in Table 8 in the Appendix. The monthly REER is computed with the time-varying weights based on the three-year average trade flows, with 2010 as the indices' base year. A more appropriate measure of the "effective" exchange rate for this project would be with the weights based on financial asset trading; however, the cross-border asset holdings data are only available after 2001.

[15] The results are very similar if computed with the past three years of monthly returns preceding year t.

Baseline

$$(2): \quad Y_{it} = \beta_0 + \beta_1 \text{Euro}_{it} + \zeta' X_{it} + \alpha_t + \epsilon_{it}$$

2SLS

$$\textit{First-Stage, (3)}: \quad \sigma_{it} = \gamma_0 + \gamma_1 \text{Euro}_{it} + \Gamma_t + u_{it}$$

$$\textit{Second-Stage, (4)}: \quad Y_{it} = \theta_0 + \theta_1 \hat{\sigma}_{it} + \Theta' X_{it} + \Omega_t + \nu_{it}$$

Y is the level of home bias (HB) and the weight on domestic equities (DW). We use three different measures of the volatility of REER: $\sigma_{i,contemp}$, $\sigma_{i,five}$ and $\sigma_{i,GARCH}$. We control for various channels that the euro adoption may have affected the level of home bias: X_{it} include size of the economy (log of real GDP), trade openness (total imports and exports as a ratio of GDP) and de jure capital control index. The data on real GDP and trade flows are collected from the IMF. We employ the de jure capital control index for country's equity inflows and outflows, constructed by Fernández et al. (2016).

Table 1 summarizes the baseline regression results of (2), estimating the effect of euro adoption on home bias. In the regression, the adoption of the euro on average across specifications has consistently and significantly lowered the degree of home bias and the weight on domestic equity. We estimate the size of the fall to be around 0.155 to 0.196. The results are robust to controlling various other factors, such as the size of the economy, the trade openness and capital control index. The size of the coefficient falls quantitatively when controlling for other indirect effects of the euro adoption on the degrees of home bias in equities; however, the effect is still sizeable and statistically significant. The results support our argument that the effect of the euro adoption on the foreign equity investment is not just a consequence of higher trade openness and less restriction on capital flows; however, this paper argues that a first order importance is of a shut-down of the nominal exchange rate risk between countries in the euro area. The estimates of other coefficients are in Table 11 in the Appendix.

The results of Table 2 further supports our argument that a complete elimination of nominal exchange rate volatility in the eurozone lowers the REER of those countries who use the euro, leading to a fall in the level of home bias. The regression results of equation (3) show that the euro adoption has lowered the monthly REER volatility by around 0.6 percentage points. The findings are consistent with three different volatility measures that we employ. We use the predicted variation in the REER volatility from the regression (3), and use the predicted REER volatility in estimating the equation (4). In Table 3, the effect of the volatility of the predicted REER on the degree of home bias is consistently positive and significant at 1% level across specifications: 1 percentage point increase in the standard deviation of the monthly REER returns increases the home bias by

0.26 to 0.29. This result confirms that when the volatility of the exchange rate falls due to the euro adoption, one holds fewer foreign equities. The estimated marginal effects from Table 1 are not very different from the ones that we get by multiplying γ_1 and θ_1, which gives the effect of the euro on the level of home bias through a fall in the REER volatility. The findings are robust to controlling various other factors. The estimates of other coefficients are in Table 12 in the Appendix.

In sum, we find that the euro effect on the level of home bias is significant and sizable even after controlling various factors, and we also directly analyze how a fall in the real effective exchange rate volatility via the euro adoption has lowered the level of home bias. On average, non-euro adopted countries have a weight of 0.8 on domestic equities and euro adopted countries have a weight of 0.58. We investigate if our model with calibrated real exchange rate volatilities for countries in *Euro* vs. *Non-Euro* can quantitatively match these average weights.

3.3 Bilateral Portfolio Equity Investment and Bilateral RER volatility

To compute the volatility of real exchange rate between *pairs*, we first collect monthly *nominal* exchange rates against the US dollar for each of the 29 countries, and calculate bilateral monthly nominal exchange rates between the pairs of 29 countries. Then, the bilateral monthly *real* exchange rates between country pairs are then computed with the consumer price indices (CPIs) from the International Financial Statistics (IFS) and the bilateral monthly nominal exchange rates. Then, the bilateral real exchange rate *volatility* of each pair in 2001-16 is calculated using monthly bilateral real exchange rates between pairs of countries in the European Union.[16]

For volatility of the bilateral real exchange rate between country i and j at year t, we compute the standard deviation of monthly *bilateral* real exchange rate returns (i) in the same contemporaneous year t, and (ii) in the previous five years (in year $t-5$ to $t-1$). They are denoted as σ_{ijt} and $\sigma_{ijt,five}$ respectively. The data of Coordinated Portfolio Investment Survey (CPIS) released by the IMF are used to analyze the cross-border portfolio equity investment holdings between countries in the European Union. The panel data constructed have 29 source and 29 destination countries. The first survey of the CPIS was conducted in 1997 and annually after 2001. Even with some shortcomings of the data set including under-reporting of asset holdings, the CPIS still offers a unique and comprehensive picture of bilateral asset holdings between country pairs. In this paper, the bilateral portfolio equity holdings (FPI) between 29 countries in the European Union are used for analysis in 2001–16. The collected data are in US dollars. Using exchange rates, the data are converted into units of the investor countries' domestic currencies and deflated using each country's CPI. The below is the set of empirical specifications for this section:

[16]The choice of years is strictly based on the data availability, not the author's discretion. Specifically, the panel data of bilateral equity holdings from the Coordinated Portfolio Investment Survey (CPIS IMF) are only available since 2001.

Baseline

$$(5): \quad \ln(\text{Real FPI in Equty})_{ijt} = \beta_0 + \beta_1 \text{Euro Pair}_{ijt} + \beta_2 \ln(\text{RGDP})_{it} \ln(\text{RGDP})_{jt}$$

$$+ \beta_3 \frac{\text{Import}_{ijt} + \text{Export}_{ijt}}{\text{GDP}_{it}} + \beta_4 \text{Capital Control}_{it} \text{Capital Control}_{jt} + \alpha_i + \alpha_j + \alpha_t + \epsilon_{ijt}$$

2SLS

First Stage, (6) : $\sigma_{ijt} = \gamma_0 + \gamma_1 \text{Euro Pair}_{ijt} + \Gamma_i + \Gamma_j + \Gamma_t + u_{ijt}$

Second Stage, (7) : $\ln(\text{Real FPI in Equty})_{ijt} = \theta_0 + \theta_1 \hat{\sigma}_{ijt} + \Theta' X_{ijt} + \Omega_i + \Omega_j + \Omega_t + \nu_{ijt}$

The effect of the adoption of the euro – a structural change in the bilateral real exchange rate (RER) volatility when a pair adopts the euro – on the bilateral equity holdings is investigated. The dependent variable, $\ln(\text{Real FPI in Equty})_{ijt}$, is real foreign portfolio equity investment of source country i to destination country j at year t. The sample covers all pairs of 29 countries in the European Union from 2001 to 2016. Euro Pair is a dummy variable, equal to one when country i and country j both use the euro[17]. This pair dummy captures a fall in the bilateral nominal exchange rate volatility to zero. Since some countries joined the euro area at different years, the dummy variable has both variation within countries and also across time. For robustness checks, we also control for other variables (X_{ijt}): the cross product of countries' log of real GDP, country $i's$ trade with country j – the sum of exports to and imports from country j (as a ratio of GDP), and the cross product of measures of capital controls on equity flows.[18] As in the previous section, GDP, CPI and bilateral trade flows are from the IMF, and the capital control index is the one constructed by Fernández et al. (2016).

Table 4 summarizes the results of regression (5). We investigate the effect of a common currency on the bilateral equity investment. The size of the coefficient gets smaller when we include source and destination country fixed effects (which we define as "country fixed effects"), and year fixed effects. Nonetheless, a sizeable and statistically significant positive impact of the euro on the bilateral foreign equity portfolio investment is estimated at around 0.8. When both countries use the euro, they hold 0.8% more of each other's equity. The findings are robust to controlling other various country pair characteristics, and the size of the estimates do not change quantitatively; the estimates in Columns 2, 3 and 4 are similar in numbers. As expected, when both countries have

[17]For Denmark, it did not adopt the euro, but its currency is pegged to the ECU and then to the euro since 1979 and in ERM II (with an opt-out). Thus, Denmark is regarded as a country using the euro. This classification does not at all affect the regression results found.

[18]The data from the IMF are in dollars. Therefore, we use the nominal exchange rate to convert it in units of domestic currency and deflated using country $i's$ CPI. Then, it is normalized by the real GDP from the IMF.

higher real GDP, lower capital controls, and higher trade flows, they invest more in each other's equity markets.

We further analyze how the bilateral RER volatility has changed after a country pair adopts the euro. Table 5 summarizes the estimation results of equation (6) with two different bilateral RER volatility measures. The effect of the predicted bilateral real exchange rate volatility on bilateral foreign equity holdings is consistently negative and significant at 1% across different specifications, including source and destination country fixed effects and year fixed effects. The estimates are robust to the measures that we use to compute the bilateral RER volatility, and are around -0.4.

We use the variation of the bilateral RER volatility explained by the adoption of the common currency, and investigate how a fall in the bilateral RER volatility, when both countries use the same currency, has shaped the equity portfolio investment between country pairs. We regress the bilateral equity portfolio investment on the predicted value of bilateral RER volatility, which we have computed from regression (6).[19] Table 6 summarizes the results. The effect of the predicted exchange rate volatility on bilateral equity holdings is negative and statistically significant at 1% significance level. One percentage point increase in the predicted value of bilateral RER volatility lowers the foreign portfolio investment between pairs by around -2%. For Columns 2 and 4, we also control for the cross product of log of real GDP, the bilateral trade flows and the cross product of capital control measures. The results are almost the same and the effect of the predicted RER volatility on the bilateral equity flows is estimated at -1.89%, even after controlling for other variables. This finding captures the effect of an elimination of the (nominal) exchange rate risk between country pairs in the eurozone on the cross-border equity investment holdings among member countries. The estimates of other coefficients are reported in Table 13 in the Appendix.

The foremost concern in the above analyses is the reverse causality issue. Capital flows might influence the level of exchange rate volatility and hence the size of foreign equity assets and/or bilateral equity holdings might indirectly influence real exchange rate volatility. First, since the dependent variable is not a flow measure, but rather stock holdings, it should be less of a problem. Secondly, even when there is an endogenity issue, the sign of the bias when estimating the effect of real exchange rate volatility on home bias is positive. With a higher level of capital flows between countries, the volatility of exchange rates is likely to go up, i.e., it is expected that a country pair may have higher bilateral real exchange rate volatility when holding higher level of each other's equity. Hence, if we adequately control for endogeneity, the estimates of the impact of the real exchange rate volatility on the foreign equity holdings should be more negative (the size of the estimates larger in the absolute value). Lastly, we use the variation in the real exchange rate volatility explained by the euro adoption, which we take it as an exogenous event that systematically changes the exchange

[19] Not including country fixed effects and year fixed effects when predicting the bilateral RER volatility does not change any of the results qualitatively, and the estimates do not vary much quantitatively.

rate volatility. This also mitigates the concern about the endogeneity.

4 Model

This section introduces a simple model, featuring infrequent trading, to explore the portfolio allocations between domestic and foreign equities. With infrequent trading, an investor on average holds on to her portfolio holdings for a longer duration. With volatile real exchange rate returns, her foreign equity holdings are likely to deviate more from the optimal than domestic equity holdings. The investor, taking this account ex-ante, lowers her demand for foreign equities. The deviation is more pronounced when the exchange rate volatility is higher, and therefore the weight on foreign equities is much lower with higher exchange rate volatility. In a way, a higher probability of sticking with the portfolio holdings that an agent chooses increases her aversion towards risk. With a reasonable level of risk aversion, our model can generate a high weight on the domestic equities, quantitatively close to the level that we see from that data offering some resolution to the home bias puzzle in equities.

With calibrated real exchange rate volatility to match the average volatility for (i) a country outside the euro area and (ii) a country inside the euro area, our model can generate the levels of home bias, quantitatively close to the ones that we see in the data in Section 3.

4.1 Environment

It is a representative agent model where each agent maximizes her expected life-time utility. The economy has a unit-measure of infinitely-lived identical households:

$$\mathbb{E}_0\{\sum_{t=0}^{\infty}\beta^t u(C_t)\}$$

$\mathbb{E}_t$ is the time t expectation operator. β is the discount factor and the period utility function u has constant-relative risk aversion (CRRA) form with risk-aversion γ. The agent gets an endowment of Y_t every period and has access to the domestic and the foreign equity markets.

Following Bacchetta and Van Wincoop (2017), the model incorporates a feature of infrequent asset trading among households. An agent has an exogenous probability p of sticking with the same portfolio holdings of both home and foreign assets and $1-p$ of changing their holdings optimally. Given a value of p, an agent has a stochastic time-interval of trading inactivity, and the average length of inaction would be $\frac{1}{1-p}$ periods. For simplicity, it is assumed that the exogenous state of inaction happens to all the agents in the economy. Since the model parameter values are calibrated with annual data and p is between 0.2 and 0.8, implying an average length of inaction is around from

1.25 to 5 years. This choice of parameter values are in line with those from the previous studies of Bacchetta and Van Wincoop (2017).[20] As aforementioned in the introduction, we assume that an agent cannot hedge her exchange rate risk.[21]

When an agent can adjust her portfolio, she can choose domestic and foreign equity holdings, S^D_{t+1} and S^F_{t+1} (both in units of home consumption basket) at time t. The budget constraint is then:

$$S^D_{t+1} + S^F_{t+1} + C_t = Y_t + S^D_t R^D_t + S^F_t R^F_t \tilde{E}_t$$

R^D_t represents the gross return from holding the domestic equity in units of home consumption baskets and R^F_t that of the foreign equity in units of foreign consumption baskets. $\tilde{E}_t = 1 + e_t$ is the gross return of the real exchange rate, which is the price of foreign consumption baskets in units of home consumption baskets.

When an agent cannot adjust her portfolio, which occurs with probability p. Then, her holdings of home and foreign equity portfolios are those after capital gains or losses are reflected.[22]

$$C_t = Y_t, \;\; S^D_{t+1} = S^D_t R^D_t, \;\; \text{and} \;\; S^F_{t+1} = S^F_t R^F_t \tilde{E}_t$$

Without loss of generality, the mean of the log of income is set to zero. The endowment and the return processes are exogenous:

$$\ln(Y_{t+1}) = \rho_y \ln(Y_t) + \epsilon^y_{t+1}, \;\; \epsilon^y_{t+1} \sim N(0, \sigma^2_y)$$

$$R^D_{t+1} = \bar{R}^d + \rho_D R^D_t + \epsilon^D_{t+1}, \;\; \epsilon^D_{t+1} \sim N(0, \sigma^2_D)$$
$$R^F_{t+1} = \bar{R}^f + \rho_F R^F_t + \epsilon^F_{t+1}, \;\; \epsilon^F_{t+1} \sim N(0, \sigma^2_F)$$
$$e_{t+1} = \rho_e e_t + \epsilon^e_{t+1}, \;\; \epsilon^e_{t+1} \sim N(0, \sigma^2_e)$$

It is also assumed that the shocks to income and return processes are jointly normal and allowed to be correlated with each other.[23] Hence, the value function problem becomes:

[20] Bacchetta and Van Wincoop (2017) use a model with parameter values, implying an average years of 2 to 8 between portfolio adjustments, and the estimated fraction of frequent traders is around 0.39% to 0.01% depending on the specifications.

[21] It is equivalent of having a large enough fixed costs for hedging the FX risk such that no investor is engaging in FX hedging. Ideally, if we have the data on the proportion of foreign equity investment hedged, then we can calibrate this fixed cost parameter to match this share. Unfortunately, to my best knowledge, there is no database that contains this information.

[22] Since the paper is only interested in the relative allocations between the two equity assets, the relaxation of the assumption that the agent needs to consume everything she has today will not affect the main findings.

[23] In fact, in the later calibration, the real exchange rate changes are uncorrelated to others. This will be further explained later in the section.

Denote $z = \{y, R^D, R^F, e\}$.

$$V_{change}(S^D, S^F, z) = \max_{S^{D'}, S^{F'}, C} U(C) + \beta p E(V_{no\,change}(S^{D'}, S^{F'}, z')) + \beta(1-p)E(V_{change}(S^{D'}, S^{F'}, z'))$$

$$\text{where } \; S^{D'} + S^{F'} + C = Y + S^D R^D + S^F R^F \tilde{E}$$

$$V_{no\,change}(S^D, S^F, z) = U(C) + \beta p E(V_{no\,change}(S^{D'}, S^{F'}, z')) + \beta(1-p)E(V_{change}(S^{D'}, S^{F'}, z'))$$

$$\text{where } \; C = Y, \;\; S^{D'} = S^D R^D, \;\; \text{and } \; S^{F'} = S^F R^F \tilde{E}$$

z follows a first-order Markov process as aforementioned. For the numerical solution, the vector of shocks is discretized into a first-order Markov process, with two grid points for each shock, using the method of Tauchen (1986) and Terry and Knotek (2011). The calibration procedure and the data will be explained further in the next subsection.

5 Calibration

We derive numerically the optimal portfolio choice between home and foreign equities given the distribution of equity returns and exchange rate returns. One period in our model is one year, and the returns of equities and labor income processes are calibrated to match the historical *average* annual return distributions in the data. We compute three different levels of average real exchange rate volatility between (i) the pairs where at least one of them is not in the eurozone, while the other country in the pair may or may not be in the eurozone, $\sigma_{Non-Euro}$, (ii) the pairs where at least one of them is in the eurozone, while the other country in the pair may or may not be in the eurozone, σ_{Euro}, and (iii) the pairs where both are in the eurozone, $\sigma_{BothEuro}$. The last one is a counter-factual environment, where all the countries are assumed to be using the same currency, the euro, and hence face lower real exchange rate volatility and zero nominal exchange rate volatility.

Calibration of the labor income process uses the annual data of 24 countries in Europe in 1980–2017 (but for many countries, the sample starts at 1995) to estimate a first-order auto-regressive process of labor income shock.[24] Total employee compensation is from from the OECD National Accounts Dataset and is deflated by CPI and population size.[25] The log of real labor income is hp-filtered.[26] Then, for each country, ρ_y and σ_y are estimated. ρ_y is calibrated to 0.8. The mean of residual standard deviations of 24 regressions is then used to calibrate σ_y and set to 0.03.[27]

[24]The data for five countries are missing. The calibration results may not change greatly even with the labor income data of those five countries since we take the mean/median of the each country's regression estimates. The year varies due to the availability of the data. The details are in Table 9 in the Appendix.

[25]CPI data and the population data are collected from the IMF IFS database.

[26]The smoothing parameter of 1600 is used as baseline but also tried a lower value, 100, but the change is minimal.

[27]Using first log differences rather than hp-filtered, the results of calibration are almost identical.

To calibrate the real returns from holding domestic and foreign stocks, the annual data of representative equity indices (end of period price) for 31 countries (29 countries plus the US and Japan) are collected from the Bloomberg Terminal. The United States and Japan are included because they are among the top 10 investment destination countries of most of the 29 European countries we focus. The end of year representative equity prices are deflated by the CPI. Then, the annual returns of benchmark equity real prices for each country are computed. The estimation of a first-order auto-regressive process of annual returns in equity indices has shown that they are not persistent, so the persistence parameters are calibrated to zero: $\rho_D = \rho_F = 0$. The sample period varies by country due to the availability of the data and is summarized in Table 10 in the Appendix. The data in year 2008 are excluded to minimize the effect of financial crisis on the equity market returns. The mean and the standard deviation of stock returns are calibrated to 0.06 and 0.3 respectively. The domestic and foreign equities are assumed to have the same expected return and the equal size of shock. Most of the correlations of real stock returns between countries lie between 0.6 and 0.9, and $\rho_{\epsilon^D,\epsilon^F}$ is calibrated to 0.7.

To compute the real exchange rate volatility, the nominal exchange rates against the US dollar from the BIS are used. Then, the annual real exchange rate between each country pair is computed with the bilateral nominal exchange rate and the consumer price indices of the two countries. For each pair, the time period differs depending on the availability of the data but the longest real exchange rate series is from 1950 to 2017. CPI data, employed to compute the bilateral real exchange rate, are available for all the countries from 1992. Then, the first log differences of annual bilateral real exchange rates are calculated and used to estimate a first-order auto-regressive process of real exchange rate returns and find that they are not persistent, so $\rho_e = 0$.

We compute three different averages of exchange rate volatility: $\sigma_{Non-Euro}$, σ_{Euro} and $\sigma_{BothEuro}$ for (i) a country outside the euro area, (ii) a country in the euro area, and (iii) a country in the euro area, hypothetically trading only with those in the euro area.

We first compute $\sigma_{Non-Euro}$ by taking the cross-sectional averages of bilateral real exchange rate volatility, where a country of a pair is outside the euro area.[28] For a counter-factual exercise, we also compute, $\sigma_{BothEuro}$, the cross-sectional average of the bilateral real exchange rate volatility of the pairs, where both use the euro. The mean values of the standard deviation of bilateral exchange rate annual returns are 14.6% for $\sigma_{Non-Euro}$ and 1.3% for $\sigma_{BothEuro}$. More details can be found in the Appendix A.5.1.

Then, for the calibration of σ_{Euro}, since the simple average of bilateral exchange rate volatility in our sample may downward bias our estimate, where, for many pairs, both countries are in the euro area. Therefore, we compute the *real effective exchange rate* that a country in the eurozone faces (for many countries, it would be $1999 - -2017$, except those who joined the euro area in

[28]The other country of a pair may be in the euro area or outside the euro area.

later phases), and compute the volatility of the annual real effective exchange rate changes. The real effective exchange rates for countries in eurozone are calculated using their actual portfolio weights on the 188 countries' equities. We assume the portfolio weights in 1999 and 2000 are the same as those of 2001, since the CPIS data cover the period starting from 2001. Since the euro was introduced in 1999 for most of countries in our sample, the real effective exchange rates in 1999 and 2000 are computed, assuming that weights are not different from that of 2001. The details are described in the Appendix A.5.2. We impute the average values of the real effective exchange rate volatility for the eurozone countries, and the computed volatility is 4.7%. We use 4.7% for σ_{Euro}.[29]

The correlation between the exchange rate changes and other shocks is assumed to be zero.[30] The exchange rate movements in the model are mere "noise" and not correlated with any of the fundamentals in the economy. This assumption is also related to the famous puzzle in international finance, "exchange rate disconnect", where macroeconomic fundamentals seem to have very low correlation with exchange rate movements.

For the correlation between labor income and domestic and foreign equity returns, there has been conflicting empirical evidence in the literature. For instance, Baxter and Jermann (1997) document that the correlation is positive while Bretscher et al. (2016) find that returns from human capital are in fact more positively correlated with the foreign stock returns, arguing against Baxter and Jermann (1997)'s argument that including human capital makes the international diversification puzzle worse. Hence, we experiment with correlation structures of income shock and equity returns to see if our argument is robust to a range of correlations that are empirically relevant.

Table 7 shows the summary of parameter values.

6 Numerical Results

We have computed three different levels of *average real exchange rate volatility*: (i) for a country outside the eurozone, $\sigma_{Non-Euro}$, (ii) for a country in the eurozone, σ_{Euro} and (iii) for a hypothetical country trading equities only with those in the euro area, $\sigma_{BothEuro}$. In this section, we compare the simulated portfolio choices with these three different levels of the real exchange rate volatility.

This section first deliberately compares the portfolio outcomes of $\sigma_{Non-Euro}$ and $\sigma_{BothEuro}$, and shows that $\sigma_{BothEuro}$ is insufficiently volatile to generate home bias among countries in the eurozone under some correlation of income shock and equity returns. Then we show that, with higher exchange rate volatility σ_{Euro}, the model is able to replicate the average weight on domestic

[29]Missing portfolio weights prior to 2001 is the main reason why we compute a simple average, when calibrating the real exchange rate volatility for the non-euro group.

[30]We have mixed estimates for the correlation between exchange rate changes and other shocks for different country pairs.

equities among countries in the eurozone.

The results below consist of three different cases in which the correlation structure between income shock and equity returns is different: (i) $\rho_{R^d,\epsilon^y} = 0$, $\rho_{R^f,\epsilon^y} = 0$, (ii) $\rho_{R^d,\epsilon^y} = 0$, $\rho_{R^f,\epsilon^y} = 0.4$, and (iii) $\rho_{R^d,\epsilon^y} = 0.4$, $\rho_{R^f,\epsilon^y} = 0$.[31] The weight on the home equity is our main item of interest, measured as $\frac{S_t^D}{S_t^D+S_t^F}$. The figures below are based on $100,000$ simulations where the first $5,000$ are taken out to ensure that the distribution does not depend on the initial values.[32] The values of p are from 0.2 to 0.8, implying an average time interval of inaction 1.25 to 5 years. The choice of the stochastic time interval is based on Bacchetta and Van Wincoop (2017)'s estimation of probability using the dynamic responses of portfolio and asset prices: on their paper, at the monthly frequency, the probability is around $0.96 - 0.99$, implying the average inaction period of 2 to 8 years. In their paper, the inaction period is for infrequent traders but that accounts for more than 99% of the population in their estimated model.

In the empirical analysis, we have seen that the countries outside the eurozone on average put the weight on the home equities around 0.8 and 0.58 for the countries in the eurozone, and we would like to investigate if our model with infrequent trading can match these average weights quantitatively. Furthermore, we would like to emphasize the role of exchange rate volatility in generating a high level of home bias in equities, showing that the results are similar across all the cases with different covariance structures of income shocks and equity returns, as long as the real exchange rate volatility is high enough.

6.1 Case 1: $\rho_{R^d,\epsilon^y} = 0$, $\rho_{R^f,\epsilon^y} = 0$

The first case presented is when the income shocks are not correlated with equity returns. Hence, in terms of the covariance structure, the domestic equity and the foreign equity are the same except the real exchange rate volatility that increases the volatility of the return on foreign equities in units of domestic consumption baskets. First, the real exchange rate volatility is set to $\sigma_{Non-Euro}$. As observed in Figure 3, an increase in the portfolio stickiness, p, shifts the distribution of the weight on the domestic equity to the right. As p goes up, the agent puts a higher weight on the domestic equities. The mean goes up by more than 0.26 as the probability goes up from 0.2 to 0.8. When the probability is between 0.6 and 0.8, the weight on the domestic equity would closely match what we observe from the data, on average 0.8.

[31]The highest correlation that we consider is 0.4, and it is among the highest estimates that the empirical studies have found. For instance, in Bretscher et al. (2016), the highest estimate is around 0.2. We would like to ascertain that our argument goes through a range of correlation that is empirically relevant.

[32]The initial weight is set as 0.5 and both home and foreign equity holdings take the first grid point of assets, which is 0.001. It is experimented with a few other initial values keeping the weight equal to 0.5 and there is hardly any change.

When the real exchange rate volatility is set to σ_{Euro} – a hypothetically *low* real exchange rate volatility assuming every country uses the euro, an increase in the probability does not change the distribution as much as it has with a high level of real exchange rate volatility. As seen from Figure 4, the weight on the domestic equity increase as p goes up but the increase in the mean domestic weight is much less. When $p = 0.8$, the mean goes up to the average weight of 0.6, close to the average level among European countries in the euro area. Even with the level of real exchange rate volatility *lower than that a country in the eurozone effectively faces*, a high portfolio stickiness can generate home bias in equities, 0.58 weight on domestic equities, when both equities returns are independent of income shocks.

In the model, agents adjust their holdings less frequently, and hence their portfolio holdings can drift away from their optimal holdings more as p goes up. With a high level of exchange rate volatility, their foreign equity holdings drift away more from the optimal than when holding domestic equities. Hence, the agent ex-ante lowers her demand for foreign equities. The deviation would be larger as the portfolio stickiness goes up, and as the exchange rate volatility is higher; therefore, the weight on foreign equities is much lower with higher exchange rate volatility and with higher portfolio stickiness.

6.2 Case 2: $\rho_{R^d,\epsilon^y} = 0$, $\rho_{R^f,\epsilon^y} = 0.4$

The second case that we examine is when the income shock is positively correlated with the foreign equity returns but uncorrelated with domestic equity returns. Hence, the investor has a stronger demand for domestic equities for a given probability of inaction. Not only is additional volatility is coming from the real exchange rate changes but also domestic income is positively correlated with the foreign stock returns; therefore, holding foreign equities poses another "risk" to the domestic investor. The magnitude of a change in the mean weight due to a change in correlation structure is small. Nonetheless, compared to the results in Case 1, given a value of p, the weight on the domestic equities has increased due to a positive correlation between income and foreign equities.

The pattern that the distribution of the weight on the domestic equities shifts to the right also persists in Figure 5 when there is an increase in p. When the probability is between 0.6 and 0.8, the weight on domestic equities under *high exchange rate volatility*, calibrated to match the one faced by non-eurozone countries, is aligned with the average weight on the domestic equities among non-eurozone countries in Europe. When the real exchange rate volatility is hypothetically *low*, set to match those between the pairs in the eurozone, the equilibrium allocation is not affected as much as those with high real exchange rate volatility when p goes up, evident from Figure 6 and the table below. Nonetheless, as p gets closer to 0.8, the mean weight on domestic equities increases to the actual average weight that countries in the eurozone put on, around 0.58.

6.3 Case 3: $\rho_{R^d,\epsilon^y} = 0.4$, $\rho_{R^f,\epsilon^y} = 0$

We also examine when the income shock is positively correlated with domestic equity returns but not correlated with foreign stock returns. Compared to Case 1, the mean domestic weight - for a given value of p - falls due to a positive correlation between domestic equity returns and income shock. Even with this covariance structure, when the real exchange rate volatility is calibrated to $\sigma_{Non-Euro}$, an increase in the portfolio stickiness renders a higher weight on domestic equity. The mean weight goes up from 0.61 to 0.88 as p goes up from 0.2 to 0.8. The histograms in Figure 7 also show the same pattern that we have seen from the previous figures.

When the volatility is hypothetically *low*, equal to $\sigma_{BothEuro}$, as evident from Figure 8, the model cannot generate home bias in equities; an agent holds higher weight on foreign equities. Moreover, an increase in the probability shifts the distribution of weight on home equities to the left: the mean weight falls from 0.48 to 0.39 as p goes up from 0.2 to 0.8.

In this case where domestic equity returns are positively correlated with income shock but with low real exchange rate volatility, the domestic equities are risker to agents. Hence, when the real exchange rate volatility is not high enough, the agents will put lower weight on riskier domestic equities, i.e., "covariance effect" (covariance between income shocks and domestic equity returns) outweighs the "variance effect" of the real exchange rates. More so, as the portfolio stickiness goes up, the agents will put even less weight on domestic equities. In our model with infrequent trading, portfolio holdings can deviate away from the optimal holdings that they would chose if they were adjusting their portfolios every period. The very deviation is larger when *the risk of asset returns* goes up, and agents take this account ex-ante when they decide how much to invest in domestic and foreign equities. Higher p effectively increases the aversion to risk, and with this covariance structure and a low level of real exchange rate volatility, investors therefore hold less of domestic equities as p goes up. The real exchange rate volatility is too low to generate a higher weight on the domestic equities.[33]

Under a hypothetical *low* exchange rate volatility across different cases, we observe that with a high probability of inaction around 0.8, it is close to the mean weight of 0.58 in Case 1 and Case 2. However, under Case 3, when p goes up, the weight on the domestic equities falls as the covariance of income shocks and domestic equity returns dominates the risk from the exchange rate returns. The hypothetical real exchange rate volatility – the average of the real exchange rate volatility among the pairs in the eurozone – is too low to generate a high weight on domestic equities. We use the

[33] A similar pattern is observed with slightly lower correlation of 0.2 between domestic equity returns and income shocks.

calibrated the real exchange rate volatility of those countries in the eurozone (σ_{Euro}), computed as the average of the real effective exchange rate volatility, when at least one country of a pair is using the euro (but the other country of a pair may or may not be in the euro area) and simulate the optimal portfolio weight again.

6.4 With Real Effective Exchange Rate Volatility of Countries in Euro Area

With $\sigma_{Euro} = 0.047$, the model is solved holding every other parameter values the same as those of the baseline. Figures 9, 10 and 11 are when $\rho_{R^d,\epsilon^y} = 0, \rho_{R^f,\epsilon^y} = 0$, when $\rho_{R^d,\epsilon^y} = 0, \rho_{R^f,\epsilon^y} = 0.4$, and when $\rho_{R^d,\epsilon^y} = 0.4, \rho_{R^f,\epsilon^y} = 0$, respectively.

Evident from the figures, with real exchange rate volatility calibrated to match that countries in the euro area effectively face, the mean weight on the domestic equities has gone up to 0.5467 and 0.6187 as p increases to 0.6 and 0.8 respectively, when labor income shocks are uncorrelated with equity returns. Also, when domestic stock returns are positively correlated with income shock, the mean values are slightly higher, 0.5472 and 0.6196 with $p = 0.6$ and 0.8 respectively. It matches the weight on domestic equities among euro adopted countries, around 0.58, when p is between 0.6 and 0.8.

Moreover, the results from Case 3 shown in Figure 11, when the domestic returns are positively correlated with domestic income shocks, also shows that the weight on domestic equities has also gone up to 0.522 and 0.6166 as p increases to 0.6 and 0.8 respectively. This result is drastically different from the one in Figure 8 when a high stickiness in the portfolio has resulted the mean weight around 0.34. When the real exchange rate volatility is calibrated to reflect the effective real exchange rate risk that investors in the eurozone face, equal to 4.7%, indeed the “variance effect" outweighs the “covariance effect". The mean weight on domestic equity with p between 0.6 to 0.8 matches with the average weight of around 0.58 on domestic equities among the countries in the eurozone.

Hence, with a level of portfolio stickiness that’s implied by p between 0.6 and 0.8, the model is able to match quantitatively the mean weights on domestic equities for the two groups of countries – countries in eurozone and outside eurozone.

7 Conclusion

This paper has documented that a country’s weight on domestic equities is higher for countries who have not adopted the euro. The adoption of the euro has greatly lowered real effective exchange rate volatility for countries in the eurozone, changing the geography of portfolio equity holdings between countries. We find empirically that the adoption of euro has lowered the level of home bias and the weight on domestic equities. Moreover, using the bilateral equity holdings data from the CPIS, when a pair of countries both use the euro, one tends to invest more in each other's equity. We find that the countries outside the eurozone on average have weight on domestic equities around 0.8 higher than those in the eurozone. Even if the countries in the eurozone have lower measures, they still exhibit a substantial degree of home bias in equities with the weight on domestic equities around 0.58.

Based on the empirical evidence, we then set up a model with infrequent trading, to see if our model can generate the weight on domestic equities across the two groups. In the model with infrequent trading, since an investor on average holds on to her portfolio holdings for a longer duration, with volatile real exchange rate returns, her foreign equity holdings are likely to deviate more from the optimal than domestic equity holdings. The agent, taking this account ex-ante, lowers her demand for foreign equities. The deviation is more pronounced when the exchange rate volatility is higher, and therefore the weight on foreign equities is much lower with higher exchange rate volatility. When there is *no* stickiness in the portfolio allocation, a level of real exchange rate volatility consistent the data cannot generate a disproportionately high portfolio weight on the domestic equities. With calibrated parameter values and portfolio stickiness, the model is able to generate home bias in equities even when domestic equity returns are positively correlated with labor income shock. Further, the model with infrequent portfolio adjustment, where probability of adjustment is between 0.6 and 0.8, quantitatively matches the average levels of the weight on the domestic equities, 0.6 for those in the euro area and 0.58 for those outside the euro area, when the average levels of real exchange rate volatility are calibrated accordingly. The mechanism that we show through the model offers a new perspective on the home bias puzzle and able to explain both qualitative and quantitative dimension of the equity home bias.

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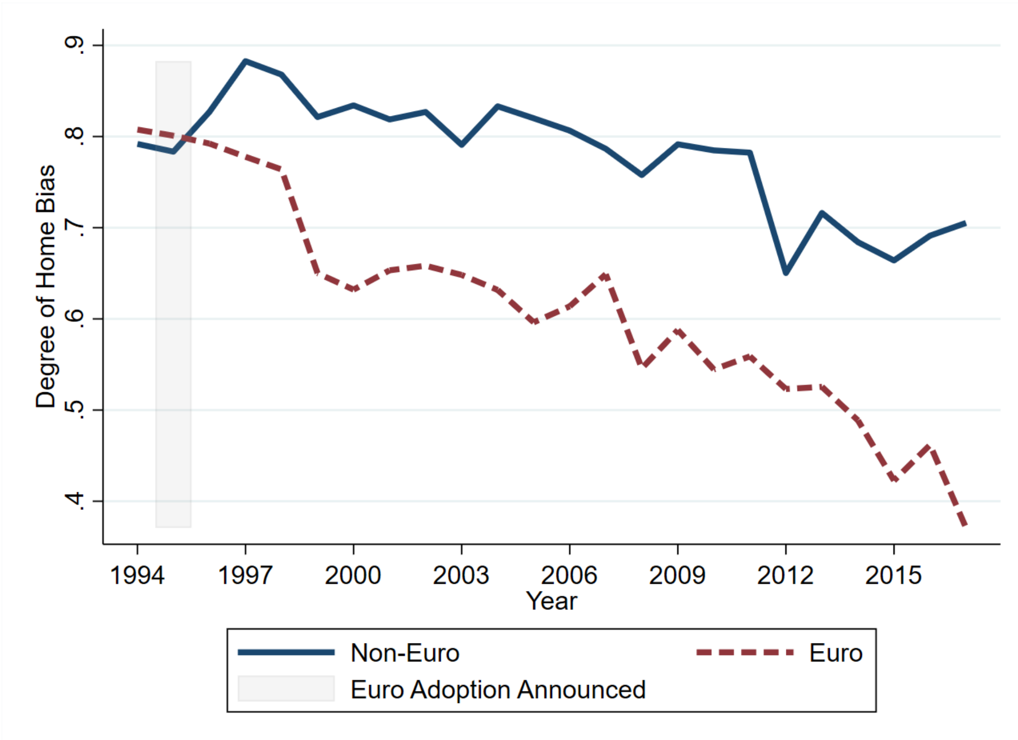
Figures

Figure 1: Home bias in Equities in 1994-2017



Notes: This figure shows the average levels of home bias for the two groups of countries in the European Union and Switzerland. Before 1999, countries who adopted the euro in 1999 are in the group *Euro* and the rest in the group *Non-Euro*. After 1999, two groups of countries are based on their currency at a given point of time. The euro adoption was announced in 1995, and the euro was first introduced in 1999. Home-bias for each country at year t is computed with the below formulae:

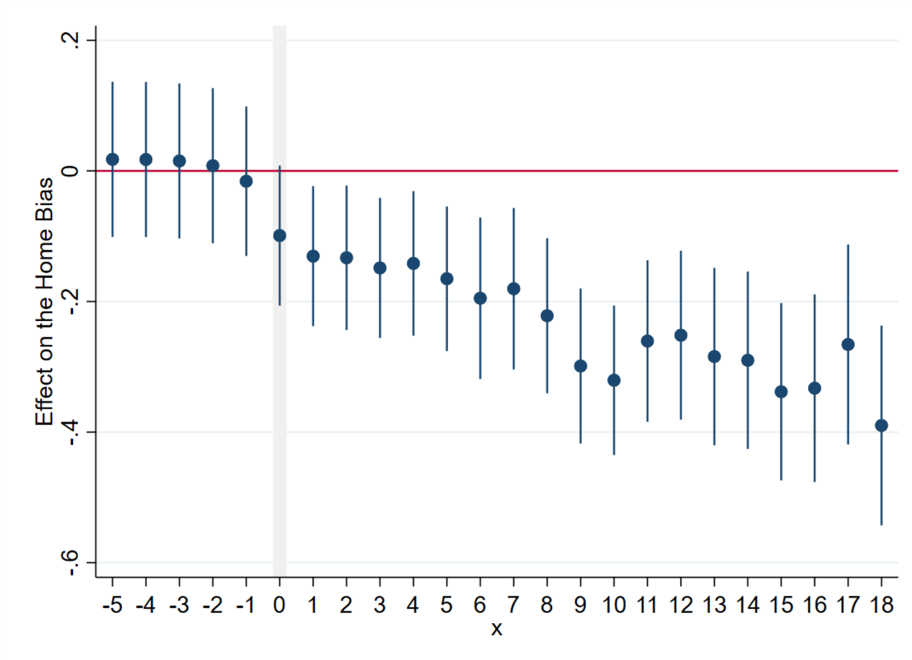
$$\text{Home Bias}_{i,t} = 1 - \frac{\text{ACT}_{i,t}}{\text{OPT}_{i,t}}$$

$$\text{ACT}_{i,t} = \frac{\text{Foreign Equity Asset}_{i,t}}{\text{Foreign Equity Asset}_{i,t} + \text{Market Capitalization}_{i,t} - \text{Foreign Equity Liability}_{i,t}}$$

$$\text{OPT}_{i,t} = 1 - \frac{\text{Market Capitalization}_{i,t}}{\text{World Market Capitalization}_{t}}$$

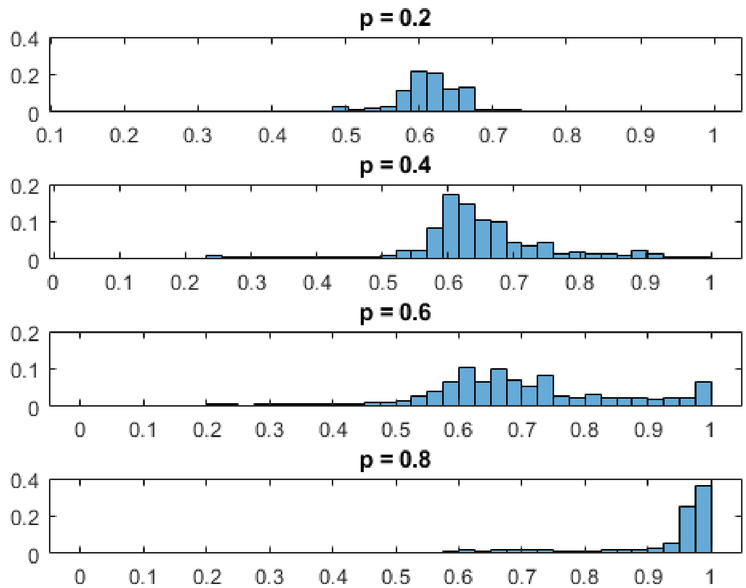
$\text{ACT}_{i,t}$ denotes the actual share of foreign equities in country i's equity holdings and hence, the weight on domestic equities is $1 - \text{ACT}_{i,t}$. $\text{OPT}_{i,t}$ is the optimal share of foreign equities in country i's equity holdings under the ICAPM framework. The data are from the IMF, Lane and Milesi-Ferretti (2007) and the WDI.

Figure 2: Event Analysis: Treatment Effect of the Euro on Home Bias in Equities



Notes: This figure shows the estimated β coefficients of $y_{it} = \alpha + \sum_{x=-5}^{18} \beta_x D_{x,t}^i + \epsilon_{it}$, where y_{it} = Home Bias in Equity$_{it}$. $D_{x,t}^i$ is equal to one in year t when a country i has adopted the euro at year $t - x$. Hence, in the year t, when a country i adopted the euro, $D_{0,t}^i = 1$. The dots show the point estimates and the bars show 95% confidence interval.

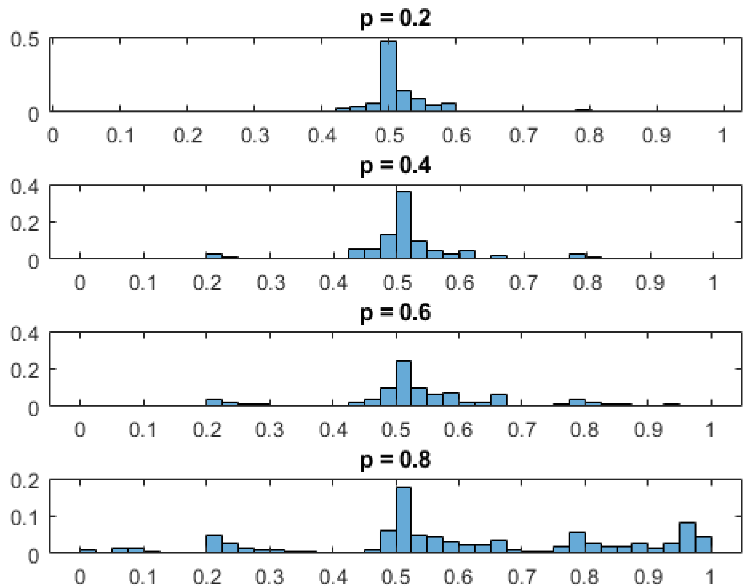
Figure 3: Weight on Home Equities: $\rho_{R^d,\epsilon^y} = 0$, $\rho_{R^f,\epsilon^y} = 0$, $\sigma_{Non-Euro}$



Portfolio Stickiness	$p = 0.2$	$p = 0.4$	$p = 0.6$	$p = 0.8$
Mean Weight	0.6141	0.6399	0.686	0.8804

Notes: This figure shows the simulated distribution of weight on domestic equity for different p, the probability of not adjusting her portfolio every period. The y-axis of the subfigures represents the fraction. The table shows the mean weight on domestic equity for each p. In this case, the correlation between domestic equity returns and income shocks is 0, and that between foreign equity returns and income shocks is 0. The volatility of exchange rate returns is calibrated to $\sigma_{Non-Euro}$.

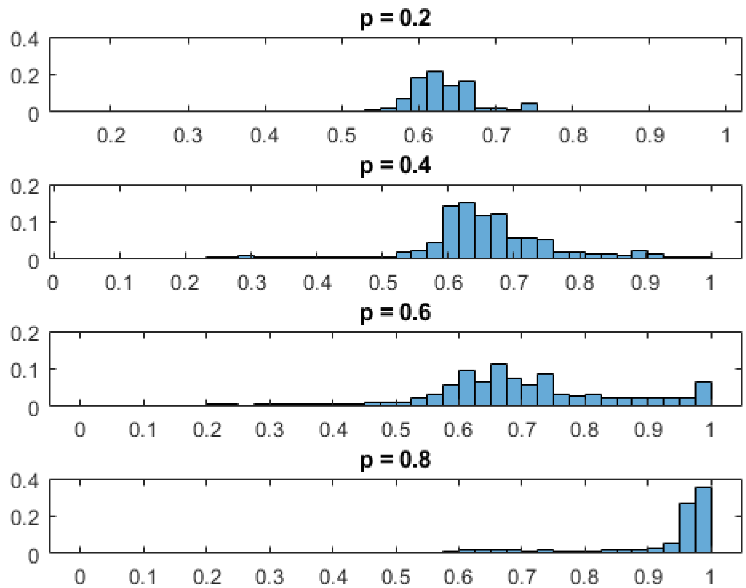
Figure 4: Weight on Home Equities: $\rho_{R^d,\epsilon^y} = 0$, $\rho_{R^f,\epsilon^y} = 0$, $\sigma_{BothEuro}$



Portfolio Stickiness	$p = 0.2$	$p = 0.4$	$p = 0.6$	$p = 0.8$
Mean Weight	0.5123	0.5135	0.5328	0.6012

Notes: This figure shows the simulated distribution of weight on domestic equity for different p, the probability of not adjusting her portfolio every period. The y-axis of the subfigures represents the fraction. The table shows the mean weight on domestic equity for each p. In this case, the correlation between domestic equity returns and income shocks is 0, and that between foreign equity returns and income shocks is 0. The volatility of exchange rate returns is calibrated to $\sigma_{BothEuro}$.

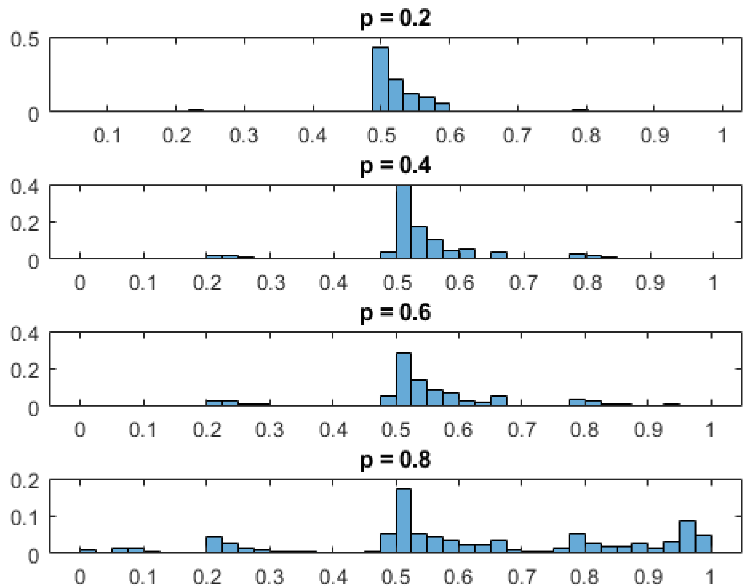
Figure 5: Weight on Home Equities: $\rho_{R^d,\epsilon^y} = 0$, $\rho_{R^f,\epsilon^y} = 0.4$, $\sigma_{Non-Euro}$



Portfolio Stickiness	$p = 0.2$	$p = 0.4$	$p = 0.6$	$p = 0.8$
Mean Weight	0.6315	0.6503	0.6907	0.8806

Notes: This figure shows the simulated distribution of weight on domestic equity for different p, the probability of not adjusting her portfolio every period. The y-axis of the subfigures represents the fraction. The table shows the mean weight on domestic equity for each p. In this case, the correlation between domestic equity returns and income shocks is 0, and that between foreign equity returns and income shocks is 0.4. The volatility of exchange rate returns is calibrated to $\sigma_{Non-Euro}$.

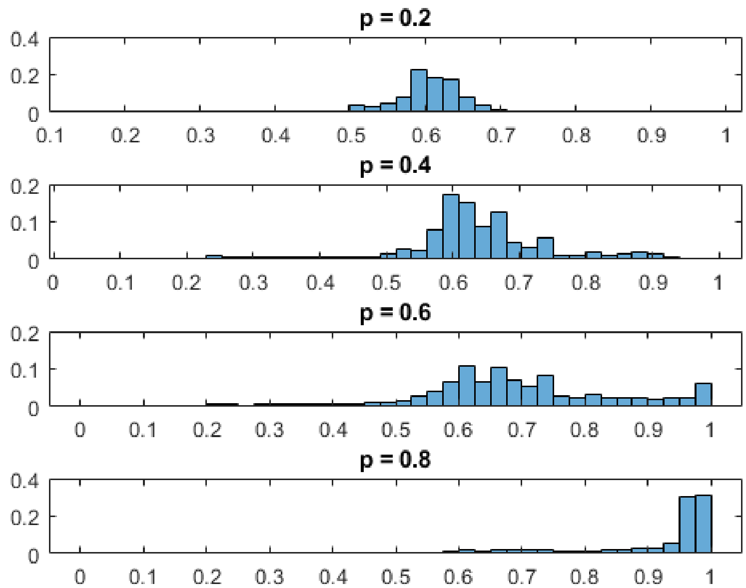
Figure 6: Weight on Home Equities: $\rho_{R^d,\epsilon^y} = 0$, $\rho_{R^f,\epsilon^y} = 0.4$, $\sigma_{BothEuro}$



Portfolio Stickiness	$p = 0.2$	$p = 0.4$	$p = 0.6$	$p = 0.8$
Mean Weight	0.5178	0.5322	0.5419	0.6081

Notes: This figure shows the simulated distribution of weight on domestic equity for different p, the probability of not adjusting her portfolio every period. The y-axis of the subfigures represents the fraction. The table shows the mean weight on domestic equity for each p. In this case, the correlation between domestic equity returns and income shocks is 0, and that between foreign equity returns and income shocks is 0.4. The volatility of exchange rate returns is calibrated to $\sigma_{BothEuro}$.

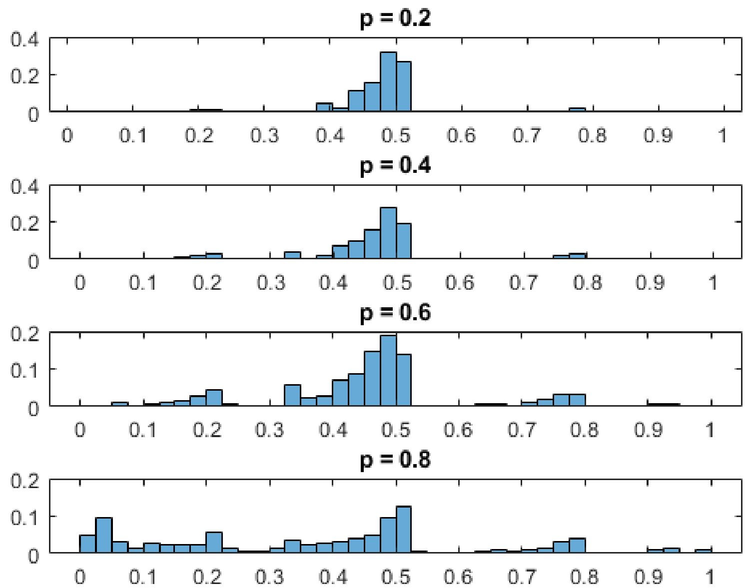
Figure 7: Weight on Home Equities: $\rho_{R^d,\epsilon^y} = 0.4$, $\rho_{R^f,\epsilon^y} = 0$, $\sigma_{Non-Euro}$



Portfolio Stickiness	$p = 0.2$	$p = 0.4$	$p = 0.6$	$p = 0.8$
Mean Weight	0.607	0.6287	0.6846	0.8791

Notes: This figure shows the simulated distribution of weight on domestic equity for different p, the probability of not adjusting her portfolio every period. The y-axis of the subfigures represents the fraction. The table shows the mean weight on domestic equity for each p. In this case, the correlation between domestic equity returns and income shocks is 0.4, and that between foreign equity returns and income shocks is 0. The volatility of exchange rate returns is calibrated to $\sigma_{Non-Euro}$.

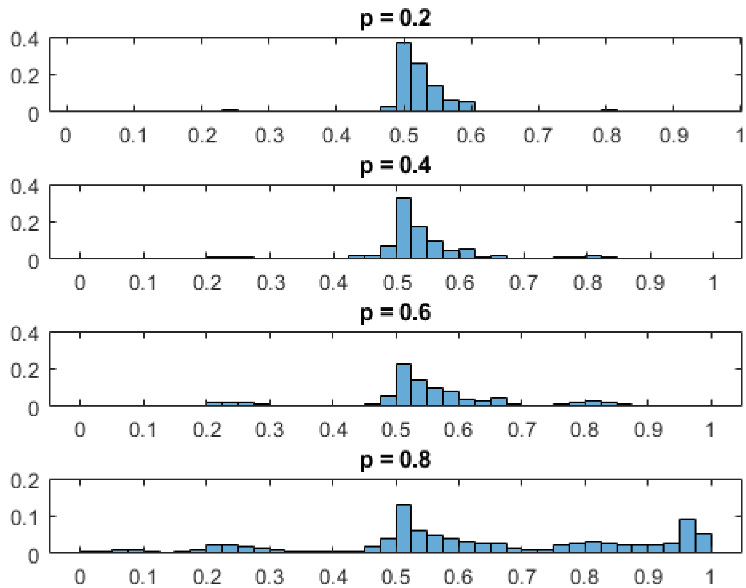
Figure 8: Weight on Home Equities: $\rho_{R^d,\epsilon^y} = 0.4$, $\rho_{R^f,\epsilon^y} = 0$, $\sigma_{BothEuro}$



Portfolio Stickiness	$p = 0.2$	$p = 0.4$	$p = 0.6$	$p = 0.8$
Mean Weight	0.4759	0.4673	0.4628	0.3874

Notes: This figure shows the simulated distribution of weight on domestic equity for different p, the probability of not adjusting her portfolio every period. The y-axis of the subfigures represents the fraction. The table shows the mean weight on domestic equity for each p. In this case, the correlation between domestic equity returns and income shocks is 0.4, and that between foreign equity returns and income shocks is 0. The volatility of exchange rate returns is calibrated to $\sigma_{BothEuro}$.

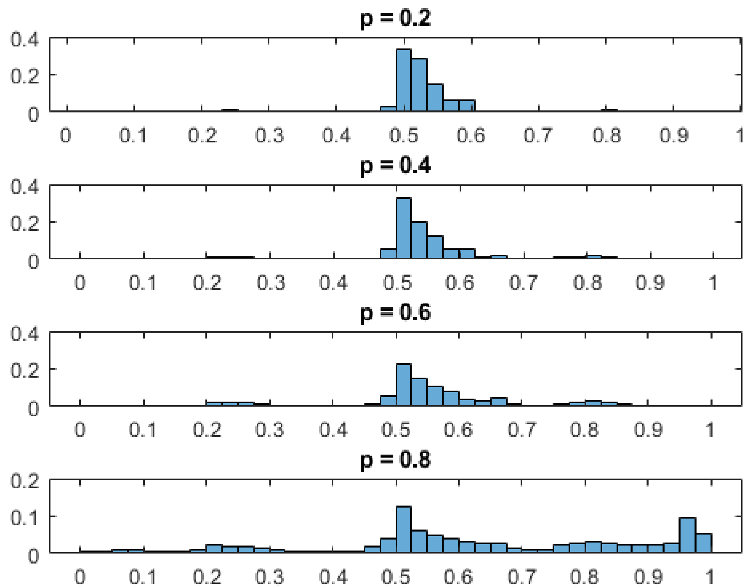
Figure 9: Weight on Home Equities: $\rho_{R^d,\epsilon^y} = 0$, $\rho_{R^f,\epsilon^y} = 0$, σ_{Euro}



Portfolio Stickiness	$p = 0.2$	$p = 0.4$	$p = 0.6$	$p = 0.8$
Mean Weight	0.5252	0.5265	0.5467	0.6187

Notes: This figure shows the simulated distribution of weight on domestic equity for different p, the probability of not adjusting her portfolio every period. The y-axis of the subfigures represents the fraction. The table shows the mean weight on domestic equity for each p. In this case, the correlation between domestic equity returns and income shocks is 0, and that between foreign equity returns and income shocks is 0. The volatility of exchange rate returns is calibrated to σ_{Euro}.

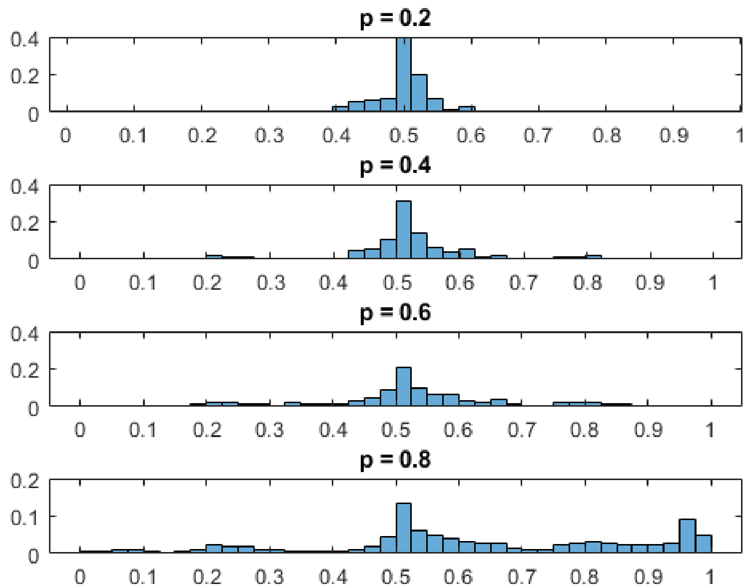
Figure 10: Weight on Home Equities: $\rho_{R^d,\epsilon^y} = 0$, $\rho_{R^f,\epsilon^y} = 0.4$, σ_{Euro}



Portfolio Stickiness	$p = 0.2$	$p = 0.4$	$p = 0.6$	$p = 0.8$
Mean Weight	0.5265	0.5344	0.5472	0.6196

Notes: This figure shows the simulated distribution of weight on domestic equity for different p, the probability of not adjusting her portfolio every period. The y-axis of the subfigures represents the fraction. The table shows the mean weight on domestic equity for each p. In this case, the correlation between domestic equity returns and income shocks is 0, and that between foreign equity returns and income shocks is 0.4. The volatility of exchange rate returns is calibrated to σ_{Euro}.

Figure 11: Weight on Home Equities: $\rho_{R^d,\epsilon^y} = 0.4$, $\rho_{R^f,\epsilon^y} = 0$, σ_{Euro}



Portfolio Stickiness	$p = 0.2$	$p = 0.4$	$p = 0.6$	$p = 0.8$
Mean Weight	0.5018	0.517	0.522	0.6166

Notes: This figure shows the simulated distribution of weight on domestic equity for different p, the probability of not adjusting her portfolio every period. The y-axis of the subfigures represents the fraction. The table shows the mean weight on domestic equity for each p. In this case, the correlation between domestic equity returns and income shocks is 0.4, and that between foreign equity returns and income shocks is 0. The volatility of exchange rate returns is calibrated to σ_{Euro}.

Tables

Empirical Analysis

Table 1: Effect of Euro on Home Bias

	HB		DW	
	(1)	(2)	(3)	(4)
Euro	-0.196***	-0.154***	-0.194***	-0.155***
	(0.02)	(0.03)	(0.02)	(0.02)
Constant	0.802***	0.903***	0.806***	0.877***
	(0.05)	(0.18)	(0.05)	(0.18)
Observations	424	368	424	368
Year FE	Yes	Yes	Yes	Yes
Other Controls	No	Yes	No	Yes

This table reports the regression results of $Y_{it} = \beta_0 + \beta_1 \text{Euro}_{it} + \zeta' X_{it} + \alpha_t + \epsilon_{it}$, where Y_{it} is the home bias in equity (HB) or the weight on domestic equity (DW). Euro_{it} is a dummy variable that is equal to one when a country i has adopted the euro at year t. The dependent variable of Columns (1) and (2) is the home bias in equity. The dependent variable of Columns (3) and (4) is the weight on domestic equity. Other controls include the size of the economy (log of real GDP), trade openness (total imports and exports as a ratio of GDP) and de jure capital control index. Standard errors are in parentheses.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 2: First-stage: Effect of Euro on REER Volatility

	$\sigma_{contemp}$ (1)	σ_{five} (2)	σ_{GARCH} (3)
Euro	-0.607***	-0.578***	-0.629***
	(0.05)	(0.09)	(0.04)
Observations	424	347	424
Year FE	Yes	Yes	Yes

This table reports the first-stage regression of $\sigma_{it} = \gamma_0 + \gamma_1 \text{Euro}_{it} + \Gamma_t + u_{it}$. We use three different measures of σ_{it} (%). $\sigma_{it,contemp}$ is the standard deviation of monthly real effective exchange rate (REER) returns in year t, $\sigma_{it,five}$ is the standard deviation of monthly REER returns in the past five years, and $\sigma_{it,GARCH}$ is the conditional volatility of monthly REER returns, estimated with GARCH(2,2). Euro$_{it}$ is a dummy variable that is equal to one when a country i has adopted the euro at year t. Columns (1), (2) and (3) shows the results of the first-stage regressions, when the dependent variables are measures of real exchange rate volatilities: $\sigma_{it,contemp}$, $\sigma_{it,five}$ and $\sigma_{it,GARCH}$, respectively. Standard errors are in parentheses.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 3: Second-stage: Effect of Euro on Home Bias via REER volatility

	HB	DW	HB	DW	HB	DW
	(1)	(2)	(3)	(4)	(5)	(6)
$\hat{\sigma}_{it}$	0.254***	0.255***	0.266***	0.268***	0.245***	0.246***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
$\hat{\sigma}_{it}$:	$\hat{\sigma}_{it,contemp}$		$\hat{\sigma}_{it,five}$		$\hat{\sigma}_{it,GARCH}$	
Observations	368	368	368	368	368	368
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Other Controls	Yes	Yes	Yes	Yes	Yes	Yes

This table reports the second-stage regression of $Y_{it} = \theta_0 + \theta_1\hat{\sigma}_{it} + \Theta' X_{it} + \Omega_t + \nu_{it}$, where Y_{it} is the home bias in equity (HB) or the weight on domestic equity (DW). $\hat{\sigma}_{it}$ (%) is from the predicted value of the real effective exchange rate volatility from the first-stage regression. The dependent variable of Columns (1), (3) and (5) is the home bias in equity. The dependent variable of Columns (2), (4) and (6) is the weight on domestic equity. The predicted values of $\sigma_{it,contemp}$ are employed in Columns (1) and (2); the predicted values of $\sigma_{it,five}$ are employed in Columns (3) and (4); and the predicted values of $\sigma_{it,GARCH}$ are employed in (5) and (6). Other controls include the size of the economy (log of real GDP), trade openness (total imports and exports as a ratio of GDP) and de jure capital control index. Standard errors are in parentheses.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 4: Effect of Euro Pair on Bilateral FPI

	(1)	(2)	(3)	(4)
Euro Pair	1.400***	0.878***	0.804***	0.757***
	(0.07)	(0.06)	(0.06)	(0.06)
Cross Product of ln(RGDP)			2.770***	3.227***
			(0.18)	(0.20)
Bilateral Trade				9.847***
				(0.52)
Cross Product of Capital Control				-0.668*
				(0.38)
Observations	10,444	10,444	10,444	7,555
Country FE	No	Yes	Yes	Yes
Year FE	No	Yes	Yes	Yes

This table reports the regression of

$$\ln(\text{Real FPI in Equty})_{ijt} = \beta_0 + \beta_1 \text{Euro Pair}_{ijt} + \beta_2 \text{ln(RGDP)}_{it}\text{ln(RGDP)}_{jt}$$
$$+ \beta_3 \frac{\text{Import}_{ijt} + \text{Export}_{ijt}}{\text{GDP}_{it}} + \beta_4 \text{Capital Control}_{it}\text{Capital Control}_{jt} + \alpha_i + \alpha_j + \alpha_t + \epsilon_{ijt}$$

The dependent variable is the log of the bilateral real foreign portfolio equity investment: country i's investment in country j's equity. The independent variables are the cross product of countries' log of real GDP; bilateral trade, country i's exports to and imports from country j (as a ratio of country i's GDP); and the cross product of measures of capital controls on equity flows. Standard errors are in parentheses.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 5: First-stage: Effect of Euro Pair on Bilateral RER Volatility

	$\sigma_{ij,contemp}$ (1)	$\sigma_{ij,five}$ (2)
Euro Pair	-0.400***	-0.407***
	(0.02)	(0.03)
Observations	12,544	12,544
Country FE	Yes	Yes
Year FE	Yes	Yes

This table reports the first-stage regression of $\sigma_{ijt} = \gamma_0 + \gamma_1 \text{Euro Pair}_{ijt} + \Gamma_i + \Gamma_j + \Gamma_t + u_{ijt}$. σ_{ijt} (%) is the bilateral real exchange rate volatility. We employ two different measures of the bilateral RER volatility, $\sigma_{ij,contemp}$ and $\sigma_{ij,five}$, as dependent variables for for Columns (1) and (2), respectively. $\sigma_{ij,contemp}$ is the standard deviation of monthly real exchange rate (RER) returns in year t, $\sigma_{ij,five}$ is the standard deviation of monthly RER returns in the past five years. Euro Pair is equal to one when both countries use the euro. Standard errors are in parentheses.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 6: Second-stage: Effect of Euro on Bilateral Equity Holdings via RER volatility

	(1)	(2)	(3)	(4)
$\hat{\sigma_{ij}}$	-2.197***	-1.894***	-2.158***	-1.861***
	(0.14)	(0.16)	(0.14)	(0.15)
$\hat{\sigma_{ij}}$:	$\hat{\sigma}_{ij,contemp}$		$\hat{\sigma}_{ij,five}$	
Observations	10,444	7,555	10,444	7,555
Country FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Other Controls	No	Yes	No	Yes

This table reports the first-stage regression of $\ln(\text{Real FPI in Equty})_{ijt} = \theta_0 + \theta_1 \hat{\sigma}_{ijt} + \Theta' X_{ijt} + \Omega_i + \Omega_j + \Omega_t + \nu_{ijt}$. The dependent variable is the log of the bilateral real foreign portfolio equity investment – country i's investment in country j's equity. The predicted values of $\sigma_{ij,contemp}$ and $\sigma_{ij,five}$ from the first-stage regressions are used as regressors (%): $\hat{\sigma}_{ij,contemp}$ for Columns (1) and (2), and $\hat{\sigma}_{ij,five}$ for Columns (3) and (4). Other controls include the cross product of countries' log of real GDP; bilateral trade, country i's exports to and imports from country j (as a ratio of country i's GDP); and the cross product of measures of capital controls on equity flows. Standard errors are in parentheses.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 7: Calibrated Parameter Values

Parameter	**Value**	**Data Source**
Pre-determined		
ρ	2.0	Standard
β	0.989	Standard
Estimated		
σ_Y	0.03	OECD National Accounts
ρ_Y	0.8	OECD National Accounts
$\bar{R}^D = \bar{R}^F$	0.06	Bloomberg: Benchmark Equity Indices
$\sigma_D = \sigma_F$	0.3	Bloomberg: Benchmark Equity Indices
$\rho_D = \rho_F$	0	Bloomberg: Benchmark Equity Indices
ρ_{R^D,R^F}	0.7	Bloomberg: Benchmark Equity Indices
$\sigma_{High,Non-Euro}$	0.146	BIS
$\sigma_{Low,BothEuro}$	0.013	BIS
σ_{Euro}	0.047	BIS
$\rho_e = 0$	0	BIS
$\rho_{\epsilon^e,\cdot}$	0	BIS
Different Cases		
ρ_{R^D,ϵ^y}	0, 0.4	Different Values for Each Case
ρ_{R^F,ϵ^y}	0, 0.4	Different Values for Each Case

A Appendix

A.1 List of Countries

Table 8: Countries in Sample

Austria	Estonia	Italy	Portugal
Belgium	Finland	Latvia	Romania
Bulgaria	France	Lithuania	Slovak Republic
Croatia	Germany	Luxembourg	Slovenia
Cyprus	Greece	Malta	Spain
Czech Republic	Hungary	Netherlands	Sweden
Denmark	Ireland	Poland	Switzerland
			United Kingdom

The table shows the list of sample countries in European Union and Switzerland we used for our anlaysis. We include the United States and Japan in the sample, when calibrating equity return processes and exchange rate volatility.

A.2 Calibration

Table 9: Labor Income: Total Employee Compensation

Country	Start Year	Country	Start Year
Austria	1995	Latvia	1995
Belgium	1995	Lithuania	1995
Bulgaria	Missing	Luxembourg	1995
Croatia	Missing	Malta	Missing
Cyprus	Missing	Netherlands	1995
Czech	1995	Poland	1999
Denmark	1995	Portugal	1995
Estonia	1995	Romania	Missing
Finland	1990	Slovak	1995
France	1980	Slovenia	1995
Germany	1991	Spain	1995
Greece	1995	Sweden	1993
Hungary	1995	Switzerland	1990
Ireland	1995	United Kingdom	1955
Italy	1995		

This table summarizes the total employee compensation data that we have employed to calibrate the income process in Section 5. The column, *Start Year*, shows the first year in which the data are available.

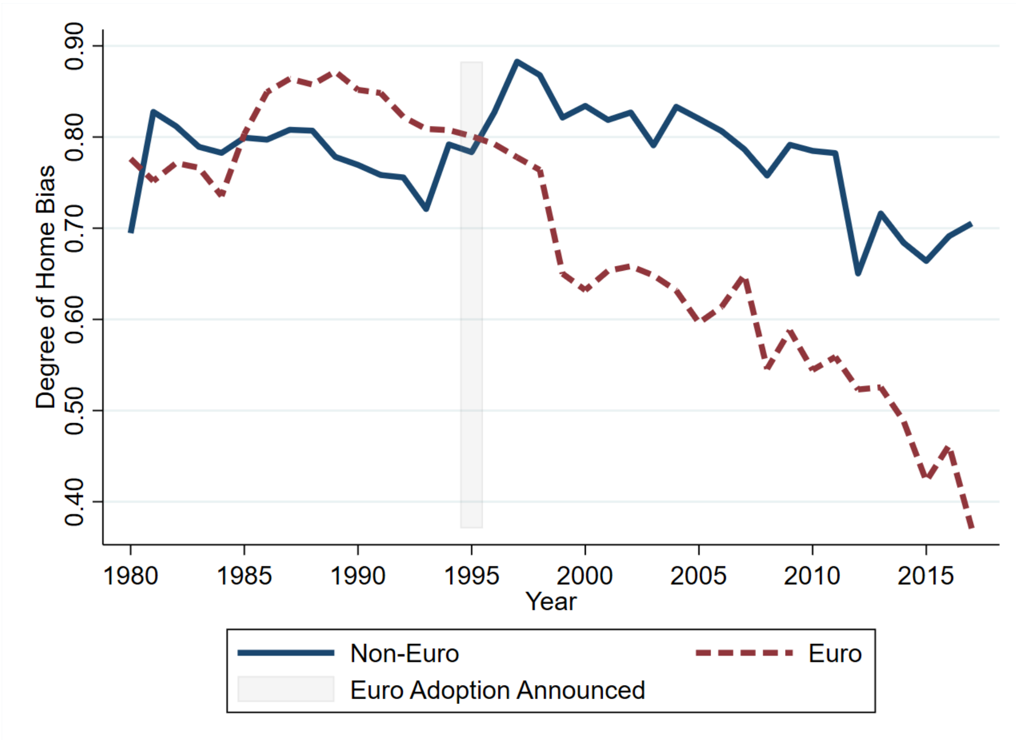
Table 10: Stock Market Indices

Country	Stock Index	Start Year	Country	Stock Index	Start Year
Austria	ATX Idex	1986	Latvia	RIGSE Index	2000
Belgium	BEL20 Index	1990	Lithuania	VILSE Index	2000
Bulgaria	SOFIX Index	2000	Luxembourg	LUXXX Index	1999
Croatia	CRO Index	2002	Malta	MALTEX Index	1995
Cyprus	CYSMMAPA Index	2004	Netherlands	AEX Index	1983
Czech	PX Index	1994	Poland	WIG Index	1991
Denmark	KFX Index	1989	Portugal	PSI20 Index	1992
Estonia	TALSE Index	1996	Romania	BET Index	1997
Finland	HEX25 Index	1988	Slovak	SKSM Index	1993
France	CAC Index	1987	Slovenia	SBITOP Index	2003
Germany	DAX Index	1959	Spain	IBEX Index	1987
Greece	ASE Index	1987	Sweden	SAX Index	1980
Hungary	BUX Index	1991	Switzerland	SMI Index	1988
Ireland	ISEQ Index	1983	UK	UKX Index	1983
Italy	FTSEMIB Index	1997	USA	SPX Index	1927
Japan	NKY Index	1970			

This table summarizes the benchmark stock indices that we have employed to calibrate the equity returns in Section 5. The column, *Start Year*, shows the first year in which the price data of each index are available.

A.3 Additional Figures

Figure 12: Home bias in Equities in 1980-2017



Note: This figure shows the average levels of home bias for the two groups of countries in the European Union and Switzerland. Before 1999, countries who adopted the euro in 1999 are in the group *Euro* and the rest in the group *Non-Euro*. After 1999, two groups of countries are based on their currency at a given point of time. The euro adoption was announced in 1995, and the euro was first introduced in 1999. Home-bias for each country at year t is computed with the below formulae:

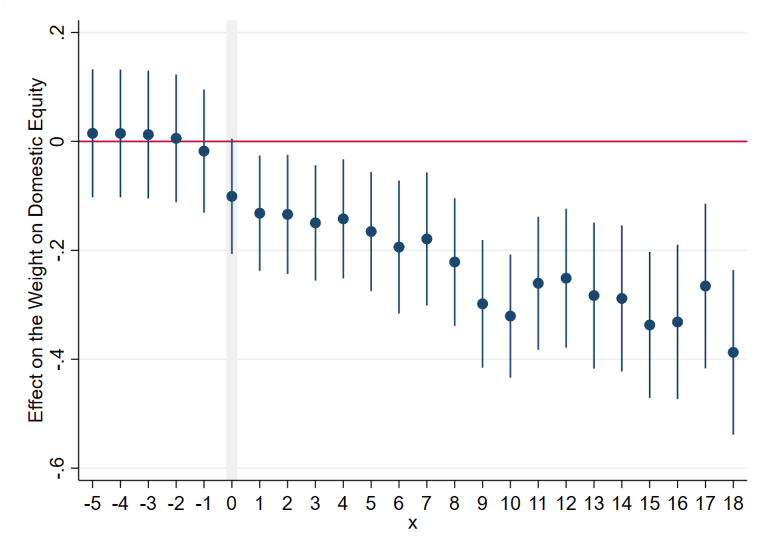
$$\text{Home Bias}_{i,t} = 1 - \frac{\text{ACT}_{i,t}}{\text{OPT}_{i,t}}$$

$$\text{ACT}_{i,t} = \frac{\text{Foreign Equity Asset}_{i,t}}{\text{Foreign Equity Asset}_{i,t} + \text{Market Capitalization}_{i,t} - \text{Foreign Equity Liability}_{i,t}}$$

$$\text{OPT}_{i,t} = 1 - \frac{\text{Market Capitalization}_{i,t}}{\text{World Market Capitalization}_{t}}$$

$\text{ACT}_{i,t}$ denotes the actual share of foreign equities in country i's equity holdings and hence, the weight on domestic equities is $1 - \text{ACT}_{i,t}$. $\text{OPT}_{i,t}$ is the optimal share of foreign equities in country i's equity holdings under the ICAPM framework. The data are from the IMF, Lane and Milesi-Ferretti (2007) and the WDI.

Figure 13: Event Analysis: Treatment Effect of the Euro on Weight on Domestic Equity



This figure shows the estimated β coefficients of $y_{it} = \alpha + \sum_{x=-5}^{18} \beta_x D^i_{x,t} + \epsilon_{it}$, where y_{it} = Weight on Domestic Equity$_{it}$. $D^i_{x,t}$ is equal to one in year t when a country i has adopted the euro at year $t - x$. Hence, in the year t, when a country i adopted the euro, $D^i_{0,t} = 1$. The dots show the point estimates and the bars show 95% confidence interval.

A.4 Additional Tables

Table 11 shows the estimates of the coefficients of other control variables of regression (2), reported in Columns (2) and (4) in Table 1.

Table 11: Effect of Euro on Home Bias: Coefficients of Control Variables

	HB (1)	DW (2)
Euro	-0.154***	-0.155***
	(0.03)	(0.02)
ln(RGDP)	-0.00260	-0.00137
	(0.01)	(0.01)
Trade Openness	-0.103***	-0.108***
	(0.03)	(0.03)
Capital Control	0.213***	0.206***
	(0.04)	(0.04)
Observations	368	368
Year FE	Yes	Yes

This table reports the regression results of $Y_{it} = \beta_0 + \beta_1 \text{Euro}_{it} + \zeta' X_{it} + \alpha_t + \epsilon_{it}$, where Y_{it} is the home bias in equity (HB) or the weight on domestic equity (DW). Euro_{it} is a dummy variable that is equal to one when a country i has adopted the euro at year t. The dependent variable of Columns (1) is the home bias in equity. The dependent variable of Columns (2) is the weight on domestic equity. The coefficients of control variables are also reported in this table. Columns (1) and (2) in this table correspond to Columns (2) and (4) in Table 1, respectively. Standard errors are in parentheses.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Tables 12 shows the estimates of the coefficients of other control variables of regression (4), reported in Table 3.

Table 12: Second-stage: Effect of Euro on Home Bias via REER volatility; Control Variables

	HB (1)	DW (2)	HB (3)	DW (4)	HB (5)	DW (6)
$\hat{\sigma}_{it}$	0.254***	0.255***	0.266***	0.268***	0.245***	0.246***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
ln(RGDP)	-0.00260	-0.00137	-0.00260	-0.00137	-0.00260	-0.00137
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Trade Openness	-0.103***	-0.108***	-0.103***	-0.108***	-0.103***	-0.108***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Capital Control	0.213***	0.206***	0.213***	0.206***	0.213***	0.206***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
$\hat{\sigma}_{it}$:	$\hat{\sigma}_{it,contemp}$		$\hat{\sigma}_{it,five}$		$\hat{\sigma}_{it,GARCH}$	
Observations	368	368	368	368	368	368
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

This table reports the second-stage regression of $Y_{it} = \theta_0 + \theta_1 \hat{\sigma}_{it} + \Theta' X_{it} + \Omega_t + \nu_{it}$, where Y_{it} is the home bias in equity (HB) or the weight on domestic equity (DW). $\hat{\sigma}_{it}$ is from the predicted value of the real effective exchange rate volatility from the first-stage regression. The dependent variable of Columns (1), (3) and (5) is the home bias in equity. The dependent variable of Columns (2), (4) and (6) is the weight on domestic equity. The predicted values of $\sigma_{it,contemp}$ are employed in Columns (1) and (2); the predicted values of $\sigma_{it,five}$ are employed in Columns (3) and (4); and the predicted values of $\sigma_{it,GARCH}$ are employed in (5) and (6). Other controls include the size of the economy (log of real GDP), trade openness – total imports and exports as a ratio of GDP, and de jure capital control index. Standard errors are in parentheses.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Tables 13 shows the estimates of the coefficients of other control variables of regression (7), reported in Columns (2) and (4) in Table 6.

Table 13: Second-stage: Effect of Euro on Bilateral Equity Holdings via RER volatility; Control Variables

	(1)	(2)
$\hat{\sigma_{ij}}$	-1.894***	-1.861***
	(0.16)	(0.15)
Cross Product of ln(RGDP)	3.227***	3.227***
	(0.20)	(0.20)
Bilateral Trade	9.847***	9.847***
	(0.52)	(0.52)
Cross Product of Capital Control	-0.668*	-0.668*
	(0.38)	(0.38)
$\hat{\sigma_{ij}}$	$\hat{\sigma}_{ijt,contemp}$	$\hat{\sigma}_{ijt,five}$
Observations	7555	7555
Country FE	Yes	Yes
Year FE	Yes	Yes

$\ln(\text{Real FPI in Equty})_{ijt} = \theta_0 + \theta_1 \hat{\sigma}_{ijt} + \Theta' X_{ijt} + \Omega_i + \Omega_j + \Omega_t + \nu_{ijt}$ The dependent variable is the log of the bilateral real foreign portfolio equity investment – country i's investment in country j's equity. The predicted values of $\sigma_{ij,contemp}$ and $\sigma_{ij,five}$ from the first-stage regressions are used as regressors: $\hat{\sigma}_{ij,contemp}$ for Columns (1) and (2), and $\hat{\sigma}_{ij,five}$ for Columns (3) and (4). Other controls include the cross product of countries' log of real GDP; bilateral trade, country i's exports to and imports from country j (as a ratio of country i's GDP); and the cross product of measures of capital controls on equity flows. Columns (1) and (2) correspond to Columns (2) and (4) in Table 6. Standard errors are in parentheses.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

A.5 Calibration of Exchange Rate Volatility

A.5.1 Calibration of $\sigma_{Non-Euro}$ and $\sigma_{BothEuro}$

We compute three different levels of average real exchange rate volatility between (i) the pairs when one of them is not in the eurozone, $\sigma_{Non-Euro}$ and (ii) the pairs when both are in the eurozone, $\sigma_{BothEuro}$.

1. Define the set of countries that use the euro every year: $C_{t,EURO}$.

2.1 Compute the bilateral real exchange rate volatility for pairs where a country i is outside the euro area: $\sigma_{Non-Euro}$.

$$\sigma_{ij,Non-Euro} = \sqrt{\text{Var}(\{\Delta RER_{ij,t} : i_t \notin C_{t,EURO}\})}$$

2.2 Then, calculate the mean value of the computed bilateral real exchange rate volatilities.

$$\sigma_{Non-Euro} = \frac{1}{N_1} \sum_{N_1} \sigma_{ij,Non-Euro}$$

3.1 First, compute the bilateral real exchange rate volatility for pairs, where both countries are in the euro area: $\sigma_{BothEuro}$

$$\sigma_{ij,BothEuro} = \sqrt{\text{Var}(\{\Delta RER_{ij,t} : i_t \in C_{t,EURO}, j_t \in C_{t,EURO}\})}$$

3.2 Then, calculate the mean value of the bilateral real exchange rate volatilities.

$$\sigma_{BothEuro} = \frac{1}{N_2} \sum_{N_2} \sigma_{ij,BothEuro}$$

A.5.2 Calibration of σ_{Euro}

Since our samples include many countries who adopted the euro in our sample period, the simple average might downward bias the estimate of σ_{Euro}. Hence, we compute the real effective exchange rate for each country i using the bilateral real exchange rate and one's portfolio share on the other country's equities, where the portfolio share is imputed from the IMF CPIS data. The data do not cover for periods earlier than 2001; so we assume that the weight is the same as that of

2001 for 1999 and 2000 weights for those countries who joined the euro area in 1999. We compute the real effective exchange rates for countries after they join the euro area.

$$\text{REER}_{i,t} = \sum_j \omega_{ij,t} * \text{RER}_{ij,t}$$

The real exchange rate for country pair i, j is computed with the nominal exchange rate and their CPIs. Then, we compute the real effective exchange rate volatility for each country i after they join the euro area. The cross-sectional mean of real effective exchange rate volatility for the countries in the euro area are then computed. We calibrate σ_{Euro} to 4.7%.