Do trade costs in goods market lead to home bias in equities?

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Abstract

I focus on three features of international markets: first, people mainly consume home produced goods (the "home bias in consumption puzzle"). Second, they hold a disproportionate share of domestic assets (the "home bias in portfolio puzzle"). Third, countries that are more open to trade are also more financially open. Following Obstfeld and Rogoff [2000], I ask whether one can replicate these three broad facts by simply adding trade costs in a two-country stochastic equilibrium model. Since trade costs generate deviations from "purchasing power parity" *i.e* real exchange rate fluctuations, equilibrium portfolios deviate from the market portfolio but not systematically in favor of domestic equities. The direction of the bias in equity portfolios depends crucially on the risk aversion of consumers, on the substituability between domestic and foreign goods and on the size of trade costs. Under reasonable parameters values, trade costs actually worsen the "home bias in portfolio puzzle". To reconcile facts and theory, I propose a combination of small frictions between financial markets and large trade costs on goods market. Obviously frictions in financial markets lead to "home bias in portfolio" but it is not the whole story. The interaction between both types of frictions also matters: reducing trade costs increases competition in goods market, which increases the volatility of domestic incomes. Facing higher risks, people want more diversified portfolios and increase their holdings of foreign assets for a given level of frictions in financial markets.

Keywords: Trade Costs, Portfolio Choice, Home Bias, "New Open Macroeconomics".

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1 Introduction

This paper is mainly motivated by three stylized facts:

1. People mainly consume domestically produced goods: the "home bias in consumption puzzle"
2. People hold a disproportionate share of domestic assets : the "home bias in portfolio puzzle"
3. International trade in goods and international trade in assets are positively related.

The first fact is well known: looking at consumption baskets, countries are not very open to trade. For instance, the openness to trade ratio in the US measured by the sum of exports and imports over GDP is only 24% in 2004. Given that the US account for about a third of world production, they should import about two thirds of their GDP in the absence of frictions in goods markets. Then, the openness ratio should be higher than 120%! Without being so ambitious about market integration, even the US and Canada are far from being perfectly integrated (Mac Callum [1995]).

The second fact is also well known: since the seminal paper of French and Poterba [1991], the "home bias in equities" is one of the most pervasive empirical observations in international economics. Although home bias could be mainly due to capital market segmentation in the eighties, this explanation might be less valid nowadays. Indeed, developed countries opened up their stock market to foreign investors in the eighties, followed by many emerging economies in the early nineties, leading to a large increase in cross-border asset trade (Lane and Milesi-Feretti [2003]). However, the home bias in equities has not decreased sizeably. In 2000, US investors still hold 85% percent of domestic equities and the "home bias in equities" is observed in all developed countries (Chan *et al.* [2004]).

The third fact is less known but there is now massive evidence that countries which are more open to trade are also more financially open. In other words, everything else equal, countries with higher import (or export) shares have larger stocks of foreign assets. Lane [2000], Aizenman [2004], Aizenman and Noy [2004], Heathcote and Perri [2004] show this result using panel data for a cross-section of countries (see also figure 4 in appendix). Looking at bilateral data on trade in goods and asset holdings, Aviat and Coeurdacier [2004] and Lane and Milesi-Feretti [2004] show that country portfolios are strongly biased towards trading partners. Moreover, Aviat and Coeurdacier [2004] show that the causality goes essentially in one direction: reducing trade barriers between countries enhances cross-border asset holdings.

There is now quite a consensus that trade costs understood in a broad sense (*i.e* transport costs, tariffs, distributive costs, "border effect"...) can explain the first fact. Indeed, as shown by Anderson and Van Wincoop [2004], trade costs are very large, probably on average as large as production costs. But what about facts 2 and 3? Obstfeld and Rogoff [2000] argue that "home bias in equities" might be also

due to frictions in international goods markets rather than frictions in financial markets. If this is true, then the third fact becomes obvious and one can replicate these three features of international markets with only one simple friction, namely trade costs.

The objective of this paper is twofold:

- First, I ask whether the Obstfeld and Rogoff [2000] argument is valid, *i.e* wether trade costs in goods markets alone can generate substantial "home bias" in portfolio. Contrary to the findings of Obstfeld and Rogoff, I find that in general trade costs actually worsen the "home bias in portfolio puzzle". Trade costs help to solve the "home bias in consumption puzzle" but at the expense of facts 2 and 3.

- Second, given the inability of the model to replicate these three broad facts with trade costs only, I rather propose a combination of small financial frictions in investing abroad and high trade costs in goods market to reconcile facts and theory. That frictions in financial markets will help to solve the "home bias in portfolio puzzle" is a tautology but it is not the whole story. The interaction between frictions in goods markets and frictions in financial markets also matters for portfolio choice. The reason is the following: reducing trade costs increases international competition in goods markets, making firms revenues more risky. As a consequence, diversification needs increase and people will more likely buy foreign assets for a given level of frictions in financial markets. Then, introducing trade costs in order to replicate fact 1 is no more at the expense of facts 2 and 3.

Coming to my first point, let us see why, under complete markets, trade costs in goods markets alone are in general not sufficient to generate some "home bias in equities". Obstfeld and Rogoff [2000] develop a static two-country general equilibrium with complete markets and trade costs. Due to trade costs, domestic investors might be reluctant to hold foreign assets since consumption is biased towards home goods and so are holdings of Arrow-Debreu securities that finance these consumption patterns. However, as they point out, holdings of equities that reproduce the complete markets consumption allocation might be different. I propose here to fill this gap and to find the effective equity holdings consistent with these consumption patterns under complete markets. I will show that the bias towards domestic equities is far from being systematic.

In a fully symmetric model with two countries, fully integrated capital and goods markets, representative agents in each country would hold a perfectly diversified portfolio, *i.e* the world market portfolio that contains half of domestic assets and half of foreign assets[1]. But in presence of trade costs, domestic and foreign investors face different aggregate price indices and will hold different equity portfolios to insure against real exchange rate fluctuations. This result is not new since Adler and Dumas [1983] show in partial equilibrium how deviations from "purchasing power parity" due to real exchange rate fluctuations

[1] This result holds if we abstract from labour revenues or equivalently labour revenues and asset returns were uncorrelated which would suppress any "hedging demand".

might lead to portfolios that deviate from the world market portfolio. In particular, agents who are more risk averse than logarithmic investors will bias their portfolios towards assets that pay more when the domestic aggregate price is higher, *i.e* when the real exchange rate appreciates, in order to stabilize their purchasing power (and inversely, agents who are less risk averse than logarithmic investors will prefer assets that pay more when prices are low). In other words, for sufficiently risk averse investors, the "revenue effect" dominates the "substitution effect" and these investors want more revenues in the states of nature where their price index is higher: consequently, they purchase assets that give higher returns when the real exchange rate appreciates. The same sort of mechanism is at work here but the model goes one step further since the general equilibrium approach allows to analyze whether domestic asset returns should be (or not) positively correlated with the real exchange rate under various types of frictions in goods markets.

A paper that is close to this approach is Uppal [1993]: he develops a dynamic general equilibrium of two endowment economies with complete markets and trade costs and find optimal international portfolio choice. However, he restricts its attention to the case of perfect substituability between home and foreign goods. I will show that this last assumption plays a crucial role even in the absence of financial frictions and relaxing it leads to a richer and more complex portfolio allocation. A related literature is also Dellas and Stockman [1989], Baxter et *al.* [1998] and Serrat [2001] who consider the presence of non-traded goods as a source of equity home bias. My approach is quite different since I look at continuous measures of frictions in goods markets rather than a dichotomy between tradables and non-tradables. This paper is also related to the "New Open Macroeconomics" literature. Since the Obstfeld and Rogoff *Redux* model [1995], this literature has brought many theoretical works to build a new workhorse model for open-economy analysis (see Lane [2003] for a survey). Those models typically rely on imperfect competition in product markets. Firms engage in monopolistic competition, which leads to operating profits that are redistributed to shareholders. In a globalized world, shareholders could likely be foreign ones, however very little attention has been brought on this aspect and these models assume that profits of domestic firms are redistributed to domestic residents. Given the size of the "home bias", this could be seen as a realistic assumption, but one could argue that home bias in equities should be an outcome of the model rather than an assumption. The model is an attempt to endogeneize portfolio choice in a two-country equilibrium with monopolistic competition. Engel and Matsumoto [2004] is also a notable exception: in their set-up, consumers hold a disproportionate part of domestic assets because of the negative correlation between labour incomes and domestic asset returns in presence of price rigidities (see also Gali [1999]). Due to price stickiness, a good productivity shock leads a firm that cannot reajust prices to reduce its labour demand, reducing consequently labour revenues. Since domestic workers want to hedge their risky labour incomes, they would rather hold domestic assets. I investigate a very different aspect that could

potentially lead to home bias in equities, namely the presence of frictions in international goods markets and the real exchange rate fluctuations generated by these frictions. Actually, in this set-up, prices are fully flexible, which eliminates mechanisms of Engel and Matsumoto's type.

Then, in presence of trade costs, the key-point for portfolio choice is whether the domestic capital returns (relative to the foreign ones) and the real exchange rate are positively or negatively correlated: a positive correlation meaning a "home bias in portfolio" when agents are more risk averse than log-. Indeed, sufficiently risk averse investors prefer assets that give higher returns when the price of their consumption bundle is higher. I show that this correlation is clearly affected by the size (and the nature) of trade costs. An increase in production in the domestic country relative to the foreign one (due to a higher productivity in the home country in my set-up) leads to a relative price change to clear the goods market: the relative price of home goods fall. I show that when goods markets are highly segmented, the fall in price must be such that domestic capital returns actually fall when production in the domestic market increases. In this case, a real exchange rate depreciation (a fall in the domestic price) is associated with lower domestic returns, making domestic assets more attractive for domestic investors to stabilize their purchasing power[2]. However, in more standard cases, *i.e* when goods markets are not "too closed", a fall in the price of domestic goods allow domestic firms to expand their market share, increasing domestic asset returns. In this case, the real exchange rate and domestic returns (relative to foreign returns) are negatively correlated[3] and we should observe a foreign bias in portfolio. Then, the bottom-line is that in standard cases, trade costs cannot generate any "home bias in equities" and the puzzle is even worsened.

I now come to my second point. Given that the model with trade costs generates some "home bias in consumption" at the expense of "foreign bias in equities", it seems reasonable to assume that some frictions between financial markets remain. Frictions in financial markets are introduced in a simple way: for each share of foreign asset bought, domestic agents must pay a constant tax rate on foreign dividends distributed[4]. This asset trade cost features any frictions in financial markets (transaction costs, informational costs, "familiarity effects", higher taxes paid on foreign dividends...). The existence of informational asymmetries or "familiarity effects" in financial markets is the main message of Coval and Moskowitz [1999], Portes and Rey [2005] and Huberman [2001] to explain international equity trade. Looking at international taxation of capital incomes, Gordon and Hines [2002] find significant differences of fiscal treatment between investment in domestic assets and investment in foreign ones. Adding frictions in financial markets can obviously generate some "home bias in portfolio" but the theoretical point I want to make clear is that the interaction between both types of frictions is also relevant for portfolio choice. I

[2] as long as they are more risk averse than log-

[3] Following Corsetti *et al.* [2004] and Kollmann [2005], I also explore the case of poor substituability between home and foreign goods (*i.e* the elasticity of substitution between home and foreign goods is smaller than one) since in this case an increase in the domestic price is always associated with higher domestic returns.

[4] These taxes on foreign dividends are redistributed to domestic residents such that nothing is lost.

show that lowering trade costs in goods markets increases the diversification benefits and enhances asset trade, which might reduce the home bias in portfolio for a given level of financial frictions (consistently with fact 3). Why does goods market integration increase the need for diversification? The reason is that a reduction in trade costs increases international competition and then increases the volatility of capital returns. Indeed, international competition amplifies the effect of a good productivity shock. Suppose that domestic firms are hit by a good productivity shock: at given factor costs, they will expand their market shares due to higher competitiveness on foreign markets, which raises profits and capital returns. When foreign firms are not sheltered from international competition (low level of trade costs), the gain in market shares of domestic firms is much higher, amplifying the impact of a good productivity shock on capital returns. Moreover, the increase in domestic firms capital returns is at the expense of foreign firms, which tends to make both assets less substitutes. This also increases the diversification benefits offered by foreign assets. The evidence that increasing competition from foreign markets make firms cash-flows more volatile is scarce but consistent with Thesmar and Thoenig [2004] and Irvine and Pontiff [2005] at the firm-level. Easterly *et al.* [2000] and Kose *et al.* [2003] show that trade openness increases volatility of growth at the macro-level[5].

Of course, real exchange rate hedging motives are still present and play in the opposite direction for portfolio composition, generating some foreign bias in portfolio. The impact of trade costs in goods markets on domestic asset holdings is then ambiguous, depending on the relative strength of these two forces: diversification benefits versus hedging real exchange rate fluctuations. I show that under realistic calibrations decreasing trade costs in goods markets enhances trade in foreign assets. The fact that a reduction in trade costs increases foreign assets holdings is more consistent with observed portfolio allocations. Finally, I shall insist on the fact that reasonably low frictions between financial markets can generate very large biases in portfolios: indeed, an increase in domestic production leads to a fall in the relative price of domestic goods and this terms-of-trade movement provides a good insurance mechanism to both investors (like in Cole and Obstfeld [1991] and Pavlova and Rigobon [2003])[6], reducing the needs for diversification.

In section 2, I derive and describe the symmetric two-country equilibrium under complete markets. I give the exact conditions under which trade costs lead to home bias in equities and show that these conditions are violated under reasonable preference parameters. Section 3 explores an extension of the model by adding frictions in financial markets. I show that the interaction of frictions in financial markets and trade costs matters for portfolio choice and that, contrary to the previous section, increasing trade costs in this case helps to solve the "home bias in equities puzzle". Section 4 discusses the results and section 5 concludes.

[5] Janiak [2004] and Traca [2005] find the same impact of trade competition on the volatility of labour incomes.
[6] and even more when competition in goods markets is low (high level of trade costs)

2 The model under complete markets

2.1 Set-up

The world economy consists of two symmetric countries, home and foreign. Home variables are denoted with (H), foreign variables with (F).

There is one representative agent in each country endowed with the same quantity of capital in the initial period to preserve symmetry.

The timing of the model is the following:

- In period 0, agents in both countries invest their initial endowment in domestic or foreign firms (portfolio choice). A risk-free bond exists but due to symmetry of countries, there is no bond-holding in equilibrium[7].

- In period 1, shocks on productivity are realized and firms produce. Production in both countries uses capital according to a constant returns to scale production function[8]. Domestic and foreign goods are imperfect substitutes (each firm in each country is producing one variety) and firms are setting prices in a standard monopolistic competition set-up *à la* Dixit-Stiglitz [1977]. In both countries, agents consume using their revenues from the dividend streams (part of firms profits and capital returns) of their assets. They both face trade costs when they import goods from the other country.

The uncertainty is defined in the following way:

Productivity in each country is stochastic and country-specific, which means that an increase in productivity affects symmetrically each firm in the country. This reduces the dimension of the uncertainty to the number of countries. Since the uncertainty is country specific, domestic firms have perfectly correlated capital returns and the portfolio choice is made between two different assets (domestic and foreign ones). Moreover, the uncertainty is bi-dimensional and agents will replicate the complete markets allocation simply by trading domestic and foreign equity shares[9].

2.2 Consumer preferences

Agents in each country (i) maximize the following function:

$$U_i = E\left[\frac{(C_i)^{1-\gamma}}{1-\gamma}\right]$$

[7] Moreover, both risky assets will have the same price.

[8] In an earlier version of the paper, we add labour inputs in the production: adding labour does not modify any of the result with respect to the presence of trade costs except that in a world were firms revenues are split between capital and labour incomes, workers-investors have an incentive to short domestic stocks since their labour incomes are over-exposed to domestic risks (see Baxter and Jermann [1995])

[9] To be precise, markets are complete at the first-order, the degree of the linear approximation. Note also that adding industry idiosyncratic shocks within a country would not change our results since these shocks would be perfectly hedged with well diversified portfolio of the different domestic industries.

where C_i is the aggregate consumption rate in country i, γ is the coefficient of relative risk-aversion.

In both countries, the representative agent consumes a basket of differentiated goods. Goods produced in each country are defined over a continuum of mass 1.

The aggregate consumption index of an agent in country H is:

$$C_H = \left[a^{1-\rho} \left(\int_0^1 \left[c_H^H(v) \right]^{\phi} dv \right)^{\frac{\rho}{\phi}} + (1-a)^{1-\rho} \left(\int_0^1 \left[c_F^H(v) \right]^{\phi} dv \right)^{\frac{\rho}{\phi}} \right]^{1/\rho}$$

where $c_j^H(v)$ is the consumption of variety (v) from country j by a representative agent in country (H) and $a \geq \frac{1}{2}$ is a parameter of bias in preferences towards domestic goods[10].

$\frac{1}{1-\phi} > 1$ is the elasticity of substitution between varieties of a country (*within-country substituability*).

Following Tille [2001], I suppose that the elasticity of substitution between home and foreign goods $\left(\frac{1}{1-\rho}\right)$ might be different from the elasticity of substitution between varieties of a country (*between-country substituability*). This might be due to specialization of countries in particular sectors: in general, I will assume that $\frac{1}{1-\phi} > \frac{1}{1-\rho}$ such that varieties inside a country are closer substitutes than varieties across countries.

Symmetrically, the aggregate consumption index of an agent in country F is:

$$C_F = \left[(1-a)^{1-\rho} \left(\int_0^1 \left[c_H^F(v) \right]^{\phi} dv \right)^{\frac{\rho}{\phi}} + a^{1-\rho} \left(\int_0^1 \left[c_F^F(v) \right]^{\phi} dv \right)^{\frac{\rho}{\phi}} \right]^{1/\rho}$$

2.3 Firms

In country (j), firms produce the final good (v) under monopolistic competition using a technology with constant returns to scale relative to capital:

$$y_j(v) = a_j k_j(v)$$

where a_j is the stochastic productivity in country j. This is the **only source of uncertainty** in the model.

Given factor costs, the marginal-cost of producing one unit of good (v) in country (j) is equal to $c_j = \frac{r_j}{a_j}$ where r_j is the cost of capital.

- **Price-setting**

As it is well known, each firm faces a demand with a constant elasticity $(1-\phi)^{-1}$. They charge in both countries a constant mark-up over marginal cost:

$$p_j(v) = \frac{c_j}{\phi}$$

[10] It can be shown that $\frac{a}{1-a}$ is homogenous in the number of varieties effectively traded.

Since $p_j(v)$ is independent on the variety (and just country-specific), I will abstract from subscripts (v) from now on.

- **Capital incomes:** in this set-up, profits and factor payments are simply a constant fraction of total sales.

$$\begin{aligned} \pi_j &= (1-\phi)p_j y_j \\ r_j k_j &= \phi p_j y_j \end{aligned}$$

Profits are fully redistributed to shareholders. I introduce $R_j k_j = r_j k_j + \pi_j = p_j y_j$, the total returns to capital.

2.4 Trade Costs

In addition to the home bias in preferences, I assume that exports from country j to country i are subject to some exogenous trade costs τ (of iceberg-type) such that the price faced by consumers in country i over goods from country j is for $i \neq j$:

$$p_j^i = (1+\tau)p_j$$

This features frictions in international goods markets such as transport costs or other barriers to international trade (trade policies, "border effect"...).

2.5 Consumer maximization

In period 1 (after the realization of productivity shocks), a representative consumer in country (H) maximizes

$$U_H = \left[\frac{(C_H)^{1-\gamma}}{1-\gamma}\right] = \frac{\left(\left[a^{1-\rho}\left(c_H^H\right)^{\rho} + (1-a)^{1-\rho}\left(c_F^H\right)^{\rho}\right]^{1/\rho}\right)^{1-\gamma}}{1-\gamma}$$

subject to a budget constraint:

$$\begin{aligned} \int_0^1 p_H(v)c_H^H(v)dv + (1+\tau)\int_0^1 p_F(v)c_F^H(v)dv &\leq I_H \qquad (\lambda_H) \\ p_H c_H^H + (1+\tau)p_F c_F^H &\leq I_H \qquad (\lambda_H) \end{aligned}$$

where I_H are total incomes of the representative agent in country (H) and λ_H is the Lagrange-Multiplier associated to the budget constraint. I_H depends on the claims of the representative agent over firms capital returns. At this point, I take portfolios chosen in period 0 as given.

I can rewrite the budget constraint by introducing the price index of a consumer in country (H):

$$P_H = \left[a\left(p_H\right)^{\frac{\rho}{\rho-1}} + (1-a)\left[(1+\tau)p_F\right]^{\frac{\rho}{\rho-1}}\right]^{\frac{\rho-1}{\rho}}$$

The budget constraint is then:

$$P_H C_H \leq I_H \qquad (\lambda_H)$$

The first-order conditions are:

For consumption:

$$1 = \lambda_H P_H C_H^{\gamma}$$

Intratemporal allocation across goods:

$$\begin{aligned} c_H^H &= a\left(\frac{p_H}{P_H}\right)^{-\frac{1}{1-\rho}} C_H \\ c_F^H &= (1-a)\left(\frac{(1+\tau)p_F}{P_H}\right)^{-\frac{1}{1-\rho}} C_H \end{aligned}$$

Symmetrically, for country (F),

$$\begin{aligned} P_F &= \left[a\left(p_F\right)^{\frac{\rho}{\rho-1}} + (1-a)\left[(1+\tau)p_H\right]^{\frac{\rho}{\rho-1}}\right]^{\frac{\rho-1}{\rho}} \\ 1 &= \lambda_F P_F C_F^{\gamma} \\ c_H^F &= (1-a)\left(\frac{(1+\tau)p_H}{P_F}\right)^{-\frac{1}{1-\rho}} C_F \\ c_F^F &= a\left(\frac{p_F}{P_F}\right)^{-\frac{1}{1-\rho}} C_F \end{aligned}$$

2.6 Aggregate demand

Aggregate demands over home and foreign goods are:

$$\begin{aligned} D_H = c_H^H + (1+\tau)c_H^F = p_H^{-\frac{1}{1-\rho}}\left[a\left(P^H\right)^{\frac{1}{1-\rho}} C_H + (1-a)(1+\tau)^{\frac{\rho}{\rho-1}}\left(P^F\right)^{\frac{1}{1-\rho}} C_F\right] \\ D_F = (1+\tau)c_F^H + c_F^F = p_F^{-\frac{1}{1-\rho}}\left[a\left(P^F\right)^{\frac{1}{1-\rho}} C_F + (1-a)(1+\tau)^{\frac{\rho}{\rho-1}}\left(P^H\right)^{\frac{1}{1-\rho}} C_H\right] \end{aligned}$$

I introduce $\xi(a,\tau) = (\frac{1-a}{a})\left(\frac{1}{1+\tau}\right)^{\frac{\rho}{1-\rho}} \in [0;1]$ that is inversely related to the trade costs (when $\rho > 0$) and to the home bias in preferences. ξ is a measure of the degree of goods market integration.

Then, the relative demand is:

$$\frac{D_H}{D_F} = (\frac{p_H}{p_F})^{-\frac{1}{1-\rho}}\left[\frac{1+\xi\left(\frac{P^F}{P^H}\right)^{\frac{1}{1-\rho}}\left(\frac{C_F}{C_H}\right)}{\left(\frac{P^F}{P^H}\right)^{\frac{1}{1-\rho}}\left(\frac{C_F}{C_H}\right)+\xi}\right] \tag{1}$$

2.7 Log-linearization around the symmetric equilibrium

I use the world price index as a numeraire to preserve symmetry: $P = P_H^{\frac{1}{2}} P_F^{\frac{1}{2}} = 1$.

I consider approximation around the symmetric equilibrium where both countries have the same productivity a^* (and consequently the same goods prices: $p_H^* = p_F^* = 1$). I denote with $(\hat{})$ the deviations of the variables from the symmetric equilibrium:

$\widehat{u} = \log(\frac{u}{u^*})$ where u^* is the value at the symmetric equilibrium.

In particular, $\widehat{a_i} = \log(\frac{a_i}{a^*})$ is the deviation of productivity from the symmetric equilibrium in country (i). Productivity shocks $(\frac{a_i}{a^*})$ are assumed to be log-normally distributed and so will be all variables $(\frac{u}{u^*})$.

Note also that given that factors are fixed, $\widehat{a_i} = \widehat{y_i} = \widehat{D_i}$.

2.7.1 Relative demand function

Log-linearizing (1) around the symmetric equilibrium gives:

$$\widehat{\frac{D_H}{D_F}} = -\frac{1}{1-\rho}\widehat{\frac{p_H}{p_F}} - \frac{1-\xi}{1+\xi}\left[\left(\frac{1}{1-\rho}-\frac{1}{\gamma}\right)\widehat{\frac{P_F}{P_H}} + \frac{1}{\gamma}\widehat{\frac{P_F C_F^\gamma}{P_H C_H^\gamma}}\right] \tag{2}$$

The log-linearization of price indexes gives[11]:

$$\widehat{P_H} = \frac{1}{1+\xi}\widehat{p_H} + \frac{\xi}{1+\xi}\widehat{p_F} \tag{3}$$

$$\widehat{P_F} = \frac{1}{1+\xi}\widehat{p_F} + \frac{\xi}{1+\xi}\widehat{p_H} \tag{4}$$

I introduce $\theta_\rho(\tau) = \left(\frac{1-\xi}{1+\xi}\right) \in [0;1]$. θ_ρ is a monotonic transformation of trade costs: when $\rho > 0$[12], θ_ρ is increasing in τ (and in a).

Then, relative demand given by (2) depends on two terms:

$$\begin{aligned}\widehat{\frac{D_H}{D_F}} &= -\left[\frac{1}{1-\rho}(1-\theta_\rho^2) + \theta_\rho^2\frac{1}{\gamma}\right]\widehat{\frac{p_H}{p_F}} - \frac{\theta_\rho}{\gamma}\widehat{\frac{\lambda_H}{\lambda_F}} \\ &= -\psi\widehat{\frac{p_H}{p_F}} - \frac{1}{\gamma}\theta_\rho\widehat{\frac{\lambda_H}{\lambda_F}}\end{aligned}$$

where $\widehat{\lambda_i} = -\widehat{P_i C_i^\gamma}$ is the Lagrange-multiplier of the budget constraint for country (i).

- $\psi\widehat{\frac{p_H}{p_F}}$: this term measures how an increase in the relative price of home goods (terms-of-trade $\frac{p_H}{p_F}$) makes agents reduce their relative demand for home goods. Without frictions ($\tau = 0$ and $a = \frac{1}{2}$), $\psi = \frac{1}{1-\rho}$ which is the elasticity of substitution between home and foreign goods.
- $\frac{\theta_\rho}{\gamma}\widehat{\frac{\lambda_H}{\lambda_F}}$ which is a relative demand shock. When markets are complete, $\lambda_H = \lambda_F$ and this term cancels out. When markets are incomplete, a shock that increases revenues in country H, increases relative demand for goods in country H due to trade costs or home bias in preferences (note that indeed this terms disappears when $\theta_\rho = 0$: when there are neither frictions nor home bias in preferences, demand shocks affect both goods symmetrically).

For this part, I consider that markets are complete. I will relax this assumption by introducing costs of holding foreign securities in next section.

2.7.2 Relative capital returns

Since shocks are country-specific and firms in country (j) fully symmetric, I can restrict my attention to aggregate capital returns in country (j):

$$R_j k_j = p_j y_j = p_j D_j \text{ (due to market-clearing).}$$

[11] Note that given the numeraire used: $\widehat{P} = \frac{1}{2}\left(\widehat{P}_H + \widehat{P}_F\right) = \frac{1}{2}\left(\widehat{p_H} + \widehat{p_F}\right) = 0$

[12] When $\rho < 0$ (*i.e* home and foreign goods are relatively poor substitutes), then θ_ρ is decreasing in τ (but increasing in a) and $\theta_\rho(0) = (2a-1)$ and $\theta_\rho(\infty) = (1-2a)$. This is because higher foreign prices due to higher τ increase aggregate prices faced by home residents since they cannot easily substitute foreign and domestic consumption.

Given that capital is fixed, we have:

$$\frac{\widehat{p_H D_H}}{p_F D_F} = \widehat{\frac{R_H}{R_F}} = (1-\psi)\,\widehat{\frac{p_H}{p_F}} = -\left[\frac{\rho}{1-\rho} + \theta_\rho^2\left(\frac{1}{\gamma} - \frac{1}{1-\rho}\right)\right]\widehat{\frac{p_H}{p_F}} \tag{5}$$

Equation (5) is a "key equation" : it tells us about the co-movements of relative prices with relative returns to capital.

Lets us consider the standard case where $\rho > 0$ (or equivalently, the elasticity of substitution between home and foreign goods is larger than 1). I will discuss later the case where $\rho < 0$.

The key point is wether $\psi < 1$ or $\psi > 1$, which means wether capital returns relative to foreign ones are higher when the price of home goods is higher or the other way around.

- when τ is high enough ($\theta_\rho^2 \to 1$), $(1-\psi) \approx \left(1 - \frac{1}{\gamma}\right)$: this means that under the realistic assumption ($\gamma > 1$), $(1-\psi) > 0$, and higher prices in the home country (better terms-of-trade) are associated with higher relative capital returns in the home country. In particular, when productivity is high in the home country, prices are lower and home returns shrink relative to foreign ones since productivity is higher for all competitors in the home market and this price decrease is not associated with higher market share on foreign markets[13]. When trade costs are high, foreign markets are sheltered from the competition from domestic firms and domestic firms cannot really expand their market share following a fall in production costs.

- when $\tau \to 0$ and $\frac{1}{2}$ ($\theta_\rho^2 \to 0$), $1-\psi \approx -\frac{\rho}{1-\rho} < 0$: higher prices in the home country are now associated with lower returns in the home country. This is due to the gain in market shares: when prices are low, domestic firms have a larger foreign demand and this gain in market share dominates the fall in price due to competition in the home market: domestic capital returns increase relative to foreign ones after a fall in the relative price of home goods[14].

I can calculate $0 < \theta_\rho^* < 1$ such that $\psi = 1$ for $\rho > 0$

$$\theta_\rho^* = \left(\frac{\gamma\rho}{\gamma + \rho - 1}\right)^{\frac{1}{2}} \tag{6}$$

when $\theta_\rho > \theta_\rho^*$ (high level of trade costs), relative prices and capital returns are positively correlated and the other way around when $\theta_\rho < \theta_\rho^*$.

When $\theta_\rho = \theta_\rho^*$, $\widehat{R_H} = \widehat{R_F}$ and returns are perfectly correlated making home and foreign assets perfect substitutes[15].

[13] For domestic investors, capital returns might well be higher in real terms since domestic prices are lower but assets do not pay in real terms.

[14] When domestic and foreign goods are poor substitutes $\left(\frac{1}{1-\rho} < 1\right)$, the "expenditure-switching effect" is never sufficient to compensate the fall in price. Domestic firms revenues and capital returns in the home country always fall when domestic prices decrease.

[15] Portfolios will be undetermined in this case.

- for $\rho > 0$

$$\frac{\partial \theta_{\rho}^{*}}{\partial \rho} > 0$$

when goods are getting closer substitutes, competition in international markets is tougher and a small decrease in domestic prices increases a lot the demand for home goods: the "expenditure switching effect" is getting stronger and trade costs must be very large to shelter foreign firms from the competition of home firms.

- for $\gamma > 1$

$$\frac{\partial \theta_{\rho}^{*}}{\partial \gamma} < 0$$

when γ is increasing, the additional aggregate domestic demand which falls primarily on domestic goods when prices are low is rather small (given that under complete markets $\widehat{C_H} = -\frac{1}{\gamma}\widehat{P_H}$). Then, a decrease in the price of home goods generate higher cash-flows of domestic firms if they can easily increase their market share (*i.e* trade costs must not be too large).

- $\frac{\partial \theta_{\rho}}{\partial a} > 0$ and $\frac{\partial \theta_{\rho}}{\partial \tau} > 0$: then, the higher are barriers to international trade in goods (trade costs and/or home bias in preferences), the more likely are relative capital returns and relative prices to be positively correlated.

2.7.3 The real exchange rate

I introduce the real exchange rate (RER) as:

$$RER = \frac{P_H}{P_F}$$

An increase in RER is an appreciation of the home real exchange rate.

Around the symmetric equilibrium:

$$\widehat{RER} = \frac{\widehat{P^H}}{P^F} = \theta_{\rho}\frac{\widehat{p_H}}{p_F} \tag{7}$$

Due to trade costs, an increase in domestic prices increases the real exchange rate. In absence of trade costs and home bias in preferences ($\theta_{\rho} = 0$), the real exchange rate is constant since both countries consume the same basket of goods. In presence of trade costs, an increase in the relative price of domestic goods is equivalent to a real exchange rate appreciation. This is consistent with a positive correlation between the terms-of-trade and the real exchange rate observed in industrialized countries (see Obstfeld and Rogoff [2000]).

Then, the real exchange rate and relative capital returns are negatively correlated when $\theta_{\rho} < \theta_{\rho}^{*}$ and positively correlated when $\theta_{\rho} > \theta_{\rho}^{*}$.

2.8 Portfolio choice

The number of shares in both countries are normalized to one. I introduce μ the number of domestic shares held by domestic investors before the realization of shocks. Due to symmetry and to market-clearing in the asset market, $(1-\mu)$ is the number of foreign shares held by a domestic investor. The domestic investor solves the following optimization problem:

$$\begin{aligned} & \max_{\{\mu\}} E(U_H) \\ s.t \quad : \quad & P_H C_H = \mu R_H k + (1-\mu) R_F k \end{aligned}$$

Instead of solving the maximization, I propose to use the symmetry and the complete markets assumption to find equilibrium portfolios. This method is tricky but one can look at the appendix for the same derivation using investor maximization.

Since markets are complete, the ratio of marginal utilities over consumption for both agents equalizes the real exchange rate (see Backus and Smith [1993] and also Corsetti *et al.* [2004]):

$$\begin{aligned} P_H C_H^{\gamma} &= P_F C_F^{\gamma} \\ \gamma\left(\widehat{C_H} - \widehat{C_F}\right) &= \widehat{P_F} - \widehat{P_H} \end{aligned}$$

Using symmetry, log-linearisation of the budget-constraints in both countries gives:

$$\begin{aligned} \widehat{P_H} + \widehat{C_H} &= \left(\mu\widehat{R_H} + (1-\mu)\,\widehat{R_F}\right) \\ \widehat{P_F} + \widehat{C_F} &= \left(\mu\widehat{R_F} + (1-\mu)\,\widehat{R_H}\right) \end{aligned}$$

Rearranging terms to express the real exchange rate in terms of relative capital returns, we get:

$$\left(\widehat{P_H} - \widehat{P_F}\right)(1-\frac{1}{\gamma}) = (2\mu - 1)\,(\widehat{R_H} - \widehat{R_F})$$

Taking covariances of the previous expression with $\frac{\widehat{p_H}}{p_F}$ and using equations (5) and (7) gives:

$$\begin{aligned} (1-\frac{1}{\gamma})cov(\widehat{P_H} - \widehat{P_F}, \frac{\widehat{p_H}}{p_F}) &= -(2\mu-1)\left[\frac{\rho}{1-\rho} + \theta_\rho^2\left(\frac{1}{\gamma} - \frac{1}{1-\rho}\right)\right] Var(\frac{\widehat{p_H}}{p_F}) \\ (1-\frac{1}{\gamma})\theta_\rho Var(\frac{\widehat{p_H}}{p_F}) &= -(2\mu-1)\left[\frac{\rho}{1-\rho} + \theta_\rho^2\left(\frac{1}{\gamma} - \frac{1}{1-\rho}\right)\right] Var(\frac{\widehat{p_H}}{p_F}) \end{aligned}$$

Then, as long as $\frac{\rho}{1-\rho} + \theta_\rho^2\left(\frac{1}{\gamma} - \frac{1}{1-\rho}\right) \neq 0$ (in this specific case, foreign and domestic assets are perfect substitutes and portfolios are undetermined), we get the share in the portfolio devoted to domestic assets (μ):

$$\mu = \frac{1}{2}\left[1 - \frac{(1-\frac{1}{\gamma})\theta_\rho}{\left(\frac{\rho}{1-\rho} + \theta_\rho^2\left(\frac{1}{\gamma} - \frac{1}{1-\rho}\right)\right)}\right] \tag{8}$$

Shareholdings of domestic equity depend on two terms:

- the market portfolio (which is $\frac{1}{2}$) due to diversification motive

- the "hedging component" due to real exchange rate fluctuations, which is

$$-\frac{1}{2}(1-\frac{1}{\gamma})\frac{\theta_\rho}{\left[\frac{\rho}{1-\rho}+\theta_\rho^2\left(\frac{1}{\gamma}-\frac{1}{1-\rho}\right)\right]}$$

We get a standard result: a logarithmic investor ($\gamma = 1$) is not affected by fluctuations in the real exchange rate and the "hedging" term disappears in this case. Of course, in absence of trade costs and home bias in preferences ($\theta_\rho = 0$), the real exchange rate is constant and the "hedging" term also cancels out. If $\gamma > 1$ and $\left(\frac{1}{1-\rho}\right) > 1$, this term is negative when $\theta_\rho < \theta_\rho^*$ (resp. positive for $\theta_\rho > \theta_\rho^*$): indeed, for a reasonable level of trade costs ($\theta_\rho < \theta_\rho^*$), the real exchange rate depreciates when domestic returns are higher than foreign ones. As a consequence, domestic investors prefer foreign assets since they give higher returns when the domestic price index is higher.

- **Cole and Obstfeld [1991] :**

Cole and Obstfeld argue that financial markets do not matter since perfect risk-sharing is insured through terms-of-trade movements: when relative price $\frac{p_H}{p_F}$ increases, the relative demand decreases. Those two effects play in opposite directions for relative returns and exactly cancel out when the elasticity of substitution between goods across countries is one and trade frictions are set to zero. In this specific case, domestic and foreign assets are perfect substitutes and equity markets are redundant. In my set-up this corresponds to the case where portfolios are undetermined due to the perfect correlation between domestic and foreign returns to capital (more generally, this happens under the specific parametrization where $\theta_\rho = \theta_\rho^*$).

- **Obstfeld and Rogoff [2000] :**

In Obstfeld and Rogoff [2000], the Arrow-Debreu allocation is simply replicated with equity shares when $\gamma = 1 - \rho$. They assume $\rho > 0$ in their calibration, which means that $\gamma < 1$. In this case, calculus simplifies tremendously and we get:

$$\mu = \frac{1}{2}(1+\theta_\rho)$$

When $\gamma < 1$, the "substitution effect" dominates and investors prefer assets that give higher returns when the price of their consumption bundle is lower. According to my set-up, the "hedging demand" due to real exchange rate fluctuations leads to home bias in equities and this bias is indeed increasing with

trade costs and home bias in preferences[16]:

$$\begin{aligned}\frac{\partial \mu}{\partial \tau} &= \frac{\partial \theta_\rho}{\partial \tau} > 0 \\ \frac{\partial \mu}{\partial a} &= \frac{\partial \theta_\rho}{\partial a} > 0\end{aligned}$$

What I show here is that the home bias they replicate under this specific calibration is far from being general (especially, under more general calibrations, one would expect $\gamma > 1$).

- **Uppal [1993] :**

In Uppal [1993], the set-up is quite different since the model is dynamic, firms are perfectly competitive, home and foreign goods are perfect substitutes and agents can reinvest their dividends in production. However, the main mechanism that leads to a foreign bias in this set-up is at work here: he argues that a good shock in the domestic country might lead to a depreciation of the exchange rate making foreign assets less risky than domestic assets from the point of view of the domestic investor (under the realistic assumption that $\gamma > 1$). In my set-up, when $\rho \to 1$, the gain in market share for domestic firms due to a fall in domestic marginal costs is so large that real exchange rate and relative returns are always negatively correlated. This leads to a foreign bias in equity as long as $\gamma > 1$.

$$\begin{aligned}\lim_{\rho \to 1} \theta_\rho^* &= 1 \\ \text{and } \theta_\rho &< \theta_\rho^*\end{aligned}$$

Consequently, agents always exhibit a foreign bias due to the presence of trade costs.

- **How realistic is the case $\theta_\rho^* < \theta_\rho$?**

For standard preferences ($\gamma > 1$ and $\rho > 0$), trade costs in goods markets will generate some home bias in portfolios if and only if $\theta_\rho^* < \theta_\rho$ (*i.e* trade costs are sufficiently high). I ask wether this condition can be verified with reasonable parameters value. Indeed, goods markets are fairly closed in the real world : for the US, the openness to trade, *i.e* the ratio of (exports+imports) over GDP is only 24% in 2004[17]. To have reasonable trade costs and reasonable elasticities of substitution to match the import share, I must then set the home-bias in preferences a fairly high. I will use $a = 0.7$ all along the paper. Since θ_ρ^* depends on the elasticity of substitution between home and foreign goods and on the coefficient of risk-aversion, I calculate θ_ρ^* for different parameters value and I compare these values with the values of θ_ρ and τ necessary to match the steady-state import share of the US (12%).

[16] One can show that in this specific case "home bias in consumption" and "home bias in portfolio" are moving one for one: the share of foreign assets in the portfolio is equal to the share of imports in total consumption

[17] Coming to our model, evaluating the steady-state share of imports over GDP to 12% will in fact bias upwards the real openness of the US since the US do not represent half of world production but I still take this as a benchmark value for openness.

The different parameters configuration are shown in table 1. The bottom-line is that under the various calibrations proposed θ_ρ is always smaller than θ_ρ^*: goods markets are not very open but they are not closed enough to generate some "home bias in equities" in this model.

γ	$\frac{1}{1-\rho}$	τ	θ_ρ	θ_ρ^*
2	1.5	95%	0.53	0.70
2	2.5	53%	0.63	0.86
2	5	25%	0.70	0.94
4	1.5	95%	0.53	0.63
4	2.5	53%	0.63	0.81
4	5	19%	0.70	0.91
6	1.5	95%	0.53	0.61
6	2.5	53%	0.63	0.80
6	5	25%	0.70	0.90

Table 1: Is $\theta_\rho > \theta_\rho^*$? Configuration of trade costs to match the US steady-state import share (12%) with $a = 0.7$ and various values for (γ) and $\left(\frac{1}{1-\rho}\right)$

- **Benchmark Calibration:**

Calibration of the parameters is presented is table 2.

Preferences	
Relative risk-aversion	$\gamma = 2$
Between-country elasticity of substitution	$\frac{1}{1-\rho} = 5$
Trade frictions	
Home-bias in preferences	$a = 0.7$
Trade costs	$\tau \in [0; 1]$

Table 2: Parameters values

Comments on the calibration:

I set the elasticity of substitution between home and foreign goods to 5. Estimates of this elasticity vary a lot across studies: estimates from micro data in international trade usually find much higher

elasticities, ranging from 4 to 15. For instance, using data on OECD countries at the 3-Digit level, Harrigan [1993] find elasticities in the range of 5 to 12. However, estimates from time-series macro data in the RBC literature usually give much lower elasticities, ranging from 1 to 3 (Backus *et al.* [1994]). In line with Obstfeld and Rogoff [2000], I choose the lower bound of estimates from the trade literature. Anyway, as long as the elasticity is larger than 1, qualitative results for this section remain unchanged.

By setting the home bias in preferences to 0.70, I match the observed steady-state import share in the US with an average trade cost $\tau = 25\%$, which seems reasonable (see table (1)).

This gives the equilibrium share of domestic assets in the portfolio (μ) as a function of τ shown in figure 1. Portfolios exhibit a foreign bias in the presence of trade frictions: at the margin, an increase in trade costs τ reduces μ and increases the foreign bias in portfolio. This is in sharp contradiction with Obstfeld and Rogoff [2000]. Moreover, the effect is rather large: increasing the trade costs from 20 to 50% (or equivalently decreasing the import share by 10%) leads to an increase in the share foreign asset holdings of 20%!

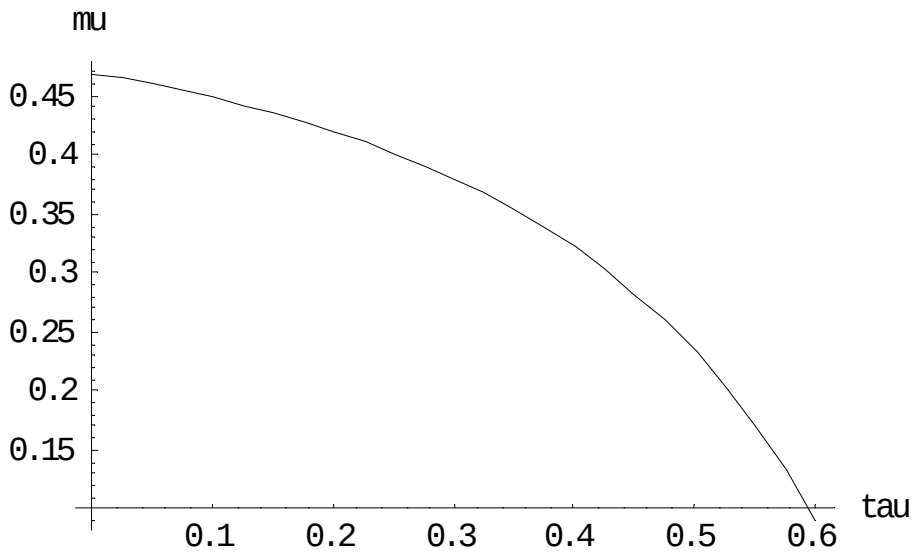

Figure 1: Impact of trade costs (τ) on holdings of domestic shares (μ). Calibration: $\gamma = 2$, $\frac{1}{1-\rho} = 5$ and $a = 0.7$.

It is central to understand that in this set-up foreign bias in portfolio is driven by the negative covariance between domestic asset returns and the real exchange rate induced by supply shocks when goods markets are not "too closed". Empirically, Hau and Rey [2003] show that it seems to be the relevant case: indeed, they find that stock market booms are associated with a depreciated currency (see also Lane [2003][18]).

[18] A large literature in finance on exchange rate exposure of individual firms also exists with mixed results: but, if

- **Comment on $\left(\frac{1}{1-\rho}\right) < 1$**

Heathcote and Perri [2002] provide short-run estimates of the elasticity of substitution between home and foreign goods that are slightly smaller than one[19]. Such a hypothesis would help us generate home bias in this model: when domestic prices are lower, the gain in market share never compensates the deterioration in the terms-of-trade since consumers cannot substitute easily domestic and foreign consumption and domestic capital returns shrink: there is an "excessive positive transmission mechanism". In this case, relative domestic prices and relative capital returns are positively correlated and domestic investors would prefer domestic assets. In particular, one can show that in the specific case where $\frac{1}{1-\rho} = \frac{1}{\gamma} < 1$, the share of foreign assets is exactly equal to the import share: home bias in consumption and home bias in portfolio fully correspond[20]. However, given that many empirical works in international trade usually agree on larger elasticities of substitution across goods, I do not consider this case as a realistic one.

2.9 Unrealistic features of the complete markets model

"Home bias in equities puzzle" versus "Home bias in consumption puzzle"

Trade costs in goods markets obviously allow us to solve the "home bias in consumption puzzle". But that under reasonable preferences ($\gamma > 1$ and $\frac{1}{1-\rho} > 1$), trade costs in goods markets actually worsen the "home bias in equities puzzle" is a rather unexpected result. As often in international economics, the resolution of one puzzle is at the expense of the others. Since the "home bias in equities" is still a very pervasive phenomenon and that trade costs are necessary to solve the "home bias in consumption puzzle", one should be able to set-up a model with trade costs that is not inconsistent with observed equilibrium portfolios. Moreover, empirically, portfolios are biased towards trading partners, suggesting that an increase in trade costs reduces foreign asset holdings. Adding small frictions in international financial markets will help us to align our three stylized facts. This is the main motivation of the next section.

3 Adding frictions in financial markets

I now assume that both investors do not face the same investment opportunity set by assuming some frictions in international financial markets. Adding frictions in financial markets will obviously lead to some "home bias in equities" but the main point is that the interaction between trade costs and financial frictions also matters for portfolio choice. I will show that a decrease in trade costs make firms revenues

anything, on average, higher firms stock returns tend to be associated with a depreciated currency in developed countries. See Dominguez and Tesar [2004] for recent work on this issue.

[19] Corsetti, Dedola and Leduc [2004] and Kollmann [2005] also assume an elasticity smaller than 1.

[20] This is the case emphasized by Kollmann [2005]. However, perhaps counter-intuitively, at the margin, an increase in τ still reduces the equity home bias in this case (whereas an increase in a leads to a higher home bias).

more volatile. As a consequence, for a given level of financial frictions, the diversification opportunities provided by foreign assets increase when trade costs are reduced: domestic investors will more likely buy foreign assets when trade costs are low.

I introduce frictions in financial markets in a simple way: for each share of foreign assets bought, domestic investors will have to pay a proportional tax (T) on the dividend earned in the second period (and *vice-versa*, foreigners have to pay the same cost on domestic asset capital incomes in order to keep the symmetry[21]). This asset trade cost (T) features any frictions in international financial markets (information cost, different tax paid on foreign capital incomes...). The existence of informational asymmetries or "familiarity effects" in financial markets is the main message of Coval and Moskowitz [1999], Portes and Rey [2005] and Huberman [2001] to explain international equity trade. Looking at international taxation of capital incomes, Gordon and Hines [2002] find significant differences of fiscal treatment between investment in domestic assets and investment in foreign ones[22].

I add two more assumptions:

- Asset trade costs paid by foreigners are redistributed to domestic shareholders (nothing is lost in transit)

- $T << 1$, such that $T\widehat{R_i}$ will be negligible[23]

The main consequence of this financial friction is that agents will depart from the first-best portfolio and risk-sharing will no longer be optimal (technically speaking, the ratio of Lagrange-Multipliers of both budget constraints will no longer be equal to 1: $\lambda_H \neq \lambda_F$). Because markets are now incomplete, I cannot use the same resolution technique to find equilibrium portfolios and I have to solve the decentralized problem.

3.1 Goods market equilibrium under incomplete markets

I keep the parameter $\xi(a,\tau) = (\frac{1-a}{a})\left(\frac{1}{1+\tau}\right)^{\frac{\rho}{1-\rho}} \in [0,1]$, that is inversely related to trade costs in goods markets: an increase in ξ meaning a deeper trade integration.

Using demand functions in section (2.6), we get the following expressions for firms revenues (and capital incomes):

$$\widehat{R_H} = p_H\widehat{D_H} = -\frac{\rho}{1-\rho}\frac{2\xi}{(1+\xi)^2}(\widehat{p_H} - \widehat{p_F}) + \frac{1}{1+\xi}\widehat{I_H} + \frac{\xi}{1+\xi}\widehat{I_F} \quad (9)$$

$$\widehat{R_F} = p_F\widehat{D_F} = -\frac{\rho}{1-\rho}\frac{2\xi}{(1+\xi)^2}(\widehat{p_F} - \widehat{p_H}) + \frac{1}{1+\xi}\widehat{I_F} + \frac{\xi}{1+\xi}\widehat{I_H} \quad (10)$$

[21] We could have introduced an iceberg cost paid *ex-ante* when agents invest in foreign assets without changing the results: it will just have complicated the analysis since the quantity of capital provided to the firms would have been affected by this cost.

[22] In particular, withholdings taxes on the repatriation of foreign dividends (which amounts to 10 to 15% of total foreign dividend incomes) have to be paid by domestic investors

[23] This allows us to abstract from the hedging demand due to stochastic redistribution.

Firms revenues increase when:

- domestic prices are lower than foreign ones due to the gain in markets shares: this effect is larger when trade costs are low (high ξ) and when international competition is tough (high ρ).

- foreign and domestic aggregate incomes ($\widehat{I_H}$ and $\widehat{I_F}$) are higher since demand is higher: the presence of trade costs makes firm revenues more sensitive to domestic incomes.

The budget constraint in both countries is:

$$\begin{aligned} I_H &= \mu R_H k + (1-\mu) R_F (1-T) k + T R_H (1-\mu) k \\ I_F &= \mu R_F k + (1-\mu) R_H (1-T) k + T R_F (1-\mu) k \end{aligned}$$

Log-linearization of the budget constraint yields[24]:

$$\widehat{I_H} = \left(\mu \widehat{R_H} + (1-\mu)\widehat{R_F}\right) \tag{11}$$

$$\widehat{I_F} = \left(\mu \widehat{R_F} + (1-\mu)\widehat{R_H}\right) \tag{12}$$

Plugging (11) and (12) into (9) and rearranging terms:

$$(\widehat{R_H} - \widehat{R_F}) = -\frac{\rho}{1-\rho}\lambda(\xi,\mu)(\widehat{p_H} - \widehat{p_F}) \tag{13}$$

where $\lambda(\xi,\mu) = \frac{2\xi}{(1+\xi)[(1-\mu)+\xi\mu]}$

Equation (13) tell us how gains in market share due to smaller relative prices affect firms revenues in equilibrium.

Using $\widehat{p_i} = \widehat{R_i} - \widehat{a_i}$, we get the expression of firms cash-flows in terms of relative productivity shocks:

$$\widehat{R_H} - \widehat{R_F} = \kappa(\xi,\mu)(\widehat{a_H} - \widehat{a_F}) \tag{14}$$

where $\kappa(\xi,\mu) = \frac{\rho\lambda(\xi,\mu)}{1-\rho+\rho\lambda(\xi,\mu)}$

When the elasticity of substitution between home and foreign goods is larger than one ($\rho > 0$), $\kappa(\xi,\mu) > 0$ and home firms revenues expand relative to the foreign ones when productivity is higher in the home country.

Coming to world income, we have[25]:

$$\widehat{I_H} + \widehat{I_F} = \widehat{R_H} + \widehat{R_F} = \widehat{a_H} + \widehat{a_F} \tag{15}$$

Then, using (14) and (15), we get equilibrium firms revenues (and capital incomes) in terms of the productivity shocks:

$$\widehat{R_H} = \frac{1}{2}(1+\kappa(\xi,\mu))\widehat{a_H} + \frac{1}{2}(1-\kappa(\xi,\mu))\widehat{a_F} \tag{16}$$

$$\widehat{R_F} = \frac{1}{2}(1+\kappa(\xi,\mu))\widehat{a_F} + \frac{1}{2}(1-\kappa(\xi,\mu))\widehat{a_H} \tag{17}$$

[24] see appendix for a proof. Note that due to the redistribution of asset trade costs, (T) does not appear in the budget constraint in equilibrium.

[25] Remind that the world price index is used as a numeraire: $\widehat{P} = \frac{1}{2}(\widehat{p_H} + \widehat{p_F}) = 0$

3.2 Volatility of incomes and diversification gains

How does a productivity shock affect firms revenues in this two-country general equilibrium? Equations (14) to (17) allow us to answer this question: $\kappa(\xi, \mu)$ is increasing in ξ or decreasing in the level of trade costs. As a consequence, the impact of a good productivity shock relative to the foreign country increases capital incomes much more when trade costs are low. This is due to the gain of market shares in international markets: when trade costs are high, at given factor costs, a good productivity shock does not allow firms to sell much more output since foreign firms are sheltered from competition, as a consequence, firms cash-flows stay roughly stable. This makes firms revenues less volatile when frictions in goods markets are high. In other words, following a good supply shock in the home country, the fall in domestic prices necessary to absorb this additional supply is higher when goods markets are more segmented, which stabilizes firms revenues. To the contrary, when trade costs are low, firms increase their market share much more following a good shock relative to foreigners, which makes firms cash-flows more volatile. The evidence that an increasing competition from foreign markets makes firms sales more volatile is consistent with Thesmar and Thoenig [2004] and and Irvine and Pontiff [2005] at he firm-level. Easterly *et al.* [2000] and Kose *et al.* [2003] show that trade openness increases volatility of growth at the aggregate level. Janiak [2004] and Traca [2005] document similar effects looking at labour incomes. Of course the amplitude of the effect depends on the degree of competition in international markets: when competition is tougher (higher ρ), domestic firms revenues are much more sensitive to productivity shocks.

Turning to the correlation of firms revenues between countries, I show that the decrease of trade costs lowers the correlation of firms revenues across countries, since expanding the market share of domestic firms is at the expense of foreign firms.

Both effects will play in the same direction for portfolio: since the volatility of domestic incomes increases and the correlation of capital returns decreases, domestic investors will more likely buy foreign assets for a given level of friction in financial markets.

3.2.1 Volatility of capital returns

The volatility of real capital returns depends on the price index that is used to deflate capital incomes. I keep the world price index to deflate incomes but results do not depend on this choice.

I introduce σ_i the volatility capital incomes $(\widehat{R_i})$ in country (i).

σ is the volatility of productivity shocks in both countries and η the correlation between these shocks across countries ("fundamental correlation").

Using (15) and (16), we get:

$$\begin{aligned}\sigma_H^2 &= \sigma_F^2 = \frac{1}{2}\sigma^2\left(1+\eta+\kappa\left(\xi,\mu\right)^2\left(1-\eta\right)\right)\\ \frac{\partial\sigma_H^2}{\partial\xi} &= \kappa\left(\xi,\mu\right)\sigma^2(1-\eta)\frac{\partial\kappa\left(\xi,\mu\right)}{\partial\xi}\end{aligned}$$

Since under reasonable parameters values, $\frac{\partial\kappa(\xi,\mu)}{\partial\xi} > 0$, the volatility of capital returns increases when goods markets are getting more integrated.

We also have the following comparative static:

$$\frac{\partial\sigma_H^2}{\partial\rho} = 2\kappa\left(\xi,\mu\right)\sigma^2(1-\eta)\frac{\partial\kappa\left(\xi,\mu\right)}{\partial\rho} > 0$$

When competition in international markets is more severe (higher ρ), the volatility of incomes increases. If agents can substitute easily home and foreign goods, the fall in price necessary to accommodate an increase in the supply of home goods is much smaller: this increases the volatility of firms revenues by reducing the magnitude of the stabilizing behavior of the terms-of-trade.

3.2.2 Diversification gains

Diversification gains are measured in terms of $cov(\widehat{R_H}-\widehat{R_F},\widehat{R_H}-\widehat{R_F})$: when $Var(\widehat{R_H}-\widehat{R_F})$ is low, small financial frictions can generate very large home bias in portfolio. Indeed, in such a case, either assets are not very risky or highly correlated which reduces the diversification gains of holding foreign assets. This term will show up in the derivation as a key-parameter to determine the impact of the friction in financial markets on portfolio biases.

$$\begin{aligned}cov(\widehat{R_H}-\widehat{R_F},\widehat{R_H}-\widehat{R_F}) &= 2\kappa^2\left(\xi,\mu\right)\sigma^2(1-\eta)\\ \frac{\partial cov(\widehat{R_H}-\widehat{R_F},\widehat{R_H}-\widehat{R_F})}{\partial\xi} &= 4\kappa\left(\xi,\mu\right)\frac{\partial\kappa\left(\xi,\mu\right)}{\partial\xi}\sigma^2(1-\eta) > 0\\ \frac{\partial cov(\widehat{R_H}-\widehat{R_F},\widehat{R_H}-\widehat{R_F})}{\partial\rho} &= 4\kappa\left(\xi,\mu\right)\frac{\partial\kappa\left(\xi,\mu\right)}{\partial\rho}\sigma^2(1-\eta) > 0\end{aligned}$$

Diversification gains increase with the integration in the goods markets (and with the degree of competition): foreign assets become more attractive under a low level of trade costs (and a high degree of competition) for a given level of frictions (T) in financial markets. This the main point I will make clear when turning to equilibrium portfolios.

3.3 Equilibrium asset portfolios

I now come to the expression of optimal portfolios:

Domestic investors choose their portfolio in the following way :

- taking prices and variance/covariance structure of returns and goods prices as given.

- taking foreign investors asset holdings as given.

The second assumption is the main reason why both investors will hold undiversified portfolios and risk-sharing will not be optimal: the externality introduced by the tax in international financial markets is not internalized by both agents[26].

Given preferences and log-normal distribution of shocks, a representative investor in the home country maximizes the following objective function with respect to μ subject to its budget constraint:

$$E(\widehat{C_H}) - \frac{\gamma - 1}{2} Var(\widehat{C_H})$$

In appendix, I show that maximizing over μ and using symmetry gives[27]:

$$\mu = \left(\frac{1}{2} + \frac{T}{\gamma Var(\widehat{R_H} - \widehat{R_F})} + \frac{1}{2} \left(1 - \frac{1}{\gamma} \right) \frac{cov(\widehat{R_H} - \widehat{R_F}, \widehat{P_H} - \widehat{P_F})}{Var(\widehat{R_H} - \widehat{R_F})} \right) \tag{18}$$

Then, asset demand of domestic assets is the sum of three terms:

- the "world market portfolio"

- the domestic bias due to the friction in financial markets: note that as expected the bias is amplified by the term $Var(\widehat{R_H} - \widehat{R_F})^{-1}$ which is the inverse of the diversification gains provided by foreign assets.

- the hedging of real exchange rate fluctuations; this term cancels out when utility is logarithmic ($\gamma = 1$) and when $\gamma > 1$, the share of domestic assets in portfolio increases if and only if the real exchange rate and the domestic returns (relative to the foreign ones) are positively correlated.

3.4 Description of equilibrium portfolios

3.4.1 Without real exchange rate hedging ($\gamma = 1$)

First, I suppose that investors have a logarithmic utility ($\gamma = 1$) which allow us to abstract from the hedging of the real exchange rate component. Then, using (18), optimal portfolio choice simplifies into:

$$\mu = \frac{1}{2} \left(1 + \frac{T}{\kappa^2 (\xi, \mu) \sigma^2 (1 - \eta)} \right) \tag{19}$$

Given that $\kappa^2 (\xi, \mu)$ is decreasing in the level of trade costs and increasing in the degree of competition in international markets (increasing in ρ), we have the simple comparative statics:

$$\frac{\partial \mu}{\partial \tau} > 0 \qquad\qquad \frac{\partial \mu}{\partial \rho} < 0$$

Higher trade costs in goods markets reduce the needs of insurance of domestic agents since diversification benefits are reduced, which increases the domestic equity bias for a given level of friction (T) in financial markets. This contrasts with the results obtained in the previous section.

Higher competition in goods markets increases the need of insurance of domestic investors.

[26] One can easily show that the equilibrium will be suboptimal and that a world central planner that internalize the externality of taxes would provide better insurance to both agents by setting the same portfolios as in the previous section.

[27] See appendix. Here we assume that domestic and foreign are imperfect substitutes, *ie* $Var(\widehat{R_H} - \widehat{R_F}) \neq 0$, otherwise portfolios are undetermined.

Calibration:

Preferences	
Relative risk-aversion	$\gamma = 1$
Between-country elasticity of substitution	$\frac{1}{1-\rho} = 5$
Productivity Shocks	
Volatility	$\sigma = 0.02$
Correlation	$\eta = 0.35$
Goods and Asset markets frictions	
Home-bias in preferences	$a = 0.70$
Trade costs	$\tau \in [0; 1]$
Financial Frictions	$T = 1.10^{-4}$

Table 3: Parameters values

The volatility and correlation of productivity shocks are made to match international business cycles correlation and business cycles volatility[28] (see Heathcote and Perri [2004]).

I set the level of frictions in financial to $T = 1.10^{-4}$. The level of financial integration is such that for the parameters value chosen, the home bias in equities is around 30% for a degree of trade openness of 25% (Export+Import over GDP ratio). One should notice that the level of frictions introduced is fairly low: indeed, counteracting terms-of-trade movements provides already a good insurance mechanism to uncertainty in both markets (like in Cole and Obstfeld [1991] and Pavlova and Rigobon [2003]) and consequently very small financial frictions generate very large portfolio biases.

The numerical results of this calibration are shown in figure 2. Decreasing trade costs from 60% to 20% corresponds to a 10% increase in the import over GDP ratio: this is associated with a 7% increase in the share of foreign asset holdings. In this benchmark calibration, a one percent increase in the import over GDP ratio leads to an 0.7% increase of foreign asset holdings. This is very close to the elasticities found in Aviat and Coeurdacier [2004] where we found an elasticity between 0.6 and 0.7.

[28]The volatility might appear low given the volatility of stock returns: indeed, the volatility of stock markets is much higher than the volatility of business cycles. However, increasing the volatility does not change any of the results. The main point is that under higher volatility, we would need higher frictions in financial markets to match observed portfolios.

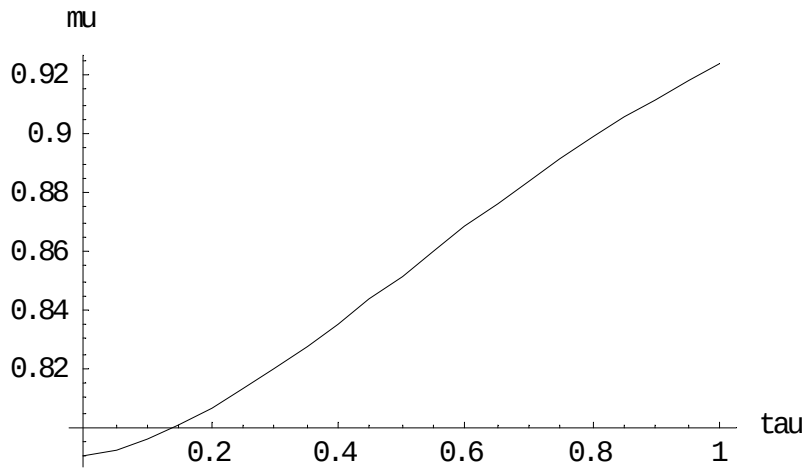

Figure 2: Impact of trade costs (τ) on holdings of domestic shares (μ) in presence of financial frictions. Parameters given in table 3.

3.4.2 With real exchange rate hedging ($\gamma = 2$)

The main criticism that can be addressed to the previous part is that the "real exchange rate hedging" component has been ignored: indeed, if one believe that workers-investors are more risk averse than log-, one would expect this component in asset demand to play in the opposite direction: indeed, as shown in the previous section, when the real exchange rate appreciates, it is bad news for domestic asset returns and domestic investors should bias their portfolio towards foreign assets to keep their purchasing power constant (and all the more that their consumption basket is biased towards home goods). Since two forces are playing in opposite directions, the dependency of asset portfolios as a function of trade costs becomes undetermined.

When $\gamma = 2$, equation (19) simplifies into:

$$\mu = \frac{1}{2}\left(1 + \frac{T}{2\kappa^2(\xi,\mu)\,\sigma^2(1-\eta)} - \frac{1}{2}\frac{1-\xi}{1+\xi}\frac{1-\rho}{\rho\lambda(\xi,\mu)}\right) \tag{20}$$

Except the relative risk aversion and the level of financial frictions, I keep the same parameters as before: indeed, since a higher risk aversion makes investors more likely to have diversified portfolios, I need to increase the level of frictions in financial markets to match observed portfolios. I set $T = 2.10^{-4}$ to keep a home bias in portfolio around 30% in the benchmark calibration (which is still reasonably low). Figure 4 shows the equilibrium portfolio as a function of trade costs: not very surprisingly, the real exchange rate hedging component dampens the effect of trade costs on the holdings of domestic assets compared to the previous case. But even in this case, an increase in trade costs reduce the purchase of foreign assets and reinforces the home bias in portfolio. The lower demand for insurance induced by a lower competition from foreign firms dominates the hedging demand to insure real exchange rate fluctuations.

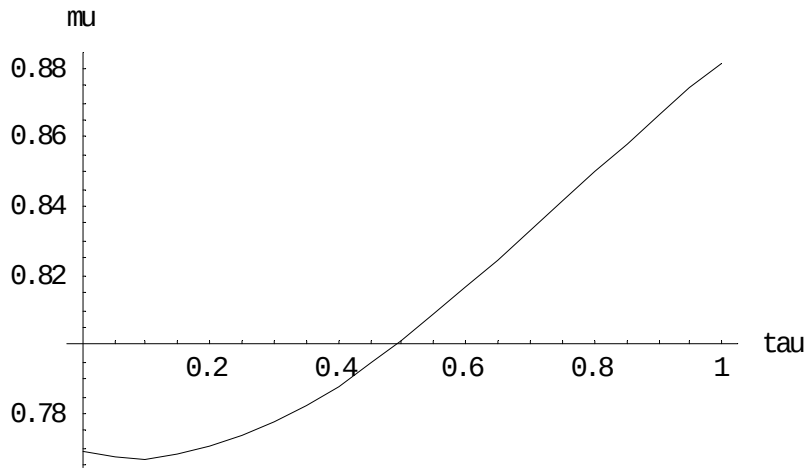

Figure 3: Impact of trade costs (τ) on holdings of domestic shares (μ) in presence of financial frictions with $\gamma = 2$

A one percent increase in the share of imports over GDP leads to a 0.5% increase in the share of foreign assets in the portfolio. This is slightly lower than the elasticities found in Aviat and Coeurdacier [2004] but economically significant.

4 Discussion

4.1 Dynamic set-up

The set-up used in this paper is static. Whether the results found in both sections are still valid in a dynamic two-country equilibrium is a meaningful question. I do not think that the overall message of the paper will be qualitatively modified in a dynamic setting. Indeed, an increase in domestic production will still lead to a decrease in domestic prices, making asset returns and real exchange rate negatively correlated in standard cases. Then, the foreign bias in portfolio to hedge real exchange rate fluctuations will certainly show up in a dynamic model. In a dynamic asset-pricing model, Pavlova and Rigobon [2003] show that real exchange rate and asset returns are moving in opposite directions following a supply shock.

Concerning the impact of frictions in financial markets, I am also very confident that the volatility of asset returns and the diversification gains provided by foreign assets will be decreasing with the level of trade costs in a dynamic set-up[29], which would amplify the effect of any friction in financial markets on portfolio composition.

The main question is what happens for investment: in the static case, capital is fixed but in a dynamic case, agents reinvest part of their incomes in production. The optimal investment path anticipated by

[29] A proof of this result is available on request in the case of log-utility

investors clearly affects their portfolio. The nature of investment goods also matters: in our set-up, since in period 0, the equilibrium is fully symmetric, no matter which mix of domestic and foreign goods is used as investment goods in domestic and foreign production. Heathcote and Perri [2004] show that in presence of a bias towards home goods as production inputs, agents exhibit a home bias in portfolio. However, in their set-up, agents have log-utility which rules out any hedging of the real exchange rate. A two-country dynamic model with trade costs, endogenous investment and portfolio choice is certainly needed.

4.2 Nature of the shocks

In this model, we only consider productivity shocks as a source of uncertainty. The results found would certainly hold in presence of any supply shocks since supply shocks are accompanied by a counteracting relative price change (and then real exchange rate change), which is the key-mechanism driving foreign bias in portfolio in the complete markets case.

However, one might expect to reverse the results of section 2 in presence of demand shocks: indeed, in presence of trade costs, a domestic demand shock affects more domestic firms than foreign ones since demand is biased domestically. For given supply, a domestic demand shock would drive domestic prices and domestic asset returns up, generating a positive correlation between both variables, even more when trade costs are high. If demand shocks are the main source of uncertainty, it could potentially generate a home bias in portfolio that is increasing in the level of trade costs. The main question is: how should we model these demand shocks? Following Stockman and Tesar [1995] and Pavlova and Rigobon [2003], we could add preference shocks in form of shocks to the discount factor to the previous set-up but since these shocks affect the agent preferences, they would also affect portfolios in a surprising way: agents will more likely buy assets that give higher returns in the states of nature where they prefer consuming today rather than tomorrow. The way demand shocks are introduced is certainly determinant and I leave for future research a full-fletch two-country model with endogenous portfolio choice in presence of supply and demand shocks.

4.3 Multi-country framework

The last caveat I want to point out is the use of a two-country framework. Indeed, in section 2, I found out that portfolio biases as a function of trade costs are non-linear: foreign bias under reasonable trade costs and home bias for very high trade costs. I suspect that a multi-country framework would lead to a very interesting portfolio allocation, which would extend in a sense this non-linearity: one might expect that home investors bias their portfolio towards assets of the closest competitors of domestic firms (low trade costs) since these assets yield higher returns when domestic firms are performing badly (and consequently

when domestic prices are high) and not at all towards countries whose firms are not competing with the domestic ones (very high trade costs). The intensive and the extensive margin of trade frictions should play in opposite directions. The proof of this conjecture is also left for future work.

5 Conclusion

In this paper, I have shown that trade costs in goods markets alone cannot generate any "home bias in portfolio" under reasonable preferences. To the contrary, if trade costs are the only source of friction in international markets, investors should bias their portfolio towards foreign assets and all the more that trade costs are high. This a very important result which goes against some conventional wisdom in international economics that has recently put forward trade costs as a the relevant friction to solve the "home bias in portfolio puzzle". I proposed then another explanation of the low level of diversification of investors: a combination of small frictions between financial markets and a low degree of openness of goods markets (high trade costs).

Indeed, I have shown that the interaction between imperfections in capital markets and trade costs matters: the reason is that trade integration increases uncertainty by increasing competition in product markets and investors will then more likely have diversified portfolios. This mechanism gives a channel through which a reduction of trade costs in goods markets enhances trade in assets and this theoretical prediction is fully in line with observed international asset allocation. I do not think that this result depends on the way capital market imperfections are modelled: here, we adopt a very simple friction by assuming some taxes on the repatriation of dividends. However, whatever the friction introduced, portfolio biases will always be amplified when diversification benefits are low and the fact that goods market integration raises the gains of diversification by raising firms sales uncertainty is certainly a robust result. There is already some evidence of this link between trade integration and firm level volatility but I guess more empirical work on this issue is needed.

Moreover, in terms of economic policy, if trade integration raises uncertainty, it should be accompanied by deeper capital markets integration to provide better insurance to firms and people incomes. This might be a reason why trade and financial globalization are often going together.

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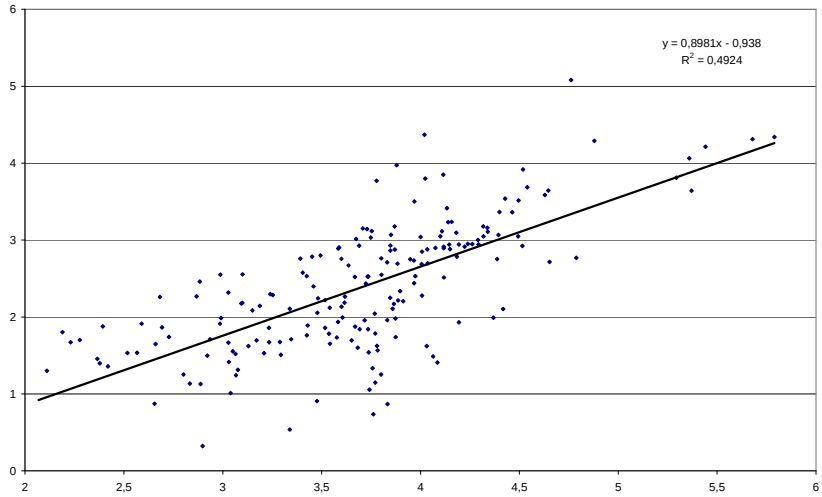
6 Appendix

6.1 Relationship between Asset and Goods Trade



Sources: Kraay *et al.* [2005] and Penn-World Tables. Author's calculations.

Figure 4: Positive Relationship between log(Financial Openness) and log(Trade Openness).

Vertical Axis: Financial Openness is defined as the ratio of (Claims of Domestic Residents on Foreign capital + Claims of Foreigners on Domestic Capital) over Domestic Aggregate Wealth.

Horizontal Axis: Trade Openness is defined as the ratio of (Goods Exports + Goods Imports) over GDP.

Data on Financial Openness are from Kraay *et al.* [2005] for a sample of 39 countries over the period 1967-1997. Data of Trade Openness are from Penn-World Tables. Each point corresponds to a five-year average of both variables for one country (6 observations per country).

6.2 Portfolios under complete markets using investor maximization

Using the log-normal distribution of variables ($\frac{u}{u^*}$), we get the following deviation of utility relative to the steady-state value U^*:

$$\begin{aligned}\frac{U_i}{U^*} &= E\left[\frac{\left(\frac{C^i}{C^*}\right)^{1-\gamma}}{1-\gamma}\right] = \frac{1}{1-\gamma}E\left[\exp((1-\gamma)\ln(\frac{C^i}{C^*})\right] \\ &= \frac{1}{1-\gamma}\exp\left[(1-\gamma)\left(E(\widehat{C_i}) - \frac{\gamma-1}{2}Var(\widehat{C_i})\right)\right]\end{aligned}$$

Then: $\max\{U_H\} \Leftrightarrow \max_\mu \left\{E(\widehat{C_H}) - \frac{\gamma-1}{2}Var(\widehat{C_H})\right\}$

Due to budget constraint:

$\widehat{C_H} = \widehat{I_H} - \widehat{P_H}$

$E(\widehat{C_H}) = E(\widehat{I_H}) - E(\widehat{P_H}) = -\frac{1}{2}Var(\widehat{I_H})$+t.i.p[30]

$$\begin{aligned}V_H &= -\frac{1}{2}Var(\widehat{I_H}) - \frac{\gamma-1}{2}Var(\widehat{I_H} - \widehat{P_H}) \\ &= -\frac{\gamma}{2}Var(\widehat{I_H}) + (\gamma-1)\,cov(\widehat{I_H}, \widehat{P_H}) \\ &= -\frac{\gamma}{2}\left[\left((\mu)^2 + (1-\mu)^2\right)Var(\widehat{R}) + 2\,(\mu)\,(1-\mu)\,cov(\widehat{R_H}, \widehat{R_F})\right] \\ &\quad + (\gamma-1)\,\mu cov(\widehat{R_H} - \widehat{R_F}, \widehat{P_H}) + t.i.p\end{aligned}$$

Due to symmetry:

$$\begin{aligned}cov(\widehat{R_H} - \widehat{R_F}, \widehat{P_H}) &= \frac{1}{2}cov(\widehat{R_H} - \widehat{R_F}, \widehat{P_H} - \widehat{P_F}) \\ &= \frac{1}{2}\frac{\theta_\rho}{1-\psi}Var(\widehat{R_H} - \widehat{R_F})\end{aligned}$$

Here I suppose $(1-\psi) \neq 0$ since when $(1-\psi) = 0$, domestic and foreign assets are perfect substitutes and portfolios are undetermined.

Then :

$$\begin{aligned}V_H = -\frac{\gamma}{2}&\left[\left((\mu)^2 + (1-\mu)^2\right)Var(\widehat{R}) + 2\,(\mu)\,(1-\mu)\,cov(\widehat{R_H}, \widehat{R_F})\right] \\ &+\mu\frac{(\gamma-1)}{2}\frac{\theta_\rho}{1-\psi}Var(\widehat{R_H} - \widehat{R_F})\end{aligned}$$

$$\begin{aligned}\frac{\partial V_H}{\partial \mu} = -\gamma&\left[((2\mu-1))\,(Var(\widehat{R}) - cov(\widehat{R_H}, \widehat{R_F}))\right] \\ &+\frac{(\gamma-1)}{2}\frac{\theta_\rho}{1-\psi}Var(\widehat{R_H} - \widehat{R_F})\end{aligned}$$

Due to symmetry:

$$Var(\widehat{R_H} - \widehat{R_F}) = 2(Var(\widehat{R}) - cov(\widehat{R_H}, \widehat{R_F}))$$

[30] where t.i.p is for terms independent on policy

$$\begin{aligned}\frac{\partial V_H}{\partial \mu} &= 0 \Leftrightarrow (2\mu - 1) = \left(1 - \frac{1}{\gamma}\right)\frac{\theta_\rho}{1-\psi} \\ \mu &= \frac{1}{2}\left(1 - \frac{(1-\frac{1}{\gamma})\theta_\rho}{\frac{\rho}{1-\rho} + \theta_\rho^2\left(\frac{1}{\gamma} - \frac{1}{1-\rho}\right)}\right)\end{aligned}$$

6.3 Derivation of the equilibrium with financial frictions

6.3.1 Derivation of the equilibrium

Log-linearization of the budget-constraint:

$$\begin{aligned}I_H &= \mu R_H k + (1-\mu)R_F(1-T)k + TR_H(1-\mu)k \\ I_F &= \mu R_F k + (1-\mu)R_H(1-T)k + TR_F(1-\mu)k\end{aligned}$$

$$I^* = R^* k$$

$$\frac{I_H - I^*}{I^*} = \left(\mu\frac{R_H - R^*}{R^*} + (1-\mu)\frac{R_F - R^*}{R^*} + (1-\mu)\left(\frac{R_H - R_F}{R^*}\right)T\right)$$

Using $T << 1$ and neglecting second-order terms like $T\widehat{u}$, we get:

$$\widehat{I_H} = \left(\mu\widehat{R_H} + (1-\mu)\,\widehat{R_F}\right)$$

Equilibrium firms revenues:

$$\begin{aligned}\widehat{R_H} &= -\frac{\rho}{1-\rho}\frac{2\xi}{(1+\xi)^2}(\widehat{p_H} - \widehat{p_F}) + \frac{1}{1+\xi}\left[\mu\widehat{R_H} + (1-\mu)\widehat{R_F}\right] + \\ &\quad \frac{\xi}{1+\xi}\left[\mu\widehat{R_F} + (1-\mu)\widehat{R_H}\right] \\ \widehat{R_F} &= -\frac{\rho}{1-\rho}\frac{2\xi}{(1+\xi)^2}(\widehat{p_F} - \widehat{p_H}) + \frac{1}{1+\xi}\left[\mu\widehat{R_F} + (1-\mu)\widehat{R_H}\right] \\ &\quad + \frac{\xi}{1+\xi}\left[\mu\widehat{R_H} + (1-\mu)\widehat{R_F}\right]\end{aligned}$$

$$\begin{aligned}\widehat{R_H}\left[\xi + (1-\mu)(1-\xi)\right] - \left[(1-\mu) + \xi\mu\right]\widehat{R_F} &= -\frac{\rho}{1-\rho}\frac{2\xi}{1+\xi}(\widehat{p_H} - \widehat{p_F}) \\ \widehat{R_F}\left[\xi + (1-\mu)(1-\xi)\right] - \left[(1-\mu) + \xi\mu\right]\widehat{R_H} &= -\frac{\rho}{1-\rho}\frac{2\xi}{1+\xi}(\widehat{p_F} - \widehat{p_H})\end{aligned}$$

$$\begin{aligned}\widehat{R_H} &= -\frac{\rho}{1-\rho}\frac{\xi}{1+\xi}\frac{(\widehat{p_H} - \widehat{p_F})}{\left[(1-\mu) + \xi\mu\right]} \\ \widehat{R_F} &= -\frac{\rho}{1-\rho}\frac{\xi}{1+\xi}\frac{(\widehat{p_F} - \widehat{p_H})}{\left[(1-\mu) + \xi\mu\right]}\end{aligned}$$

6.3.2 Porfolio choice

$$E(\widehat{C_H}) - \frac{\gamma-1}{2} Var(\widehat{C_H})$$

Due to budget constraint : $\widehat{P_H} + \widehat{C_H} = \widehat{I_H}$

$$E(\widehat{I_H}) - E(\widehat{P_H}) - \frac{\gamma-1}{2} Var(\widehat{I_H} - \widehat{P_H}) = -T(1-\mu) + T(1-\mu_F) - \frac{\gamma}{2} Var(\widehat{I_H}) - (\gamma-1)\, cov(\widehat{I_H}, \widehat{P_H}) + t.i.p$$

where μ_F is the number of foreign shares held by foreigners: in equilibrium $\mu_H = \mu_F = \mu$ but the domestic investor chooses its portfolio taking μ_F as given.

$$\begin{aligned} Var(\widehat{I_H}) &= (\mu)^2 Var(\widehat{R_H}) + (1-\mu)^2 Var(\widehat{R_F}) \\ &\quad +2(\mu)(1-\mu) cov(\widehat{R_H}, \widehat{R_F}) \\ cov\left(\widehat{I_H}, \widehat{P_H}\right) &= (\mu) cov(\widehat{R_H}, \widehat{P_H}) + (1-\mu) cov(\widehat{R_F}, \widehat{P_H}) \\ &= \mu cov(\widehat{R_H} - \widehat{R_F}, \widehat{P_H}) + t.i.p \end{aligned}$$

Then the objective function is equivalent to:

$$\begin{aligned} V_H &= \frac{2T\mu}{\gamma} - (\mu)^2 Var(\widehat{R_H}) - (1-\mu)^2 Var(\widehat{R_F}) - 2(\mu)(1-\mu) cov(\widehat{R_H}, \widehat{R_F}) \\ &\quad +2\left(1 - \frac{1}{\gamma}\right) \mu cov(\widehat{R_H} - \widehat{R_F}, \widehat{P_H}) + t.i.p \end{aligned}$$

Maximizing over μ gives:

$$\begin{aligned} 0 &= \frac{\partial V_H}{\partial \mu} = \frac{2T}{\gamma} + 2(\mu) Var(\widehat{R_H}) - 2(1-\mu) Var(\widehat{R_F}) \\ &\quad +2(1-2\mu) cov(\widehat{R_H}, \widehat{R_F}) \\ &\quad +2\left(1 - \frac{1}{\gamma}\right) cov(\widehat{R_H} - \widehat{R_F}, \widehat{P_H}) \end{aligned}$$

$$2(2\mu-1)(Var(\widehat{R}) - cov(\widehat{R_H}, \widehat{R_F})) = \frac{2T}{\gamma} + \left(1 - \frac{1}{\gamma}\right) cov(\widehat{R_H} - \widehat{R_F}, \widehat{P_H} - \widehat{P_F})$$

$$\mu = \left(\frac{1}{2} + \frac{T}{\gamma Var(\widehat{R_H} - \widehat{R_F})} + \frac{1}{2}\left(1 - \frac{1}{\gamma}\right) \frac{cov(\widehat{R_H} - \widehat{R_F}, \widehat{P_H} - \widehat{P_F})}{Var(\widehat{R_H} - \widehat{R_F})} \right)$$

Or equivalently, using the equilibrium variance/covariance structure of returns and prices:

$$\mu = \left(\frac{1}{2} + \frac{T}{2\gamma\kappa^2(\xi,\mu)\sigma^2(1-\eta)} - \frac{1}{2}\left(1 - \frac{1}{\gamma}\right) \frac{1-\xi}{1+\xi} \frac{1}{\frac{\rho}{1-\rho}\lambda(\xi,\mu)} \right)$$