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Jorge D. Selaive and Vicente Tuesta

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Real Exchange Rate Anomaly*

Jorge D. Selaive†
New York University

Vicente Tuesta&
New York University

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Abstract: An unresolved issue in international macroeconomics is the apparent lack of risk-sharing across countries, which contradicts the prediction of models based on the assumption of complete markets. We assess the importance of financial frictions in this issue by constructing an incomplete market model with stationary net foreign assets (*NFA*) and imperfect pass-through (*IPT*). In this paper, there is a cost of bond holdings that allows us to incorporate the dynamics of *NFA* into the risk-sharing condition. On theoretical grounds, our results suggest that the dynamics of *NFA* may account for the lack of risk-sharing across countries. In addition, the *IPT* mechanism, by closing the current account channel, does not help to explain this feature of the data. On empirical grounds, we test the risk-sharing condition derived in the paper, and we find that growth factors of consumption and real exchange rates behave in a manner that may be consistent with a significant role for the net foreign asset position.

Keywords: Net Foreign Assets, Imperfect Pass-through, Incomplete Markets, Uncovered Interest Rate Parity

JEL Classification Numbers: F31, F32, F41

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† Correspondence to Jorge D. Selaive, e-mail: js899@nyu.edu.

& Correspondence to Vicente Tuesta, e-mail: vt246@nyu.edu.

1 Introduction

Chari, Kehoe and McGrattan (2001), hereafter CKM, find that the main discrepancy between complete markets sticky price models and the data is that models predict a high cross-correlation between the real exchange rate and relative consumptions across countries. However, in the data there is not a clear pattern. They refer to this discrepancy as the *consumption-real exchange rate anomaly*.[1]

In order to break the tight link between the real exchange and relative consumptions, CKM restricted the set of assets that can be traded across the countries. In their setup, uncontingent nominal bonds denominated in home currency are traded, so asset markets are incomplete. Although this channel was theoretically promising in addressing the *anomaly*, it failed to explain it.[2]

One of the limitations of their approach is that the uncovered interest parity (UIP) holds. The UIP relation postulates that the interest rate differential between two countries should equal the expected exchange rate change. However, there is vast empirical evidence suggesting that UIP does not hold (see Chinn and Meredith (2002) for a recent reference). Moreover, recent evidence presented by Lane and Milesi-Ferretti (2001b) assigns a significant role to the net foreign asset position (hereafter, NFA) in determining the real interest rate differential[3]. Finally, the assets market structure where a single risk-free uncontingent nominal bond is traded has been tested and partially rejected by Obstfeld (1989), Ravn (2001) and Head, Mattina and Smith (2002).

During the last few years, New Open Economy Macroeconomics models ($NOEM$) have gained appeal among designers of business cycle models and policy makers. One of the main advantages of these models is that they allow the analysis of positive implications and normative policy prescriptions under the rigor of an explicit microfunded model (Lane (2001) provides a survey of this literature). In general, these models have assumed complete assets market[4]. However, models under this asset market structure cannot explain the *consumption-real exchange rate anomaly* since the real exchange rate evolves according to the ratio of marginal utilities of consumption, and a large positive cross-correlation between the real exchange rate and relative consumption is predicted[5].

Another feature of these models is that they have considered the implications of two polar cases of pricing assumptions under nominal rigidities[6]: Producer Currency Pricing, where there is perfect pass-through (PPT), and *Price-to-Market* where the pass-through is zero in the short-run. Producer Currency Pricing brings about a strong *expenditure-switching effect* that redirects world demand in favor of domestic

[1]Backus and Smith (1993) had reported this anomaly in a IRBC model with non-traded goods.

[2]Obstfeld and Rogoff (2000) list this "disconnect" among the central unresolved puzzles in international macroeconomics.

[3]Monetary shocks may also account for large deviations in the UIP. See Kim and Roubini (2000) and Faust and Rogers (2003).

[4]Corsetti and Pesenti (2002), in a stochastic environment, introduce incomplete markets, although they shut down the current account channel by assuming unitary intratemporal elasticity of substitution between home and foreign goods.

[5]This conclusion is limited to the case where there are no preference shocks. We do not rely on these shocks to explain the *anomaly*.

[6]Empirical evidence assembled by Engel and Rogers (1996), Engel (1993) and Goldberg and Knetter (1997), among others, shows that there are large deviations from the law of one price for traded goods. On the other hand, departures from PPP are also an empirical regularity already documented by many other authors. It is important to clarify that the law of one price may hold even when PPP does not.

tradable goods after a nominal depreciation of the exchange rate which ends up splitting outputs and commoving consumptions. On the other hand, under *Price-to-Market,* prices are set in the currency of the final consumer, and the *expenditure-switching effect* is eliminated. The previous two extreme price-setting assumptions have been rejected at the empirical level[7], and it seems to be appealing to consider intermediate degrees of pass-through.

The aim of this paper is to evaluate how a *stochastic new open macro model* with incomplete and imperfect financial markets, along with imperfect pass-through, helps to solve the *consumption-real exchange rate anomaly.* We also check the robustness of our results by testing econometrically the risk-sharing condition derived in the paper.

To set up our model we follow previous contributions by Kollmann (2002), P. Benigno (2001) and Schmitt-Grohe and Uribe (2001). Two risk-free one period nominal uncontingent bonds are traded, and a cost of undertaking positions in the international financial markets allows us to characterize imperfect financial markets. Under our asset market structure, the NFA breaks the tight link between real exchange rate and marginal utilities that characterizes models with complete markets. This result arises because in our model the uncovered interest parity does not hold, and importantly, it is affected by the net foreign asset position due to the presence of a cost of bond holdings.

We also need to choose the channel of real exchange rate fluctuations. There are two approaches: deviations from the law of one price for traded goods across countries, or fluctuations in the relative prices of non-traded to traded goods. In our paper, we combine both by introducing non-tradable goods into the economy, and distribution costs in order to generate deviations from the law of one price in the tradable sector[8]. Non-traded goods are appealing in an incomplete market setup because they allow an assessment of the impact on transfers from their relative prices. Recently, Lane and Milesi-Ferretti (2001a) argue that a model with only tradable goods may neglect the potential impact on transfers from the relative price of non-traded goods. Hence, the wealth effect stemming from the level of net foreign assets on the labor supply of non-tradable goods may be better captured in a heterogenous sector model. On the other hand, we follow Bunstein, Neves and Rebelo (2000) and Corsetti and Dedola (2002) in order to get deviations from the law of one price so we allow for partial degrees of pass-through in a dynamic sticky prices environment.[9]

In the model, the UIP does not hold because of the presence of a cost of undertaking positions in the international asset market that interacts with the incomplete asset market structure. Deviations from the UIP will allow us to give an explicit role to the NFA in the risk-sharing condition, breaking the monotonic positive relation between the real exchange rate and relative consumptions.

[7]See Campa and Goldberg (2002) for an extensive analysis of the determinants of the pass-through across the OECD countries.

[8]Betts and Kehoe (2001) investigate the relationship between a measure of relative price of non-traded goods to traded goods across countries and the real exchange rate in a sample of 52 countries. They find that 1/3 of the real exchange variance is explained by fluctuations in the relative price of nontraded goods. Stockman and Tesar (1995) present models in which the real exchange rate is exactly the relative price of nontraded to traded goods across countries. Backus and Smith (1993) also conclude that non-traded goods may account for many features of international macroeconomics data.

[9]The latter authors develop a two-period model where distribution costs incurred in the delivery of tradable goods generate a gap between the consumer and the producer price of import goods.

Our results suggest that incomplete asset markets, in which the net foreign asset position enters in the risk-sharing condition, help to address the *consumption-real exchange rate anomaly.* The model predicts a zero or even negative cross-correlation between the real exchange rate and relative consumptions as it is observed in the data. When a country accumulates assets, there is a wealth effect that reduces the labor supply in the non-tradable sector, which affects the relative price of non-traded goods, and disconnects the real exchange rate and relative consumptions. After considering intermediate degrees of pass-through the *anomaly* turns out to be more severe since the current account channel is dampened, and therefore, the wealth effects are diminished.

The sensitivity analysis shows that the larger the intratemporal elasticity of substitution between foreign and home traded goods the better the model does in explaining the *anomaly*. The previous result stems from the fact that the NFA position becomes more responsive to changes in the terms of trade as this elasticity gets higher.

Another interesting result is that the larger the international financial friction the stronger is the wealth effect associated with the incomplete market structure. Thus, the NFA becomes more important in explaining the *anomaly*.

We also investigate two variations of the benchmark model, and doing so we check the robustness of our results. The first variation introduces perfect mobility of labor across sector. The second variation is a flexible-price version of the model. Our previous results hold under these two extensions.

In our model, a negative comovement between the real exchange rate and relative consumptions is predicted after a productivity shock in the tradable sector. Following the shock, there is a worsening of the terms of trade that generates an increase in domestic output above domestic consumption. The asset accumulation triggers a real exchange rate appreciation which is consistent with the *Harrod-Balassa-Samuelson effect (HBS).* The wealth effect generates a decrease in the labor supply in the nontraded sector that increases the relative prices of nontraded goods, and consequently, appreciates the real exchange rate. When we introduce IPT, the NFA accumulation is smaller due to the dampening of the expenditure-switching effect.

Motivated by the results of the calibrated model, we use the generalized method of moments (GMM) to test the risk-sharing condition derived in the paper. Our estimations suggest that growth factors of consumption and real exchange rates may behave in a manner which is consistent with a significant role for the NFA. Therefore, it seems reasonable to consider a theory where the NFA position affects the risk-sharing across countries.

Our paper is organized as follows. In Section 2 we introduce the model and illustrate briefly the equations in log-linear form. In Section 3 we analyze the quantitative properties of the model and we also perform a sensitivity analysis.In Section 4 we test empirically the risk-sharing condition derived in section 2. Finally, section 5 concludes.

2 The Model

In this section, we introduce a dynamic two-country *new open macro model*. We extend the model to allow for tradable and non-tradable goods, incomplete financial integration and imperfect pass-through in a *stochastic* environment.

2.1 Preferences

Population in the home country belongs to the interval $[0, n]$, while in the foreign economy it is in the segment $(n, 1]$. Similarly, tradable and non-tradable firms at home produce goods on the interval $[0, n]$ and are indexed by h. Foreign firms do so on the interval $(n, 1]$ and are indexed by f. C_t^h denotes the level of consumption in period t for individual h, $\frac{M_t^h}{P_t}$ his real balances holdings and $N_{T,t}^h$ $N_{NT,t}^h$ denotes agent $h's$ labor supply in the tradable and non-tradable sector, respectively. The preferences of a household h in the country H are assumed to be[10]

$$U_t^h = E_t \left\{ \sum_{s=t}^{\infty} \beta^{s-t} \left[U(C_{t+s}^h) + L\left(\frac{M_{t+s}^h}{P_{t+s}}\right) - V\left(N_{T,t+s}^h, N_{NT,t+s}^h\right) \right] \right\}, \tag{1}$$

Labor is the only input in this economy, and $V(.)$ is increasing, convex and separable in both labors[11] $(N_{T,}^h, N_{NT}^h)$. $L(.)$ is increasing and concave in real balances.

We define the consumption index as

$$C_t^h \equiv \left[\gamma^{1/\varepsilon} \left(C_{T,t}^h\right)^{\frac{\varepsilon-1}{\varepsilon}} + (1-\gamma)^{1/\varepsilon} \left(C_{NT,t}^h\right)^{\frac{\varepsilon-1}{\varepsilon}} \right]^{\frac{\varepsilon}{\varepsilon-1}}, \tag{2}$$

where ε is elasticity of substitution between tradable and non-tradable goods, and γ is the share of tradable goods in the consumption basket. C_T is the sub-index of consumption for traded goods defined as

$$C_{T,t}^h \equiv \left[n^{\frac{1}{\theta}} \left(C_{H,t}^h\right)^{\frac{\theta-1}{\theta}} + (1-n)^{\frac{1}{\theta}} \left(C_{F,t}^h\right)^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}}, \tag{3}$$

where θ is elasticity of substitution between home and foreign tradable goods. C_H^j and C_F^j are indexes of consumption across the continuum of differentiated goods produced in country H and F, and are given by

$$C_{H,t}^h \equiv \left[\left(\frac{1}{n}\right)^{\frac{1}{\sigma}} \int_0^n c_t^h(h)^{\frac{\sigma-1}{\sigma}} dh \right]^{\frac{\sigma}{\sigma-1}}, C_{F,t}^h \equiv \left[\left(\frac{1}{1-n}\right)^{\frac{1}{\sigma}} \int_n^1 c_t^h(f)^{\frac{\sigma-1}{\sigma}} df \right]^{\frac{\sigma}{\sigma-1}}, \tag{4}$$

where $\sigma > 1$ is the elasticity of substitution across goods produced within a country. Similarly, the consumption of non-traded goods in the home country is given by

$$C_{NT,t}^h \equiv \left[\left(\frac{1}{n}\right)^{\frac{1}{\sigma}} \int_0^n c_{NT,t}^h(h)^{\frac{\sigma-1}{\sigma}} dh \right]^{\frac{\sigma}{\sigma-1}}, \tag{5}$$

[10]Note that utility is separable in consumption, real money holdings and labour effort. β is the intertemporal discount factor ($0<\beta < 1$).

[11]This assumption implies inmobility of labors across sectors. In our sensitivity analysis we relax this assumption allowing for perfect labor mobility across sectors.

In this context, the general price index that corresponds to the previous specification is given by

$$P_t \equiv \left[\gamma\left(P_{T,t}\right)^{1-\varepsilon}+(1-\gamma)\left(P_{NT,t}\right)^{1-\varepsilon}\right]^{\frac{1}{1-\varepsilon}}, \tag{6}$$

where the price index for tradable goods has the following form

$$P_{T,t} \equiv \left[n\left(P_{H,t}\right)^{1-\theta}+(1-n)\left(P_{F,t}\right)^{1-\theta}\right]^{\frac{1}{1-\theta}}, \tag{7}$$

with prices of home and foreign tradable goods, and non-tradable goods defined, respectively as

$$P_{H,t} \equiv \left[\left(\frac{1}{n}\right)\int_0^n p_t(h)^{1-\sigma}dh\right]^{\frac{1}{1-\sigma}},\ P_{F,t} \equiv \left[\left(\frac{1}{1-n}\right)\int_n^1 p_t(f)^{1-\sigma}df\right]^{\frac{1}{1-\sigma}}, \tag{8}$$

$$P_{NT,t} \equiv \left[\left(\frac{1}{n}\right)\int_0^n p_{NT,t}(h)^{1-\sigma}dh\right]^{\frac{1}{1-\sigma}}, \tag{9}$$

where $p_t(i)$ and $p_{NT,t}(i)$ are prices of good i sold in the home country, in home currency and at consumer level, for both tradable and nontradable goods, respectively.

A feature of our specification is the presence of distribution costs which imply a wedge between producer and consumer prices. This follows closely Burnstein, Neves and Rebelo (2000) and Corsetti and Dedola (2002). With *competitive firms* in the distribution sector, the consumer price of good h will be given by

$$p_t(h) = \overline{p}_t(h) + \kappa P_{NT,t} \tag{10}$$

where $\overline{p}_t(h)$ denote the price of home goods at producer level and κ are the units of a basket of differentiated non-traded goods necessary to bring one unit of traded goods to the consumers[12]. For the rest of the paper, upper bar represents prices at producer level.

2.2 Asset Market Structure

In this section, we first introduce the complete asset market structure that has been the *workhorse* of most NOEM literature after Obstfeld and Rogoff (1995). Then, we briefly present the incomplete asset markets structure that CKM treated in their work - also known as *bond economy.* Finally, we characterize an incomplete and imperfect financial assets market structure where the net foreign assets position plays a different role in the dynamic of the real exchange rate, and enters explicitly in the risk-sharing equation.

2.2.1 Complete Markets

We define the real exchange rate as $q_t \equiv \frac{\mathcal{S}_t P_t^*}{P_t}$. Under both domestic and international complete markets[13], it follows that the ratio of marginal utilities of the two countries equalizes the real exchange rate at every

[12] Here, $\kappa = \left[\int_0^1 \kappa(h)^{\frac{\sigma-1}{\sigma}}dh\right]^{\frac{\sigma}{\sigma-1}}$ is a Dixit-Stiglitz index that also applies to the consumption of differentiated non-traded goods. For simplicity, we are assuming that there are no distribution costs in the delivery of non-tradable goods.

[13] The consumers in both economies can trade contingent one-period nominal bonds denominated in home currency.

state of the nature (see CKM for details).

$$q_t = k_o \frac{U_c(C_t)}{U_c(C_t^*)} \tag{11}$$

where k_o is a function of predetermined variables.

From (11), we can see that the relative consumption across countries is proportional to real exchange rate[14]. In our model, the presence of non-traded goods precludes full risk-sharing across countries, even if the law of one price holds. This equilibrium condition predicts a positive and high cross-correlation between the real exchange rate and the relative consumptions.

We will build our model under the realistic assumption of imperfect degree of pass-through from exchange rate to import prices. The introduction of IPT in a complete asset market structure allows to capture a key aspect of the transmission mechanism of shocks across countries. However, it fails to break the link between real exchange rate and relative consumption which tends to be very low in the data (see Table A.2.). Therefore, in order to factor the relevance of IPT, we need to incorporate an incomplete asset market structure.

2.2.2 Incomplete Markets

The standard approach: Bond Economy. An alternative incomplete assets market structure may be based on the possibility of househols to trade an uncontingent nominal bond denominated in units of home currency. Under this structure the risk-sharing condition reads as follows (see CKM for further details).

$$E_t\left(\frac{U_c(C_{t+1})}{U_c(C_t)}\frac{P_t}{P_{t+1}}\right) = E_t\left(\frac{U_c(C_{t+1}^*)}{U_c(C_t^*)}\frac{S_t P_t^*}{S_{t+1}P_{t+1}^*}\right) \tag{12}$$

From the above expression the relation between the real exchange rate and marginal utilities only holds in expected first differences[15]. A stationarity problem could arise under this market structure, which would prevent a proper analysis of small deviations around a deterministic steady state. In particular, without further modification, such incomplete markets structrure implies a non-stationary distribution of wealth across countries. Lucas and Stokey (1984) propose an endogenous discount factor that increases the marginal "impatience" as the economy accumulates net foreign assets so the distribution of wealth evolves along a stationary path[16]. On the other hand, Cavallo and Ghironi (2002) and Ghironi (2000) achieve stationary by an overlapping generation model that ensures an endogenously well-defined steady-state[17].

[14] Under PPP, this condition implies perfect risk-sharing of consumption across countries. This is not the case when there are shocks to preferences. See P. Benigno (2001).

[15] In log-linear form, this expression reads as

$$E_t\left(\widehat{q}_{t+1} - \widehat{q}_t\right) = E_t\left[\left(\widehat{U}_c(C_{t+1}^*) - \widehat{U}_c(C_{t+1})\right) - \left(\widehat{U}_c(C_t^*) - \widehat{U}_c(C_t)\right)\right]$$

[16] Theoretically, Mendoza (1991) develops an small open economy model, incomplete market economy and a endogenous discount factor. Head, Mattina and Smith (2002) evaluate empirically this market structure, and reject it since key parameters of the utility function are insignificant and inconsistent with the theory.

[17] Under a different approach, Corsetti and Pesenti (2001) shut down the current account transmission mechanism by assuming a unitary intratemporal elasticity of substitution between home and foreign goods.

As equation (12) illustrates, incomplete asset markets-*bond economy*- allows us to break the *link* between real exchange rate and relative consumptions. However, as CKM pointed out, this asset market structure does not help to resolve the *anomaly*. They find that the wealth effects in their model are extremely small.[18]

One of the limitations of this approach is that the uncovered interest parity holds, a result that has been extensively rejected in empirical studies (see Chinn and Meredith (2002) for a recent reference). In particular, there is no role for the net asset position in determining real interest rate differentials. Lane and Milesi-Ferretti (2001b) reveal the importance of this channel.

Furthermore, Ravn (2001) and Head, Mattina and Smith (2002) have shown that this market structure is not supported by the empirical evidence under many different assumptions on preferences. They show that, under exogenous incomplete asset markets, the real exchange rate does not play a significant role in explaining the risk sharing across countries. Therefore, a *bond economy* seems to fail on both empirical and theoretical grounds.

Incomplete and Imperfect Asset Markets. In order to break the monotonic relationship between the real exchange rate and relative consumptions we generate deviations from the UIP. We assume that these deviations stem from a cost of holding foreign bonds that allows us to introduce the net foreign asset position dynamics into the UIP.

In this context, we have chosen to model incomplete markets following P. Benigno (2001) where two risk-free one-period nominal bonds are traded, and a cost of bond holdings is introduced to achieve stationarity[19]. One bond is denominated in domestic currency and the other one in foreign currency. Then, the real budget constraint of the domestic household h will be given by

$$\frac{B_{H,t}^h}{P_t\left(1+i_t\right)}+\frac{S_t B_{F,t}^h}{P_t\left(1+i_t^*\right)\phi\left(\frac{S_t B_{F,t}}{P_t}\right)} \leq \frac{B_{H,t-1}^h+S_t B_{F,t-1}^h+M_{t-1}^h}{P_t}-\frac{M_t^h}{P_t} + \frac{W_T^h N_T^h+W_{NT}^h N_{NT}^h}{P_t}-C_t^h+\frac{TR_t^h}{P_t}+\frac{\Pi_t^h}{P_t} \quad (13)$$

where W_T^h and W_{NT}^h are the nominal wages in the tradable and nontradable sectors, respectively. Π_t^h are nominal profits for home consumer. We assume that each consumer holds one firm in each sector (domestic firms are located in the interval $[0,n]$ and the size of the home population is normalized to n) and there is no trade in firms' shares. TR_t^h is a nominal transfer that individual j receives from the government. $B_{H,t}$ is household h's holding of the risk free nominal bond, in Home currency. $B_{F,t}$ is household h's holding of the risk-free nominal bond in Foreign currency. The function $\phi(.)$ depends on the real holdings of the foreign assets in the entire economy, and therefore is taken as given by the domestic household[20]. $\phi(.)$

[18]Corsetti et. al (2002) consider a different incomplete asset market structure where an endogenous discount factor is needed to pin down a well defined steady state.

[19]Schmitt-Grohe and Uribe (2001) and Kollmann (2002) develop small open-economy models introducing the same cost to achieve stationarity. Heathcote and Perri (2001) also make a similar assumption in a two-country RBC model.

[20]As Benigno, P.(2001) points it out, some restrictions on $\phi(.)$ are necessary: $\phi(0)=1$; assumes the value 1 only if $B_{F,t}=0$; differentiable; and decreasing in the neighborhood of zero.

will allow us to obtain a well-defined steady state, and to capture the costs of undertaking positions in the international asset market[21]. The government has a budget given by

$$\int_0^n M_t^h dh - \int_0^n M_{t-1}^h dh + \int_0^n TR_t^h dh = 0$$

The first order conditions with respect to the labor supply for tradable and non tradable sectors imply[22]

$$V_N\left(N_{T,t}^h\right) = U_c\left(C_t\right)\frac{W_{T,t}^h}{P_t} \tag{14}$$

$$V_N\left(N_{NT,t}^h\right) = U_c\left(C_t\right)\frac{W_{NT,t}^h}{P_t} \tag{15}$$

The first order condition with respect to real money holdings implies

$$L\left(\frac{M_t^h}{P_t}\right) = U_c\left(C_t\right)\frac{i_t}{1+i_t} \tag{16}$$

In this model we describe the monetary policy through an interest rate feedback rule, therefore, equation (16) determines the optimal holdings of real money balances.

We further assume that the initial level of wealth is the same across all households belonging to the same country. This assumption combined with the fact that all households within a country work for all firms sharing the profits in equal proportion, implies that within a country all the households face the same budget constraint. In their consumption decisions, they will choose the same path of consumption. We can then drop the index h and consider a representative household for each country.

The conditions characterizing the allocations of domestic and foreign consumption, and holding of nominal bonds are:

$$U_c(C_t) = (1+i_t)\,\beta \mathrm{E}_t\left\{U_c(C_{t+1})\frac{P_t}{P_{t+1}}\right\} \tag{17}$$

$$U_c(C_t^*) = (1+i_t^*)\,\beta \mathrm{E}_t\left\{U_c(C_{t+1}^*)\frac{P_t^*}{P_{t+1}^*}\right\} \tag{18}$$

$$U_c(C_t) = (1+i_t^*)\,\phi\left(\frac{B_{F,t}S_t}{P_t}\right)\beta \mathrm{E}_t\left\{U_c(C_{t+1})\frac{P_t S_{t+1}}{P_{t+1}S_t}\right\} \tag{19}$$

$$\frac{S_t B_{F,t}}{P_t\left(1+i_t^*\right)\phi\left(\frac{B_{F,t}S_t}{P_t}\right)} = \frac{S_t B_{F,t-1}}{P_t} + \frac{P_{H,t}C_{H,t}}{P_t} + \frac{S_t P_{H,t}^* C_{H,t}^*}{P_t} + \frac{P_{NT,t}Y_{NT,t}}{P_t} - C_t \tag{20}$$

Equations (17) and (18) correspond to the euler equations of the home and foreign countries, respectively. Equation (19) represents household H's Euler equation derived by maximizing the holdings of the nominal bond denominated in foreign currency. Finally, equation (20) corresponds to the resource constraint of country H, which is obtained by aggregating the equilibrium budget constraint of the households

[21]Another way to describe this cost is to assume the existence of intermediaries in the foreign asset market (which are owned by the foreign households) who can borrow and lend to households of country F at a rate $(1+i^*)$, but can borrow from and lend to households of country H at a rate $(1+i^*)\phi(.)$.

[22]We are assuming that sectorial labors enter separately in the utility function which we may associate to the following analytical expression:
$V\left(N_T, N_{NT}\right) = \left(N_T^{1+\eta} + N_{NT}^{1+\eta}\right)/(1+\eta)$.

with that of the government. From these conditions we are able to derive both the new uncovered interest parity and the risk-sharing equilibrium condition where both are affected by the net foreign asset position of the domestic economy.

2.3 Price Setting under IPT

In order to get a tractable model, we assume that prices are sticky in the non-tradable sector and flexible in the tradable one. We also consider distribution costs in order to get deviations from the law of one price and consequently intermediate degrees of pass-through. This follows previous contributions by Burnstein, Neves and Rebelo (2000) and Corsetti and Dedola (2002) where they assume that to deliver traded goods to consumers requires a component of differentiated non-traded goods.

2.3.1 Non-Tradable Sector

The firms' price setting decision behavior is modelled through a Calvo-type mechanism. We assume that prices are subject to changes at random intervals. In each period a seller faces a fixed probability $(1-\alpha)$ of adjusting the price, irrespective on how long it has been since the last change had occurred. In this model suppliers behave as monopolists in selling their products. The objective of a home firm selling non-traded goods is to maximize the expected discounted value of profits[23].

$$Max_{\widetilde{p}_{NT,t}(h)} E_t \sum_{k=0}^{\infty} \alpha^k \zeta_{t,t+k} \{\widetilde{p}_{NT,t+k}(h)\, \widetilde{y}^d_{NT\ t,t+k}(h) - W^h_{NT,t+k} N^h_{NT,t+k}\} \tag{21}$$

subject to

$$\widetilde{y}^d_{NT,t}(h) = \left(\frac{\widetilde{p}_{NT,t}(h)}{P_{NT,t}}\right)^{-\sigma} \left[C^d_{NT,t} + \eta^d_t\right], \tag{22}$$

where

$$C^d_{NT,t} = n(1-\gamma)\left(\frac{P_{NT,t}}{P_t}\right)^{-\varepsilon} C_t, \tag{23}$$

$$\eta^d_t = kn\gamma\left[\left(\frac{P_{H,t}}{P_{T,t}}\right)^{-\theta}\left(\frac{P_{T,t}}{P_t}\right)^{-\varepsilon} + \left(\frac{P_{F,t}}{P_{T,t}}\right)^{-\theta}\left(\frac{P_{T,t}}{P_t}\right)^{-\varepsilon}\right] C_t, \tag{24}$$

where $\widetilde{y}^d_{NT,t}(h)$ is the total individual demand for nontraded goods which is composed by the demand of nontraded goods for consumption, $C^d_{NT,t}$, and the demand for distribution services by the tradable firms η^d_t.

The supplier maximizes (21) with respect to $\widetilde{p}_{NT,t}(h)$ given the demand function and taking as given the sequences of prices $\left\{P^i_{H,t}, P^i_{F,t}, P^i_{T,t}, P^i_{NT,t}, P^i_t, C^i_t\right\}$ for $i = H, F$. Each firm produces according to a linear technology

$$y_{NT,t}(h) = Z_{NT,t} N^h_{NT,t} \tag{25}$$

[23] $\zeta_{t+s} = \beta^s \frac{U_C(C_{t+s})}{P_{t+s}} \frac{P_t}{U_C(C_t)}$ is the pricing Kernel associated to the first order condition for the recursive competitive equilibrium.

where $Z_{NT,t}$ is the country-specific productivity shock to the non-tradable sector at time t.

The optimal choice of $\widetilde{p}_{NT,t}(h)$ is:

$$\widetilde{p}_{NT,t}(h) = \frac{\sigma}{(\sigma-1)} \frac{E_t \sum_{k=0}^{\infty} \alpha^k \zeta_{t,t+k} \frac{W^h_{NTt+k}}{Z_{NT,t+k}} \widetilde{y}^d_{NT\ t,t+k}(h)}{E_t \sum_{k=0}^{\infty} \alpha^k \zeta_{t+k} \widetilde{y}^d_{NT\ t,t+k}(h)} \tag{26}$$

Finally, Calvo-price setting implies the following state equation for $P_{NT,t}$

$$P^{1-\sigma}_{NT,t} = \alpha P^{1-\sigma}_{NT,t-1} + (1-\alpha)\,\widetilde{p}_{NT,t}(h)^{1-\sigma} \tag{27}$$

Analogous expression can be derived for the optimal non-tradable price setting in the foreign economy.

2.3.2 Tradable Sector

In this model we assume that the tradable sector is completely flexible. The presence of distribution services intensive in local non-traded goods will imply different demand elasticities across markets, therefore, firms will charge different prices in each market. Then, firms face the following maximization problem:

$$Max_{\overline{p}(h),\overline{p}^*(h)}[\overline{P}_H C^d_t(h) + S_t \overline{P}^*_H C^{*d}_t(h)] - \frac{W_{T,t}}{Z_{T,t}}[C^d_t(h) + C^{*d}_t(h)] \tag{28}$$

subject to

$$C^d_t(h) = n\gamma \left(\frac{\overline{p}_t(h) + \kappa P_{NT,t}}{P_{H,t}}\right)^{-\sigma} \left(\frac{P_{H,t}}{P_{T,t}}\right)^{-\theta} \left(\frac{P_{T,t}}{P_t}\right)^{-\varepsilon} C_t, \tag{29}$$

$$C^{d*}_t(h) = (1-n)\,\gamma \left(\frac{\overline{p}^*_t(h) + \kappa P^*_{NT,t}}{P^*_{H,t}}\right)^{-\sigma} \left(\frac{P^*_{H,t}}{P^*_{T,t}}\right)^{-\theta} \left(\frac{P^*_{T,t}}{P^*_t}\right)^{-\varepsilon} C^*_t, \tag{30}$$

The optimal prices at producer level, $\overline{p}_t(h)$ and $\overline{p}^*_t(h)$ are

$$\overline{p}_t(h) = \overline{P}_{H,t} = \frac{\sigma}{(\sigma-1)} \frac{W_{T,t}}{Z_{T,t}} + \frac{k}{(\sigma-1)} P_{NT,t}, \tag{31}$$

$$\overline{p}^*_t(h) = \overline{P}^*_{H,t} = \frac{\sigma}{(\sigma-1)} \frac{W_{T,t}}{S_t Z_{T,t}} + \frac{k}{(\sigma-1)} P^*_{NT,t}, \tag{32}$$

The marginal cost for tradable goods varies as a function of the prices of non-traded goods. In this sense, the price setting of tradable goods at home will depend implicitly on the productivity shocks in the non-tradable sector. Under the presence of distribution costs the elasticity of demand for domestic goods is not the same at home and abroad, and firms will charge different prices in each market. Optimal price setting implies deviations from the law of one price $\left(\overline{P}_{H,t} \neq S_t \overline{P}^*_{H,t}\right)$ unless the degree of distribution margin, k, is equal to zero.

2.4 Monetary Policy

For the specification of monetary policy we consider a rule that embeds different types of rules. The general form of the interest rate rule is

$$\frac{1+i_t}{1+\bar{i}} = \Psi\left(F, \xi_t^m\right) \tag{33}$$

where F is the set of target variables for the home country, and ξ_t^m is a pure monetary shock reflecting interest rate movements that do not correspond to the endogenous reaction of the monetary authority to instrumental variables. Monetary shocks can be motivated by assuming that the central bank sometimes deviates from its own rule, that it makes mistakes in doing the monetary policy, or by assuming that the demand for money is itself stochastic. In the latter case, the shock rather than being policy shock would correspond to shocks to the parameters of the model.

2.5 The Log-linear Model

In this section, we present a full log-linear version of the model which is summarized in table 1. Appendices A, B, C and D provide details on the derivation. In what follows, a variable $\widehat{X}_t$ represents the log-deviation of X_t with respect to its steady state, $\overline{X}$, and $\widetilde{X}_t$ represents the log-deviation of the flexible price level of X_t with respect to its steady.

From the first order condition (17) we obtain the standard Euler equation, IS, for the representative domestic consumer. This equation holds under both complete and incomplete markets.

The uncovered interest rate parity is derived by taking the difference between the log-linear approximation of equations (17) and (19), and is given by the following expression:

$$\widehat{i}_t - \widehat{i}_t^* = E_t \Delta S_{t+1} - \delta b_t \tag{34}$$

Notice that the above equation incorporates a cost of borrowing in foreign currency and may be consistent with the empirical failure of the UIP[24]. In our case, there is a time varying risk-premium that depends on both the net foreign asset position of the country (b_t) and a cost of bond holdings (δ). This risk-premium could be positive or negative depending on the Home country being a borrower or a lender in the international assets market. This equation implies a negative relation between the interest rate differential and the NFA position of the economy. A country that accumulates assets faces a smaller implicit cost of bond holding (δb_t), and consequently, the interest rate differential is smaller. The parameter δ measures the elasticity of the interest rate differential to changes in the NFA position. The higher this elasticity, the larger the effect of the current account channel on the interest rate differential. Notice that the UIP does not hold even if the law of one price does.

[24] When the UIP relation holds a regression of exchange rate returns on the interest rate differential should give an intercept of zero and a slope coefficient of unity. However, this hypothesis has been consistently rejected in the data.

Table 1
The sticky-price version of the model

$\rho E_t \left(\widehat{C}_{t+1} - \widehat{C}_t \right) = \widehat{i}_t - E_t \pi_{t+1}$	*IS*
$E_t \Delta S_{t+1} = \widehat{i}_t - \widehat{i}_t^* + \delta b_t$	*UIP*
$\rho E_t \left(\left(\widehat{C}_{t+1} - \widehat{C}_{t+1}^* \right) - \left(\widehat{C}_t - \widehat{C}_t^* \right) \right) = E_t \left(\widehat{q}_{t+1} - \widehat{q}_t \right) - \delta b_t$	*Risk-Sharing*
$\pi_{NT,t} = \kappa^{NT} \left[a_0 \widehat{T}_t + (\rho + \eta) \widehat{C}_t + a_1 \widehat{R}_t - (1+\eta) Z_{NT,t} \right] + \beta E_t \pi_{NT,t+1}$	AS_H
$\pi_{NT,t}^* = \kappa^{NT^*} \left[-a_0^* \widehat{T}_t^* + (\rho + \eta) \widehat{C}_t^* + a_1^* \widehat{R}_t^* - (1+\eta) Z_{NT^*,t} \right] + \beta E_t \pi_{NT,t+1}^*$	AS_F
$\beta b_t = b_{t-1} + b_1 \widehat{T}_t + b_2 \widehat{R}_t + b_3 \widehat{R}_t^* - b_4 \left(\widehat{C}_t - \widehat{C}_t^* - \widehat{q}_t \right)$	*NFA*
$-\overline{R}(1-n) \widehat{T}_t = -c_0 \widehat{R}_t - (1+\eta) Z_{T,t} + \rho \widehat{C}_t + \eta \widehat{Y}_H$	P_H
$-\overline{R}(1-n) \widehat{T}_t^* = -c_0 \widehat{R}_t^* - (1+\eta) Z_{T,t} + \rho \widehat{C}_t + \eta \widehat{Y}_H - \widehat{q}_t$	P_{H^*}
$\overline{R} n \widehat{T}_t = -c_0 \widehat{R}_t - (1+\eta) Z_{T^*,t} + \rho \widehat{C}_t^* + \eta \widehat{Y}_F + \widehat{q}_t$	P_F
$-n \overline{R} \widehat{T}_t^* = -c_0 \widehat{R}_t^* - (1+\eta) Z_{T^*,t} + \rho \widehat{C}_t^* + \eta \widehat{Y}_F$	P_{F^*}
$\widehat{q}_t = \widehat{q}_{t-1} + \Delta S_t + \frac{\gamma}{\gamma + (1-\gamma)\overline{R}^{\varepsilon - 1}} \left(\pi_{T,t}^* - \pi_{T,t} \right) + \frac{(1-\gamma)}{\gamma \overline{R}^{1-\varepsilon} + (1-\gamma)} \left(\pi_{NT,t}^* - \pi_{NT,t} \right)$	*RER*
$\pi_t \equiv \frac{\gamma}{\gamma + (1-\gamma)\overline{R}^{\varepsilon-1}} \pi_{T,t} + \frac{(1-\gamma)}{\gamma \overline{R}^{1-\varepsilon} + (1-\gamma)} \pi_{NT,t}$; $\pi_t^* \equiv \frac{\gamma}{\gamma + (1-\gamma)\overline{R}^{\varepsilon-1}} \pi_{T,t}^* + \frac{(1-\gamma)}{\gamma \overline{R}^{1-\varepsilon} + (1-\gamma)} \pi_{NT,t}^*$	$CPI_H; CPI_F$
$\pi_{T,t} \equiv \left[\frac{\overline{R}-1}{\overline{R}} \pi_{NT,t} + \frac{(1-n)}{\overline{R}} \Delta S_t \right]$; $\pi_{T,t}^* \equiv \left[\frac{\overline{R}-1}{\overline{R}} \pi_{NT,t}^* - \frac{n}{\overline{R}} \Delta S_t \right]$	$TI_H; TI_F$

Parameters:
$a_0 \equiv \left(\frac{1}{2} - n\right) \theta \eta \upsilon; a_0^* \equiv \left(\frac{1}{2} - n\right) \theta \eta \upsilon^*; a_1 \equiv \left(\gamma \overline{R}^{1-\varepsilon}\right) / \left(\gamma \overline{R}^{1-\varepsilon} + (1-\gamma)\right) + \eta \mu;$
$a_1^* \equiv \gamma \overline{R}^{1-\varepsilon} / \left(\gamma \overline{R}^{1-\varepsilon} + (1-\gamma)\right) + \eta \mu^*;$
$b_1 \equiv \frac{\lambda}{n}(1-n)(\theta - 1) + (1 - \lambda/n) \upsilon \theta \left(\frac{1}{2} - n\right);$
$b_2 \equiv \left[\lambda (1-\gamma)(1-\varepsilon) - (1-\lambda/n) \gamma \overline{R}^{1-\varepsilon})\right] / \left(\gamma \overline{R}^{1-\varepsilon} + (1-\gamma)\right) + (1-\lambda/n)\mu;$
$b_3 \equiv [\lambda(1-n)(1-\gamma)/n(1-\varepsilon)] / \left(\gamma \overline{R}^{1-\varepsilon} + (1-\gamma)\right); b_4 \equiv \lambda(1-n)/n;$
where $\lambda \equiv n \gamma \overline{R}^{1-\varepsilon} / \left[\gamma \overline{R}^{1-\varepsilon} + \left(\gamma + (1-\gamma)\overline{R}^{\varepsilon - 1}\right)^{\frac{1}{1-\varepsilon}} \left((1-\gamma)\overline{R}^{\varepsilon} + 2nk\gamma\right) / \overline{R}^{\varepsilon}\right];$
$\kappa^{NT} \equiv (1 - \alpha\beta)(1-\alpha) / \alpha (1 + \sigma\eta); \kappa^{NT^*} \equiv (1 - \alpha^* \beta)(1 - \alpha^*) / \alpha^* (1 + \sigma\eta);$
$\mu \equiv \frac{\varepsilon \left((1-\upsilon)\gamma \overline{R}^{1-\varepsilon} - \upsilon(1-\gamma) \right)}{\gamma \overline{R}^{1-\varepsilon} + (1-\gamma)}; \mu^* \equiv \frac{\varepsilon \left((1-\upsilon^*)\gamma \overline{R}^{1-\varepsilon} - \upsilon^*(1-\gamma) \right)}{\gamma \overline{R}^{1-\varepsilon} + (1-\gamma)}$
$\upsilon = 2n\kappa / \left(2n\kappa + \frac{(1-\gamma)}{\gamma} \overline{R}^{\varepsilon}\right); \upsilon^* = 2(1-n)\kappa / \left(2(1-n)\kappa + \frac{(1-\gamma)}{\gamma} \overline{R}^{\varepsilon}\right);$
$c_0 = \left(\overline{R}(1-\gamma) + \gamma \left(\overline{R} - 1\right) \overline{R}^{1-\varepsilon}\right) / \left(\gamma \overline{R}^{1-\varepsilon} + (1-\gamma)\right)$ and $\overline{R} = 1 + \frac{k\sigma}{\sigma - 1}$.
$\delta \equiv -\phi'(0) \overline{C}$, $b_t = (B_{F,t}/P_t^*) C^{-1}$, $T_t \equiv \frac{P_{F,t}}{P_{H,t}}$, $T_t^* \equiv \frac{P_{H,t}^*}{P_{F,t}^*}$, $R_t \equiv \frac{P_{T,t}}{P_{NT,t}}$, and $R_t^* \equiv \frac{P_{T,t}^*}{P_{NT,t}^*}$.
$\widehat{Y}_H, \widehat{Y}_F$ are defined in appendix C.

The *risk-sharing* condition under incomplete markets is obtained by combining the UIP equation and the corresponding Euler equations for each country, and reads as:[25]

$$\rho E_t \left(\left(\widehat{C}_{t+1} - \widehat{C}^*_{t+1} \right) - \left(\widehat{C}_t - \widehat{C}^*_t \right) \right) = E_t \left(\widehat{q}_{t+1} - \widehat{q}_t \right) - \delta b_t \quad (35)$$

Equation (35) illustrates the mechanism through which the NFA position affects the risk-sharing. The characterization of this incomplete asset market structure maintains the gap between relative consumptions that emerges in the incomplete asset structure specified in equation (12), but now, in addition, the dynamic of the net foreign assets plays an explicit role. As long as there is either asset accumulation or decumulation, the real exchange rate will be affected by the net foreign asset position, and therefore, the link between the real exchange rate and relative consumptions that characterizes complete markets models will be broken down. Ceteris paribus, there is a negative relation between the real exchange rate and the NFA, i.e., an asset accumulation implies a real exchange rate appreciation. The larger the asset accumulation the greater will be the effect of the NFA position on the real exchange rate dynamics. Similarly, the larger the cost of undertaking positions in the international financial market, δ, the greater the effect of the NFA on the *risk-sharing* condition. Finally, if either $\delta \to 0$ or $b_t = 0$ at every period, the *risk-sharing* boils down to the one that characterizes a *bond economy.*

The *aggregate supply,* AS_H, comes from the log-linearization of equation (26) and (27). The aggregate supply block will not differ under a different specification of the market structure, but it is affected by the degree of pass-through in the economy.

The *dynamics for the net foreign asset position* is obtained after log-linearizing equation (20). The terms of trade enter in the NFA and its effect is influenced by the presence of distribution costs. As expected, the relative price of non-traded goods along with the real exchange rate affect the current account dynamics.

It is also possible to establish a relation between the market rate,$T_t \equiv \frac{P_F}{P_H}$, and the terms of trade at producer level $ToT_t \equiv \overline{P}_{F,t}/S_t\overline{P}^*_{H,t}$. Combining equation (10) and the previous definition of the terms of trade, we obtain that

$$\widehat{ToT}_t = \widehat{T}_t \frac{\overline{R}}{\overline{R} - k} - \widehat{\Psi}^p_t, \quad (36)$$

$$\widehat{\Psi}^p_t = \widehat{\Psi}^p_{t-1} - \frac{\overline{R} - k - 1}{\overline{R} - k} \left(\pi_{NT,t} - \pi^*_{NT,t} - \Delta S_t \right) \quad (37)$$

where $\Psi^p_t \equiv S_t\overline{P}^*_{H,t}/\overline{P}_{H,t}$.

Notice that Ψ^p_t accounts for the deviations from the law of one price at producer level. Hence, we can

[25] To assess the empirical relevance of the net foreign asset position in the "disconnectness" of relative consumptions and the real exchange rate, testing this risk-sharing condition is a natural next step. Gagnon (1996), focusing on annual data for 20 industrial countries from 1973-1995, finds that, in the long run, there is a significant and robust relationship between the real exchange rate and NFA. Conversely, Kollmann (1995), Ravn (2001) and Head et. al. (2002) test different risk-sharing conditions derived under perfectly integrated financial markets. They find little connection between the real exchange rate and relative consumptions. In Selaive and Tuesta (2003), we further explore this issue remarking the importance of financial frictions and the key role of the NFA in explainig the apparent lack of international risk-sharing.

derive a relationship between deviations from the law of one price at consumer and at producer level

$$\widehat{\Psi}_t^c - \widehat{\Psi}_{t-1}^c = \frac{\overline{R} - k}{\overline{R}} \left(\widehat{\Psi}_t^p - \widehat{\Psi}_{t-1}^p \right) + \frac{k \Delta S_t}{\overline{R}} \tag{38}$$

where $\Psi_t^c \equiv S_t P_{H,t}^* / P_{H,t}$.

When $k = 0$, there is perfect pass-through and the law of one price holds, $\widehat{T}_t = \widehat{ToT}_t$ and $\widehat{\Psi}_t^p = \widehat{\Psi}_t^c = 0$.[26]

Finally, to completely characterize the equilibrium dynamics of the model, we specify the monetary policy through interest rate feedback rules. The instruments the authority targets are CPI expected inflation (π_t) and Output Gap (y_t).[27]

$$\widehat{i}_t = \gamma_\pi E_t \pi_{t+1} + \gamma_y y_t + \xi_t^m \tag{39}$$

$$\widehat{i}_t^* = \gamma_\pi^* E_t \pi_{t+1}^* + \gamma_y^* y_t^* + \xi_t^{*m} \tag{40}$$

where γ_π and γ_y are the weights given to instrumental targets.

By the previous endogenous feedback rules, we are able to consider the systematic component of monetary policy. This is in line with recent normative literature in monetary policy[28].

From identities CPI_H and TI_H, we observe that changes in nominal exchange rate is an indirect target for the monetary authority, and in particular, it is affected by the degree of pass-through. Lower degrees of pass-through tend to close that channel and to equalize non-tradable and CPI inflations.

3 Simulation of the Model

3.1 Parametrization

The parameters utilized in our model are reported in table 2. Our parametrization intends to characterize the qualitative properties of the model and to highlight the main mechanism introduced by the incomplete and imperct asset market structure, rather than match the data.

We set a quarterly discount factor, β, equal to 0.99, which implies an annualized rate of interest of 4%. We calibrate our model assuming that country H is U.S. and country F is Europe, with a symmetric country size, n, equal to 0.5.

For the coefficient of risk aversion parameter, ρ, we choose a value of 5 as in CKM. Regarding this parameter, Eichenbaum et. al. (1988) find a range between 0.5 and 3. On the other hand, Hall (1988) suggests a value greater than 5. The inverse of the elasticity of labor supply, η, is calibrated according to Rotemberg and Woodford (1998) and is set equal to 0.47.

For parameter δ we assume two possible values, 10^{-3} and 10^{-2} which imply a 10 and 100-basis point spreads of the domestic rate (in the foreign currency market) over the foreign rate, respectively. In order

[26]Observe that $\widehat{\Psi}_t^c$ could be associated to an analogous variable in Monacelli (2002) that measures the *law of one price gap*. This author incorporates an imperfect pass-through mechanism by domestic importers facing a pricing decision similar to the domestic producer, setting prices directly in local currency.

[27]We define output gap as the deviations of output with respect to the flexible price allocation under complete markets. See appendix C.

[28]See Gali, Gertler and Lopez-Salido (2001) among others for empirical evidence.

to highlight the importance of NFA positions in the transmission mechanism of shock, we assume a very low value for δ in our benchmark parametrization.

We choose a degree of monopolistic competition, σ, equal to 7.66 following Rotemberg and Woodford (1998). This implies an average mark-up of 15 percent.

The value of the elasticity of substitution between traded and non-traded goods, ε, is set following Kravis and Lipsey (1987) equal to 0.77. The value of the elasticity of substitution between traded goods, θ, is set equal to 2, in the line of values reported by Backus, Kehoe and Kydland (1992), even though, we make sensitivity analyses for values in the interval $[1, 6]$[29]. The weight associated with traded versus non traded goods, γ, is set equal to 0.6 following Gatsios, Kollinzas and Levasseur (2002).

We set the distribution cost parameter, κ, equal to 0.8 which implies a margin of 47 percent of the retail price of consumer goods due to distribution costs[30]. In order to evaluate the effect of IPT, we make also a sensitivity analysis varying this parameter in the interval $[0, 1]$.

Consistent with the RBC literature, we choose a low-persistent scenario for productivity shocks in the tradable sector, and we set autocorrelations equal to 0.95. We assume their variances following Kehoe and Perri (2002) and Baxter and Crucini (1995) where $var(\varepsilon_T) = var(\varepsilon_{T^*}) = (0.007)^2$. Baxter and Crucini (1995) and Kollmann (1996) find little evidence of spillover effects in technology shocks, and we rely on their result in our paper. For the non-tradable sector productivity shocks, we assume in both countries an autocorrelation equal to 0.93, and $var(\varepsilon_{NT}) = var(\varepsilon_{NT^*}) = (0.002)^2$ following Corsetti et. al.(2002). We do not impose any further structure on the shocks.

Following recent literature related with forward-looking monetary policy rules, in particular, Clarida Gali and Gertler (2000), we assume that α and α^* are 0.66 and 0.75, respectively, which implies a duration of price stickiness of 3 and 4 quarters in U.S. and Europe, respectively. With respect to the monetary policy, we set the coefficient on output gap, $\phi = 0.5$, and the coefficient on inflation, $\gamma_\pi = 1.5$. In our simulations we do not incorporate monetary shocks.

3.2 Responses to Productivity Shocks

We can get some intuition of our quantitative results by analyzing the IRFs to domestic shocks. Any linkage between real exchange rate and relative consumptions across countries depends on two aspects: the asset market structure and the nature of the shock. We focus on two economies: imperfect financial integration with both PPT *(dotted line)* and IPT *(thick line).*

Traded sector productivity shock: In Figure 3 we depict the responses to a 1 percent productivity shock in the tradable sector of the domestic economy which decays with an autoregressive coefficient of 0.95.

Under PPT, a productivity shock in the tradable sector delivers a negative comovement between real exchange rate and relative consumptions. Following this shock, and stemming from the worsening of terms

[29] Obstfeld and Rogoff (2000) presents a survey regarding the empirical estimates of θ. In general, they suggest high values for this elasticity.

[30] Burnstein, Neves and Rebelo (2002) show that distribution costs are large and account for about 40-60 percent of the retail price in U.S.

of trade, domestic output increases and foreign output decreases. In addition, consumption increases but less than proportional than real income, and therefore, an asset accumulation occurs. The NFA accumulation generates a real exchange rate appreciation. The wealth effect decreases the labor supply in the non-traded sector, and consequently, an increase in the relative price of nontraded goods triggers an appreciation of the real exchange rate. The domestic economy continues accumulating assets within the first 20 quarters before reverting on the downward path to the steady state. Notably, the net foreign asset dynamics shows the similar high persistence as in the data. With IPT the expenditure-switching effect is dampened, and the NFA accumulation is smaller.[31]

It is important to note that in our benchmark calibration, θ was set larger than 1 which implies that worsening of the terms of trade bring about current account surpluses in the domestic economy.

In a nutshell, conditional to a traded productivity shock, a net foreign asset accumulation contributes to a real appreciation due to wealth effects that are transfered to the nontraded sector. On the other hand, the worsenings in the terms of trade increases the relative consumptions and decreases relative outputs. The IPT mechanism amplifies the real exchange rate appreciation and dampens the increase in both relative consumptions and relative outputs.

Non-traded sector productivity shock: Responses to a 1 percent domestic non-traded productivity shock are shown in Figure 4. The autorregresive coefficient is equal to 0.93. When the economy is hit by a productivity shock in the non-tradable sector, the comovement between real exchange rate and relative consumptions is positive under both PPT and IPT. This comovement is driven mainly by the traditional HBS. According to the HBS effect, an increase in the relative price of traded/non-traded goods in the home country with respect to the foreign country leads to a real exchange rate depreciation. When the price of non-traded goods falls, the real exchange rate depreciates because the domestic consumption bundle becomes less expensive than the foreign consumption bundle. Non-traded consumption increases at home and so does relative consumptions. When the pass-through is imperfect the *expenditure-switching effect* is dampened, and the NFA reacts by less.

3.3 Quantitative Properties of the Model

The results of our simulations are summarized in Table 3. Both relative tradable and non-tradable shocks are included. We evaluate the unconditional correlation between real exchange rate and relative consumptions as well as some other statistics. The first column of the table reports H-P filtered statistics for the data from quarterly time series. United States is considered as the home country and an aggregate of Europe as the foreign country.

A good starting point is the complete market-PPT model. We perform our simulations under a standard Taylor Rule where the monetary authority reacts to expected CPI inflation and output gap. The expenditure-switching effect, which is complete for tradable goods, triggers a very positive correlation between consumptions (0.88). This benchmark model delivers a perfect cross-correlation of the real exchange

[31] The responses are very similar to the ones obtained by Cavallo and Ghironi (2002) where they find an asset accumulation after a tradable productivity shock.

rate and relative consumptions while it is well known that in the data this correlation is negative (-.17). Our results are in the line of Kehoe and Perri (2002) and Heathcote and Perri (2001), among others.

As a way to reconcile the previous findings with the data, we introduce IPT (see third column in table 3). We dampen the link of consumptions and *this is basically the main aspect in which the PPT and IPT models look different*[32].

The next step is to analize the bond economy. In terms of the *anomaly* the results are virtually identical to the ones under complete markets, and the cross-correlation is still equal to one. This result is in the line of CKM (2001) where they point out that that the wealth effects that arise from this market incompleteness are too small, and therefore, the link between the real exchange rate and relative consumptions is not affected.

Considering the discrepancy between the data and the simulated model under both complete markets and the bond economy structures, we study an incomplete and imperfect markets. First, we consider a conservative friction in the international financial markets, and set δ equal to 10^{-3} which implies 10-basis-point spread of the domestic rate over the foreign rate.

In terms of the *consumption-real exchange rate anomaly*, the incomplete assets market structure under PPT delivers a cross-correlation closer to the data (0.17 vs -0.17), and clearly lower than the value we obtain under the bond economy. Furthermore, if we increase tthe cost of bond holdings by setting δ equal to 10^{-2}, we can get values even closer to the ones observed in the data (-0.13 vs -0.17).

We perform a similar exercise under IPT. The cross-correlation between real exchange rate and relative consumptions increases with respect to the PPT model, and the *anomaly* gets more severe. *Therefore, IPT does not help in solving the consumption-real exchange rate anomaly. In fact, the IPT model worse the fit under the benchmark parametrization.*

The bottom line is that incomplete and imperefect asset markets along with imperfect markets can help resolve the *anomaly* in a PPT environment. The interaction of the incomplete markets structure and financial frictions are crucial. On the other hand, the IPT mechanism does not help in this direction. Basically, as we decrease the degree of pass-through, the effect of the net foreign asset position on the risk-sharing condition is dampened, and we get closer to a *bond economy.*

3.4 Sensitivity Analysis

The Elasticity of substitution between home and foreign traded goods, θ : Here, we examine our findings considering scenarios with different values for the elasticity of substitution between home and foreign traded goods. We have already showed that the asset market structure we have introduced breaks down the cross-correlation between the real exchange rate and relative consumption through the current account channel. Furthermore, the effect of the terms of trade on the NFA is shaped by the elasticity of substitution between home and foreign traded goods. In table 4 we perform a sensitivity analyses to show

[32] There are important gains in volatility of the real exchange rate, but these results are beyond the scope of this paper.

the importance of the elasticity of substitution in explaining the *anomaly*[33].

Clearly, θ is a crucial parameter, and as it becomes larger it exacerbates the net foreign assets position channel breaking the link between the real exchange rate and relative consumptions that characterizes a bond economy. When $\theta = 1$, under PPT, the terms of trade do not enter in the current account dynamics[34] (see equation NFA in table 1). Hence, the cross-correlation turns out to be perfect. Conversely, under IPT, the cross-correlation is not perfect since wealth effects are now solely transmitted through the relative prices of non-traded goods.

Cost of Bond Holdings: Not for characterizing the incomplete asset market structure, but for getting a well defined steady state, we need to introduce a cost of undertaking positions in the international financial markets. This cost is captured by the parameter δ.

As we have already pointed out, in our model there is a tight link between the UIP and the risk-sharing condition. The presence of a cost of bond holdings generate deviations from UIP which affect the risk-sharing across countries. In this context, δ is at the heart of this incomplete asset market structure and turns out to be important in explaining the *anomaly*.

In figure 3, we plot different values of the cross-correlation between the real exchange rate and relative consumptions by varying the cost of bond holdings parameter. Clearly, the larger the cost, the lower the cross-correlation. Thus, the larger are the financial frictions in the international markets the more relevant is the NFA in explaining the lack of risk sharing that characterizes complete markets models.

Degrees of Pass-Through: To show how the degree of pass-through affects the cross-correlation between the real exchange rate and relative consumptions, we vary the parameter k which is closely related to the degree of pass-through (see figure 4). As we increase the distribution margin, the cross-correlation increases. The IPT mechanism undermines the NFA dynamics by dampening the expenditure-switching effect.[35]

Perfect Labor Mobility: Thus far, the analysis has been focused on a specification where the labor supply across sectors is separable. In this context, there is no labor mobility across tradable and non-tradable sector. Our logic for relaxing this assumption is to allow for some degree of labor mobility across sectors[36]. We follow Stockman and Tesar (1995) where they assume that labor is perfectly mobile between traded and nontraded sectors. To this end, we consider a disutility of working of the following form:

$$V\left(N_{T,t}^{h} + N_{NT,t}^{h}\right) = \frac{1}{1+\eta}\left[N_T + N_{NT}\right]^{1+\eta} \tag{41}$$

[33]Obstfeld and Rogoff (2000) outline the importance of the intratemporal elasticity of substitution. Benigno P. (2001) find that the larger the intratemporal elasticity of substitution the higher the cost of imperfect risk sharing.

[34]When $\theta = 1$, under PPT, the current account channel is inhibited which eliminates the effect of NFA on the risk-sharing condition.

[35]This constrast with Corsetti, Dedola and Leduc (2002), where the incomplete asset market structure is not enough to break the tight link between the real exchange rate and relative consumptions.

[36]It is also the case, as Corsetti, Dedola and Leduc (2002) and Burnstein, Eichenbaum and Rebelo (2001) point it out, that the IPT mechanism by distribution costs seems to work mainly through a large flow of labor between the tradable and nontradable sectors.

Under this specification the marginal rate of substitution between consumption and working is equalized across sectors, and therefore, real wages are the same. Thus, once we add perfect mobility, the marginal cost dynamics changes and so does the Phillips curve. In particular, the Phillips curve under this specification will also depend on the foreign consumption and the relative price between traded and non-traded goods abroad. We calculated the statistics under the benchmark parametrization. The results, reported in table 5, confirm our previous findings.

Flexible Prices: The results of a flexible price version of our model are reported in table 5. The statistics behave quite similarly to the ones obtained under sticky-prices. However, with flexible prices we get smaller cross-correlations between the real exchange rate and relative consumptions under both PPT and IPT. The previous result is driven mainly by the particular Taylor rule used in the benchmark calibration since the response to output gap tends to offset the real exchange rate appreciation that is triggered by the effect of the foreign assets on the relative price of non-traded goods.

It is also the case that IPT does not help in explaining the *anomaly* with respect to the PPT model, unless the elasticity of substitution between home and foreign traded goods is equal to one. With a unitary elasticity and perfect pass-though, tradable shocks do not enter in the reduced form coefficient matrix, and the real exchange rate reacts only to non-tradable shocks[37].

4 Empirical Testing

In this section we aim to test empirically the risk-sharing condition we have derived in our paper, equation (35). First pointed out by Obstfeld (1989), under complete markets the link between real exchange rate and relative consumptions holds even if there are frictions in goods markets, including non-traded goods, pricing to market, local currency pricing, or transportation costs. Previous results have shown that the complete market model cannot match the observed consumption and real exchange rate growth rates. It is also the case that empirical evidence has cast strong doubts on the incomplete market assumption in which only one risk-free bond can be used for international financial transactions (e.g. Kollmann (1995)).

We use the generalized method of moments (GMM), in the line of previous contributions by Kollmann (1995) and Head et. al. (2002), to test the risk-sharing condition derived in the paper for Australia. The data for all the estimations are obtained from the *Quarterly National Accounts* (QNA) of the OECD, the IMF's *International Financial Statistics* (IFS), and the net foreign asset position database of Lane and Milesi-Ferretti (2001a). We complete the data for the NFA position for the period 1998 to 2000 using the quarterly cumulative current account.

First, we estimate the risk-sharing condition between Australia and the Rest of the World (*RoW*) considering in our definition of *RoW* the Euro Area, Japan and US.[38] Consumption series include private

[37]Stickiness in the non-traded sector has been introduced to deliver a very tractable model. Thus, by considering a perfectly flexible tradable sector, the real exchange rate evolves following closely the relative prices of non-tradable goods across countries. In this context, neither the degree of pass-through nor the the stickiness in the non-traded sector affects the persistence of this variable.

[38]This contrasts with Kollmann (1995), Head et. al. (2002) who present results on country-pairs basis, with the US acting as the reference country. Ravn (2001) analyzes the case of country-RoW; however, his incomplete asset market structure is

consumption plus services. The real effective exchange rate is taken from the IFS for the period 1980:1-2000:4. The NFA position was disaggregated to get quarterly series by the methodology of Chow and Lin (1971) considering the current account as the related series.

By way of contrast, our first estimation closely follows Kollmann (1995). In the moment condition we allow for different coefficients of risk aversion for Australia and RoW. For the period 1970:1 to 2000:4, the risk-sharing condition estimated by Kollmann gives us the following

$$E_t \left[\underset{(1.196)}{-0.333} \Delta \widehat{C}_{t+1} - \underset{(1.517)}{0.603} \Delta \widehat{C}^*_{t+1} - \Delta \widehat{q}_{t+1} \right] = 0, \tag{42}$$

Standard errors are shown in parentheses. We have used two lags of each variable as instruments. The associated $p - value$ of the J statistic is 0.92. All standard errors were modified using a Newey-West correction. From equation (42) we see that the risk aversion parameter has the correct sign but is not significant for the domestic economy while the coefficient that corresponds to the rest of the world is negative. It is also useful to test the bond economy restricting the risk aversion coefficient to be the same across countries. Below we show the results

$$E_t \left[\underset{(1.246)}{-0.197} \left(\Delta \widehat{C}_{t+1} - \Delta \widehat{C}^*_{t+1} \right) - \Delta \widehat{q}_{t+1} \right] = 0, \tag{43}$$

The associated $p - value$ of the J statistic is 0.80. The instruments in this case are two lags of each variable. Again, the risk-aversion parameter is negative and not significant, which confirms the lack of link between the real exchange rate and relative consumptions that characterizes a *bond economy,* and it is also consistent with previous findings by Kollmann (1995) and Ravn (2001). These results may be due to the choice of the functional form and/or to the risk-sharing condition failure[39]. Even so, we argue that this risk-sharing hypothesis could be failing because of the omission of the NFA position of the country. Thus, we perform an empirical testing of the risk-sharing under imperfect financial integration. As a benchmark we will use the results obtained in the estimation of equation (43).

In our model, the incomplete and imperfect asset market structure described in section 2 implies that the link between the real exchange rate and relative consumptions is affected by the presence of net foreign assets. The risk-sharing condition implies that an increase in the net foreign asset position today generates a expected real depreciation. By the same token, as consumers expect the relative price of home goods to be cheaper, home consumption increases relative to foreign consumption.

Under rational expectations, we define the following new set of orthogonality conditions associated with the asset market structure proposed in the paper:

$$E_t \left\{ \rho \left(\Delta \widehat{C}_{t+1} - \Delta \widehat{C}^*_{t+1} \right) - \Delta \widehat{q}_{t+1} + \delta b_t \right\} Z_t = 0 \tag{44}$$

where Z_t corresponds to the vector of instruments, and Δ stands as the first difference operator so $\left(\Delta \widehat{C}_{t+1} - \Delta \widehat{C}^*_{t+1} \right)$ is the growth rate of relative consumptions. Similarly, $\Delta \widehat{q}_{t+1}$ is the growth rate of

independent of the NFA position dynamics.

[39] Ravn (2001) includes non-separability in the utility function, money balances, leisure, government expenditure and habit persistence. His results also reject this risk-sharing hypothesis.

the real exchange rate, and b_t corresponds to the ratio of NFA position in current dollars to GDP in current dollars.

We use instruments dated t or earlier. For the estimation, our vector of instruments includes lagged growth of relative consumptions, lagged change in real exchange rate and lags of the net foreign asset position. We have chosen a reduced set of instruments other than NFA in order to minimize the potential bias that might arise from the excess of overidentifying restrictions in small samples.[40]

Theoretically, the NFA position has to return to a long-run stationary equilibrium. We perform some tests to check for non-stationarity in the NFA position for Australia, and we can not reject the null of unit root for this variable.[41]

Equation (45) shows the estimation of the new risk-sharing condition between Australia and the RoW for the period 1980:1 to 2000:4.

$$E_t\left[\underset{(0.620)}{2.503}\left(\Delta\widehat{C}_{t+1}-\Delta\widehat{C}^*_{t+1}\right)-\Delta\widehat{q}_{t+1}+\underset{(0.002)}{0.006}b_t\right]=0 \tag{45}$$

The striking result is that estimate of the risk-aversion parameter turns out to be positive and significant[42]. It seems that the inclusion of the NFA position allows us to capture some aspects of the smooth consumption possibilities, making the risk-aversion estimate positive and significant. Furthermore, the estimate of the cost of bond holdings is also positive and significant[43]. This finding confirms the prediction of our theory that a NFA accumulation will generate an expected real exchange depreciation.

To check the robustness of our findings, we perform a bilateral estimation between Australia and US. In this case, we extend the sample period to run from 1975:1 until 2000:4. The results are shown in the next equation[44]

$$E_t\left[\underset{(0.465)}{1.583}\left(\Delta\widehat{C}_{t+1}-\Delta\widehat{C}^*_{t+1}\right)-\Delta\widehat{q}_{t+1}+\underset{(0.0022)}{0.0044}b_t\right]=0 \tag{46}$$

The result are quite similar to the Australia vs RoW estimation. Again the coefficient of risk aversion is positive, bigger than one and significant. On the other hand, the cost of bond holding parameter has the right sign.

Our previous findings bring some evidence in favor of a theory in which the net foreign asset position plays an explicit role in risk-sharing across countries. The influence of the net foreign asset position may be better capturing both the associated time varying risk-premium and smooth consumption possibilities for Australia.

[40]The NFA position for Australia is very persistent. In this context, it is advisable to consider a large number of lags as instruments to capture this fact.

[41]Augmented Dicker-Fuller and Phillips Perron tests can not reject the null hypothesis of unit root. It is also the case that the power of unit root test is limited in small samples and can lead to misleading interpretations under highly persistent series.

[42]Recent empirical evidence presented by Yogo (2002) locates the value of the elasticity of intertemporal substitution -inverse of the risk aversion parameter- below one.

[43]A proper correction of standard errosr may be appealing when the series are very persistent.

[44]The bilateral estimation Australia-USA of the *bond economy* performs quite similar to its multilateral version shown in the text.

Since weak identification problems may invalidate hypothesis testing[45], we use the procedure suggested by Stock and Wright (2000) to test if our instruments are weak.[46] We construct the conventional 90% confidence ellipse with the 90% S-set, and the tests for our models are reported in figure 5.[47] Under the reasonable assumption that the risk-aversion parameter is not "too large" as previous empirical evidence has suggested (see Yogo (2002)), our estimations may not be driven by important weak identification problems.

In a nutshell, it seems reasonable to consider a theory where the NFA position affects the risk-sharing across countries.[48] It appears that growth factors of consumption and real exchange rates behave in a manner which may be consistent with the assumptions implicit in our incomplete and imperfect market structure. Although our findings are in favor of our theory, for some other larger economies the NFA position may not be capturing a time varying risk-premium. To assess more precisely the importance of NFA in the risk sharing across countries, a more extensive analysis covering a larger number of countries is a natural next step.

5 Conclusions

An important issue in international macroeconomics is the lack of risk-sharing across countries. Standard complete market models predict a high and positive cross-correlation between the real exchange rate and relative consumptions while in the data we observe the opposite.

In this paper we have taken a step toward solving this *anomaly* stressing the importance of international financial frictions in this issue. We have enriched previous models with a particular incomplete asset market structure in which the net foreign asset position affects the real exchange rate dynamics by entering in the risk-sharing condition. Our results suggest that the interaction of incomplete markets and imperfect financial integration may deliver very low cross-correlations between real exchange rate and relative consumptions. In our model, financial frictions generate deviations from UIP, which allow us to affect the risk-sharing condition through the NFA position. In this context, there is an explicit link between the UIP puzzle and the consumption real exchange rate *anomaly*. Finally, the imperfect pass-through mechanism, by closing the current account channel, does not help to explain the lack of risk-sharing.

We conclude our work by testing empirically the risk-sharing condition derived in the paper. We find some support for the incomplete asset market structure since growth factors of consumption and real

[45] Consumption growth is very unpredictable, and the change in the real exchange rate exhibits a very low persistence with respect to the original series. Therefore, our instruments could be weakly correlated with the endogenous regressors and the possibility of weak identification could arise.

[46] Stock, Wright and Yogo (2002) also present a survey about the procedures available for detecting and handling weak instruments in GMM estimations.

[47] The *S-set* consists of parameter values at which one fails to reject the join hypothesis that the parameters are the true values and that the overidentifying conditions are valid. It contains all parameters that pass the 90% χ^2_k test, where k is the degree of freedom, and therefore, contains the topology of the objective function. As a rule- of-thumb, if the *S-sets* are unreasonably large, then the parameters are poorly identified. See Stock and Wright (2000) for more details.

[48] Gagnon (1996), focusing on annual data for 20 industrial countries from 1973-1995, finds that there is a significant and robust relationship between the real exchange rate and NFA. An increase in the NFA position delivers a real exchange rate appreciation.

exchange rates behave in a manner which is consistent with a significant role for the net foreign asset position.

Throughout the paper we have emphasized the importance of net foreign assets explaining the low cross-correlation between real exchange rate and relative consumptions. Our results are based on simplifying assumptions that facilitate the analysis. Extending the model allowing for home bias, capital accumulation, different Taylor rules and stickiness in the tradable sector may change the dynamics of real exchange rate, and therefore, the comovement between the real exchange rate and relative consumptions.

Appendices

A. Steady State

We define the symmetric steady state around which we will approximate the economy. The inflation and depreciation rates are zero, and there are no productivity shocks ($Z_i = 1$) for all $i = T, NT, T^*, NT^*$.

From equations (17) and (18) we get

$$\beta = \frac{1}{1+\bar{i}_t} = \frac{1}{1+\bar{i}_t^*} \tag{A1}$$

which along with equation (19) implies $\frac{\overline{SB_F}}{\overline{P}} = 0$ in steady state.

From equation (20) we obtain

$$\overline{C} = \frac{\overline{W_T}}{P}\overline{N}_T + \frac{\overline{W_{NT}}}{P}\overline{N}_{NT} \tag{A2}$$

and from the resource constraint of the foreign country

$$\overline{C^*} = \frac{\overline{W}_T^*}{P^*}\overline{N_T^*} + \frac{\overline{W}_{NT}^*}{P^*}\overline{N_{NT}^*} \tag{A3}$$

In equilibrium,(14) and (15) together with the corresponding foreign conditions imply

$$V_N\left(\overline{N}_T\right) = U_c\left(\overline{C}\right)\frac{\overline{W}_T}{\overline{P}} \tag{A4}$$

$$V_N\left(\overline{N}_{NT}\right) = U_c\left(\overline{C}\right)\frac{\overline{W}_{NT}}{\overline{P}} \tag{A5}$$

$$V_N\left(\overline{N}_T^*\right) = U_c\left(\overline{C}^*\right)\frac{\overline{W^*}_T}{\overline{P}^*} \tag{A6}$$

$$V_N\left(\overline{N}_{NT}^*\right) = U_c\left(\overline{C}^*\right)\frac{\overline{W^*}_{NT}}{\overline{P}^*} \tag{A7}$$

We log-linearize around a steady state where $\overline{N}_T = \overline{N_T^*}$ and $\overline{N}_{NT} = \overline{N_{NT}^*}$, and combining $(A4)$, (A5),(A6) and (A7) we get

$$\overline{C} = \overline{C}^*$$

In steady state the consumer prices in domestic and foreign markets are

$$\overline{P}_{NT} = \Phi\overline{W}_{NT} \tag{A8}$$

$$\overline{P}_{NT}^* = \Phi\overline{W}_{NT}^* \tag{A9}$$

$$\overline{P}_H = \Phi \overline{W}_T + \frac{k\sigma}{(\sigma-1)}\overline{P}_{NT} \tag{A10}$$

$$\overline{P}^*_H = \Phi \frac{\overline{W}_T}{\overline{S}} + \frac{k\sigma}{(\sigma-1)}\overline{P}^*_{NT} \tag{A11}$$

$$\overline{P}_F = \Phi \overline{W}^*_T \overline{S} + \frac{k\sigma}{(\sigma-1)}\overline{P}_{NT} \tag{A12}$$

$$\overline{P}^*_F = \Phi \overline{W}^*_T + \frac{k\sigma}{(\sigma-1)}\overline{P}^*_{NT} \tag{A13}$$

or equivalently

$$\begin{aligned}
(n+(1-n)\overline{T}^{1-\theta})^{\frac{1}{\theta-1}}(\gamma+(1-\gamma)\overline{R}^{\varepsilon-1})^{\frac{1}{\varepsilon-1}} &= \Phi\frac{V_N\left(\overline{Y}_H\right)}{U_c(\overline{C})} + \frac{k\sigma}{(\sigma-1)}(1-\gamma+\gamma\overline{R}^{1-\varepsilon})^{\frac{1}{\varepsilon-1}} \\
(n+(1-n)\overline{T}^{*\theta-1})^{\frac{1}{1-\theta}}(\gamma+(1-\gamma)\overline{R}^{*\varepsilon-1})^{\frac{1}{\varepsilon-1}} &= \Phi\frac{V_N\left(\overline{Y}_H\right)}{U_c(\overline{C}^*)} + \frac{k\sigma}{(\sigma-1)}(1-\gamma+\gamma\overline{R}^{*1-\varepsilon})^{\frac{1}{\varepsilon-1}} \\
(1-n+n\overline{T}^{\theta-1})^{\frac{1}{\theta-1}}(\gamma+(1-\gamma)\overline{R}^{\varepsilon-1})^{\frac{1}{\varepsilon-1}} &= \Phi\frac{V_N\left(\overline{Y}_F\right)}{U_c(\overline{C})} + \frac{k\sigma}{(\sigma-1)}(1-\gamma+\gamma\overline{R}^{1-\varepsilon})^{\frac{1}{\varepsilon-1}} \\
(1-n+n\overline{T}^{*1-\theta})^{\frac{1}{\theta-1}}(\gamma+(1-\gamma)\overline{R}^{*\varepsilon-1})^{\frac{1}{\varepsilon-1}} &= \Phi\frac{V_N\left(\overline{Y}_F\right)}{U_c(\overline{C}^*)} + \frac{k\sigma}{(\sigma-1)}(1-\gamma+\gamma\overline{R}^{*1-\varepsilon})^{\frac{1}{\varepsilon-1}}
\end{aligned}$$

where $\Phi = \frac{\sigma}{(\sigma-1)}$

Similarly, the domestic prices for the non-tradables goods are given by

$$\begin{aligned}
(\gamma\overline{R}^{1-\varepsilon}+(1-\gamma))^{\frac{1}{\varepsilon-1}} &= \Phi\frac{V_N\left(\overline{Y}_{NT}\right)}{U_c(\overline{C})} \\
(\gamma\overline{R}^{*1-\varepsilon}+(1-\gamma))^{\frac{1}{\varepsilon-1}} &= \Phi\frac{V_N\left(\overline{Y}_{NT^*}\right)}{U_c(\overline{C}^*)}
\end{aligned}$$

where

$$\begin{aligned}
\overline{Y}_H &= \overline{C}_H + \overline{C_H}^* \\
\overline{Y}_F &= \overline{C}_F + \overline{C}^*_F \\
\overline{Y}_{NT} &= (1-\gamma)((1-\gamma)+\gamma\overline{R}^{1-\varepsilon})^{\frac{\varepsilon}{1-\varepsilon}}\overline{C} + k\left[\overline{C}_H + \overline{C}_F\right] \\
\overline{Y}^*_{NT} &= (1-\gamma)((1-\gamma)+\gamma\overline{R}^{*1-\varepsilon})^{\frac{\varepsilon}{1-\varepsilon}}\overline{C}^* + k\left[\overline{C_H}^* + \overline{C}^*_F\right]
\end{aligned}$$

and

$$\overline{C}_H = n\gamma(n+(1-n)\overline{T}^{1-\theta})^{\frac{\theta}{1-\theta}}(\gamma+(1-\gamma)\overline{R}^{\varepsilon-1})^{\frac{\varepsilon}{1-\varepsilon}}\overline{C}$$

$$\overline{C_H}^* = (1-n)\gamma((n+(1-n)\overline{T}^{*\theta-1})^{\frac{\theta}{1-\theta}}(\gamma+(1-\gamma)\overline{R}^{*\varepsilon-1})^{\frac{\varepsilon}{1-\varepsilon}}\overline{C}^*$$

$$\overline{C}_F = n\gamma((1-n)+n\overline{T}^{\theta-1})^{\frac{\theta}{1-\theta}}(\gamma+(1-\gamma)\overline{R}^{\varepsilon-1})^{\frac{\varepsilon}{1-\varepsilon}}\overline{C}$$

$$\overline{C}^*_F = (1-n)\gamma((1-n)+n\overline{T}^{*1-\theta})^{\frac{\theta}{1-\theta}}(\gamma+(1-\gamma)\overline{R}^{*\varepsilon-1})^{\frac{\varepsilon}{1-\varepsilon}}\overline{C}^*$$

$$\overline{\overline{\eta}}(n) = k\left[\overline{C}_H + \overline{C}_F\right]$$

Since $\overline{Y}_H = \overline{Y}_F$ and $\overline{Y}_{NT} = \overline{Y}^*_{NT}$. We can pin down $\overline{T}$, $\overline{T}^*$, $\overline{R}$ and $\overline{R}^*$.

It is easy to show that $\overline{T} = \overline{T}^* = 1$, and $\overline{R} = \overline{R}^* = \left(1 + \frac{k\sigma}{(\sigma-1)}\right)$ is a solution. Then we get $\frac{\overline{\overline{\eta}}(n)}{\overline{Y}_N} = 2n\kappa/\left(2n\kappa + \frac{(1-\gamma)}{\gamma}\overline{R}^{\varepsilon}\right) = v$, and $\frac{\overline{C}_N}{\overline{Y}_N} \equiv 1 - v$ which will be used in the next appendix.

B. Phillips Curve

In this section we log-linearize the price setting for non tradable goods, equation (26), around the steady state defined in appendix A.

We can write equation (26) as:

$$E_t \sum_{k=0}^{\infty} (\alpha\beta)^k \frac{U_C(C_{t+k}) P_{NT,t+k}}{P_{t+k}} \{ \frac{\widetilde{p}_{NT,t}(h)}{P_{NT,t+k}} - \frac{\sigma}{\sigma-1} \frac{W^h_{NT,t+k}}{P_{NT,t+k} Z_{NT,t+k}} \} \widetilde{y}^d_{NT\ t,t+k}(h) = 0 \tag{B1}$$

which can be re-written as

$$E_t \sum_{k=0}^{\infty} (\alpha\beta)^k \frac{U_C(C_{t+k}) P_{NT,t+k}}{P_{t+k}} \{ \frac{\widetilde{p}_{NT,t}(h)}{P_{NT,t+k}} - \frac{\sigma}{\sigma-1} \frac{W^h_{NT,t+k}}{P_{t+k} Z_{NT,t+k}} \frac{P_{t+k}}{P_{NT,t+k}} \} \widetilde{y}^d_{NT\ t,t+k}(h) = 0 \tag{B2}$$

After taking a log-linear approximation of the previous expression, and defining $\widehat{p}_{NT\ t,t+k}(h) = \ln(\widetilde{p}_{NT,t}(h)/P_{NT,t+k})$, we obtain

$$E_t \sum_{k=0}^{\infty} (\alpha\beta)^k \left[\widehat{p}_{NT\ t,t+k}(h) - \frac{\widehat{W}^h_{NT,t+k}}{P_{t+k} Z_{NT,t+k}} \frac{\widehat{P}_{t+k}}{P_{NT,t+k}} \right] = 0, \tag{B3}$$

where

$$\frac{\widehat{W}^h_{NT,t+k}}{P_{t+k} Z_{NT,t+k}} = \frac{\widehat{W}^h_{NT,t+k}}{P_{t+k}} - \widehat{Z}_{NT,t+k} \tag{B4}$$

From the first order condition respect to the labor supply in the non-traded sector, equation (15) we get

$$\frac{\widehat{W}^h_{NT,t+k}}{P_{t+k}} = \eta \widehat{N}^h_{NT,t+k} + \rho \widehat{C}_{t+k}, \tag{B5}$$

where $\eta \equiv \frac{\overline{N} V_{NN}(\overline{N})}{V_N(\overline{N})}$ and $\rho \equiv -\frac{\overline{C} U_{CC}(\overline{C})}{U_C(\overline{C})}$. From log-linearizing the production of non tradable goods we obtain

$$\widehat{N}_{NT,t+k}(h) = \widehat{y}_{NT,t+k}(h) - \widehat{Z}_{NT,t+k} \tag{B6}$$

Recall that $R_t = \frac{P_{T,t}}{P_{NT,t}}, R^*_t = \frac{P^*_{T,t}}{P^*_{NT,t}}, T_t = \frac{P_{F,t}}{P_{H,t}}, T^*_t = \frac{P^*_{H,t}}{P^*_{F,t}}$. Then, from the price index definitions

$$\frac{P_t}{P_{NT}} \equiv [\gamma R_t^{1-\varepsilon} + (1-\gamma)]^{\frac{1}{1-\varepsilon}}, \tag{B7}$$

which in log-linear form can be expressed as

$$\frac{\widehat{P}_t}{P_{NT}} \equiv \frac{\gamma \overline{R}^{1-\varepsilon} \widehat{R}_t}{\overline{X}_1}, \tag{B8}$$

where $\overline{X}_1 \equiv \gamma \overline{R}^{1-\varepsilon} + (1-\gamma)$.

Now we are able to get the total demand for home non-traded goods, equation (22) ,that in log-linear form can be expressed:

$$\begin{aligned} \widehat{y}_{NT,t+k}(h) &= \frac{\overline{C}_N}{\overline{Y}_N}\left(-\sigma \widehat{p}_{NT\ t,t+k}(h) + \frac{\gamma\varepsilon \overline{R}^{1-\varepsilon}\widehat{R}_t}{\overline{X}_1} + \widehat{C}_t\right) + \\ & \frac{\overline{\eta}(n)}{\overline{Y}_N}\left[\begin{array}{c} -\sigma \widehat{p}_{NT\ t,t+k}(h) + \frac{\overline{C}_H}{\overline{C}_H+\overline{C}_F}\left(\theta(1-n)\widehat{T}_t - \frac{(1-\gamma)\varepsilon}{\overline{X}_1}\widehat{R}_t + \widehat{C}_t\right) + \\ \frac{\overline{C}_F}{\overline{C}_H+\overline{C}_F}\left(-\theta n \widehat{T}_t - \frac{(1-\gamma)\varepsilon}{\overline{X}_1}\widehat{R}_t + \widehat{C}_t\right) \end{array}\right] \end{aligned} \tag{B9}$$

$$\widehat{y}_{NT,t+k}(h) = -\sigma \widehat{p}_{NT\ t,t+k}(h) + \upsilon\theta\left(\frac{1}{2} - n\right)\widehat{T}_t + \mu \widehat{R}_t + \widehat{C}_t \tag{B9\_A}$$

where $\mu \equiv \frac{\varepsilon\left((1-\upsilon)\gamma \overline{R}^{1-\varepsilon} - \upsilon(1-\gamma)\right)}{\gamma \overline{R}^{1-\varepsilon} + (1-\gamma)}$.

To obtain the above expression we have used the log-linear forms of the demands for home and foreign goods domestically, equations (29) and (30). Note that

$$\widehat{p}_{NT\ t,t+k}(h) = \widehat{p}_{NT\ t,t}(h) - \sum_{j=1}^{k} \pi_{NT,t+j} \tag{B10}$$

and from log-linearizing (27)

$$\widehat{p}_{NT\ t,t}(h) = \frac{\alpha}{1-\alpha}\pi_{NT,t} \tag{B11}$$

Then, combining expressions $(B4)$,$(B6)$,$(B5)$and $(B8)$ we get

$$\frac{\widehat{W}^j_{NT,t+k}}{P_{t+k} Z_{NT,t+k}} \frac{\widehat{P}_{t+k}}{P_{NT,t+k}} = \left\{ \eta \widehat{y}_{NT,t+k}(h) + \rho \widehat{C}_{t+k} - (1+\eta)\widehat{Z}_{NT,t+k} + \frac{\gamma \overline{R}^{1-\varepsilon}\widehat{R}_t}{\overline{X}} \right\} \tag{B12}$$

Plugging (B9) into (B12) and using this result together with $(B11)$ and $(B3)$ we get the aggregate supply equation :

$$\pi_{NT,t} = \kappa \widehat{mc}_t + \beta E_t \pi_{NT,t+1} \tag{B13}$$

where $\widehat{mc}_t \equiv \left[a_0 \widehat{T}_t + (\rho+\eta)\widehat{C}_t + a_1 \widehat{R}_t - (1+\eta) Z^{NT}_t\right]$. This corresponds to the aggregate supply expression AS_H in Table 1.

The coefficients are:

$a_0 \equiv \left(\frac{1}{2} - n\right)\theta\eta\upsilon$; $a_1 \equiv \gamma \overline{R}^{1-\varepsilon} / \left(\gamma \overline{R}^{1-\varepsilon} + (1-\gamma)\right) + \eta\mu$, $\kappa^{NT} \equiv (1-\alpha\beta)(1-\alpha)/\alpha(1+\sigma\eta)$,

$\kappa^{NT^*} \equiv (1-\alpha^*\beta)(1-\alpha^*)/\alpha^*(1+\sigma\eta)$, *where* $\upsilon \equiv 2n\kappa / \left(2n\kappa + \frac{(1-\gamma)}{\gamma}\overline{R}^{\varepsilon}\right)$ and $\overline{R} \equiv 1 + \frac{k\sigma}{\sigma - 1} > 1$

When we assume perfect mobility across sectors, the home *aggregate supply* will read as

$$\pi_{NT,t} = \kappa^{NT}\left[a_0 \widehat{T}_t + (\rho + \eta - \Omega)\widehat{C}_t + \Omega \widehat{C}^*_t + a_1 \widehat{R}_t + a_2 \widehat{R}^*_t - (1 + (1-\omega)\eta)\widehat{Z}_{NT,t} - \omega\eta \widehat{Z}_{T,t}\right] + \beta E_t \pi_{NT,t+1} ;$$

where $\omega = 1/\left(1 + 2n\kappa + \frac{(1-\gamma)}{\gamma}\overline{R}^{\varepsilon}\right)$ and $\Omega = \omega\eta(1-n)$.

C. Flexible Price Allocation and Output Gap

In this appendix we derive the flexible price allocation needed to determine the output gap. We define $X^R = X - X^*$ and $X^W = nX + (1-n)X^*$. First, the flexible price allocation under complete markets is given by

$$\begin{aligned}
\widetilde{T}_t &= \frac{(1+\eta)}{\overline{R}+\eta\theta}\widetilde{Z}^R_{T,t} \\
\widetilde{R}^R_t &= \left(\frac{(1+\eta)\rho}{(\rho+\eta)\,c_0+\rho a_1}\right)\widetilde{Z}^R_{NT,t} \\
\widetilde{R}^W_t &= \left(\frac{1+\eta}{c_1+a_1}\right)\left[\widetilde{Z}^W_{NT,t}-\widetilde{Z}^W_{T,t}\right] \\
\widetilde{C}^R_t &= \left(\frac{c_0(1+\eta)}{(\rho+\eta)\,c_0+\rho a_1}\right)\widetilde{Z}^R_{NT,t} \\
\widetilde{C}^W_t &= \left(\frac{(1+\eta)}{(\rho+\eta)\,(c_1+a_1)}\right)\left[c_1\widetilde{Z}^W_{NT,t}+a_1\widetilde{Z}^W_{T,t}\right]
\end{aligned}$$

where $c_0 = \left(\overline{R}(1-\gamma)+\gamma\left(\overline{R}-1\right)\overline{R}^{1-\varepsilon}\right)/\left(\gamma\overline{R}^{1-\varepsilon}+(1-\gamma)\right)$ and $c_1 = c_0+\eta\varepsilon\,(1-\gamma)\,/\left(\gamma\overline{R}^{1-\varepsilon}+(1-\gamma)\right)$.

Then, we can determine the output gap as

$$\begin{aligned}
y_t &= \omega\widehat{Y}_{H,t}+(1-\omega)\,\widehat{Y}_{NT,t}-\left(\omega\widetilde{Y}_{H,t}+(1-\omega)\,\widetilde{Y}_{NT,t}\right), \\
y^*_t &= \omega\widehat{Y}_{F,t}+(1-\omega)\,\widehat{Y}^*_{NT,t}-\left(\omega\widetilde{Y}_{F,t}+(1-\omega)\,\widetilde{Y}^*_{NT,t}\right)
\end{aligned}$$

where

$$\begin{aligned}
\widetilde{Y}_{H,t} &= \widetilde{Y}_t^{\,W}+(1-n)\,\widetilde{Y}_t^{\,R}, \\
\widetilde{Y}_{F,t} &= \widetilde{Y}_t^{\,W}-n\widetilde{Y}_t^{\,R}, \\
\widetilde{Y}_{NT,t} &= \widetilde{Y}^W_{NT,t}+(1-n)\,\widetilde{Y}^R_{NT,t}, \\
\widetilde{Y}^*_{NT,t} &= \widetilde{Y}^W_{NT,t}-n\widetilde{Y}^R_{NT,t},
\end{aligned}$$

and

$$
\begin{aligned}
\widehat{Y}_H &= \theta\left(1-n\right)\widehat{T}_t - \frac{\varepsilon\left(1-\gamma\right)}{\gamma\overline{R}^{1-\varepsilon}+\left(1-\gamma\right)}\left(n\widehat{R}_t+(1-n)\widehat{R}_t^*\right)+n\widehat{C}_t+\left(1-n\right)\widehat{C}_t^* \\
\widehat{Y}_F &= -\theta n\widehat{T}_t - \frac{\varepsilon\left(1-\gamma\right)}{\gamma\overline{R}^{1-\varepsilon}+\left(1-\gamma\right)}\left(n\widehat{R}_t+(1-n)\widehat{R}_t^*\right)+n\widehat{C}_t+\left(1-n\right)\widehat{C}_t^* \\
\widehat{Y}_{NT} &= \upsilon\theta\left(\frac{1}{2}-n\right)\widehat{T}_t+\mu\widehat{R}_t+\widehat{C}_t \\
\widetilde{Y}_t^R &= \theta\widetilde{T}_t \\
\widetilde{Y}_t^W &= -\varepsilon\frac{\left(1-\gamma\right)}{\gamma R^{1-\varepsilon}+\left(1-\gamma\right)}\widetilde{R}_t^W+\widetilde{C}_t^W \\
\widetilde{Y}_{NT,t}^R &= \mu\widetilde{R}_t^R+\widetilde{C}_t^R \\
\widetilde{Y}_{NT,t}^W &= \upsilon\theta\left(\frac{1}{2}-n\right)\widetilde{T}_t+\mu\widetilde{R}_t^W+\widetilde{C}_t^W
\end{aligned}
$$

D. Current Account Dynamics under IPT

Here, we will log-linearize the current account equation (20). First, some steady state definitions are needed:

$\overline{R} \equiv 1 + \frac{k\sigma}{\sigma-1}$; $\frac{\overline{\eta}(n)}{\overline{Y}_N} = \upsilon = 2n\kappa / \left(2n\kappa + \frac{(1-\gamma)}{\gamma}\overline{R}^{\varepsilon}\right)$. Remember that $\widehat{T}_t = -\widehat{T}_t^*$.

$$\begin{aligned}
\widehat{Y}_{NT} &= \upsilon\theta\left(\frac{1}{2} - n\right)\widehat{T}_t + \mu\widehat{R}_t + \widehat{C}_t \\
\widehat{C}_{F,t} &= -\theta n\widehat{T}_t - \frac{\varepsilon(1-\gamma)}{\gamma\overline{R}^{1-\varepsilon} + (1-\gamma)}\widehat{R}_t + \widehat{C}_t \\
\widehat{C}_{H,t} &= \theta(1-n)\widehat{T}_t - \frac{\varepsilon(1-\gamma)}{\gamma\overline{R}^{1-\varepsilon} + (1-\gamma)}\widehat{R}_t + \widehat{C}_t \\
\widehat{C}_{H,t}^* &= \theta(1-n)\widehat{T}_t - \frac{\varepsilon(1-\gamma)}{\gamma\overline{R}^{1-\varepsilon} + (1-\gamma)}\widehat{R}_t^* + \widehat{C}_t^* \\
\widehat{C}_{N,t} &= \frac{\varepsilon\gamma\overline{R}^{1-\varepsilon}}{\gamma\overline{R}^{1-\varepsilon} + (1-\gamma)}\widehat{R}_t + \widehat{C}_t
\end{aligned}$$

where $\mu \equiv \frac{\varepsilon\left((1-\upsilon)\gamma\overline{R}^{1-\varepsilon} - \upsilon(1-\gamma)\right)}{\gamma\overline{R}^{1-\varepsilon} + (1-\gamma)}$

The current account can be rewritten (20)as:

$$\frac{S_t B_{F,t}}{P_t\left(1+i_t^*\right)\phi\left(\frac{B_{F,t}S_t}{P_t}\right)} - \frac{S_t B_{F,t-1}}{P_t} = \frac{P_{T,t}}{P_t}\frac{P_{H,t}}{P_{T,t}}C_{H,t} + q_t\frac{P_{T,t}^*}{P_t^*}\frac{P_{H,t}^*}{P_{T,t}^*}C_{H,t}^* + \frac{P_{NT,t}}{P_t}C_{NT_t} - C_t \tag{E1}$$

We will log-linearize the following component of the right hand side of $(E1)$

$$Y_t \equiv \frac{P_{T,t}}{P_t}\frac{P_{H,t}}{P_{T,t}}C_{H,t} + q_t\frac{P_{T,t}^*}{P_t^*}\frac{P_{H,t}^*}{P_{T,t}^*}C_{H,t}^* + \frac{P_{NT,t}}{P_t}C_{NT_t} \tag{E2}$$

we need the following steady state definitions:

$$\begin{aligned}
\overline{\frac{P_T}{P}\frac{P_H}{P_T}}\overline{C_H} &= n\gamma[\gamma + (1-\gamma)\overline{R}^{1-\varepsilon}]^{-1} = \frac{n\gamma\overline{R}^{1-\varepsilon}}{\gamma\overline{R}^{1-\varepsilon} + (1-\gamma)} \\
\overline{Y} &= \frac{1}{\gamma\overline{R}^{1-\varepsilon} + (1-\gamma)}\left[\gamma\overline{R}^{1-\varepsilon} + (1-\gamma) + 2n\kappa\gamma\overline{R}^{-\varepsilon}\right] \\
\frac{\overline{\frac{P_T}{P}\frac{P_H}{P_T}}\overline{C_H}}{\overline{Y}} &= \lambda \equiv n\gamma\overline{R}^{1-\varepsilon} / \left[\gamma\overline{R}^{1-\varepsilon} + (1-\gamma) + 2nk\gamma\overline{R}^{-\varepsilon}\right] \\
\frac{\overline{q}_t\overline{\frac{\overline{P}_T^*}{P^*}}\overline{\frac{P_H^*}{P_T^*}}\overline{C_H^*}}{\overline{Y}} &= \lambda\frac{(1-n)}{n} \\
\frac{\overline{\frac{P_N}{P}}\overline{C_N}}{\overline{Y}} &= 1 - \lambda - \lambda\frac{(1-n)}{n} = 1 - \frac{\lambda}{n}
\end{aligned}$$

Log-linearizing Y_t we get

$$\widehat{Y}_t = \lambda\left[\frac{(1-\gamma)}{\gamma\overline{R}^{1-\varepsilon}+(1-\gamma)}\widehat{R}_t-(1-n)\,\widehat{T}_t+\widehat{C}_{H,t}\right]+\lambda\frac{(1-n)}{n}\left[\widehat{q}_t+\frac{(1-\gamma)}{\gamma\overline{R}^{1-\varepsilon}+(1-\gamma)}\widehat{R}^*_t-(1-n)\,\widehat{T}_t+\widehat{C}^*_{H,t}\right] + \left(1-\frac{\lambda}{n}\right)\left[-\frac{\gamma\overline{R}^{1-\varepsilon}}{\gamma\overline{R}^{1-\varepsilon}+(1-\gamma)}\widehat{R}_t+\widehat{Y}_{N,t}\right] \tag{E3}$$

combining the above equation with the demands $\widehat{C}_{H,t}$ and $\widehat{C}^*_{H,t}$ we get

$$\beta b_t = b_{t-1}+v_1\widehat{T}_t+v_2\widehat{R}_t+v_3\widehat{R}^*_t+v_4\left(\widehat{q}_t+\widehat{C}^*_t\right)+v_5\widehat{Y}_{NT}+v_6\widehat{C}_t \tag{E4}$$

$v_1 \equiv \frac{\lambda}{n}(1-n)(\theta-1)$;
$v_2 \equiv \left[\lambda\left((1-\gamma)-\varepsilon(1-\gamma)\right)-(1-\lambda/n)\gamma\overline{R}^{1-\varepsilon})\right]/\left(\gamma\overline{R}^{1-\varepsilon}+(1-\gamma)\right)$;
$v_3 \equiv \left[\lambda(1-n)/n\left((1-\gamma)-\varepsilon(1-\gamma)\right)\right]/\left(\gamma\overline{R}^{1-\varepsilon}+(1-\gamma)\right)$
$v_4 \equiv \lambda(1-n)/n; v_5 \equiv (1-\lambda/n); v_6 \equiv \lambda-1$
Plugging $\widehat{Y}_{NT}$

$$\beta b_t = b_{t-1}+v_1\widehat{T}_t+v_2\widehat{R}_t+v_3\widehat{R}^*_t+v_4\left(\widehat{q}_t+\widehat{C}^*_t\right)+v_5\left(\upsilon\theta\left(\frac{1}{2}-n\right)\widehat{T}_t+\mu\widehat{R}_t+\widehat{C}_t\right)+v_6\widehat{C}_t \tag{E5}$$

Replacing the parameters in order to get equation NFA in table 1:
$\beta b_t = b_{t-1}+\left(v_1+v_5\upsilon\theta\left(\frac{1}{2}-n\right)\right)\widehat{T}_t+(v_2+v_5\mu)\,\widehat{R}_t+v_3\widehat{R}^*_t+v_4\left(\widehat{q}_t+\widehat{C}^*_t\right)+(v_5+v_6)\,\widehat{C}_t$
$\beta b_t = b_{t-1}+\left(\frac{\lambda}{n}(1-n)(\theta-1)+(1-\lambda/n)\upsilon\theta\left(\frac{1}{2}-n\right)\right)\widehat{T}_t$
$+\left(\left[\lambda\left((1-\gamma)-\varepsilon(1-\gamma)\right)-(1-\lambda/n)\gamma\overline{R}^{1-\varepsilon})\right]/\left(\gamma\overline{R}^{1-\varepsilon}+(1-\gamma)\right)+(1-\lambda/n)\mu\right)\widehat{R}_t$
$+\left[\lambda(1-n)/n\left((1-\gamma)-\varepsilon(1-\gamma)\right)\right]/\left(\gamma\overline{R}^{1-\varepsilon}+(1-\gamma)\right)\widehat{R}^*_t+\lambda(1-n)/n\left(\widehat{q}_t+\widehat{C}^*_t\right)+\lambda\frac{n-1}{n}\widehat{C}_t$
we get the dynamics of the current account shown in table 1:

$$\beta b_t = b_{t-1}+b_1\widehat{T}_t+b_2\widehat{R}_t+b_3\widehat{R}^*_t-b_4\left(\widehat{C}_t-\widehat{C}^*_t-\widehat{q}_t\right) \tag{E6}$$

where
$b_1 \equiv \frac{\lambda}{n}(1-n)(\theta-1)+(1-\lambda/n)\upsilon\theta\left(\frac{1}{2}-n\right)$;
$b_2 \equiv \left[\lambda\left((1-\gamma)-\varepsilon(1-\gamma)\right)-(1-\lambda/n)\gamma\overline{R}^{1-\varepsilon})\right]/\left(\gamma\overline{R}^{1-\varepsilon}+(1-\gamma)\right)+(1-\lambda/n)\mu$;
$b_3 \equiv \left[\lambda(1-n)/n\left((1-\gamma)-\varepsilon(1-\gamma)\right)\right]/\left(\gamma\overline{R}^{1-\varepsilon}+(1-\gamma)\right)$;
$b_4 \equiv \lambda(1-n)/n$;
$b_t = (B_{F,t}/P^*_t)\,C^{-1}$.

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Table 2
Benchmark Parametrization

Baseline		
	Preferences	$\beta = 0.99$; $\sigma = 7.88$; $\eta = 0.47$; $\rho = 5$; $\theta = 2$; $\varepsilon = 0.77; \gamma = 0.6; n = 0.5$
	Technology shocks	$\rho_T = \rho_T^* = 0.95; var(\varepsilon_T) = var(\varepsilon_T^*) = (0.007)^2$. $\rho_{NT} = \rho_{NT}^* = 0.93; var(\varepsilon_{NT}) = var(\varepsilon_{NT}^*) = (0.002)^2$.
	Distributions costs	No distribution costs. $\kappa = 0$; Distribution costs. $\kappa = 0.8$
	Taylor Rule	$\gamma_\pi = 1.5$; $\gamma_y = 0.5$
	Incomplete Markets	$\delta = 0.001 - (10\ basis\ points)$
	Sticky prices	$\alpha = 0.75; \alpha^* = 0.66$

Table 3

Statistic	Data	Complete Markets		Bond Economy		Incomplete and Imperfect Asset Market Model			
		PPT	IPT	PPT	IPT	PPT, delta =0.001	PPT, delta =0.01	IPT, delta=0.001	IPT, delta=0.01
Autocorrelations									
Real Exchange Rate	0.814	0.70	0.71	0.72	0.77	0.71	0.70	0.71	0.72
Net Foreign Asset Position **	0.95	-.-	-.-	0.94	0.95	0.95	0.95	0.96	0.96
Cross-Correlations									
RER-Relative Consumption	-0.17	1.00	1.00	1.00	1.00	0.17	-0.13	0.61	0.10
RER-Net Foreign Assets	0.02	-.-	-.-	-.-	-.-	-0.11	-0.12	-0.15	-0.26
Domestic Consumption-Foreign Consumption	0.16	0.88	0.32	0.89	0.35	0.63	0.10	0.49	0.27

- Based on H-P filtered quaterly data from US time series (1973-2000) and an aggregate of European countries. The data was obtained from Chari et al (2002) and Heathcote and Perri (2002) webpages. Some statistics are authors' calculations
- The imperfect pass-through was simulated under k=0.8 which implies a 47% margin of distribution costs

* The benchmark economy considers a standard Taylor Rule targeting CPI inflation and Output Gap.

** Lane and Milesi-Ferretti (2001). Quarterly series were constructed by disaggregating annual data by Chow and Lin (1971)'s methodology

Table 4

Cross-Correlation Real Exchange Rate and Relative consumptions ($\delta = 0.001$)

	$\theta = 1$	$\theta = 2$	$\theta = 3$	$\theta = 4$	$\theta = 5$	$\theta = 6$
PPT	1.00	0.17	0.01	-0.04	-0.05	-0.05
IPT	0.75	0.61	0.43	0.31	0.24	0.19

-Exercises are over the benchmark parametrization ($\varepsilon = 0.77, \eta = 0.47, \gamma = 0.6, \rho = 5$)

Table 5

Statistic	Data	Non-Separability of labor *		Flexible Prices			
		PPT, delta =0.001	IPT, delta=0.001	PPT, delta =0.001	PPT, delta =0.01	IPT, delta=0.001	IPT, delta=0.01
Autocorrelations							
Real Exchange Rate	0.814	0.71	0.71	0.71	0.72	0.71	0.72
Net Foreign Asset Position **	0.95	0.96	0.96	0.96	0.96	0.96	0.96
Cross-Correlations							
RER-Relative Consumption	-0.17	0.37	0.51	0.10	-0.42	0.72	0.31
RER-Net Foreign Assets	0.02	-0.04	-0.14	-0.19	-0.34	-0.17	-0.28
Domestic Consumption-Foreign Consumption	0.16	0.65	0.51	0.86	0.71	0.61	0.47

- Based on H-P filtered quaterly data from US time series (1973-2000) and an aggregate of European countries. The data was obtained from Chari et al (2002) and Heathcote and Perri (2002) webpages. Some statistics are authors' calculations
- The imperfect pass-through was simulated under k=0.8 which implies a 47% margin of distribution costs

* With a standard Taylor Rule targeting CPI inflation and Output Gap.

** Lane and Milesi-Ferretti (2001). Quarterly series were constructed by disaggregating annual data by Chow and Lin (1971)'s methodology

Figure 1: Incomplete Markets: Productivity Shock in the Domestic Tradable Sector

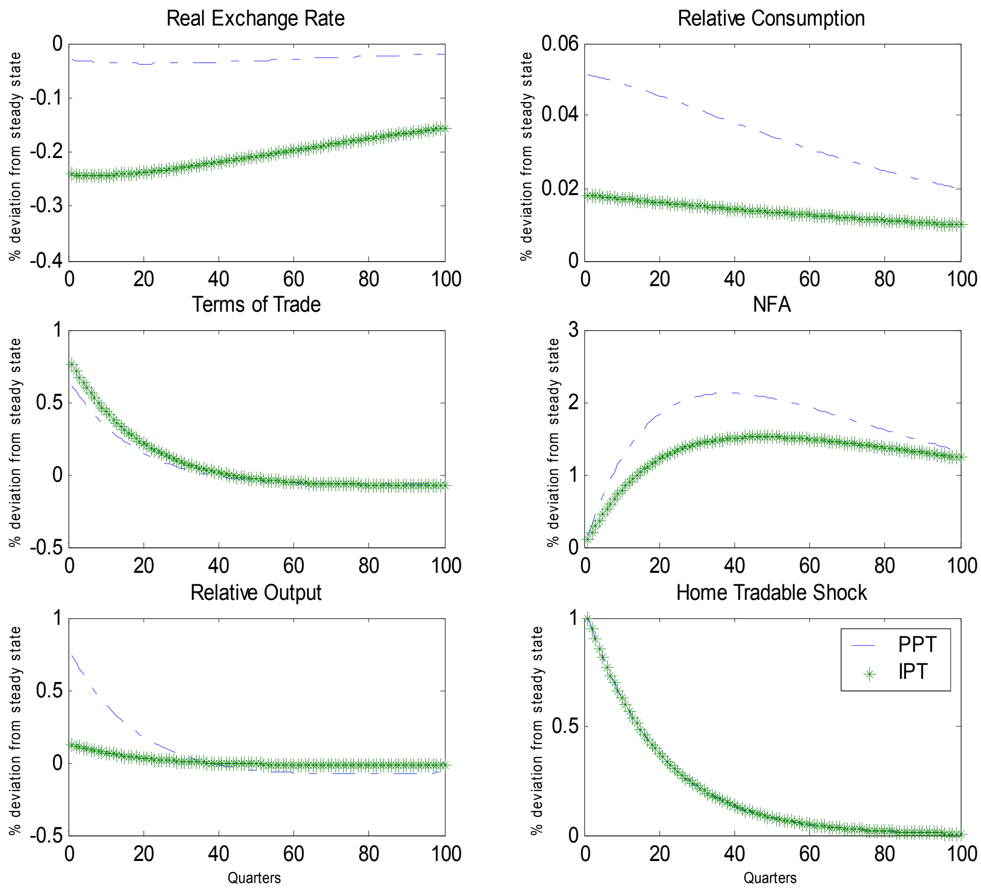


Figure 2: Incomplete Markets:Productivity Shock in the Domestic Non-Tradable Sector

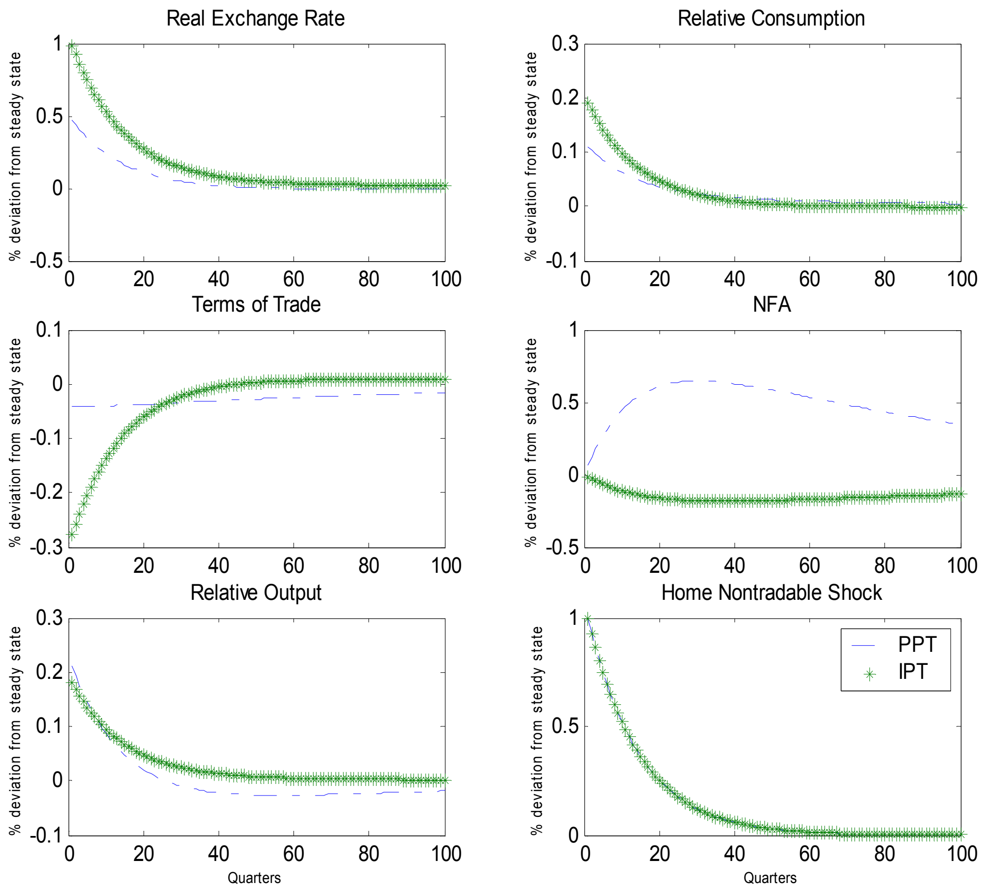
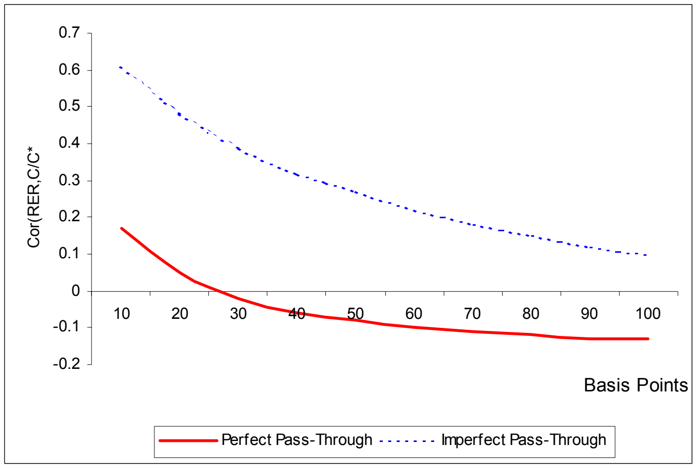
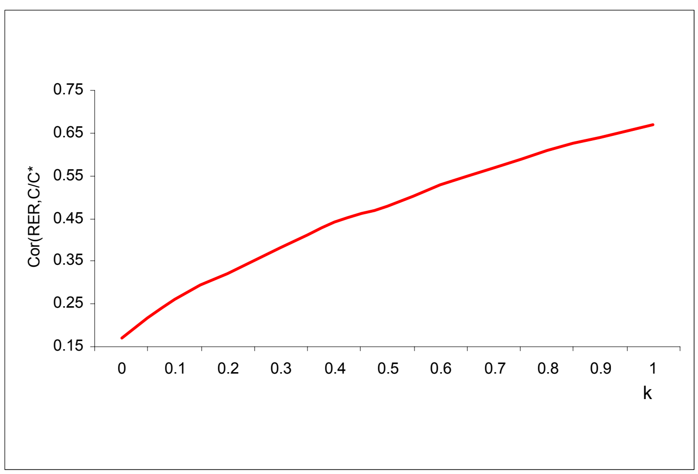


Figure 3. *Effect of the Cost of Bondholding Parameter* (δ)



Notes: Graph under the benchmark parametrization ($\varepsilon = 0.77, \theta = 2; \eta = 0.47, \gamma = 0.6, k = 0.8, \rho = 5$)

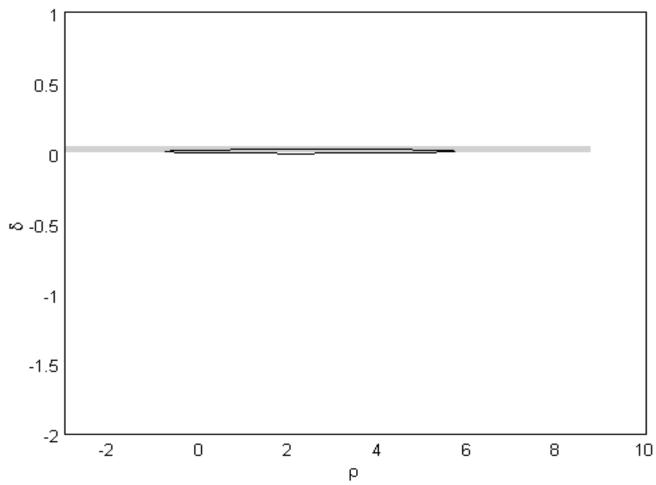
Figure 4. *Effect of Distribution Costs (k)*



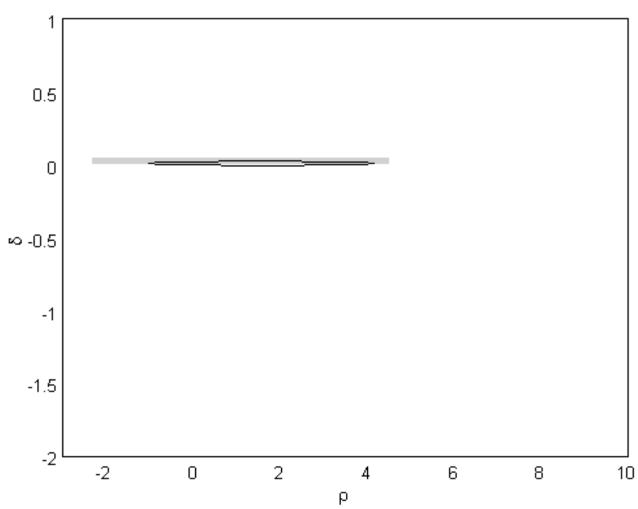
Notes: Graph under the benchmark parametrization ($\varepsilon = 0.77, \theta = 2; \eta = 0.47, \gamma = 0.6, \delta = 0.001, \rho = 5$)

Figure 5: Join S-sets

(a)



(b)



Note: Join *S-set* (shaded) and 90% confidence ellipse.