How Important is the Currency Denomination of Exports in Open-Economy Models?*

Michael Dotsey[†]

Margarida Duarte[‡]

Federal Reserve Bank
of Philadelphia

University of Toronto

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Abstract

We show in a quantitative open-economy model that standard alternative assumptions about the currency in which firms price export goods are virtually inconsequential for the properties of aggregate variables, other than the terms of trade. This result is in contrast to a large literature that emphasizes the importance of the currency denomination of exports for the properties of open-economy models.

Keywords: local currency pricing; producer currency pricing; international relative prices; exchange rates; nontraded goods; distribution services.

JEL classification: F3, F41

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[†]Federal Reserve Bank of Philadelphia, Ten Independence Mall, Philadelphia, PA 19106. E-mail address: michael.dotsey@phil.frb.org.

[‡]Corresponding author. Department of Economics, University of Toronto, 150 St. George Street, Toronto, ON M5S 3G7, Canada. Tel: 416 978 6208. Fax: 416 978 6713. E-mail address: margarida.duarte@utoronto.ca.

1 Introduction

The high volatility and persistence of real exchange rate movements are well-known puzzles in international macroeconomics. Standard decompositions of real exchange rate movements systematically find that movements in the relative price of traded goods across countries are key in understanding real exchange rate behavior whereas movements in the relative price of traded to nontraded goods across countries play a smaller role.¹ That is, in the data, the behavior of the relative price of traded goods (and even highly traded goods) across countries mimics closely the behavior of real exchange rates. This finding has generated much interest in the behavior of the relative price of traded goods across countries. Furthermore, in the context of open-economy macroeconomic models with nominal price rigidities, this evidence has generated an extensive debate on the nature of the pricing decisions of firms that operate in different national markets and on the implications of alternative price-setting regimes for exporters.²

There are two standard price-setting regimes for exporters in models with nominal price rigidities, typically referred to as producer currency pricing (PCP) and local currency pricing (LCP).³ Under PCP, exports are priced in the currency of the producer and the foreign price of home exports varies one-to-one with nominal exchange rate changes.⁴ In these models the law of one price holds for traded goods and, absent additional features, these models do not generate large movements in the the real exchange rate or in the relative price of traded goods across countries. Under LCP, it is assumed that firms are able to price discriminate across national markets and set prices in the currency of the buyer.⁵ With nominal price rigidities, prices of imports respond slowly to exchange rate changes under LCP. Therefore,

¹See Engel (1999) for the seminal contribution.

²See, for instance, Engel (2002), Obstfeld (2001), Obstfeld and Rogoff (2000a), and the references therein.

³There are also models in which some firms follow PCP and others follow LCP (e.g., Betts and Devereux, 2000, among others). Devereux, Engel, and Storgaard (2004) consider a model in which the currency-denomination of exports is endogenous, as opposed to the exogenous cases considered here.

⁴See, for instance, Obstfeld and Rogoff (1995). In these models, the adjustment of the nominal exchange rate to exogenous shocks has an immediate impact on the demand for home goods relative to foreign goods. A nominal depreciation, for instance, makes foreign goods more expensive relative to domestic goods worldwide, directing world expenditure toward home goods (expenditure switching effect). This effect is also a central mechanism in the traditional Mundell-Flemming-Dornbush open-economy models. (See Obstfeld and Rogoff (1996), chapter 9.)

⁵See Betts and Devereux (1996, 2000) for the initial contributions.

these models are consistent with the empirical evidence on the slow pass-through of exchange rate changes to consumer prices and substantial deviations from the law of one price.⁶ In addition, these models can generate large movements in real exchange rates and the relative price of traded goods across countries.⁷ Obstfeld and Rogoff (2000b), however, present empirical evidence against LCP and there is, thus, an ongoing debate regarding which pricing mechanism is the most appropriate.⁸

In this paper, we contrast the implications of the two alternative pricing regimes that are standard in the open-economy macro literature, PCP and LCP, in a calibrated two-country model. In the benchmark model the countries are of equal size and in the robustness section we consider the case of asymmetric countries. The models feature three sectors of production: intermediate traded goods, nontraded goods, and retail goods. Nontraded goods are used both as an input into the production of retail goods and as consumption services. We find that the two alternative assumptions regarding the currency denomination of exports are virtually inconsequential for the properties of aggregate variables, other than the terms of trade. In particular, the real exchange rate and the international relative price of retail goods behave similarly across the two price-setting regimes. Our finding follows from the fact that trade represents a relatively small fraction of GDP, that the presence of the retail and nontraded goods sectors with sticky prices dampens the effects of the pricing regime on aggregate variables, and that the behavior of the nominal exchange rate is close to a random walk. The two pricing assumptions do, however, differ somewhat with respect to the behavior of the terms of trade and the price of imports and their correlations with other variables in the model. For instance, the terms of trade (as well as the price of imports) have a positive correlation with exchange rates in both models, but the correlation is higher under PCP. That is, the terms of trade tend to worsen when the exchange rate depreciates under both

⁶See, for instance, Engel and Rogers (1996) and Goldberg and Knetter (1997) among many others.

⁷In fact, LCP is a common feature of models with nominal price rigidities that address real exchange rate behavior. See, among many others, Bergin and Feenstra (2001), Kollmann (2001), Chari, Kehoe, and McGrattan (2003), Steinsson (2008), Carvalho and Nechio (2008).

⁸Obstfeld and Rogoff (2000b) present empirical evidence indicating a strong tendency for the terms of trade (defined as the relative price of imports to exports) to worsen with nominal exchange rate depreciations. This evidence supports the importance of the expenditure switching effect of exchange rate changes. Obstfeld and Rogoff (2000b) point out that, in contrast, in a model with LCP and prices set one period in advance the terms of trade tend to improve when the nominal exchange rate depreciates.

price-setting regimes, but this effect is somewhat stronger in the PCP model. Nevertheless, it is hard to discriminate between the two pricing regimes based on these correlations alone. Our results highlight the fact that in the context of a quantitative open-economy model, the difference between the polar international pricing regimes is not as extensive as standard analyses may suggest.

A number of recent papers have considered alternative pricing regimes in new open-economy models. Betts and Devereux (1999) explore the transmission of monetary and fiscal shocks in a two country model under the two alternative pricing regimes. In their model, all goods are traded and the trade share is 50%. They find that a positive monetary shock generates a sharp nominal exchange rate depreciation and that the transmission of this shock depends critically on the pricing regime. In contrast, fiscal shocks generate a much smaller nominal exchange rate response and the transmission of these shocks does not depend as critically on the pricing regime. Gust, Leduc, and Sheets (2009) study the relationship between the pricing regime and the trade balance. They find that the response of the trade balance to shocks is not affected substantially by the pricing regime of exporters. The focus of our paper is on the implications of the pricing regime for the business cycle properties of a quantitative two-country model calibrated to match the weight of the retail and external sectors in the U.S. economy.

There also exists a growing literature on the implications that different pricing regimes have for optimal monetary policy and welfare. Notable examples include Devereux and Engel (2003), Corsetti and Pesenti (2005), and Sutherland (2005), showing that the nature of price adjustment matters for the determination of optimal monetary policy and the optimal degree of exchange rate volatility. Most of this literature abstracts from nontraded goods and a retail sector. Corsetti, Dedola, and Leduc (2007) extend the analysis of optimal policy to an environment with a retail sector and LCP pricing, while Corsetti, Dedola, and Leduc (2010) provide an excellent discussion of this literature. Given the similar behavior of consumption and labor across pricing regimes in our model, it would be interesting to see what the implications of our model structure are for the design of optimal monetary.

The paper is organized as follows. In the next section we motivate how, in the context of a simple model, the presence of the retail and nontraded goods sector with sticky prices

dampens the effect of the pricing regime on real exchange rate behavior. In section 3 we present the model and briefly discuss the calibration. In section 4 we consider the implications of the two polar alternative price-setting regimes for the producers of traded goods. We assess the robustness of our findings in section 5 and we conclude in section 6.

2 Production Structure and Pricing Regimes

In this section, we see how the implications of the two alternative price-setting regimes for the co-movement of the terms of trade and the real exchange rate with the nominal exchange rate hinge critically on the structure of the economy. In particular, we see how the price-setting regime has stark implications for the behavior of the terms of trade. The implications for the behavior of the real exchange rate, however, depend on the presence of a retail sector with sticky prices.

Consider a simple model with two countries, home and foreign. In each country there is a continuum of firms producing differentiated varieties of a country-specific traded good. That is, firm h , $h \in [0, 1]$, located in the home country produces variety h of the home traded good. Suppose firms set prices one period in advance.

Under PCP, firm h in the traded sector chooses one price $P_{H,t}^{PCP}(h)$, denominated in home currency, at time $t - 1$ to maximize expected profits from sales in both markets in period t . Hence, in period t home consumers face the price $P_{H,t}^{PCP}(h)$ for home-variety h and foreign consumers face the foreign-currency price $P_{H,t}^{*PCP}(h) = P_{H,t}^{PCP}(h)/S_t$, where S_t is the equilibrium exchange rate in the period t . While the price of the composite domestic traded good in period t is pre-determined, the price of the imported good varies one-to-one with movements in the nominal exchange rate. Therefore, after a shock that, say, depreciates the nominal exchange rate, the terms of trade of the home country, defined as the domestic-currency price of imports relative to the price of exports $\tau = P_F/(SP_H^*)$, also depreciates in the period of the shock.

Under LCP, firm h chooses two prices, $P_{H,t}^{LCP}(h)$ and $P_{H,t}^{*LCP}(h)$, denominated in home and foreign currency, respectively, at time $t - 1$. These prices maximize expected profits from sales in each market in period t . Since the price of domestic and imported traded goods are

pre-determined in each country in the currency of the buyer the terms of trade of the home country falls with a nominal exchange rate depreciation.⁹

We consider now the implications of these two pricing regimes for the real exchange rate. Assume first that households consume a Cobb-Douglas aggregate of domestic and foreign traded goods. Then, under LCP the real exchange rate moves one-to-one with unanticipated nominal exchange rate fluctuations in period t . Under PCP, real exchange rate movements are proportional to terms of trade movements, where the factor of proportionality depends on the degree of home bias. In the absence of home bias, the real exchange rate is constant.¹⁰

Assume now that agents consume, instead, a continuum of varieties of retail goods, produced using domestic and foreign traded goods. Assume also that retail firms set prices one period in advance. In this case, retail prices are pre-determined and thus price levels in both countries are pre-determined regardless of the price-setting regime of traded goods firms. With sticky retail prices the real exchange rate moves one-to-one with the nominal rate under both PCP and LCP. That is, the presence of the retail sector with sticky prices dampens the role of the pricing regime on the behavior of the real exchange rate. This result follows because firms in the retail sector are “LCP firms.” That is, by default, these firms set prices in local currency. Therefore, the presence of these firms mitigates differences between LCP and PCP that arise in the intermediate traded goods sector.

A similar argument also applies to a nontraded goods sector with sticky prices. In the following section, we develop a general equilibrium two-country model. Each period, each country produces differentiated varieties of three different goods: an intermediate traded good, a nontraded good, and a retail good. We find that in our calibrated model the behavior of aggregate variables, other than the terms of trade, does not differ much across the two price-setting regimes. We argue that this finding is robust to critical model variations.

⁹Note that under PCP $\tau = (SP_F^*)/P_H$, implying that the terms of trade moves one-for-one with the nominal exchange rate. Under LCP, the two variables move in opposite directions.

¹⁰The price level in the home country is given by $P = P_H^{\omega_H} P_F^{1-\omega_H} / \tilde{\omega}_H$, where ω_H measures the degree of home bias for domestic goods and $\tilde{\omega}_H$ is a function of ω_H .

3 The Model

We consider a model economy with two countries, denominated home and foreign. We allow for countries to be of different sizes. The home country is populated by a continuum of households in the interval $[0, \lambda)$ and the foreign country is populated by households in the interval $[\lambda, 1]$. The structure of the model follows closely that of Dotsey and Duarte (2008). Each country is populated by households, firms, and a monetary authority. The production structure of each economy is depicted in Figure 1. Each country produces nontraded goods and intermediate traded goods using capital and labor. In addition, each country produces retail goods using local and imported intermediate traded goods together with nontraded goods (retail services). Households in each country consume retail goods and nontraded consumption goods. They rent capital and labor services to firms in the intermediate traded goods sector and the nontraded goods sector, and they trade noncontingent nominal bonds with the foreign household.

In what follows, we describe the economy of the home country. The foreign economy is analogous, and asterisks denote foreign country variables.

3.1 Production

There are three sectors of production in the model: the nontraded goods sector, the intermediate traded goods sector, and the retail sector. The three sectors are treated symmetrically in assuming that firms in each sector produce a continuum of differentiated varieties and set prices in a staggered fashion.

3.1.1 The Intermediate Traded Goods Sector

Intermediate traded goods are produced using primary inputs, capital and labor. There is a continuum of firms in this sector, each producing a differentiated variety h , $h \in [0, \lambda)$. The production function is $y_{H,t}(h) = z_{H,t}k_{H,t}(h)^\alpha l_{H,t}(h)^{1-\alpha}$, where H refers to the home intermediate traded goods sector.¹¹ The term $z_{H,t}$ represents a productivity shock specific

¹¹In the foreign country, firms in the intermediate traded goods sector produce differentiated varieties $y_{F,t}(f)$, $f \in [\lambda, 1]$.

to this sector, and $k_{H,t}(h)$ and $l_{H,t}(h)$ denote the use of capital and labor services by firm h .

Each firm in this sector sells its variety to firms in the domestic and foreign retail sectors. Firms in this sector are monopolistically competitive, and we consider two alternative pricing regimes: producer currency pricing and local currency pricing.

Under PCP, each firm chooses one price, denominated in units of domestic currency, for home and foreign markets. We assume that firms set prices for J periods in a staggered way. That is, each period, $1/J$ of firms optimally choose prices that are set for J periods.¹² The problem of a firm adjusting its price in period t is described by

$$\max_{P_{H,t}(0)} \sum_{j=0}^{J-1} \mathbb{E}_t [\vartheta_{t+j|t} (P_{H,t}(0) - P_{t+j} \psi_{H,t+j}) y_{H,t+j}(j)], \quad (1)$$

where $y_{H,t+j}(j) = x_{H,t+j}(j) + x_{H,t+j}^*(j)$, and $x_{H,t+j}(j)$ and $x_{H,t+j}^*(j)$ denote the constant-elasticity ς demand curves from home and foreign markets faced by this firm in period $t+j$ and $\psi_{H,t}$ is the real marginal cost of production in this sector. The term $\vartheta_{t+j|t}$ denotes the pricing kernel, used to value profits at date $t+j$, which are random as of t , and P_{t+j} is the aggregate price level. As is standard in the New Keynesian literature, the price chosen by firms that adjust prices in period t , $P_{H,t}(0)$, is a function of current and future marginal cost, and current and future output. Specifically,

$$P_{H,t}(0) = \frac{\varsigma}{\varsigma - 1} \frac{\sum_{j=0}^{J-1} \mathbb{E}_t [\beta^j u_{c,t+j} \psi_{H,t+j} y_{H,t+j}(j)]}{\sum_{j=0}^{J-1} \mathbb{E}_t \left[\beta^j \frac{u_{c,t+j}}{P_{t+j}} y_{H,t+j}(j) \right]}. \quad (2)$$

Under PCP, the price charged to foreigners for home traded goods is given by

$$P_{H,t}^*(j) = \frac{P_{H,t}(j)}{S_t}, \quad j = 0, \dots, J-1, \quad (3)$$

where S denotes the nominal exchange rate (expressed as units of domestic currency per unit of foreign currency). That is, the law of one price holds for all intermediate traded goods, regardless of when prices were last adjusted. Note that while prices of locally-produced

¹²Therefore, at any date there are J vintages of intermediate traded goods: the vintage whose price was reset the current period and $J-1$ vintages with preset prices (chosen in each of the $J-1$ previous periods).

traded inputs are sticky, the prices of all vintages of imported varieties vary one-to-one with exchange rate changes.

Under LCP, producers of intermediated traded goods are able to price-discriminate across markets. Each period $1/J$ of firms optimally choose a price, denominated in the buyer's currency, for each market. These two prices are set for J periods. The problem of a firm adjusting its prices in period t is given by

$$\max_{P_{H,t}(0), P_{H,t}^*(0)} \sum_{j=0}^{J-1} \mathbb{E}_t [\vartheta_{t+j|t} ((P_{H,t}(0) - P_{t+j}\psi_{H,t+j}) x_{H,t+j}(j) + (S_{t+j}P_{H,t}^*(0) - P_{t+j}\psi_{H,t+j}) x_{H,t+j}^*(j))]. \quad (4)$$

The optimal prices chosen by firms that adjust prices in period t now depend on current and future sales in each market and are given by

$$P_{H,t}(0) = \frac{\varsigma}{\varsigma - 1} \frac{\sum_{j=0}^{J-1} \mathbb{E}_t [\beta^j u_{c,t+j} \psi_{H,t+j} x_{H,t+j}(j)]}{\sum_{j=0}^{J-1} \mathbb{E}_t \left[\beta^j \frac{u_{c,t+j}}{P_{t+j}} x_{H,t+j}(j) \right]}, \quad (5)$$

$$P_{H,t}^*(0) = \frac{\varsigma}{\varsigma - 1} \frac{\sum_{j=0}^{J-1} \mathbb{E}_t [\beta^j u_{c,t+j} \psi_{H,t+j} x_{H,t+j}^*(j)]}{\sum_{j=0}^{J-1} \mathbb{E}_t \left[\beta^j \frac{u_{c,t+j}}{P_{t+j}} S_{t+j} x_{H,t+j}^*(j) \right]}. \quad (6)$$

Under LCP, the law of one price need not hold for any vintage of prices. First, firms that reset prices in the current period may choose to price discriminate across markets and choose prices $P_{H,t}(0)$ and $P_{H,t}^*(0)$ such that the law of one price does not hold, $P_{H,t}(0) \neq S_t P_{H,t}^*(0)$. Second, unanticipated movements in the nominal exchange rate imply automatic deviations from the law of one price for the remaining $J-1$ vintages of prices that are not reset in period t (prices in each market are set in the buyer's currency and, thus, insulated from exchange rate changes by construction). Prices of both locally-produced and imported traded inputs are sticky in the buyer's currency.

Note that the pricing regime affects the equilibrium of the model because prices are sticky. With flexible prices the optimal price depends only on the nominal marginal cost of production and the price elasticity of demand ς . It follows that in our model, under LCP, firms choose prices in domestic and foreign currencies that obey the law of one price when prices are flexible. That is, with flexible prices there are no differences between the two

pricing regimes.

3.1.2 The Nontraded Goods Sector

This sector, indexed by N , has a structure analogous to the intermediate traded goods sector. Each firm n , $n \in [0, \lambda)$, operates the production function $y_{N,t}(n) = z_{N,t} k_{N,t}(n)^\alpha l_{N,t}(n)^{1-\alpha}$, where all the variables have analogous interpretations. The price-setting problem for a firm in this sector is

$$\max_{P_{N,t}(0)} \sum_{j=0}^{J-1} E_t [\vartheta_{t+j|t} (P_{N,t}(0) - P_{t+j} \psi_{N,t+j}) y_{N,t+j}(j)],$$

where $y_{N,t+j}(j) = x_{N,t+j}(j) + c_{N,t+j}(j)$ represents demand from firms in the retail sector and consumers faced by this firm in period $t + j$. The optimal price is given by an expression analogous to equation (2).

3.1.3 The Retail Sector

Firms in this sector combine domestic and imported traded goods with (nontraded) retail services in fixed proportions to bring retail goods to consumers. There is a continuum of firms in this sector, indexed by R , each producing a differentiated variety r , $r \in [0, \lambda)$. Each firm combines all varieties of domestic and imported intermediate traded goods to produce the composite good x_T , given by

$$x_{T,t}(r) = \left[\omega_H^{\frac{1}{\xi}} x_{H,t}(r)^{\frac{\xi-1}{\xi}} + (1 - \omega_H)^{\frac{1}{\xi}} x_{F,t}(r)^{\frac{\xi-1}{\xi}} \right]^{\frac{\xi}{\xi-1}}, \quad (7)$$

where $x_{H,t}(r)$ and $x_{F,t}(r)$ are Dixit-Stiglitz aggregators of all home and foreign intermediate traded varieties, respectively, with elasticity of substitution ς between any two varieties. Each firm also combines all nontraded varieties to produce x_N , using a Dixit-Stiglitz aggregator. Firms then bring the intermediate traded good x_T to market by combining it in fixed proportions with nontraded goods x_N . The production function of variety r of the retail good is

$$y_{R,t}(r) = \min \left\{ \frac{x_{N,t}(r)}{\omega}, \frac{x_{T,t}(r)}{1 - \omega} \right\}. \quad (8)$$

Firms in this sector sell their differentiated varieties to consumers for consumption and

investment purposes. These firms set prices for J periods in a staggered way and the problem of a firm adjusting its price in period t is given by

$$\max_{P_{R,t}(0)} \sum_{j=0}^{J-1} E_t [\vartheta_{t+j|t} (P_{R,t}(0) - P_{t+j} \psi_{R,t+j}) y_{R,t+j}(j)],$$

where $y_{R,t+j}(j) = c_{R,t+j}(j) + i_{t+j}(j)$ represents the demand for consumption and investment purposes faced by this firm in period $t + j$. The optimal price is given by an expression analogous to equation (2).

3.2 Households

There is a continuum of households in the interval $[0, \lambda)$. Since households are identical we abstract from an household index for simplicity. The problem of the household is standard. Each household in the home country maximizes the expected value of lifetime utility, given by

$$U_0 = E_0 \sum_{t=0}^{\infty} \frac{\beta^t}{1-\sigma} \left\{ \left(a c_t^\eta + (1-a) \left(\frac{M_{t+1}}{P_t} \right)^\eta \right)^{\frac{1-\sigma}{\eta}} \exp \left\{ \frac{-\psi_0}{1+\psi_1} l_t^{1+\psi_1} (1-\sigma) \right\} - 1 \right\}, \quad (9)$$

where l_t denotes hours worked, M_{t+1}/P_t denotes real money balances held from period t to period $t + 1$, and c_t denotes consumption of a composite good which is an aggregate of the retail good $c_{R,t}$ and the nontraded good $c_{N,t}$, and is given by

$$c_t = \left(\omega_R^{\frac{1}{\gamma}} c_{R,t}^{\frac{\gamma-1}{\gamma}} + (1-\omega_R)^{\frac{1}{\gamma}} c_{N,t}^{\frac{\gamma-1}{\gamma}} \right)^{\frac{\gamma}{\gamma-1}}, \gamma > 0. \quad (10)$$

The parameter γ denotes the elasticity of substitution between retail and nontraded goods and ω_R is a weight. The consumption of retail goods and nontraded goods, c_R and c_N , are each Dixit-Stiglitz aggregators of all the varieties of the retail and nontraded goods, $c_R(r)$ and $c_N(n)$, $r, n \in [0, \lambda)$, respectively, with constant elasticity of substitution ς .

Each consumer in the home country owns the capital stock k_t , holds domestic currency, and trades a riskless bond denominated in home-currency units with foreign households. The stock of bonds held by the household at the beginning of period t is denoted by B_{t-1} . These

bonds pay the gross nominal interest rate R_{t-1} . There is a cost of holding bonds given by $\Phi_b(B_{t-1}/P_t)$, where $\Phi_b(\cdot)$ is a convex function.¹³ Each consumer rents labor services l_t and capital services k_t to domestic firms at rates w_t and r_t , respectively, both expressed in units of consumption goods. Finally, each household receives nominal dividends D_t from domestic firms and transfers T_t from the monetary authority. The period- t budget constraint of the representative consumer, expressed in home-currency units, is given by

$$P_t c_t + P_{R,t} i_t + M_{t+1} + B_t + P_t \Phi_b \left(\frac{B_{t-1}}{P_t} \right) \leq P_t (w_t l_t + r_t k_t) + R_{t-1} B_{t-1} + D_t + M_t + T_t. \quad (11)$$

The law of motion for capital accumulation is

$$k_{t+1} = k_t(1 - \delta) + k_t \Phi_k \left(\frac{i_t}{k_t} \right), \quad (12)$$

where δ is the depreciation rate of capital and $\Phi_k(\cdot)$ is a convex function representing capital adjustment costs.¹⁴

Each household chooses sequences of consumption, hours worked, investment, money holdings, debt holdings, and capital stock to maximize the expected discounted lifetime utility (9) subject to the sequence of budget constraints (11) and laws of motion of capital (12).

3.3 The Monetary Authority

The monetary authority issues domestic currency. Additions to the money stock are distributed to consumers through lump-sum transfers such that $T_t^{agg} = M_t^s - M_{t-1}^s$, where T^{agg} represents aggregate (or total) transfers. The monetary authority is assumed to follow an interest rate rule similar to those studied in the literature. In particular, the interest rate is given by

$$R_t = \rho_R R_{t-1} + (1 - \rho_R) [\bar{R} + \rho_{R,\pi} (E_t \pi_{t+1} - \bar{\pi}) + \rho_{R,y} \ln(y_t/\bar{y})], \quad (13)$$

¹³This cost of holding bonds guarantees that the equilibrium dynamics of our model are stationary. See Schmitt-Grohé and Uribe (2003) for a discussion and alternative approaches.

¹⁴Capital adjustment costs are incorporated to reduce the response of investment to country-specific shocks. In their absence, the model would imply excessive investment volatility. See, for instance, Baxter and Crucini (1995).

where π_t denotes CPI inflation, y_t denotes real GDP, and a barred variable represents its target value.

3.4 Market Clearing Conditions and Model Solution

The model is closed by imposing standard market clearing conditions for labor, capital, and bonds. We focus on the symmetric and stationary equilibrium of the model. The model is solved by linearizing the equations characterizing the equilibrium around the steady-state and solving numerically the resulting system of linear difference equations.

The parameter values used to solve the model are reported in Table 1. In the benchmark economy we assume that the world economy is symmetric. That is, the two countries have the same size ($\lambda = 0.5$) and they share the same structure and parameter values. The model is calibrated using U.S. data and productivity data from the OECD STAN database, with a period in our model corresponding to one quarter.

We now discuss some key parameter values and refer the reader to Dotsey and Duarte (2008) for a detailed discussion of the calibration of the benchmark economy. We choose the weights on consumption of retail goods ω_R , on nontraded retail services ω , and on domestic traded inputs ω_H to simultaneously match, given all other parameter choices, the average share of consumption of nontraded goods in GDP, the average share of retail services in GDP, and the average trade share.¹⁵ Over the period 1973-2004, these shares averaged 0.44, 0.19, and 0.07, respectively, in the United States. Therefore, our model is consistent with the weight of the external sector and the weight of nontraded goods in GDP.¹⁶

The elasticity of substitution between domestic and imported traded goods, ξ in equation (7), is a critical parameter in two-country models.¹⁷ In our benchmark calibration, we set this elasticity to 0.85, close to the mid-point of import and export price elasticities estimated by

¹⁵We measure the trade share (both in the data and in the model) as $(\text{Imp} + \text{Exp}) / (2 * \text{Gross Output})$ because exports and imports in national accounts are gross measures. We measure retail services in the data as the value added from retail trade, wholesale trade, and transportation excluding transit and ground transportation services. We measure consumption of nontraded goods in the data as consumption services.

¹⁶Given these parameter choices, the model implies that the share of nontraded consumption in total consumption in steady-state is 0.55. This value is consistent with empirical findings for the United States. See, for instance, Stockman and Tesar (1995).

¹⁷See, for example, Heathcote and Perri (2002) and Corsetti, Dedola, and Leduc (2008).

Hooper, Johnson, and Marquez (1998) for the United States. In section 5, we also consider a version of the model with a lower elasticity of substitution between domestic and imported inputs.

We assume that technology shocks follow independent $AR(1)$ processes. Based on regressions using data on total factor productivity (TFP) for manufacturing and for wholesale and retail services for the United States and an aggregate of its major trading partners, we set the autocorrelation coefficient to 0.98 for all processes. This characterization of productivity as a stationary but highly persistent process is consistent with other data series on productivity in manufacturing. Consistent with these regressions we also set the ratio of the standard deviations of innovations to TFP on manufacturing and services to 2. The level of the standard deviation of innovations to TFP on manufacturing is chosen to match the volatility of GDP.

4 Implications of the Pricing Regime

In this section we compare the behavior of the benchmark model under the two alternative price-setting regimes. HP-filtered population moments are reported in Table 2 under “Benchmark.” We also report statistics for HP-filtered data in the first column of the table.¹⁸ The table reports the standard deviation of a variable relative to that of GDP. We measure net exports as the ratio of nominal net exports to nominal GDP and we report the standard deviation of this ratio.

Two main features arise from the statistics for the benchmark model under the two pricing regimes. First, the business-cycle statistics reported in Table 2, other than correlations of the terms of trade and price of imports, are not affected substantially by the pricing regime. For example, the standard deviations of the real exchange rate and the terms of trade under PCP relative to those under LCP are 1.04 and 1.01. The nominal exchange rate is slightly more volatile under PCP, with the ratio 1.15. The model also implies similar persistence across pricing mechanisms as well as cross-country correlations and correlations of real exchange

¹⁸The data take the United States as the home country and a composite of its main trading partners as the foreign country. See the appendix for a description of the data.

rates with other aggregate variables. Second, the correlations of the terms of trade and the price of imports with other variables (particularly so exchange rates) are substantially higher under PCP than LCP.¹⁹

To gain some intuition on the differences between the two pricing regimes, Figures 2 and 3 plot the responses of selected variables to a productivity shock in the traded and nontraded goods sectors, respectively. In each figure, the panels on the left plot the response under PCP and the panels on the right plot the response under LCP. A first glance at these figures reveals that these responses are almost indistinguishable between the two pricing mechanisms, except for the response of the terms of trade and the price of imports to a productivity shock in the nontraded goods sector.

In response to a shock to productivity in the traded goods sector, the behavior of all variables is similar under both pricing arrangements. As Figure 2 shows, the response of the nominal exchange rate to this shock is small.²⁰ Recall from section 3.1.1 that differences between the two pricing regimes arise from unanticipated movements in the nominal exchange rate in the presence of sticky prices. As a result, under LCP, unanticipated shocks to productivity in the traded goods sector do not generate large deviations from the law of one price, even for traded inputs whose prices are preset. Therefore, the response of all variables is similar across the two pricing mechanisms.

In contrast, a positive shock to productivity in the nontraded goods sector generates a sharp exchange rate depreciation. Therefore, this shock has the potential to generate large differences between the two pricing regimes. We find that in response to this shock, the behavior of the terms of trade, the price of imports, and (to a lesser extent) the price of the traded composite x_T differs markedly across the two pricing arrangements. However, these differences do not feed through and aggregate variables such as exchange rates, output, and the price level behave similarly across the two pricing arrangements.

The domestic-currency price of imports P_F increases sharply under PCP following a shock

¹⁹We note that the similar behavior of variables other than the terms of trade and price of imports across price setting regimes does not depend on the nature of monetary policy, given by equation (13). We obtain similar results when we replace equation (13) with a money-supply rule.

²⁰The response of exchange rates to shocks to productivity in the traded goods sector is small because home and foreign retail firms use home and foreign intermediate traded inputs in about the same proportion (i.e., ω_H in equation (7) is close to $1/2$). For further discussion, see Dotsey and Duarte (2008).

to productivity in the nontraded goods sector. The newly reset prices of imported goods rise (in foreign currency) in response to the increase in domestic demand, and all prices of imported goods (newly reset and preset) move one-for-one (in local currency) with the exchange rate. Therefore, the price in local currency of the imported composite good P_F rises by more than the exchange rate. Under LCP, instead, the price of imports is sticky in domestic currency. Therefore, P_F increases slowly in response to the shock. After all firms have reset prices (4 periods) the response of P_F is similar under the two regimes.

The terms of trade represent the relative price of imports in terms of exports in the home country, and it is given by $\tau = P_F/(SP_H^*)$. Under PCP the law of one price holds and the terms of trade can be re-written as $\tau = SP_F^*/P_H$. Note also that under PCP P_H and P_F^* are sticky. Therefore, following a positive shock to productivity in the nontraded goods sector, the terms of trade depreciates, together with the nominal exchange rate, generating an expenditure-switching effect toward domestic goods.²¹ In contrast, P_F and P_H^* are sticky under LCP. Thus, on impact, the depreciation of the nominal exchange rate lowers the price of imported goods relative to exports. However, as additional vintages of firms adjust their prices, the pricing effect dominates and the terms of trade eventually depreciates.

Despite the different responses of the prices of traded goods and the terms of trade, aggregate variables such as GDP, consumption, exchange rates, and the price level (among other variables) respond similarly across the two pricing regimes. We point to two reasons behind this result. First, the LCP-PCP distinction affects a relatively small portion of the economy and the presence of the retail and nontraded goods sectors with sticky prices dampens the effects of the pricing regime on aggregate variables.²² Although the response of the price of imports to shocks to productivity in the nontraded goods sector differs markedly between PCP and LCP, this difference diminishes as prices are aggregated up to the consumer price level (see the top panels in Figure 3). As we motivated in section 2, firms in the retail

²¹Following this shock, the domestic price of exports P_H rises by less than the exchange rate since only the newly reset price (in domestic currency) of exports rises as domestic firms re-adjust their prices (due to higher domestic wages).

²²In contrast, Betts and Devereux (1999) show that the pricing regime is critical to the transmission of monetary shocks in a model where all goods are traded and the import share is 50%. The response of the nominal exchange rate to a fiscal shock is much smaller and thus the pricing regime is not as critical to the transmission of this shock.

and nontraded goods sectors are “LCP pricers.” Hence, their presence mitigates differences between the two pricing regimes that arise in the intermediate traded goods sector as the economies are aggregated up.

Second, in our model, nominal exchange rates are very persistent, implying that the firms that reset prices in any given period respond much the same way under LCP as they do under PCP. To see this recall from equations (5) and (6) that, under LCP, firms choose the prices of their good that maximize discounted expected profits in each market. The log-linearized equations for the prices chosen in period t for the home intermediate traded good sold at home and abroad are given by,

$$\hat{P}_{H,t}(0) = E_t \left[\sum_{j=0}^{J-1} \rho_j \left(\hat{\psi}_{H,t+j} + \hat{P}_{t+j} \right) \right], \quad (14)$$

and

$$\hat{P}_{H,t}^*(0) = \hat{P}_{H,t}(0) - E_t \left[\sum_{j=0}^{J-1} \rho_j \hat{S}_{t+j} \right], \quad (15)$$

respectively.²³ These equations imply that the law of one price holds for newly priced goods when the exchange rate follows a random walk. Therefore, given that the exchange rate is close to a random walk in our model, it follows that the law of one price holds approximately for newly priced goods. Differences across the two price-setting regimes following a shock only arise from deviations from the law of one price for the three vintages of intermediate traded goods whose prices are preset. However, as additional vintages of firms reset their prices after a shock, the distinction between the two price-setting mechanisms disappears quickly and, thus, any potential differences are short-lived.

The distinguishing feature between the two alternative pricing mechanisms is the higher cross-correlations of the terms of trade and the price of imports with other variables under PCP than under LCP. In particular, the correlation coefficient between the terms of trade and the nominal and real exchange rates is 0.53 and 0.64 with PCP and 0.13 and 0.26 with

²³A hat denotes the deviation from steady-state of the log of the variable, and we have linearized around a zero inflation steady state. Note that variables that scale the level of demand do not enter these equations because, to a first-order approximation around the optimal price, they influence marginal cost and marginal revenue to the same extent. The term ρ_j is $\beta^j / \left(\sum_{j=0}^{J-1} \beta^j \right)$. For β close to one, $\rho_j \approx 1/J$.

LCP. The corresponding cross-correlations for the United States are 0.32 and 0.23, which suggests that the truth lies somewhere between the two extreme pricing specifications.²⁴ However, the pricing specification mostly affects only these correlations, while other features of the model appear to be insensitive to whether one works with a LCP or PCP view of the world.

5 Robustness

In this section, we consider three extensions to our benchmark model. In the first extension, we consider additional sources of exogenous variation in the model. Second, we consider a version of the model that generates higher nominal exchange rate volatility than the benchmark model. Finally, we consider the case of a world economy with asymmetric economies.

5.1 Additional exogenous shocks

The benchmark model is driven by shocks to productivity in the nontraded and intermediate traded goods sectors. We now include two additional shocks in our model. We consider a monetary policy shock and a shock to the discount rate of households.

With a monetary policy shock the interest rate rule in equation (13) depends also on a temporary iid-Normal shock, η_t^R . Following Smets and Wouters (2004) we set the ratio of the standard deviation of innovations to productivity in the traded goods sector to the monetary policy shock to 2.8.²⁵

Figure 4 depicts the responses of key variables to an expansionary monetary policy shock in the home country under both pricing regimes. In response to this shock, output and consumption increase and the nominal exchange rate depreciates on impact under both

²⁴We emphasize the cross-correlations for the United States because we have calibrated the model to U.S. data. We point out that the United States is not an outlier in terms of these cross-correlations. For example, the correlation of the terms of trade with the nominal exchange rate for Canada, France, Germany, Italy, and the United Kingdom ranges from 0.34 to 0.70, with an average of 0.47.

²⁵We use the results for the sample period 1983-2002. Smets and Wouters (2004) do not distinguish between traded and nontraded goods sectors. Our calibration magnifies the role of shocks to the monetary policy rule because the standard deviation of innovations to productivity in the traded goods sector is twice as large as that of the nontraded goods sector.

pricing regimes. Under PCP, this nominal depreciation makes foreign goods in the home country relatively more expensive than under LCP. Therefore, the price of imports increases by more on impact under PCP than under LCP. The impact response of the terms of trade also differs sharply across regimes. The difference between the impact response of prices across the two pricing regimes disappears as we aggregate prices up and the response of the price level is similar across regimes. The response of the real exchange rate is similar across regimes. In Table 2 we report statistics for the economy driven by productivity and monetary policy shocks (column heading “Monet. Pol.”). The cross-correlations of the terms of trade and the price of imports with other variables are larger under PCP compared to the case under LCP. As in the benchmark economy the nominal exchange rate is slightly more volatile under PCP. The behavior of other macroeconomic variables is similar across pricing regimes. In particular, the volatility of the real exchange rate and its cross-correlations with other variables are similar across the two regimes.

We also consider a preference shock that affects the discount rate that determines the intertemporal substitution decisions of households. In particular, expected lifetime utility of households in equation (9) becomes $U_0 = E_0 \sum_{t=0}^{\infty} \beta^t \eta_t^b U(c_t, \frac{M_{t+1}}{P_t}, l_t)$, where η_t^b follows an AR(1) process. Following Smets and Wouters (2004) we set the auto-correlation coefficient to 0.74 and we set the ratio of the standard deviation of innovations to productivity in the traded goods sector to the preference shock to 0.9.

Figure 5 depicts the responses of key variables to a preference shock in the home country under both pricing regimes. This shock increases home consumption, investment, and output. Agents in the home country now wish to pull consumption forward and as the shock dissipates consumption falls. The falling path of consumption implies that the real rate of interest falls as well, and hence the desired capital stock increases leading to an increase in investment demand. Thus, output increases in the home country. The increase in output and the decline in the real interest rate has positive spillover effects to the foreign country, implying that foreign output and consumption also increase significantly. Because there is not a significant degree of home bias in our benchmark economy, the foreign country experiences a significant increase in the demand for its traded good. Therefore, the response of nominal and real exchange rates to this shock is small and the response of all variables is very

similar across the two pricing regimes. In Table 2 we report statistics for the model driven by productivity and preference shocks under the column heading “Preference.” Note that in our calibration preference shocks are the main source of variation in the model. Since these shocks generate little nominal exchange rate volatility we find that the differences between the two pricing regimes are smaller than in the benchmark case.

5.2 Higher exchange rate volatility

Differences between the two pricing assumptions arise from the interplay between unanticipated movements in the nominal exchange rate and nominal price rigidities. That is, the larger the response of the nominal exchange rate to exogenous shocks, the larger the potential for the two pricing regimes to differ. To further explore the importance of the currency denomination of exports we consider a version of our model with a lower elasticity of substitution between domestic and imported inputs. As in Corsetti, Dedola, and Leduc (2008), a low elasticity of substitution generates strong wealth effects and implies higher volatility of exchange rates relative to output. We set $\xi = 0.53$ to match the volatility of the nominal exchange rate relative to that of GDP under PCP.²⁶ In Table 2, we report statistics for this economy under the column heading “Low Elast.” With this lower elasticity exchange rates and the terms of trade are much more volatile than output. Under PCP, exchange rates are more than three times as volatile as output. We find that nominal and real exchange rates become more volatile under PCP than LCP (about 26 and 18 percent respectively). However, despite this difference and a much higher volatility of the nominal exchange rate, we still find that the behavior of other aggregate variables is not much different across the two pricing regimes. Also as before, we find that the correlations of the terms of trade and the price of imports are substantially higher under PCP than LCP.

5.3 Asymmetric countries

In this section we consider a world economy with two countries of different sizes and different degrees of openness. We calibrate the smaller economy to Canada. Because Canada trades

²⁶We recalibrate the model to match all other targets.

mostly with the United States we match the relative size of the small economy in our model to the size of Canada relative to the United States, about 10%, by setting $\lambda = 0.09$.²⁷ We choose values for the weight on consumption of retail goods ω_R , the weight on nontraded retail services ω , and the weight on traded inputs of the home country ω_H in each country to simultaneously match the average share of consumption of services in GDP, the average share of retail services in GDP, and the trade share in Canada and the United States. In Canada, these shares averaged 0.41, 0.17, and 0.21 between 1981 and 2009.²⁸ Note that Canada is a much more open economy than the United States. For the United States, we use the average shares of consumption of services in GDP and retail services in GDP reported earlier, 0.44 and 0.19, respectively. For the trade share, we restrict attention to U.S. trade with Canada, which implies a trade share of 2 percent.²⁹

In Table 3 we report statistics for the small economy under both pricing regimes. We assume that firms in the intermediate traded goods sector of the large economy always set prices in the producer currency (PCP).³⁰ Therefore, the change in regime only affects the currency denomination of exports from the small country to the large country. We find that the behavior of aggregate variables is not much different across the two pricing regimes. As before, the terms of trade are less correlated with exchange rates and net exports are less volatile under LCP than PCP. This model generates low nominal exchange rate volatility and the difference across regimes is smaller than in the benchmark economy.³¹

²⁷Between 1971 and 2009, Canadian GDP relative to U.S. GDP (PPP converted) averaged 9 percent. During the same period, on average, about 75 percent of Canadian exports and about 70 percent of Canadian imports go to and come from the United States.

²⁸The measurement of these shares in the data follows our procedure for the United States, described in section 3.4.

²⁹The new parameter values are $\omega_R = 0.48$, $\omega = 0.33$, and $\omega_H = 0.11$ for the small economy and $\omega_R = 0.44$, $\omega = 0.38$, and $(1 - \omega_H) = 0.9$ for the large economy (which produces the F traded good). The remaining parameter values are the same as those reported in Table 1, except for the capital adjustment costs. This parameter is chosen to match the volatility of consumption relative to output in the small economy. The calibration implies that consumption per capita in the large economy is 3 percent higher than in the small economy.

³⁰There is strong empirical evidence suggesting that most U.S. exporters price in U.S. dollars. Goldberg and Tille (2008), for instance, report that 99.8 percent of U.S. exports are invoiced in U.S. dollars (Table 1, page 183).

³¹We note that our results do not depend on the assumption that exporters in the large economy always price in the producer currency (PCP). We find similar results when exporters in the large economy also price in the buyer's currency (LCP). In Dotsey and Duarte (2009) we report similar results for a model with two symmetric economies and a high import share.

For the small economy (Canada), shocks to productivity in the foreign (U.S.) intermediate traded goods sector are the shocks that generate most volatility in domestic output.³² This feature of our calibrated asymmetric case is not surprising as both countries have a significant bias toward consuming the traded good produced in the large economy. Figure 6 plots the response of variables in the small economy to a positive productivity shocks to the traded goods sector of the large economy. In response to this shock, the price of the foreign traded input gradually falls as firms adjust prices. As a result, consumers in the small economy postpone demand for this good and demand falls on impact. As prices fall, demand increases and the small economy booms along with the large economy. The terms of trade appreciates significantly for the small economy but exchange rates do not move very much. Because the bias for foreign inputs in the small country, $(1-\omega_H)$, is approximately equal to the home bias in the large country, terms of trade movements do not generate significant real exchange rate movements. The real exchange rate is largely driven by movements in the relative price of nontraded goods across the two countries and the prices of nontraded goods are not much affected by this shock. Since these shocks generate very small responses of nominal and real exchange rates, there is not much difference in the behavior of the model under the two polar pricing regimes.

6 Conclusion

In this paper we contrast the implications of producer currency pricing and local currency pricing in a quantitative two-country model. The model features nontraded goods that are used as final service consumption and in the production of retail goods. The model is consistent with the weight of nontraded goods and the weight of the external sector in the U.S. economy. We find that different assumptions regarding the currency denomination of exports are virtually inconsequential for the properties of aggregate variables, other than the terms of trade. We also note that our basic result carries through in our calibrated model

³²In contrast, in the benchmark economy shocks to productivity in the domestic nontraded goods sector are the shocks that generate most volatility in domestic output, followed by shocks to productivity in the domestic traded goods sector. This ranking holds despite the fact that the standard deviation of innovations to z_N is half that of innovations to z_H . Shocks to foreign productivity generate little volatility of domestic output.

without nontraded goods. We choose to include nontraded goods in our benchmark model for two reasons. First, nontraded final consumption and nontraded retail services are not trivial in the U.S. economy and our model has implications that are closer in line with the data than a model that abstracts from nontraded goods. Second, the calibrated model with nontraded goods generates higher nominal exchange rate volatility than the model without nontraded goods. It is important that the benchmark model can generate large responses of the nominal exchange rate since differences between the two pricing mechanisms arise from the interplay between unanticipated movements in the nominal exchange rate and nominal price rigidities.

The key finding in our benchmark model and two variations is that the two pricing regimes differ only with respect to the behavior of the terms of trade and price of imports and their correlations with other variables in the model. For instance, the terms of trade have a higher positive correlation with exchange rates under PCP than with LCP. Importantly, our results highlight the fact that in the context of a quantitative open-economy model the difference between the polar international pricing regimes is not as extensive as standard analyses may suggest.

A Data

We use quarterly data from 1973:Q1 to 2004:Q3 for the United States and the “rest of the world,” an aggregate of Canada, Japan, and 15 European countries (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Norway, the Netherlands, Portugal, Spain, Sweden, and the United Kingdom). For details on the data for GDP, its expenditure components, employment, and exchange rates, see Dotsey and Duarte (2008).

The series for the U.S. price of imports is the import price index from the Bureau of Economic Analysis (BEA). This series starts in 1982:Q3. We extended it backwards to 1973:Q1 using the growth rates of the U.S. import price index obtained from the International Financial Statistics of the International Monetary Fund. The terms of trade is obtained by dividing the import price index by the export price index from the BEA. We extended the export price series backwards in the same way as the price of imports. Data for import prices from selected countries of origin is available from the BEA from 1990:Q4 onwards. We constructed a fictitious U.S. price of imports from the countries that constitute the “rest of the world” in our dataset. The correlation coefficient between this constructed series and the U.S. import price index from the BEA is 0.97 for the period 1990:Q4-2010:Q1.

The data are available at www.economics.utoronto.ca/duarte/research/research.html or from the authors upon request.

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Figure 1: Production Structure of the Home Economy

Table 1: Calibration

<i>Relative Size</i>	
Size of home economy (λ)	0.5
<i>Preferences</i>	
Coefficient of risk aversion (σ)	2
Disutility from labor 1 (ψ_0)	3.45
Disutility from labor 2 (ψ_1)	0.15
Interest elasticity of money demand ($1/(\nu - 1)$)	-0.03
Weight on consumption (a)	0.99
<i>Aggregates</i>	
Elast. of substitution c_N and c_R (γ)	0.74
Elast. of substitution x_H and x_F (ξ)	0.85
Elast. of substitution individual varieties (ς)	10
Weight on c_R (ω_R)	0.44
Weight on x_N (ω)	0.38
Weight on x_H (ω_H)	0.65
<i>Production and Adjustment Functions</i>	
Capital share (α)	1/3
Price stickiness (J)	4
Depreciation rate (δ)	0.025
Capital adjustment cost	-6.3 & -5.7
Bond holdings cost (θ_b)	0.001
<i>Monetary Policy</i>	
Coeff. on lagged interest rate (ρ_R)	0.9
Coeff. on expected inflation ($\rho_{R,\pi}$)	1.8
Coeff. on output ($\rho_{R,y}$)	0.07
<i>Productivity Shocks</i>	
Autocorrelation coefficient	0.98
Std. dev. of innovations to z_H & z_N	0.006 & 0.003

Notes: The capital adjustment cost function is parametrized to match the standard deviation of consumption relative to that of GDP (0.64).

Table 2: Results

Statistic	Data	Benchmark		Monet. Pol.		Preference		Low Elastic.	
		PCP	LCP	PCP	LCP	PCP	LCP	PCP	LCP
<i>Stand. dev. rel. to GDP</i>									
Consumption	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64
Investment	2.87	2.39	2.56	2.50	2.64	2.69	2.72	2.61	2.75
Employment	0.66	1.09	1.16	1.22	1.26	1.47	1.48	1.10	1.24
Price Level	0.69	0.21	0.24	0.32	0.32	0.30	0.30	0.22	0.27
Nominal e.r. (S)	3.33	1.55	1.35	1.38	1.22	0.62	0.57	3.33	2.65
Real e.r. (q)	3.18	1.49	1.43	1.28	1.24	0.53	0.53	3.36	2.86
Terms of trade (τ)	1.96	2.19	2.18	1.87	1.89	0.71	0.78	4.73	4.22
<i>Stand. dev. Net Exports</i>	0.44	0.26	0.16	0.28	0.18	0.23	0.18	0.38	0.32
<i>Auto-correlations</i>									
Nominal e.r.	0.85	0.80	0.79	0.80	0.79	0.81	0.81	0.79	0.79
Real e.r.	0.83	0.80	0.81	0.79	0.80	0.78	0.80	0.80	0.81
Terms of trade	0.78	0.87	0.88	0.87	0.87	0.85	0.85	0.87	0.88
<i>Cross-correlations</i>									
Between q and									
Nominal e.r.	0.98	0.99	0.99	0.97	0.97	0.93	0.93	0.99	0.99
GDP	0.16	0.49	0.43	0.45	0.40	0.22	0.19	0.43	0.35
Consumption	0.12	0.49	0.45	0.45	0.41	0.19	0.17	0.14	0.14
Rel. consumptions	-0.07	0.85	0.85	0.82	0.83	0.48	0.47	0.27	0.28
Net exports	-0.04	-0.53	-0.47	-0.52	-0.47	-0.41	-0.40	-0.65	-0.18
Between τ and									
GDP	-0.16	0.50	0.28	0.45	0.21	0.21	0.02	0.38	0.23
Nominal e.r.	0.32	0.53	0.13	0.53	0.11	0.49	0.03	0.89	0.14
Real e.r.	0.23	0.64	0.26	0.64	0.23	0.68	0.21	0.92	0.51
Net exports	0.00	-0.46	-0.18	-0.43	-0.04	-0.36	0.25	-0.60	-0.68
Between P_F and									
GDP	-0.33	0.41	0.27	0.37	0.23	0.19	0.10	0.37	0.27
Nominal e.r.	0.31	0.73	0.50	0.72	0.50	0.64	0.43	0.94	0.74
Real e.r.	0.19	0.79	0.59	0.78	0.57	0.70	0.50	0.95	0.78
Cross-country									
GDP	0.57	0.29	0.45	0.38	0.53	0.77	0.83	0.45	0.58
Consumption	0.37	0.34	0.44	0.39	0.50	0.69	0.72	0.49	0.52
Investment	0.42	0.38	0.40	0.35	0.38	0.61	0.62	0.31	0.34
Employment	0.44	0.46	0.62	0.54	0.68	0.83	0.88	0.63	0.65

Table 3: Results - Small Economy

Statistic	PCP	LCP
<i>Stand. dev. rel. to GDP</i>		
Consumption	0.60	0.60
Investment	2.84	2.58
Employment	1.38	1.45
Price Level	0.26	0.30
Nominal e.r. (S)	1.08	0.93
Real e.r. (q)	1.04	0.97
Terms of trade (τ)	1.70	1.53
<i>Stand. dev. Net Exports</i>	0.60	0.43
<i>Auto-correlations</i>		
Nominal e.r.	0.80	0.79
Real e.r.	0.80	0.81
Terms of trade	0.88	0.93
<i>Cross-correlations</i>		
Between q and		
Nominal e.r.	0.98	0.98
GDP	0.10	0.00
Consumption	0.00	-0.07
Net exports	-0.45	-0.45
Between τ and		
GDP	0.12	0.19
Nominal e.r.	0.39	0.22
Real e.r.	0.56	0.41
Net exports	-0.36	-0.10
Between P_F and		
GDP	0.01	-0.09
Nominal e.r.	0.51	0.45
Real e.r.	0.62	0.56

Notes: This table reports statistics for the small economy in the two-country model described in section 5.3.

Figure 2: PCP versus LCP - Positive Shock to z_H

Note: P - price level; P_{x_T} - price of intermediate traded inputs; P_F - price of imports; y - real output; c - consumption; nx - net exports; S - nominal exchange rate; q - real exchange rate; τ - terms of trade.

Figure 3: PCP versus LCP - Positive Shock to z_N

Figure 4: PCP versus LCP - Expansionary Monetary Policy Shock

Figure 5: PCP versus LCP - Positive Preference Shock

Figure 6: PCP versus LCP - Positive Shock to z_F^*