# Dominant Currency Paradigm

## A New Model for Small Open Economies*

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**Abstract**

Most trade is invoiced in very few currencies. Despite this, the Mundell-Fleming benchmark and its variants focus on pricing in the producer's currency or in local currency. We model instead a 'dominant currency paradigm' for small open economies characterized by three features: pricing in a dominant currency; pricing complementarities, and imported input use in production. Under this paradigm: (a) terms of trade are stable; (b) dominant currency exchange rate pass-through into export and import prices is high regardless of destination or origin of goods; (c) exchange rate pass-through of non-dominant currencies is small; (d) expenditure switching occurs mostly via imports and export expansions following depreciations are weak. Using merged firm level and customs data from Columbia we document strong support for the dominant currency paradigm and reject the alternatives of producer currency and local currency pricing.

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# 1 Introduction

Nominal exchange rates have always been at the center of fierce economic and political debates on spillovers, currency wars, and competitiveness. It is easy to understand why: in presence of price rigidities, nominal exchange rate fluctuations are associated with fluctuations in relative prices and therefore have consequences for real variables such as the trade balance, consumption, and output.

The relationship between nominal exchange rate fluctuations and other nominal and real variables depends critically on the currency in which prices are rigid. The first generation of New Keynesian ($NK$) models and leading paradigm in international macroeconomics assumes prices are sticky in the currency of the producing country, so called 'producer currency pricing' ($PCP$). In that paradigm, the law of one price holds and a nominal depreciation reduces the price of exports relative to imports (the terms of trade) thus improving competitiveness. This paradigm was developed in the seminal contributions of Mundell (1963) and Fleming (1962), Svensson and van Wijnbergen (1989), and Obstfeld and Rogoff (1995). There is, however, pervasive evidence that the law of one price fails to hold as surveyed in Burstein and Gopinath (2014). Out of this observation grew a second pricing paradigm. In the original works of Betts and Devereux (2000) and Devereux and Engel (2003), prices are instead assumed to be sticky in the currency of the destination market, so called 'local currency pricing' ($LCP$). In that paradigm, a nominal depreciation raises the price of exports relative to imports, an increase in the terms of trade, thus worsening competitiveness. Both paradigms have been extensively studied in the literature with regards to their predictions for domestic outcomes and international spillovers. A survey of this research is contained in the recent handbook chapter by Corsetti et al. (2010).

Recent empirical work using granular data on international prices questions the validity of both approaches. Firstly, there is very little evidence that the best description of pricing in international markets follows either $PCP$ or $LCP$. Instead, the vast majority of trade is invoiced in a small number of 'dominant currencies', with the U.S. dollar playing an outsized role. This is documented in Goldberg and Tille (2008) and more recently in Gopinath (2015). Moreover, these prices are found to be rigid for significant durations in their currency of invoicing, as documented by Gopinath and Rigobon (2008) and Fitzgerald and Haller (2012). Secondly, exporters price in markets characterized by strategic complementarities in pricing that give rise to variations in the elasticity of demand and desired mark-ups[1]. Thirdly, most exporting firms employ imported inputs in production reducing the value added content of exports.[2] The workhorse $NK$ models in the literature instead assume constant cost-price mark-ups and abstract from intermediate inputs.

Based on these observations, this paper proposes an alternative: the 'dominant currency paradigm' ($DCP$) for the small open economy. Under $DCP$, firms set export prices in a dominant currency (most often the dollar) and change them infrequently. They face strategic complementarities in pricing, so that desired mark-ups vary over time and across destination markets. Finally, there is roundabout production, with domestic and foreign inputs employed in production. With these assumptions, the model departs fundamentally from the canonical $NK$ small open economy model in e.g. Galí (2008). We emphasize five main results. First, terms-of-trade are stable, playing little to no role in expenditure switching. Second, the dominant currency exchange rate passthrough into export and import prices is high, regardless of the destination or origin of the goods. Third, the exchange rate pass-through of non-dominant currencies is negligible. Fourth, depreciations have a limited expansionary impact on exports. Lastly, expenditure switching occurs nevertheless through imports, arising from fluctuations in the relative price of imported to domestic goods that in turn are driven by movements in a country's exchange rate relative to the dominant currency, regardless of the country of origin of the imported goods.

[1]Burstein and Gopinath (2014) survey the evidence on variable mark-ups.

[2]The fact that most exporters are also importers is now well documented in the literature. See Bernard et al. (2009), Kugler and Verhoogen (2009), Manova and Zhang (2009) among others. This is also reflected in the fact that value added exports are significantly lower than gross exports, particularly for manufacturing, as documented in the works of Johnson (2014) and Johnson and Noguera (2012). Amiti et al. (2014) present empirical evidence of the influence of strategic complementarities in pricing and of imported inputs on pricing decisions of Belgian firms.

Using a novel firm-level and customs data for a representative small open economy, Columbia, we document strong support for the predictions of the model. The data rejects the alternative benchmarks of producer and local currency pricing in favor of the dominant currency paradigm.

Section 2 presents the baseline model and discusses in details its predictions for the terms of trade, exchange rate pass-through, and the impact of monetary policy shocks across pricing regimes. In contrast to the $PCP$ and $LCP$ paradigms, the $DCP$ paradigm is associated with stable terms of trade. This stability, however, differs from predictions of models with flexible prices and strategic complementarities in pricing as in Atkeson and Burstein (2008). Unlike these models, the term of trade stability is associated with volatile movements of the relative price of imported to domestic goods for non-dominant (currency) countries that will be the focus of our analysis. Furthermore, this volatility is driven by fluctuations in the value of its currency relative to the dominant currency, regardless of the country of origin of the imported goods. Consequently, demand for imports depends on the value of its currency relative to the dominant currency. When a country's currency depreciates relative to the dominant currency, all else equal, it reduces its demand for imports from *all* countries.

In the case of exports, in contrast to $PCP$, which associates exchange rate depreciations with increases in quantities exported, $DCP$ predicts a negligible impact on goods exported to the dominant-currency destination. For exporting firms whose dominant currency prices are unchanged there is no increase in exports and for those firms changing prices the rise in marginal cost following the rise in the price of imported inputs and the complementarities in pricing dampens their incentive to reduce prices and stimulate exports. The impact on exports to non-dominant currency destinations depends on the co-movement of the destination country currency with the dominant currency. If the two strongly positively co-move then $DCP$ predicts a weak impact on exports to non-dollar destinations. On the other hand, if it is only weakly correlated then it can lead to a decline in exports.

Taken together, these results indicate that expenditure switching is not driven by movements in the terms-of-trade and its effect on exports but by the impact of movements in the relative price of imported to domestic goods on imports.

Fluctuations in the value of dominant currencies can also have implications for cyclical fluctuations in global trade (sum of exports and imports). Under $DCP$, a strengthening of dominant currencies relative to non-dominant ones is associated with a decline in imports across the periphery without a commensurate increase in exports, thus negatively impacting global trade. In contrast, in the case of $PCP$, the rise in export competitiveness for the periphery generates an increase in exports that has an offsetting effect on the decline in imports. Moreover, the increase in exports dampens the decline in imports as production relies on imported intermediate inputs. In the case of $LCP$, both the import and export response is muted so the impact on the global trade is weak.

We then proceed to test the novel empirical predictions of our model for a small open economy, Colombia, that is representative of emerging markets in its heavy reliance on dollar invoicing, with 98.3% (98.4%) of its exports (manufacturing exports) invoiced in dollars.

We document that, as predicted by $DCP$, the pass-through into import and export (Colombian) peso prices measured as the elasticity relative to the peso-dollar exchange rate starts out high for import prices *and* export prices and then gradually declines over time. This is true regardless of the origin of imports or destination of exports. In the case of export prices to dollar destinations, the contemporaneous pass-through estimate is 84% while the cumulative pass-through slowly decreases after two years to 56%. In the case of import prices from dollar origins, the pass-through is very high, around 100%, and the cumulative effect after two years declines to 81%. For exports (imports) to (from) non-dollar destinations, the estimated pass-through starts at around 86% (87%) and decreases to 47% (49%) after two years.

Secondly, we find that, conditional on the peso-dollar exchange rate, the bilateral exchange rate is quantitatively insignificant as an explanatory factor in bilateral transactions with non-dollar economies. Unconditionally, the pass-through of the bilateral exchange rate into peso export prices to non-dollar destinations is 70% at the annual horizon. However, when we control for the peso-dollar exchange rate the coefficient on the bilateral exchange rate drops to 9% while the coefficient on the peso-dollar exchange rate is 70%. These predictions are also consistent with $DCP$.

Thirdly, we also find that, following a weaker peso/dollar exchange rate, the pass-through to export quantities to dollar destinations is mainly insignificantly different from zero while there is a pronounced decline in quantities imported from both dollar and non-dollar countries. Exports to non-dollar destinations also decline. Further, the relevant exchange rate is the peso/dollar exchange rates as opposed to the bilateral exchange rate for both export and import quantities.

Lastly, while Colombia's overall terms of trade is very volatile and strongly correlated with the exchange rate, when we strip out commodity prices we find the terms of trade to be highly stable—a feature consistent with the predictions of $DCP$.

To further compare the different pricing paradigms we simulate a model economy that is subject to commodity price and productivity shocks, and test its ability to match the data. As the model nests $DCP$, $PCP$ and $LCP$ we can evaluate the success of the various paradigms. Using a combination of calibration and estimation we document that the data strongly rejects the $PCP$ and $LCP$ paradigm in favor of the $DCP$ paradigm.

**Related Literature:** Our paper is related to a relatively small literature that models dollar pricing. These include Corsetti and Pesenti (2005), Goldberg and Tille (2008), Goldberg and Tille (2009), Devereux et al. (2007), and Canzoneri et al. (2013). All of these models, with the exception of Canzoneri et al. (2013), are effectively static with one period ahead price stickiness. In addition, they all assume constant desired mark-ups and production functions that use only labor. Our paper combines dynamic pricing, variable mark-ups and imported inputs use in production in a New Keynesian environment, all of which are important ingredients to match the facts on pricing in international trade. Importantly, in contrast with these papers, we empirically evaluate the dominant currency paradigm employing data from Colombia using novel tests that the model generates.

Before we proceed to describe the model we briefly present evidence on the preponderance of dominant currency invoicing in world trade.

**Invoicing Currency:** The volume of global merchandize trade has grown tremendously over the last several decades, and the vast majority of this trade is denominated in very few currencies. Gopinath (2015) uses invoicing data for half of world imports and exports to demonstrate that the dollar share as an invoicing currency is around 4.7 times its share in world imports and 3.1 times its share in world exports. The currency that comes second in terms of its use in world trade is the euro, however its share is closely aligned with its share in world imports and exports with a ratio of 1.2, when trade within the euro area is also included and strictly below one when it is excluded. All other currencies have a minimal role.[3]

Tables A-1 and A-2 report, for a list of 45 countries, the share of exports and imports that are invoiced in dollars, in euros, and in the country's own currency, as well as the country's share of export(imports) coming from (going to) the United States and the same measures for the Euro area. From the tables it is apparent that the dollar almost always has the largest invoicing share. The euro also has large shares but only in the case of European countries (both, members and non-members of the monetary union). Additionally, only a handful of countries have sizable shares of trade invoiced in their own currency, mostly international reserve currencies (Japan, the U.K., the U.S.); however, these shares are significantly below the share of the dollar for the US. Finally, note that the dollar share column is greater than the US trade share column for every single country—that is, regardless of how much a country trades with the US, the share of its exports and imports invoiced in dollars is greater than the actual trade with the US.[4] As the share of world trade attributable to emerging markets has grown over the last fifteen years to constitute 33% of world exports and 37% of world imports, the share of invoicing in dollars

[3]The large invoicing share in dollars extends well beyond commodities traded on an exchange.

[4]In the case of countries in the euro area, the US trade share is computed considering only the trade that takes place with countries outside of the monetary union.

mainly and to a lesser extent in euros has gained even greater prominence.[5] These facts point to a world where a disproportionate share of trade is invoiced in very few currencies, and the dollar has an outsized role. They also highlight that the literature with its focus on $PCP$ and $LCP$ has ignored what arguably is the empirically more relevant description of the world of $DCP$ where the dominant currency is most often the dollar.

In the following sections, we explore the theoretical and empirical implications of the $DCP$ phenomenon and contrast it with the $PCP$ and $LCP$ paradigms.

# 2 Model

We model a small open economy, $H$ (for Home) that trades goods and assets with a rest of the world that we divide into two regions: $U$ (for the dominant currency country) and $R$ (for the Rest). The nominal exchange rate between country $i \in \{U, R\}$ and Home is denoted $\mathcal{E}_{i,t}$, expressed as Home currency per unit of foreign currency, so that an increase in $\mathcal{E}_{i,t}$ represents a depreciation of the Home currency against that of country $i$. Under the small open economy assumption, we assume that prices and quantities in $U$ and $R$ are exogenous from the perspective of $H$. We will spell out precisely what this assumption means when setting up the model.

As in the canonical small open economy framework of Galí (2008) firms adjust prices infrequently, *à la* Calvo. We however depart from Galí (2008) along the following dimensions: Firstly, we nest three different pricing paradigms: local currency pricing and dominant currency pricing alongside producer currency pricing. Secondly, the production function uses not just labor but also intermediate inputs produced domestically and abroad. Thirdly, we allow for strategic complementarity in pricing that gives rise to variable mark-ups, as opposed to constant mark-ups. Fourthly, international asset markets are incomplete with only riskless bonds being traded, as opposed to the assumption of complete markets. We describe the details below.

[5]We follow the IMF classification to define emerging markets.

## 2.1 Households

Home is populated with a continuum of symmetric households of measure one. In each period household $h$ consumes a bundle of traded goods $C_t(h)$. Each household also sets a wage rate $W_t(h)$ and supplies an individual variety of labor $N_t(h)$ in order to satisfy demand at this wage rate. Households own all domestic firms. To simplify exposition we omit the indexation of households when possible. The per-period utility function is separable in consumption and labor and given by,

$$U(C_t, N_t) = \frac{1}{1-\sigma_c} C_t^{1-\sigma_c} - \frac{\kappa}{1+\varphi} N_t^{1+\varphi} \tag{1}$$

where $\sigma_c > 0$ is the household's coefficient of relative risk aversion, $\varphi > 0$ is the inverse of the Frisch elasticity of labor supply and $\kappa$ scales the disutility of labor.

The consumption aggregator $C$ is implicitly defined by a Kimball (1995) homothetic demand aggregator:

$$\sum_i \frac{1}{|\Omega_i|} \int_{\omega \in \Omega_i} \gamma_i \Upsilon \left( \frac{|\Omega_i| C_{iH}(\omega)}{\gamma_i C} \right) d\omega = 1. \tag{2}$$

In eq. (2) $C_{iH}(\omega)$ represents the consumption by households in country $H$ of variety $\omega$ produced by country $i$ where $i \in \{H, U, R\}$. $\gamma_i$ is a parameter that captures home bias in $H$ and $|\Omega_i|$ is the measure of varieties produced in region $i$. The function $\Upsilon$ satisfies the constraints $\Upsilon(1) = 1$, $\Upsilon'(.) > 0$ and $\Upsilon''(.) < 0$.

This demand structure gives rise to strategic complementarities in pricing and variable mark-ups. It captures the classic Dornbusch (1987) and Krugman (1987) channel of variable mark-ups that gives rise to pricing to market as we describe below.

Home households solve the following optimization problem,

$$\max_{C_t, W_t, B_{U,t+1}, B_{t+1}(s')} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U(C_t, N_t)$$

subject to the per-period budget constraint expressed in home currency,

$$P_t C_t + \mathcal{E}_{U,t}(1+i_{U,t})B_{U,t} + B_t = W_t(h)N_t(h) + \Pi_t + \mathcal{E}_{U,t}B_{U,t+1} + \sum_{s'\in\mathcal{S}} Q_t(s')B_{t+1}(s') + \mathcal{E}_{U,t}\zeta_t \quad (3)$$

where $P_t$ is the price index for the domestic consumption aggregator $C_t$. $\Pi_t$ represents domestic profits that are rebated back to households who own the domestic firms. Households also trade a risk-less international bond denominated in dollars that pays a nominal interest rate $i_{U,t}$. $B_{U,t+1}$ are the dollar holdings of the international bond purchased at time $t$. Households also have access to a full set of domestic state contingent securities (in $H$ currency) that are traded domestically and in zero net supply. Denoting $\mathcal{S}$ the set of possible states of the world, $Q_t(s)$ is the period-$t$ price of the security that pays one unit of home currency in period $t+1$ and state $s \in \mathcal{S}$, and $B_{t+1}(s)$ are the corresponding holdings. Finally, $\zeta_t$ represents an exogenous dollar income shock to the domestic budget constraint. This is a simple way to capture shocks such as commodity price movements for small commodity exporters.

The optimality conditions for the household are given by:

$$C_{iH,t}(\omega) = \gamma_i \psi\left(D_t \frac{P_{iH,t}(\omega)}{P_t}\right) C_t, \quad (4)$$

where $\psi(.) \equiv \Upsilon'^{-1}(.) > 0$ so that $\psi'(.) < 0$. $D_t \equiv \sum_i \int_{\Omega_i} \Upsilon'\left(\frac{|\Omega_i| C_{iH,t}(\omega)}{\gamma_i C_t}\right) \frac{C_{iH,t}(\omega)}{C_t} d\omega$ and $P_{iH,t}(\omega)$ denotes the home price of variety $\omega$ produced in country $i$ and sold in $H$. Define the elasticity of demand $\sigma_{iH,t}(\omega) \equiv -\frac{\partial \log C_{iH,t}(\omega)}{\partial \log Z_{iH,t}(\omega)}$, where $Z_{iH,t}(\omega) \equiv D_t \frac{P_{iH,t}(\omega)}{P_t}$. The log of the mark-up is $\mu_{iH,t}(\omega) \equiv \log\left(\frac{\sigma_{iH,t}}{\sigma_{iH,t}-1}\right)$. A relevant characteristic is the elasticity of the mark-up $\Gamma_{iH,t}(\omega) = \frac{\partial \mu_{iH,t}}{\partial \log Z_{iH,t}(\omega)}$. The price index $P_t$ satisfies,

$$P_t C_t = \sum_i \int_{\Omega_i} P_{iH,t}(\omega) C_{iH,t}(\omega) d\omega$$

Inter-temporal optimality conditions for dollar bonds and peso bonds are given by,

$$C_t^{-\sigma_c} = \beta(1+i_{U,t})\mathbb{E}_t C_{t+1}^{-\sigma_c} \frac{P_t}{P_{t+1}} \frac{\mathcal{E}_{U,t+1}}{\mathcal{E}_{U,t}} \quad (5)$$

$$C_t^{-\sigma_c} = \beta(1+i_t)\mathbb{E}_t C_{t+1}^{-\sigma_c}\frac{P_t}{P_{t+1}} \tag{6}$$

where $(1+i_t) = (\sum_{s'\in\mathcal{S}} Q_t(s'))^{-1}$ is the inverse of the price of a peso bond at time $t$ that delivers one peso in every state of the world in period $t+1$.

Households are subject to a Calvo friction when setting wages in pesos: in any given period, they may adjust their wage with probability $1-\delta_w$, and maintain the previous-period nominal wage otherwise. As we will see, they face a downward sloping demand for the specific variety of labor they supply given by, $N_t(h) = \left(\frac{W_t(h)}{W_t}\right)^{-\vartheta} N_t$, where $\vartheta > 1$ is the constant elasticity of labor demand and $W_t$ is the aggregate wage rate. The standard optimality condition for wage setting is given by:

$$\mathbb{E}_t \sum_{s=t}^{\infty} \delta_w^{s-t}\Theta_{t,s} N_s W_s^{\vartheta(1+\varphi)}\left[\frac{\vartheta}{\vartheta-1}\kappa P_s C_s^{\sigma} N_s^{\varphi} - \frac{\bar{W}_t(h)^{1+\vartheta\varphi}}{W_s^{\vartheta\varphi}}\right] = 0, \tag{7}$$

where $\Theta_{t,s} \equiv \beta^{s-t}\frac{C_s^{-\sigma_c}}{C_t^{-\sigma_c}}\frac{P_t}{P_s}$ is the stochastic discount factor between periods $t$ and $s \geq t$ used to discount profits and $\bar{W}_t(h)$ is the optimal reset wage in period $t$. This implies that $\bar{W}_t(h)$ is preset as a constant markup over the expected weighted-average between future marginal rates of substitution between labor and consumption and aggregate wage rates, during the duration of the wage. This is a standard result in the New Keynesian literature, as derived, for example, in Galí (2008).

## 2.2 Producers

Each home producer manufactures a unique variety $\omega$ that is sold both domestically and internationally. The output of the firm is used both for final consumption and as an intermediate input for production.

The production function uses a combination of labor $L_t$ and intermediate inputs $X_t$, with a Cobb Douglas production function:

$$Y_t = e^{a_t} L_t^{1-\alpha} X_t^{\alpha} \tag{8}$$

where $\alpha$ is the constant share of intermediates in production and $a_t$ is a productivity shock. The intermediate input aggregator $X_t$ takes the same form as the consumption aggregator in eq. (2):

$$\sum_i \frac{1}{|\Omega_i|} \int_{\omega \in \Omega_i} \gamma_i \Upsilon \left( \frac{|\Omega_i| X_{iH,t}(\omega)}{\gamma_i X_t} \right) d\omega = 1. \tag{9}$$

The labor input $L_t$ is a CES aggregator of the individual varieties supplied by each household,

$$L_t = \left[ \int_0^1 L_t(h)^{(\vartheta-1)/\vartheta} \mathrm{d}h \right]^{\vartheta/(\vartheta-1)}$$

with $\vartheta > 1$.

In each country $i$ a good produced in $H$ can be used for consumption or as intermediate input. We assume that the foreign demand for domestic individual varieties (both for consumption and as intermediate input) takes a form similar to that in eq. (4).

Markets are segmented so firms can set different prices by destination market and invoicing currency. Denote $P^j_{Hi,t}(\omega)$ the price of a domestic variety $\omega$ sold in market $i$ and invoiced in currency $j$. The per-period profits of the domestic firm producing variety $\omega$ are then given by:

$$\Pi_t(\omega) = \sum_{i,j} \mathcal{E}_{j,t} P^j_{Hi,t}(\omega) Y^j_{Hi,t}(\omega) - \mathcal{MC}_t \, Y_t(\omega) \quad , \tag{10}$$

with the convention that $\mathcal{E}_{H,t} \equiv 1$. In that expression, $Y^j_{Hi,t}(\omega) = C^j_{Hi,t}(\omega) + X^j_{Hi,t}(\omega)$ is the demand for domestic variety $\omega$ in country $i$ invoiced in currency $j$, both used for consumption and as an input in production, while $Y_t(\omega) = \sum_{i,j} Y^j_{Hi,t}(\omega)$ is the total demand across destination markets and invoicing currencies.

Denote $\mathcal{MC}_t$ the marginal cost of domestic firms. It is given by:

$$\mathcal{MC}_t = \frac{1}{\alpha^\alpha (1-\alpha)^{1-\alpha}} \cdot \frac{W_t^{1-\alpha} P_t^\alpha}{e^{a_t}}. \tag{11}$$

The optimality conditions for hiring labor are given by,

$$(1-\alpha)\frac{Y_t}{L_t} = \frac{W_t}{\mathcal{MC}_t}, \qquad L_t(h) = \left( \frac{W_t(h)}{W_t} \right)^{-\vartheta} L_t, \tag{12}$$

and the demand for intermediate inputs is determined by,

$$\alpha\frac{Y_t}{X_t} = \frac{P_t}{\mathcal{MC}_t}, \qquad X_{iH,t}(\omega) = \gamma_i\psi\left(D_t\frac{P_{iH,t}(\omega)}{P_t}\right)X_t, \tag{13}$$

with

$$W_t = \left[\int W_t(h)^{1-\vartheta}dh\right]^{\frac{1}{1-\vartheta}}.$$

### 2.2.1 Pricing

Firms choose prices at which to sell at $H$ and in international markets $U$ and $R$, with prices reset infrequently. As in Galí (2008) we consider a Calvo pricing environment where firms are randomly chosen to reset prices with probability $1-\delta_p$. A core focus of this paper is on the implications of various pricing choices by firms. We assume that firms set their prices either in the producer currency, in the destination currency, or in the dominant currency. Without lack of generality, we consider that $U$'s currency is the dominant currency. Denote $\theta^u_{i,j}$, $\theta^i_{i,j}$ and $\theta^j_{i,j}$ as the fraction of exports from region $i$ to region $j$ that are priced in the dominant currency, in the producer's currency, and in the local currency respectively, with $\sum_{k\in\{u,i,j\}}\theta^k_{i,j} = 1$ for any $\{i,j\}\in\{H,U,R\}^2$.

The benchmark of producer currency pricing ($PCP$) corresponds to the case where $\theta^i_{i,j} = 1$ for every $i\neq j$. The case of local currency pricing ($LCP$) corresponds to $\theta^j_{i,j} = 1$ for every $i\neq j$. Under the dominant currency paradigm ($DCP$), $\theta^U_{i,j} = 1$ for every $i\neq j$. Lastly, we assume that all domestic prices are sticky in the home currency, an assumption consistent with a large body of evidence: $\theta^i_{i,i} = 1$ for every $i$.

Consider the pricing problem of a domestic firm selling in country $i$ and invoicing in currency $j$, and denote $\bar{P}^j_{Hi,t}(\omega)$ its *reset* price. This reset price satisfies the following optimality condition:

$$\mathbb{E}_t\sum_{s=t}^{\infty}\delta_p^{s-t}\Theta_{t,s}Y^j_{Hi,s|t}(\omega)(\sigma_{Hi,s}(\omega)-1)\left(\mathcal{E}_{j,s}\bar{P}^j_{Hi,t}(\omega) - \frac{\sigma_{Hi,s}(\omega)}{\sigma_{Hi,s}(\omega)-1}\mathcal{MC}_s\right) = 0 \tag{14}$$

with the convention that $\mathcal{E}_{H,t}\equiv 1$. In this expression, $Y^j_{Hi,s|t}(\omega)$ is the quantity sold in country $i$ invoiced in currency $j$ at time $s$ by a firm that reset prices at time $t$ and $\sigma_{Hi,s}(\omega)$ is the elasticity of demand. This expression implies that $\bar{P}^{j}_{Hi,t}(\omega)$ is preset as a markup over expected future marginal costs expressed in currency $j$, $\mathcal{MC}_s(\omega)/\mathcal{E}_{s,t}$, during the duration of the price. Observe that because of strategic complementarities, the markup over expected future marginal costs is not constant.

## 2.3 Interest Rates

### 2.3.1 Home interest rate $i_t$

The domestic risk-free interest rate is set by $H$'s monetary authority and follows an inflation targeting Taylor rule with inertia:

$$i_t - i^* = \rho_m(i_{t-1} - i^*) + (1 - \rho_m)\phi_M \pi_t + \varepsilon_{i,t} \tag{15}$$

In eq. (15), $\phi_M$ captures the sensitivity of policy rates to domestic price inflation $\pi = \Delta \ln P_t$, while $\rho_m$ captures the inertia in setting rates. $\epsilon_{M,t}$ evolves according to an $AR(1)$ process, $\varepsilon_{i,t} = \rho_{\varepsilon_i}\varepsilon_{i,t-1} + \varepsilon_{m,t}$.

### 2.3.2 Dollar interest rate $i_{U,t}$

As in Schmitt-Grohe and Uribe (2003), we assume the dollar interest rate at which $H$ borrows internationally, $i_{U,t}$, is related to the exogenous international interest rate $i^*_t$ according to:

$$i_{U,t} = i^* + \psi(e^{B_{U,t+1}-\bar{B}} - 1), \tag{16}$$

where $\psi > 0$ measures the responsiveness of the dollar rate to the country's net foreign position $B_{U,t+1}$. $\bar{B}$ is the steady state (exogenous) dollar denominated debt. The dollar interest rate is an increasing function of the deviation of the aggregate level of debt from the steady state level of debt. Because of the dependence on aggregate debt individual households do not internalize the effect of their borrowing choices on the interest rate. Equation eq. (16) is a standard assumption in the $SOE$ literature to induce stationarity of $B_{U,t}$ in a log-linearized environment.

## 2.4 Closing the model and Equilibrium

Under the assumption that $H$ is a small open economy, aggregate prices and quantities in $U$ and $R$ are exogenous. We assume further that they are constant, at their steady state.[6] Nevertheless, we do not impose that $\mathcal{E}_{U,t}$ and $\mathcal{E}_{R,t}$ are perfectly correlated.[7] This allows us to explore separately how fluctuations in $\mathcal{E}_{U,t}$ and $\mathcal{E}_{R,t}$ impact prices and quantities in $H$, under different pricing paradigms. Fluctuations in $\mathcal{E}_{U,t}/\mathcal{E}_{R,t}$ could arise either from movements in the $U$-$R$ exchange rate, or from financial frictions that prevent arbitrage in the three currencies. We assume the following reduced form relation between the two real exchange rates, that we later discipline with data:

$$\ln \mathcal{E}_{R,t} - \ln P_t = \eta \left(\ln \mathcal{E}_{U,t} - \ln P_t\right) + \epsilon_{R,t} \tag{17}$$

In eq. (17) $\epsilon_{R,t}$ captures idiosyncratic fluctuations in the $U$-$R$ exchange rate while $\eta$ captures comovements between the two real exchange rates.

**Definition 1 (Equilibrium)** *A competitive equilibrium of the monopolistically small open economy $H$ consists of:*

*a) Households maximizing utility over consumption, labor supply and portfolio choice, and firms maximizing profits over labor demand, intermediate inputs and prices in each market.*

*b) Market clearing: $L_t = N_t$, $B_t^h = 0$, $Y_{Hi,t} = C_{Hi,t} + X_{Hi,t}$.*

*c) Real exchange rates of $R$ and $U$ evolving according to eq. (17).*

*d) Exogenous shocks to domestic monetary policy, $\epsilon_{M,t}$, the budget constraint, $\zeta_t$, productivity $a_t$, and the real exchange rate $\epsilon_{R,t}$ that follow $AR(1)$ processes.*

■

[6] The alternative of assuming that prices and quantities in $U$ and $R$ are time-varying would require that we specify how they are determined and interact with one another. This is beyond the scope of the current paper.

[7] With a constant exchange rate between $R$ and $U$, standard parity conditions would impose that $\mathcal{E}_{U,t}$ and $\mathcal{E}_{R,t}$ are proportional to each other.

We solve the model by log-linearization methods around a zero inflation steady state.

## 2.5 Some Analytics

Before proceeding to simulate the models dynamics we provide some general insights into its inner workings. This in turn generates testable predictions that we take to the data in Section 4. In Section 3 we adopt a specific functional form for the demand aggregator $\Upsilon$ and provide an expression for the elasticity of the mark-up defined previously $\Gamma_{ij,t}$. Importantly, approximating up to the first order around a point of symmetric prices it can be shown that the pricing equations only depend on the constant $\Gamma_{ij,t} = \Gamma$ evaluated at the steady state.

### 2.5.1 Exchange Rate Pass-through

We first discuss exchange rate pass-through ($ERPT$), that is, the impact of a nominal exchange rate movement on local prices, for the two extremes of flexible prices and fully rigid preset prices. In the following expressions, $p$, $w$ and $e$ denote $\ln P$, $\ln W$ and $\ln \mathcal{E}$ respectively. All proofs are relegated to the appendix.

**Proposition 1 (Flexible prices)** *When prices are fully flexible ($\delta_p = 0$) exchange rate pass-through into export prices ($p_{Hi,t}$) and import prices ($p_{iH,t}$) expressed in $H$ currency are given by:*

$$\begin{aligned}
\Delta p_{Hi,t} &= \frac{1}{1+\Gamma}\left[\frac{\alpha\gamma_i}{1-\alpha\gamma_H}+\Gamma\right]\Delta e_{i,t} \\
&+\frac{1}{1+\Gamma}\frac{\alpha\gamma_j}{1-\alpha\gamma_H}\Delta e_{j,t} \\
&+\frac{1}{1+\Gamma}\frac{1-\alpha}{1-\alpha\gamma_H}\Delta w_t - \frac{1}{1+\Gamma}\frac{1}{1-\alpha\gamma_H}\Delta a_t \qquad (18)
\end{aligned}$$

$$\begin{aligned}
\Delta p_{iH,t} &= \frac{1}{1+\Gamma}\left[1+\Gamma\frac{\alpha\gamma_H\gamma_i}{1-\alpha\gamma_H}\right]\Delta e_{i,t} \\
&+\frac{\Gamma}{1+\Gamma}\frac{\alpha\gamma_H\gamma_j}{1-\alpha\gamma_H}\Delta e_{j,t} \\
&+\frac{\Gamma}{1+\Gamma}\gamma_H\frac{1-\alpha}{1-\alpha\gamma_H}\Delta w_t - \frac{\Gamma}{1+\Gamma}\gamma_H\Delta a_t \qquad (19)
\end{aligned}$$

*where $j \neq i$, for $i,j \in \{U,R\}^2$.* ■

Consider first export prices, Eq. (18). When prices are fully flexible the export price is determined by the marginal cost of $H$ firms and their desired mark-up.

The marginal cost of $H$ firms depends on wages, the price of intermediate inputs, and productivity. The price of intermediate inputs in $H$ depends in turn on the cost of production in each country expressed in $H$ currency and the preference shares $\gamma_i$ in the aggregator eq. (9). Because of the roundabout nature of production, the impact of wages on marginal cost $(1-\alpha)/(1-\alpha\gamma_H)$ exceeds its direct share $(1-\alpha)$ in the production function, and is increasing in $\gamma_H$, the preference for home goods. If there is full home-bias $\gamma_H = 1$ the impact of wages on marginal costs is one to one.

Secondly, since prices and quantities in the foreign countries are constant, exchange rate fluctuations directly affect the cost of imported inputs and therefore affect the marginal cost of producing $H$ goods. This cost is increasing in the share of these inputs $\gamma_i$, $i \neq H$. What this implies is that third currency exchange rates matter for bilateral export prices in addition to bilateral exchange rates.

Lastly, the desired mark-up depends on the degree of strategic complementarity, controlled by $\Gamma$, the elasticity of the mark-up to prices. When $\Gamma > 0$, firms wish to keep their prices stable relative to their competitors' prices in destination markets. This is captured by the term $\Gamma/(1+\Gamma)\Delta e_{i,t}$ in equation (18).

If domestic wages are rigid ($\Delta w_t = 0$), productivity is unchanged ($\Delta a_t = 0$), and $\eta = 1$ in eq. (17), we obtain the following expression for the export price exchange rate pass-through:

$$ERPT^x \equiv \frac{\Delta p_{Hi,t}}{\Delta e_{i,t}} = 1 - \frac{1-\alpha}{(1+\Gamma)(1-\alpha\gamma_H)} \tag{20}$$

In the case with no intermediate inputs used in production, $\alpha = 0$, and constant mark-ups $\Gamma = 0$ as in Galí (2008), $ERPT^x$ is equal to zero or equivalently the pass-through into destination currency prices is 100%, the full pass-through benchmark in the literature: firms set their local price as a constant markup above a fixed wage, regardless of the exchange rate.[8] When intermediate inputs are used in production but there is full home bias so that $\gamma_H = 1$ and $\Gamma = 0$, then again $ERPT^x = 0$, since in that case, marginal cost depends only on (constant) local wages and productivity.

When $\gamma_H < 1$ or $\Gamma > 0$, we obtain $ERPT^x > 0$ or equivalently an imperfect pass-through into destination currency prices. With less than full home bias, $\gamma_H < 1$ the cost of imported inputs and domestic marginal costs increase with a depreciation of the domestic currency, pushing up local currency prices. The lower the home bias in intermediate inputs the higher is $ERPT^x$. Similarly, with strategic complementarities, $\Gamma > 0$, domestic firms increase their markup when the domestic currency depreciates. The stronger the strategic complementarities, the higher is $EPRT^x$.

Consider next import prices, eq. (19). Import prices of foreign goods in foreign currency depends on the foreign cost of production, foreign firms' desired mark-up and the exchange rate of the foreign currency. Recall that we assume that foreign prices and quantities (and hence foreign marginal costs) are constant. It follows that import prices depend only the desired mark-up and the bilateral exchange rate. In turn, with strategic complementarities, the desired mark-up varies with the local competitors' marginal costs. $H$'s marginal cost depends on local productivity, local wages, and the price of intermediate inputs. The latter in turn depends on the preferences shares $\gamma_i$ and exchange rate fluctuations between $U$, $R$ and $H$. This implies that third-currency exchange rates matter for bilateral imports in addition to bilateral exchange rates.

By analogy with eq. (20), we can define an import price exchange rate pass-through under

[8] Equation (20) can be compared to the analysis in Burstein-Gopinath where the pass-through is in terms of destination currency prices from exchange rate changes expressed as destination currency per unit of home currency, equal in our notations to $1 - ERPT^x = \frac{1}{1+\Gamma}\frac{1-\alpha}{1-\alpha\gamma_H}$.

the same assumptions as:

$$ERPT^m \equiv \frac{\Delta p_{iH,t}}{\Delta e_{i,t}} = 1 - \frac{\Gamma}{1+\Gamma}\left[1 - \frac{\alpha\gamma_H}{1-\alpha\gamma_H}(\gamma_i + \gamma_j)\right] \tag{21}$$

According to eq. (21), when $\Gamma = 0$, the pass through into home currency prices is 1 (100%): foreign firms set a constant price in foreign currency, converted into $H$ currency at the prevailing exchange rate. By contrast, with strategic complementarities, $\Gamma > 0$, foreign firms set prices that depend on their local competitors' marginal costs and the pass-through is incomplete: $ERPT^m < 1$.

The next proposition considers the case of fully rigid prices ($\delta_p = 1$).

**Proposition 2 (Fully rigid prices)** *When prices are fully rigid and pre-determined in their currency of invoicing, pass-through into export and import prices expressed in $H$ currency for $i \in \{U, R\}$ are given by,*

$$\Delta p_{Hi,t} = \theta^U_{Hi}\Delta e_{U,t} + \mathbb{I}_{i=R} \cdot \theta^R_{Hi}\Delta e_R \tag{22}$$

$$\Delta p_{iH,t} = \theta^U_{iH}\Delta e_{U,t} + \mathbb{I}_{i=R} \cdot \theta^R_{iH}\Delta e_R \tag{23}$$

*where $\mathbb{I}_{i=R}$ takes the value 1 when $i = R$ and 0 otherwise.*

- *In the case of PCP, $\theta^H_{HU} = 1$ and $\theta^H_{HR} = 1$*

$$\begin{aligned} \Delta p_{Hi,t} &= 0 \cdot \Delta e_{i,t} + 0 \cdot \Delta e_{j\neq i,t}, \qquad \Delta p_{iH,t} = 1 \cdot \Delta e_{i,t} + 0 \cdot \Delta e_{j\neq i,t}, \qquad \forall i \\ tot_{Hi,t} &= \Delta p_{Hi,t} - \Delta p_{iH,t} = -1 \cdot \Delta e_{i,t} \qquad \forall i \end{aligned}$$

- *In the case of LCP, $\theta^U_{HU} = 1$ and $\theta^R_{HR} = 1$*

$$\begin{aligned} \Delta p_{Hi,t} &= 1 \cdot \Delta e_{i,t} + 0 \cdot \Delta e_{j\neq i,t} \qquad \Delta p_{iH,t} = 0 \cdot \Delta e_{i,t} + 0 \cdot \Delta e_{j\neq i,t} \qquad \forall i \\ tot_{Hi,t} &= \Delta p_{Hi,t} - \Delta p_{iH,t} = 1 \cdot \Delta e_{i,t} \qquad \forall i \end{aligned}$$

- *In the case of DP, $\theta^U_{HU} = 1$ and $\theta^U_{HR} = 1$.*

$$\begin{aligned} \Delta p_{Hi,t} &= 1 \cdot \Delta e_{U,t} + 0 \cdot \Delta e_{i\neq U,t} \qquad \Delta p_{iH,t} = 1 \cdot \Delta e_{U,t} + 0 \cdot \Delta e_{i\neq U,t} \qquad \forall i \\ tot_{Hi,t} &= \Delta p_{Hi,t} - \Delta p_{iH,t} = 0 \qquad \forall i \end{aligned}$$

*where $tot_{Hi}$ is the terms of trade between regions $H$ and $i$* ■

This proposition highlights that in the event of dominant currency pricing and extreme price stickiness the only relevant exchange rate is the dollar exchange rate $e_{U,t}$, regardless of destination or origin country. Moreover, because export and import prices load perfectly on the dollar exchange rate, the terms of trade are constant. This contrasts with the predictions under $PCP$ and $LCP$ where one of the export or import prices loads on the bilateral exchange rate $e_{i,t}$, and therefore movements in the terms of trade load fully on the bilateral exchange rate: under $PCP$ a depreciation of the nominal exchange rate worsens the terms of trade. The reverse occurs under $LCP$. We test empirically these propositions in the data in section 4.

### 2.5.2 Price dynamics: the general case

We now log-linearize the equilibrium equ. (14) around a steady state with zero inflation and stable nominal exchange rates. Define $P_{i,t}$ the price index in destination country $i$. Denoting $\bar{p}^j_{Hi,t} = \log \bar{P}^j_{Hi,t}(\omega)$ and $\mathtt{mc}_{Hi,t} = \log(\mathcal{MC}_t(\omega)/\mathcal{E}_{i,t}P_{i,t})$ the log of $H$'s nominal marginal cost deflated by the price index in the destination country $i$, we obtain the following recursive form (see the appendix for derivations):

$$\bar{p}^j_{Hi,t} - \check{p}^j_{i,t-1} = \frac{1-\beta\delta_p}{1+\Gamma}(\mathtt{mc}_{Hi,s} + \mu) + \Delta\check{p}^j_{i,t} + \beta\delta_p \mathbb{E}_t(\bar{p}^j_{Hi,t+1} - \check{p}^j_{i,t}) \tag{24}$$

where $\check{p}^j_{i,t} = \log P_{i,t} + e_{i,t} - e_{j,t}$ is the (log) price index for country $i$ expressed in currency $j$, $\mu$ is the log of the steady state desired gross markup, and $\Gamma$ is the steady-state elasticity of that markup.

Eq. (24) plays a central role in our analysis and contains a number of important insights. First, it makes clear that the relevant reference for the reset price $\bar{p}^j_{Hi,t}$ is the destination price index converted to currency $j$: $\check{p}^j_{i,t}$. It is destination country and invoicing currency specific. Second, the reset price increases above that reference price when future (log) real marginal costs, $\mathtt{mc}^j_{Hi,s}$, are expected to be above their steady state value $-\mu$, or when the reference price itself is expected to increase. Third, eq. (24) reveals that strategic complementarities ($\Gamma > 0$) dampen the impact of future movements in the real marginal cost on reset prices, but not that of future movements in the reference price. Finally, it nests the three different paradigms (corresponding to different values for the invoicing currency $j$). In particular, it illustrates that the currency paradigm matters for the reset price only through differences in firm's reference price $\check{p}^j_{i,t}$. This is so because domestic firms selling in market $i$ face the same real marginal cost $\texttt{mc}_{Hi,t}$ regardless of their currency of invoicing.[9]

An equivalent set of equations holds for firms located in regions $U$ and $R$:

$$\bar{p}^j_{iH,t} - \check{p}^j_{t-1} = \frac{1-\beta\delta_p}{1+\Gamma}(\texttt{mc}_{iH,s} + \mu) + \Delta\check{p}^j_t + \beta\delta_p\mathbb{E}_t(\bar{p}^j_{iH,t+1} - \check{p}^j_t) \tag{25}$$

where $\bar{p}^j_{iH,t}$ is the reset price for country $i$ firms exporting to $H$ in currency $j$, $\check{p}^j_t = p_t - e_{j,t}$ is the (log) domestic price level converted to currency $j$, and $\texttt{mc}_{iH,s} = \log(\mathcal{MC}^i_s\mathcal{E}_{i,s}/P_s)$ is the real foreign marginal cost for $i$ firms deflated by $H$'s price level.

Lastly, define the (log) export price index to country $i$ and currency $j$, $p^j_{Hi,t}$, and the (log) import price index from country $i$ and currency $j$, $p^j_{iH,t}$, with $\pi^j_{Hi,t}$ and $\pi^j_{iH,t}$ the corresponding destination/source and currency specific inflation rates. To the first order, they satisfy:

$$\pi^j_{Hi,t} = (1-\delta_p)(\bar{p}^j_{Hi,t} - p^j_{Hi,t-1}) \tag{26}$$

$$\pi^j_{iH,t} = (1-\delta_p)(\bar{p}^j_{iH,t} - p^j_{iH,t-1}) \tag{27}$$

With a few additional steps of algebra, we can derive destination and invoicing currency-specific forward looking Phillips curves for exports and import prices:

$$\pi^j_{Hi,t} = \frac{\lambda_p}{1+\Gamma}(\texttt{mc}_{Hi,t} + \mu) + \lambda_p\left(\check{p}^j_{i,t} - p^j_{Hi,t}\right) + \beta\mathbb{E}_t\pi^j_{Hi,t+1} \tag{28}$$

$$\pi^j_{iH,t} = \frac{\lambda_p}{1+\Gamma}(\texttt{mc}_{iH,t} + \mu) + \lambda_p\left(\check{p}^j_t - p^j_{iH,t}\right) + \beta\mathbb{E}_t\pi^j_{iH,t+1} \tag{29}$$

where $\lambda_p = (1-\delta_p)(1-\beta\delta_p)/\delta_p$. The first term on the right hand side reflects the impact of movements in real marginal costs. It is destination/origin specific and does not vary across pricing paradigms, for a given real marginal cost. The second term reflects the response of export/import prices to the gap with the price level in the destination market. If $\check{p}^j_{i,t} > p^j_{Hi,t}$ for instance, export prices to destination $i$ in currency $j$ will increase over time. The last term

[9] Of course, under different pricing paradigms, the dynamic evolution of the real marginal cost $\texttt{mc}_{Hi,t}$ will be different. See below.

is the forward looking element of the Phillips curve.

Next we substitute $\texttt{mc}_{Hi,t} = (1-\alpha)w_t + \alpha p_t - a_t + \kappa - e_{i,t} - p_{i,t}$ where $\kappa$ is some unimportant constant which we ignore in what follows, to obtain:

$$\pi^j_{Hi,t} = \frac{\lambda_p}{1+\Gamma}\left((1-\alpha)w_t + \alpha p_t - a_t - e_{i,t} - p_{i,t} + \mu\right) + \lambda_p\left(\check{p}^j_{i,t} - p^j_{Hi,t}\right) + \beta\mathbb{E}_t\pi^j_{Hi,t+1}$$

This expression illustrates the three channels through which changes in the exchange rate affect export prices: the currency of invoicing $j$ via the reference price (and indirectly via the domestic price level $p$); strategic complementarities ($\Gamma > 0$) and imported intermediate inputes ($\alpha > 0$). A similar derivation for import prices yields:

$$\pi^j_{iH,t} = \frac{\lambda_p}{1+\Gamma}\left(\log\mathcal{MC}^i_t + e_{i,t} - p_t + \mu\right) + \lambda_p\left(\check{p}^j_t - p^j_{iH,t}\right) + \beta\mathbb{E}_t\pi^j_{iH,t+1}.$$

# 3 Monetary Policy

As the previous discussion reveals there are starkly different implications for exchange rate pass-through, the terms of trade and pricing to market under the different currency pricing regimes. In this section we present numerical impulse responses to a monetary policy shock to contrast the responses under different pricing regimes.

**Preference Aggregator:** To start with we specify a functional form for the demand function $\Upsilon$. We adopt the Klenow and Willis (2006) formulation that gives rise to the following demand for individual varieties:

$$Y_{iH,t}(\omega) \equiv C_{iH,t}(\omega) + X_{iH,t}(\omega) = \gamma_i\left(1 + \epsilon\ln\frac{\sigma-1}{\sigma} - \epsilon\ln Z_{iH,t}\right)^{\sigma/\epsilon}\cdot(C_t + X_t)$$

where $Z \equiv \frac{P_{iH}(\omega)}{P}D$ as previously defined and $\sigma$ and $\epsilon$ are two parameters that determine the elasticity of demand and its variability. The elasticity of demand and the elasticity of the mark-up are given by,

$$\sigma_{iH,t} = \frac{\sigma}{\left(1 + \epsilon\ln\frac{\sigma-1}{\sigma} - \epsilon\ln Z_{iH,t}\right)} \qquad \Gamma_{iH,t} = \frac{\epsilon}{\left(\sigma - 1 - \epsilon\ln\frac{\sigma-1}{\sigma} + \epsilon\ln Z_{iH,t}\right)}$$

In a symmetric steady state $Z_{iH,t} = (\sigma - 1)/\sigma$, the elasticity of demand is $\sigma$ and the elasticity of mark-up $\Gamma \equiv \frac{\epsilon}{\sigma - 1}$.

**Parameter Values:** Table 1 lists parameter values employed in the simulation. The time period is a quarter. Several parameters take values standard in the literature (see e.g. Galí, 2008). Following Christiano et al. (2011) we set the wage stickiness parameter $\theta^w = 0.85$ corresponding roughly to a year and a half average duration of wages. The steady state elasticity of substitution $\sigma$ is assumed in the model to be the same across varieties within a region and also across regions. Accordingly we calibrate to an average of these elasticities measured in the literature. Specifically, Broda and Weinstein (2006) obtain a median elasticity estimate of 2.9 for substitution across imported varieties, while Feenstra et al. (2010) estimate a value close to 1 for the elasticity of substitution across domestic and foreign varieties. Accordingly we set $\sigma = 2$.

To parameterize $\epsilon$ we employ the estimate from Amiti et al. (2016) who exploit rich data on prices set by domestic and foreign firms in Belgium to estimate $\Gamma = 1$. Because in steady state $\Gamma = \frac{\epsilon}{\sigma - 1}$ this implies $\epsilon = 1$. Importantly the estimate for $\Gamma$ in Amiti et al. (2016) corresponds closely to a previous estimate in Amiti et al. (2014) and to a more back-of-the envelope estimate by Gopinath and Itskhoki (2010) which suggests that this is a reasonable value for parameterization.

The home bias shares are set to $\{\gamma_H, \gamma_U, \gamma_R\} = \{3/5, 1/5, 1/5\}$. This implies steady state spending on imported goods in the consumption bundle and intermediate input bundle equal to twenty percent. In Section 4 we estimate this directly from the data for Colombia.

Figures 1 and 2 plot the impulse response to a negative 25 basis point shock to interest rates.[10] In each sub-figure we contrast the response under the regimes of $DCP$, $PCP$ and $LCP$.

Following the monetary shock domestic interest rates decline (Figure 1(a)) but less that

[10] $\eta = 1$ so that the impulse response of $e_{U,t}$ and $e_{R,t}$ are identical.

| | Parameter | Value |
|---|---|---|
| Household Preferences | | |
| Discount factor | $\beta$ | 0.99 |
| Risk aversion | $\sigma_c$ | 2.00 |
| Frisch elasticity of $N$ | $\varphi^{-1}$ | 0.50 |
| Disutility of labor | $\kappa$ | 1.00 |
| Production | | |
| Interm share | $\alpha$ | 2/3 |
| Demand | | |
| Elasticity | $\sigma$ | 2.00 |
| Super-elasticity | $\epsilon$ | 1.00 |
| Rigidities | | |
| Wage | $\delta_w$ | 0.85 |
| Price | $\delta_p$ | 0.75 |
| Monetary Rule | | |
| Inertia | $\rho_m$ | 0.50 |
| Inflation sensitivity | $\phi_M$ | 1.50 |
| Shock persistence | $\rho_{\varepsilon_i}$ | 0.50 |

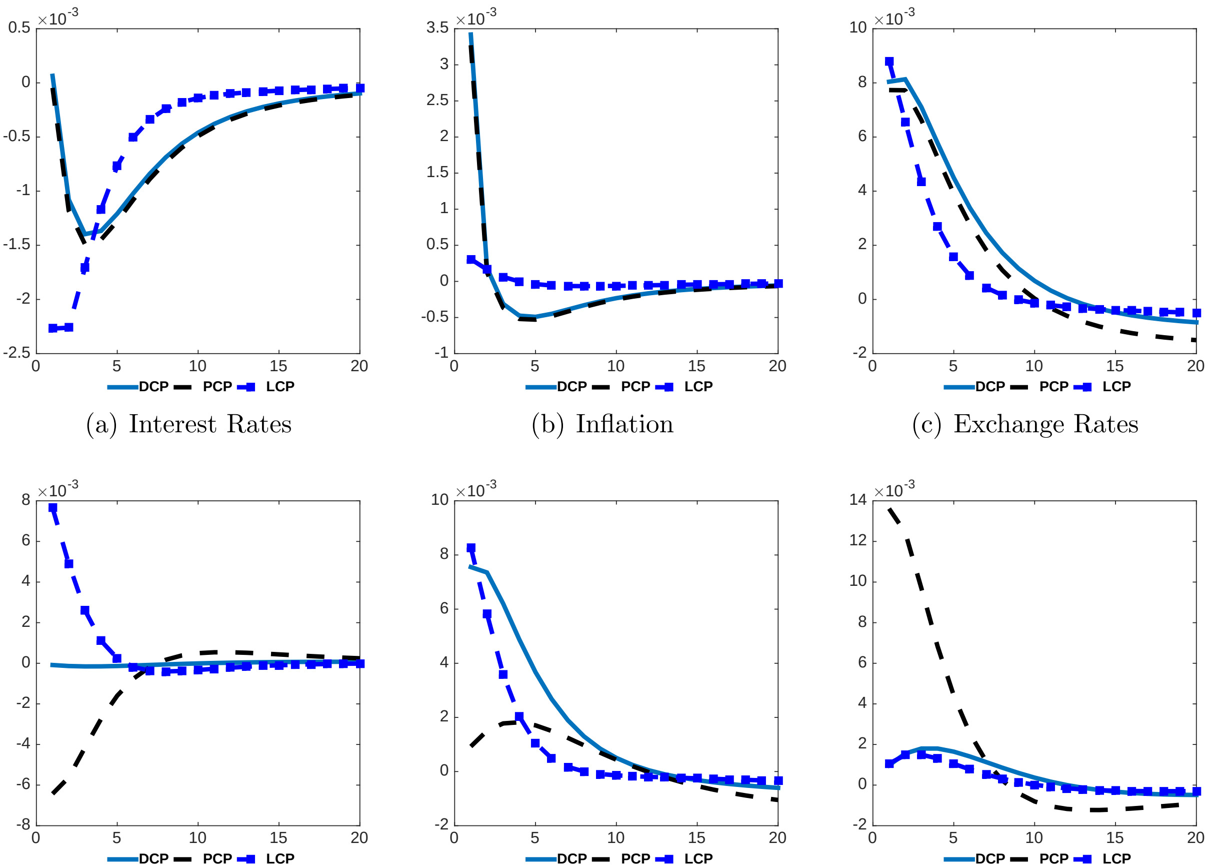
Note: other parameter values as reported in the text.

Table 1: Parameter Values

one-to-one as the exchange rate depreciates by around 0.8% raising inflationary pressures on the economy. This in turn dampens the fall in interest rates via the monetary rule. As seen in Figure 1(b) the increase in inflation (0.35%) in the case of $DCP$ and $PCP$ far exceeds that of $LCP$. This follows from the fact that currency exchange rate movements have a smaller impact on the domestic prices of imported goods when import prices are sticky in domestic currency (i.e. $LCP$).

The exchange rate depreciation is associated with almost a one to one depreciation of the terms of trade in the case of $PCP$ and a one to one appreciation in the case of $LCP$. Distinctively, in the case of $DCP$ the terms of trade depreciates negligibly and remains stable. This follows from the fact that both export and import prices are stable in the dominant currency under $DCP$.

With stable export and import prices in the dominant currency under $DCP$, the $H$ currency price of exports and imports rise with the exchange rate depreciation as depicted in Figure 1(e) and 2(a). This in turn generates a significant decline in imports (0.4%) , despite the




(a) Interest Rates (b) Inflation (c) Exchange Rates

(d) Terms of Trade (e) Export Price (f) Export Quantity

Figure 1: Monetary policy shock

expansionary effect of monetary policy, and only a modest increase in exports (0.1%). This contrasts with the $PCP$ benchmark that generates a large increase in exports and with the $LCP$ benchmark that generates an increase in imports as in this case the import prices are initially shielded from the exchange rate depreciation.

An implication of these diverging patterns is that a weaker currency in emerging markets whose invoicing is consistent with $DCP$ is associated with declines in trade (defined as the sum of export and import quantities) as shown in Figure 2(f), in contrast to the case of $PCP$ and $LCP$. In the case of $DCP$ trade declines by 0.2% as imports fall without a commensurate increase in exports. In the case of $PCP$ trade expands by 0.5% as the increase in exports outweighs the increase in imports. Because of the use of imported inputs to export this further dampens the fall in imports in the case of $PCP$. In the case of $LCP$ trade increases by 0.27% mainly because of the increase in imports.

The stability of prices in the dominant currency alongside the rigidity of wages in home currency generates an increase in mark-ups in the case of $DCP$ as depicted in Figure 2(c). While this is similar to the case of $LCP$ where mark-ups also rise, there is a more modest increase in mark-ups in the case of $DCP$ because of the increase in marginal costs arising from the higher price of imported inputs, an effect absent in the case of $LCP$. In contrast, mark-ups decline in the case of $PCP$ as marginal costs increase alongside a stable price in home currency.

Lastly, figure 2(d) plots the differences in (log) prices at which goods are sold at home relative to exported. As is evident there is a large decline in the relative price of goods sold at home in the case of $LCP$ and $DCP$. This is far more muted in the case of $PCP$ and arises entirely through the variable mark-up channel because of $\Gamma \neq 0$.

# 4 Empirical Evidence

To test the implications of the model we use novel data on exports, imports and firm production from Colombia. As we describe below, these data provide us with a great amount of detail on

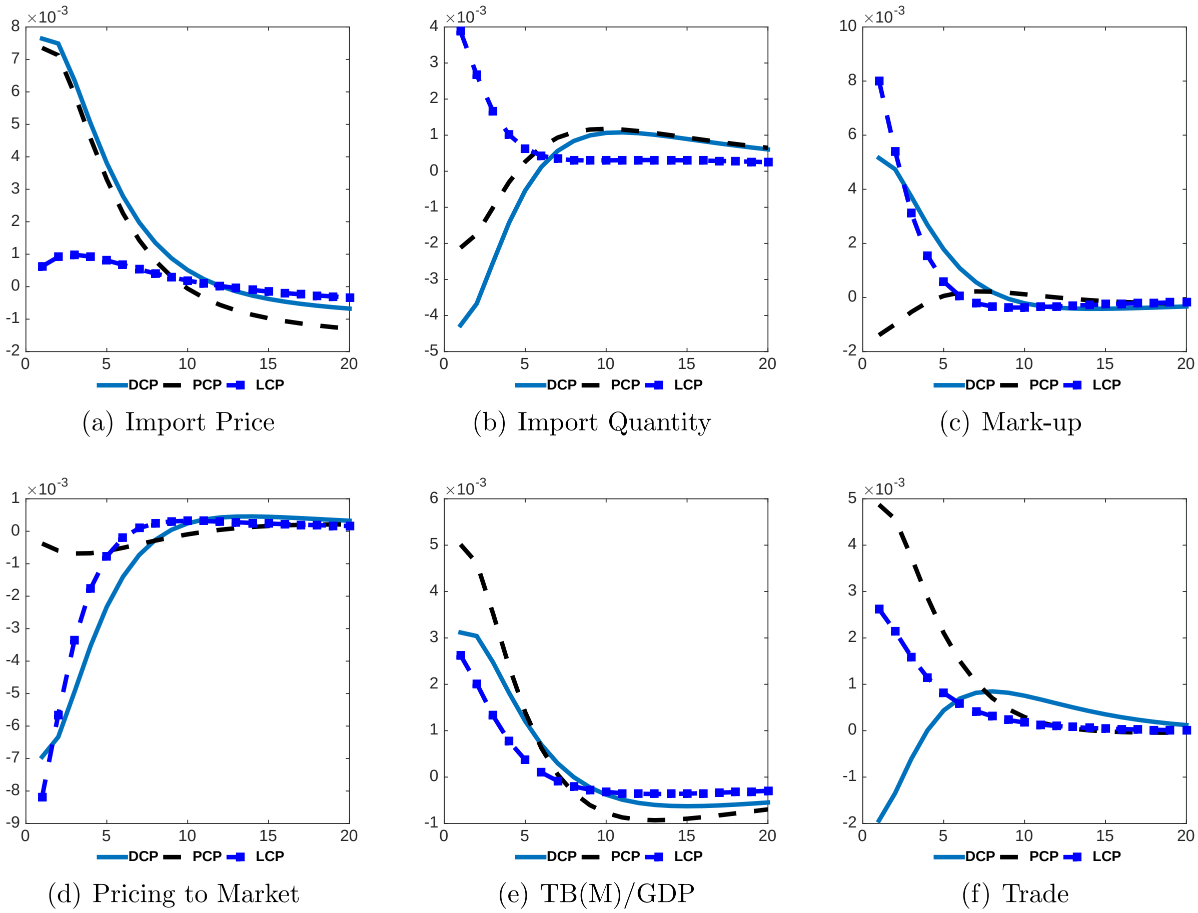



Figure 2: Monetary policy shock (continued)

the firms' international transactions and, moreover, allow us to directly observe the imported input share, that is, the empirical counterpart of $1-\gamma_H$. Below, we first describe our data sources. Then we present our estimation results and show that the data rejects $PCP$ and $LCP$ in favor of $DCP$.

## 4.1 Data Sources

We combine two different firm-level datasets: one has information on firms' foreign market participation, while the other contains detailed balance sheet and operational information.

The data on international trade are from the customs agency (DIAN), and the department of statistics (DANE), and include information on the universe of Colombian importers and exporters. We have access to the data through the Banco de la República. The data include the trading firm's tax identification number, the 10-digit product code (according to the Nandina classification system, based on the Harmonized System), the FOB value (in U.S. dollars) and volume (net kilograms) of exports (imports), and the country of destination (origin), among other details.[11] The data are available on a monthly basis, and for our analysis we aggregate exports and imports at the annual or quarterly level. These data are available for the period between 2000 and 2015.

Further, starting in 2007, our exports data include information on the invoicing currency of each transaction. In Table A-3 we present the distribution of currencies, broken down by destination groups. It is evident that the vast majority of Colombian exports are priced in dollars. Even for exports to the euro zone, or the U.K, the overwhelming invoicing currency is the dollar. Although some transactions are negotiated in euros, Colombian pesos, or Venezuelan bolívares among other currencies, the U.S. dollar accounts for over 98% of all exports. Moreover, the distribution is very similar if we look at the value of exports negotiated in each currency

[11] In the case of imports, there are cases where the imported good was produced in one country but actually arrived to Colombia from a third country. This case is most commonly seen for goods produced in China arriving to Colombia from either the United States or Panama. To avoid introducing unnecessary noise in our empirical work, we only keep in our regressions those observations where the country of origin and purchase are the same.

instead of the number of transactions. In this regard the Colombian economy is representative of a large number of economies that rely extensively on dollar invoicing.

The data on firms' production and input consumption are from "Superintendencia de Sociedades," the agency in charge of supervising corporations. In contrast to the trade data, this dataset includes mostly relatively large firms. But these firms account for most of Colombian trade, accounting for roughly three quarters of the total value of exports and imports. See Casas et al. (2016) for a detailed description of these data.

Finally, we obtain data on exchange rates from the International Monetary Fund. The Colombian exchange rate (peso) is a commodity currency, and fluctuations in the peso[12] are strongly negatively correlated with fluctuations in commodity prices.[13] Figure 3 displays the relation between the Colombian peso (solid black line) and the overall (log) terms of trade (dashed blue line), defined as the log difference between export and import prices. This terms of trade is driven primarily by commodity prices. The correlation between the two series is -0.62, and the regression coefficient is -1.15 with an $R^2$ of 0.38. If however we focus on the non-commodity terms of trade (dots-and-dash red line) we find that the terms of trade is far more stable with a regression coefficient of -0.33 and $R^2$ of 0.36, consistent with the predictions of the model under $DCP$.

## 4.2 Results

We use these data to test the main implications of the model. In all of our empirical analysis, we focus on manufactured goods, excluding products in the petrochemicals and basic metals industries and we follow the ISIC Rev. 3.1 classification to define which products are manufactures. Moreover, we also use subsample of differentiated products only (instead of the full

[12]The Colombian peso officially switched to a floating status in 1999.

[13]These commodity prices are also exogenous to the economy because while mining output makes up 58.4% of total exports for Colombia, it is small relative to world commodity markets. For example, Colombia's oil production was 1.1% of world oil production in 2014.

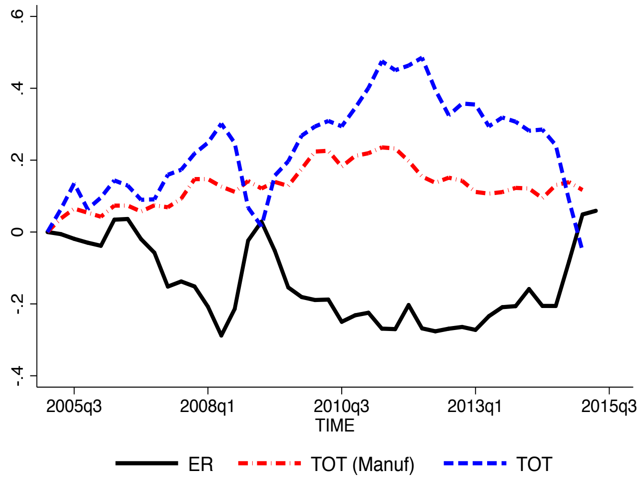



Figure 3: Exchange Rate and Terms of Trade

set of manufactures presented) constructed using the classification of goods by Rauch (1999).[14] We define prices and quantities at the 10-digit product, country, year (or quarter) level. Prices are given by the FOB value per net kilogram, and quantities are given by total net kilograms. Exchange rates are the annual (or quarterly) average.

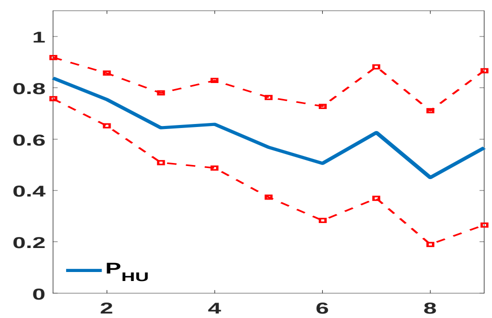
**Exchange rate pass-through:** We estimate the pass-through of exchange rates into import and export prices to understand the pricing behavior of Colombian firms using the dynamic lag regression described in Burstein and Gopinath (2014):

$$\Delta x_t = \alpha + \sum_{s=0}^{8} \beta_s \Delta e_{t-s} + \mathbf{Z}_t + \epsilon_t, \tag{30}$$

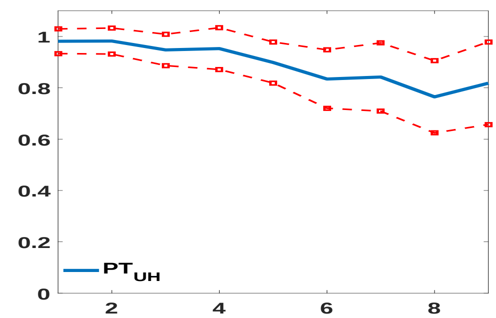
where $\Delta x_t$ is the quarterly log change in export/import prices expressed in pesos. $\Delta e_{t-s}$ is the quarterly log change in the nominal exchange rate of the *peso relative to the dollar* regardless of origin or destination country. We have the contemporaneous effect and eight lags. $\mathbf{Z}_t$ is a control vector that includes quarterly log changes in the producer price index in Colombia and in the origin/destination country (contemporaneous and eight lags) and fixed effects by firm-

[14]In our reported estimates, we follow Rauch's conservative classification, although the results are virtually unchanged if we use the liberal definition instead.

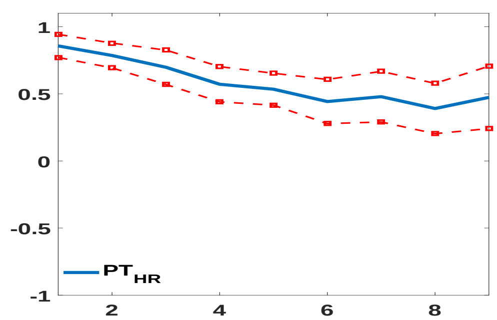
industry-country. The cumulative estimates, $\sum_{s=0}^{k} \beta_s$ and two standard error bands (where the standard errors are clustered at the level of quarter-year) are plotted as the blue solid line and the dashed with squares red line in Figure 4(a) for export prices from Colombia to dollar destinations and Figure 4(b) for import prices from dollar destinations. For non-dollar countries the figures are similarly reported in Figures 4(c) and 4(d).



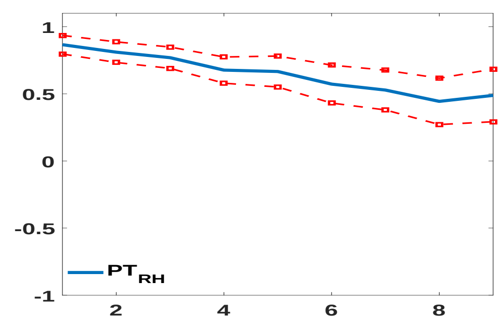

(a) *Export prices (dollar destination)*




(b) *Import prices (dollar origin)*




(c) *Export prices (non-dollar destination)*




(d) *Import prices (non-dollar origin)*

Figure 4: ERPT - Export and Import Prices

A striking feature of the pass-through estimates is that all pass-throughs start out high at close to one and decline over time. This is the case for both export and import prices and for dollar and non-dollar destinations/origins and follows the prediction of $DCP$ where if prices are set in the dominant currency, in this case the dollar, the pass-through of peso/dollar exchange rates into export and import prices in pesos is almost one to one initially and then declines over time. In the case of export prices to dollar destinations the contemporaneous estimate is 0.84

and then the cumulative pass-through slowly decreases after two years to 0.56. In the case of import prices from dollar origins pass-through is very high, around 1 and the cumulative effect declines to 0.81. For non-dollar destinations the estimated pass-through starts at around 0.86 and decreases to 0.47 after two years.

The second set of regressions we estimate tests the importance of non-dominant currencies in pass-through. We report here the results from annual regressions of the log change in export/import prices on the log change in the bilateral exchange rates and then we add in the peso/dollar exchange rate and the peso/euro exchange rate. Specifically,

$$\Delta x_t = \alpha + \tilde{\beta}_U \Delta e_{R,t} + \tilde{\beta}_R \Delta e_{U,t} + \mathbf{Z}_t + \epsilon_t, \tag{31}$$

where the other controls are the same as those reported previously and we cluster the standard errors by year.

The estimates are reported in Tables 2-5 respectively for the various specifications. As is clearly evident from non-dollar destinations the introduction of the peso/dollar exchange rate knocks down the coefficient on the bilateral exchange rate in all specifications. This finding once again is consistent with $DCP$.

Table 2: ERPT into Colombian Export Prices (Dollarized Economies, $U$)

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | $\Delta p_{COP}$ | $\Delta p_{COP}$ | $\Delta p_{COP}$ | $\Delta p_{COP}$ | $\Delta p_{COP}$ | $\Delta p_{COP}$ |
| $\Delta e_{COP/USD}$ | 0.699*** | 0.677*** | 0.830*** | 0.863*** | 0.798*** | 0.821*** |
| | (0.0324) | (0.0630) | (0.0341) | (0.0410) | (0.0440) | (0.0595) |
| $\Delta e_{COP/Euro}$ | | 0.0366 | | -0.0460 | | -0.0323 |
| | | (0.0667) | | (0.0288) | | (0.0447) |
| $\Delta PPI$ | | | -0.0611 | -0.0547 | 0.116 | 0.120 |
| | | | (0.141) | (0.113) | (0.143) | (0.126) |
| $\Delta PPI^*$ | | | 0.218*** | 0.227*** | 0.193*** | 0.199*** |
| | | | (0.0490) | (0.0468) | (0.0495) | (0.0505) |
| Observations | 169,749 | 169,749 | 159,002 | 159,002 | 98,820 | 98,820 |
| R-squared | 0.289 | 0.289 | 0.290 | 0.290 | 0.304 | 0.304 |
| Sample | M | M | M | M | D | D |

*Notes:* All regressions include Firm-Industry-Country fixed effects. Standard errors clustered at the year level. The sample includes all manufactured (M) products excluding petrochemicals and metal industries in columns (1)-(4) and only differentiated (D) products in columns (5)-(6). The export destinations are the Dollarized economies: USA, Panama, Puerto Rico, Ecuador, and El Salvador. '***', '**', and '*' indicate significance at the 1, 5, and 10 percent level, respectively.

Table 3: ERPT into Colombian Export Prices (Non-Dollarized Economies, $R$)

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|---|
| | $\Delta p_{COP}$ | $\Delta p_{COP}$ | $\Delta p_{COP}$ | $\Delta p_{COP}$ | $\Delta p_{COP}$ | $\Delta p_{COP}$ | $\Delta p_{COP}$ |
| $\Delta e_{COP/LCU}$ | 0.697*** | 0.0896* | 0.0801** | 0.559*** | 0.110* | 0.143** | 0.122 |
| | (0.115) | (0.0464) | (0.0333) | (0.155) | (0.0542) | (0.0453) | (0.0906) |
| $\Delta e_{COP/USD}$ | | 0.660*** | 0.652*** | | 0.626*** | 0.681*** | 0.671*** |
| | | (0.0473) | (0.0750) | | (0.0533) | (0.0603) | (0.0928) |
| $\Delta e_{COP/Euro}$ | | | 0.0422 | | | -0.0701 | -0.0438 |
| | | | (0.0842) | | | (0.0590) | (0.0762) |
| $\Delta PPI$ | | | | 1.100** | 0.280 | 0.208 | 0.161 |
| | | | | (0.362) | (0.162) | (0.172) | (0.202) |
| $\Delta PPI^*$ | | | | -0.355 | 0.0647 | 0.117 | 0.183 |
| | | | | (0.277) | (0.161) | (0.174) | (0.187) |
| Observations | 204,664 | 204,664 | 184,825 | 137,151 | 137,151 | 118,198 | 72,408 |
| R-squared | 0.306 | 0.308 | 0.300 | 0.310 | 0.312 | 0.303 | 0.320 |
| Sample | M | M | M | M | M | M | D |

*Notes:* All regressions include Firm-Industry-Country fixed effects. Standard errors clustered at the year level. The sample includes all manufactured (M) products excluding petrochemicals and metal industries in columns (1)-(6) and only differentiated (D) products in column (7). The export destinations include all countries except the Dollarized economies (USA, Panama, Puerto Rico, Ecuador, and El Salvador), economies with currencies pegged to the dollar, and Venezuela. Columns (3) and (6) exclude euro destinations. '***', '**', and '*' indicate significance at the 1, 5, and 10 percent level, respectively.

Table 4: ERPT into Colombian Import Prices (Dollarized, $U$)

| | (1) $\Delta p_{COP}$ | (2) $\Delta p_{COP}$ | (3) $\Delta p_{COP}$ | (4) $\Delta p_{COP}$ | (5) $\Delta p_{COP}$ | (6) $\Delta p_{COP}$ |
|---|---|---|---|---|---|---|
| $\Delta e_{COP/USD}$ | 0.976*** | 0.975*** | 1.003*** | 1.034*** | 0.969*** | 0.970*** |
| | (0.0173) | (0.0369) | (0.0278) | (0.0435) | (0.0328) | (0.0375) |
| $\Delta e_{COP/Euro}$ | | 0.00159 | | -0.0404 | | -0.00132 |
| | | (0.0563) | | (0.0534) | | (0.0603) |
| $\Delta PPI$ | | | 0.147 | 0.151 | 0.253** | 0.253** |
| | | | (0.0963) | (0.102) | (0.0988) | (0.0983) |
| $\Delta PPI^*$ | | | 0.0947** | 0.113*** | -0.0127 | -0.0121 |
| | | | (0.0359) | (0.0327) | (0.0530) | (0.0396) |
| Observations | 508,559 | 508,559 | 508,247 | 508,247 | 264,495 | 264,495 |
| R-squared | 0.226 | 0.226 | 0.226 | 0.226 | 0.252 | 0.252 |
| Sample | M | M | M | M | D | D |

*Notes:* All regressions include Firm-Industry-Country fixed effects. Standard errors clustered at the year level. The sample includes all manufactured (M) products excluding petrochemicals and metal industries in columns (1)-(4) and only differentiated (D) products in columns (5)-(6). The imports originate from the Dollarized economies: USA, Panama, Puerto Rico, Ecuador, and El Salvador. '***', '**', and '*' indicate significance at the 1, 5, and 10 percent level, respectively.

Table 5: ERPT into Colombian Import Prices (Non-Dollarized, $R$)

| | (1) $\Delta p_{COP}$ | (2) $\Delta p_{COP}$ | (3) $\Delta p_{COP}$ | (4) $\Delta p_{COP}$ | (5) $\Delta p_{COP}$ | (6) $\Delta p_{COP}$ | (7) $\Delta p_{COP}$ |
|---|---|---|---|---|---|---|---|
| $\Delta e_{COP/LCU}$ | 0.742*** | 0.301*** | 0.289*** | 0.461*** | 0.257** | 0.282*** | 0.289** |
| | (0.126) | (0.0791) | (0.0861) | (0.132) | (0.0829) | (0.0873) | (0.0923) |
| $\Delta e_{COP/USD}$ | | 0.540*** | 0.484*** | | 0.547*** | 0.628*** | 0.624*** |
| | | (0.0662) | (0.119) | | (0.0460) | (0.0646) | (0.0760) |
| $\Delta e_{COP/Euro}$ | | | 0.182 | | | -0.0365 | -0.0360 |
| | | | (0.167) | | | (0.0974) | (0.108) |
| $\Delta PPI$ | | | | 1.623** | 0.696** | 0.834*** | 0.739*** |
| | | | | (0.664) | (0.229) | (0.137) | (0.119) |
| $\Delta PPI^*$ | | | | -0.631** | 0.185 | 0.276*** | 0.244* |
| | | | | (0.211) | (0.121) | (0.0774) | (0.120) |
| Observations | 824,364 | 824,364 | 600,041 | 582,201 | 582,201 | 368,247 | 182,233 |
| R-squared | 0.287 | 0.290 | 0.316 | 0.268 | 0.271 | 0.294 | 0.306 |
| Sample | M | M | M | M | M | M | D |

*Notes:* All regressions include Firm-Industry-Country fixed effects. Standard errors clustered at the year level. The sample includes all manufactured (M) products excluding petrochemicals and metal industries in columns (1)-(6) and only differentiated (D) products in column (7). The imports originate from al countries except for the Dollarized economies (USA, Panama, Puerto Rico, Ecuador, and El Salvador), economies with currencies pegged to the dollar, and Venezuela. Columns (3) and (6) exclude euro destinations. '***', '**', and '*' indicate significance at the 1, 5, and 10 percent level, respectively.

**Quantities:** An important prediction of $DCP$ that differs substantially from $PCP$ and $LCP$ is the differential quantity responses of imports and exports. Using a first order approximation we have for export and import quantities respectively,

$$\frac{\Delta y_{Hi}}{\Delta e_U} = -\sigma \left( \frac{\Delta p_{Hi}}{\Delta e_U} - \frac{\Delta e_i}{\Delta e_U} \right) \tag{32}$$

$$\frac{\Delta y_{iH}}{\Delta e_U} = -\sigma \left( \frac{\Delta p_{iH}}{\Delta e_U} - \frac{\Delta p}{\Delta e_U} \right) + \frac{\Delta y_d}{\Delta e_U} \tag{33}$$

where $y_d = \log(C + X)$ is (log) domestic demand. We have suppressed terms that are held fixed because of the $SOE$ assumption. Consider the case of imports and exports from and to $U$. In this case $\frac{\Delta e_i}{\Delta e_U} = 1$ and $\frac{\Delta p_{Hi}}{\Delta e_U}$ is also close to 1. Consequently the impact on exports is close to 0. In the case of imports, controlling for demand and home competitors prices, quantities are almost as sensitive as the elasticity of demand given that $\frac{\Delta p_{iH}}{\Delta e_U}$ is close to 1. This would also be the case for imports from $R$. Importantly the relevant exchange rate here again is the exchange rate of $H$ relative to the dominant currency $U$ with the bilateral exchange rate playing a minor role.

In the case of exports to $R$ quantity responses are less straightforward as it depends on the co-movement between $e_U$ and $e_R$. If this co-movement is sufficiently short of 1 then a weakening of the $H$ currency relative to the dominant currency can lead to a decline in exports to $R$ destination.

Tables 6-9 report the results from the quantity regressions in the data. A few things stand out. Starting with the dollarized economies, the pass-through to export quantities to $U$ is insignificantly different from zero in all specifications except one in which case we actually have the exports decline. On the other hand, for imports from $U$ there is a pronounced decline in quantities imported across all specifications. In the case of the nondollarized economies, the decline in imports from $R$ is also significantly negative and, importantly, the relevant exchange rate is peso/dollar exchange rates as opposed to the bilateral exchange rate. For exports we again have that the relevant exchange rate is the peso/dollar exchange rate. We however observe exports declining following a weakening of the peso relative to the dollar which as we pointed out previously is possible when the co-movement of the destination currency with the dollar is sufficiently weak.

Table 6: ERPT into Colombian Export Quantities (Dollarized, $U$)

| | (1) $\Delta q$ | (2) $\Delta q$ | (3) $\Delta q$ | (4) $\Delta q$ |
|---|---|---|---|---|
| $\Delta e_{COP/USD}$ | -0.608* | -0.466 | -0.421 | -0.0447 |
| | (0.277) | (0.344) | (0.331) | (0.372) |
| $\Delta e_{COP/Euro}$ | 1.172 | 1.207 | 0.576 | 0.662 |
| | | (0.386) | | (0.428) |
| $\Delta PPI$ | 1.172 | 1.207 | 0.576 | 0.662 |
| | (0.940) | (1.008) | (1.069) | (1.296) |
| $\Delta PPI^*$ | 0.454 | 0.487* | 0.803** | 0.897*** |
| | (0.259) | (0.247) | (0.311) | (0.265) |
| $\Delta GDP^*$ | 0.289 | 0.325 | -0.00557 | 0.0573 |
| | (1.304) | (1.318) | (1.548) | (1.508) |
| Observations | 159,002 | 159,002 | 98,820 | 98,820 |
| R-squared | 0.225 | 0.225 | 0.232 | 0.232 |
| Sample | M | M | D | D |

*Notes:* All regressions include Firm-Industry-Country fixed effects. Standard errors clustered at the year level. The sample includes all manufactured (M) products excluding petrochemicals and metal industries in columns (1)-(2) and only differentiated products in columns (3)-(4). The export destinations are the Dollarized economies: USA, Panama, Puerto Rico, Ecuador, and El Salvador. '***', '**', and '*' indicate significance at the 1, 5, and 10 percent level, respectively.

Table 7: ERPT into Colombian Import Quantities (Dollarized, $U$)

| | (1) $\Delta q$ | (2) $\Delta q$ | (3) $\Delta q$ | (4) $\Delta q$ |
|---|---|---|---|---|
| $\Delta e_{COP/USD}$ | -1.104*** | -0.939** | -1.123*** | -0.950* |
| | (0.255) | (0.397) | (0.296) | (0.455) |
| $\Delta e_{COP/Euro}$ | | -0.233 | | -0.243 |
| | | (0.414) | | (0.462) |
| $\Delta PPI$ | 1.5 | 1.584 | 1.369 | 1.459 |
| | (1.068) | (1.075) | (1.174) | (1.174) |
| $\Delta PPI^*$ | -0.128 | -0.0972 | 0.0418 | 0.0739 |
| | (0.317) | (0.327) | (0.364) | (0.363) |
| $\Delta GDP$ | 3.538 | 3.916 | 2.699 | 3.096 |
| | (2.750) | (2.798) | (3.199) | (3.250) |
| Observations | 508,263 | 508,263 | 264,501 | 264,501 |
| R-squared | 0.184 | 0.184 | 0.206 | 0.206 |
| Sample | M | M | D | D |

*Notes:* All regressions include Firm-Industry-Country fixed effects. Standard errors clustered at the year level. The sample includes all manufactured (M) products excluding petrochemicals and metal industries in columns (1)-(2) and only differentiated (D) products in columns (3)-(4). The imports originate from the Dollarized economies: USA, Panama, Puerto Rico, Ecuador, and El Salvador. '***', '**', and '*' indicate significance at the 1, 5, and 10 percent level, respectively.

Table 8: ERPT into Colombian Export Quantities (Non-Dollarized, $R$)

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | $\Delta q$ | $\Delta q$ | $\Delta q$ | $\Delta q$ | $\Delta q$ | $\Delta q$ |
| $\Delta e_{COP/LCU}$ | -0.872*** | -0.113 | -0.251 | -1.136*** | -0.283 | -0.416 |
| | (0.254) | (0.245) | (0.278) | (0.306) | (0.295) | (0.294) |
| $\Delta e_{COP/USD}$ | | -1.057*** | -0.972** | | -1.156*** | -0.966** |
| | | (0.271) | (0.327) | | (0.277) | (0.325) |
| $\Delta e_{COP/Euro}$ | | | 0.0359 | | | -0.0352 |
| | | | (0.321) | | | (0.323) |
| $\Delta PPI$ | 1.869 | 2.852** | 2.986** | 1.927 | 2.990** | 2.978** |
| | (1.420) | (1.222) | (1.108) | (1.533) | (1.275) | (1.208) |
| $\Delta PPI^{*}$ | 0.051 | -0.328 | -0.463 | -0.396 | -0.792 | -0.861* |
| | (0.469) | (0.393) | (0.297) | (0.544) | (0.495) | (0.388) |
| $\Delta GDP^{*}$ | 2.995*** | 1.676 | 1.753 | 3.479*** | 2.049 | 2.195 |
| | (0.882) | (1.194) | (1.153) | (0.989) | (1.349) | (1.248) |
| Observations | 137,151 | 137,151 | 118,198 | 83,948 | 83,948 | 72,408 |
| R-squared | 0.253 | 0.254 | 0.249 | 0.261 | 0.262 | 0.256 |
| Sample | M | M | M | D | D | D |

*Notes:* All regressions include Firm-Industry-Country fixed effects. Standard errors clustered at the year level. The sample includes all manufactured (M) products excluding petrochemicals and metal industries in columns (1)-(3) and only differentiated (D) products in columns (4)-(6). The export destinations include all countries except the Dollarized economies (USA, Panama, Puerto Rico, Ecuador, and El Salvador), economies with currencies pegged to the dollar, and Venezuela. Columns (3) and (6) exclude euro destinations. '***', '**', and '*' indicate significance at the 1, 5, and 10 percent level, respectively.

Table 9: ERPT into Colombian Import Quantities (Non-Dollarized, $R$)

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | $\Delta q$ | $\Delta q$ | $\Delta q$ | $\Delta q$ | $\Delta q$ | $\Delta q$ |
| $\Delta e_{COP/LCU}$ | -0.569** | -0.174 | -0.297 | -0.597** | -0.183 | -0.259 |
| | (0.216) | (0.125) | (0.246) | (0.234) | (0.142) | (0.243) |
| $\Delta e_{COP/USD}$ | | -0.881*** | -0.942*** | | -0.908*** | -0.983** |
| | | (0.188) | (0.270) | | (0.234) | (0.315) |
| $\Delta e_{COP/Euro}$ | | | -0.0828 | | | -0.0901 |
| | | | (0.353) | | | (0.363) |
| $\Delta PPI$ | 0.587 | 1.738* | 2.130* | 0.605 | 1.785* | 2.146* |
| | (1.120) | (0.829) | (0.983) | (1.112) | (0.844) | (0.968) |
| $\Delta PPI^{*}$ | 0.0695 | -0.794** | -1.164*** | 0.103 | -0.780** | -1.057** |
| | (0.398) | (0.260) | (0.364) | (0.397) | (0.286) | (0.342) |
| $\Delta GDP$ | 6.306*** | 4.561** | 4.982** | 6.614*** | 4.813** | 4.894** |
| | (1.593) | (2.026) | (2.177) | (1.586) | (2.035) | (2.171) |
| Observations | 582,306 | 582,306 | 368,351 | 292,551 | 292,551 | 182,298 |
| R-squared | 0.209 | 0.210 | 0.220 | 0.232 | 0.234 | 0.247 |
| Sample | M | M | M | D | D | D |

*Notes:* All regressions include Firm-Industry-Country fixed effects. Standard errors clustered at the year level. The sample includes all manufactured (M) products excluding petrochemicals and metal industries in columns (1)-(3) and only differentiated (D) products in columns (4)-(6). The imports originate from al countries except for the Dollarized economies (USA, Panama, Puerto Rico, Ecuador, and El Salvador), economies with currencies pegged to the dollar, and Venezuela. Columns (3) and (6) exclude euro destinations. '***', '**', and '*' indicate significance at the 1, 5, and 10 percent level, respectively.

| | Parameter | Value |
|---|---|---|
| Measured | | |
| Domestic Input Share | $\gamma_H$ | 0.60 |
| from $U$ | $\gamma_U$ | 0.20 |
| from $R$ | $\gamma_R$ | 0.20 |
| Export Invoicing Shares | | |
| to $U$ | $\theta^U_{HU}$ | 1.00 |
| to $R$ | $\theta^U_{HR}, \theta^R_{HR}$ | 0.93,0.07 |
| Shocks | | |
| commodity prices | $\sigma_\zeta, \rho_\zeta$ | 0.09, 0.74 |
| Estimated | | |
| Import Invoicing Shares | | |
| from $U$ | $\theta^U_{UH}$ | 0.98 |
| from $R$ | $\theta^U_{RH}, \theta^R_{RH}$ | 0.88, 0.12 |
| $e_R$ process | $\eta, \sigma_R$ | 1.03, 0.009 |
| $a$ process | $\sigma_a, \rho_a, \rho_{a,\zeta}$ | 0.054,0.474,-0.35 |

Note: other parameter values as reported in the text.

Table 10: Parameter Values

## 4.3 Discerning Pricing Paradigms

The empirical evidence points strongly to $DCP$. To further test the different pricing paradigms along the lines suggested in Section 2.5 we simulate a model economy that is subject to commodity price shocks and productivity shocks. We use a combination of calibration and estimation to parameterize the model and these are reported in Table 10. The values reported in Table 1 remain as before.

The share of intermediate inputs that are imported is taken directly from the data to be 40% and accordingly $\gamma_H = 0.6$ as also reported in Table 1. We observe this measure directly as firms in our production and input consumption dataset report their total spending in inputs broken down by domestic and foreign. As the share of imported inputs originating from dollar countries $\gamma_U$ and non-dollar countries $\gamma_R$ is the same we calibrate $\gamma_U = \gamma_R = 0.2$. We calibrate the process for commodity price shocks to match the autocorrelation and standard deviation of

HP-filtered commodity prices.[15]

We estimate the remaining parameters using a minimum distance estimator that minimizes the sum of squared deviations from moments in the data. Specifically, we minimize,

$$\mathbf{m}(\vec{\tau})\Omega^{-1}\mathbf{m}^{\mathbf{T}}(\vec{\tau})$$

where $\vec{\tau} = \{\theta^U_{UH}, \theta^U_{RH}, \theta^R_{RH}, \zeta, \sigma_R, \sigma_a, \rho_a, \rho_{a,\zeta}\}$ is a vector of eight parameters. We allow for common shocks to $a$ and $\xi$ by allowing for non-zero $\rho_{a,\zeta}$. To estimate these, we use a vector of the following ten moments $\mathbf{m}(\vec{\tau})$ that theory suggests is informative about the parameters.

- Import Invoicing Shares: To estimate the import invoicing shares,
  - $\theta^U_{UH}$: We use the contemporaneous estimate $\beta_0$ from regression 30 for import prices from dollar countries.
  - $\theta^R_{RH}$ and $\theta^U_{RH}$: We use the coefficients from regressing the quarterly change in import prices from non-dollar destinations on the peso/dollar and peso/origin country exchange rates. $\Delta p_{RH,t} = \beta_U \cdot \Delta e_{U,t} + \beta_R \cdot \Delta e_{R,t} + \epsilon_t$
- Relation between $e_R$ and $e_U$: To estimate $\eta$ and $\sigma_R$ we regress the change in (log) non-dollarized countries exchange rates on the change in (log) peso/dollar exchange rate, weighting the regression using trade weights. That is, we regress $\Delta e_R = \hat{\xi}\Delta e_U + \epsilon_R$. We use the estimate for $\hat{\xi}$ and the standard deviation of the residuals from these regressions to estimate $\eta$ and $\sigma_R$.
- Process for $a$: We match moments for the standard deviation (0.023) and autocorrelation (0.62) of manufacturing value added. To ascertain the correlation $\rho_{a,\zeta}$ we match the time zero pass-through into export prices to dollar destinations.

[15] Specifically, we use the IMF's price index for all primary commodities, at the quarterly frequency, from 2000Q1 to 2016Q2. We HP filter the log of the index and compute the autocorrelation and the standard deviation of the cyclical component.

- <u>Additional Moments:</u> We match the time zero coefficient on pass-through into export and import prices for $R$ goods.

The weighting matrix $\Omega^{-1}$ is a diagonal matrix where the entries are the inverse of the variance of the data moments. We estimate all the parameters together and consequently all of the moments at some level matter for all parameter values. The estimated values from this minimization are reported in Table 10 and the moment match between the model and data are reported in Table 11. The matching procedure does very well except for the standard deviation of the $\sigma_R$ where the model values are significantly lower than in the data. As Table 10 reports the data strongly points towards $DCP$ with almost all of the import invoicing share in dollars.

Using these values we simulate the model and plot the pass-through estimates from the estimated model, the $DCP$ model, the $PCP$ and $LCP$ models against the estimates from the data. In the case of the latter three we force the invoicing shares to take the extreme values of each of the paradigms. Figure 5 reports the values for dollar destinations and Figure 6 for non-dollar destinations.

| | Data | Model |
|---|---|---|
| $\beta^U_{0,UH}$ | 0.98 | 0.98 |
| $\beta^U_{0,RH}$ | 0.89 | 0.82 |
| $\beta^H_{0,RH}$ | 0.18 | 0.13 |
| $\hat{\xi}$ | 0.71 | 0.71 |
| $\hat{\sigma}_R$ | 0.036 | 0.013 |
| $\hat{\rho}_{a,\zeta}$ | 0.84 | 0.88 |
| $\hat{\sigma}_a$ | 0.023 | 0.024 |
| $\hat{\rho}_a$ | 0.64 | 0.64 |
| $\beta^U_{0,HR}$ | 0.86 | 0.80 |
| $\beta^U_{0,RH}$ | 0.87 | 0.88 |

Table 11: Moment Matching

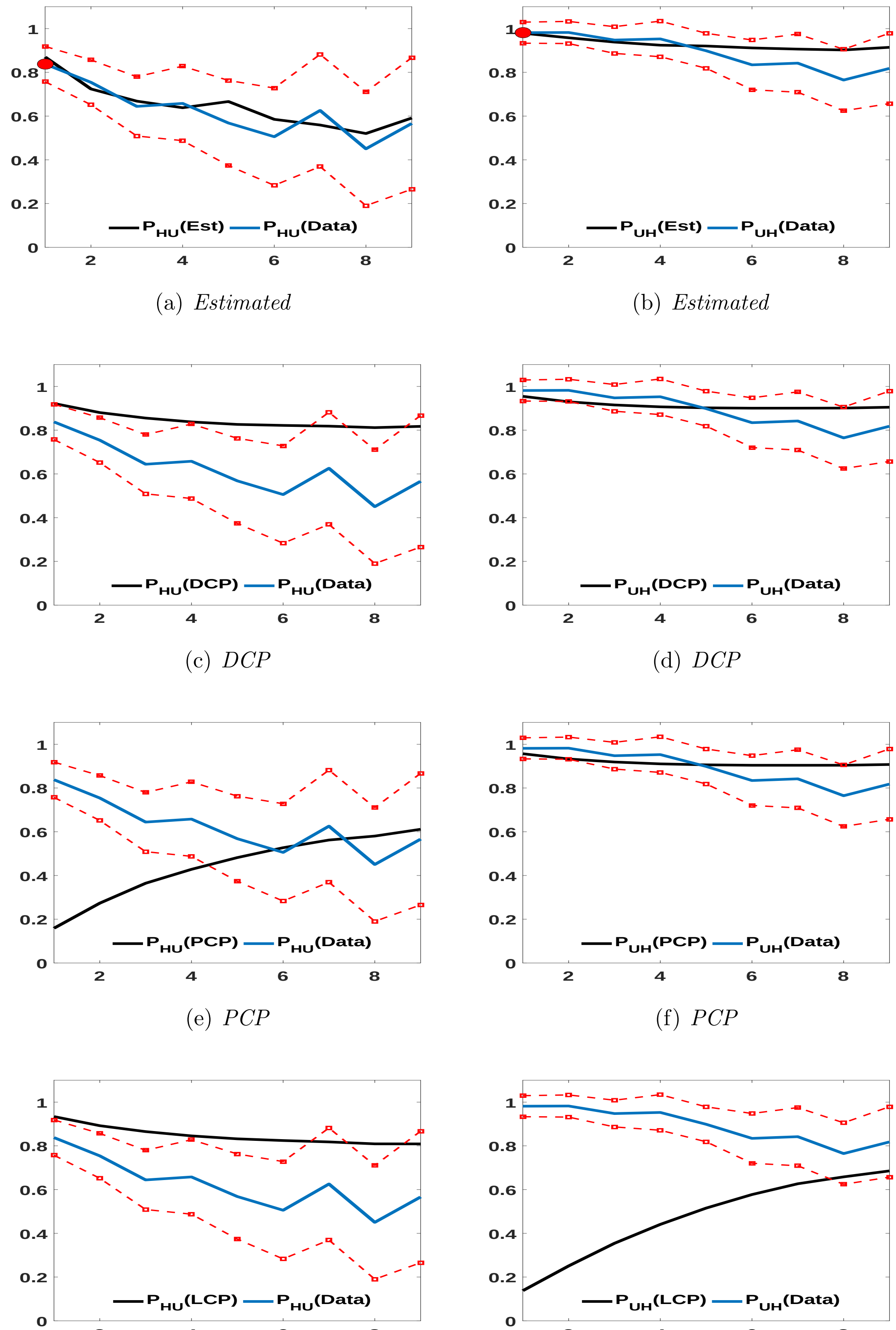
As is evident the estimated model and $DCP$ perform much better than the other paradigms. The $PCP$ paradigm gets the pass-through into export prices wrong because it implies low pass-through initially, with prices sticky in the exporting currency and then it gradually increases over time. The $LCP$ paradigm gets import pass-through wrong as it assumes prices are sticky in the destination currency. So pass-through into import prices is initially low and then it increases over time. In the case of non-dollar trading partners we similarly observe that the $DCP$ models performance is far better than the $PCP$ and $LCP$ case. Also as reported in Table 13 the estimated model and $DCP$ are both able to generate the data fact that the relevant exchange rate is the peso/dollar ER and not the bilateral exchange rate for $R$ destinations for price pass-through. The evidence clearly favors $DCP$ over $PCP$ and $LCP$.

Table 12: ERPT Quantities

| | (1) $\Delta y_{HU}$ | (2) $\Delta y_{UH}$ | (3) $\Delta y_{HR}$ | (4) $\Delta y_{RH}$ |
|---|---|---|---|---|
| $\Delta e_U$ | 0.39 | -1.55 | -1.54 | -1.48 |
| $\Delta e_R$ | -0.10 | 0.02 | 1.83 | -0.06 |

*Notes:* Regression coefficients from estimated model simulated data.

Lastly, Table 12 documents that the estimated model generates a weak expansion in exports to $U$ destinations following a depreciation and a more pronounced contraction in imports from both $U$ and $R$ consistent with the empirical evidence in Tables 6-8. Exports to $R$ are negatively impacted by depreciations relative to the dollar.



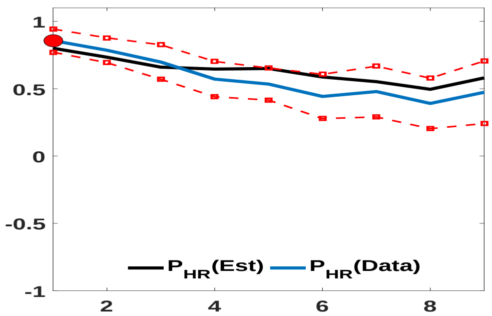

(a) *Estimated* (b) *Estimated*

(c) *DCP* (d) *DCP*

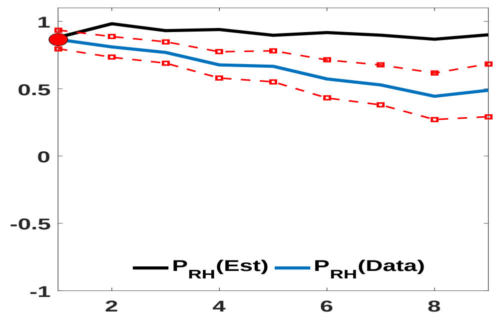
(e) *PCP* (f) *PCP*

(g) *LCP* (h) *LCP*

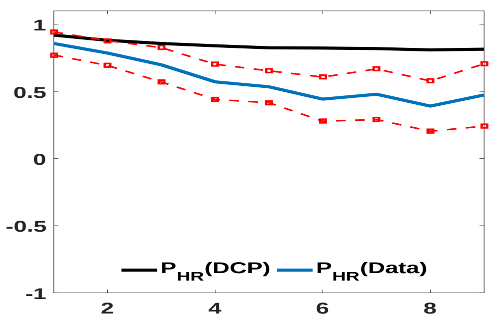
Figure 5: ERPT - Export and Import Prices, U



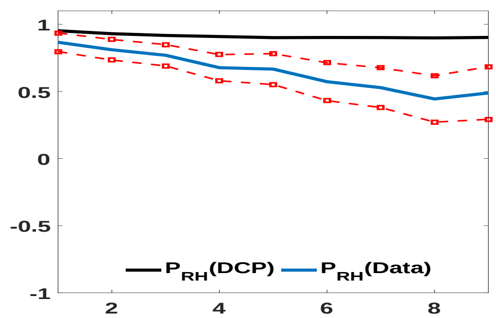

(a) *Estimated*



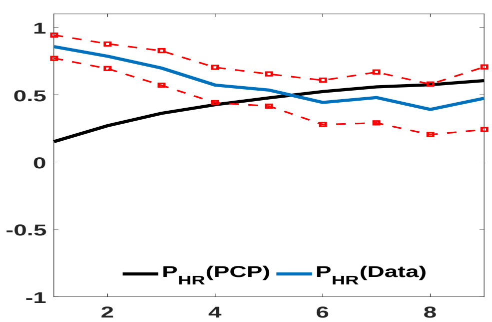

(b) *Estimated*



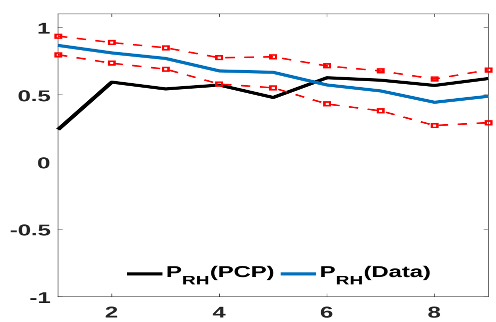

(c) *DCP*



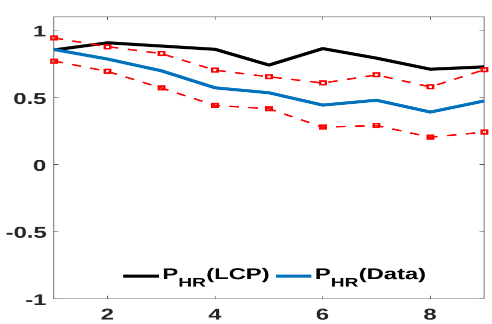

(d) *DCP*



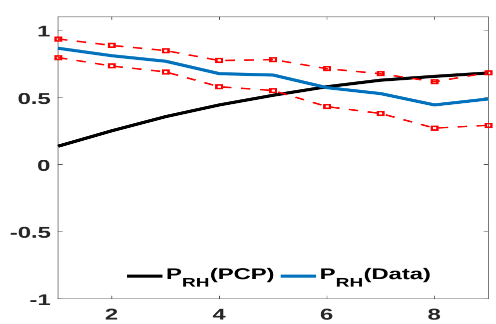

(e) *PCP*




(f) *PCP*




(g) *LCP*




(h) *LCP*

Figure 6: ERPT - Export and Import Prices, R

Table 13: ERPT (Non-Dollarized Economies, $R$)

| | (1) $\Delta p_{HR}$ | (2) $\Delta p_{HR}$ | (3) $\Delta p_{RH}$ | (4) $\Delta p_{RH}$ |
|---|---|---|---|---|
| | | *Data* | | |
| $\Delta e_R$ | 0.697*** | 0.0896* | 0.742*** | 0.301*** |
| | (0.115) | (0.0464) | (0.126) | (0.0791) |
| $\Delta e_U$ | | 0.660*** | | 0.540*** |
| | | (0.0473) | | (0.0662) |
| | | *Estimated* | | |
| $\Delta e_R$ | 0.71 | 0.15 | 0.79 | 0.16 |
| $\Delta e_U$ | | 0.70 | | 0.79 |
| | | *DCP* | | |
| $\Delta e_R$ | 0.70 | 0.09 | 0.77 | 0.05 |
| $\Delta e_U$ | | 0.77 | | 0.90 |
| | | *PCP* | | |
| $\Delta e_R$ | 0.52 | 0.09 | 0.95 | 0.97 |
| $\Delta e_U$ | | 0.56 | | -0.03 |
| | | *LCP* | | |
| $\Delta e_R$ | 0.71 | 1.00 | 0.78 | 0.03 |
| $\Delta e_U$ | | -0.02 | | 0.67 |

*Notes:* All data regressions include Firm-Industry-Country fixed effects. Standard errors clustered at the year level. The sample includes manufactured products excluding petrochemicals and metal industries. The export destinations include all countries except the Dollarized economies (USA, Panama, Puerto Rico, Ecuador, and El Salvador), economies with currencies pegged to the dollar, and Venezuela. Columns (3) and (6) exclude euro destinations. '***', '**', and '*' indicate significance at the 1, 5, and 10 percent level, respectively.

# 5 Conclusion

In this paper we present a new pricing paradigm for small open economies, the dominant currency paradigm. $DCP$ is characterized by three main features: pricing in a dominant currency, strategic complementarities in pricing and imported input use in production. We use these elements to develop a new model for small open economies, and we use it to understand the consequences of shocks that generate fluctuations in the exchange rate on small open economies.

In particular, we find that the model predicts stability in the terms of trade while, at the same time, volatile movements in the price of imported goods relative domestic goods. Moreover, this volatility is driven by fluctuations in the exchange rate with respect to the dominant currency. Hence, following a depreciation of the exchange rate, imports from all origins will decrease. In contrast, $DCP$ predicts that exports to dominant-currency destinations will have no impact, while the impact on exports to other destinations will depend on the co-movement of the exchange rate of the destination country with the dominant currency.

Taken together, these findings imply that a weakening of emerging market currencies relative to the dominant (dollar) currency following, say, a monetary policy easing in the former or a decline in commodity prices, will be associated with a decline in world trade (exports plus imports) relative to $PCP$ or $LCP$.

Finally, we demonstrate that these $DCP$ predictions when compared to the data (from Colombia) outperform the dominant paradigms of producer and local currency pricing in the literature.

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# 6 Appendix (In Progress)

The relevant log-linear reset pricing equations and evolution of prices can be expressed for each region as,

**H:**

$$
\begin{aligned}
\tilde{\bar{p}}_{HH,t} &= \beta\delta_p \mathbb{E}_t \tilde{\bar{p}}_{HH,t+1} + \beta\delta_p \mathbb{E}_t \pi_{t+1} + \tfrac{1-\beta\delta_p}{1+\Gamma}\left[\tilde{mc}_t + \bar{\mu}\right] \\
\bar{p}^j_{Hj,t} &= \beta\delta_p \mathbb{E}_t \bar{p}^j_{Hj,t+1} + \tfrac{1-\beta\delta_p}{1+\Gamma}\left[\tilde{mc}_t - \tilde{e}_{j,t} + \Gamma(p^j_{j,t}) + \bar{\mu}\right] \\
\tilde{\bar{p}}^H_{Hj,t} &= \beta\delta_p \mathbb{E}_t \left(\tilde{\bar{p}}^H_{Hj,t+1} + \pi_{t+1}\right) + \tfrac{1-\beta\delta_p}{1+\Gamma}\left[\tilde{mc}_t + \Gamma(p^j_{j,t} + \tilde{e}_{j,t}) + \bar{\mu}\right] \\
\bar{p}^U_{HR,t} &= \beta\delta_p \mathbb{E}_t \bar{p}^U_{HR,t+1} + \tfrac{1-\beta\delta_p}{1+\Gamma}\left[\tilde{mc}_t - \tilde{e}_{U,t} + \Gamma(p^R_{R,t} - \tilde{e}_{U,t} + \tilde{e}_{R,t}) + \bar{\mu}\right]
\end{aligned}
$$

$$
\begin{aligned}
\tilde{p}_{HH,t} - \tilde{p}_{HH,t-1} + \pi_t &= (1-\theta_P)(\tilde{\bar{p}}_{HH,t} - p_{HH,t-1} + \pi_t) \\
p^U_{Hj,t} - p^U_{Hj,t-1} &= (1-\theta_P)(\bar{p}^U_{Hj,t} - p^U_{Hj,t-1}) \\
\tilde{p}^H_{Hj,t} - \tilde{p}^H_{Hj,t-1} + \pi_t &= (1-\theta_P)(\tilde{\bar{p}}^H_{Hj,t} - \tilde{p}^H_{Hj,t-1} + \pi_t) \\
p^R_{HR,t} - p^R_{HR,t-1} &= (1-\theta_P)(\bar{p}^R_{HR,t} - p^R_{HR,t-1})
\end{aligned}
$$

$$
\begin{aligned}
\tilde{p}_{HU,t} &= \theta^U_{HU}(p^U_{HU,t} + \tilde{e}_{U,t}) + \theta^H_{HU}(\tilde{p}^H_{HU,t}) \\
\tilde{p}_{HR,t} &= \theta^U_{HR}(p^U_{HR,t} + \tilde{e}_{U,t}) + \theta^H_{HR}\tilde{p}^H_{HR,t} + \theta^R_{HR}(p^R_{HR,t} + \tilde{e}_{R,t})
\end{aligned}
$$

**U:**

$$
\begin{aligned}
\bar{p}^U_{U,H,t} &= \beta\delta_p \mathbb{E}_t \bar{p}^U_{U,H,t+1} + \tfrac{1-\beta\delta_p}{1+\Gamma}\left[mc^U_{U,t} + \Gamma(-\tilde{e}_{U,t}) + \bar{\mu}\right] \\
\tilde{\bar{p}}^H_{U,H,t} &= \beta\delta_p \mathbb{E}_t \tilde{\bar{p}}^H_{U,H,t+1} + \beta\delta_p \mathbb{E}_t \pi_{t+1} + \tfrac{1-\beta\delta_p}{1+\Gamma}\left[(mc^U_{U,t} + \tilde{e}_{U,t}) + \bar{\mu}\right]
\end{aligned}
$$

$$
\begin{aligned}
p^U_{UH,t} - p^U_{UH,t-1} &= (1-\theta_P)(\bar{p}^U_{UH,t} - p^U_{UH,t-1}) \\
\tilde{p}^H_{UH,t} - \tilde{p}^H_{UH,t-1} + \pi_t &= (1-\theta_P)(\tilde{\bar{p}}^H_{UH,t} - \tilde{p}^H_{UH,t-1} + \pi_t)
\end{aligned}
$$

$$
\tilde{p}_{UH,t} = \theta^U_{UH}(p^U_{UH,t} + \tilde{e}_{U,t}) + \theta^H_{UH}\tilde{p}^H_{UH,t}
$$

**R:**

$$
\begin{aligned}
\tilde{\bar{p}}^H_{R,H,t} &= \beta\delta_p \mathbb{E}_t \tilde{\bar{p}}^H_{R,H,t+1} + \beta\delta_p \mathbb{E}_t \pi_{t+1} + \tfrac{1-\beta\delta_p}{1+\Gamma}\left[(mc^R_{R,t} + \tilde{e}_{R,t}) + \bar{\mu}\right] \\
\bar{p}^U_{R,H,t} &= \beta\delta_p \mathbb{E}_t \bar{p}^U_{R,H,t+1} + \tfrac{1-\beta\delta_p}{1+\Gamma}\left[mc^R_{R,t} - \tilde{e}_{U,t} + \tilde{e}_{R,t} + \Gamma(-\tilde{e}_{U,t}) + \bar{\mu}\right] \\
\bar{p}^R_{R,H,t} &= \beta\delta_p \mathbb{E}_t \bar{p}^R_{R,H,t+1} + \tfrac{1-\beta\delta_p}{1+\Gamma}\left[mc^R_{R,t} + \Gamma(-\tilde{e}_{R,t}) + \bar{\mu}\right]
\end{aligned}
$$

$$p^U_{RH,t} - p^U_{RH,t-1} = (1-\theta_P)(\bar{p}^U_{RH,t} - p^U_{RH,t-1})$$
$$\tilde{p}^H_{RH,t} - \tilde{p}^H_{RH,t-1} + \pi_t = (1-\theta_P)(\tilde{\bar{p}}^H_{RH,t} - \tilde{p}^H_{RH,t-1} + \pi_t)$$
$$p^R_{RH,t} - p^R_{RH,t-1} = (1-\theta_P)(\bar{p}^R_{RH,t} - p^R_{RH,t-1})$$

$$\tilde{p}_{RH,t} = \theta^U_{RH}(p^U_{RH,t} + \tilde{e}_{U,t})) + \theta^H_{RH}\tilde{p}^H_{RH,t} + \theta^R_{RH}(p^R_{RH,t} + \tilde{e}_{R,t}))$$

## 6.1 Proof of Propositions

**Proposition 1:** The proof follows straightforwardly from using the equations in the **H** block and substituting $\delta_p = 0$ and the equation for marginal cost and evolution of $p$.

$$\Delta p_{Hi,t} = \frac{1}{1+\Gamma}\Delta mc_t + \frac{\Gamma}{1+\Gamma}\left(\Delta p^i_{i,t} + \Delta e_{i,t}\right)$$

$$\Delta mc_t = (1-\alpha)\Delta w_t + \alpha\Delta p_t - \Delta a_t$$

$$\begin{aligned}
\Delta p_t &= \gamma_H \Delta p_{HH,t} + \gamma_U \Delta p_{UH,t} + \gamma_R \Delta p_{RH,t} \\
&= \gamma_H \Delta mc_t + \sum_{i \in U,R} \gamma_i \left(\Delta mc^i_{i,t} + \Delta e_{i,t}\right) \\
\Delta mc_t &= \frac{1-\alpha}{1-\alpha\gamma_H}\Delta w_t + \frac{\alpha}{1-\alpha\gamma_H}\sum_{i \in U,R} \gamma_i \left(\Delta mc^i_{i,t} + \Delta e_{i,t}\right) - \frac{1}{1-\alpha\gamma_H}\Delta a_t
\end{aligned}$$

The final expression follows when setting $\Delta mc^i_{i,t} = 0$. On the import side,

$$\Delta p_{Hi,t} = \frac{1}{1+\Gamma}\left(\Delta mc^i_{i,t} + \Delta e_{i,t}\right) + \frac{\Gamma}{1+\Gamma}\left(\Delta p_t\right)$$

**Proposition 2:** The proof follows immediately assuming $\delta_p = 1$ and from the equations ruling the composite import and export price dynamics relative to the different invoicing assumed. For the **PCP** invoicing regime, substitute $\theta^H_{HU} = 1$ and $\theta^H_{HR} = 1$ in block **H**, for the case of export prices. Substitute $\theta^U_{UH} = 1$ and $\theta^R_{RH} = 1$ in block **U** and **R** respectively, for the case of import prices.

For the **LCP** invoicing regime, substitute $\theta^{U}_{HU} = 1$ and $\theta^{R}_{HR} = 1$ in block H, for the case of export prices. Substitute $\theta^{H}_{UH} = 1$ and $\theta^{H}_{RH} = 1$ in block **U** and **R** respectively, for the case of import prices.

For the **DP** invoicing regime, substitute $\theta^{U}_{HU} = 1$ and $\theta^{U}_{HR} = 1$ in block H, for the case of export prices. Substitute $\theta^{U}_{UH} = 1$ and $\theta^{U}_{RH} = 1$ in block **U** and **R** respectively, for the case of import prices.

## 6.2 Invoicing

Table A-1: Exports Invoicing and US Export and Euro Area Shares

| | Dollar Share | Euro Share | Own Currency Share | US Export Share | Euro Export Share |
|---|---|---|---|---|---|
| Algeria | 0.99 | 0.01 | 0.00 | 0.19 | 0.53 |
| Argentina | 0.97 | 0.02 | 0.00 | 0.08 | 0.14 |
| Australia | 0.77 | 0.01 | 0.20 | 0.06 | 0.05 |
| Brazil | 0.94 | 0.04 | 0.01 | 0.17 | 0.20 |
| Bulgaria | 0.45 | 0.56 | 0.00 | 0.03 | 0.48 |
| Canada | 0.70 | · | 0.23 | 0.80 | 0.04 |
| China | · | · | 0.05 | 0.19 | 0.13 |
| Colombia | 0.99 | 0.00 | 0.01 | 0.41 | 0.12 |
| Czech Republic | 0.14 | 0.72 | 0.10 | 0.02 | 0.67 |
| Denmark | 0.23 | 0.31 | 0.19 | 0.05 | 0.37 |
| Estonia* | 0.21 | 0.56 | 0.00 | 0.06 | 0.33 |
| Hungary | 0.18 | 0.71 | 0.02 | 0.03 | 0.62 |
| Iceland | 0.45 | 0.28 | 0.05 | 0.08 | 0.52 |
| India | 0.86 | 0.08 | 0.00 | 0.16 | 0.15 |
| Indonesia | 0.93 | 0.01 | 0.00 | 0.11 | 0.10 |
| Israel | 0.71 | 0.20 | 0.00 | 0.34 | 0.22 |
| Japan | 0.50 | 0.08 | 0.39 | 0.22 | 0.10 |
| Latvia* | 0.36 | 0.48 | 0.00 | 0.02 | 0.35 |
| Lithuania* | 0.48 | 0.45 | 0.05 | 0.04 | 0.31 |
| Malaysia | 0.90 | · | 0.00 | 0.15 | 0.09 |
| Norway | 0.56 | 0.38 | 0.03 | 0.06 | 0.43 |
| Pakistan | 0.91 | 0.04 | 0.00 | 0.19 | 0.19 |
| Poland | 0.30 | 0.64 | 0.04 | 0.02 | 0.57 |
| Romania | 0.36 | 0.64 | 0.00 | 0.03 | 0.56 |
| South Africa | 0.52 | 0.17 | 0.25 | 0.10 | 0.21 |
| South Korea | 0.85 | 0.06 | 0.01 | 0.15 | 0.10 |
| Sweden | 0.27 | 0.22 | 0.39 | 0.08 | 0.40 |
| Switzerland | 0.19 | 0.35 | 0.35 | 0.11 | 0.48 |
| Thailand | 0.82 | 0.02 | 0.07 | 0.15 | 0.09 |
| Turkey | 0.46 | 0.41 | 0.02 | 0.06 | 0.37 |
| Ukraine | 0.76 | 0.07 | 0.00 | 0.03 | 0.18 |
| United Kingdom | 0.29 | 0.13 | 0.51 | 0.14 | 0.49 |
| United States | 0.97 | · | – | – | 0.15 |
| *Euro Area:* | | | | | |
| Belgium | 0.32 | 0.54 | – | 0.15 | 0.62 |

Table A-1: (continued)

| | Dollar Share | Euro Share | Own Currency Share | US Export Share | Euro Export Share |
|---|---|---|---|---|---|
| Cyprus | 0.48 | 0.25 | – | 0.02 | 0.34 |
| France | 0.4 | 0.5 | – | 0.14 | 0.49 |
| Germany | 0.24 | 0.62 | – | 0.15 | 0.42 |
| Greece | 0.61 | 0.35 | – | 0.08 | 0.39 |
| Italy | 0.32 | 0.61 | – | 0.14 | 0.45 |
| Luxembourg | 0.32 | 0.54 | – | 0.11 | 0.73 |
| Netherlands | 0.36 | 0.5 | – | 0.11 | 0.59 |
| Portugal | 0.35 | 0.55 | – | 0.13 | 0.64 |
| Slovakia | 0.04 | 0.95 | – | 0.05 | 0.52 |
| Slovenia | 0.12 | 0.81 | – | 0.05 | 0.56 |
| Spain | 0.34 | 0.58 | – | 0.10 | 0.56 |

*Notes:* For countries in the euro area we report their US exports shares excluding the monetary union. The countries with an asterisk joined the euro area towards the end of our sample period so we consider them out of the monetary union for purposes of this table. A dot (·) means that the data is missing.

Table A-2: Imports Invoicing and US and Euro Area Import Shares

| | Dollar Share | Euro Share | Own Currency Share | US Import Share | Euro Import Share |
|---|---|---|---|---|---|
| Algeria | · | 0.49 | 0.00 | 0.07 | 0.48 |
| Argentina | 0.88 | 0.08 | 0.00 | 0.14 | 0.16 |
| Australia | 0.53 | 0.08 | 0.31 | 0.14 | 0.15 |
| Brazil | 0.84 | 0.11 | 0.01 | 0.18 | 0.20 |
| Bulgaria | 0.43 | 0.59 | 0.00 | 0.02 | 0.43 |
| Canada | 0.75 | 0.05 | 0.20 | 0.57 | 0.08 |
| China | · | · | 0.07 | 0.09 | 0.11 |
| Colombia | 0.99 | 0.00 | 0.01 | 0.29 | 0.13 |
| Czech Republic | 0.19 | 0.68 | 0.09 | 0.03 | 0.56 |
| Denmark | 0.25 | 0.32 | 0.12 | 0.03 | 0.47 |
| Estonia* | 0.34 | 0.53 | 0.00 | 0.03 | 0.31 |
| Hungary | 0.27 | 0.57 | 0.04 | 0.02 | 0.56 |
| Iceland | 0.32 | 0.36 | 0.06 | 0.10 | 0.31 |
| India | 0.86 | 0.10 | 0.00 | 0.06 | 0.12 |
| Indonesia | 0.81 | 0.04 | 0.01 | 0.07 | 0.08 |
| Israel | 0.73 | 0.21 | 0.03 | 0.14 | 0.31 |
| Japan | 0.71 | 0.03 | 0.23 | 0.13 | 0.09 |
| Latvia* | 0.36 | 0.53 | 0.00 | 0.01 | 0.43 |
| Lithuania* | 0.51 | 0.39 | 0.01 | 0.02 | 0.36 |
| Morocco | · | 0.55 | 0.00 | 0.06 | 0.47 |
| Norway | 0.21 | 0.29 | 0.30 | 0.06 | 0.34 |
| Pakistan | 0.84 | 0.07 | 0.00 | 0.05 | 0.09 |
| Peru | 0.93 | · | 0.00 | 0.20 | 0.10 |
| Poland | 0.30 | 0.58 | 0.06 | 0.03 | 0.50 |
| Romania | 0.31 | 0.67 | 0.00 | 0.02 | 0.53 |
| South Korea | 0.81 | 0.05 | 0.02 | 0.12 | 0.08 |
| Sweden | 0.25 | 0.36 | 0.25 | 0.04 | 0.49 |
| Switzerland | 0.13 | 0.53 | 0.31 | 0.07 | 0.66 |
| Thailand | 0.79 | 0.04 | 0.04 | 0.08 | 0.07 |
| Turkey | 0.59 | 0.31 | 0.03 | 0.06 | 0.33 |
| Ukraine | 0.75 | 0.16 | 0.00 | 0.03 | 0.21 |
| United Kingdom | 0.47 | 0.15 | 0.32 | 0.10 | 0.45 |
| United States | 0.93 | 0.02 | – | – | 0.14 |
| *Euro Area:* | | | | | |
| Belgium | 0.37 | 0.54 | – | 0.15 | 0.59 |
| Cyprus | 0.56 | 0.15 | – | 0.06 | 0.52 |
| France | 0.47 | 0.45 | – | 0.14 | 0.49 |
| Germany | 0.35 | 0.55 | – | 0.11 | 0.40 |

Table A-2: (continued)

| | Dollar Share | Euro Share | Own Currency Share | US Import Share | Euro Import Share |
|---|---|---|---|---|---|
| Greece | 0.63 | 0.33 | – | 0.05 | 0.45 |
| Italy | 0.51 | 0.44 | – | 0.07 | 0.47 |
| Luxembourg | 0.43 | 0.44 | – | 0.24 | 0.78 |
| Netherlands | 0.47 | 0.42 | – | 0.14 | 0.42 |
| Portugal | 0.43 | 0.52 | – | 0.06 | 0.67 |
| Slovakia | 0.22 | 0.77 | – | 0.02 | 0.38 |
| Slovenia | 0.3 | 0.66 | – | 0.06 | 0.58 |
| Spain | 0.41 | 0.54 | – | 0.08 | 0.49 |

*Notes:* For countries in the euro area we report their US imports shares excluding imports from the monetary union. The countries with an asterisk joined the euro area towards the end of our sample period so we consider them out of the monetary union for purposes of this table. A dot (·) means that the data is missing.

Table A-3: Currency Distribution, by Destination

| Destination | Currency | All Exports | Manufactures |
|---|---|---|---|
| US | US Dollar | 99.71% | 99.93% |
| | Euro | 0.02% | 0.03% |
| | Colombian Peso | 0.27% | 0.03% |
| Dollar economies | US Dollar | 99.73% | 99.91% |
| | Euro | 0.03% | 0.04% |
| | Colombian Peso | 0.23% | 0.03% |
| CAN | US Dollar | 99.75% | 99.90% |
| | Euro | 0.07% | 0.07% |
| | Colombian Peso | 0.18% | 0.03% |
| Latin America | US Dollar | 99.18% | 99.34% |
| | Euro | 0.13% | 0.13% |
| | Colombian Peso | 0.22% | 0.03% |
| | Bolívar (Ven) | 0.44% | 0.45% |
| | Mexican Peso | 0.02% | 0.02% |
| | Colón (CR) | 0.01% | 0.01% |
| European Union | US Dollar | 90.73% | 86.19% |
| | Euro | 8.64% | 13.28% |
| | Colombian Peso | 0.31% | 0.26% |
| | Sterling Pound | 0.28% | 0.21% |
| Euro zone | US Dollar | 88.78% | 84.48% |
| | Euro | 0.39% | 15.22% |
| | Colombian Peso | 10.80% | 0.25% |
| | Sterling Pound | 0.01% | 0.01% |

Source: Authors' calculations based on data from DIAN/DANE.
Notes: (1) Exports of coke, refined petroleum products, and nuclear fuel (ISIC 23), and basic metals (ISIC 27) excluded from "Manufactures". (2) Distribution calculated for number of invoices in each currency.