Dollar Pricing Redux*

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Abstract

A country's exchange rate is at the center of economic and political debates on currency wars and trade competitiveness. The real consequences of exchange rate fluctuations depend critically on how firms set prices in international markets. Recent empirical evidence has challenged the dominant 'producer currency' pricing and 'local currency' pricing paradigms in the literature. In this paper we propose a new paradigm, consistent with the empirical evidence and characterized by three features: pricing in dollars, strategic complementarity in pricing and imported inputs in production. We call this the 'dollar pricing' paradigm and contrast its theoretical predictions with prior approaches in a general equilibrium New Keynesian model. We then employ novel data for Colombia to evaluate the implications of exchange rate fluctuations associated with commodity price shocks and show that the findings strongly support the dollar pricing paradigm.

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1 Introduction

A country's nominal exchange rate is at the center of fierce economic and political debates on spillovers, currency wars and trade competitiveness. This is because in the 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 national output.

It is well known that the implications of a nominal exchange rate movement for real variables depend critically on the currency in which prices are rigid. The first generation of models and leading paradigm in international macroeconomics assumes that 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 depreciation reduces the price of exports relative to imports, improving competitiveness. This paradigm is developed in the seminal contributions of Mundell (1963) and Fleming (1962), Svensson and van Wijnbergen (1989) and Obstfeld and Rogoff (1995). A second generation pricing paradigm grew out of the pervasive evidence that the law of one price fails to hold. 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 market in which they are sold, so called 'local currency pricing' (LCP). In this case a depreciation leads to an appreciation of the terms of trade, raising the prices of exports relative to imports. Both these paradigms, which assume symmetry in terms of price setting, have been extensively studied in the literature with regards to their predictions for international spillovers and optimal monetary policy. A survey of this research is contained in the latest handbook chapter by Corsetti et al. (2010).

Recent empirical work using granular data on prices in international trade questions the validity of both paradigms. Firstly, there is very little evidence that the best description of pricing in international markets is either PCP or LCP. On the contrary, the vast majority of trade is invoiced in very few currencies, with the U.S. dollar having an outsized role. This is documented in Goldberg and Tille (2008) and Gopinath (2015). Prices are also found to be rigid for significant durations in their currency of invoicing, for countries for which this data are available, as documented by Gopinath and Rigobon (2008), Fitzgerald and Haller (2012).

Secondly, exporters price in markets characterized by strategic complementarities in pricing that give rise to variations in desired mark-ups[1], and use imported inputs to produce.[2] These features help rationalize why exporters coalesce on few currencies (Gopinath et al. (2010)). The work horse general equilibrium open economy models set aside these features by assuming that labor is the only input in production and demand is CES giving rise to constant desired price mark-ups over marginal cost.

In this paper we do the following: First, consistent with the empirical evidence, we build a model of a 'dollar pricing' paradigm (DP) by combining the features of dollar price rigidity, strategic complementarities in pricing, and production with imported inputs, in a general equilibrium new Keynesian model. We contrast the predictions of this paradigm with those of LCP and PCP. Second, we employ the universe of customs data for Colombia alongside firm production information to compare the model's predictions for the response of exchange rates, import and export prices and quantities to a commodity price shock, to those in the data.

We model a small open economy commodity exporter[3] that trades goods and assets with the rest of the world. There is a manufacturing sector where firms have pricing power in world markets and a homogenous goods (commodities) sector where the economy is a price taker. The demand for the output of the manufacturing sector is modeled using a Kimball aggregator that gives rise to strategic complementarities in pricing and variable mark-ups. The manufacturing sector output is produced using labor and imported inputs. Wages adjust sluggishly à la Calvo and are set in the home currency.

We first demonstrate that when prices and wages are fully flexible, the greater is the strategic complementarity in pricing, and the higher the share of imported inputs in production, the lower is the pass-through of real exchange rate changes (relative price of non-traded goods) into prices of manufactured goods, and consequently, lower is the sensitivity of quantities exported to real exchange rate changes. The intuition for this is as follows: with more strategic complementarities, firms prefer to adjust their markup in response to a cost shock of a given size. The higher is the share of imported intermediates the lower is the effect of the price of non-traded goods on marginal costs, and therefore the smaller the

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

[2]The fact that most exporters are also importers is now well documented in the literature by 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)

[3]The advantage of focusing on a commodity exporter are twofold. First, commodity prices can arguably be considered exogenous for most commodity exporters. Second, as is well known from Chen et al. (2010), commodity currencies are closely tied to commodity prices.

cost shock. Both forces mute the response of the price of manufactured goods and therefore the response of exports to real exchange rate changes.

Further, the greater is the strategic complementarity in pricing, higher is the volatility of the real exchange rate and consumption, while at the same time lower is the volatility of the manufacturing sector terms of trade to commodity price shocks. The intuition for this is as follows: Suppose that the commodity exporting country experiences a negative shock to commodity prices. To satisfy the external resource constraint the country needs to reduce its consumption of traded goods and use of imported intermediate inputs. The extent to which it needs to do this, and consequently the extent of real depreciation required, depends inversely on its ability to raise export income through higher exports from the manufacturing sector that in turn benefits from lower marginal costs following the real depreciation. Because the pass-through from the real depreciation to export prices and hence to export quantities is lower the greater the strategic complementarity in pricing it calls for a greater depreciation of the real exchange rate.

We then contrast the dynamics of the model under the three cases of DP, PCP, and LCP. We focus on the responses of the manufacturing terms of trade, the price and quantity of manufacturing exports and imports, and the mark-ups of manufacturing firms. In response to a negative commodity price shock the terms of trade mildly depreciates in the case of DP, strongly depreciates in the case of PCP and strongly appreciates in the case of LCP. When we compare the pass-through's of exchange rate changes into export and import prices expressed in home currency across pricing regimes we obtain the following contrasting results: In the case of DP both pass-through's are quantitatively close to one and decline slowly over time. In the case of PCP, the pass-throughs initially diverge sharply, with the pass-through for export prices close to zero and the pass-through for import prices close to one. Further, the pass-through into home currency export prices increase over time, in contrast with the DP case. In the case of LCP there is a similar divergence in the pass-through rates as in the case of PCP, with the difference that it is pass-through into export prices which start high and close to one, while pass-through into import prices start low and close to zero.

Consistent with the pass-through estimates for prices, in the case of DP the pass-through into export quantities is small with a gradual increase over time, while there is a sharp decline in imports quantities. That is, exchange rate depreciations in the case of DP result in a larger response in imports than in exports. In the case of PCP, there is a sharp increase in exports and a small increase in imports initially with a gradual decrease over time. In the case of LCP both exports and imports increase somewhat over time. In the case of mark-ups, following a decline in commodity prices, there is a sharp increase in mark-ups in the case of LCP, a sharp decline in mark-ups in the case of PCP and a moderate increase in mark-ups in the case of DP.

We then proceed to analyze data for Colombia, an oil-exporting country that is representative of emerging markets in that it relies heavily on dollar invoicing. We find that the manufacturing terms of trade has low sensitivity to the exchange rate. A 1% depreciation of the exchange rate is associated with a 0.3% depreciation of the manufacturing terms of trade. The pass-through into import and export peso prices starts out close to 1 for import prices and to 0.8 for export prices and then declines some over time. While there is a significant drop in quantities imported, the impact on exports is insignificantly different from zero. Overall we find that the data strongly supports the DP paradigm.

Our paper is related to a small literature that examines the consequences of dollar pricing. These include Corsetti and Pesenti (2005), Goldberg and Tille (2008), Goldberg and Tille (2009) and Devereux et al. (2007). Unlike the models in these papers, which are static with one period ahead price stickiness, and assume constant desired mark-ups and production functions that use only labor, we combine dynamic pricing, variable mark-ups and imported inputs use in production, all of which are important ingredients to match the facts on pricing in international trade.

2 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. Figure 1 taken from Gopinath (2015) uses invoicing data for 55% of world imports, and 57% of world exports to demonstrate this fact.[4] Figure 1(a) represents the share of imports that are imported from the US, Eurozone, or the rest of the world; versus the share of imports that are invoiced in dollars, euros, or other currencies. Figure 1(b) does the same for exports. If the world were best described as PCP we should observe that import trade shares and invoicing shares line up with each other. That is, the share of dollar invoicing in world imports should be equal to the share of world imports originating from the U.S.[5] If the

[4] Invoicing facts have also been reported by Goldberg (2013), Goldberg and Tille (2009) and Ito and Chinn (2013).

[5] The U.S. is excluded from the sample because of course there is no "U.S." trade counter-party, which would only serve to artificially increase the non-US trade and the dollar invoicing share.

world was LCP then we should expect to see that the bar for invoicing shares is dominated by "other currencies," which is not what we see in the data. In the data, the dollar share as an invoicing currency is estimated to be around 4.7 times its share in (the sample of) world imports. In the case of the euro, its share is more closely aligned at 1.2, however this is because trade within the euro area is also included. If the sample is restricted to only the trade of euro area countries with non-euro area countries, as we document later, this ratio falls strictly below one. The invoicing facts for exports, Figure 1(b), resemble those for imports. The dollars share as an invoicing currency is estimated to be around 3.1 times its share in (the sample of) world exports, while for the euro it is 1.2 times.

Tables 1 and 2 report, for a list of 45 countries, the share of imports and exports that are invoiced in dollars, in euros, and in the country's own currency as well as the country's share of imports (exports) coming from (going to) the United States. 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; 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.[6]

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. The dominant benchmarks of LCP and PCP would suggest a world of symmetry in invoicing, with all currencies shares lined up more closely with their country's shares in world trade. Importantly, 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 (Figure 2), the share of invoicing in dollars has gained greater prominence.[7] To explore the implications of this, in the next section we model a world where a single currency, the dollar, is used in international trade and compare the predictions to those of LCP and PCP.

[6] 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.

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

3 Model

In this section we model a three sector small open economy that trades goods and assets with the rest of the world. There is a manufacturing sector where firms have pricing power in world markets and a homogenous goods sector where the economy is a price taker. There is also a non-traded sector that is modeled as an endowment. The single nominal exchange rate denoted $\mathcal{E}_t$ is expressed as home currency per unit of foreign currency. Henceforth we shall refer to the home currency as peso and the foreign currency as dollar. We compare three pricing scenarios: producer currency pricing, local currency pricing, and dollar-pricing.

3.1 Households

The small open economy is populated with a continuum of symmetric households. Households are indexed by $h \in [0, 1]$, but we often omit the index h to simplify exposition. In each period household's consume a bundle of imported traded goods C_T, and non-traded goods C_N. Each household also sets a wage rate $W_t(h)$ and supplies labor $N_t(h)$ in order to satisfy demand at this wage rate. They own all domestic firms and profits are rebated lump sum to them. The per-period utility function is 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 N_t represents labor supply. The consumption aggregator C is Cobb-Douglas over the traded and non-traded good, $C = C_T^{\gamma} C_N^{1-\gamma}$. Households solve

$$\max_{C_{T,t}, C_{N,t}, N_t, B_t^f, B_t^h(s)} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U(C_t, N_t)$$

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

$$P_t C_t + \mathcal{E}_t R_t^f B_t^f + B_t^h = W_t N_t + \Pi_{M,t} + \Pi_{O,t} + P_{N,t} Y_N + \mathcal{E}_t B_{t+1}^f + \sum_s Q_t^h(s) B_t^h(s) \tag{2}$$

where $P_t = \frac{1}{\gamma^{\gamma}(1-\gamma)^{1-\gamma}} (P_{T,t})^{\gamma} P_{N,t}^{1-\gamma}$ is the price of the home consumption bundle and $P_t C_t = P_{T,t} C_T + P_{N,t} C_{N,t}$ measures household consumption expenditures. $\Pi_{M,t}$ and $\Pi_{O,t}$ represents profits generated in the manufacturing and homogenous goods sector, respectively. Households are also endowed each period with non-traded goods Y_N whose price is $P_{N,t}$.

Households trade a riskless bond denominated in dollars with the rest of the world, that pays out a gross interest rate R_t^f. As is common in the literature we assume the foreign gross interest rate evolves according to,

$$R_t^f = R^* + \psi(e^{B_{t+1}^f - \bar{B}^f} - 1) \tag{3}$$

where $\psi > 0$. $\bar{B}^f$ is steady state debt denominated in foreign currency. Households also have access to a full set of domestic state contingent securities (in pesos) that they can trade among themselves and that are in zero net supply. Denoting $\mathcal{S}$ the set of possible states of the world, $Q_t^h(s)$ is the period-t price of the security that pays one pesos in period $t+1$ and state $s \in \mathcal{S}$.

Intra-temporal optimality requires that the allocation of consumption across traded and non-traded goods satisfy,

$$\frac{C_{N,t}}{C_{T,t}} = \frac{1-\gamma}{\gamma}\frac{P_{T,t}}{P_{N,t}} \tag{4}$$

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

$$C_t^{-\sigma_c} = \beta R_t^f \mathbb{E}_t C_{t+1}^{-\sigma_c} \frac{P_t}{P_{t+1}} \frac{\mathcal{E}_{t+1}}{\mathcal{E}_t} \tag{5}$$

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

where R_t^h is the inverse of the price of a peso bond at time t that delivers one peso for sure 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 $1-\theta_w$, and maintain the previous-period nominal wage otherwise. The optimality condition for wage setting is given by:

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

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 t and s 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).

3.2 Homogenous good sector

Output in the homogenous sector is produced using labor, N_O, subject to diminishing returns.[8]

$$Y_{O,t} = e^{z_{O,t}} N_{O,t}^{\nu} \tag{8}$$

where $0 < \nu < 1$. The labor input $N_{O,t}$ is a CES aggregator of the individual varieties supplied by each household, $N_{O,t} = \left[\int_0^1 N_{O,t}(h)^{(\eta-1)/\eta} \mathrm{d}h\right]^{\eta/(\eta-1)}$ with $\eta > 1$. The output is sold on international markets at the world dollar price, $P_{O,t}^*$, and is taken as given by the homogenous goods producers. Profits in this sector are given by,

$$\Pi_{O,t} = \mathcal{E}_t P_{O,t}^* Y_{O,t} - W_t N_{O,t} \tag{9}$$

and are non-zero because of diminishing returns. The optimal amount of labor hired is determined by the condition that equates the marginal product of labor to the wage rate.

$$P_{O,t}^* \mathcal{E}_t \vartheta e^{z_{O,t}} N_{O,t}^{\vartheta-1} = W_t, \qquad N_{O,t}(h) = \left(\frac{W_t(h)}{W_t}\right)^{-\eta} N_{O,t}, \tag{10}$$

where $W_t = \left[\int_0^1 W_t(h)^{1-\eta} \mathrm{d}h\right]^{1/(1-\eta)}$.

3.3 Manufacturing Sector

Each firm in the manufacturing sector uses labor, $N_M(\omega)$, and imported intermediate inputs, $X(\omega)$, to produce a unique variety ω. The production function is,

$$Y_{M,t}(\omega) = e^{z_{M,t}} N_{M,t}(\omega)^{1-\alpha} X_t(\omega)^{\alpha} \tag{11}$$

where $z_{M,t}$ captures aggregate productivity in the manufacturing sector. The labor input $N_{M,t}$ is a CES aggregator of the individual varieties supplied by each household, $N_{M,t} = \left[\int_0^1 N_{M,t}(h)^{(\eta-1)/\eta} \mathrm{d}h\right]^{\eta/(\eta-1)}$ with $\eta > 1$.

[8] The subscript O for the homogenous goods sector is a reference to 'oil'.

We assume that all of the manufacturing output is exported, and the external demand for variety ω is modeled using a Kimball aggregator that gives rise to strategic complementarities in pricing. We adopt the Klenow-Willis (2006) formulation:

$$C^f_{M,t}(\omega) = C^f_M D(P^f_t(\omega)/P^f_M) = C^f_M \cdot \left[1 - \varepsilon \log(P^f_t(\omega)/P^f_M)\right]^{\frac{\sigma}{\varepsilon}} \tag{12}$$

where $P^f(\omega)$ is the price set by the manufacturing firm expressed in the currency of the foreign country (dollar). The parameter ε is the key parameter that influences the variability of desired mark-ups. In the limit as $\varepsilon \to 0$ we obtain the CES benchmark of constant mark-ups when prices are fully flexible given by $\sigma/(\sigma-1)$. The time varying elasticity of demand is defined as $\sigma_t(\omega) = \partial \log(C^f_{M,t}(\omega))/\partial \ln(P^f_t(\omega)/P^f_M)$.

Consistent with the small open economy assumption, the foreign price level P^f_M and aggregate consumption level, C^f_M are taken as exogenous. The firm's per-period profits are:

$$\Pi_{M,t}(\omega) \quad = \quad C^f_{M,t}(\omega)\mathcal{E}_t P^f_t(\omega) - W_t N_{M,t}(\omega) - P_{X,t}(\omega) X_t(\omega) \tag{13}$$

Marginal cost is given by,

$$\mathcal{MC}_t = \frac{1}{\alpha^\alpha (1-\alpha)^{1-\alpha}} \cdot \frac{W_t^{1-\alpha} P^\alpha_{X,t}}{e^{z_{M,t}}} \tag{14}$$

The optimality conditions for hiring labor are given by,

$$(1-\alpha)\frac{\mathcal{E}_t P^f_t(\omega) Y_{M,t}(\omega)}{N_{M,t}(\omega)} = e^{\mu_t(\omega)} W_t, \qquad N_{M,t}(h) = \left(\frac{W_t(h)}{W_t}\right)^{-\eta} N_{M,t}, \tag{15}$$

where $\mu_t(\omega) \equiv \frac{P^f_t(\omega)}{\mathcal{MC}_t}$ is the log mark-up at time t and is variable.

The demand for intermediate inputs is given by,

$$\alpha \frac{\mathcal{E}_t P^f_t(\omega) Y_{M,t}(\omega)}{X_t(\omega)} = e^{\mu_t(\omega)} P_{X,t}. \tag{16}$$

3.4 Pricing

We contrast the outcomes under three pricing assumptions in international markets: producer currency pricing, local currency pricing, and dollar pricing. In each case we consider a Calvo pricing environment where firm's are randomly chosen to reset prices with probability $1-\theta_p$. Firms choose prices to maximize the expected net present value of profits conditional on no price change,

$$\mathbb{E}_t \sum_{s=t}^{\infty} \theta_p^{s-t} \Theta_{t,s} \Pi_s(\omega).$$

3.4.1 Dollar Pricing (DP)

Manufacturing exports: When prices are set in dollars, the optimal (dollar) reset price, $\bar{P}_f^f(\omega)$, satisfies the equation,

$$\mathbb{E}_t \sum_{s=t}^{\infty} \theta_p^{s-t} \Theta_{t,s} C_{M,s}^f(\omega)(\sigma_s(\omega)-1)\left(\mathcal{E}_s \bar{P}_f^f(\omega) - \frac{\sigma_s(\omega)}{\sigma_s(\omega)-1}\mathcal{MC}_s(\omega)\right) = 0 \tag{17}$$

Define the (log) manufacturing export price index,

$$p_t^f \equiv \int_\omega p_t^f(\omega) d\omega = \int_\omega p_{f,t}^f(\omega) d\omega = p_{f,t}^f$$

Because of the Calvo pricing assumption and symmetry across firms, $p_{f,t}^f$ evolves according to,

$$p_{f,t}^f = \theta_p p_{f,t-1}^f + (1-\theta_p)\bar{p}_{f,t}^f \tag{18}$$

Imports: While these prices are taken as exogenous under the small open economy assumption, to capture DP, we assume that the price of imported goods is fixed in dollars at $\bar{P}_t^*$. Accordingly, the home import price is:

$$P_{T,t} = P_{X,t} = \mathcal{E}_t \bar{P}_t^* \tag{19}$$

3.4.2 Producer Currency Pricing (PCP)

Manufacturing exports: When prices are set in the producer's currency, the optimal (peso) reset price, $\bar{P}_h^f(\omega)$ satisfies the equation,

$$\mathbb{E}_t \sum_{s=t}^{\infty} \theta_p^{s-t} \Theta_{t,s} C_{M,s}^f(\omega)(\sigma_s(\omega)-1)\left(\bar{P}_h^f(\omega) - \frac{\sigma_s(\omega)}{\sigma_s(\omega)-1}\mathcal{MC}_s(\omega)\right) = 0 \tag{20}$$

The (log) manufacturing export price index is now,

$$p_t^f \equiv \int_\omega p_t^f(\omega)d\omega = \int_\omega p_{h,t}^f(\omega)d\omega - e_t = p_{h,t}^f - e_t$$

where e_t is the log of the exchange rate, and $p_{h,t}^f$ evolves according to,

$$p_{h,t}^f = \theta_p p_{h,t-1}^f + (1-\theta)\bar{p}_{h,t}^f \tag{21}$$

Imports: Under PCP, the price of imported goods is fixed in the currency of the producing country. Accordingly,

$$P_{T,t} = P_{X,t} = \mathcal{E}_t \bar{P}_{T,t}^* \tag{22}$$

As is evident, the distinction between DP and PCP shows up on export prices, while it is the same in the case of import prices, given our environment where the ROW is the dollar block.[9]

3.4.3 Local Currency Pricing (LCP)

Manufacturing exports: The manufacturing pricing problem is identical to the case of dollar pricing.
Imports: Following LCP, we assume the price of imported goods is fixed in the home currency. Accordingly,

$$P_{T,t} = P_{X,t} = \bar{P}_t^h \qquad\qquad P_{T,t}^* = \bar{P}_t^h/\mathcal{E}_t \tag{23}$$

Definition 1 *We solve for the rational expectations competitive equilibrium of the DP, PCP and LCP models, where*

a) DP satisfies equations (2-19), PCP satisfies equations (2-16) and equations (20-22), and LCP satisfies equations (2-18) and equation (23).

b) Markets clear such that $C_{N,t} = Y_N$, $N_t = N_{O,t} + N_{M,t}$, and $B_t^h = 0$.

[9]With more than two countries, DP differs from LCP on the import side too because of third-party currency invoicing. Under PCP exports from country A to country B are invoiced in country A's currency. Under DP they are invoiced in dollars. As discussed above, there is substantial evidence of third-party invoicing. We plan to explore this richer set-up in the future.

c) The monetary block of the model is described by a money supply rule, $m_t = \rho_m m_{t-1} + \epsilon_{m,t}$ *and money demand* $m_t - p_t = \eta_c c_t - \eta_r r_t^h$.[10]

d) (log)World price of the homogenous goods sector evolves according to an $AR(1)$, $p^*_{o,t} = \rho_o p^*_{o,t-1} + \epsilon_{o,t}$

Before we proceed to simulate the dynamics of the model it is useful to study the features of this economy in the long-run, when prices and wages are fully flexible.

4 Long-run

To provide an analytical characterization we consider the case where the utility function for consumption is in logs ($\sigma_c = 1$), the Frisch elasticity of labor supply is infinite ($\varphi = 0$), and trade is balanced. In the flexible price case we set $\mathcal{E} = 1$ (without loss of generality) and express all prices relative to the price of the imported good, which we choose to be the numeraire.

The real exchange rate is simply a function of the relative price of non-traded goods, specifically $\tilde{P}_N^{1-\gamma}$, where $\tilde{P}_N$ is the price of the non-traded good expressed in units of the imported good.[11]

Under monopolistic pricing, and with the specification of Kimball demand chosen (12), (log) markup when prices are set flexibly satisfy:

$$\mu_t(\omega) = \log \frac{\sigma}{\sigma - 1 + \varepsilon \log(P_t^f(\omega)/P_M^f)}$$

and the price elasticity of the mark-up $\Gamma = \partial\mu/\partial \ln(P_t^f/P_M^f)$ is given by,

$$\Gamma(\omega) = \frac{\varepsilon}{\sigma - 1 + \varepsilon(\log(P_t^f(\omega)/P_M^f))}$$

Taking a log-linear approximation around a symmetric point, and combining the intra-temporal condition eq. (4), combined with the flexible wage and price setting conditions, $\frac{W}{P_N^{1-\gamma}} = C$ and $P_M^f = e^{\mu^f} \frac{W^{1-\alpha}}{\alpha^\alpha(1-\alpha)^{1-\alpha}}$, and market clearing in the non-traded sector, $C_N = Y_N$, we obtain the following proposition,

[10] We do not expect the qualitative analysis to change in any meaningful way with an interest rate rule.

[11] This follows from the small open economy assumption.

Proposition 1 *The greater is the strategic complementarity in pricing, Γ, and the higher the share of imported inputs in production, α, the lower is the pass-through of real exchange rate changes into prices of manufactured goods, and consequently, lower is the sensitivity of quantities exported to real exchange rate changes.*

$$\hat{p}^f = \frac{1-\alpha}{1+\Gamma}\hat{p}_N \qquad\qquad \hat{c}_M^f = -\sigma\frac{1-\alpha}{1+\Gamma}\hat{p}_N$$

■

A real appreciation of the country's currency raises the marginal cost of the firm, however the extent to which it does so is decreasing in the share of imported intermediate inputs in production. This is captured by the term $(1-\alpha)$. Conditional on the change in marginal costs, $(1-\alpha)\hat{p}_N$, the extent to which the firm raises its export prices depends on its desired mark-up. Given fixed world manufacturing prices, the greater the degree of strategic complementarity in pricing, Γ, the smaller the desire of the firm to pass-through the marginal cost increases into higher prices. As $\Gamma \to 0$ and $\alpha \to 0$, we arrive at the benchmark of hundred percent pass-through from real exchange rate fluctuations. However, given that the data supports $\Gamma > 0$ and $\alpha > 0$, pass-through is much more incomplete.

In the next proposition we consider a particular exogenous shock that drives changes in the real exchange rate, namely shocks to the relative price of the homogenous sector output $\tilde{P}_O$. The external resource constraint $C_T + X_T = \tilde{P}_O Y_O + \tilde{P}_M^f C_M^f$ is used to pin down the required change in the real exchange rate. The following proposition follows:

Proposition 2 *The greater is the strategic complementarity in pricing, higher ε and therefore Γ, higher is the volatility of the real exchange rate and consumption. By contrast, higher is Γ lower is the volatility of the non-commodity terms of trade, $\hat{p}^f$, and of manufacturing exports to commodity price shocks.*

$$\hat{p}_N = \frac{\frac{s_O}{1-\nu}\hat{p}_O}{1 + s_O\frac{\nu}{1-\nu} + s_M\frac{(\sigma-1)(1-\alpha)}{1+\Gamma}\frac{e^\mu-\alpha}{e^\mu}}$$

$$\hat{p}^f = (1-\alpha)\frac{\frac{s_O}{1-\nu}\hat{p}_O}{(1+\Gamma)\left(1 + s_O\frac{\nu}{1-\nu}\right) + s_M(\sigma-1)(1-\alpha)\frac{e^\mu-\alpha}{e^\mu}}$$

where $s_O = \frac{\bar{\tilde{P}}_O\bar{Y}_O}{C_T}$, $s_M \equiv \frac{\tilde{P}^f C_M^f}{C_T}$ are steady state values that do not depend on ε.

■

The intuition for this proposition is as follows: Suppose there is a negative shock to the price of oil, which is a negative terms of trade shock. To satisfy the external resource constraint the country needs to cut down on its consumption of traded goods and imports of intermediate inputs. The extent to which it needs to do this, and consequently the extent of real depreciation (decline in relative price of non-traded goods) required depends on its ability to raise export income through higher exports from the manufacturing sector that benefits from lower marginal costs following the real depreciation. As follows from Proposition 1, the higher is Γ lower is the gain in exports for a given depreciation of the real exchange rate. A higher Γ therefore calls for a larger depreciation.[12] A larger depreciation therefore goes along with a smaller depreciation of the (manufacturing) terms of trade. A more volatile real exchange rate therefore goes hand in hand with a less volatile manufacturing terms of trade.

We now proceed to a dynamic analysis that contrasts the three pricing models.

5 Dollar Pricing Redux

We now solve for the dynamics of the three pricing models employing log linear approximations around a zero inflation steady state. The reset price equations for manufacturing output (17) and (20) give rise to the below pricing dynamics for the aggregate manufacturing price index under DP (LCP) and PCP regimes, respectively.

$$\bar{p}^f_{f,t} = \beta\theta_p \mathbb{E}_t \bar{p}^f_{f,t+1} + \frac{1-\beta\theta_p}{1+\Gamma}\left[mc_t - e_t + \Gamma p^f_M + \bar{\mu}\right] \tag{24}$$

$$\bar{p}^f_{h,t} = \beta\theta_p \mathbb{E}_t \bar{p}^f_{h,t+1} + \frac{1-\beta\theta_p}{1+\Gamma}\left[mc_t + \Gamma(p^f_M + e_t) + \bar{\mu}\right] \tag{25}$$

where $\bar{\mu} \equiv \log\frac{\sigma}{\sigma-1}$. In the case of DP the marginal cost on the right hand side is expressed in dollars, $mc_t - e_t$, while in the case of PCP, it is expressed in the home currency. Because this is a two country environment DP and LCP have the same pricing equations for manufacturing exports. However, this does not imply that the chosen prices are the same as we demonstrate below, because of differences in the evolution of marginal costs across the two cases.

[12] The comparative statics with respect to α do not yield itself to closed form solutions because the steady state values s_O and s_M also depend on α.

The higher the degree of variable mark-ups, that is higher is Γ, the lower the sensitivity of prices (in the currency in which they are set) to changes in marginal costs, as would be the case with a higher degree of price-stickiness θ_p. At the same time a higher Γ raises the sensitivity to the foreign manufacturing price index. The evolution of the aggregate price indices follow, $p^f_{i,t} - p^f_{i,t-1} = (1-\theta_p)(\bar{p}^f_{i,t} - p^f_{i,t-1})$ for $i = f, h$.

5.1 Impulse Responses

In this section we study the response to a one time negative price shock to the homogenous good sector. As described in Section 4, such a terms of trade shock, in the presence of incomplete financial markets, generates a depreciation of the real exchange rate. In the presence of nominal rigidities this is partly accomplished by a depreciation of the nominal exchange rate.

Figures 3(c), 3(e), 3(f) and 4(d) contrast the impulse response of the terms of trade, manufacturing exports, imports and manufacturing firm's mark-up to the shock. As is evident these impulse responses display in almost all cases important qualitative and quantitative differences. First consider the *non-commodity* terms of trade, 3(c), defined as the ratio of the price of manufacturing exports to the price of imports (tot_M), all expressed in dollar terms, $\frac{P^f_t}{P^*_{T,t}}$. In the case of DP there is a very slight depreciation of the terms of trade in contrast to a sharp depreciation of the terms of trade in the case of PCP and a sharp appreciation of the terms of trade in the case of LCP.

In the case of DP and LCP because prices are sticky in dollars the decline in dollar prices is gradual in both cases, however it declines by more in the case of LCP as depicted in figure 3(d). This is because in the case of DP the depreciation of the exchange rate raises the home currency cost of inputs, and consequently the decline in marginal costs that the depreciation affords is smaller as compared to the case of LCP for which imported input prices are sticky in the home currency. The small response of dollar export prices, and the constancy of dollar import prices together generate a small depreciation of tot_M. The sharp appreciation of the tot_M in the case of LCP follows from the decline in import prices denominated in dollars, a consequence of stickiness in local currency. As for PCP the sharp depreciation of tot_M follows from the stickiness of export prices in the home currency. The differential quantity response for manufacturing exports, depicted in 3(e), follows from the differential export price responses in the three cases.

The current account to GDP deteriorates in all three cases, figure 4(a), which follows from the decision of households to borrow in the face of a transitory negative shock. The non-commodity trade balance, figure 4(c) improves owing the fall in imports and increase in exports, however this improvement is the smallest for the case of DP owing to the smallest response in manufacturing exports.

Figure 4(d) plots the diverging responses of mark-ups of manufacturing sector firms, with a sharp increase in mark-up in the case of LCP, a sharp decline in mark-up in the case of PCP and a moderate increase in mark-up in the case of DP. Once again the difference between LCP and DP arises from the lack of sensitivity of imported input costs to the exchange rate in the case of LCP, which in turn generates a sharper increase in mark-ups.

5.2 Exchange Rate Pass-through

It is common to estimate the pass-through of exchange rates into a country's import and export prices to understand the pricing behavior of firms. Burstein and Gopinath (2014b) provide a recent survey of this literature. One specification involves regressing the change in (log) prices on current and lagged changes in the (log) exchange rate.

In figures 5(a)-5(f), we plot the cumulative sum of the coefficients of the exchange rates from the following regressions estimated on the model simulated data,

$$\Delta s_t = \alpha + \sum_{\ell=0}^{8} \beta_\ell \Delta e_{t-\ell} + \varepsilon_t \tag{26}$$

Figures 5(a)-5(c) depicts the pass-through of exchange rate changes into the home currency price of exports (dashed line), where $\Delta s_t = \Delta p_t^f + \Delta e_t$, and the home currency price of imports (solid line), $\Delta p_{T,t}$, for the three cases of DP, PCP and LCP. Each point represents $\sum_{\ell=0}^{j} \beta_j$ There are large differences across the three cases. In the case of DP both pass-through's start out close to one and the pass-through into export prices declines towards 0.66. The flat line for import pass-through follows from the constancy of $P_{T,t}^*$. The important feature is that both pass-through's are quantitatively close and they decline over time.

In the case of PCP, the contemporaneous effect for pass-through's diverge sharply, with the pass-through for export prices below 0.2 and the pass-through for import prices close to one. The pass-through into home currency export prices increase over time, in contrast with the DP case. In the case of LCP there is a similar divergence in the pass-through rates for early lags as in the case of PCP, with the important difference that the lines are flipped around, that is pass-through into export prices start high, while pass-through into import prices start low.

Figures 5(d)-5(f) plot the cumulative coefficients for pass-through into quantities, with the dashed line representing exports (manufacturing only) and the solid line imports. Consistent with the pass-through estimates for prices, in the case of DP the pass-through into export quantities is small with a gradual increase over time, while there is a sharp decline in imports. In other words, exchange rate depreciations in the case of DP result in a bigger response in imports than in exports. In the case of PCP, there is a sharp increase in exports and a small increase in imports initially with a gradual decrease over time. The initial small positive arises because of the demand for imported inputs used to produce exports that rises sharply. In the case of LCP both exports and imports increase over time.

Armed with these contrasting predictions we turn to empirical evidence in the next section to examine how the facts compare with the predictions.[13]

6 Empirical Evidence

To investigate the relationship between firms, exchange rates and the macroeconomy we use data for Colombia. Besides data availability, there are other good reasons to study Colombia. Firstly, because the Colombian exchange rate (peso) is a commodity currency and fluctuations in the peso[14] are closely tied to fluctuations in commodity prices[15] we are less subject to the long standing critique of standard general equilibrium models of exchange rates that have trouble explaining exchange rate fluctuations at quarterly frequencies using observable shocks, the so called exchange rate disconnect puzzle (Meese and Rogoff (1983)). In the case of Colombia there is a strong negative co-movement between the exchange rate

[13]Here, we briefly speak to the question of endogenous currency choice. That is, given the model's assumptions and its specific parameterizations, if firms in the SOE could choose which currency to price in, what would it be? As derived in Gopinath et al. (2010) a proxy measure for this decision is the pass-through *conditional on a price change*. If this pass-through is more (less) than 0.5 (this is an argument based on second order approximations) the firm will choose to price in dollars (peso). In the model generated data this conditional pass-through estimate is 0.86 and consequently the firm would choose to price in dollars. The use of imported inputs and strategic complementarity in pricing are both essential to making dollar pricing optimal.

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

[15]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.

and commodity prices at quarterly frequencies. Figure 7 displays the relation between the Colombian peso (solid black line) and the overall terms of trade (dashed blue line), where the two closely track each other. The correlation between the two series is -0.62, and the regression coefficient is -1.15 with an R^2 of 0.38. The Colombian economy therefore provides a useful lens through which to evaluate the performance of open economy macro models. Secondly, the Colombian economy is representative of a large number of economies that rely extensively on dollar invoicing, with 98% of its exports invoiced in dollars. We provide further details in the next section.

6.1 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 includes information on all importers and exporters. We have access to the data through the Banco de la República. The data on exports include the exporting 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, the country of destination, and the currency of each transaction, among other details. The data on imports include the importing firm's tax identification number, the 10-digit product code, both the FOB and CIF value and the volume of imports, and the countries of origin and purchase, among other details. Both datasets are available on a monthly basis, and for our analysis we aggregate exports and imports at the annual or quarterly level. Trade data is available for the period between 2000 and 2015.

The data on firms' production and input consumption are from "Superintendencia de Sociedades," the agency in charge of supervising corporations. Specifically, the data are from the "Sistema de Información y Riesgo Empresarial" (SIREM) database. The SIREM includes relatively large firms, and firms in financial trouble.[16] The data are at an annual frequency and are self-reported by the firms. We have access to public information such as

[16]Firms must report their financial data if their assets and/or income (adjusted by inflation) are grater than 30,000 times the current legal monthly minimum wage, if their external liability is grater than the total assets, if the financial expenditures are at least 50% of their income, if their cash flow is negative, or if their losses reduce the net equity below 70% of the social capital. During our sample period the average minimum monthly wage was 250 dollars; it oscillated between a minimum of 165 dollars in 2005, and a maximum of 315 dollars in 2012 and 2013.

balance sheets, as well as to confidential data included in the annexes filed by the firms.[17] Thus, we are able to observe a great amount of details about each firm that are not usually available in other datasets. These variables include the firm's tax identification, the income obtained from the sales of each product (at the 4-digit level, according to the ISIC classification system), the purchase of inputs (broken down between domestic and foreign materials), investments, detailed labor information, and some financial information such as financial obligations with domestic and foreign banks. Additionally, we observe organizational variables such as whether the firm is a standalone firm, an affiliate, a headquarters with affiliates, or part of a conglomerate, and the firm's location. Our firm data cover the period 2005–2014.

Throughout the paper, we focus on manufacturing firms producing noncommodity, tradable goods.[18] For our analysis we exclude manufacturers of coke, refined petroleum products and nuclear fuel (ISIC 23), and manufacturers of basic metals (ISIC 27), which include metals such as gold, silver, platinum, and nickel, since as commodity producers their dynamics are different from those of other manufacturing firms.

Given that both datasets include information on firms from several industries, and that we observe in the data multi-product firms not limited to manufacturing activities, we need to define precisely which observations to use in our estimations. For the empirical exercises that rely exclusively on our trade data, since we have information at the product level, we keep all the observations corresponding to exports and imports of manufactures. In the case of the SIREM, where data is at the firm level, we need to classify each firm (and not each product) as a manufacturer or not. Taking advantage of the detailed income data, we define as manufacturers those firms for which income from manufactures represents at least 50% of the total operational income in any given year, and we exclude those firms with income from the manufacture of coke, refined petroleum products, nuclear fuel, or basic metals.[19]

We merge both datasets using the firms' tax identification number. After the merge we are left, on average, with 34% of all exporters (and 40% of exporters of manufactures). Since we keep relatively large firms, these represent 65% of the value and 80% of the volume of all exports, and 77% of the value and 63% of the volume of manufacturing exports. In

[17]We obtained access to the confidential data through the Banco de la República.

[18]We follow the ISIC classification (Rev. 3.1) to define which goods are manufactures.

[19]As alternative definitions of manufacturing firms we considered those whose main product is a manufacture, or those with positive income from manufacturing. The descriptive statistics presented below and the main results of the pass-through regressions are very similar under all definitions.

Table 3, we break down these percentages by year. While we do observe some variations from year to year, the share of exports included in our merged data remains fairly constant.

When we look at the representativeness of our data in terms of imports, we find a similar pattern. In terms of the total number of importers, our merged data contains 27% of all importers and 30% of the importers of manufactures. However, as mentioned above, these represent relatively large firms, and the share of imports is much larger: the firms in our sample represent over 74% of total imports, measured either with the FOB value or the net weight of imported goods. Table 4 shows these percentages broken down by year. Again, the share of imports included in our merged dataset is relatively constant across years.

In Table 5, we break exports across destinations. The table includes countries with a share of manufacturing exports of at least 1%. Based on the value of manufacturing exports, Colombia's main trading partners are the United States and Venezuela, followed by Ecuador and Peru. The list is completed by other Latin American countries, European countries, Japan and Canada.[20]

Starting in 2007, our exports data includes information on the invoicing currency of each transaction. The distribution of exports across currencies is presented in Table 6. It is evident that the vast majority of Colombian exports are priced in dollars. 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 instead of the number of transactions. In Table 7 we present the distribution of currencies, broken down by destination groups. Even for exports to the euro zone, or the U.K, the overwhelming invoicing currency is the dollar.

6.2 Terms of Trade

Figure 7 plots the manufacturing terms of trade (dashed and dotted red line) for Colombia alongside the overall terms of trade and the nominal exchange rate. Unlike the overall terms of trade the manufacturing terms of trade has low sensitivity to the exchange rate. A 1% depreciation of the exchange rate is associated with a 0.33% depreciation of the

[20]It is worth noting that among the countries included in "Other", China, the Netherlands, India, and Switzerland are important trade partners for goods not included in our set of manufactures. In particular, China receives 5% of total exports, and 3% of exports of manufactures including petrochemicals and basic metals.

manufacturing terms of trade. Using model simulated data we find that DP comes closest to this low sensitivity with a depreciation of 0.24%, PCP generates a much greater sensitivity of 0.68%. LCP generates the wrong sign with a 0.5% appreciation following a depreciation of the exchange rate.

6.3 Empirical Pass-through Estimates

Figures 6 and 7 plot the empirical counterpart of eq. (26) using Colombian import and export price and quantity data. Specifically, for export (import) prices we construct unit values using the f.o.b value at the 10-digit product code level for a specific destination (origin) divided by the volume of exports at the same level of disaggregation for each quarter from 2005-2015. To be consistent with the model we restrict exports to and imports from dollarized economies. These include the USA, Panama, Puerto Rico, Ecuador, and El Salvador. We include fixed effects at the firm-country-industry level. The solid lines represent the cumulative β over nine quarters and the dashed lines represent two standard error bands, where standard errors are clustered by year. The pass-through into import (solid line) and export (solid with squares) peso prices start out close to one for import prices and to 0.8 for export prices and then decline some over time.

Table 9 reports annual pass-through estimates using annual changes in peso export prices and annual changes in exchange rates. In columns 1-2 we just include the exchange rate and the same firm-country-industry fixed effects as in the figures. In columns 3-4, the estimates are reported using controls for origin and destination producer price index (PPI), as controls for costs and allowing for strategic complementarity in pricing. In columns 5-6 we use controls for the firms productivity estimated using Gandhi et al. (2016)[21] We also estimate pass-throughs for the subset of manufactured goods that are differentiated products as defined by Rauch (1999). These are reported in the even-numbered columns, and it is clear that the results are essentially unchanged. We repeat the exercise for import prices in Table 7. Regardless of the controls used, pass-through into export peso prices is close to 0.8 and for import prices is close to 1 over one year. The destination country's PPI also shows up as significant for pricing decisions. In line with strategic complementarity in pricing a higher price in the destination country all else equal is associated with the

[21] We estimate TFP following the method proposed by Gandhi et al. (2016), that exploits the information contained in the firm's first-order conditions to account for unobserved productivity through the observed demand for flexible inputs, while eliminating the productivity term from the estimation itself to avoid the simultaneity bias. We use information on sales and input usage from our SIREM data to estimate firm-specific productivity for the period between 2005–2013.

exporting firm charging a higher price. When compared to the model generated figures 5(a)-5(f) it is clear that the pass-through patterns in the data support strongly the DP model as opposed to PCP or LCP.

Figure 7 and Tables 11 and 12 perform the same pass-through analysis but where the dependent variable is quantities instead of prices. The quantities exported depend on the price charged by the exporting firm relative to the price charged by its competitors (PPI^*) and the level of demand in the destination country. The price charged by the firm in turn depends on the exchange rate, its own costs (PPI) and the competitors price level (PPI^*). We therefore estimate a specification that has export quantities on the left hand side, and the exchange rate, domestic and foreign PPI and foreign demand on the right hand side. We do the same for imports but with domestic demand replacing foreign demand.

The figure suggests that while there is a significant drop in quantities imported, the estimates for exports is highly noisy and insignificantly different from zero. Table 11 reports the pass-through into export quantities. We observe that while the coefficient on the exchange rate are negative when we do not include any controls, they become statistically insignificant once we add foreign PPI and GDP to control for costs and foreign demand. Similarly, Table 12 reports the pass-through into import quantities. In this case, we find that the pass-through is always negative and close to -1.1. This pattern is again consistent with the predictions of DP and contrary to those of LCP and PCP.

7 Conclusion

In this paper we examine the combined features of dollar pricing, strategic complementarities in pricing and imported input use in production to understand the consequences for economies of shocks that generate fluctuations in the exchange rate. We demonstrate that these predictions when compared to the data outperform the dominant paradigms of producer and local currency pricing in the literature. In future work we plan to extend the model to a multi-country environment so as to capture the consequences of using the dollar in third party transactions, an important feature of the data.

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Table 1: Exports Invoicing and US Export Shares

	Dollar Share	Euro Share	Own Currency Share	US Export Share
Algeria	0.99	0.01	0.00	0.19
Argentina	0.97	0.02	0.00	0.08
Australia	0.77	0.01	0.20	0.06
Brazil	0.94	0.04	0.01	0.17
Bulgaria	0.45	0.56	0.00	0.03
Canada	0.70	·	0.23	0.80
China	·	·	0.05	0.19
Colombia	0.99	0.00	0.01	0.41
Czech Republic	0.14	0.72	0.10	0.02
Denmark	0.23	0.31	0.19	0.05
Estonia*	0.21	0.56	0.00	0.06
Hungary	0.18	0.71	0.02	0.03
Iceland	0.45	0.28	0.05	0.08
India	0.86	0.08	0.00	0.16
Indonesia	0.93	0.01	0.00	0.11
Israel	0.71	0.20	0.00	0.34
Japan	0.50	0.08	0.39	0.22
Latvia*	0.36	0.48	0.00	0.02
Lithuania*	0.48	0.45	0.05	0.04
Malaysia	0.90	·	0.00	0.19
Norway	0.56	0.38	0.03	0.06
Pakistan	0.91	0.04	0.00	0.19
Poland	0.30	0.64	0.04	0.22
Romania	0.36	0.64	0.00	0.13
South Africa	0.52	0.17	0.25	0.05
South Korea	0.85	0.06	0.01	0.15
Sweden	0.27	0.22	0.39	0.08
Switzerland	0.19	0.35	0.35	0.11

Table 1: (continued)

	Dollar Share	Euro Share	Own Currency Share	US Export Share
Thailand	0.82	0.02	0.07	0.15
Turkey	0.46	0.41	0.02	0.06
Ukraine	0.76	0.07	0.00	0.03
United Kingdom	0.29	0.13	0.51	0.14
United States	0.97	·	–	–
Euro Area:				
Belgium	0.32	0.54	–	0.15
Cyprus	0.48	0.25	–	0.02
France	0.40	0.50	–	0.14
Germany	0.24	0.62	–	0.15
Greece	0.61	0.35	–	0.08
Italy	0.32	0.61	–	0.14
Luxembourg	0.32	0.54	–	0.11
Netherlands	0.36	0.50	–	0.11
Portugal	0.35	0.55	–	0.02
Slovakia	0.04	0.95	–	0.03
Slovenia	0.12	0.81	–	0.05
Spain	0.34	0.58	–	0.10

Notes: For countries in the euro area we report their exports outside of 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 2: Imports Invoicing and US Import Shares

	Dollar Share	Euro Share	Own Currency Share	US Import Share
Algeria	·	0.49	0.00	0.07
Argentina	0.88	0.08	0.00	0.14
Australia	0.53	0.08	0.31	0.14
Brazil	0.84	0.11	0.01	0.18
Bulgaria	0.43	0.59	0.00	0.02
Canada	0.75	0.05	0.20	0.57
China	·	·	0.07	0.09
Colombia	0.99	0.00	0.01	0.29
Czech Republic	0.19	0.68	0.09	0.03
Denmark	0.25	0.32	0.12	0.03
Estonia*	0.34	0.53	0.00	0.03
Hungary	0.27	0.57	0.04	0.02
Iceland	0.32	0.36	0.06	0.10
India	0.86	0.10	0.00	0.06
Indonesia	0.81	0.04	0.01	0.07
Israel	0.73	0.21	0.03	0.14
Japan	0.71	0.03	0.23	0.13
Latvia*	0.36	0.53	0.00	0.01
Lithuania*	0.51	0.39	0.01	0.02
Morocco	·	0.55	0.00	0.06
Norway	0.21	0.29	0.30	0.06
Pakistan	0.84	0.07	0.00	0.05
Peru	0.93	·	0.00	0.20
Poland	0.30	0.58	0.06	0.03
Romania	0.31	0.67	0.00	0.02
South Korea	0.81	0.05	0.02	0.12
Sweden	0.25	0.36	0.25	0.04
Switzerland	0.13	0.53	0.31	0.07

Table 2: (continued)

	Dollar Share	Euro Share	Own Currency Share	US Import Share
Thailand	0.79	0.04	0.04	0.08
Turkey	0.59	0.31	0.03	0.06
Ukraine	0.75	0.16	0.00	0.03
United Kingdom	0.47	0.15	0.32	0.10
United States	0.93	0.02	–	–
Euro Area:				
Belgium	0.37	0.54	–	0.15
Cyprus	0.56	0.15	–	0.06
France	0.47	0.45	–	0.14
Germany	0.35	0.55	–	0.11
Greece	0.63	0.33	–	0.05
Italy	0.51	0.44	–	0.07
Luxembourg	0.43	0.44	–	0.24
Netherlands	0.47	0.42	–	0.14
Portugal	0.43	0.52	–	0.06
Slovakia	0.22	0.77	–	0.02
Slovenia	0.30	0.66	–	0.06
Spain	0.41	0.54	–	0.08

Notes: For countries in the euro area we report their imports from outside 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.

	Parameter	Value	Data
Household Preferences			
Discount factor	β	0.98	
Risk aversion	σ_c	2.00	
Frisch elasticity of N	φ^{-1}	0.50	
Disutility of labor	κ	1.00	
Traded share in C	γ	0.33	
$\mathcal{SE}$ of M/P to i	ν_1	0.20	
$\mathcal{SE}$ of M/P to C	ν_2	10	
NFL to GDP	$\bar{B}$	2.50	0.31
Oil			
Share of GDP	ϑ, z_O	0.66, 1	0.20
Persistence	ρ_O	0.90	
Manufacturing			
Interm share	α	0.66	
Demand $\mathcal{E}$	σ	2.00	
Demand super-$\mathcal{E}$	ε	2.00	
Share of GDP	C_M^f	0.80	0.12
Non-traded share of GDP	Y_N	9.00	0.68
Rigidities			
Wage	θ_w	0.75	
Price	θ_p	0.75	

Note: other parameter values as reported in the text.

Table 3: Representativenss of the Data: Exporters

	All Exports			Manufactures		
	Exporters	Value	Volume	Exporters	Value	Volume
2005	27.4%	71.5%	82.9%	33.7%	75.3%	54.1%
2006	32.5%	72.8%	83.5%	39.2%	77.4%	56.5%
2007	31.2%	72.7%	84.3%	36.7%	75.8%	56.7%
2008	31.1%	69.0%	81.7%	36.8%	69.7%	57.5%
2009	34.6%	74.6%	87.5%	40.6%	75.6%	64.6%
2010	37.4%	67.0%	77.4%	44.2%	78.6%	67.2%
2011	39.0%	61.3%	75.8%	45.7%	78.7%	69.0%
2012	37.0%	60.5%	76.3%	43.7%	80.0%	73.6%
2013	35.2%	59.0%	75.8%	42.2%	79.9%	72.7%
2014	33.7%	55.7%	66.9%	41.1%	77.9%	73.3%
Full Sample	33.7%	64.8%	78.9%	40.2%	76.7%	63.3%

Source: Authors' calculations based on data from SIREM and DIAN/DANE.
Note: Exports of coke, refined petroleum products, and nuclear fuel (ISIC 23), and basic metals (ISIC 27) excluded from "Manufactures".

Table 4: Representativenss of the Data: Importers

	All Imports			Manufactures		
	Importers	Value	Volume	Importers	Value	Volume
2005	24.0%	67.8%	74.7%	26.1%	66.7%	71.8%
2006	28.0%	72.5%	73.6%	30.4%	72.1%	72.6%
2007	25.3%	72.1%	73.9%	27.6%	72.1%	74.9%
2008	25.6%	72.4%	75.5%	27.9%	71.9%	75.4%
2009	30.2%	68.6%	68.6%	33.0%	71.0%	76.3%
2010	27.9%	73.6%	73.0%	30.5%	75.9%	82.2%
2011	32.1%	75.3%	78.5%	35.2%	76.7%	85.5%
2012	34.3%	76.5%	75.0%	38.4%	79.9%	86.4%
2013	25.4%	69.9%	65.3%	27.3%	75.4%	78.0%
2014	24.2%	68.3%	68.2%	25.8%	73.3%	78.9%
Full Sample	27.4%	71.7%	72.1%	29.9%	74.0%	78.3%

Source: Authors' calculations based on data from SIREM and DIAN/DANE.
Note: Imports of coke, refined petroleum products, and nuclear fuel (ISIC 23), and basic metals (ISIC 27) excluded from "Manufactures".

Table 5: Distribution of Exports by Destination

	All Exports		Manufactures	
	2005-2015 Total	Yearly average	2005-2015 Total	Yearly average
Venezuela	7.63%	7.23%	20.73%	19.46%
United States	35.84%	35.05%	17.69%	17.99%
Ecuador	3.95%	3.95%	11.13%	11.07%
Peru	2.51%	2.57%	6.46%	6.59%
Mexico	1.68%	1.75%	4.47%	4.62%
Brazil	2.04%	2.14%	3.52%	3.68%
Chile	2.40%	2.37%	2.88%	2.93%
Japan	0.98%	1.02%	2.36%	2.38%
Panama	3.25%	3.53%	2.25%	2.28%
Germany	1.18%	1.19%	2.01%	2.05%
Costa Rica	0.78%	0.77%	1.88%	1.88%
Dominican Republic	1.40%	1.34%	1.46%	1.49%
Canada	1.03%	1.03%	1.42%	1.44%
Spain	3.24%	3.33%	1.39%	1.39%
Belgium	1.11%	1.13%	1.34%	1.39%
Guatemala	0.76%	0.75%	1.24%	1.25%
United Kingdom	1.84%	1.83%	1.17%	1.13%
Italy	1.36%	1.36%	1.14%	1.14%
Other	27.00%	27.63%	15.46%	15.84%

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 the FOB value of exports in 2005 dollars.

Table 6: Currency Distribution

	All Exports	Manufactures
US Dollar	98.28%	98.39%
Euro	0.72%	0.70%
Colombian Peso	0.67%	0.52%
Venezuelan Bolívar	0.27%	0.33%
Sterling Pound	0.02%	0.01%
Mexican Peso	0.01%	0.01%
Other currencies	0.03%	0.03%

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.

Table 7: 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.

Table 8: Share of Imported Inputs (%)

	All Manufacturers					Exporters				
	Average	Median	SD	Min	Max	Average	Median	SD	Min	Max
2005	40.2	0.0	28.3	0.0	100.0	43.9	11.4	30.1	0.0	100.0
2006	38.7	0.0	28.0	0.0	100.0	42.5	8.8	29.7	0.0	100.0
2007	38.0	0.0	27.6	0.0	100.0	42.1	10.2	29.9	0.0	100.0
2008	35.8	0.0	27.7	0.0	100.0	39.9	10.4	29.6	0.0	100.0
2009	37.2	0.0	28.0	0.0	100.0	42.3	10.0	29.9	0.0	100.0
2010	35.4	0.0	28.1	0.0	100.0	41.1	13.5	29.9	0.0	100.0
2011	36.0	0.0	28.3	0.0	100.0	41.2	11.5	30.3	0.0	100.0
2012	39.0	0.0	29.0	0.0	100.0	44.3	13.5	31.1	0.0	100.0
2013	37.4	0.0	28.5	0.0	100.0	41.7	12.5	30.3	0.0	100.0
2014	38.1	0.0	29.9	0.0	100.0	44.3	15.3	31.7	0.0	100.0

Source: Authors' calculations based on data from SIREM and DIAN/DANE.
Note: Average weighted with income.

Table 9: Pass-Through into Colombian Export Prices

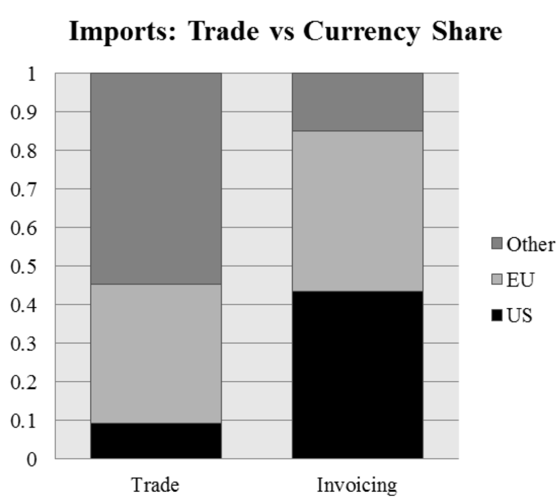
VARIABLES	Δp (1)	Δp (2)	Δp (3)	Δp (4)	Δp (5)	Δp (6)
Δe	0.699***	0.705***	0.830***	0.798***	0.857***	0.882***
	(0.0324)	(0.0284)	(0.0341)	(0.0440)	(0.0967)	(0.160)
ΔPPI			-0.0611	0.116	-0.0620	0.135
			(0.141)	(0.143)	(0.228)	(0.279)
ΔPPI^{*}			0.218***	0.193***	0.249***	0.217**
			(0.0490)	(0.0495)	(0.0601)	(0.0791)
ΔTFP					0.0011	0.0014
					(0.0008)	(0.0008)
Observations	169,749	106,073	159,002	98,820	50,082	29,732
R-squared	0.282	0.295	0.284	0.298	0.273	0.298
Products	Manuf	Diff	Manuf	Diff	Manuf	Diff

Notes: All regressions include Firm-Industry-Country fixed effects. Standard errors clustered at the year level. The export destinations are the Dollarized economies: the USA, Panama, Puerto Rico, Ecuador, and El Salvador. 'Manuf' stands for manufactured products excluding petrochemicals and metal industries; 'Diff' stands for differentiated products. Data for TFP regressions span until 2013. '***', '**', and '*' indicate significance at the 1, 5, and 10 percent level, respectively.

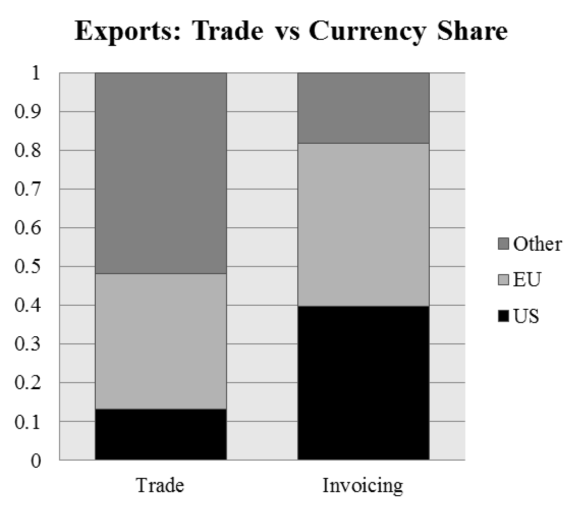
Table 10: Pass-Through into Colombian Import Prices

VARIABLES	Δp (1)	Δp (2)	Δp (3)	Δp (4)	Δp (5)	Δp (6)
Δe	0.976***	0.992***	1.003***	0.969***	1.013***	1.067***
	(0.0173)	(0.0206)	(0.0278)	(0.0328)	(0.0567)	(0.138)
ΔPPI			0.147	0.253**	-0.233	-0.474
			(0.0963)	(0.0988)	(0.188)	(0.358)
ΔPPI^*			0.0947**	-0.0127	0.320***	0.194
			(0.0359)	(0.0530)	(0.0752)	(0.175)
ΔTFP					-0.0007	-0.0019
					(0.0006)	(0.0013)
Observations	508,559	264,612	508,247	264,495	54,737	24,123
R-squared	0.226	0.252	0.226	0.252	0.232	0.254
Products	Manuf	Diff	Manuf	Diff	Manuf	Diff

Notes: All regressions include Firm-Industry-Country fixed effects. Standard errors clustered at the year level. The imports originate from the Dollarized economies: the USA, Panama, Puerto Rico, Ecuador, and El Salvador. 'Manuf' stands for manufactured products excluding petrochemicals and metal industries; 'Diff' stands for differentiated products. Data for TFP regressions span until 2013. '***', '**', and '*' indicate significance at the 1, 5, and 10 percent level, respectively.



(a)



(b)

Figure 1: Dollar Invoicing in World Trade

Table 11: Pass-Through into Export Quantities

VARIABLES	Δq (1)	Δq (2)	Δq (3)	Δq (4)
Δe	-0.805***	-0.836***	-0.421	-0.327
	(0.171)	(0.213)	(0.234)	(0.273)
ΔPPI^*			0.677**	0.914**
			(0.299)	(0.394)
ΔGDP^*			-0.103	-0.200
			(1.453)	(1.729)
Observations	169,749	106,073	159,002	98,820
R-squared	0.225	0.232	0.225	0.232
Products	Manuf	Diff	Manuf	Diff

Notes: All regressions include Firm-Industry-Country fixed effects. Standard errors clustered at the year level. The exports go to the Dollarized economies: the USA, Panama, Puerto Rico, Ecuador, and El Salvador. 'Manuf' stands for manufactured products excluding petrochemicals and metal industries; 'Diff' stands for differentiated products. '***', '**', and '*' indicate significance at the 1, 5, and 10 percent level, respectively.

Table 12: Pass-Through into Import Quantities

VARIABLES	Δq (1)	Δq (2)	Δq (3)	Δq (4)
Δe	-1.135***	-1.185***	-1.056***	-1.140***
	(0.186)	(0.188)	(0.217)	(0.246)
ΔPPI			1.391	1.404
			(1.030)	(1.131)
ΔGDP			3.352	2.756
			(2.736)	(3.184)
Observations	508,575	264,618	508,575	264,618
R-squared	0.184	0.205	0.185	0.206
Products	Manuf	Diff	Manuf	Diff

Notes: All regressions include Firm-Industry-Country fixed effects. Standard errors clustered at the year level. The imports originate from the Dollarized economies: the USA, Panama, Puerto Rico, Ecuador, and El Salvador. 'Manuf' stands for manufactured products excluding petrochemicals and metal industries; 'Diff' stands for differentiated products. '***', '**', and '*' indicate significance at the 1, 5, and 10 percent level, respectively.

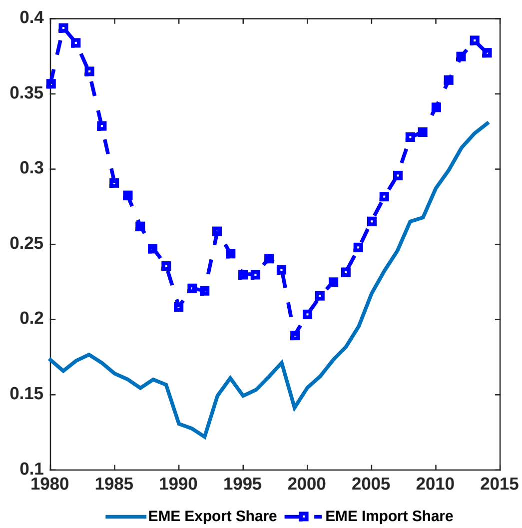
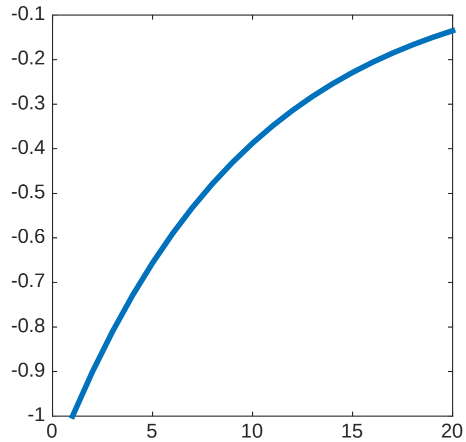
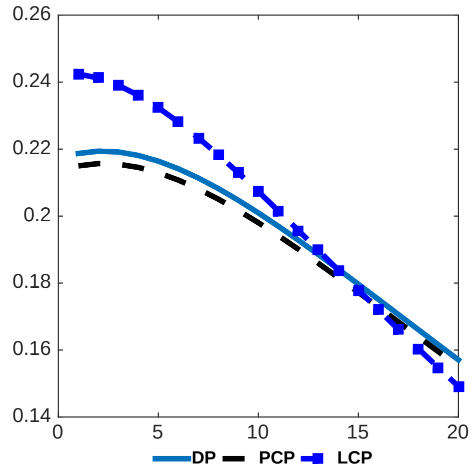


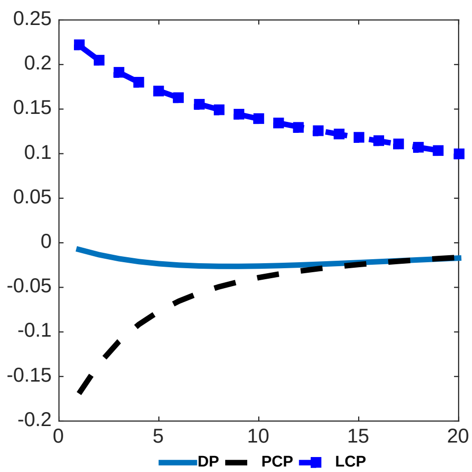
Figure 2: Share of Emerging Markets in World Trade



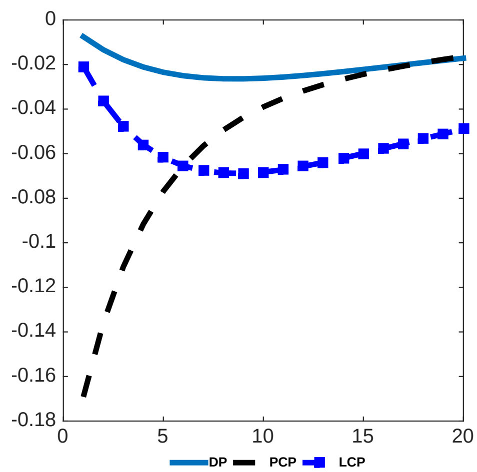
(a) Commodity price



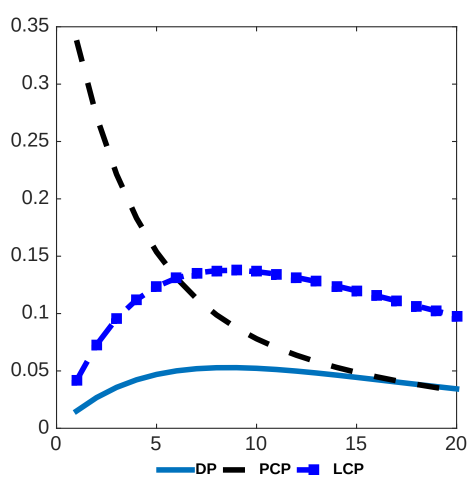
(b) Exchange Rates



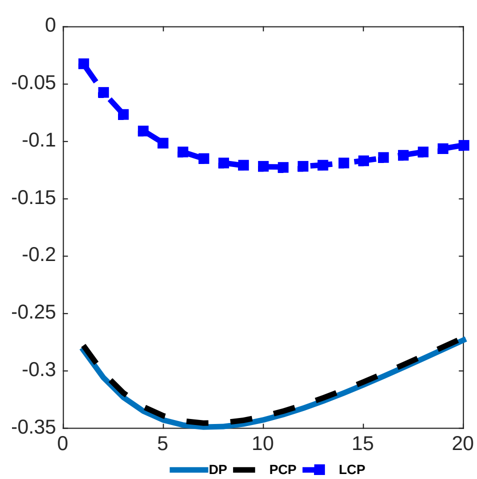
(c) Terms of Trade $\frac{P_t^f}{P_{T,t}^*}$



(d) Export Price (Manuf)

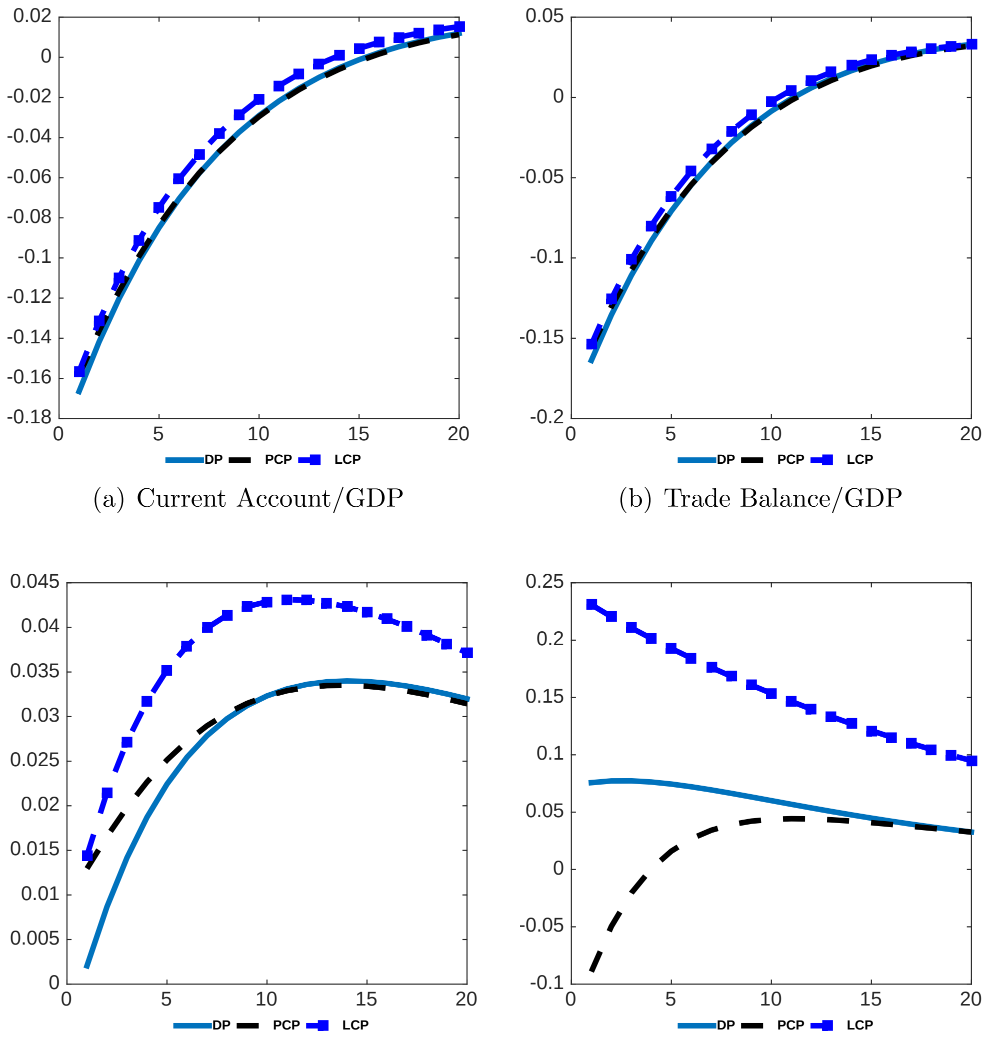


(e) Export Quantity (Manuf)



(f) Imports

Figure 3: Impulse response to commodity price shock



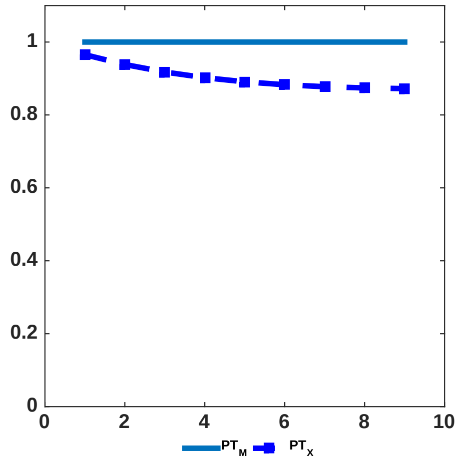
(a) Current Account/GDP

(b) Trade Balance/GDP

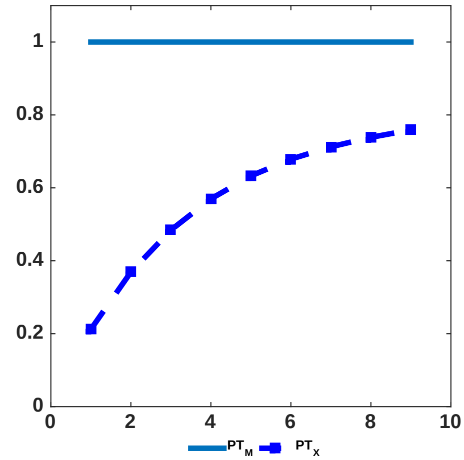
(c) Trade Balance(manuf)/GDP

(d) Mark-up

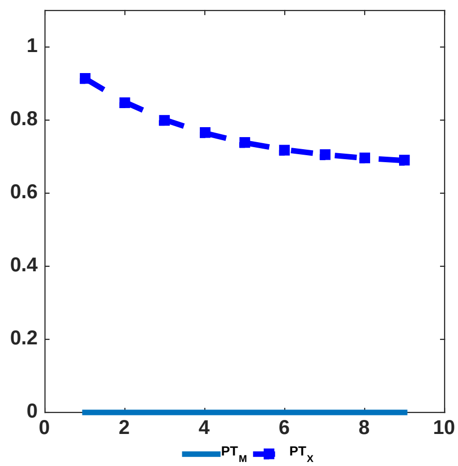
Figure 4: Impulse response to commodity price shock (continued)



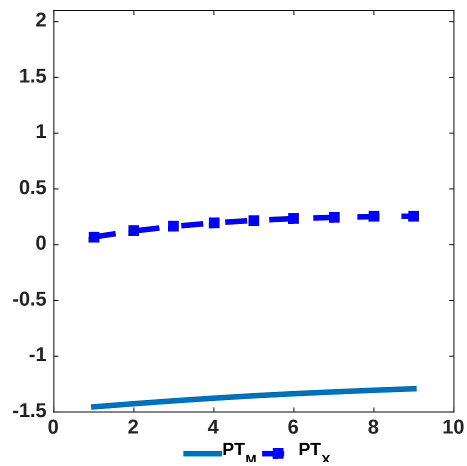
(a) *DP (Prices)*



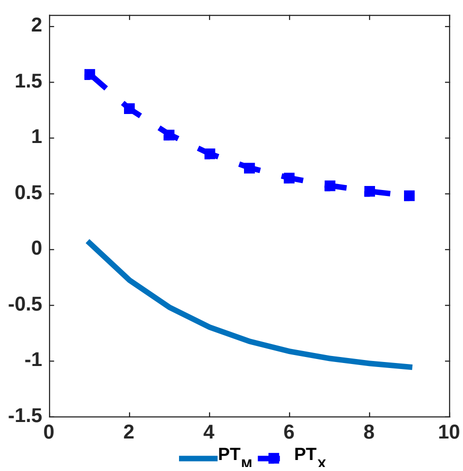
(b) *PCP (Prices)*



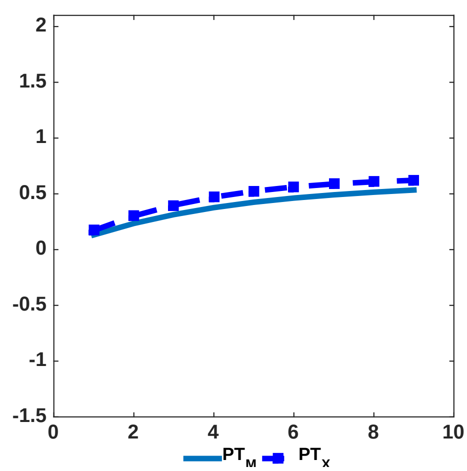
(c) *LCP (Prices)*



(d) *DP (Quantity)*



(e) *PCP (Quantity)*



(f) *LCP (Quantity)*

Figure 5: Exchange Rate Pass-Through

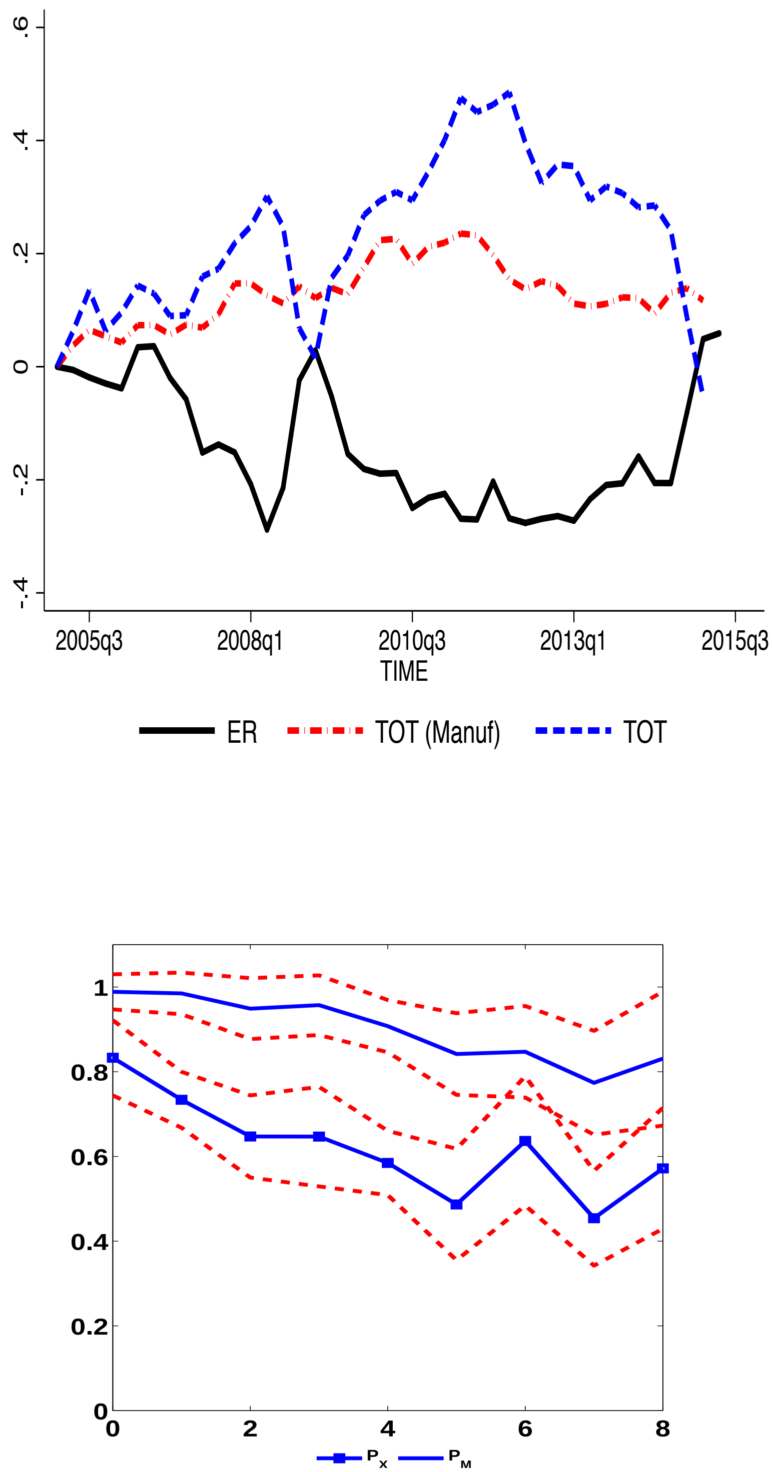


Figure 6: Colombia: Pass-through into Import and Export Prices

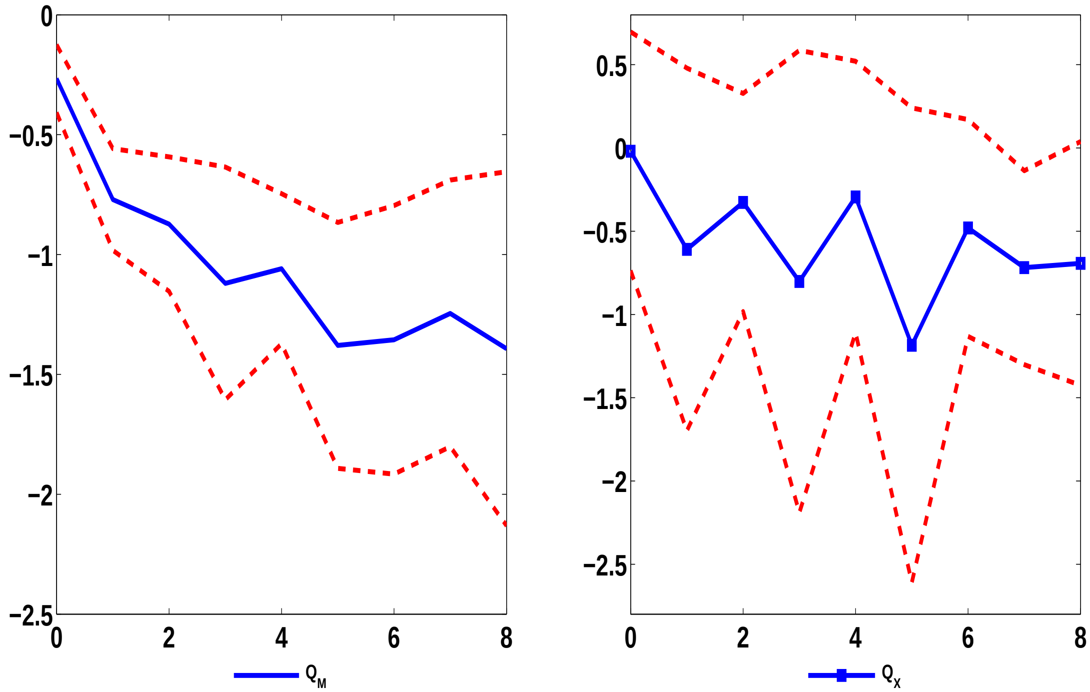


Figure 7: Colombia: Pass-through into Import and Export Quantities