Dollar Dominance and the Export Channel of Monetary Policy Transmission*

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Abstract

An emerging academic and policy view contends that a monetary-policy induced depreciation by a (non-US) country invoicing in dollars cannot stabilise activity, as the classical expenditure-switching channel is muted. This weakens the exchange-rate channel of monetary policy transmission. The key premises underlying this view are that i) exporters have monopoly power and ii) their prices are sticky in US dollars. However, goods priced in dollars are typically traded in highly competitive global markets and tend to have more flexible prices; this is particularly the case for exporters in emerging or developing countries. We propose a new open economy model with more realistic assumptions and show that loosening monetary policy boosts exports and activity; the limit to any expansion is not demand, but supply capacity. We furthermore show that low pass-through is not informative about the degree of nominal stickiness: limited price responses are an equilibrium result in our model, rather than an assumption. We present new evidence that both exports and activity respond strongly to exchange-rate changes driven by monetary policy.

Keywords: Monetary policy, expenditure-switching channel of monetary policy transmission, dominant currency, commodity prices, exchange rates.
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1. Introduction

Can counter-cyclical monetary policy help stabilise the economy? The dominance of the dollar in international trade has led academics and policymakers to re-evaluate their answers to this perennial question. An emerging view contends that an exchange-rate depreciation by a (non-US) country invoicing in dollars does not materially boost its exports. In the economics jargon, the classical expenditure-switching towards that country's exports is curtailed. This weakens monetary-policy transmission and undermines the Friedman (1953) and Mundell-Fleming (Mundell, 1963; Fleming, 1962) case for floating exchange rates: that they can function as efficient shock absorbers by rapidly adjusting external prices. Indeed, the International Monetary Fund (IMF) has suggested that weakened expenditure-switching worsens the cost-benefit calculation for using flexible exchange rates to stabilise the economy (IMF, 2019).[1]

This challenge to the Mundell-Fleming framework has come from a rapidly expanding collection of new positive evidence on the prevalence of vehicle currencies such as the dollar in trade.[2] This evidence contradicts the standard Mundell-Fleming assumption that non-US producers price exports in their own currency: Producer Currency Pricing (PCP). The PCP framework, formalised in an optimising setting in the seminal work by Obstfeld and Rogoff (1995), had lent support for the classic Friedman (1953) arguments for floating exchange rates as automatic stabilisers. Recent work (Egorov and Mukhin, 2023; Basu et al., 2020) has therefore explored the normative implications of an alternative, Dominant Currency Pricing (DCP) model, as formulated by Gopinath et al. (2020). These papers suggest that DCP limits the expenditure-switching benefits of exchange rates in external adjustment.

[1] In particular, stabilisation of trade volumes would require larger exchange rate movements, with negative balance sheet or inflationary consequences, requiring the use of other policy tools. See also IMF (2020), who suggest that when coupled with unhedged FX debt, dollar invoicing "may bolster the case" for using capital controls.

[2] See Goldberg and Tille (2008), Gopinath (2015), Amiti et al. (2022) and Corsetti et al. (2022).

However, these challenges to the allocative role of exchange rates and monetary policy rest on two further assumptions. The first assumption is that those exporters invoicing in dollars have monopoly power and face limited international competition. The second assumption is that these firms are subject to nominal rigidities, meaning their US dollar prices are sticky. Given these two assumptions, exchange-rate changes by non-US countries do not affect the dollar prices charged. With no change in prices, there is no changes in quantity demanded and no impact on exports.

In this paper, we argue that these joint assumptions of monopoly power and sticky dollar export prices are inconsistent with some key empirical facts on dollar pricing. In particular, invoicing in dollars is most prevalent for more homogeneous exports sold in highly competitive international markets, where firms have limited market power. And the US dollar prices of these exports tend to be more flexible, given the costs of price stickiness are larger for goods with high demand elasticities. These relationships are strongest in emerging and developing economies, which is exactly where dollar invoicing is most common. A major part of these economies' exports consist of commodities, which are a clear example of exports priced in dollars, but sold in globally competitive markets with flexible prices. A further large proportion of their exports are 'commodity-like' homogeneous goods, and this is especially the case for those invoiced in dollars.

The crucial empirical observation that motivated these auxiliary assumptions was evidence of limited exchange-rate pass-through into (dollar) export prices. Limited pass-through was interpreted as evidence of a friction: sticky dollar prices. We show how the same observation can arise instead as an equilibrium outcome, in a setting with flexible prices. Exchange-rate pass-through estimates are therefore not informative about the degree of nominal rigidities. This cautions against using these estimates to draw normative conclusions about the optimality of different exchange-rate regimes and monetary policies.

We present a new open economy framework that permits more realistic microeconomic assumptions by allowing intra-sector international competition for tradable goods, as in Feenstra et al. (2018). In our framework, which nests both sticky-price DCP and PCP models as special cases, domestic exporters can face intense competition from international competitors producing highly substitutable varieties of the same good, even where substitution elasticities between different goods remain low. This allows us to match the microeconomic evidence that demand elasticities are higher at a more disaggregated level (Broda and Weinstein, 2006; Imbs and Mejean, 2015); and that they are particularly high for the types of goods and countries that typically use dollar invoicing (Imbs and Mejean, 2017).

Similarly, we incorporate heterogeneity in nominal rigidities across producers, allowing us to match the microeconomic evidence that prices are updated more frequently for goods commonly invoiced in dollars. Observations of low pass-through for these firms instead emerge endogenously in our framework. Our model includes sticky wages, representing sticky non-tradable input prices more broadly, which lead to monetary non-neutrality (as do sticky consumer prices in other, more monopolistic sectors). We then use our model to examine the impact of a loosening in domestic monetary policy that depreciates the currency in a small open economy, comparing to the benchmark sticky price DCP and PCP cases.

Our key theoretical finding is that in our framework, a monetary policy-induced depreciation still significantly boosts both exports and aggregate demand. We therefore restore the allocative properties of the exchange rate of the benchmark PCP framework of Obstfeld and Rogoff (1995).[3] And we do this despite replicating the empirical finding of limited observed pass-through to dollars that motivated the standard sticky-price

[3] This relates to the finding in Barro and Tenreyro (2006) that what matters is the wedge between marked-up prices and competitive prices, irrespective of where in the production chain the stickiness lies – whether in product prices, as in PCP, or in wages, as in our framework; in Barro and Tenreyro (2006)'s setting, intermediate inputs have sticky prices, whereas final products prices are flexible. Barro and Tenreyro (2006) also highlight that competitive products have more flexible prices.

DCP assumptions.

Our result derives from using assumptions on elasticities and price flexibility in line with the microeconomic evidence. With sticky wages, the exchange-rate depreciation lowers the domestic cost of production expressed in dollars. Absent any adjustment in price, this increases exporter profitability. Highly elastic demand means that passing through even a small part of this reduction in cost can cause a substantial increase in export quantities. With flexible export prices, exporters do lower prices slightly, trading some of their profitability margin for a large increase in market share. The limit to the export expansion in our model is supply capacity, rather than demand. As the demand expansion runs into capacity constraints or increasing domestic marginal costs, this offsets the effect of the initial depreciation on dollar costs, leading to limited reduced-form dollar pass-through in equilibrium.

In the perfectly competitive limit, relevant for many emerging and developing economy commodity exporters, there is no impact at all on the global price of the commodity after a depreciation. The adjustment comes entirely through an expansion of exports, until the increase in domestic marginal costs equals the size of the depreciation. This parallels the price behaviour we would observe if prices were completely rigid in dollars, but has implications for export quantities that are diametrically opposed.

While price and quantity adjustment happens at the firm level (intensive margin) in the model, the setting can be expanded to capture entry by firms whose exports become profitable after the depreciation, thanks to the fall in dollar domestic costs. Bilbiie (2021) models a similar entry channel, and shows it replicates the features of price flexibility in a model with nominal rigidities.

In addition to matching the microeconomic evidence, our paper also conducts an empirical test using macroeconomic data. Our prediction of a material export response is the key differentiator between our framework and sticky-price DCP models.

Using a sample of emerging and developing countries, for which our microeconomic assumptions are most likely to hold, we find robust evidence in favour of our prediction. Monetary policy expansions leading to exchange rate depreciations cause significant increases in exports and aggregate activity.

Related literature Our findings relate to early debates in the new open economy macroeconomics literature launched by Obstfeld and Rogoff (1995). Their model, and subsequent work by Galí and Monacelli (2005), Clarida et al. (2001) and Corsetti and Pesenti (2001) used the Mundell-Fleming assumption of PCP. Monetary policy-induced depreciations, combined with nominal stickiness in producer prices, therefore led to a fall in export prices (once converted into local currency), and expenditure switching towards the depreciated economy.

These findings were challenged by Betts and Devereux (2000) and Devereux and Engel (2003), who argued that local currency pricing (LCP) – pricing in the currency of the importer – better explained evidence of limited exchange-rate pass-through. As with the assumption of sticky-price DCP, their assumed rigidity in local currency prices prevented expenditure switching following depreciations. With a limited allocative role for the exchange rate, LCP models were less favourable about the benefits of flexible exchange rates. Our model, by restoring the allocative role of the exchange rate in a model with dollar pricing, provides a setting in which the normative implications of DCP can resemble PCP frameworks rather than LCP. Our arguments and our model could also apply equally to LCP settings, if firms invoicing in local currencies are exporting into competitive markets.

Our paper builds on the recent literature on dominant currency pricing, surveyed by Gopinath and Itskhoki (2022), which argued that dollar pricing was likely to be a good first approximation for many countries (particularly emerging and developing economies). Our framework studies monetary policy under dollar pricing, nesting sticky-price DCP models as a special case, but challenging their implications for exchange-rate flexibility. Complementary challenges to some of the assumptions or implications of the DCP framework were made in Obstfeld (2020) and Gagnon and Sarsenbayev (2023).

Our model is also related to the Salter-Swan framework of policy analysis (named after Salter (1959) and Swan (1963)), elegantly microfounded for a two-good economy by Schmitt-Grohe and Uribe (2021). In our model we embed a richer demand system, market structure, production networks and shock dynamics, with multiple goods (or sectors) and varieties within each sector, and a role for imported intermediate inputs. Our setup also allows different degrees of price flexibility across sectors, nesting both the flexible-price Salter-Swan and sticky-price DCP models. Following Feenstra et al. (2018), our framework allows different elasticities of substitution between varieties across countries, relative to different types of good within a country. Different market structures lead to very different implications for the export channel of monetary transmission. We therefore formalise some of the intuition and arguments set out by Tenreyro (2019) and Frankel (2023). We also highlight the crucial role of supply constraints in determining the allocative properties of the exchange rate.

Our paper makes three contributions relative to these literatures. First, it combines evidence and theory to challenge the DCP (and LCP) literature's inference that low exchange-rate pass-through implies nominal rigidities (and monopoly power). Our framework provides an alternative interpretation with different policy implications. Second, it formalises these ideas by studying an open economy New Keynesian setting with a more flexible market structure. Intra-sector international competition allows us to use assumptions consistent with microeconomic evidence on elasticities and price rigidity. In contrast to existing sticky-price DCP models, our framework predicts a material response of export volumes to exchange-rate changes driven by monetary policy. Our third contribution is to test this prediction using a sample of emerging and developing countries. Our macroeconomic evidence suggests that monetary-policy related depreciations cause a significant increase in exports.

The framework we present fits with many stylised facts on pricing in international macroeconomics (or solves the associated 'puzzles').[4] First, it presents an alternative explanation for the finding that the terms of trade are relatively stable following exchange rate movements (Gopinath et al., 2020). As under PCP, depreciations do increase competitiveness in our framework; but as under DCP this increase in competitiveness does not appear in the equilibrium terms of trade – in our case, owing to offsetting increases in marginal cost. Second, our model offers an explanation to the PPP puzzle (Rogoff, 1996) – the volatility and persistence of the real exchange rate, and the associated Mussa puzzle (Mussa, 1986) – the large increase in nominal and real exchange rate volatility following the post-Bretton Woods switch to floating exchange rates. Crucially, our explanation predicts limited movements in optimal reset prices after exchange rate deviations, rather than relying on nominal rigidities, consistent with the evidence in Blanco and Cravino (2020) and Itskhoki and Mukhin (2021). Third, our model's mechanism via sticky wages is consistent with evidence that depreciations lead to slow adjustment of non-tradable prices. This is confirmed by Burstein et al. (2005) using well-identified large depreciation episodes.

Our results also have implications for the literature estimating exchange-rate pass-through, as surveyed in Burstein and Gopinath (2014). Our framework highlights the possibility of a very different interpretation of many reduced-form pass-through regressions. Since these regressions typically omit or struggle to fully capture marginal costs, they risk misinterpreting offsetting movements in marginal costs as a lack of direct exchange-rate pass-through. In our framework, firms pass through changes in marginal cost fully, since prices are flexible, and apparent limited pass-through is a result, rather than owing to an assumption of sticky prices. Our findings here resemble

[4] See Obstfeld and Rogoff (2000).

the argument in Head et al. (2012), who also model sticky prices as an equilibrium result.

Our empirical findings, namely the expansionary impact of a depreciation caused by a monetary policy loosening, confirm the predictions of our model and speak directly to the theoretical ambiguity discussed recently by Auclert et al. (2021).[5] As the authors point out, under some calibrations of a heterogeneous-agent setting, depreciations may cause a contraction in activity; our empirical findings resolve that ambiguity: in our sample of developing and emerging economies, depreciations stemming from monetary policy are expansionary, in part owing to an increase in export volumes. This result echoes the findings from Champagne and Sekkel (2018) for Canada and De Gregorio et al. (2024) for Chile, both important commodity exporters.[6]

The paper is organised as follows. Section 2 presents a simple graphical analysis to explain the role played by the assumptions of monopoly power and price stickiness in US dollars. Section 3 discusses the three microeconomic empirical observations that motivate our assumptions (and their deviation from current dominant currency models). Section 4 introduces the model and discusses its monetary policy implications via the exports channel. Section 5 presents new macroeconomic empirical estimates on the impact of monetary policy – via the exchange rate – on exports and activity for developing and emerging economies. Section 6 presents concluding remarks.

[5]See also Díaz Alejandro (1963).

[6]See also Cesa-Bianchi et al. (2020) for the United Kingdom, who find that, consistent with our model and results for emerging and developing countries, a tightening monetary policy shock causes an appreciation of sterling and a fall in exports and overall activity. While the UK economy is not a large exporter of commodities, it does export goods on which it has relatively limited market power in global markets (Broadbent, 2017). These aggregate results are consistent with the UK using PCP for sectors with higher market power and sticky prices, and flexible DCP for more competitive sectors. Corsetti et al. (2022) report that most UK exports to outside the EU (excluding the US) is done in sterling, with a further significant proportion in a vehicle currency, and less than 10% in local currencies. In a recent contribution, Fukui et al. (2023) also find an expansionary effect from depreciations using a very different identification strategy; in their study, and in contrast with our focus here, the depreciation is not driven by monetary policy – depreciating countries' interest rates in their sample do not change relative to their control group in their study. This points to a different underlying shock and mechanism than the one we study both theoretically and empirically in this paper.

2. The Export Response to a Depreciation: Intuition

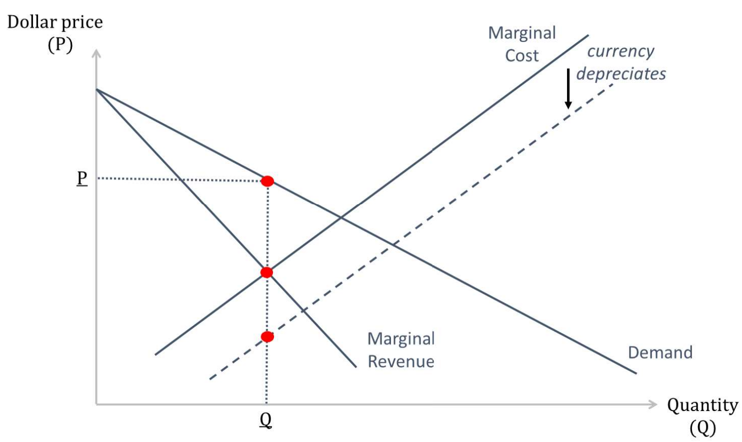
This section explains intuitively, with a simple graphical exposition, the critical role played by assumptions on price stickiness and monopoly power in determining the export response to a depreciation. It illustrates how varying those assumptions therefore alters the conclusions on the impact of monetary policy on activity via the expenditure-switching channel.

We present three different cases, showing the joint determination of price and quantity for a representative export firm under different assumptions. For simplicity of exposition, the figures are highly stylised, portraying linear demands and upward-sloping marginal cost curves. In the model we present later, we focus on the case of CES demand functions, where demand curves will be concave. The main conclusions, however, are not affected by these simplifications.

2.1. The Monopolist-exporter Case

We first examine the case of a monopolist producer who sets the (sticky) price in a dominant currency (the dollar), as illustrated in Figure 1.

Figure 1: Sticky-price Monopolist Exporter Facing a Depreciation



Note: Costs (in dollars) fall, but price and quantity demanded are unchanged.

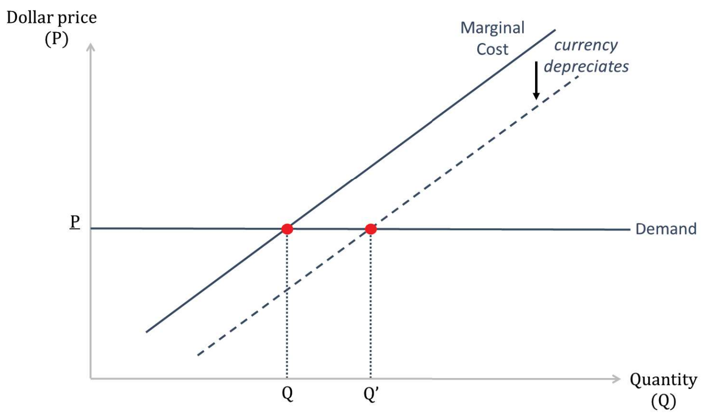
The vertical axis shows the dollar price charged, which is initially optimally chosen at the point where downward sloping marginal revenue meets upward sloping marginal cost.

A depreciation of the country's currency lowers domestic costs (expressed in dollars), as shown in the downward movement of the marginal cost curve. The implicit assumption (at the macroeconomic level) is that some of the costs priced in domestic currency do not fully adjust in response to the depreciation. These costs could be sticky domestic wages, or rents, for example. Because the good price is assumed to be sticky in US dollar, the quantity demanded does not adjust, despite the fall in costs and increase in margins. Exports do not change.

2.2. The Competitive Commodity-exporter Case

We consider next the case of perfectly competitive exporter, selling a commodity whose price is determined in global markets. This is illustrated in Figure 2.

Figure 2: Competitive Commodity Exporter Facing a Depreciation



Note: Costs (in dollars) fall, price is unchanged and quantity supplied increases.

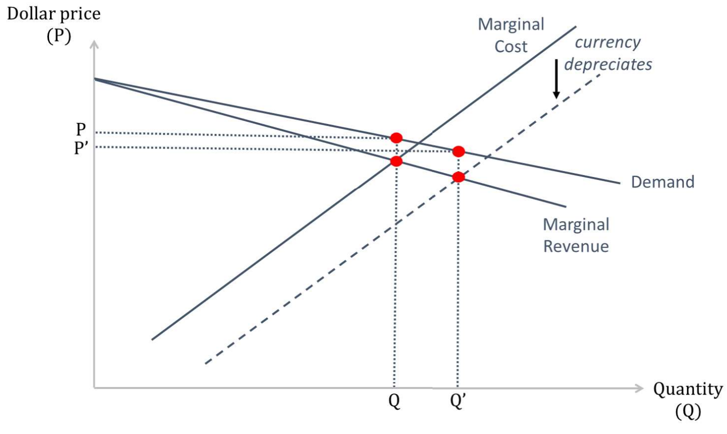
The exporter faces a perfectly elastic demand curve and the price of the commodity is fully flexible. As in the previous case, a depreciation of the currency lowers domestic costs for the exporter. The price in dollars remains unchanged, but the depreciation leads to an expansion in quantities exported. There is zero reduced-form pass-through of the exchange-rate depreciation into the dollar price of the exported commodity. But this does not stem from nominal stickiness, rather from the infinitely high demand elasticity, and an offsetting increase in marginal costs.

In this case, the size of the increase in export volumes will be limited entirely by supply capacity, rather than demand. This is captured for an individual firm by the slope of the marginal cost curve (and the macroeconomic response of sticky domestic costs such as wages). With a flat marginal cost curve, the exporter expands supply materially; with a steep curve, or hard capacity constraints resulting in a vertical curve, the export volumes change is limited.

2.3. The Intermediate Case

We turn now to an intermediate case in which the exporter faces an elastic demand and has some monopoly power, illustrated in Figure 3.

Figure 3: Flexible-price, High-demand elasticity Monopolistically-competitive Exporter Facing a Depreciation



Note: Costs (in dollars) fall, price falls slightly, and quantity increases.

With elastic demands, the incentive to adjust prices in response to cost changes increases significantly. This is because profits increase proportionally more when the exporter adjusts, given greater sensitivity of demand. In other words, high demand elasticities naturally induce more price flexibility.

In equilibrium, however, despite price flexibility, optimal prices only move a small amount. Elastic demand leads to a shallow slope of the demand curve, so the overall dollar price adjustment is small. The optimal price moves from P to P′, far smaller than the initial depreciation. Yet the quantity demanded adjusts by a large margin: from Q to Q′.

As in the case of the commodity-exporter, the lack of price response is unrelated to nominal stickiness. Instead there is minimal reduced form pass-through of the depreciation because the firm moves along the upward-sloping marginal cost curve. The equilibrium quantity adjustment will again depend crucially on supply capacity.

3. Motivating Empirical Observations

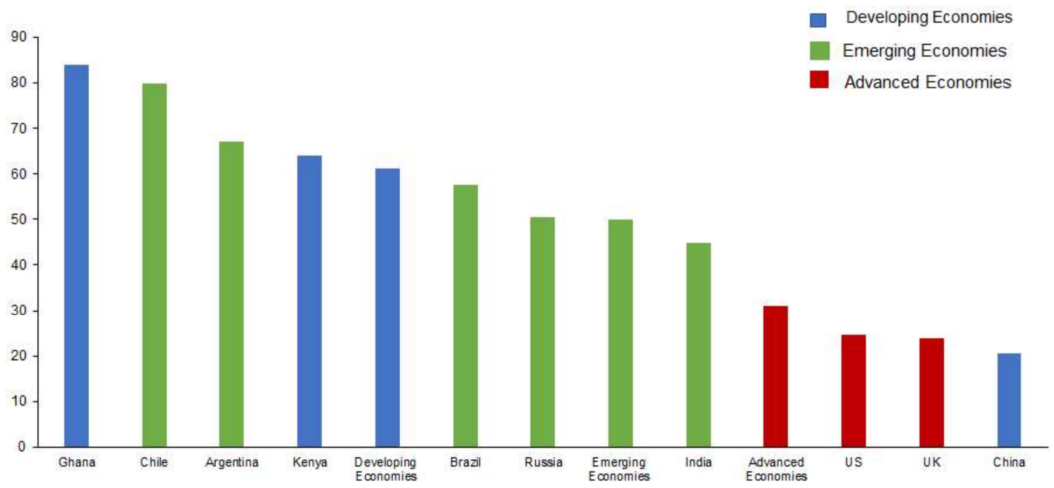
This section discusses the three empirical observations that motivate our assumptions and their deviation from the DCP premises of monopoly power and price stickiness.

Fact 1. Homogeneous products (sold in competitive markets) represent a large share of exports in low- and middle-income economies The share of commodities or commodity-like products sold in highly competitive export markets varies across countries. This is illustrated in Figure 4, which shows the share of homogeneous products in total exports, in selected countries at different levels of development. Following the classification proposed by Rauch (1999), homogeneous products are defined as those traded in organised exchanges or reference priced.[7] The chart shows averages from 1990 to 2015. The figure also shows the averages by income groups, according to the the World Bank's income-level classification in 2020.

As the Figure shows, low- and middle-income countries have average export shares of homogeneous products of around 50 percent or higher, while high-income countries

[7] Trade data come from the UN Comtrade 4-digit database.

Figure 4: Homogeneous goods share of exports, 1985-2015 average



Source: UN Comtrade

are on average somewhat below 40 percent. Sub-Saharan Africa, Latin America and the Caribbean, and the Middle East and North Africa are all characterised by shares of homogeneous products that exceed 50 percent of their total exports.

Fact 2. Goods sold in competitive markets (with high-demand elasticity) tend to have more flexible prices This empirical fact is grounded on a solid theoretical reason: with high demand elasticities, price stickiness is more costly for sellers. The strong empirical association between price flexibility and the degree of competition or of product homogeneity has been documented by multiple studies in different countries. Bils and Klenow (2004), using data from the US Bureau of Labour Statistics on consumer and goods expenditures, show that more homogeneous goods (such as fresh food and energy), display a much higher frequency of price adjustment than more differentiated goods and services. They also report that more competitive products, where competition is proxied by an inverse measure of sectoral concentration, display much more frequent price adjustments. This is corroborated by Nakamura and Steinsson (2008), who document that homogeneous goods sold in more competitive markets have a higher price change frequency. In particular, they find that the median monthly frequency of price change for finished-good producer prices is 10.8 percent, compared to 98.9 percent for crude materials. (Similar findings are documented in earlier work by Blinder et al., 1998; Carlton, 1986).

Studies for euro-area countries by Vermeulen et al. (2012), Dhyne et al. (2006), Cornille and Dossche (2006), Hernando and Alvarez (2004) and Fabiani et al. (2004) find that a higher degree of competition (proxied by different variables across studies) results in more flexible price adjustment. In particular, prices of energy and food are changed at significantly higher frequency than non-energy and services prices. Lach and Tsiddon (1992) and Konieczny and Skrzypacz (2005) find similar results for Israel and Poland, respectively. Gautier et al. (2022) also find that euro-area prices are more flexible for goods consisting of a higher share of energy and raw material inputs.

These differences in price flexibility across sectors are also evident in developing and emerging economies. Gouvea (2007) studies the micro data underlying Brazil's CPI basket and documents that more homogeneous products tend to display more frequent price adjustments. Overall, Gouvea (2007) also finds a higher frequency of price adjustment in Brazil than in advanced economies. Alvarez et al. (2018) find similar results for Argentina, recording a higher frequency of price changes among homogenous good sectors and a higher frequency of adjustment overall. Nchake et al. (2015) document analogous patterns for Lesotho.

To the extent that developing and emerging economies produce more homogeneous goods, price flexibility should be more prevalent in these economies and hence flexibility should be a fitting model assumption.

Fact 3. Invoicing in vehicle currency is more prevalent in homogeneous, competitive-good sectors. Seminal insights on vehicle currencies by McKinnon (1979), Carse et al. (1979), and Magee and Rao (1980) emphasise that invoicing in vehicle currency is more prevalent in homogeneous, competitive good sectors and, in particular, primary commodity markets. This is tightly related, in turn, to the high degree of price flexibility in those markets. Magee and Rao (1980) highlight the economic value of continuous price monitoring in highly competitive sectors made possible by the use of vehicle currency. A premise in their work is that dollar invoicing does not imply sticky prices; on the contrary, vehicle-currency invoicing is used to facilitate the continuous international comparability and price adjustments characteristic of competitive, homogeneous product sectors.

In groundbreaking empirical work, Goldberg and Tille (2008) show that vehicle-currency invoicing is more prevalent in homogeneous good sectors (like commodities) that tend to be reference priced or traded in organized exchanges. As the authors explain, the prevalence of the dollar in trade flows that do not involve the United States reflects trade in homogeneous products where firms need to keep their price in line with their competitors. Using micro-level data on Canadian imports, Goldberg and Tille (2008) show that the likelihood of vehicle-currency pricing is higher for exporters selling homogeneous goods (vis-a-vis sellers of differentiated products) and decreases with the market share of the exporting country. The use of a vehicle currency, combined with flexibility in price adjustment, allows sellers to reduce price differences with their competitors. By contrast, producers of more differentiated products have more pricing power and care less about relative price movements from their competitors.

In related work, Gopinath et al. (2010) using BLS import price data for the United States show that dollar pricing is more prevalent in homogeneous-good sectors such as 'Animal or Vegetable Fats and Oils', 'Wood and articles of Wood' and 'Mineral Products'. On the other hand, differentiated goods are more commonly priced in the exporters' own currencies.

A corollary of Fact 1 and Fact 3 is the well-known observation that vehicle-currency invoicing is much more prevalent in developing and emerging countries. Importantly, from Fact 2 and Fact 3, and as emphasised in Magee and Rao (1980), vehicle-currency invoicing should be associated with higher price-flexibility.

These three facts challenge the key assumptions underpinning sticky-price DCP models, particularly for developing and emerging countries – namely, monopoly power in export markets and sticky dollar prices. First, developing and emerging countries tend to export homogeneous products, which are associated with high competition (or high demand elasticity), rather than monopoly power. Second, the high competition and high demand elasticity in turn lead to price flexibility, not price stickiness, as the profit incentive to adjust prices (even if marginally) is stronger under more elastic demands. Finally, homogeneous goods sold in competitive markets require flexible-price vehicle-currency invoicing, not sticky-price vehicle-currency invoicing.

4. A Model of the Export Channel

This section presents a new open economy macroeconomic model that we use to study the export channel of monetary policy transmission. It sets a model that has dominant, dollar currency pricing, and production using imported intermediate inputs, in line with the key features of the recent New Keynesian DCP literature. But we also include a flexible market structure that permits intra-sector international competition, and heterogeneity in the degree of price stickiness.

We calibrate the model to represent a typical emerging or developing small open economy, particularly if a commodity exporter. Simulating the model economy's response to a monetary policy shock leads to a strong response of exports to a monetary policy-induced depreciation, matching the allocative properties of standard PCP frameworks, rather than sticky-price DCP models. We discuss the appropriate calibration for an advanced economy, highlighting that similar intuition may still follow through in many cases. Finally, we explore the mechanism, highlighting the crucial roles of supply constraints and price flexibility.

4.1. Households

A unit mass of households indexed by h in the home country, j, has lifetime expected utility given by

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{C_{j,t}^{1-\sigma_c}}{1-\sigma_c} - \frac{N_{j,t}(h)^{1+\varphi}}{1+\varphi} \right), \tag{1}$$

where $C_{j,t}$ is total consumption; $N_{j,t}(h)$ is labour supply; σ_c is the coefficient of relative risk aversion and the reciprocal of the intertemporal elasticity of substitution; and φ is the reciprocal of the labour supply elasticity.

Total consumption has a nested CES structure, as in Feenstra et al. (2018), which allows for a distinction between the elasticity of substitution between different goods or industries, and the elasticity of substitution between different varieties of the same good produced at home or abroad.[8] This reverses the nested CES structure often used in the open-economy macro literature (e.g. Galí and Monacelli, 2005), which allows substitution between baskets of goods produced in different countries, but does not permit competition at a lower level of aggregation. A household in country j consumes a bundle of goods given by

$$C_{j,t} \equiv \left(\int_0^1 C_{j,t}(g)^{\frac{\sigma-1}{\sigma}} dg \right)^{\frac{\sigma}{\sigma-1}}, \tag{2}$$

where σ is the elasticity of substitution across different goods or industries. Within each category g, consumption consists of different varieties produced either at home (country j) or abroad (in all countries $i \neq j$). Each country produces a set of varieties of each good of measure $|\Omega_i^g|$, all of which may be sold domestically, but potentially also as exports in each other country.

[8] The idea of variable cross-country competition for different products was set out by Armington (1969); similar demand setups are used in Eaton and Kortum (2002) and Feenstra et al. (2018).

Consumption of good g in the home country j is given by

$$C_{j,t}(g) \equiv \left(\sum_i \left(\frac{\gamma_{ij}^g}{|\Omega_i^g|} \right)^{\frac{1}{\eta^g}} \int_{\omega \in \Omega_i^g} C_{ij,t}^g(\omega)^{\frac{\eta^g - 1}{\eta^g}} d\omega \right)^{\frac{\eta^g}{\eta^g - 1}}, \tag{3}$$

where $C_{ij,t}^g(\omega)$ denotes consumption by home (j) households of variety ω, of good g, produced (and exported) by country (i). For $i = j$, this consists of domestically produced varieties. The elasticity of substitution between domestic and foreign varieties, as well as between different varieties within a country is given by η^g, which may vary for different types of good. The parameter γ_{ij}^g captures a preference for varieties of the good produced in country i, with $\sum_i \gamma_{ij}^g = 1$ and γ_{jj}^g representing home bias, arising directly from consumer preferences or proxying for trade and distribution costs associated with exporting. A value of $\gamma_{jj}^g = 1$ therefore implies that good g is a non-tradable good for country j, while $\gamma_{ij}^g = 0$ implies it is not exported from country i to country j.

These indices imply consumption demand in country j of

$$C_{j,t}(g) = \left(\frac{P_{j,t}(g)}{P_{j,t}} \right)^{-\sigma} C_{j,t} \tag{4}$$

for good g and of

$$C_{ij,t}^g(\omega) = \frac{\gamma_{ij}^g}{|\Omega_i^g|} \left(\frac{P_{ij,t}^g(\omega)}{P_{j,t}(g)} \right)^{-\eta^g} C_{j,t}(g) \tag{5}$$

for variety ω of good g, produced in country i, where $P_{ij,t}^g(\omega)$ is the price of the good (in j currency). $P_{j,t}(g)$ is a (j currency) price index for varieties of good g, defined as

$$P_{j,t}(g) \equiv \left(\sum_i \frac{\gamma_{ij}^g}{|\Omega_i^g|} \int_{\omega \in \Omega_i^g} P_{ij,t}^g(\omega)^{1-\eta^g} d\omega \right)^{\frac{1}{1-\eta^g}}. \tag{6}$$

And the country j consumer price index is given by

$$P_{j,t} \equiv \left(\int_0^1 P_{j,t}(g)^{1-\sigma} dg \right)^{\frac{1}{1-\sigma}}. \tag{7}$$

Imposing $\eta^g = \sigma$ would imply a market structure similar to standard DCP models suchs as Gopinath et al. (2020) or Egorov and Mukhin (2023). In those models, there is no distinction between different varieties of the same good, on the one hand, and different goods or industries, on the other. In our more general setup, the degree of international competition influences the scope for substitution between different varieties.

In our model, the influence of different relative prices, and so of exchange rates, will vary across different goods. At one extreme, consumer goods with a high degree of brand loyalty (e.g. some types of car), or highly specialised intermediate inputs (e.g. some types of computer software), are likely to have low values of η^g. For these goods, the price relative to other goods in the CPI $\left(\frac{P_{j,t}(g)}{P_{j,t}} \right)$ will be the main determinant of demand. At the other extreme, for highly homogeneous goods such as commodities, $\eta^g >> \sigma$ is likely. The key relevant price will be the price relative to other varieties $\left(\frac{P^g_{ij,t}(\omega)}{P_{j,t}(g)} \right)$, including those produced abroad. At the limit $\eta^g \to \infty$, goods are perfectly competitive, and any fluctuations in exchange rates in a single producing country is likely to be met by an offsetting adjustment in domestic currency price.

Exchange rates. We use $\mathcal{E}_{ij}$ to denote the price of currency i in currency j, such that an increase in $\mathcal{E}_{ij}$ implies a depreciation of currency j against i. A key exchange rate in the model is the bilateral exchange rate against the dominant, vehicle currency, which we assume is the dollar. The price of dollars in currency j is given by $\mathcal{E}_{\$j}$.

Asset markets. Domestically, consumers have access to a full set of state-contingent securities (in zero net supply), with $B_{j,t}$ denoting domestic debt repaid by consumers in country j at the beginning of period t. $B_{j,t+1}(s)$ denotes newly issued one-period domestic debt, to be repaid in period $t+1$ in state $s \in S$, where S is the set of all possible states. Internationally, there is no risk sharing across countries, with consumers having access only to risk-free securities in US dollars, with dollar debt given by $B^{\$}_{j,t}$.

Wage setting. As in Erceg et al. (2000), each household is a monopoly supplier of differentiated labour, denoted $N_{j,t}(h)$, at wage rate $W_{j,t}(h)$.[9] Labour is bundled together for use in production using an index:

$$L_{j,t} = \left(\int_0^1 N_{j,t}(h)^{\frac{\vartheta-1}{\vartheta}} dh \right)^{\frac{\vartheta}{\vartheta-1}}. \tag{8}$$

Cost minimisation by firms or a labour aggregator, taking the wage rate as given, gives differentiated labour demand of:

$$N_{j,t}(h) = \left(\frac{W_{j,t}(h)}{W_{j,t}} \right)^{-\vartheta} L_{j,t}, \tag{9}$$

where $W_{j,t} \equiv \left(\int_0^1 W_{j,t}(h)^{1-\vartheta} dh \right)^{\frac{1}{1-\vartheta}}$ is the aggregate wage index. Households are subject to a Calvo (1983)-type friction in wage-setting in domestic currency, and may only change their wage each period with probability $1 - \delta_w$.

Households in country j maximise (1) by choosing a sequence of consumption, wage and debt positions $\{C_{j,t}, W_{j,t}(h), \{B_{j,t+1}(s)\}_{s\in S}, B^{\$}_{j,t+1}\}_{t=0}^{\infty}$, subject to labour demand (9) and the sequence of budget constraints:

$$P_{j,t}C_{j,t} + \mathcal{E}_{\$j,t}(1 + i^{\$}_{j,t})B^{\$}_{j,t} + B_{j,t} = W_{j,t}(h)N_{j,t}(h) + \Pi_{j,t} + \mathcal{E}_{\$H,t}B^{\$}_{j,t+1} + \sum_{s\in S} Q_{j,t+1}(s)B_{j,t+1}(s), \tag{10}$$

[9] We drop the index h for consumption, since domestic risk-sharing means that $C_{j,t}(h) = C_{j,t}$ for all $h \in (0,1)$.

where $\Pi_{j,t}$ are lump-sum profits redistributed from domestic firms; $Q_{j,t+1}(s)$ is the period t price of debt that pays one unit of currency in state s in period $t+1$ and $i^{\$}_{j,t}$ is the dollar interest rate paid on internationally traded debt in country j.[10]

Defining the risk-free domestic interest rate ($1 + i_{t+1} \equiv \frac{1}{\sum_{s \in S} Q_{j,t+1}(s)}$) as the inverse of the price of one-period debt that pays one unit of domestic currency in any state of the world, then the maximisation implies a standard intertemporal Euler equation:

$$C_{j,t}^{-\sigma_c} = \beta(1 + i_{j,t+1})\mathbb{E}_t \left(C_{j,t+1}^{-\sigma_c} \frac{P_{j,t}}{P_{j,t+1}} \right) \tag{11}$$

A similar condition for the internationally traded bond implies an uncovered interest parity condition:

$$(1 + i_{j,t+1}) = (1 + i^{\$}_{j,t+1})\mathbb{E}_t \left(\frac{\mathcal{E}_{\$j,t+1}}{\mathcal{E}_{\$j,t}} \right) \tag{12}$$

The optimality condition for wage setting in period t is given by

$$\mathbb{E}_t \sum_{s=0}^{\infty} (\beta\delta_w)^s N_{j,t+s}(h) C_{j,t+s}^{-\sigma_c} \left[\frac{\overline{W}_{j,t}(h)}{P_{j,t+s}} - \frac{\vartheta}{\vartheta - 1} N_{j,t+s}(h)^{\varphi} C_{j,t+s}^{\sigma_c} \right] = 0 \tag{13}$$

where $\overline{W}_{j,t}(h)$ is the optimal reset wage in period t.

4.2. Firms

Firms produce using labor and intermediate inputs, taking wages, input prices and their industry's total factor inputs as given. Firms are monopolistically competitive and prices are also staggered, for sticky-price sectors, following Calvo (1983). The production function of a firm in country j producing variety ω of good g is given by:

$$Y_{j,t}^{g}(\omega) = A_{j,t}^{g} (L_{j,t}^{g}(\omega))^{1-\alpha} (X_{j,t}^{g}(\omega))^{\alpha} \left[(L_{j,t}^{g})^{1-\alpha} (X_{j,t}^{g})^{\alpha} \right]^{\nu_g - 1} \tag{14}$$

[10]Following Schmitt-Grohe and Uribe (2003), we allow for a country-specific risk premia on the bond to ensure stationarity of the linearised model.

$A^g_{j,t}$ is the productivity for good g; $X^g_{j,t}(\omega)$ the use of intermediate inputs by the firm producing variety ω, and $L^g_{j,t}(\omega)$ its labour input, with α and $(1-\alpha)$ their respective shares in the production process. $X^g_{j,t} \equiv \int_{\omega \in \Omega^g_j} X^g_{j,t}(\omega) d\omega$ and $L^g_{j,t} \equiv \int_{\omega \in \Omega^g_j} L^g_{j,t}(\omega) d\omega$ are the total use of each input by the industry producing good g. $\nu_g \leq 1$ determines returns to scale for that sector, with decreasing returns for $\nu_g < 1$ and constant returns for $\nu_g = 1$. Decreasing returns at the industry level are a simple way of capturing the features that are likely to lead to an upward-sloping marginal cost curve, including segmented factor markets, or a fixed (good-specific) factor of production such as land or (in the short run) capital.

Firms use domestic and imported varieties of consumption goods as intermediate inputs, with $X_{j,t}$ taking an identical form to the consumption aggregator:

$$X_{j,t} \equiv \left(\int_0^1 X_{j,t}(g)^{\frac{\sigma-1}{\sigma}} dg \right)^{\frac{\sigma}{\sigma-1}}, \tag{15}$$

where the index (g) refers to the consumption good used, and we omit the indices for the good and variety being produced.

Combining the resulting intermediate input demands with consumption demand given by (4) and (5) leads to overall export demand of variety ω produced in country j and exported to country i of:

$$Y^g_{ji,t}(\omega) = \frac{\gamma^g_{ji}}{|\Omega^g_j|} \left(\frac{P^g_{ji,t}(\omega)}{P_{i,t}(g)} \right)^{-\eta^g} \left(\frac{P_{i,t}(g)}{P_{i,t}} \right)^{-\sigma} (C_{i,t} + X_{i,t}), \tag{16}$$

where $P^g_{ji,t}(\omega)$ is the price in i currency. For country j, $Y^g_{jj,t}(\omega)$ is domestic demand for the variety.

Pricing. Each firm sets prices in each market separately, potentially subject to a Calvo friction. For each good, firms in each country set prices either in dollars (DCP), given by $P^{g,\$}_{ji,t}(\omega)$ or in in their own currency (producer currency pricing, or PCP), given by

$P^{g,j}_{ji,t}(\omega)$. In a given period, each firm is able to optimally reset prices with a good-specific probability $1-\delta^g_p$. The good-specific probability allows for hetereogeneity in the degree of nominal rigidities across different types of goods, in line with the microeconomic evidence.

Per period profits for producer pricing varieties in country j are given by

$$\Pi_{j,t}(\omega) = \sum_i \left(P^{g,j}_{ji,t}(\omega) Y^g_{ji,t}(\omega) - MC_{j,t} Y^g_{ji,t}(\omega) \right), \tag{17}$$

where $MC_{j,t}$ are marginal costs. For dollar pricing varieties, it is convenient to express per period dollar profits as

$$\Pi^{\$}_{j,t}(\omega) = \sum_i \left(P^{g,\$}_{ji,t}(\omega) Y^g_{ji,t}(\omega) - \frac{MC_{j,t} Y^g_{ji,t}(\omega)}{\mathcal{E}_{\$j,t}} \right), \tag{18}$$

where for each export location, the first term is total dollar revenues, and the second term is total dollar costs.

Firms maximise expected discounted profits in any currency by posting a separate price in each export destination i, subject to demand (16) and the identity $P^g_{ji,t}(\omega) = \mathcal{E}_{ki,t} P^{g,k}_{ji,t}(\omega)$, which converts the local currency i price to the invoicing currency price for each pricing currency $k = j, \$$. For producer-currency pricing firms, profit maximisation in period t gives the optimal reset price satisfying

$$\mathbb{E}_t \left[\sum_{s=0}^{\infty} (\beta \delta^g_p)^s \frac{C^{\sigma_c}_{j,t} P_{j,t}}{C^{\sigma_c}_{j,t+s} P_{j,t+s}} Y^g_{ji,t+s}(\omega) \left(\overline{P}^{g,j}_{ji,t}(\omega) - \frac{\eta^g}{\eta^g - 1} MC_{j,t+s} \right) \right] = 0, \tag{19}$$

with the producer-currency price set equal to a mark-up $\frac{\eta^g}{\eta^g-1}$ over a weighted average of future marginal costs. A similar condition holds for dollar-pricing firms:

$$\mathbb{E}_t \left[\sum_{s=0}^{\infty} (\beta \delta^g_p)^s \frac{C^{\sigma_c}_{j,t} P_{j,t}}{C^{\sigma_c}_{j,t+s} P_{j,t+s}} Y^g_{ji,t+s}(\omega) \left(\overline{P}^{g,\$}_{ji,t}(\omega) - \frac{\eta^g}{\eta^g - 1} \frac{MC_{j,t+s}}{\mathcal{E}_{\$j,t+s}} \right) \right] = 0, \tag{20}$$

with dollar prices set as a mark-up over the weighted average of future dollar marginal costs.

Since the period t optimal dollar reset price can also be expressed as $\overline{P}^{g,\$}_{ji,t}(\omega) = \frac{\overline{P}^{g,j}_{ji,t}(\omega)}{\mathcal{E}_{\$j,t}}$, then (20) implies that the dollar reset price will only differ from the optimal producer-currency reset price when the dollar exchange-rate ($\mathcal{E}_{\$j,t}$) is expected to appreciate or depreciate in periods $s > t$. Given the UIP condition, this occurs whenever the domestic interest rate differs from the dollar interest rate. Under flexible prices ($\delta^g_p \to 0$), the invoicing currency becomes irrelevant, since current period dollar prices depend only on current period dollar marginal costs.

Costs. Cost minimisation each period, subject to (14), gives the marginal cost of producing good g, variety ω: in terms of labour input,

$$MC^g_{j,t}(\omega) = \frac{W_{j,t}L_{j,t}(\omega)}{(1-\alpha)Y^g_{j,t}(\omega)}; \tag{21}$$

and intermediates,

$$MC^g_{j,t}(\omega) = \frac{P_{j,t}X_{j,t}(\omega)}{\alpha Y^g_{j,t}(\omega)}. \tag{22}$$

Combining the two conditions gives

$$MC^g_{j,t}(\omega) = MC^g_{j,t} = \frac{1}{(1-\alpha)^{1-\alpha}\alpha^{\alpha}} \frac{W^{1-\alpha}_{j,t} P^{\alpha}_{j,t} [L^{1-\alpha}_{j,t} X^{\alpha}_{j,t}]^{1-\nu^g}}{A^g_{j,t}}, \tag{23}$$

with marginal costs, and the optimal input shares, therefore the same across different varieties of the same good produced in the same country. These marginal costs are increasing in industry output of the good if $\nu^g < 1$.[11]

[11]Strictly, our upward sloping marginal cost curves shown in the stylised charts in Section 2 therefore arise in the model at the domestic industry level, rather than at the individual firm or variety level. Under fully flexible prices, however, our specification is equivalent, to a log-linear approximation, to assuming decreasing returns and upward sloping marginal costs at the individual firm level.

4.3. Monetary policy and market clearing

We close the model using a simple inflation-targeting Taylor rule specification for monetary policy in each country, given by:

$$\frac{1+i_{j,t}}{1+i_j^*} = \left(\frac{1+i_{j,t-1}}{1+i_j^*}\right)^{\rho} (1+\pi_{j,t})^{(1-\rho)\phi_\pi} \zeta_{j,t}, \tag{24}$$

where ρ is a parameter determining policy smoothing, $\phi_\pi > 1$ is the response to deviations of inflation from target, i_j^* is the steady state equilibrium nominal interest rate in country j, and $\zeta_{j,t}$ is an AR(1) monetary policy shock in j.

Market clearing for each variety produced in country j gives

$$Y_{j,t}^g(\omega) = \sum_i Y_{ji,t}^g(\omega). \tag{25}$$

While in factor markets:

$$L_{j,t} = \int_0^1 L_{j,t}^g dg, \tag{26}$$

and

$$X_{j,t} = \int_0^1 X_{j,t}^g dg, \tag{27}$$

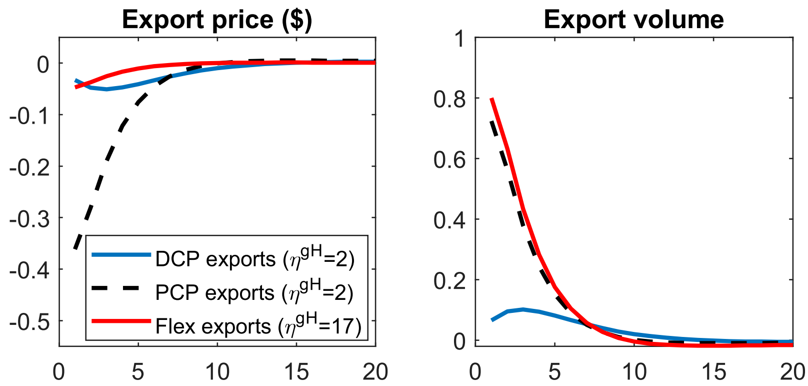
where g refers to the good being produced.

4.4. The export channel of monetary policy transmission

This section simulates the model under different assumptions for pricing and demand. We compare across different models in response to a monetary-policy loosening. The results illustrate how our model restores the strong export response to exchange-rate depreciations of the classic PCP models. But it does so while also matching the empirical findings of limited exchange-rate pass through and terms-of-trade fluctuations.

Our headline result is shown in Figure 5. We simulate three models in response to

Figure 5: Export responses to a home monetary policy shock under different models



Note: IRFs to a 25 basis point negative monetary policy shock. The results are generated under the calibration shown in Table 1.

a monetary policy loosening that generates an exchange-rate depreciation. Our flexible price exports model with intra-sector international competition is shown in solid red lines. For comparison, we show a standard producer-currency pricing (PCP) model along the lines of Obstfeld and Rogoff (1995) in black dashed lines; and a benchmark sticky-price dominant currency pricing (DCP) model along the lines of Gopinath et al. (2020) in solid blue lines.

Our model replicates the allocative properties of the Obstfeld and Rogoff (1995) PCP framework: export volumes increase strongly in response to a depreciation. But we get this despite a limited price response, similar to the sticky-price DCP framework. Taken together, our results suggest that one should be cautious in drawing conclusions about the response of export volumes to exchange rates from their price.

The rest of this section delves into the mechanism in more detail. We begin by discussing the calibration of the model simulations, including our assumptions on trading patterns for different types of good. We then show the full set of simulated responses following a monetary-policy shock in the different models. And we explain in detail the mechanisms underlying these different results.

Calibration. To illustrate our results and mechanisms, we first calibrate the model to represent a small, open emerging or developing economy. We use a simplified market structure, similar to that used in Egorov and Mukhin (2023). We think of this as particularly relevant to economies who export commodities or relatively homogeneous products. We allow for three types of goods. More homogeneous goods are denoted by g_H, where we permit prices to be flexible, but with international competition leading to a high demand elasticity. The other two types of goods are differentiated and there is monopoly power in their markets, with sticky prices; they are denoted by g_M or g_N; we explain the differences between these two types next.

We use some stylised assumptions on trade patterns: our small open economy has two representative trading partners – the US and the rest of the world. Home represents our developing or emerging economy. It produces its homogeneous goods g_H only for export to the global market. In contrast, its differentiated goods g_N are non-tradable, and consumed entirely at home. It also imports differentiated monopolistic goods g_M from the US and the rest of the world.

The consumption basket of home therefore simplifies to

$$C_{H,t} = \left(\kappa_M C_{H,t}(g_M)^{\frac{\sigma-1}{\sigma}} + (1-\kappa_M) C_{N,t}(g_N)^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}}, \tag{28}$$

where κ_M is the share of home consumption consisting of the differentiated imported good, with the rest of consumption consisting of non-tradables.The intermediate input basket uses the same proportions of goods.

Our calibration sets $\eta_{g_H} >> \eta_{g_M} = \eta_{g_N} = \sigma$, which means that demand for each variety of non-tradables reduces to:

$$Y_{H,t}(\omega)^{g_N} = Y^{g_N}_{HH,t}(\omega) = \frac{1}{|\Omega^{g_N}_H|}\left(\frac{P^{g_N}_{HH,t}(\omega)}{P_{H,t}}\right)^{-\sigma}(C_{H,t} + X_{H,t}), \tag{29}$$

Absent large fluctuations in the global price of the homogeneous export good, demand from the US for each variety is approximately

$$Y^{g_H}_{HU,t}(\omega) \approx \frac{1}{|\Omega^{g_H}_H|} \left(\frac{P^{\$,g_H}_{HU,t}(\omega)}{P^{\$}_{U,t}(g_H)} \right)^{-\eta_{g_H}} \gamma^{g_H}_{HU} \left(C_{U,t} + X_{U,t} \right), \tag{30}$$

with an analagous demand from the rest of the world.

Table 1: Flexible price export model calibration

Parameter	Description	Value
	Household preferences	
β	Discount factor	0.99
σ_c	Risk aversion	2
φ	Frisch elasticity	2
ϑ	Labour demand elasticity	4
	Demand	
σ	Cross-product elasticity	2
κ_M	Import/tradable share in home consumption	0.5
η^{g_N}	Non-tradable cross-variety elasticity	2
η^{g_H}	Home export cross-variety elasticity	17
η^{g_M}	Imported good cross-variety elasticity	2
$\gamma^{g_N}_{HH}$	Home consumption of non-tradables	1
$\gamma^{g_H}_{HH}$	Home consumption of home exports	0
$\gamma^{g_M}_{UH}$	Share of US in home imports	0.5
$\gamma^{g_M}_{RH}$	Share of ROW in home imports	0.5
	Supply	
α	Intermediate share	2/3
ν^{g_N}	Non-tradable returns to scale	1
ν^{g_H}	Home export returns to scale	0.8
A^{g_N}, A^{g_H}	Productivity	1
δ_w	Wage rigidity	0.75
$\delta^{g_N}_p$	Non-tradable good price rigidity	0.75
$\delta^{g_H}_p$	Home export price rigidity	0
$\delta^{g_M}_p$	Imported good price rigidity	0.75
	Monetary policy	
ρ	Taylor rule smoothing	0.4
ϕ_π	Taylor rule inflation weight	1.5

Table 1 gives the full calibration of the model. In line with the type of goods (commodities, or commodity-like goods) exported in many emerging and developing economies, our model assumes that exports are priced flexibly ($\delta^{g_H}_p = 0$) and that they are homogeneous, with $\eta^{g_H} = 17$. This elasticity is the mean elasticity over different products in Broda and Weinstein (2006) for the period 1972-1988. This mean is taken from products classified at the most disaggregated level, which is the measure most relevant for capturing our channel of international competition. Coincidentally, it is also the elasticity the same authors report for the crude oil sector for the same period (at a higher level of aggregation), so it also captures well the market structure for a highly competitive commodity.[12]

We compare this to standard sticky-price models which otherwise have the same calibration. For these models we set $\delta_p^{gH} = 0.75$, consistent with a mean price duration of 1 year. Without intra-sector competition, these models are also equivalent to assuming that $\eta^{gH} = \sigma = 2$. With price stickiness, the currency choice matters, so we compare to two cases: the DCP assumption of exports priced in dollars; and the Mundell-Fleming PCP assumption of exports priced in the home currency.

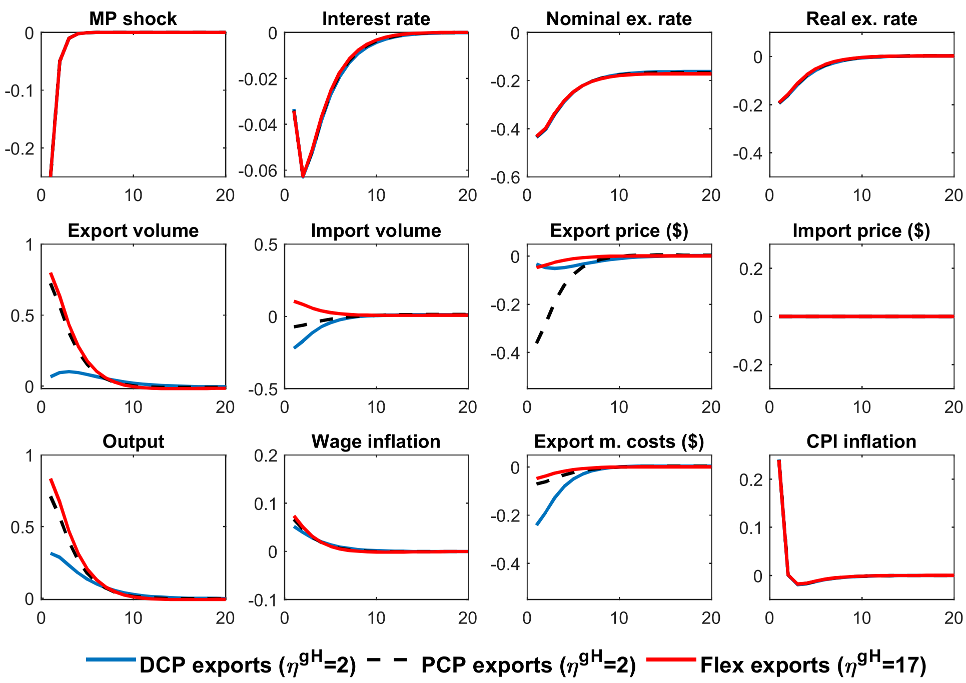
The calibration for most other parameters is standard, in line with the literature or the parameterisation used in Gopinath et al. (2020). One exception is the returns to scale parameter, which, jointly with productivity, pins down the relative size and input shares of the sectors in steady state. We set productivity equal in each sector, normalised to 1. We then assume constant returns to scale in the non-tradable goods, but decreasing returns to scale in the export sector, which ensures it has an upward sloping supply curve curve.[13] We explore the sensitivity to this assumption in the next subsection. Wage stickiness also affects the response of marginal costs to increases in exports: wages are set to be equally sticky to differentiated good prices, also with a mean duration of 1 year.

[12]Figure A.1 shows that the model responses are almost identical using the lower mean elasticity of 13 that Broda and Weinstein (2006) report for the period 1990-2001, and that the export volume response is only somewhat dampened (and price response only somewhat stronger) using a value of 4, the lowest mean elasticity they report, when averaging at the highest level of aggregation.

[13]These assumptions imply that in our model's steady state, the non-tradable and export sectors are similar in size (non-tradable output is 4% larger than exports). The export sector is more resource intensive, using around 65% of total labour and intermediate inputs. In our sticky price DCP and PCP simulations, where the export sector is monopolistic, the same calibration implies a smaller steady-state export sector, with non-tradable output 2.2 times larger than exports; accordingly, only 41% of steady state inputs are used in the export sector.

Full simulation results. Figure 6 shows the full impulse responses from these three different models in response to a 25 basis point monetary policy shock. In all cases, the fall in the interest rate leads to a nominal depreciation of around 0.4%, around half of which unwinds gradually. The exchange-rate depreciation leads to a jump in import prices, since these are not sticky in local currency. This feeds through into an increase in CPI inflation, and means that the real exchange rate depreciation is smaller, given the 50% share of non-tradables in the price basket.

Figure 6: Quarterly impulse responses to a home monetary policy shock under different models



Note: IRFs to a 25 basis point negative monetary policy shock. The results are generated under the calibration shown in Table 1. Inflation and interest rates are shown in quarterly per cent. The nominal and real exchange rates are shown as $\mathcal{E}^{-1}_{\$H,t}$ and $P^{-1}_{H,t}\mathcal{E}^{-1}_{\$H,t}P_{U,t}$ such that a decrease in the plotted exchange rate corresponds to an depreciation of the home currency.

As shown, the responses of export volumes and export prices differ across models. Under producer currency pricing (black dashed lines), the dollar export price falls nearly in line with the nominal depreciation, as exporters are unable to reprice to reflect the weaker exchange rate. This leads to a large expenditure-switching effect driven by US and rest of the world's consumers, so the quantity of exports goes up by 0.7%. The extra expansion in output drives up marginal costs, in part owing to higher wages, and in part to decreasing returns to scale. As a result, dollar marginal costs barely fall despite the depreciation, and exporters' markups are squeezed more than they would optimally choose, absent sticky prices.

Under sticky dollar pricing for exports (blue solid lines), dollar marginal costs fall from the depreciation. But the dollar price is unable to move for most firms, so it changes little, meaning markups rise by more than firms would optimally choose. With little price change, exports increase only marginally – the expenditure-switching channel is switched off. Aggregate output still expands, but this is mainly from a rise in non-tradable output in response to lower real interest rates.

The red solid lines show that our model replicates the price response of the DCP model, but restores the expenditure-switching quantity response of PCP. Export prices fall only a small amount, but this is because there is only a small fall in the optimal reset price, rather than owing to price rigidities. This is consistent with the decomposition of Blanco and Cravino (2020), which shows that the co-movement between nominal and real exchange rates relates to (small) movements in reset prices, rather than sticky prices.

With a high elasticity of substitution across varieties in different countries, even a small price change induces a large expenditure-switching effect, and exports increase by 0.8%, similar to the PCP case. As with PCP, the extra export output drives up dollar marginal costs, offsetting the downward pressure from the depreciation. Equilibrium is restored when marginal cost equates with marginal revenue, which, given the elastic demand curve, is only slightly lower than the original price.

These results turn on their head two of the key mechanisms in the sticky-price dominant-currency pricing framework. First, despite full pass-through to export prices, the net change in export prices is much smaller than the initial depreciation. Reduced form regressions that do not fully account for all changes in marginal cost are therefore likely to over-estimate the role for price stickiness. Second, the key constraint on export output is supply, rather than demand. The expenditure-switching demand channel is as strong as under producer-currency pricing, and output will increase to satisfy demand until it runs into a capacity constraint, for example, in the form of higher input costs, or fixed factors of production.

Table 2 summarises the responses of some of the key variables in the different models, to compare to the empirical results in the next section.

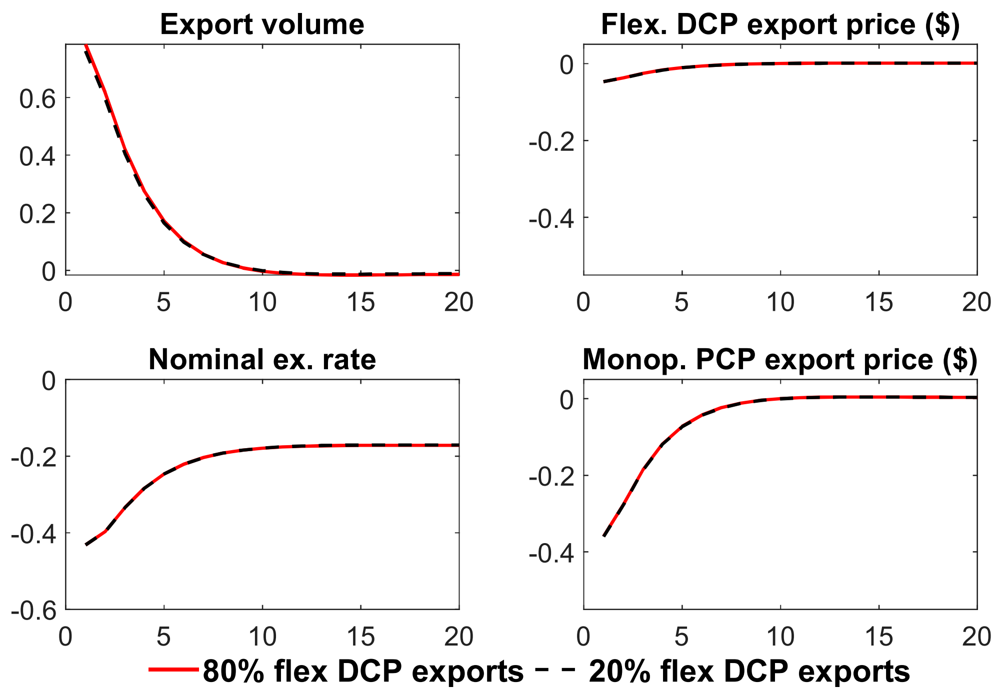
Table 2: Year 1 average responses to exogenous 1pp cut in interest rates

	Sticky producer prices, differentiated exports ($\delta_p^{g_H} = 0.75, \eta^{g_H} = 2$)	**Sticky dollar prices, differentiated exports** ($\delta_p^{g_H} = 0.75, \eta^{g_H} = 2$)	**Flexible prices, homogeneous exports** ($\delta_p^{g_H} = 0, \eta^{g_H} = 17$)
Dollar exchange rate (% depr.)	0.36	0.36	0.36
Annual CPI inflation (end year 1, %)	0.21	0.21	0.21
Output (%)	0.48	0.25	0.52
Dollar export price (%)	-0.24	-0.05	-0.03
Export volume (%)	0.48	0.09	0.54

Varying the share of homogeneous DCP exporters. Our model assumption that all exporting firms sell more homogeneous, flexibly priced goods is a good approximation for many emerging and developing economies, as discussed in Fact 1 of our motivating empirical observations in Section 3. But evidence from advanced economies and some emerging economies is consistent with a mix of homogeneous and more differentiated exports, as shown in Figure 4. Similarly, different firms in advanced economies typically follow different pricing strategies, with different degrees of price flexibility and more than one different currency used (Amiti et al., 2022; Corsetti et al., 2022). Corsetti et al. (2022) further show multiple currencies used within the same firm, even for the same product and export destination.

A corollary of the results presented above, however, is that the implications of our model follow through as long as Facts 2 and 3 from Section 3 hold at the sector, firm, or even product level. That is, as long as products sold using dollars or other vehicle currencies are more homogeneous, flexibly priced goods, then there remains a potent export channel of monetary policy operating via the exchange rate. This can be the case even in advanced economies where there are larger shares of differentiated goods, where producers have more market power, and there are greater nominal rigidities.

Figure 7: Quarterly impulse responses to a home monetary policy shock under different steady state export shares



Note: IRFs to a 25 basis point negative monetary policy shock. The results are generated under the calibration shown in Table 1, with the addition of a second export good sector that produces a differentiated good, g^{H2}*, with sticky home currency prices, calibrated as* $\delta_p^{gH2} = 0.75$*,* $\eta^{gH2} = 2$ *and* $A^{gH2} = 2.2$*. The nominal exchange rate is shown as* $\mathcal{E}^{-1}_{\$H,t}$ *such that a decrease in the plotted exchange rate corresponds to an depreciation of the home currency.*

This point is illustrated in Figure 7, which introduces a second export good into our model. We assume this is differentiated, with prices sticky in the exporting producer's currency. We set the relative productivity of each export sector such that when facing the same steady state global demand, the size of the two sectors is equal.[14] The figure shows impulse responses to a monetary-policy shock when the steady-state share of homogeneous, flexible dollar-pricing firms is 80% (red solid lines), and when it is only 20% (black dashed lines).[15]

Our calibration implies that flexible-price homogeneous firms pricing in dollars and differentiated good PCP firms both expand exports by a similar amount. Consequently, a monetary policy shock that depreciates the currency leads to an almost identical expansion of exports, irrespective of the share of each type of good/firm, shown in the top-left panel. For flexible price goods, the intuition is as before: with highly elastic demand, the expansion occurs with only a small decrease in dollar prices (top-right panel). For differentiated goods, sticky home currency prices mean most of the depreciation passes through into lower dollar prices, so despite a low elasticity, the large price reduction stimulates an export expansion.

These results may be an upper bound on the advanced economy impact, however, since they assume that all differentiated good firms price in domestic currency. In practice the impact of monetary-policy induced exchange-rate movements on exports will depend on the share of differentiated producers that price in either a local or dominant currency. These shares, and therefore the appropriate calibration of our model, will vary across countries and potentially over time. In Belgium, for example, Amiti et al. (2022) find that 37% of differentiated good exports are priced in Euros, compared to 42% in dollars, and the remaining 21% in a third currency, usually a local currency.

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[14] This requires that productivity of the second, monopolistic export good is 2.2 times larger than the more elastic good.

[15] Specifically, we vary relative steady-state demand for each export good by adjusting their relative global demand.

Price flexibility. Our model's calibration of price flexibility is also likely to be a good approximation for many developing and emerging economies, particularly those exporting commodities. For advanced economies, the evidence underlying Fact 2 from Section 3 suggests that while more homogeneous goods and services always have more flexible prices than differentiated goods, median price durations vary across different subcategories. For non-commodity homogeneous goods in advanced economies, price durations of up to two quarters are common.

Assuming slightly longer price durations consistent with some advanced economy observations has relatively little qualitative impact on our main results, however. Even away from the perfectly flexible limit, high elasticity and somewhat flexible prices still generates a significant export quantity response. Intuitively, the response is noticeably lower only for the one or two extra periods in which prices are sticky.[16]

Moreover, product-wide price flexibility can arise even when individual prices are sticky, as long as there is entry of new exporters. This will be likely as potential entrants' products will become more competitive after a depreciation. Firms opting to enter (or re-enter) the market for a particular good can do so at the optimal price, free of any nominal rigidities affecting their competitors. For this reason, estimates of price flexibility using microdata are likely to represent a lower bound for the product-wide flexibility. Our model parameter represents the sum of both the intensive and extensive margins of price adjustment. Bilbiie (2021) presents a model in which complete price flexibility arises from this extensive margin when there is free entry.

To summarise, this section has shown how our model can be used to analyse the richer distribution of demand conditions and pricing strategies for advanced-economy exporters. Crucially, even if there are a greater number of monopolistic or sticky-price firms exporting, as long as dominant currency pricing firms tend

[16] See Figure A.2, which compares results when dollar export prices are fully flexible, to when they are fixed for 2 or 3 quarters.

to have higher demand elasticity and more flexible prices, then DCP is unlikely to have large allocative implications, relative to the PCP benchmark. (Though DCP can help rationalise empirical findings of low pass-through to prices, as, in line with the empirical literature, it is a marker of higher demand elasticities.)

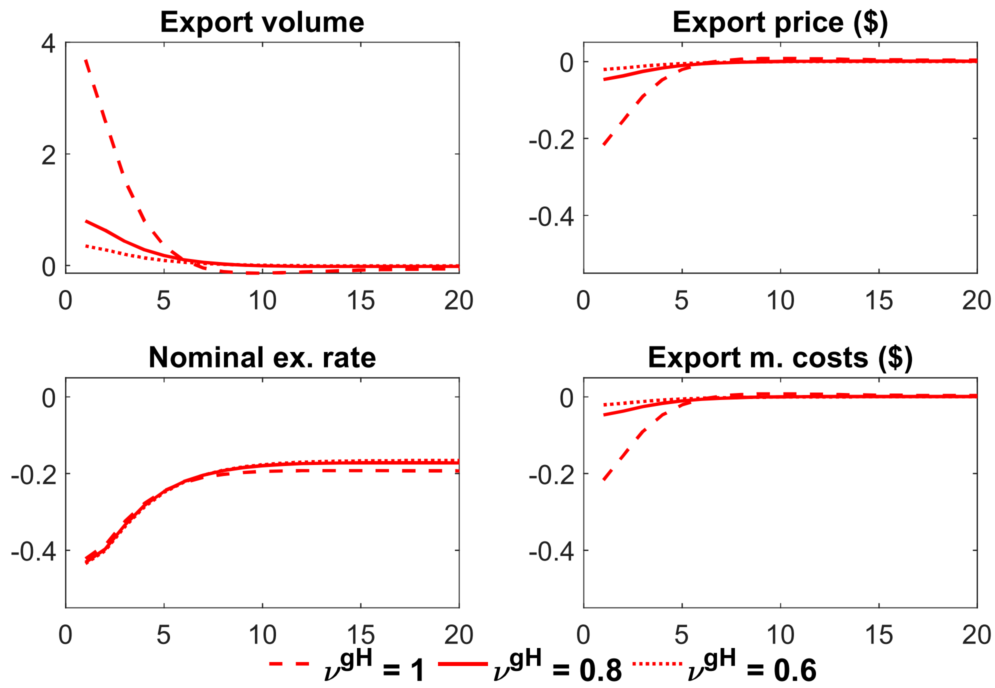
4.5. The role of supply constraints

Given flexible prices, the key constraint for exporters in our model is supply. For an indiviual exporter, as illustrated in Section 2, these constraints can be characterised by the slope of their marginal cost curve. Steeply upward sloping marginal cost limits the response of exports to the exchange-rate or other price movements. This subsection illustrates the sensitivity of the export quantity response to the tightness of those constraints, or the effective slope of the marginal cost curve.

This is illustrated in Figure 8, which returns to an assumption of a single export good, with fully flexible prices and elastic demand. It varies the returns to scale parameter, ν^{gH} in the exporter production function, holding all other parameters fixed. The solid line shows moderately decreasing returns to scale, in line with the calibration used in Figure 6. The dashed line instead shows constant returns to scale in production. And the dotted line shows the response with sharply decreasing returns to scale, implying a sharply increasing marginal cost.

The simulations highlight the importance of this parameter in determining both the export volume and potentially the export price response. Under constant returns to scale, a very large increase in exports occurs, since this feeds back relatively little into marginal costs. Dollar marginal costs fall owing to the depreciation, though this fall is partly offset by higher imported intermediate costs. Under either decreasing returns to scale calibration, there is a further offset of the marginal cost fall from the increase in export volumes, which ultimately limits the size of the price reduction and makes for a smaller rise in exports.

Figure 8: Quarterly impulse responses to a home monetary policy shock under different assumptions on returns to scale



Note: IRFs to a 25 basis point negative monetary policy shock. The results are generated under the calibration shown in Table 1, other than ν^{gH}, which is varied as described. The nominal exchange rate is shown as $\mathcal{E}^{-1}_{\$H,t}$, such that a decrease in the plotted exchange rate corresponds to an depreciation of the home currency.

Our specification for decreasing returns to scale is one that would arise with a fixed factor of production, such as land. But it could also represent many different alternative sources of supply constraints, such as slow-moving capital with adjustment costs, or the frictions associated with reallocating resources across sectors. It is also plausible that these constraints are larger in the short run, but fade over time.

An additional effect that is present in our model is the impact of higher wages. Even with constant returns to scale for each firm or sector, as aggregate exports and output increase, this leads to higher wage inflation, driving up domestic marginal costs and offsetting a small part of the depreciation. With sticky wages, this is small, but as wages become more flexible, the supply constraint arising via this general equilibrium channel increases. At the limit, with fully flexible wages (and prices), dollar marginal costs do not move and the depreciation has no impact. But this effect is quantitatively small in our simulations, given our assumption of wage stickiness.

Our results also have implications for the literature estimating exchange-rate pass-through, as surveyed in Burstein and Gopinath (2014). Good measures of marginal cost are difficult to come by, so the literature typically needs to rely on proxies, if used at all. Our framework implies that doing so risks omitting an important variable that should be correlated with the exchange rate. At a minimum, researchers should be aware that reduced-form regressions seeking to calculate exchange-rate 'pass-through' will often combine the direct pass-through of the exchange-rate movement with any indirect impact on marginal costs from an increase or decrease in export quantities.

5. The Empirical Impact of Depreciations in Emerging and Developing Economies

In this section we conduct a macroeconomic test of the model's predictions. We focus on emerging and developing economies, where dollar pricing is most prevalent. As highlighted by our model results, estimates of exchange-rate pass-through do not differentiate between sticky-price DCP models and our framework, unless one can control perfectly for other changes in domestic marginal costs.

The key difference we have shown between these two models is the response of export volumes to the exchange rate. But as the exchange rate is an endogenous variable, any causal impact will be blurred in the data by a host of other shocks. For example, falls in export demand in our model induce a monetary policy loosening and an associated depreciation. Regressions of export volumes on the exchange rate would blur the positive export response with the initial export fall.

While fully exogenous movements in the exchange rate are hard to come by, we draw on our model prediction that monetary policy shocks that lead to depreciations should boost exports significantly in our model. We therefore seek to test the predictions using their empirical counterpart.

Empirical approach . We use a novel panel database of 39 emerging and developing economies constructed by Brandao-Marques et al. (2021). We follow the authors' methodology, which in turn builds on Jorda (2005)'s local projection model, to study how exogenous changes in monetary policy with their associated changes in exchange rates affect exports and activity. Specifically, as in Brandao-Marques et al. (2021), monetary policy shocks are identified by purging the impact of current macroeconomic conditions, along with expectations of future inflation and activity, on interest rate changes. Monetary policy shocks are obtained as residuals $\hat{\epsilon}_{i,t}$ from an estimated interest-rate rule of the form:

$$\Delta i_{i,t} = \phi_{\pi^f} E_t \pi_i^f + \phi_{y^f} E_t y_i^f + \sum_{j=1}^{2} \phi_\pi \pi_{i,t-j} + \sum_{j=1}^{2} \phi_y \Delta y_{i,t-j} + \sum_{j=1}^{2} \phi_e \Delta NEER_{i,t-j} + \sum_{j=1}^{2} \phi_i i_{i,t-j} + \epsilon_{i,t},$$

where $\Delta i_{i,t}$ is the change in interest rate, $E_t \pi_i^f$ is the forecast for inflation at time t, and $\Delta NEER_{i,t}$ is the nominal effective exchange-rate change.

These monetary shocks are by construction uncorrelated with current or future inflation and activity; as such, they represent an exogenous driver of exchange-rate changes. The question we are interested in assessing is whether a loosening of monetary policy with its associated exchange-rate depreciation leads to an expansion of exports and, more generally, of activity, against the null hypothesis of no change.

To carry out this assessment, we estimate the effects of the monetary policy change on a set macro variables ($y_{i,t+h}$) at each time horizon (h) using Jorda (2005)'s local projection method with country-fixed effects (μ_i^h). The estimated equation is given by:

$$y_{i,t+h} = \mu_i^h + \sum_{j=0}^{2} \gamma_j^h \hat{\epsilon}_{i,t-j} + \delta_0^h \Delta NEER_{i,t} * \hat{\epsilon}_{i,t} + \sum_{j=0}^{2} \beta_j^h * controls_{i,t-j} + \omega_{i,t}^h,$$

where $\omega_{i,t}^h$ captures the estimation residuals. Following this estimation, we report the response functions of the key macroeconomic aggregates resulting from a contractionary stardardised change in the policy impulse, $\gamma_0^h + sd(NEER) * \delta_0^h$.

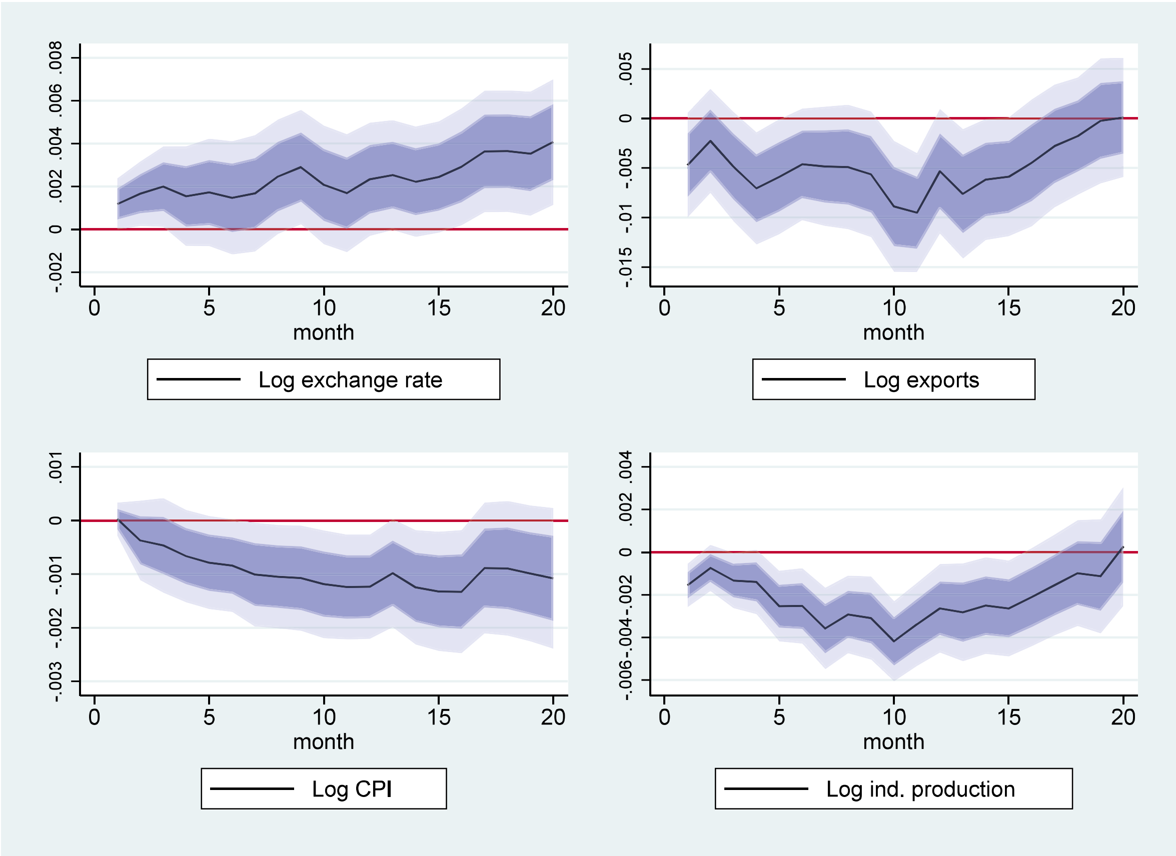
Results. The point estimates of the impulse responses, along with the 68 and 90 percent confidence intervals are displayed in Figure 9. The top left panel shows a sustained appreciation of the exchange rate ranging from 0.2 to 0.4 percent over the period. This is similar in size to the model results summarised in Table 2. The response of dollar exports, plotted in the top-right panel, shows a contraction that peaks (in absolute value) at around 9 percent 12 months after the policy shock. Over the first year the average fall is 0.57%, similar in size to the impulse responses under either PCP or flexible prices for exports.

The responses of the CPI index (bottom-left panel) and industrial production (bottom-right) are in line with most estimates of monetary policy shock impacts in advanced economies. CPI shows a slow fall, reaching the peak impact about 17 months after the shock. The response of industrial production shows a material fall, reaching a peak impact (in absolute value) 10 months after the policy shock.

In comparing the empirical results to the calibrated models, it is clear that the data look closer to either the flexible-price simulation or to PCP, where exports respond strongly to the policy change: a 2 percent appreciation would be associated to a fall in exports of roughly 1.5 percent, in contrast to the sticky-price DCP prediction of almost no change in exports after a comparable appreciation.

Combining these results with one of the key motivating observations of the DCP framework – the lack of measured pass-through of exchange rate changes – helps us choose our DCP model with intra-sector competition ahead of the PCP. But crucially, in this model, as in PCP, there is an important role for exports in the monetary transmission mechanism.

Figure 9: Effect of a monetary tightening shock on Exchange Rate, Exports, CPI and Industrial Production



Note: local projections to a 1 standard deviation negative monetary policy shock. The dark and light shaded areas show 68% and 90% confidence intervals respectively.

We have presented in this section a test exploiting exogenous policy shocks to distinguish the two models that is consistent with the theory. We think the test is better suited to compare the models than the main alternative test suggested in the literature.

Discussion. An alternative test of quantity responses would be to use estimated gravity equations for trade. The test, however, does not allow differentiation between the models presented here. The strategy consists of regressing bilateral trade flows between two countries on both the bilateral exchange rate between the two countries' currencies and on the exchange rates between the exporting country's currency and the dollar (the dollar exchange rate).

However, there are issues with this strategy given the endogeneity of the exchange rates. As highlighted by Gopinath et al. (2020), this makes any causal interpretation of the various exchange-rate coefficients impossible. One particular concern is reverse causality: in periods of weak exports and activity, countries may want to stimulate the economy through an exchange-rate depreciation, driving causality in the other direction.

A different complication concerns misspecification of the gravity equation. As implied by Anderson and van Wincoop (2003)'s seminal contribution, it is not possible to separately identify from bilateral gravity equations between two countries (other than the United States) the impact of one of the country's exchange rate vis-a-vis the dollar (or the currency of other third country not included in the pair). This is because the dollar exchange rate (or any third currency) will pick up a host of other omitted country-specific factors that are relevant determinants of bilateral trade flows. These omitted factors are the reason why typically gravity equations control for country-time fixed effects. The usual approach presents a challenge to using these equations for dominant currencies, as the dollar exchange rate is collinear and fully absorbed by country-time effects.

6. Concluding Remarks

Recent policy and academic work has highlighted the importance of dollar pricing in international trade, particularly in emerging and developing economies. But policy conclusions from existing DCP models also rely on two further premises: monopoly power and sticky prices in export markets. These assumptions appear at odds with the experience of firms that choose to price in dollars, many of whom export commodities, or 'commodity-like' homogeneous goods.

Our more general open economy framework permits greater global competition and price flexibility for some goods, while retaining the assumptions of monopoly power and nominal rigidities for others. Our model can therefore capture the salient features of dollar pricing, including the microeconomic evidence on price flexibility, demand elasticities, and on the use of imported intermediates. Our main results calibrate the model to be consistent with many emerging and developing economies, who are flexible price takers in export markets, with sticky-price monopolistic competition for imports and non-tradables.

These results highlight that these assumptions lead to limited observed exchange-rate pass through – as in the data – even though export prices are flexible. Importantly, export quantities react strongly to exchange-rate movements in our setting, restoring the policy implications of classic PCP models. Identifying this effect on volumes provides an additional, macroeconomic test of the framework, and we provide new empirical evidence in support of it for emerging and developing economies.

We also examine alternative calibrations, more consistent with advanced economies. Even for these economies, as long as dollar pricing is linked with more flexibly-priced, homogeneous goods at the firm level, the export channel of monetary transmission is likely to remain active. Future work could use our model to compare the strength of this channel quantitatively across countries. Overall, our results suggest that monetary policy and the exchange rate can continue to be effective stabilisation tools, even in a world of dollar dominance. The policy implications of dollar pricing may need to be reassessed.

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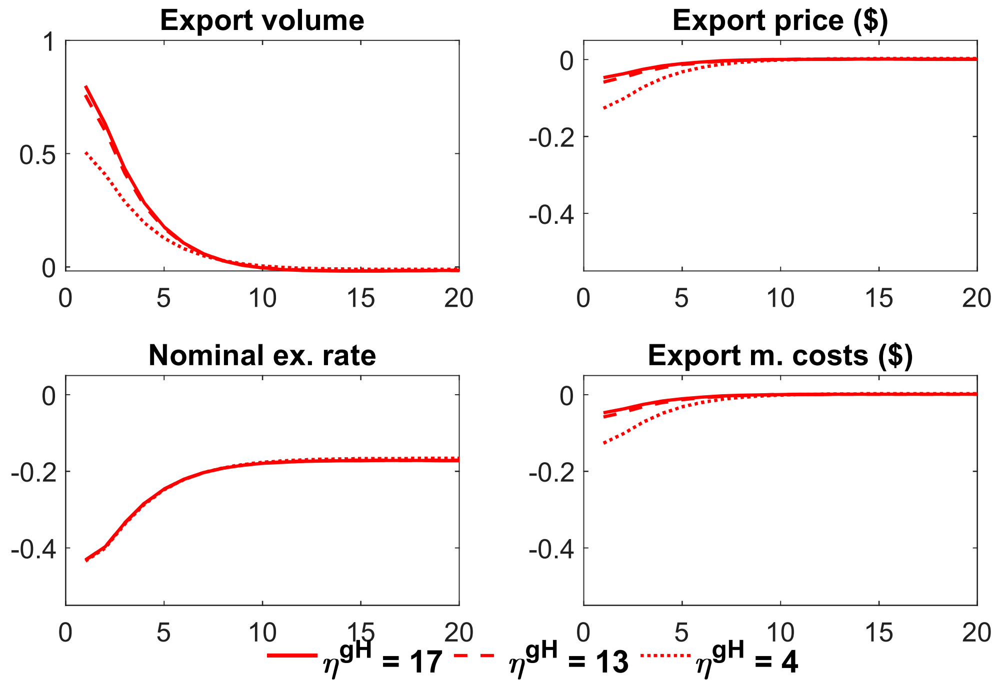
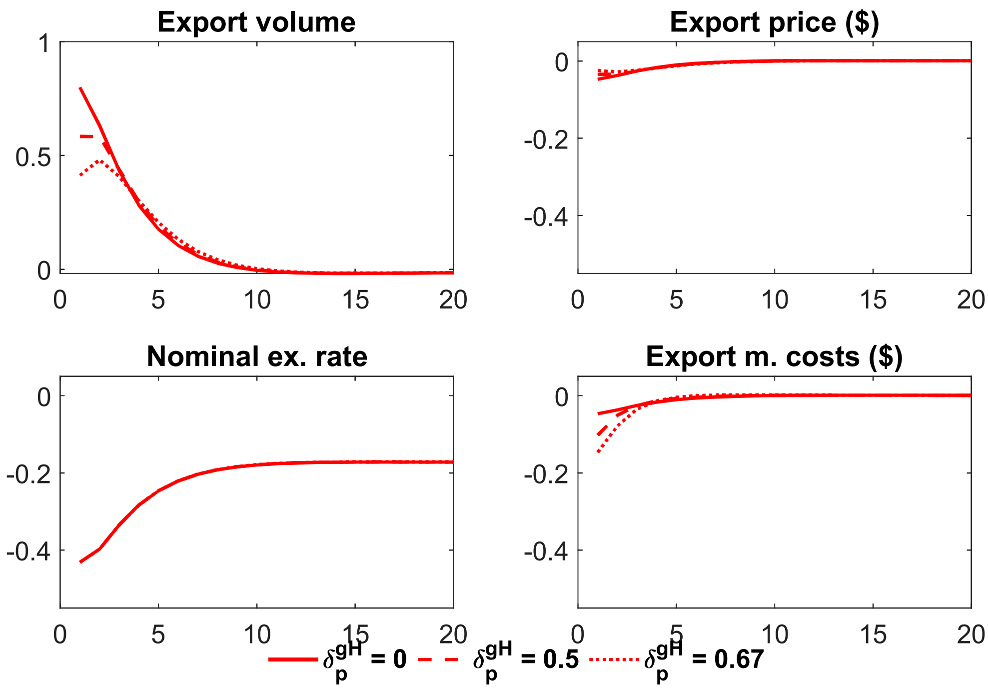
A. Appendix

Figure A.1: Quarterly impulse responses to a home monetary policy shock under different assumptions on export cross-variety elasticity



Note: IRFs to a 25 basis point negative monetary policy shock. The results are generated under the calibration shown in Table 1, other than η^{gH}*, which is varied as described. The nominal exchange rate is shown as* $\mathcal{E}^{-1}_{\$H,t}$*, such that a decrease in the plotted exchange rate corresponds to an depreciation of the home currency.*

Figure A.2: QUARTERLY IMPULSE RESPONSES TO A HOME MONETARY POLICY SHOCK UNDER DIFFERENT ASSUMPTIONS ON DOLLAR EXPORT PRICE STICKINESS



Note: IRFs to a 25 basis point negative monetary policy shock. The results are generated under the calibration shown in Table 1, other than δ_p^{gH}, which is varied as described. The nominal exchange rate is shown as $\mathcal{E}_{\$H,t}^{-1}$, such that a decrease in the plotted exchange rate corresponds to an depreciation of the home currency.