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Dominant-currency pricing and the global output spillovers from US dollar appreciation

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Abstract

Different export-pricing currency paradigms have different implications for a host of issues that are critical for policymakers such as business cycle co-movement, optimal monetary policy, optimum currency areas and international monetary policy co-ordination. Unfortunately, the literature has not reached a consensus on which pricing paradigm best describes the data. Against this background, we test for the empirical relevance of dominant-currency pricing (DCP). Specifically, we first set up a structural three-country New Keynesian dynamic stochastic general equilibrium model which nests DCP, producer-currency pricing (PCP) and local-currency pricing (LCP). In the model, under DCP the output spillovers from shocks that appreciate the US dollar multilaterally decline with an economy's export-import US dollar pricing share differential, i.e. the difference between the share of an economy's exports and imports that are priced in the dominant currency. Underlying this prediction is a change in an economy's net exports in response to multilateral changes in the US dollar exchange rate that arises because of differences in the extent to which exports and imports are priced in the dominant currency. We then confront this prediction of DCP with the data in a sample of up to 46 advanced and emerging market economies for the time period from 1995 to 2018. Specifically, controlling for other cross-border transmission channels, we document that consistent with the prediction from DCP the output spillovers from US dollar appreciation correlate negatively with recipient economies' export-import US dollar invoicing share differentials. We document that these findings are robust to considering US demand, US monetary policy and exogenous exchange rate shocks as a trigger of US dollar appreciation, as well as to accounting for the role of commodity trade in US dollar invoicing.

Keywords: Dominant-currency pricing, US shocks, spillovers.
JEL-Classification: F42, E52, C50.

Non-technical summary

In the classic Mundellian international macroeconomic model it is assumed that export prices are sticky in the producer's currency (producer-currency pricing; PCP). An alternative suggested more recently is to assume that export prices are sticky in the importer's currency (local-currency pricing; LCP). And even more recently, it has been suggested as yet another alternative that export prices are sticky in a dominant currency regardless of their destination, for example in US dollar (dominant-currency pricing; DCP). Importantly, the dynamic relationships between key macroeconomic variables in response to domestic and US shocks are rather different under DCP, PCP and LCP. For example, in contrast to widespread intuitions shaped by the implicit assumption of PCP, changes in an economy's exchange rate do not affect its terms of trade under DCP, and hence play little or even no role in expenditure switching. Also, under DCP pass-through of changes in an economy's exchange rate against the dominant currency is high while that of changes in exchange rates against non-dominant currencies is small. And while a multilateral depreciation of an economy's exchange rate has a limited expansionary impact on its exports, expenditure switching still occurs through imports. And finally, the US dollar exchange rate is driving global trade rather than only transactions in which the US is involved. Because different export pricing paradigms have different implications for a variety of issues including business cycle co-movement and risk sharing, optimal monetary policy, optimum currency areas, and international monetary policy co-ordination, it is critical for academics and policymakers to know which paradigm is relevant in the data.

In this paper we contribute to the literature by providing evidence for the empirical relevance of DCP for a large share of global trade. In particular, based on a structural model we first show that under DCP the output spillovers from a multilateral US dollar appreciation decline with an economy's export-import US dollar pricing share differential, i.e. the difference between the share of an economy's exports and imports that are subject to DCP. The intuition is that as an economy's share of exports that is subject to DCP rises relative to the corresponding share of imports, appreciation of the US dollar will elicit stronger expenditure switching in the economy's trading partners and hence produce a larger decline in its exports than in its imports, which implies that its net exports and thus output will fall more strongly. We exploit this prediction from the model in order to test for the empirical relevance of DCP in the data. In particular, because of the lack of data on economies' export-import US dollar pricing share differentials, we test the joint hypothesis that the data are characterised by partial DCP and that the export invoicing currency coincides with the pricing currency. More concretely, we test empirically whether economies' export-import US dollar invoicing share differentials are negatively related to cross-country differences in the estimated output spillovers from US dollar appreciation.

Specifically, we first estimate the spillovers from US dollar appreciation using two-country

VAR models for up to 46 advanced and emerging market economies for the time period from 1995 to 2018. The two-country VAR models consist of the US and one economy at the time. We identify a positive US demand, contractionary monetary policy and exogenous exchange rate shocks that appreciate the US dollar using standard sign restrictions. In a second step, we run cross-sectional regressions in order to explain the cross-country differences in the estimated output spillovers from US dollar appreciation. Specifically, we regress the output spillovers estimated from the VAR models on the export-import US dollar invoicing share differential. In the regressions we also control for cross-country differences in the susceptibility to other spillover transmission channels that are relevant in the structural model: Economies' susceptibility to bilateral US and multilateral demand channels of spillovers reflected by their overall openness to trade as well as their bilateral trade integration with the US; and differences in the strength of expenditure switching conditional on trade pricing reflected by economies' exchange rate flexibility vis-à-vis the US dollar. Our findings are consistent with the predictions of partial DCP from the theoretical model (and the assumption that the currency of pricing coincides with the currency of invoicing of exports): Economies that exhibit larger export-import US dollar invoicing share differentials exhibit smaller — less positive or more negative — output spillovers from US dollar appreciation. We document that these findings are robust to a range of alternative specifications of the empirical framework both regarding the VAR model and the cross-sectional regressions, including in particular controlling for the importance of commodity trade. Finally, we also consider the spillovers from Euro instead of US dollar appreciation and document that the findings provide less support for partial DCP, which is consistent with what one would expect given the much less prominent role of the Euro in global trade.

1 Introduction

In the classic Mundellian international macroeconomic model it is assumed that export prices are sticky in the producer's currency (producer-currency pricing; PCP Mundell, 1963; Fleming, 1962; Obstfeld and Rogoff, 1995). An alternative suggested more recently is to assume that export prices are sticky in the importer's currency (local-currency pricing; LCP Betts and Devereux, 1996, 2000; Engel, 2000; Devereux and Engel, 2003). And even more recently, it has been suggested as yet another alternative that export prices are sticky in a dominant currency regardless of their destination, for example in US dollar (dominant-currency pricing; DCP Casas et al., 2016; Boz et al., 2017; Gopinath et al., 2019). Importantly, the dynamic relationships between key macroeconomic variables in response to domestic and US shocks are rather different under DCP, PCP and LCP. For example, in contrast to widespread intuitions shaped by the implicit assumption of PCP, changes in an economy's exchange rate do not affect its terms of trade under DCP, and hence play little or even no role in expenditure switching. Also, under DCP pass-through of changes in an economy's exchange rate against the dominant currency is high while that of changes in exchange rates against non-dominant currencies is small. And while a multilateral depreciation of an economy's exchange rate has a limited expansionary impact on its exports, expenditure switching still occurs through imports. And finally, the US dollar exchange rate is driving global trade rather than only transactions in which the US is involved. Because different export pricing paradigms have different implications for a variety of issues including business cycle co-movement and risk sharing, optimal monetary policy, optimum currency areas, and international monetary policy co-ordination, it is critical for academics and policymakers to know which paradigm is relevant in the data.

Against this background, Casas et al. (2016) as well as Boz et al. (2017) provide evidence suggesting that DCP fits the data better than PCP or LCP.[1] Specifically, Casas et al. (2016) analyse customs data from Colombia on exports and imports at the firm level and find that — consistent with the predictions of DCP — pass-through of changes in the US dollar exchange rate to peso import and export prices is large relative to that of changes in bilateral exchange rates, regardless of the origin of imports or the destination of exports. Regarding quantities, Casas et al. (2016) find that following a depreciation of the peso against the US dollar Colombian export quantities to dollar destinations do not fall, that exports to non-dollar destinations do fall, and that imports from both dollar and non-dollar economies fall. As regards exchange rate pass-through to prices, Casas et al. (2016) document that when quantities respond the relevant exchange rate is the peso-dollar and not the bilateral exchange rate. And finally, Casas et al. (2016) find that Colombia's terms-of-trade — when adjusted for commodity prices — are rather stable. Boz et al. (2017) provide similar evidence based on an annual panel dataset of bilateral import and export prices and quantities for 55 economies.

[1] The papers by Casas et al. (2016) as well as Boz et al. (2017) have been combined into Gopinath et al. (2019).

In this paper we contribute to the literature by providing new evidence for the empirical relevance of DCP and by addressing some important shortcomings of existing work. Specifically, we first show that in a standard structural open-economy model under DCP the output spillovers from shocks that appreciate the US dollar multilaterally decline with an economy's export-import DCP share differential, i.e. the difference between the share of an economy's exports and imports that are subject to DCP. The intuition is that as an economy's share of exports that is subject to DCP rises relative to the corresponding share of imports, a multilateral appreciation of the US dollar elicits stronger expenditure switching in the economy's trading partners and hence produces a larger decline in its exports, which implies that its net exports will fall more strongly. We exploit this prediction from the model in order to test for the empirical relevance of DCP in the data. In particular, because of the lack of data on economies' export-import US dollar pricing share differentials, we test the *joint* hypothesis that the data are characterised by DCP and that the export *invoicing* currency coincides with the *pricing* currency. More concretely, we test empirically whether economies' export-import US dollar invoicing share differentials are negatively related to cross-country differences in the estimated output spillovers from shocks that appreciate the US dollar multilaterally. We find that the data are consistent with the hypothesis that a large share of global trade is subject to DCP: Output spillovers from shocks that appreciate the US dollar multilaterally are statistically significantly and negatively related to economies' export-import US dollar invoicing share differentials.

In more detail, we first consider a three-country New Keynesian dynamic stochastic general equilibrium model for the US and the rest of the world. We split the rest of the world in two regions of equal size in order to account for the role of DCP for non-US, third-country trade. Importantly, the model we set up nests the cases of PCP, LCP and DCP as well as combinations thereof. We then explore the output spillovers from US demand, monetary policy and uncovered interest rate parity (UIP) shocks that appreciate the US dollar multilaterally, and in particular how these vary across different assumptions regarding the currency in which exports are priced. In particular, in case of PCP the output spillovers from US dollar appreciation to the rest of the world are positive. Specifically, US dollar appreciation increases the rest of the world's net exports vis-à-vis the US, as it reduces (raises) the rest of the world's imports from (exports to) the US through expenditure switching. In contrast, in case of LCP the output spillovers from US dollar appreciation to the rest of the world are muted. Specifically, as both US and rest of the world export prices are sticky in the importer's currency, US dollar appreciation does not trigger significant expenditure switching. Most importantly, however, both in case of PCP and LCP there is no expenditure switching in trade between the economies in the rest of the world as their exchange rates depreciate symmetrically against the US dollar.

In case of *full* DCP all export prices are sticky in US dollar regardless of the destination and origin, which implies that US dollar appreciation does elicit expenditure switching in trade between the economies in the rest of the world. Specifically, assume for simplicity that trade of economies in the rest of the world is exclusively intra-regional, i.e. the rest of the world does not trade with the US. Because prices of intra-regional imports in the rest of the world are sticky in US dollar, US dollar appreciation triggers expenditure switching away from imports from other economies in the rest of the world towards domestically-produced goods. As a mirror image, economies' exports to other economies in the rest of the world priced in US dollar accordingly decline due to these expenditure switching effects. Most importantly, however, because US dollar appreciation reduces intra-regional exports and imports through expenditure switching to the exact same degree in all economies in the rest of the world, intra-regional net exports and hence GDP are unchanged.

In contrast to the case of full DCP, in case of *partial* DCP — that is the shares of an economy's exports and imports that are subject to DCP being different in general — the output spillovers from US dollar appreciation that stem from intra-regional trade in the rest of the world are in general different from zero. For example, in case of an economy in the rest of the world featuring a positive export-import DCP share differential — i.e. a larger share of exports than imports being priced in US dollar — US dollar appreciation reduces its imports from other economies in the rest of the world by less through expenditure switching than it reduces its exports to other economies in the rest of the world. As a result, the output spillovers from US dollar appreciation that arise through intra-regional trade are smaller — less positive or more negative — for an economy with a positive export-import DCP share differential. The model thus implies a testable prediction regarding the magnitude of output spillovers from US dollar appreciation under partial DCP: The output spillovers from US dollar appreciation decline with economies' non-US export-import DCP share differentials. We document that this prediction from partial DCP is qualitatively robust to changes in model parametrisation, considering a variety of shocks that induce US dollar appreciation such as positive US demand, contractionary US monetary policy and UIP shocks, as well as to the inclusion of additional model features such as trade in intermediate inputs for production. Due to the lack of data on export and import pricing, we consider the *joint* hypothesis of partial DCP being empirically relevant and that the currency of export pricing coincides with the currency of invoicing. The prediction from this joint hypothesis is that output spillovers from US dollar appreciation are negatively related to economies' non-US export-import US dollar *invoicing* share differential.

We then confront this prediction of the model with the data. Specifically, we first estimate the spillovers from US dollar appreciation using two-country VAR models for up to 46 advanced and emerging market economies for the time period from 1995 to 2018. The two-country VAR models consist of the US and one non-US economy at the time. We identify US demand, US monetary policy and UIP shocks using model-consistent sign restrictions. In a second step, we run cross-sectional regressions of the cross-country differences in the spillovers from US dollar appreciation on economies' non-US export-import US dollar invoicing share differential. In the regressions we also control for cross-country differences in the susceptibility to other spillover transmission channels that are relevant in the structural model: Economies' susceptibility to bilateral US and multilateral demand channels of spillovers reflected by their overall openness to trade as well as their bilateral trade integration with the US; and differences in the strength of expenditure switching conditional on trade pricing reflected by economies' exchange rate flexibility vis-à-vis the US dollar. Our findings are consistent with the predictions of partial DCP from the theoretical model and the hypothesised coincidence of the currency of pricing with the currency of invoicing of exports: Economies that exhibit a larger non-US export-import US dollar invoicing share differential exhibit smaller — less positive or more negative — output spillovers from US dollar appreciation. We document that these findings are robust to a range of alternative specifications of the empirical framework both regarding the two-country VAR models and the cross-sectional regression, in particular controlling for the possible role of commodity trade in US dollar invoicing and identification using external instruments instead of sign restrictions. Finally, we also consider the spillovers from multilateral Euro instead of US dollar appreciation and document that the findings provide less support for partial DCP, which is consistent with what one would expect given the much less prominent role of the Euro in global trade.

Our paper is related to existing literature. Devereux et al. (2007) discuss the "US dollar standard" as a combination of PCP and LCP in a two-country model for the US and the rest of the world. Cook and Devereux (2006) and Goldberg and Tille (2009) are early contributions discussing the role of DCP for third-country trade. In particular, Cook and Devereux (2006) explore the effects of DCP in a partial equilibrium three-country New Keynesian model and show that it is critical in order to account for the muted dynamics of South East Asian exports against the background of the sizable currency depreciations during the Asian financial crisis. Goldberg and Tille (2009) explore welfare and international monetary policy co-ordination under DCP in a static three-country general equilibrium model. More recently, Gopinath et al. (2019) consider a rich three-country New Keynesian DSGE model that nests PCP, LCP and DCP, and derive testable predictions in order to assess the empirical relevance of DCP. In particular, Gopinath et al. (2019) show that under DCP trade prices and quantities respond to the US dollar rather than to bilateral exchange rates. Furthermore, Gopinath et al. (2019) provide extensive empirical evidence based on global trade data for 2500 country pairs as well as customs data for Colombia that is consistent with these predictions from DCP.[2] Finally, Zhang (2018) sets up a two-period three-country general equilibrium model and shows that under DCP exchange rates of economies with larger shares of the consumption basket priced in US dollar exhibit smaller depreciations and larger interest rate rises in response to contractionary US monetary policy shocks. Zhang (2018) then provides empirical evidence using high-frequency estimates of the financial market effects of US monetary policy shocks for a set of advanced economies with developed financial markets that are consistent with

[2]Similar evidence is found by Chen et al. (2018) using highly disaggregated customs data for the UK.

the predictions of DCP.[3]

We contribute to this existing literature by providing new evidence for the empirical relevance of DCP in several dimensions and by addressing some important shortcomings of existing work. More specifically, relative to Gopinath et al. (2019), we contribute to the literature by assessing the empirical relevance of DCP testing for its predictions for *output* rather than trade price or quantity spillovers from changes in the US dollar exchange rate. Moreover, we consider *exogenous* changes in the US dollar exchange rate rather than reduced-form regressions, which is more consistent with the experiments in the theoretical models from which the testable predictions of DCP are derived and which reduces the risk of omitted variable bias in the empirical analysis. Relative to Zhang (2018), we contribute to the literature by assessing the empirical relevance of DCP testing for its predictions for output spillovers from US shocks at the *business cycle* frequency rather than those on asset prices at the daily frequency, which does not indicate how persistent the estimated effects are at horizons relevant for macroeconomic models and policymakers. Moreover, relative to Zhang (2018) we also include in our analysis a broad range of *emerging market economies* instead of focusing on advanced economies with developed financial markets. This is particularly informative for assessing the empirical relevance of DCP as US dollar invoicing of trade is much more widespread in emerging market than in advanced economies. Finally, both relative to Gopinath et al. (2019) as well as Zhang (2018) our analysis focuses on *partial* rather than full DCP, which seems to be more relevant empirically given the invoicing landscape documented in Gopinath (2015). Accounting for partial rather than full DCP is also important because it implies asymmetries in expenditure switching at home and abroad that generates an additional net export and hence output spillover channel from US dollar exchange rate variation.

The rest of the paper is organised as follows. Section 2 presents the structural three-country model and derives the testable prediction. Section 3 carries out the empirical analysis. Finally, Section 4 concludes.

[3] A different strand of the literature is concerned with firms' choice of pricing currency, see Corsetti and Pesenti (2004), Devereux et al. (2004), Bacchetta and van Wincoop (2005), Goldberg and Tille (2008), Gopinath et al. (2010), Devereux and Shi (2013), Mukhin (2018), as well as Gopinath and Stein (2018). As in Gopinath et al. (2019), in this paper we take pricing currency as given. Gopinath et al. (2010) as well as Mukhin (2018) show that firms' currency pricing decision is effectively a zero-one and once-and-for-all decision for a given economic environment that determines the currency in which firms' optimal price is most stable, such as the monetary policy regime, the structure of marginal costs due to domestic wages vs. imported intermediates, whether the export market features competition from local producers or exporters from third economies (see Figure 1 in Mukhin, 2018). Importantly, Gopinath et al. (2010) as well as Mukhin (2018) show that firms' choice of pricing currency does in general not change during the adjustment to *temporary* shocks. Hence, as argued also in Gopinath et al. (2019), we expect the predictions from partial DCP to be insensitive to endogenising currency choice. Finally, as documented in Gopinath (2015), the choice of invoicing currency is rather stable over the sample period we consider.

2 The model

In this section we set up a three-country New Keynesian DSGE model to derive predictions regarding the differences in spillovers from shocks that appreciate the US dollar multilaterally across different configurations of partial DCP in economies' imports and exports. As we will show, the predicted differences in the spillovers are specific to partial DCP and do not occur under different PCP/LCP combinations, and hence allow us to assess whether partial DCP fits the data better than PCP or LCP or combinations thereof. The model we set up is similar to the one considered in Boz et al. (2017), but we leave out some features which are not critical for our purposes. Specifically, the model we consider includes the minimum set of features necessary to produce the predictions from partial DCP that we later confront with the data: Three economies which trade with each other as well as sticky prices. In Appendix D we document that the predictions are qualitatively identical in more elaborate versions of the model that include capital, sticky wages, frictions in domestic financial markets, and trade in intermediate inputs to production.

2.1 Model set up

We consider three large economies, namely E, F and D. D is the issuer of the dominant currency, and E and F are two economies that together form the rest of the world. For expositional convenience, throughout this section we will refer to these economies as the US instead of D, EME instead of E, and the rest of the world (RoW) instead of F. Economies generally feature a symmetric structure.

Figure 1 provides a schematic overview of each domestic economy. In particular, each economy is inhabited by five types of agents: Households, intermediate good producers, final and imported good bundlers, consumption good bundlers, and a monetary authority. Households consume, provide labor and trade domestic as well as international bonds. Each intermediate good producer produces a unique variety of goods. Intermediate good varieties are imperfect substitutes and can either be used for domestic final good production or for exports. Goods prices are sticky. All intermediate goods sold domestically are priced in the producer's currency. In contrast, a fraction of exporters in each economy exhibits DCP, i.e. they price their exports in the dominant currency, and the remaining firms exhibit PCP (or LCP). We assume pricing-to-market, meaning that export prices may differ across destination markets. Several good bundlers operating under perfect competition and employing a standard CES technology combine differentiated intermediate goods into a final consumption good. The final non-traded consumption good is a standard CES composite of bundles of intermediate goods sources from all countries. The monetary authority sets the nominal interest rate subject to a simple Taylor rule with inertia. Given the symmetry of the three countries, for expositional convenience we only report the relevant equations for EME (E). If not stated otherwise, the equations are analogous for US (D) and RoW (F).[4]

2.1.1 Households

We assume each economy is inhabited by a continuum of symmetric households. In each period a household h consumes a non-traded consumption good bundle $C_{E,t}(h)$ and provides labor service $N_{E,t}(h)$; in the following we omit the reference to household h for simplicity. The period-by-period utility function is given by

$$U(C_{E,t}, N_{E,t}) = \frac{1}{1-\sigma^c} C_{E,t}^{1-\sigma^c} - \frac{\kappa}{1+\varphi} N_{E,t}^{1+\varphi}. \tag{1}$$

The household's expected lifetime utility is given by

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \varepsilon_{E,t}^{\beta} U(C_{E,t}, N_{E,t}), \tag{2}$$

with β being the household's discount factor and $\varepsilon_{E,t}^{\beta}$ a preference shock that evolves according to a first-order autoregressive process.

We assume financial markets are incomplete internationally and households can trade two risk-free bonds: A domestic bond, $B_{E,t}^{E}$, denominated in the domestic currency and a foreign bond $B_{E,t}^{D}$ denominated in US dollar.[5] Finally, households own domestic firms and receive their profits Π_t. The household's budget constraint is given by

$$\frac{B_{E,t}}{P_{E,t}^C R_{E,t}} + \frac{\mathcal{E}_{E,t}^D B_{E,t}^D}{P_{E,t}^C R_{E,t}^D} + C_{E,t} = \frac{B_{E,t-1}}{P_{E,t}^C} + \frac{\mathcal{E}_{E,t}^D B_{E,t-1}^D}{P_{E,t}^C} + \frac{W_{E,t} N_{E,t}}{P_{E,t}^C} + \frac{\Pi_{E,t}^h}{P_{E,t}^C}. \tag{3}$$

where we choose the final consumer price $P_{E,t}^C$ as the numéraire. $R_{E,t}, R_{E,t}^D$ are the domestic and the US-\$ interest rate, respectively. We assume wages are flexible, implying that the real wage is given by $w_{E,t} = \kappa N_{E,t}^{\varphi} / \Lambda_{E,t}$.

The first-order condition with respect to consumption is given by

$$\Lambda_{E,t} = \varepsilon_{E,t}^{\beta} C_{E,t}^{-\sigma_c}, \tag{4}$$

and those for the holdings of domestic and foreign bonds by

$$\Lambda_{E,t} = R_{E,t} \beta \mathbb{E}_t \left(\Lambda_{E,t+1} \frac{P_{E,t}^C}{P_{E,t+1}^C} \right), \tag{5}$$

[4] A more detailed model appendix is available from the authors upon request.

[5] Note that the assumption that the international bond is denominated in US dollar does not change the results up to a first-order approximation. We could also allow for trade in two or three internationally traded bonds denominated in different currencies.

$$\Lambda_{E,t} = R^D_{E,t}\beta\mathbb{E}_t\left(\Lambda_{E,t+1}\frac{\mathcal{E}^D_{E,t+1}}{\mathcal{E}^D_{E,t}}\frac{P^C_{E,t}}{P^C_{E,t+1}}\right). \tag{6}$$

Imposing an arbitrage-free market, Equations (5) to (6) can be combined to form a UIP condition.

As in Schmitt-Grohe and Uribe (2003) and Boz et al. (2017), in order to render the linearised solution of the model stationary and for the foreign bonds to have a well-defined steady state, we attach a risk premium to the foreign interest rate faced by domestic households; as usual, the risk premium is dependent on the aggregate level of foreign debt in the economy relative to its steady-state value. Also, we postulate a shock $\varepsilon^{\mathcal{E}^D_E}_{E,t}$ to the risk premium in order to allow for changes in the exchange rate that are not driven by fundamentals (Itskhoki and Mukhin, 2017). The risk premium is given by

$$R^D_{E,t} = R_{D,t}e^{\left(-\chi\frac{\hat{B}^D_{E,t}-\bar{B}^D_E}{\bar{Y}_{E,t}}+\varepsilon^{\mathcal{E}^D_E}_{E,t}\right)}. \tag{7}$$

2.1.2 Consumption good bundlers

Consumption good bundlers operate under perfect competition and combine the domestically produced final good bundle and two non-traded final import good bundles into the non-traded consumption good bundle consumed by domestic households using the CES technology

$$Y^c_{E,t} = \left[n_E^{\frac{1}{\psi_f}}Y_{E,t}^{\frac{\psi_f-1}{\psi_f}} + \upsilon_E^{D\,\frac{1}{\psi_f}}Y_{E,t}^{D\,\frac{\psi_f-1}{\psi_f}} + \upsilon_E^{F\,\frac{1}{\psi_f}}Y_{E,t}^{F\,\frac{\psi_f-1}{\psi_f}}\right]^{\frac{\psi_f}{\psi_f-1}}. \tag{8}$$

Consumption good bundlers take the prices of the final imported good bundles of EME from RoW ($P^F_{E,t}$) and from US ($P^D_{E,t}$) as well as of the domestic final good bundle ($P_{E,t}$) as given. While n_E governs the degree of home bias[6] in the non-traded consumption good bundle in EME, υ^F_E and υ^D_E represent the steady-state share of the bundle accounted for by EME imports from RoW and US, respectively. Obviously, $n_E + \upsilon^D_E + \upsilon^F_E = 1$, and bilateral import shares are identical, i.e. $\upsilon^F_E = \upsilon^E_F, \upsilon^D_E = \upsilon^E_D, \upsilon^D_F = \upsilon^F_D$, so that trade is balanced in the steady state. Demand for the components of the non-traded consumption good is determined by

[6] Given the symmetric size of the three economies, n_E can be interpreted as a measure of home bias if $n_E > \frac{1}{3}$.

cost minimisation and given by

$$Y_{E,t} = n_E \left(\frac{P_{E,t}}{P^c_{E,t}}\right)^{-\psi_f} Y^c_{E,t}, \tag{9}$$

$$Y^F_{E,t} = \upsilon^F_E \left(\frac{P^{F^I}_{E,t}}{P^c_{E,t}}\right)^{-\psi_f} Y^c_{E,t}, \tag{10}$$

$$Y^D_{E,t} = \upsilon^D_E \left(\frac{P^{D^I}_{E,t}}{P^c_{E,t}}\right)^{-\psi_f} Y^c_{E,t}, \tag{11}$$

with $P^{D^I}_{E,t}$ and $P^{F^I}_{E,t}$ representing the aggregate export-price index of US and RoW in EME currency, respectively, and $P_{E,t}$ the price of the domestically produced final good in EME. $P^c_{E,t}$ is the consumer-price index in EME given by

$$P^c_{E,t} = \left[n_E P^{1-\psi_f}_{E,t} + \upsilon^D_E {P^{D^I}_{E,t}}^{1-\psi_f} + \upsilon^F_E {P^{F^I}_{E,t}}^{1-\psi_f}\right]^{\frac{1}{1-\psi_f}}. \tag{12}$$

2.1.3 Domestic and import final good bundlers

Final good bundlers operate under perfect competition and assemble a final good bundle from the continuum of differentiated intermediate goods using a CES technology. Final good bundlers are specialised based on the origin of the intermediate goods; for example, in EME there is one final good bundler that combines domestically produced intermediate goods, one that combines imported intermediate goods from US, and one that combines imported intermediate goods from RoW, respectively. The differentiated intermediate goods are imperfect substitutes, and individual intermediate good producers face a downward-sloping demand curve, with the demand for each intermediate good from the corresponding final good bundler in EME given by

$$Y^E_{E,t}(i) = \left(\frac{p_{E,t}(i)}{P_{E,t}}\right)^{-\psi_i} Y^E_{E,t}, \tag{13}$$

$$Y^D_{E,t}(i) = \left(\frac{p^D_{E,t}(i)}{P^{D^I}_{E,t}}\right)^{-\psi_i} Y^D_{E,t}, \tag{14}$$

$$Y^F_{E,t}(i) = \left(\frac{p^F_{E,t}(i)}{P^{F^I}_{E,t}}\right)^{-\psi_i} Y^F_{E,t}, \tag{15}$$

where ψ_i is the elasticity of substitution between differentiated intermediate goods.

2.1.4 Intermediate good producers

In every economy there is a continuum of intermediate good firms producing different varieties of goods using a technology with labour as the only input

$$Y_{E,t}(i) = L_{E,t}(i), \tag{16}$$

implying that real marginal costs are given by the real wage. Intermediate good producers are subject to price-setting frictions à la Calvo. Specifically, each firm i faces a constant probability of $(1-\theta_p)$ of being able to adjust its price. The first-order condition for the choice of the optimal reset price for *domestic* sales of an EME firm is given by

$$\mathbb{E}_0 \sum_{s=0}^{\infty} \theta_p^s \Theta_{t,t+s} Y_{E,t+s}^{E}(i) P_{E,t+s} \left(\frac{\widehat{p}_{E,t}(i)}{P_{E,t+s}} - \frac{\psi_i}{\psi_i - 1} MC_{t+s} \right) = 0, \tag{17}$$

with $\Theta_{t,t+s} = \beta^s \frac{\Lambda_{E,t+s}}{\Lambda_{E,t}} \frac{P_{E,t}^C}{P_{E,t+s}^C}$ representing the household's stochastic discount factor. Regarding export pricing, we assume that a fraction γ_E^F of EME intermediate good producers that export to RoW exhibits PCP, while the remainder fraction $1-\gamma_E^F$ exhibits DCP.[7] Thus, the aggregate price index for exports of EME to RoW in RoW currency is given by

$$P_{F,t}^{E^I} = \left[\gamma_E^F \mathcal{E}_{F,t}^E \tilde{P}_{E,t}^{F^{1-\psi_i}} + (1-\gamma_E^{EF}) \mathcal{E}_{F,t}^D \widehat{P}_{E,t}^{F^{1-\psi_i}} \right]^{\frac{1}{1-\psi_i}}, \tag{18}$$

where $\tilde{P}_{E,t}^F$ and $\widehat{P}_{E,t}^F$ represent the PCP and DCP export-price indices of EME intermediate good producers that export to RoW, respectively. The latter are themselves price indices of the bundles of the corresponding DCP/PCP exports.

We allow DCP exporters to take into account the fact that their prices are sticky in a foreign currency. Also, we assume pricing-to-market, i.e. export prices are specific to the destination market. Against this background, the first-order condition for DCP exports from EME to RoW is given by

$$\mathbb{E}_0 \sum_{s=0}^{\infty} \theta_p^s \Theta_{t,t+s} Y_{E,t+s}^{F}(i) P_{E,t+s}^F \left(\mathcal{E}_{E,t+s}^D \frac{\widehat{p}_{E,t}^F(i)}{P_{E,t+s}^{F^I}} - \frac{\psi_i}{\psi_i - 1} MC_{t+s} \right) = 0, \tag{19}$$

and for PCP exports by

$$\mathbb{E}_0 \sum_{s=0}^{\infty} \theta_p^s \Theta_{t,t+s} Y_{E,t+s}^{F}(i) P_{E,t+s}^F \left(\frac{\tilde{p}_{E,t}^F(i)}{P_{E,t+s}^{F^I}} - \frac{\psi_i}{\psi_i - 1} MC_{t+s} \right) = 0. \tag{20}$$

The relevant equations for EME exports to US are analogous.

[7] All model predictions are qualitatively robust to assuming that the non-DCP component of bilateral trade between EME and RoW is subject to LCP instead of PCP or combinations thereof.

2.1.5 Monetary policy

The monetary authority sets the domestic interest rate and follows a Taylor rule with inertia. Written in deviations from the steady state, the feedback rule is given by

$$R_{E,t} = \rho_R R_{E,t-1} + (1-\rho_R)\left(\phi_\pi \pi^c_{E,t} + \phi_y \tilde{y}_{E,t}\right) + \epsilon^R_{E,t}, \tag{21}$$

where $\epsilon^R_{E,t}$ represents a monetary policy shock and $\tilde{y}_{E,t}$ deviations of output from the undistorted (flexible price) steady state.

2.1.6 Market clearing

To close the model we impose market clearing in all goods, labor and bond markets. We assume bonds to be in zero net supply and US bonds to be the only bonds traded internationally. The aggregate budget constraint of EME satisfies

$$\frac{NFA_{E,t}}{P^c_{E,t}} = R^E_{D,t}\frac{NFA_{E,t-1}}{P^c_{E,t}} + CA_{E,t},$$

with $CA_{E,t}$ denoting the current account and $NFA_{E,t}$ as the net foreign asset position (i.e. the position in US bonds) in EME currency

2.2 Parametrisation and model solution

Regarding the shares of foreign inputs in the consumption bundle we replicate a world with three country blocks, namely the US, an EME region and the rest of the world. Specifically, in the country sample we study below the average share of economies' exports accounted for by the US is about 12%. Moreover, imports account for about 12% of the US consumption bundle. Hence, we choose the bundle shares reported in Table 1. For the other parameter values we follow Boz et al. (2017) and choose the values reported in Table 2. However, we document in Appendix C by means of a Monte Carlo experiment that the predictions from partial DCP that we derive from the model are not specific to these parameter values. We solve the model using a first-order approximation around the non-stochastic steady state.

2.3 The global spillovers from US demand shocks

We consider the spillovers from a positive US demand shock as a laboratory experiment in which the US dollar appreciates multilaterally to derive model predictions that we later bring to the data in order to test for the empirical relevance of partial DCP. In the baseline we consider a positive US demand shock to induce US dollar appreciation. One reason for this choice is that demand shocks are typically found to account for a substantial fraction of the variation in macroeconomic data (see, for example, Smets and Wouters, 2007) so that we expect to exploit a favourable signal-to-noise ration in our empirical analysis. We consider a positive US demand shock instead of a US monetary policy shock because evidence suggests that in the data the spillovers from the latter transmit strongly through financial channels in addition to trade. This implies that we would need to ponder about including frictions in international financial markets in the model, which might unnecessarily complicate grasping the mechanisms we are interested in. Similarly, we would need to include a broader set of controls in the empirical analysis below, and in many cases controls for which data are not readily available. Moreover, in the data it is typically found that monetary policy shocks only account for a rather small share of the variance of many variables of interest, in particular exchange rates, implying a low signal-to-noise ratio in the context of our empirical analysis below. In contrast, the evidence suggests that UIP residuals account for a large share of the variation in exchange rates in the data (Engel and West, 2010; Itskhoki and Mukhin, 2017). However, UIP shocks are also much harder to identify empirically. Moreover, UIP shocks are also not straightforward to motivate structurally, notwithstanding some recent progress (Itskhoki and Mukhin, 2017; Engel and Wu, 2018; Jiang et al., 2018); recall for example that we introduce an exogenous exchange rate shock in an ad hoc manner in our model in Equation (7). We nevertheless do examine below the spillovers from US dollar appreciation induced by contractionary US monetary policy and UIP shocks.[8]

We first discuss the transmission of a US dollar appreciation induced by a positive US demand shock to EME and RoW for the polar cases in which *all* exporting firms in US, EME and RoW are either PCP, LCP or DCP exporters. After having illustrated the transmission channels in these polar cases, we discuss the more interesting case of partial DCP, in which only a fraction of exporters in EME and RoW exhibits DCP.

2.3.1 Full PCP, LCP or DCP

Figure 2 presents the dynamic effects of a multilateral US dollar appreciation induced by a positive US demand shock on output and bilateral export prices for the polar cases of full PCP, LCP and DCP. Regardless of the pricing assumed for exporters in US, EME and RoW, the positive US demand shock increases output in the US. Together with the increase in inflation this causes the US central bank to raise interest rates. The resulting interest rate differentials with respect to EME and RoW interest rates elicit a multilateral appreciation of the US dollar. Also regardless of the pricing assumed for exporters in the US, EME and RoW, the rise in US output raises US demand for imports from EME and RoW for a given level of exchange rates and export prices, and hence implies a positive output spillover through a

[8] We do not consider cost-push or productivity shocks as the literature has not reached a consensus on their effects on the exchange rate.

bilateral demand channel. Next we discuss the transmission of the US dollar appreciation to EME and RoW through expenditure switching.

Under full PCP (black solid line), the US dollar appreciation raises local-currency import prices for EME and RoW imports from US, while it lowers local-currency prices of US imports from EME and RoW. Therefore, expenditure switching raises bilateral net exports vis-à-vis US and thus output in EME and RoW. In contrast, under full LCP (red dashed line) local-currency import prices are rather stable. As a result, little expenditure switching occurs and spillovers from US dollar appreciation are smaller than under PCP. Finally, notice that both under PCP and LCP the bilateral exchange rate between EME and RoW is stable, as their currencies depreciate against the US dollar by the same extent. As a result, there is no expenditure switching in trade between EME and RoW in response to US dollar appreciation.

For the case of full DCP (blue dash-dotted line) it is useful to split the discussion between trade that does and does not involve the US. First, because US imports are priced in US dollar as in the case of LCP, local-currency import prices in US remain rather stable. In contrast, EME and RoW local-currency import prices of imports from US rise, given that US export prices are sticky in US dollar. As a result, EME and RoW bilateral net exports with US rise. Notice, however, that under DCP the latter rise by less than in case of PCP, because expenditure switching occurs only in EME and RoW but not in US. Second, unlike in the cases of PCP and LCP, under DCP trade between EME and RoW does respond to the US dollar appreciation. Specifically, because EME exports to RoW and vice versa are priced in US dollar, the latter's appreciation reduces gross trade between EME and RoW due to expenditure switching in both economies. Note, however, that bilateral net exports between EME and RoW remain stable, as their bilateral exports and imports decline to the exact same degree.

Overall, thus, in the case of *full* DCP the output spillovers from the US dollar appreciation to EME and RoW are determined by the response of their bilateral net exports with the US. And because bilateral net exports with US rise due to expenditure switching in EME and RoW but not in US, the *peak* output spillovers are in between those obtained under PCP and LCP. The output spillovers in EME and RoW are smaller under DCP than under LCP in the *very short term* because of different endogenous monetary policy reactions. Specifically, recall that under full DCP all imports are priced in US dollar. Therefore, US dollar appreciation has a stronger impact on consumer-price inflation in EME and RoW than in the cases of PCP and LCP, especially because of the large shares of the consumption bundles being accounted for by non-US imports (see Table 1), and thereby induces the central banks to tighten monetary policy; this finding for the very short term is consistent with the mechanisms highlighted by Mukhin (2018) and Zhang (2018).

2.3.2 Partial DCP

The data are unlikely to coincide with one of the polar cases discussed so far. For example, Figure 4 documents that in the data even if EMEs invoice a very large share of their trade in US dollar, other currencies play a non-negligible role as well. Therefore, we move beyond the polar cases discussed above and consider *partial* DCP. Specifically, in the baseline partial DCP parametrisation of the model we assume 50% of bilateral trade between EME and RoW is subject to DCP and PCP, respectively: 50% of EME exports to RoW are priced in US dollar and the remaining 50% in EME currency; analogously, 50% of RoW exports to EME are priced in US dollar and the remaining 50% in RoW currency. Notice that this partial DCP in exports translates into partial DCP in imports: 50% of EME imports from RoW are priced in US dollar, and the remaining 50% in RoW currency, and vice versa. At the same time, we assume trade with the US is subject to full DCP, that is all exports to and all imports from the US are priced in US dollar; note that from the perspective of the US DCP amounts to PCP exports and LCP imports.

Figure 3 presents the dynamic effects of US dollar appreciation for this particular partial DCP parametrisation of the model (black solid line). For this baseline case of partial DCP the output spillovers from US dollar appreciation are essentially a combination of those from the cases of full DCP and PCP above. Specifically, given that trade with US is entirely subject to DCP, the bilateral spillovers from US to EME — that is bilateral demand effects from US and expenditure switching in EME away from imports from US towards domestically produced goods — are identical under full and partial DCP. As under full DCP, there is also some expenditure switching between EME and RoW, as 50% of their bilateral exports are subject to DCP. Most importantly, however, as the DCP shares in bilateral exports between EME and RoW are symmetric in this baseline parametrisation of partial DCP, their bilateral exports fall in tandem with their bilateral imports, and hence their bilateral net exports are again unchanged. The non-DCP component of bilateral trade between EME and RoW is unaffected by expenditure switching, because it is subject to PCP and because the bilateral exchange rate between EME and RoW is stable. The overall output spillovers from US dollar appreciation thus arise exclusively through bilateral spillovers from US, as under the case of full DCP. Notice for later reference that in this symmetric baseline parametrisation of partial DCP, the EME and RoW *non-US export-import DCP share differentials* are zero, as the shares of exports and imports that are subject to DCP are both 50%.

Figure 3 also depicts the dynamic effects of US dollar appreciation for the case in which the baseline scenario is altered by raising the share of EME exports to the RoW which is subject to DCP to 100% (red dashed line). This parametrisation implies a *positive* EME (and a negative RoW) non-US export-import DCP share differential. In this case, EME bilateral export prices in RoW currency rise by more than RoW bilateral export prices in EME currency. As a result, expenditure switching in bilateral trade is stronger in RoW than in EME, so that EME bilateral net exports with RoW fall and RoW bilateral net exports with EME rise. The fall in EME bilateral net exports with RoW reduces the overall output spillover from US dollar appreciation to EME, in fact even turning it negative for the first few quarters.[9]

Finally, Figure 3 also depicts the dynamic effects of US dollar appreciation for the case in which the baseline scenario is altered by lowering the share of EME exports to RoW which is subject to DCP to 0% (blue dash-dotted line). This parametrisation implies a *negative* EME (and a positive RoW) non-US export-import DCP share differential. In this case, EME export prices in RoW currency rise by less than RoW export prices in EME currency. As a result, expenditure switching in bilateral trade is weaker in RoW than in EME, so that EME bilateral net exports with RoW rise and RoW bilateral net exports with EME fall. The rise in EME bilateral net exports with RoW increases the overall output spillovers from US dollar appreciation to EME.

Notice that while — as discussed in Section 2.3.1 — the *level* of the output spillovers in the very short term is largely determined by the monetary policy response to the rise in consumer prices also under partial DCP (see Mukhin, 2018; Zhang, 2018), the *variation* in the output spillovers to EME across different values of the non-US export-import DCP share differentials is due to differences in the response of bilateral net exports with RoW. This can be seen from noting that as the EME non-US export-import DCP share differential falls — for example due to a larger share of imports from RoW priced in US dollar — the output spillovers to EME *rise*, consistent with a rise in EME bilateral net exports driven by a stronger decline in imports from RoW than in exports to RoW. Moreover, larger output spillovers to EME in case of a smaller non-US export-import DCP share differential due to a larger share of imports from RoW priced in US dollar arise *although* EME monetary policy tightens more strongly in the face of a more pronounced rise in import and hence consumer prices. Thus, the variation in the output spillovers to EME across different non-US export-import DCP share differentials is unambiguously due to variation in bilateral net exports and not due to variation in the spillovers to consumer prices and associated monetary policy responses as discussed in Mukhin (2018) and Zhang (2018).[10] Another way to see this is to note that in the scenarios we vary the share of EME exports to RoW that are subject to DCP, while we keep *constant* the share of EME imports from RoW that are subject to DCP; our findings are the same if we induce variation in the non-US export-import DCP share differentials by varying the import rather than the export DCP share.

[9]The EME currency depreciates somewhat against the RoW currency in this partial DCP parametrisation. Hence, the PCP component of bilateral trade between EME and RoW mitigates somewhat the reduction in the output spillovers to EME.

[10]Interestingly, we do find empirical evidence that is consistent with the variation in spillovers to *consumer prices* through the mechanism discussed in Mukhin (2018) and Zhang (2018): The effect of US dollar appreciation induced by a US monetary policy shock on consumer prices in the rest of the world is larger for economies which have a larger share of imports invoiced in US dollar. That these larger consumer-price spillovers do not translate into larger — i.e. more *negative* — output spillovers suggests that the mechanism arising through monetary policy responding with a tightening to the rise in inflation is weaker than the expenditure switching/net exports channel. Our findings for the estimates of the spillovers from US monetary policy to consumer prices are available on request.

The key prediction from partial DCP is thus that the output spillovers from multilateral US dollar appreciation are negatively related to economies' non-US export-import DCP share differential. In Appendix C we document the robustness of the model prediction from partial DCP in several dimensions. Specifically, first, we document by means of a Monte Carlo experiment that the prediction from partial DCP is not specific to the particular parametrisation of the model. We also show that the prediction from partial DCP also obtains in case of a contractionary US monetary policy or a UIP shock that induce the multilateral appreciation of the US dollar. Moreover, we document that the prediction also obtains in more elaborate versions of the model. Specifically, we consider a model with trade in intermediate goods used as inputs to production rather than only for consumption. Second, we consider a version of the model with capital, frictions in domestic financial markets, and sticky wages. And finally, we discuss that additional model features such as non-constant demand elasticity and local distribution services do not change the predictions from the model qualitatively.

One could argue a more plausible version of the model would feature the US, a small open economy and a large rest of the world block; this would also link more closely to the empirical analysis below. Notice, however, that in the context of our paper such a specification would not account for the role of DCP in trade between the economies that make up the rest of the world. Eventually, that would blur the exposition of the mechanisms we are interested in. Specifically, when the US dollar appreciates multilaterally import prices in the small open economy would soar given its large degree of openness, inducing a substantial tightening in monetary policy. In contrast, import prices in the rest of the world would be much more stable, given its size and hence limited degree of openness. As a result, the small open economy's currency would appreciate against that of the rest of the world, inducing expenditure switching in bilateral non-DCP trade. Moreover, the small open economy's currency would depreciate less against the US dollar, mitigating expenditure switching in DCP trade. Both effects would add transmission channels that contribute to the overall effects of US dollar appreciation in the small open economy and thereby blur the exposition of the role of DCP. Most importantly, however, such a scenario would be empirically implausible, because it would not account for fact that the rest of the world is an aggregate of small open economies which trade with each other subject to DCP. And this means that import prices in each individual small open economy in the rest of the world would soar as much as in the small open economy considered specifically, contrary to the implications of a model with a large rest of the world block. A possible solution would be to specify that a share of domestic sales in the rest of the world block are priced in US dollar. Our view is that such a model would feature several additional layers of expositional complexity, but no important conceptual gains.

In the next section we confront the model prediction with the data in order to assess the empirical relevance of partial DCP. Before doing so, we however have to amend the hypothesis we intend to test. In particular, dominant-currency *pricing* shares are not observed in the data; and, in fact, if they were, there would not be any need to test for the empirical relevance of DCP in the first place. What we do observe are export and import *invoicing* rather than pricing shares. However, the currency of invoicing need in general not coincide with the currency in which trade prices are sticky. Some evidence for a few individual countries suggests that the currency of pricing is closely related to the currency of invoicing, see Gopinath and Rigobon (2008) for US imports and exports, Fitzgerald and Haller (2014) for Irish exports to the UK as well as Friberg and Wilander (2008) for Swedish exports; notably, to the best of our knowledge there is no evidence for EMEs, for which DCP may be particularly relevant. Therefore, in the next section we will test the *joint* hypothesis that the data are characterised by partial DCP *and* that the currency of invoicing coincides with the currency in which trade prices are sticky. The associated alternative hypothesis is that *either* the data are not characterised by partial DCP *or* that the currency of invoicing does not coincide with the currency in which trade prices are sticky. Thus, if the evidence was such as to reject the hypothesis we test, this may be the case even if partial DCP is empirically relevant, namely in case the invoicing currency does not coincide with the pricing currency. If anything, thus, having to incorporate and test the assumption that the pricing currency coincides with the invoicing currency stacks the deck against finding evidence that partial DCP is empirically relevant.

3 Empirical evidence

In this section we first estimate spillovers from US shocks that appreciate the US dollar to a broad set of advanced and emerging market economies. Then, we assess whether cross-country differences in spillover-recipient economies' non-US export-import US dollar invoicing share differentials can explain the cross-country heterogeneities in the estimated output spillovers from such shocks that appreciate the US dollar.[11] In the latter exercise we also control for cross-country heterogeneities in economies' susceptibility to other cross-border transmission channels that are present in the model, namely bilateral US and multilateral demand effects as well as susceptibility to expenditure switching determined by the degree of exchange rate flexibility.

3.1 Estimating the spillovers from US dollar appreciation

We estimate spillovers from US shocks using two-country VAR models involving the US and one spillover-recipient economy at a time. Specifically, consider a two-country VAR model

$$\boldsymbol{x}_t = \boldsymbol{A}(L)\boldsymbol{x}_{t-1} + \boldsymbol{P}\boldsymbol{\epsilon}_t, \qquad \boldsymbol{\epsilon}_t \sim (\boldsymbol{0}, \boldsymbol{I}), \tag{22}$$

[11]Consistent with the analysis in the model in the previous section we consider the *non-US* rather than overall export-import US dollar invoicing share differentials. The intuition is that trade with the US is likely to be subject to DCP entirely (see Figure 4).

with

$$\boldsymbol{x}_t \equiv \begin{bmatrix} \boldsymbol{x}_{us,t} \\ s_t^{usd} \\ \boldsymbol{x}_{it} \end{bmatrix}, \qquad \boldsymbol{x}_{jt} \equiv \begin{bmatrix} y_{jt} \\ \pi_{jt} \\ i_{jt} \end{bmatrix}, \; j \in \{us, i\}, \tag{23}$$

and where i indexes non-US economies, y_{it} denotes real GDP, π_{it} CPI inflation, i_{it} the nominal short-term interest rate, and s_t^{usd} is the nominal effective US dollar exchange rate. Upon estimation of the VAR model, we impose standard sign restrictions to identify US demand, monetary policy, supply shock and UIP shocks. In particular, consistent with the model in Section 2, we impose the restrictions that in case of a positive US demand shock US real GDP, CPI inflation and the nominal short-term interest rate rise, and that the nominal effective exchange rate of the US dollar appreciates. In case of a contractionary US monetary policy shock we impose the restrictions that US real GDP and CPI inflation fall, that the nominal short-term interest rate rises, and that the US dollar nominal effective exchange rate appreciates. In the baseline specification, we also impose that a contractionary US monetary policy shock lowers output abroad (Banerjee et al., 2016; Georgiadis, 2016; Dedola et al., 2017; Iacoviello and Navarro, 2018); imposing this restriction is not consequential for our results. In case of a positive supply shock we impose the restrictions that US real GDP falls, that CPI inflation rises, and that the nominal short-term interest rate rises. Finally, we also identify a UIP shock imposing the restrictions that it appreciates the US dollar, lowers US interest rates, real GDP and CPI inflation; again, identification of the UIP shock is not consequential for our results. We impose all sign restrictions on impact. While we again focus on the output spillovers from a US demand shock in the baseline, we consider the spillovers from US monetary policy and UIP shocks in extensions below. Moreover, in robustness checks below instead of sign restrictions we consider identification using external instrumental variables (Stock and Watson, 2012; Mertens and Ravn, 2013).

We estimate the VAR models in Equation (22) for up to 46 economies for the time period from — at most, given data availability — 1995q1 to 2018q3. The set of economies we consider is reported in Table 3 and covers around 57% of non-US global GDP. We only consider economies for which we also have data on US dollar invoicing shares.[12] We combine data from the updated GVAR toolbox (see Smith and Galesi, 2011), the IMF's International Financial Statistics (IFS) as well as national sources accessed through Haver.[13] We use data on shadow rates of Wu and Xia (2016) for the US, the euro area economies and the UK as well as from Krippner (2013) for Japan.[14] We include four lags of $\boldsymbol{x}_t$ in Equation (22).

[12]Despite the availability of export and import currency invoicing share data in Gopinath (2015), in our baseline we do not consider Pakistan due to lack of data on quarterly real GDP. We also do not consider economies with a population of less than one million in our baseline, i.e. Iceland and Luxembourg. Finally, we do not consider Algeria in our baseline, as 99% of its exports are accounted for by oil. However, we document in the robustness checks below that our results do not change when we include these countries. China is not included because there is no invoicing data.

[13]The country data are plotted in Figures 15 to 18 in Appendix D. The data are plotted only for the time period which we use for estimation.

[14]For euro area economies we combine national with euro area interest rate data to obtain a time series for pre and post-Euro periods.

We consider Bayesian estimation with uninformative normal diffuse priors using the BEAR toolbox of Dieppe et al. (2016). In robustness checks below we consider alternative specifications of the VAR models as regards *inter alia* the priors used in Bayesian estimation, the choice of endogenous variables, accounting for extreme observations during country-specific, regional and global crises, the sample period, imposing a small open economy assumption, and controlling for oil-specific demand shocks.

Figure 5 reports the estimates of the output spillovers from a positive US demand shock at the country level. Specifically, Figure 5 reports the average of the posterior medians of the response of real GDP over the first eight quarters.[15] Dark-shaded bars indicate EMEs, and light-shaded bars AEs. The estimates suggest that there are pronounced cross-country heterogeneities in the output spillovers. While most economies benefit from a positive US demand shock in terms of output, the spillovers are negative in several cases. In fact, among EMEs, with the exception of Isreal and Turkey, spillovers from a positive US demand shock are positive only for European EMEs, while they are negative to non-European EMEs as well as for Ukraine. This is also illustrated in Figure 6, which shows that the spillovers to a GDP-weighted non-European EME block are negative, while those to a Euopean EME block and an AE block are positive. Overall, the estimated output spillovers from a positive US demand shock to the economies included in our sample is slightly positive.

3.2 Relationship between spillovers from US dollar appreciation and export-import US dollar invoicing share differentials

3.2.1 Data on US dollar export and import invoicing

In order to obtain economies' non-US export-import US dollar invoicing share differentials we combine data from various sources. In particular, our baseline source for invoicing data is Gopinath (2015), who in turn builds and improves on the data collected by Kamps (2006), Goldberg and Tille (2008), as well as Ito and Chinn (2014). We combine the latter with data collected by the ECB in collaboration with national statistical authorities for several euro area and EU economies, data from Devereux et al. (2017) for Canada, and from Ito et al. (2016) for Japan. Second, to the extent possible we combine invoicing data from various sources and calculate time averages of economies' invoicing shares for the same sample periods for which we estimate the corresponding VAR models. Third, starting from economies' *total* export and import US dollar invoicing shares we construct *non-US* export and import US dollar invoicing shares. To do so, we use, to the extent available, information on the share of an economy's exports to and imports from the US that is invoiced in US dollar from Gopinath (2015); if this information is not available, we assume that all of an economy's exports to and

[15] The full profiles of the impulse response estimates are provided in Figures 19 to 20 in Appendix B.

imports from the US are invoiced in US dollar.[16]

Figure 7 displays the resulting shares of non-US exports and imports invoiced in US dollar as well as the non-US export-import US dollar invoicing share differentials. The data again exhibit substantial cross-country heterogeneity. Large and/or positive non-US export-import US dollar invoicing share differentials are typically observed for commodity exporters such as Argentina, Australia, Brazil, Indonesia, or Norway, a theme to which we return in more detail below.

3.2.2 Unconditional relationship between US dollar invoicing share differentials and spillovers from US dollar appreciation

Figure 8 presents the GDP-weighted averages of the real GDP spillovers from a positive US demand shock across groups of economies that feature positive and negative non-US export-import US dollar invoicing share differentials, respectively. Consistent with the prediction of partial DCP in the model in Section 2, the output spillovers are smaller on average for the group of economies with positive non-US export-import US dollar invoicing share differentials than for the group of economies with negative non-US export-import US dollar invoicing share differentials.

The left-hand side panel in Figure 9 displays the unconditional correlation between the output spillovers and the non-US export-import US dollar invoicing share differential of spillover-recipient economies at the country level. Again consistent with the prediction of partial DCP, the correlation between the output spillovers from US dollar appreciation and economies' non-US export-import US dollar invoicing share differentials is negative and highly statistically significant: The output spillovers are smaller for economies which feature a larger share of non-US exports than imports invoiced in US dollar.

[16] In particular, the non-US export-import US dollar invoicing share differential is given by

$$\begin{aligned}
\Delta^{us\$}_{i,nonus} &\equiv \frac{X^{us\$}_{i,nonus}}{X_{i,nonus}} - \frac{M^{us\$}_{i,nonus}}{M_{i,nonus}} = \frac{X^{us\$}_{i} - X^{us\$}_{i,us}}{X_{i,nonus}} - \frac{M^{us\$}_{i} - M^{us\$}_{i,us}}{M_{i,nonus}} \\
&= \frac{X^{us\$}_{i} - X^{us\$}_{i,us}}{X_{i}} \cdot \frac{X_i}{X_{i,nonus}} - \frac{M^{us\$}_{i} - M^{us\$}_{i,us}}{M_{i}} \cdot \frac{M_i}{M_{i,nonus}} \\
&= \left(\delta^{x,us\$}_i - \frac{X^{us\$}_{i,us}}{X_{i,us}} \cdot \frac{X_{i,us}}{X_i}\right) \cdot \frac{1}{1-s^{x,us}_i} - \left(\delta^{m,us\$}_i - \frac{M^{us\$}_{i,us}}{M_{i,us}} \cdot \frac{M_{i,us}}{M_i}\right) \cdot \frac{1}{1-s^{m,us}_i} \\
&= \left(\delta^{x,us\$}_i - \delta^{x,us\$}_{i,us} \cdot s^{x,us}_i\right) \cdot \frac{1}{1-s^{x,us}_i} - \left(\delta^{m,us\$}_i - \delta^{m,us\$}_{i,us} \cdot s^{m,us}_i\right) \cdot \frac{1}{1-s^{m,us}_i}, \qquad (24)
\end{aligned}$$

where $\delta^{\ell,us\$}_i$ represents economy i's share of total exports/imports invoiced in US dollar, $\delta^{\ell,us\$}_{i,us}$ represents economy i's share of exports/imports in trade with the US invoiced in US dollar, and $s^{\ell,us}_i$ represents the share of exports to/imports from the US in economy i's total exports/imports.

3.2.3 Regression analysis controlling for other transmission channels and cross-country heterogeneity

The transmission channel for the output spillovers from US dollar appreciation that we highlight in the structural model in Section 2 focuses on expenditure switching between economies in the rest of the world. However, even in the model the spillovers in general materialise through additional channels. While these additional channels are irrelevant for the variation in the spillovers that we obtain when varying the export-import DCP share differential in the model because they are held constant in each scenario, this is not the case for the sample of economies we consider in the empirical analysis: In the data, economies do not only differ in their non-US export-import US dollar invoicing share differentials, but also in many dimensions that imply differential susceptibility to these additional transmission channels. We thus run regressions in which we control for economies' differential susceptibility to additional transmission channels of spillovers from US dollar appreciation.

In the baseline regression specification we control only for transmission channels that are present in the model in Section 2. More specifically, first, a positive US demand shock raises US demand for imports for a given level of the exchange rate and export prices. The sign of the spillovers through this bilateral US demand channel is positive. Second, the multilateral appreciation of the US dollar gives rise to expenditure switching effects. Because of LCP of exports of the rest of the world to the US, the appreciation of the US dollar is rather inconsequential in terms of expenditure switching. In contrast, PCP of exports of the US to the rest of the world implies that the appreciation of the US dollar elicits expenditure switching away from imports from the US towards domestically produced goods, which implies positive output spillovers. The sign of the spillovers from a positive US demand shock through this bilateral expenditure switching in trade with the US is also positive. Third, in order for the latter bilateral and the multilateral expenditure switching effects to unfold, economies' exchange rates must be flexible in the first place. Hence, exchange rate flexibility raises the output spillovers from a positive US demand shock that appreciates the US dollar through expenditure switching. Finally, conditional on the bilateral demand effects emanating from the US as well as the bilateral and multilateral expenditure switching, economies which are more open to trade overall benefit more from the latter through higher-order spillovers in general equilibrium. Therefore, the sign of the spillovers from a positive US demand shock through multilateral channels is positive. To summarise, we control for economies' exposure to bilateral trade with the US, multilateral trade with the rest of the world, and their exchange rate flexibility; for all coefficient estimates we expect positive signs.

More specifically, we run the regression

$$\Delta\widehat{y}_i = \alpha + \beta \cdot \delta_i + \boldsymbol{\gamma}'\boldsymbol{z}_i + \eta_i, \tag{25}$$

where $\Delta\widehat{y}_i$ denotes the estimated average real GDP spillover from a positive US demand shock over the first eight quarters depicted in the bottom row in Figure 5, δ_i the non-US export-import US dollar invoicing share differential depicted in Figure 7, and $\boldsymbol{z}_i$ includes the proxies for the susceptibility of spillover-recipient economies to bilateral and multilateral demand and expenditure switching effects as well as their exchange rate flexibility. In particular, in $\boldsymbol{z}_i$ we include spillover-recipient economies' overall non-US trade integration measured by the ratio of the sum of non-US imports and exports to GDP taken from the World Bank's World Development Indicators (WDI); the ratio of spillover-recipient economies' bilateral trade with the US to GDP calculated based on data from the IMF's Direction of Trade Statistics; and spillover-recipient economies' exchange rate flexibility using the data from Ilzetzki et al. (2019).[17] In the robustness checks below we report results from regressions in which we consider alternative definitions of the dependent variable (such as the horizon over which the cross-sectional spillover is defined), additional controls that account for other cross-border transmission channels, alternative country samples, GDP-weighted and robust regressions, as well as a bootstrap that accounts for the dependent variable in Equation (25) being estimated in a first stage.

Figure 10 presents the time-series averages of the variables in $\boldsymbol{z}_i$. As for the invoicing shares, to the extent possible we calculate the time averages over the same time period for which we estimate the corresponding VAR models. Figure 26 in Appendix D shows the unconditional correlations between the variables in $\boldsymbol{z}_i$ and the spillover estimates $\Delta\widehat{y}_i$. Consistent with the discussion above, all unconditional correlations are positive, even if not all are statistically significant. Finally, Table 4 reports summary statistics of the data we use in the estimation of Equation (25).

Table 5 reports the results of the estimation of the baseline specification of Equation (25). In column (1) we include the share of economies' non-US exports and imports invoiced in US dollar separately. Both coefficient estimates are statistically significant and have the expected signs. Specifically, a larger share of exports invoiced in US dollar is associated with smaller output spillovers from US dollar appreciation; in contrast, a larger share of imports invoiced in US dollar is associated with larger output spillovers from US dollar appreciation. Column (2) reports the regression results for the specification with the non-US export-import US dollar invoicing share differential, which even improve somewhat relative to the results in column (1) in terms of fit. The right-hand side panel in Figure 9 presents the conditional correlation — i.e. the slope estimate $\widehat{\beta}$ reported in column (2) — after controlling for the variables in $\boldsymbol{z}_i$. The results document that the coefficient estimate of the non-US export-import US dollar invoicing share differential reported in column (2) in Table 5 is not driven by outliers. Finally, column (3) in Table 5 replicates the estimation results from column (2) with the difference that the regression is estimated on standardised data. The results document that varying the export-import US dollar invoicing share differential has an economically large impact on

[17]As we need to account for the flexibility of spillover-recipient economies' exchange rate vis-à-vis the US dollar, we overwrite the flexibility assessment of Ilzetzki et al. (2019) for European — and in particular euro area — economies, assuming a flexible exchange rate regime.

the output spillovers from US dollar appreciation. Thus, our findings are consistent with the model prediction and hence provide evidence for the empirical relevance of partial DCP.

We next consider several extensions to our baseline specifications, including a closer examination of the role of commodity trade in US dollar invoicing, considering the effects of US dollar appreciation induced by a contractionary US monetary policy and UIP rather than a positive US demand shock, and the evidence for partial DCP obtained from considering spillovers from a euro area demand shock in conjunction with economies' export-import Euro invoicing share differential. We examine these extensions in more detail, and hence discuss them more prominently than the robustness checks that follow thereafter.

3.3 The role of commodity trade

One might argue that the transactions invoiced in US dollar captured by the invoicing share data constructed by Gopinath (2015) are primarily related to commodity exports and imports. This begs two questions. First, given our estimates are consistent, are the DCP effects we find also relevant for non-commodities trade? Second, while commodities are invoiced in US dollar it is typically believed that their prices are not sticky in US dollar. Hence, should we expect to find stronger evidence consistent with the predictions from partial DCP if we focus on export-import US dollar invoicing share differentials relating only to non-commodity trade? While these two questions are not entirely mutually consistent, it is important to ensure that our results are not unduly specific to or unduly driven by commodity trade. We consider two exercises to address these issues.

First, we control for the share of economies' commodity exports and imports in total trade in the regression in Equation (25). Specifically, given the inherent difficulty in drawing a line between commodities and non-commodities, we consider three different classifications. First, in the World Development Indicators (WDI) World Bank staff constructs "agricultural raw materials exports", "fuel exports" and "ores and metals exports" based on United Nations COMTRADE data; we sum these shares to obtain the share of commodity exports and imports in total exports and imports, respectively. Second, as in Boz et al. (2017) we define commodity exports and imports fairly broadly as trade of goods in HS chapters 1-27 and 72-83 in the COMTRADE data, which essentially comprises animal, vegetable, food, mineral, and metal products. And third, as in Goldberg and Tille (2008) as well as Zhang (2018), we apply the classification of traded goods that are sufficiently homogenous to feature organised markets or reference prices at the three-digit SITC level in the COMTRADE data as proposed by Rauch (1999).

Table 6 reports results from regressions in which we control simultaneously for economies' non-US export-import US dollar invoicing share differentials and the share of commodity exports and imports as well as the latter's differentials. Columns (2) and (3) report results based on the WDI classification, columns (4) and (5) based on that of Boz et al. (2017), and columns (6) and (7) based on that of Rauch (1999). Most importantly, the coefficient estimates on economies' non-US export-import US dollar invoicing share differential remain negative and highly statistically significant even after controlling for commodity exports and imports. Thus, the evidence suggests that the US dollar and DCP are relevant for the output spillovers from US dollar appreciation even beyond commodity exports and imports. Finally, Figure 11 shows the conditional correlations for the relationship between the spillovers from US dollar appreciation and economies' non-US export-import US dollar invoicing share differentials underlying the regressions in columns (3), (5) and (7) in Table 6. The conditional correlations indicate that controlling for commodity exports and imports helps to account for the particularities of several economies that stand out in the baseline results in the right-hand side panel in Figure 9, in particular Australia and Norway.

Second, Table 7 reports results from regressions in which we just drop large commodity exporters and importers. In column (2) we drop large commodity exporters, in column (4) large commodity importers, and in column (6) both large commodity exporters and importers. Large exporters/importers are those exceeding the 90% percentile in the distribution of the share of commodity exports/imports in total exports/imports according to the WDI classification (results are again very similar when using the other classifications). Columns (3), (5) and (7) report results from regressions in which we include separate coefficients on the non-US export-import US dollar invoicing share differential for commodity exporters and importers, respectively. Overall, the results suggest that our findings for the role of US dollar invoicing are not driven by or specific to commodity trade.

3.4 US monetary policy and UIP shocks

Recall that we focus on a US demand shock to induce a multilateral US dollar appreciation in our baseline instead of a monetary policy shock because the latter only accounts for a rather small share of the variation in exchange rates in the data. Moreover, while recent research has documented the importance of UIP shocks for the variation in exchange rates (see, for example Itskhoki and Mukhin, 2017), we do not consider such a shock in our baseline as it is hard to identify in the data. However, to the extent possible it is important to document that our findings are not specific to the spillovers from US dollar appreciation induced by a positive US demand shock.

Figures 21 and 22 in Appendix D document that the predictions from partial DCP that we discuss in the context of a positive US demand shock in the model in Section 2 also obtain in case of a contractionary US monetary policy and a UIP shock. In short, the reason for this is that the US dollar appreciates multilaterally in all cases. Specifically, while bilateral demand effects emanating from the US are negative in case of a contractionary US monetary policy and a UIP shock rather than positive as in case of a positive US demand shock, in both cases output spillovers materialise through expenditure switching in trade between the economies in the rest of the world under partial DCP in the face of an appreciation of the US dollar. Hence, the variation in the spillovers across different partial DCP scenarios is qualitatively identical across a variety of shocks that appreciate the US dollar multilaterally.

Against this background, column (3) in Table 8 reports results from the regression of Equation (25) in which the dependent variable is the average response of economies' real GDP over the first eight quarters after a contractionary US monetary policy shock that appreciates the US dollar has materialised.[18] Analogously, column (5) in Table 8 reports results from a regression of Equation (25) in which the dependent variable is the average response of economies' real GDP over the first eight quarters after a UIP shock that appreciates the US dollar has materialised.[19] For both alternative shocks the results are consistent with the baseline. In robustness checks below we report results for the output spillovers from US demand, monetary policy and UIP shocks based on identification using external instruments instead of sign restrictions.

3.5 Spillovers from euro area demand shocks as a placebo test

DCP effects are in theory not constrained to arise in the context of a single dominant — or in this context better referred to as "vehicle" — currency. Against this background, it is in principle possible to test for the empirical relevance of partial DCP using export-import invoicing share differentials in any vehicle currency and the spillovers from shocks in the corresponding currency issuer.

Unfortunately, doing so is practically constrained by several issues. First, extensive cross-country data is only available for the shares of trade invoiced in the exporter's currency, the US dollar, and the Euro. Hence, we can at most examine one additional vehicle currency besides the US dollar. Second, the Euro does not appear to be an important vehicle currency, at least from a global perspective. Specifically, the panels in the top row of Figure 12 compare the share of economies' exports that is destined to the euro area with the share of economies' exports that is invoiced in Euro (left-hand side panel) as well as the share of economies' exports destined to the US with the share of economies' exports invoiced in US dollar (right-hand side panel); the bottom panels present the corresponding comparisons for imports. The data document that in contrast to the US dollar, for most economies invoicing in Euro occurs to an extent that matches economies' trade with the euro area. In fact, at best only Eastern

[18] The spillovers are estimated from VAR models analogous to those used for the estimation of the spillovers from US demand shocks; the only difference is that we do *not* impose the sign restriction that foreign output declines in response to a contractionary US monetary policy shock.

[19] Forbes et al. (2018) as well as Leiva-Leon et al. (2019) use sign restrictions that are different from those we consider to identify a UIP shock. In our view, this reflects the difficulty of identifying UIP shocks in the data, which underlies our decision to not consider UIP shocks as our baseline despite the evidence suggesting that they are important drivers of exchange rates in the data.

European economies invoice a larger share of their exports in Euro than the share of their exports that are destined to the euro area; and similarly for imports.[20]

Against the background of these caveats, we should not expect to find strong evidence that supports the predictions from partial DCP in case of the Euro. In this sense, one may view the analysis of the empirical evidence for partial DCP using euro area demand shocks and Euro invoicing shares as a placebo test. Table 9 reports results from regressions of Equation (25) analogous to those reported in Table 5. Obviously, the sample size is reduced as all euro area economies are dropped while only the US is added. Columns (1) and (2) report results for the full sample, and columns (3) and (4) for a sample that includes only European and neighbouring economies. In the full sample, the coefficient estimate of the export-import Euro invoicing share differential has the expected negative sign but is — as we would expect against the background of the discussion above — estimated rather imprecisely. In the extended European sample, the coefficient estimate is negative as well, but even less precisely estimated, which is not surprising given the very small number of observations.

3.6 Robustness checks

3.6.1 Identification using external instruments

Columns (2), (4) and (6) in Table 8 report results from specifications in which we use spillover estimates obtained using external instruments instead of sign restrictions for identification in the VAR models (Stock and Watson, 2012; Mertens and Ravn, 2013). Specifically, we consider the estimated demand shock from the medium-scale DSGE model for the US studied in Kulish et al. (2017) as an external instrument for the structural US demand shocks in the VAR models.[21] For the US monetary policy shock in the VAR models we consider as instruments the intra-day changes in Federal Funds futures over narrow windows around US monetary policy decision meetings used in Gertler and Karadi (2015).[22] And as in Engel and Wu (2018), for the UIP shock in the VAR models we consider as instruments the logarithm

[20]Third, in the context of the empirical exercise explored in this paper there is greater measurement error in the Euro invoicing share differentials. In particular, unlike in case of the US, for the euro area it is not plausible to assume that if no data is available all of its exports and imports are invoiced in Euro, see for example Figure 4. For this reason, in the regressions below we use the overall share of economies' exports and imports invoiced in Euro — which includes trade invoiced in Euro that involves the euro area — instead of the non-euro area export-import Euro invoicing share differential. The variable that represents the importance of partial DCP in the regressions is thus not perfectly aligned with the relevant parameter in the model in Section 2.

[21]Considering the model of Kulish et al. (2017) is appealing because it accounts for the zero lower bound and is estimated for a substantial overlap with our sample period, namely from 1983 to 2014. The demand shock is given by the "risk premium" shock, which is, as discussed in **?**, closely linked to the discount factor/intertemporal preference shock that we consider in Section 2: The risk premium shock alters the consumption Euler equation and also enters the equation determining the price of capital. We are grateful to Mariano Kulish for sharing these shock series with us.

[22]The data for the monetary policy shock are available for 1991m1 to 2012m6, which we aggregate to quarterly frequency consistently with Gertler and Karadi (2015).

of the price of gold, the VIX, squares of G10 economies' CPI inflation, real GDP growth, the square as well as the absolute value of the growth rate of the bilateral US dollar exchange rate.[23,24] In order to reduce the likelihood of obtaining excessively noisy estimates, for all estimations we drop economies for which we have less than 15 years of quarterly data for the first-stage regression.[25] Our results are robust to these variations in the identification of US demand, monetary policy and UIP shocks.

3.6.2 Controlling for financial spillovers

In our baseline regression specification we control for other cross-border transmission channels of US demand shocks, in particular bilateral and multilateral demand effects as well as expenditure switching. However, a US demand shock may also transmit to the global economy by affecting domestic financial conditions in the US and spill over to financial conditions abroad. In terms of sign, the effect of a positive US demand shock through financial channels is ambiguous, for example because it entails positive asset price spillovers on the one hand, but negative spillovers through the financial channel of exchange rates on the other hand.[26] The latter operates on economies' US dollar exposures, which may be related to and may hence correlate with exposure to US dollar trade invoicing (Gopinath and Stein, 2018).

We control for the possible role of financial channels in transmitting a US demand shock globally by augmenting $\boldsymbol{z}_i$ in Equation (25) to include several variables reflecting economies' financial exposure to the US dollar in particular and to global financial markets more generally. Specifically, we add economies' gross foreign asset and liability position relative to GDP, typically used as a measure of overall financial integration; the US dollar-denominated foreign assets (excluding foreign exchange reserves) and liabilities relative to GDP, respectively, reflecting economies' susceptibility to balance sheet exchange rate valuation effects in response to the appreciation of the US dollar and the size of US dollar re-financing needs; and the share of US dollar foreign liabilities in total foreign-currency liabilities, reflecting the diversification and hence the ease of substituting US dollar liabilities by other currencies.[27] For the regressions that include variables reflecting economies' susceptibility to financial spillovers,

[23] The results are almost identical when we consider a smaller set of instruments, for example only the price of gold.

[24] Engel and Wu (2018) study the role of the convenience yield differential — which is equivalent to the CIP deviation — for the observed variation in exchange rates. Because the CIP deviation is a component of the UIP residual, exogenous variation in the CIP deviation can be exploited to identify exogenous variation in the UIP residual. In robustness checks Engel and Wu (2018) consider an instrumental variables regression to estimate the effect of changes in CIP deviations on the exchange rate.

[25] Notice that in an external instrumental variables framework the samples for the first-stage regression and for the estimation of the VAR model need not coincide.

[26] The motivation for the financial channel of exchange rates is the work by Bruno and Shin (2015), which shows that local currency appreciation against the US dollar flatters the balance sheets of borrowers in EMEs subject to US dollar liabilities, and hence increases their lending capacity.

[27] The gross foreign asset and liability data are taken from updates of the External Wealth of Nations Database of Lane and Milesi-Ferretti (2007), and the foreign-currency exposure related data from the update of Lane and Shambaugh (2010) constructed by Benetrix et al. (2015).

we exclude financial centers, namely Belgium, Ireland, Netherlands, Switzerland, and the UK. We also exclude Argentina, for which the foreign-currency exposure data might be less reliable due to its sovereign defaults in the early 2000s.[28]

Table 10 reports the results from the regressions which include the financial variables. Column (1) replicates the baseline results and column (2) reports the results from the baseline specification for the reduced sample without financial centers and Argentina. And column (8) reports results from a regression in which financial centers and Argentina are included. Most importantly, the results for the non-US export-import US dollar invoicing share differential are unchanged.

3.6.3 Alternative VAR model specifications

Table 12 reports results from regressions using spillover estimates obtained from alternative specifications of the VAR models. In particular, column (2) reports results from a regression using spillover estimates from BVAR model estimations with Minnesota rather than uninformative priors. Columns (3) and (4) report results from regressions using spillover estimates obtained from eight and five-variable rather than seven-variable VAR models; in the eight-variable VAR model we add rest-of-the-world real GDP in order to account for higher-order spillovers as discussed in Georgiadis (2017), and in the five-variable VAR models we only include the spillover recipient economy's real GDP in $\boldsymbol{x}_{it}$ in Equation (22). Column (5) reports results from a regression using spillover estimates obtained from a VAR model in which we add as exogenous variable a time series of global oil-specific demand shocks.[29] This robustness check is meant to ensure that we do not confound US demand and global oil-specific demand shocks. Column (6) reports results from a regression using spillover estimates obtained from a VAR model in which we include dummy variables (and their lags) as exogenous variables in order to remove global, regional or country-specific extreme events from the sample, such as the global, the Asian or the Argentine financial crisis. Column (7) reports the results from a robustness check in which we use spillover estimates obtained from VAR models estimated only up to 2007, the time prior to the global financial crisis and the zero-lower bound period.[30] And finally, column (8) reports results from a regression using spillover estimates obtained assuming that the non-US economy is a small open economy, i.e. imposing block exogeneity in the two-country VAR model. Notice that this specification has the appealing property that the identified US shocks are identical across all two-country VAR models. In all cases the results are robust.

[28]Data for Bulgaria and Cyprus are not available in Lane and Shambaugh (2010) or Benetrix et al. (2015).

[29]The shocks are obtained from a modified version of the model of Kilian and Murphy (2012) maintained at the ECB for assessing the drivers of oil price changes.

[30]Due to the reduction of the length of the sample period, we consider VAR models with only one lag for this exercise.

3.6.4 Alternative spillover definitions

Table 11 reports results from regressions in which we consider alternative definitions of the dependent variable $\Delta\widehat{y}_i$ in Equation (25). Recall that in the baseline we consider the average real GDP spillover estimate over the first eight quarters after the US demand shock has occurred. Columns (2) to (4) report results from regressions in which the dependent variable is the average real GDP spillover over the first four, twelve or sixteen quarters after the US demand shock has occurred, respectively. And column (5) reports results from a panel regression in which we include all horizons, namely

$$\Delta\widehat{y}_{ih} = \alpha_h + \beta \cdot \delta_i + \boldsymbol{\gamma}'\boldsymbol{z}_i + \eta_{ih}, \tag{26}$$

where h represents the impulse response horizon and α_h are horizon fixed effects. Our results are robust to these alternative definitions of the dependent variable in the cross-section regression.

3.6.5 Alternative country samples

Table 13 reports results from regressions of Equation (25) for alternative country samples. In particular, columns (2) and (3) report regression results when we drop Finland and Croatia or Australia and Norway; in column (4) we drop all four at the same time. Column (5) reports results from a regression in which we drop financial centers, namely Belgium, Cyprus, Ireland, Netherlands, Switzerland, and the UK. And in column (6) we report results from a regression in which all economies dropped in columns (2) to (5) are dropped together. Finally, in column (7) we report results from a larger sample in which we additionally include Algeria, Iceland, Luxembourg, and Pakistan, which are not included in the baseline because they are either very small countries, or do not have quarterly data for real GDP or are extremely dependent on oil exports. The results hardly change across country samples.

3.6.6 Alternative cross-section regression specifications

Table 14 reports results from alternative cross-section regression specifications. Column (2) reports results from a median regression that is robust to outliers, and column (3) from a weighted least squares regression in which the weights are given by global GDP shares. Again, the results are robust across specifications. And finally, Figure 13 presents the distribution of the coefficient estimate for the non-US export-import US dollar invoicing share differential across all replications of a bootstrap that accounts for the dependent variable being an estimate obtained from the two-country VAR models.[31] The implied p-value for the coefficient

[31] Specifically, the bootstrap re-samples from the posterior distribution of the eight-quarter averages of the posterior median of the estimates of the output spillovers from a positive US demand shock.

estimate for the non-US export-import US dollar invoicing share differential in Equation (25) is below 5%, essentially consistent with the results reported in Table 5.

4 Conclusion

Different assumptions on the pricing of economies' exports have different implications for a host of issues that are critical for policymakers, including optimal monetary policy, optimum currency areas and international monetary policy co-ordination. In general, the role of the exchange rate as a shock absorber largely depends on the export pricing paradigm. For instance, the exchange rate channel of monetary policy that arises through expenditure switching under PCP is weakened under DCP. Moreover, the US dollar and thereby US monetary policy does not only influence global financial conditions, but also to a large extent global trade, import prices and ultimately global inflation. However, the literature has not reached a consensus on which export pricing paradigm best reflects the data. Against this background, in this paper we assess the empirical relevance of DCP. Specifically, we first derive a prediction regarding the cross-country heterogeneity in output spillovers from shocks that appreciate the US dollar multilaterally from a New Keynesian DSGE model: Under partial DCP, the output spillovers decline with an economy's export-import US dollar pricing share differential. We then confront this prediction with the data. In particular, we estimate the output spillovers from US demand, monetary policy and UIP shocks that all appreciate the US dollar and correlate them with economies' export-import US dollar invoicing share differentials. Our findings are consistent with the hypothesis that partial DCP is empirically relevant for a large share of global trade.

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A Tables

Table 1: Parameter values for bundle shares

EME (E)		
Share of EME consumption bundle accounted for by EME final product	n_E	0.6
Share of EME consumption bundle accounted for by RoW final product	υ_E^F	0.34
Share of EME consumption bundle accounted for by US final product	υ_E^D	0.06
RoW (F)		
Share of RoW consumption bundle accounted for by RoW final product	n_F	0.6
Share of RoW consumption bundle accounted for by EME final product	υ_F^E	0.34
Share of RoW consumption bundle accounted for by US final product	υ_F^D	0.06
US (D)		
Share of US consumption bundle accounted for by US final product	n_D	0.88
Share of US consumption bundle accounted for by EME final product	υ_D^E	0.06
Share of US consumption bundle accounted for by RoW final product	υ_D^F	0.06

Table 2: Parameter values

Consumption good bundlers		
Demand elasticity for domestic and foreign final goods	ψ_f	2
Intermediate goods producers		
Calvo probability for prices	θ_p	0.75
Demand Elasticity for diff. intermediate	ψ_i	2
Households		
Risk aversion	σ_c	2
Discount factor	β	0.99
Demand Shock persistence	ρ^β	0.5
Inverse Frisch elasticity of labour	φ	2
Central bank		
Central bank smoothing parameter	ρ_R	0.5
Central bank inflation sensitivity	ϕ_π	1.5
Central bank output sensitivity	ϕ_y	0.5
Sensitivity of foreign interest rates to NFA	μ	0.001

Table 3: Economies included

Advanced	AUS, AUT, BEL, CAN, CHE, CYP, DEU, DNK, ESP, FIN, FRA, GBR, GRC, *ISL*, IRL, ITA, JPN, *LUX*, NLD, NOR, PRT, SWE
EM Europe	BGR, CZE, EST, HUN, LTU, LVA, POL, ROU, SVK, SVN, URK
EM Asia	IDN, IND, KOR, MYS, *PAK*, THA
EM Latin America	ARG, COL, BRA, PER
EM Middle East and Africa	*DZA*, ISR, MAR, TUR

Table 4: Summary statistics

	mean	min	p5	p95	max	sd	count
Two-year real GDP response	0.06	-0.31	-0.11	0.28	0.35	0.13	42
Non-US trade rel. to GDP	77.53	19.61	21.27	139.61	144.51	37.12	42
Trade with US rel. to GDP	6.42	1.60	1.74	16.29	47.68	8.31	42
Exchange rate flexibility against USD	3.64	1.58	2.15	4.00	4.00	0.66	42
Non-US exports USD invoicing share	38.59	0.00	6.80	93.23	98.31	29.45	42
Non-US imports USD invoicing share	40.67	3.53	8.43	84.51	98.52	26.13	42
Non-US X/M USD invoicing share differential	-2.08	-20.64	-16.66	13.16	37.19	11.31	42

Table 5: Baseline results

	(1)	(2)	(3)
Non-US trade rel. to GDP	0.001*	0.001**	0.233**
	(0.07)	(0.04)	(0.04)
Trade with US rel. to GDP	0.003**	0.003**	0.185**
	(0.02)	(0.02)	(0.02)
Exchange rate flexibility against USD	0.088**	0.096***	0.489***
	(0.02)	(0.00)	(0.00)
Non-US exports USD invoicing share	-0.004***		
	(0.00)		
Non-US imports USD invoicing share	0.003**		
	(0.01)		
Non-US X/M USD invoicing share differential		-0.004***	-0.310***
		(0.00)	(0.00)
Adjusted R-squared	0.48	0.50	0.50
Observations	42	42	42

Robust standard errors.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 6: The role of commodity exports and imports

	Baseline	WDI		Boz et al.		Rauch	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Non-US trade rel. to GDP	0.001**	0.001**	0.001**	0.001*	0.001**	0.001*	0.001**
	(0.04)	(0.02)	(0.02)	(0.06)	(0.05)	(0.06)	(0.03)
Trade with US rel. to GDP	0.003**	0.003*	0.002	0.004**	0.003**	0.003*	0.003*
	(0.02)	(0.09)	(0.19)	(0.01)	(0.02)	(0.10)	(0.06)
Exchange rate flexibility against USD	0.096***	0.097***	0.085***	0.101***	0.094***	0.091**	0.096***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)
Non-US X/M USD invoicing share differential	-0.004***	-0.005***	-0.005***	-0.003**	-0.003**	-0.004**	-0.004**
	(0.00)	(0.00)	(0.01)	(0.03)	(0.03)	(0.05)	(0.02)
Share of commodity in total exports		0.002		-0.000		0.000	
		(0.11)		(0.76)		(0.99)	
Share of commodity in total imports		0.001		0.002		-0.001	
		(0.53)		(0.47)		(0.73)	
Commodity export/import share differential			0.001		-0.000		0.000
			(0.24)		(0.51)		(0.74)
Adjusted R-squared	0.50	0.50	0.49	0.47	0.48	0.47	0.48
Observations	42	42	42	42	42	42	42

Robust standard errors.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 7: Dropping commodity exporters and importers

	Baseline	Comm. exp.		Comm. imp.		Comm. exp. & imp.	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Non-US trade rel. to GDP	0.001**	0.001	0.001**	0.000	0.001**	0.000	0.001**
	(0.04)	(0.11)	(0.02)	(0.27)	(0.05)	(0.63)	(0.03)
Trade with US rel. to GDP	0.003**	0.004	0.003**	0.004***	0.003**	0.006**	0.003*
	(0.02)	(0.19)	(0.05)	(0.00)	(0.03)	(0.02)	(0.09)
Exchange rate flexibility against USD	0.096***	0.074***	0.085***	0.152***	0.097***	0.128***	0.084**
	(0.00)	(0.01)	(0.00)	(0.00)	(0.01)	(0.00)	(0.03)
Non-US X/M USD invoicing share differential	-0.004***	-0.006**	-0.006**	-0.003***	-0.003***	-0.004*	-0.005**
	(0.00)	(0.02)	(0.02)	(0.00)	(0.01)	(0.08)	(0.03)
Commodity exporter dummy			0.025				0.025
			(0.50)				(0.58)
Commodity exporter dummy x X/M USD invoicing share differential			0.003				0.003
			(0.35)				(0.37)
Commodity importer dummy					0.008		0.003
					(0.85)		(0.95)
Commodity importer dummy x X/M USD invoicing share differential					-0.001		-0.001
					(0.85)		(0.85)
Adjusted R-squared	0.50	0.42	0.48	0.53	0.47	0.42	0.45
Observations	42	32	42	32	42	25	42

Robust standard errors.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 8: Results for spillovers from US monetary policy and UIP shocks

	Demand		Monetary policy		UIP	
	(1) SRs	(2) IV	(3) SRs	(4) IV	(5) SRs	(6) IV
Non-US trade rel. to GDP	0.001**	0.000**	0.000	0.000	0.003***	-0.001
	(0.04)	(0.04)	(0.64)	(0.30)	(0.00)	(0.16)
Trade with US rel. to GDP	0.003**	-0.000	-0.004**	0.000	-0.003	0.002**
	(0.02)	(0.27)	(0.05)	(0.67)	(0.12)	(0.03)
Exchange rate flexibility against USD	0.096***	0.000	-0.040	0.033**	-0.082**	0.102***
	(0.00)	(0.98)	(0.45)	(0.03)	(0.03)	(0.00)
Non-US X/M USD invoicing share differential	-0.004***	-0.000**	-0.002**	-0.001**	-0.002*	-0.002*
	(0.00)	(0.01)	(0.03)	(0.02)	(0.08)	(0.06)
Adjusted R-squared	0.50	0.10	0.02	0.26	0.20	0.27
Observations	42	39	42	37	42	42

Robust standard errors.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 9: Regression results for spillovers from euro area demand shock

	All		Only Europe^{+}	
	(1)	(2)	(3)	(4)
Non-EA trade rel. to GDP	0.001	0.000	0.016**	0.014**
	(0.87)	(0.89)	(0.01)	(0.01)
Trade with EA rel. to GDP	0.003	0.003	-0.003	0.000
	(0.26)	(0.14)	(0.50)	(0.87)
Exchange rate flexibility against EUR	0.119**	0.116**	0.165***	0.140***
	(0.04)	(0.02)	(0.01)	(0.00)
Exports EUR invoicing share	-0.010		-0.002	
	(0.20)		(0.79)	
Imports EUR invoicing share	0.011		0.007	
	(0.20)		(0.38)	
X/M EUR invoicing share differential		-0.010		-0.001
		(0.18)		(0.83)
Adjusted R-squared	0.06	0.11	0.60	0.58
Observations	26	26	14	14

Robust standard errors.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 10: Controlling for financial spillover channels

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Non-US trade rel. to GDP	0.001**	0.001*	0.001*	0.001*	0.001**	0.001	0.000	0.000
	(0.04)	(0.07)	(0.06)	(0.05)	(0.02)	(0.35)	(0.81)	(0.39)
Trade with US rel. to GDP	0.003**	0.002	0.002	0.001	0.001	0.002	0.001	0.005***
	(0.02)	(0.11)	(0.19)	(0.58)	(0.58)	(0.11)	(0.52)	(0.01)
Exchange rate flexibility against USD	0.096***	0.085***	0.076***	0.079***	0.115***	0.068**	0.100**	0.114***
	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.01)	(0.01)	(0.00)
Non-US X/M USD invoicing share differential	-0.004***	-0.004***	-0.004***	-0.004***	-0.004***	-0.004***	-0.005***	-0.003***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.01)
GFAL/GDP			0.026				-0.033	-0.004
			(0.64)				(0.66)	(0.93)
USD foreign assets (excl. res.)/GDP				0.001			-0.001	-0.002
				(0.52)			(0.74)	(0.12)
USD foreign liabilities/GDP					0.004**		0.007*	0.005*
					(0.03)		(0.05)	(0.09)
Share of USD foreign liabilities						-0.001	-0.003	-0.002
						(0.51)	(0.20)	(0.20)
Adjusted R-squared	0.50	0.40	0.39	0.39	0.46	0.39	0.45	0.51
Observations	42	34	34	34	34	34	34	40

Robust standard errors.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 11: Alternative VAR model specifications

	(1) Baseline	(2) BVAR	(3) 8 vars	(4) 5 vars	(5) Oil shocks	(6) Dummies	(7) 95-07	(8) SOE
Non-US trade rel. to GDP	0.001**	0.001***	0.000	0.001*	0.001*	0.001**	-0.000	0.001
	(0.04)	(0.00)	(0.34)	(0.06)	(0.05)	(0.03)	(0.89)	(0.12)
Trade with US rel. to GDP	0.003**	0.001	0.003***	0.004**	0.002**	0.003*	0.006**	0.005*
	(0.02)	(0.23)	(0.01)	(0.02)	(0.03)	(0.08)	(0.01)	(0.08)
Exchange rate flexibility against USD	0.096***	0.047**	0.095***	0.134***	0.100***	0.092***	0.169***	0.163***
	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Non-US X/M USD invoicing share differential	-0.004***	-0.003***	-0.003***	-0.005***	-0.003**	-0.002**	-0.003*	-0.004***
	(0.00)	(0.00)	(0.01)	(0.01)	(0.02)	(0.02)	(0.08)	(0.01)
Adjusted R-squared	0.50	0.56	0.41	0.55	0.49	0.34	0.28	0.51
Observations	42	42	42	42	42	42	42	42

Robust standard errors.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 12: Alternative spillover definitions

	(1) Baseline	(2) 1-year	(3) 4-year	(4) 3-year	(5) Panel
Non-US trade rel. to GDP	0.001**	0.000	0.001**	0.001**	0.001**
	(0.04)	(0.24)	(0.04)	(0.03)	(0.05)
Trade with US rel. to GDP	0.003**	0.003***	0.004	0.003	0.004**
	(0.02)	(0.01)	(0.11)	(0.12)	(0.05)
Exchange rate flexibility against USD	0.096***	0.082***	0.125*	0.110*	0.133*
	(0.00)	(0.00)	(0.08)	(0.05)	(0.05)
Non-US X/M USD invoicing share differential	-0.004***	-0.003***	-0.004**	-0.004***	-0.003***
	(0.00)	(0.00)	(0.02)	(0.01)	(0.01)
Adjusted R-squared	0.50	0.47	0.46	0.47	
Observations	42	42	42	42	840

Robust standard errors. Panel regression includes horizon dummies and Driscoll-Kraay robust standard errors.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 13: Alternative samples

	(1) Baseline	(2) -FIN/HRV	(3) -AUS/NOR	(4) -(2) and (3)	(5) -Fin. centers	(6) Small N	(7) Large N
Non-US trade rel. to GDP	0.001**	0.001**	0.001**	0.001***	0.001**	0.001**	0.000
	(0.04)	(0.01)	(0.01)	(0.01)	(0.04)	(0.01)	(0.37)
Trade with US rel. to GDP	0.003**	0.003***	0.002*	0.003***	0.003**	0.003**	0.001
	(0.02)	(0.00)	(0.05)	(0.01)	(0.05)	(0.03)	(0.56)
Exchange rate flexibility against USD	0.096***	0.090***	0.077***	0.076***	0.099***	0.075***	0.059
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.16)
Non-US X/M USD invoicing share differential	-0.004***	-0.003***	-0.006***	-0.005**	-0.004***	-0.005**	-0.005***
	(0.00)	(0.00)	(0.01)	(0.01)	(0.00)	(0.02)	(0.00)
Adjusted R-squared	0.50	0.55	0.51	0.56	0.51	0.57	0.30
Observations	42	40	40	38	36	32	46

Robust standard errors.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 14: Alternative regression specifications

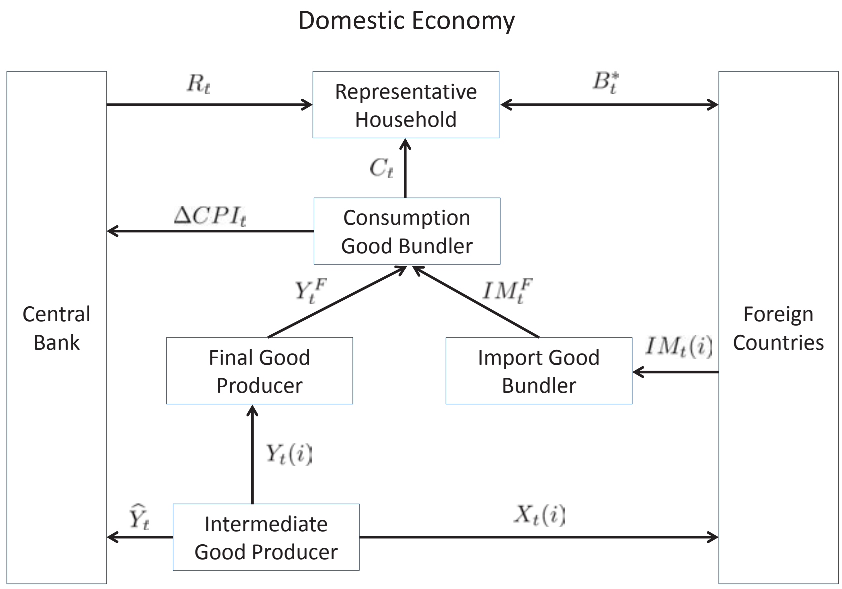
	(1) Baseline	(2) rreg	(3) GDP weights
Non-US trade rel. to GDP	0.001**	0.001*	0.001*
	(0.04)	(0.07)	(0.07)
Trade with US rel. to GDP	0.003**	0.003*	0.003***
	(0.02)	(0.10)	(0.01)
Exchange rate flexibility against USD	0.096***	0.085***	0.075***
	(0.00)	(0.00)	(0.00)
Non-US X/M USD invoicing share differential	-0.004***	-0.003*	-0.004**
	(0.00)	(0.05)	(0.03)
Adjusted R-squared	0.50	0.41	0.62
Observations	42	42	42

p-values in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

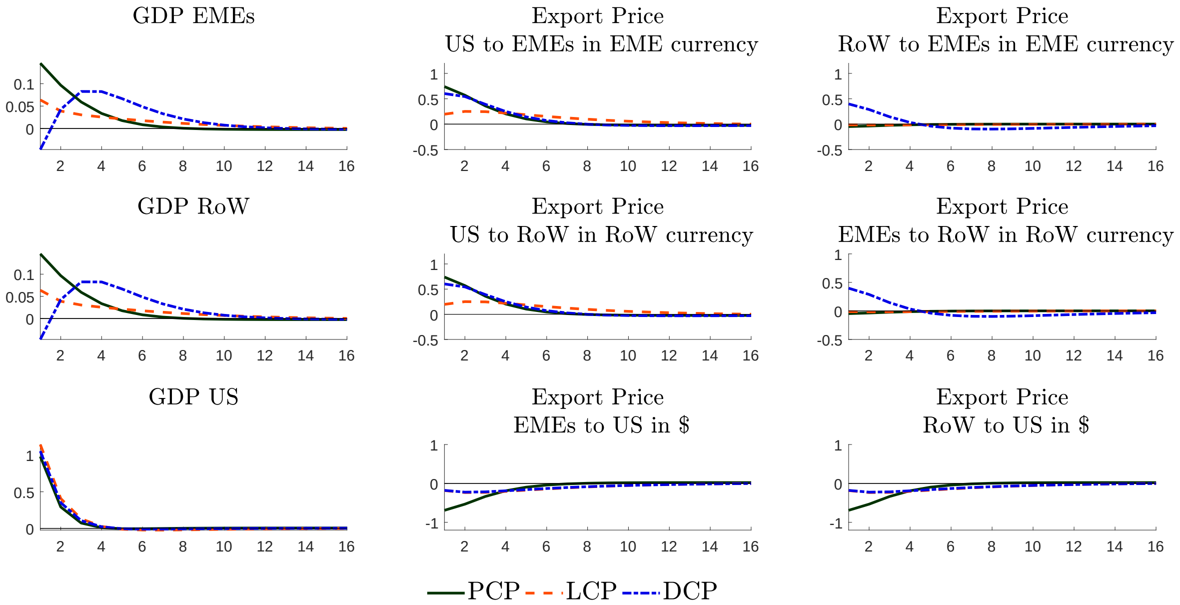
B Figures

Figure 1: Schematic overview of the domestic economy



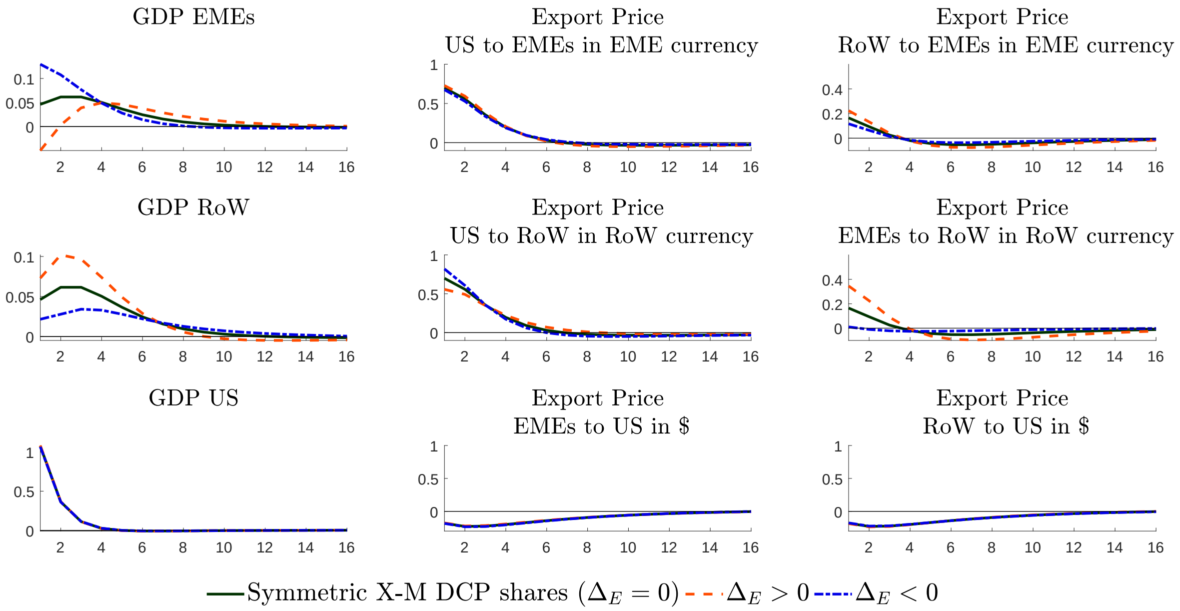
Note: The figure provides a schematic overview of the structure of each economy in the model laid out in Section 2. Import good bundlers exist for imports from each trading partner, in the figure these are collapsed into one bundler only for expositional simplicity.

Figure 2: Dynamic effects of a positive US demand shock under PCP, LCP and DCP



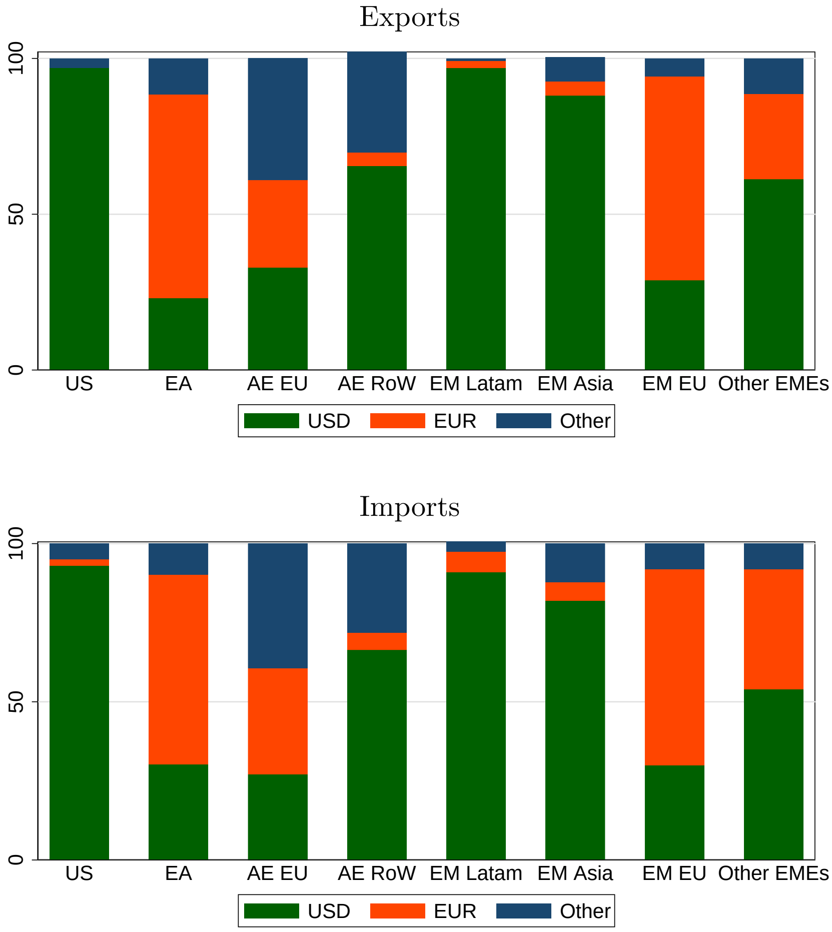
Note: The figure presents the dynamic effects of a positive US demand shock on real GDP and bilateral export prices denoted in the currency of the importer. The figure provides the impulse responses for three polar parameterisations of the model: All exporters exhibit PCP (black solid lines), LCP (red dashed lines), and DCP (blue dash-dotted lines).

Figure 3: Dynamic effects of a positive US demand shock under partial DCP



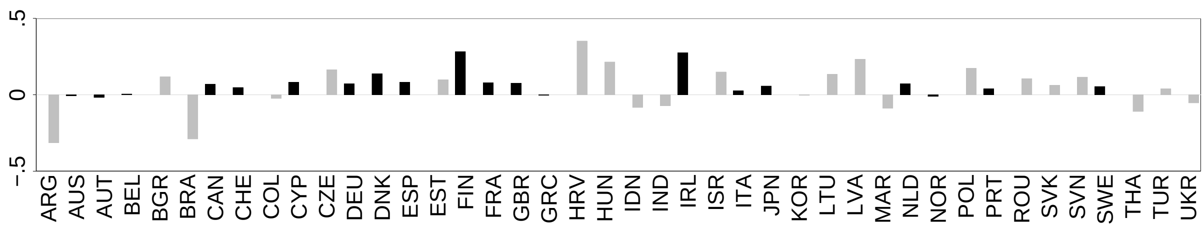
Note: The figure presents the dynamic effects of a positive US demand shock on real GDP and bilateral export prices denoted in the currency of the importer for the case of partial DCP. The figure provides the impulse responses for three alternative parameterisations of export pricing in EMEs and the RoW: 50% of EME exports to the RoW are priced in US dollar and vice versa (black solid line, "symmetric X-M DCP shares ($\Delta_E = 0$)"); 100% of EME exports to the RoW and 50% of RoW exports to EMEs are priced in US dollar (red dashed line, $\Delta_E > 0$); 0% of EME exports to the RoW and 50% of RoW exports to EMEs are priced in US dollar (blue dashed-dotted line, $\Delta_E < 0$). In all cases tarde with the US is subject to full DCP, i.e. all exports to and of the US are priced in US dollar.

Figure 4: Global trade invoicing landscape



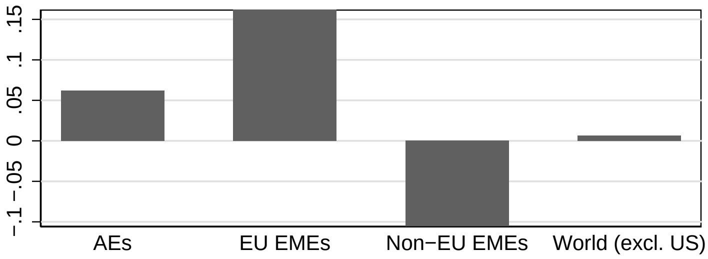
Note: The figure presents the shares of economies' exports and imports invoiced in US dollar, Euro and other currencies. Data for euro area countries includes intra-euro area trade. The data are taken from Gopinath (2015).

Figure 5: Estimated GDP responses to a positive US demand shock



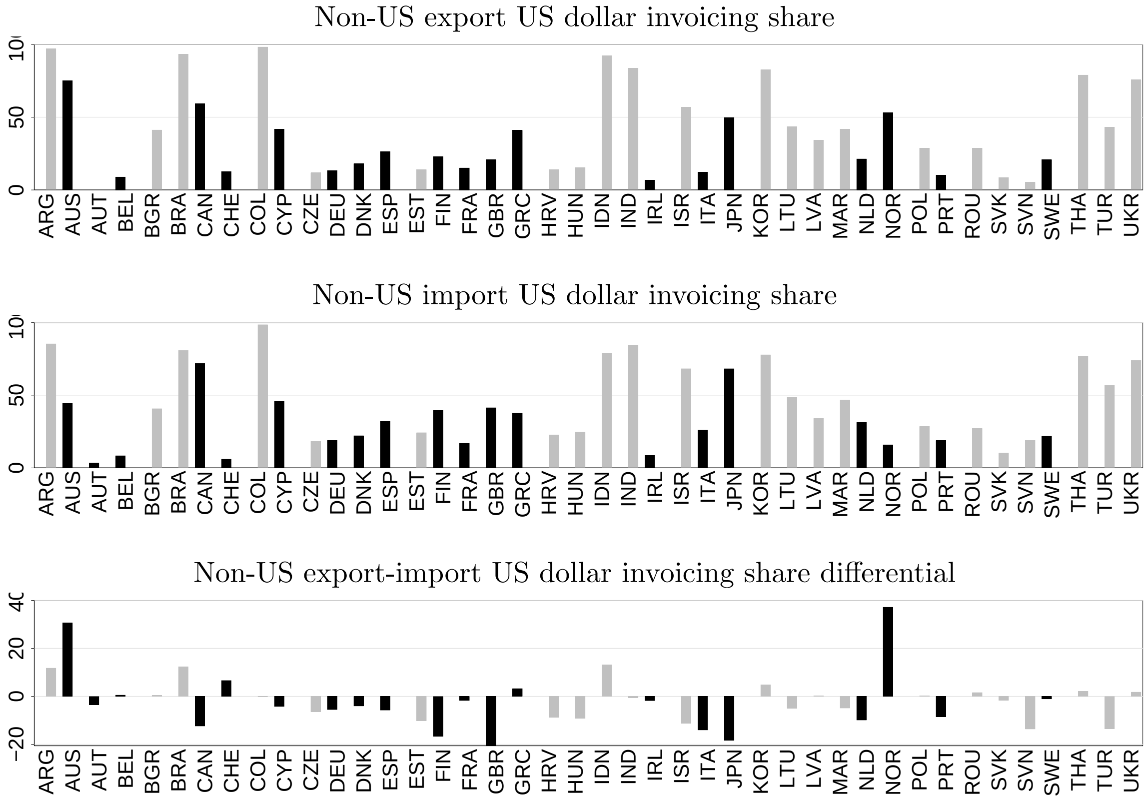
Note: The figure shows the averages over eight quarters of the point estimates of the real GDP effects of a positive US demand shock. The spillover estimates are obtained from estimation of the two-country VAR models described in Section 3.1. The full profiles of the underlying impulse response estimates are provided in Figures 19 to 20 in Appendix B.

Figure 6: Estimated GDP responses to a positive US demand shock across country groups



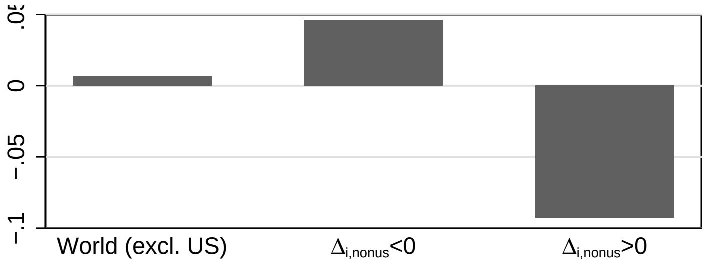
Note: The figure shows the GDP-weighted averages of the eight-quarter averages of the point estimates of the real GDP effects of a positive US demand shock across country groups. See also the note to Figure 5.

Figure 7: US dollar invoicing shares



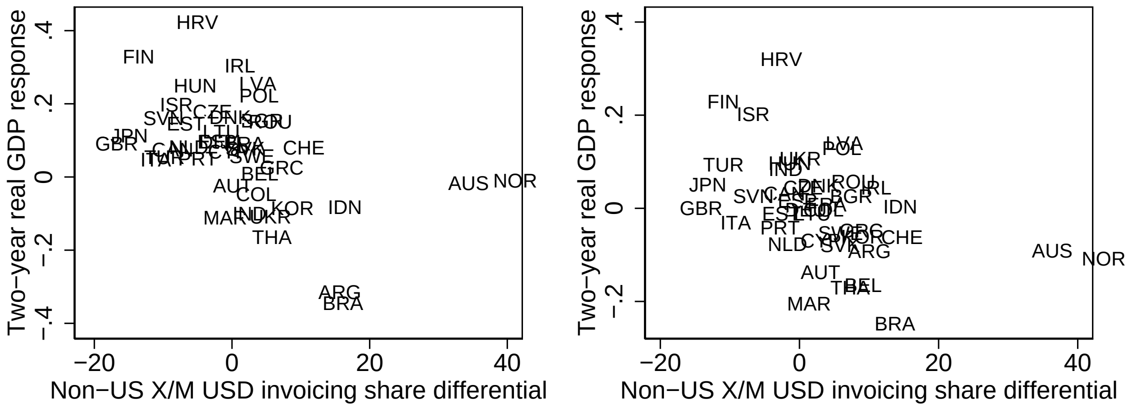
Note: The figure presents the time averages of non-US export and import invoicing shares and the implied differential we use in the empirical analysis in Section 3. To the extent possible given data availability, the averages are calculated over the same time period for which the corresponding two-country VAR models are estimated. The data are taken from Gopinath (2015), the ECB, Devereux et al. (2017) as well as Ito et al. (2016), see Section 3.2 for more details. Data for euro area economies includes intra-euro area trade.

Figure 8: Estimated GDP responses to a positive US demand shock across country groups with positive and negative export-import US dollar invoicing share differential



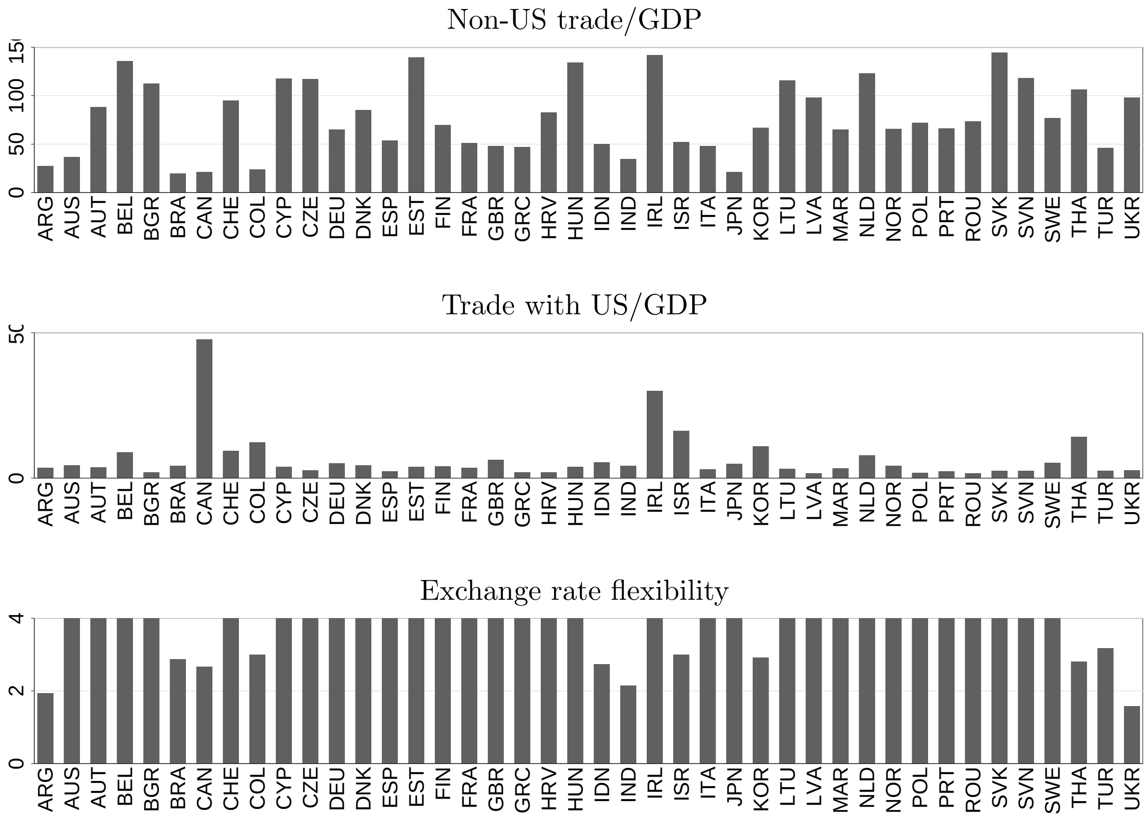
Note: The figure shows the GDP-weighted averages of the eight-quarter averages of the point estimates of the real GDP effects of a positive US demand shock across country groups. See also the note to Figure 5.

Figure 9: Relationship between spillovers from a positive US demand shock and non-US export/import US dollar invoicing share differential



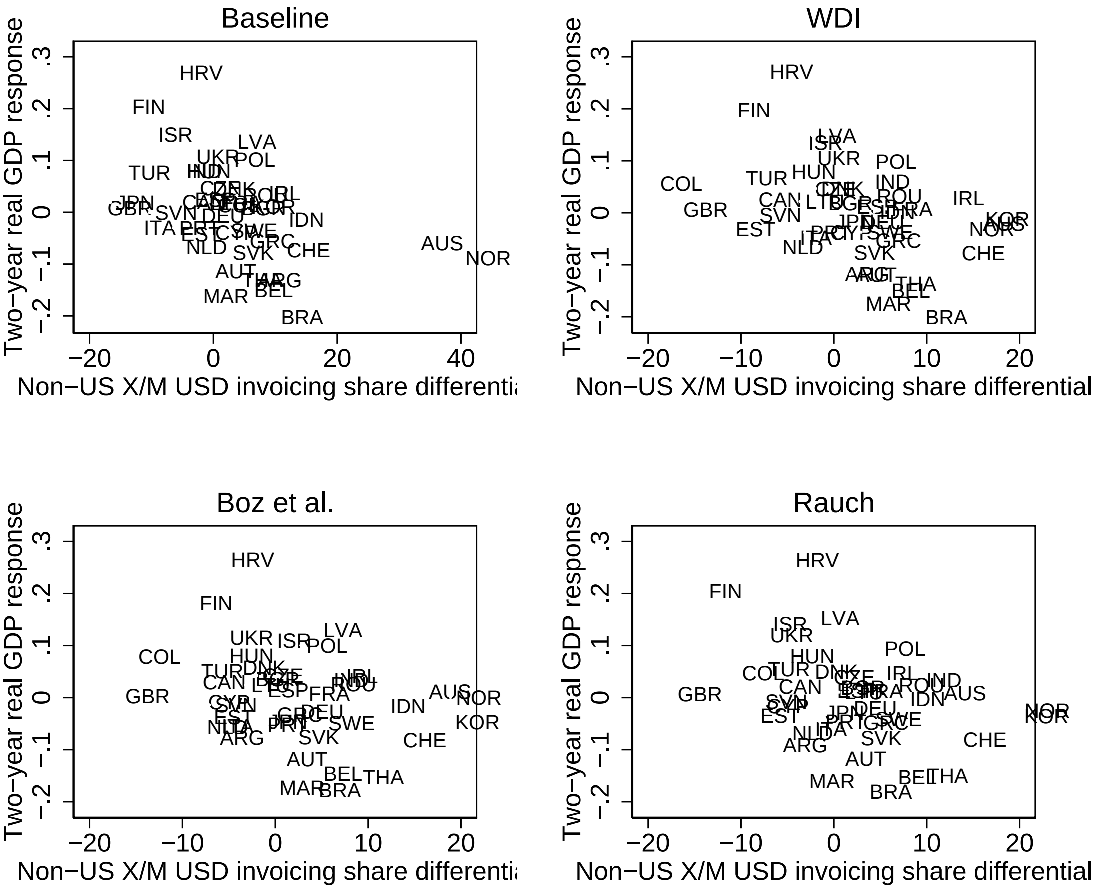
Note: The figure depicts the correlation between the estimated spillovers from a positive US demand shock and economies' non-US export-import US dollar invoicing share differential. The spillover estimate are obtained from the two-country VAR models and are give by the average over the first eight quarters after the US demand shock has occurred. The left-hand side panel depicts the unconditional correlation, and the right-hand side panel the conditional correlation obtained after controlling for the other explanatory variables included in the regression in Equation (25), that is spillover-recipient economies' overall non-US trade integration measured by the ratio of the sum of imports and exports to GDP taken from the World Bank's World Development Indicators (WDI); the ratio of spillover-recipient economies' bilateral trade with the US to GDP calculated based on data from the IMF's Direction of Trade statistics; and spillover-recipient economies' exchange rate flexibility using the data from Ilzetzki et al. (2017).

Figure 10: Determinants of the spillovers from US demand shocks



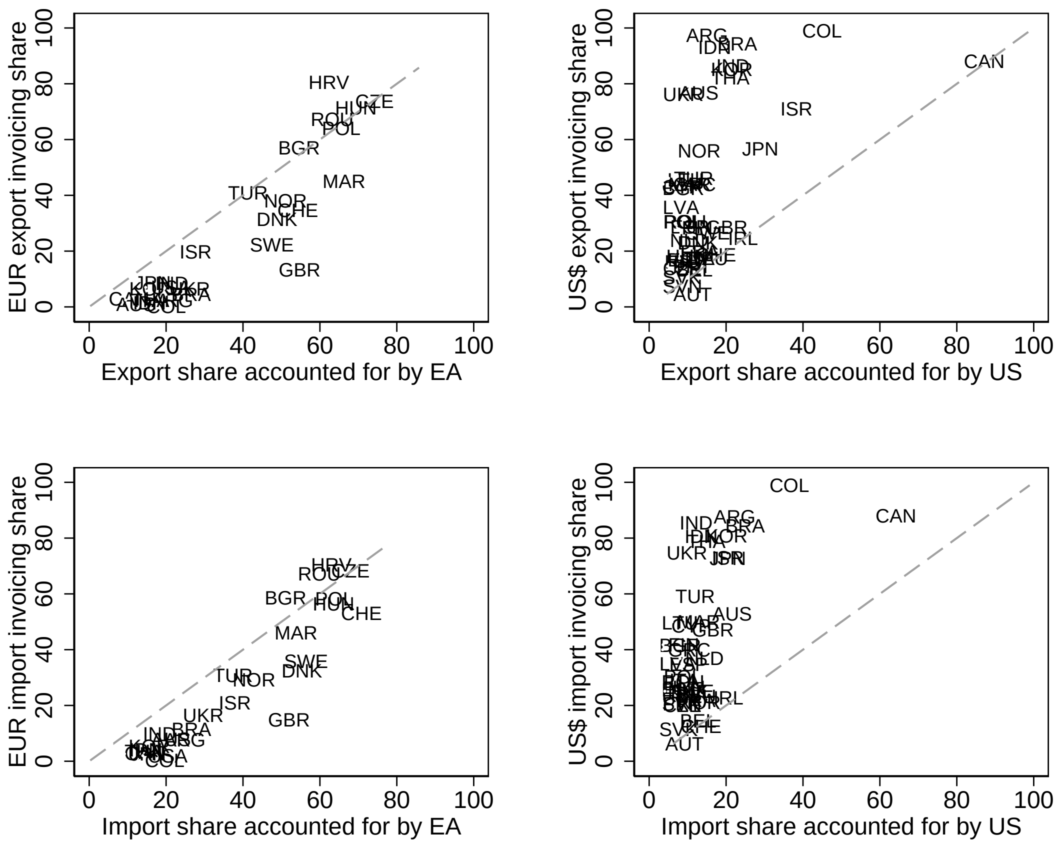
Note: The figure displays the time averages of the control variables variables included in the regression in Equation (25), that is spillover-recipient economies' the overall non-US trade integration measured by the ratio of the sum of imports and exports to GDP taken from the World Bank's World Development Indicators (WDI); the ratio of spillover-recipient economies' bilateral trade with the US to GDP calculated based on data from the IMF's Direction of Trade statistics; and spillover-recipient economies' exchange rate flexibility using the data from Ilzetzki et al. (2017). To the extent possible given data availability, the averages are calculated over the same time period for which the corresponding two-country VAR models are estimated.

Figure 11: Relationship between spillovers from a positive US demand shock and country characteristics controlling for commodity exports and imports



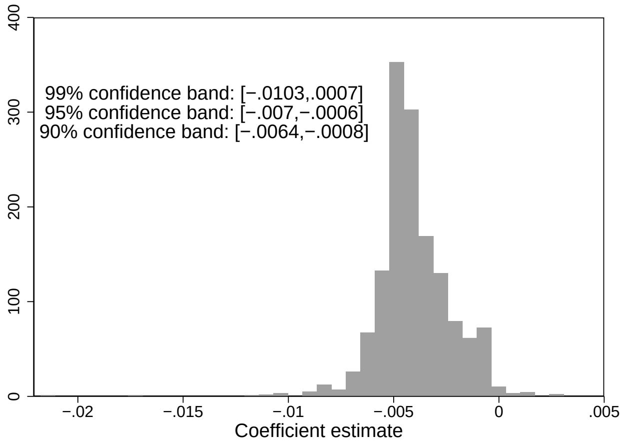
Note: The figure depicts the conditional correlation between the estimated spillovers from a positive US demand shock and control variables variables included in the regression in Equation (25) as well as economies' commodity export-import share differential. The top left-hand side panel presents the conditional scatterplot from the baseline specification without accounting for commodity trade, the top right-hand side panel is based on data for the shares of economies' exports and imports accounted for by commodities are taken from the World Bank's WDI, the lower left-hand side panel on the classification of Boz et al. (2017), and the lower right-hand side panel on the classification of Rauch (1999).

Figure 12: Euro and US dollar invoicing shares compared with export and import shares



Note: The figure provides information about the relationship between economies' US dollar and Euro invoicing shares in exports and imports as well as the shares of trade accounted for the US and the euro area. In particular, the upper left-hand side panel compares economies' shares of exports invoiced in Euro and the share of exports destined to the euro area. The right-hand side panel depicts the corresponding comparison for imports, and the panels in the bottom row depict the corresponding comparisons for the US dollar invoicing shares and the share of trade accounted for by the US.

Figure 13: Distribution of coefficient estimate across bootstrap replications



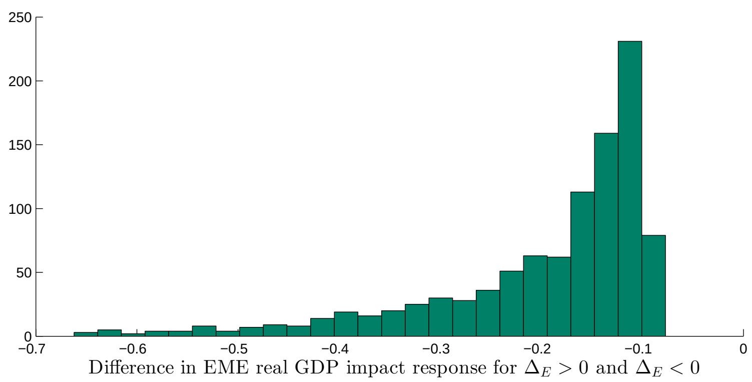
Note: The figure presents the distribution of the coefficient estimate for the non-US export-import US dollar invoicing share differential in Equation (25) across all replications of the bootstrap. The bootstrap re-samples on the posterior distribution of the eight-quarter averages of the posterior median of the estimates of the output spillovers from a positive US demand shock.

C Robustness of model prediction from partial DCP

C.1 A Monte Carlo experiment exploring the sensitivity of the prediction from DCP to model parametrisation

One may wonder whether the prediction that the output spillovers from a positive US demand shock are negatively related to economies' non-US export-import DCP share differential only obtains under very specific parameterisations of the model. For example, the strength of expenditure switching in the face of US dollar exchange rate changes depends on the elasticity of substitution between foreign and domestically produced goods. In order to document that the prediction we derive above is rather general in the sense that it is not specific to particular parameterisations of the model, we carry out a Monte Carlo experiment. In each replication, we draw values for a subset of parameters from a uniform distribution over a support than spans the range of values that are used in the literature. Specifically, we draw values for all economies for the inter-temporal elasticity of substitution $\sigma_c \in [0.5, 4]$, the demand elasticity for domestic and foreign final goods $\psi_f \in [0.75, 4]$, the demand elasticity for differentiated intermediates $\psi_i \in [1.1, 3]$, as well as the Calvo parameters for price stickiness $\theta_p \in [0.65, 0.85]$. Figure 14 presents the distribution of the difference between EME output spillovers in positive and negative non-US export-import DCP pricing share parameterisations across 1,000 replications of a Monte Carlo experiment. Essentially no parametrisation changes the prediction that output spillovers are larger in case of a negative export-import DCP pricing share differential qualitatively.

Figure 14: Distribution of difference between EME output spillovers in positive and negative non-US export-import DCP pricing share parameterisations across replications of a Monte Carlo experiment



Note: The figure presents the distribution of the difference between the model-implied output spillover from a positive US demand shock in EMEs across the cases of 100% and 0% of EME exporters exhibiting subject to DCP. In each replication of the Monte Carlo experiment we draw values for all economies for the intertemporal elasticity of substitution $\sigma_c \in [0.5, 4]$, the demand elasticity for domestic and foreign final goods $\psi_f \in [0.75, 4]$, the demand elasticity for differentiated intermediates $\psi_i \in [1.1, 3]$, as well as the Calvo parameters for price stickiness $\theta_p \in [0.65, 0.85]$.

C.2 Intermediate inputs trade

Georgiadis et al. (2019) set up a structural model and show that exchange rate pass-through to important prices is reduced even in the case of DCP if an economy's trading partners are integrated in global value chains. Against this background, the question arises whether accounting for intermediate inputs trade in our model would overturn qualitatively the prediction of partial DCP regarding the asymmetry that worsens the bilateral net exports of EME vis-à-vis RoW in the face of US dollar appreciation. Specifically, if the price of the intermediate input good bundle rises this could partly be passed through into prices mitigating the differences in competitiveness stemming from the differences in the export-import DCP pricing share differentials between EME and RoW. While this effect is indeed operative in a model with trade in intermediate goods used as inputs in production instead of only for consumption, given that prices are sticky in the short run, it does not qualitatively offset the role of export-import DCP pricing share differentials for the spillovers from shocks that appreciate the US dollar that we highlight in the baseline version of the model. This is documented in Figure 23, which shows the spillovers from a positive US demand shock in a version of the model with trade in intermediate goods used for inputs in production.[32]

C.3 Capital, sticky wages and financial frictions

We extend our baseline model in that each economy is inhabited by seven rather than five types of agents: Households, financial intermediaries, intermediate goods producers, final good bundlers, capital good producers and a monetary authority. Households trade international bonds, provide deposits to local intermediaries and provide labor monopolistically while being subject to nominal rigidities in wage setting. The financial intermediaries are modelled as in Gertler and Karadi (2011), and thus intermediate funds between firms and households while being subject to a leverage constraint.[33] Figure 24 documents that also in this more elaborate version of the baseline model the predictions from partial DCP obtain.

C.4 Non-constant demand elasticity and local distribution services

Finally, we briefly discuss the implications of additional model features that have been put forth in the literature on export pricing and exchange rate pass-through, namely non-constant elasticity of demand (which implies complementarities in price setting) and local distribution

[32] Another aspect to consider is that it is reasonable to assume that there is also some degree of home bias in the use of intermediate inputs. An initial rise in domestic production in response to a foreign shock will thereby cause the demand for domestic intermediates to rise by more than for foreign intermediates for a given level of prices. Given the fact that differences in competitiveness arise in the short run mainly due to differences in the export-import DCP pricing share differentials, this even slightly amplifies the effect we highlight in the baseline version of the model.

[33] All equations are explicitly derived in an appendix available from the authors.

services. Specifically, we argue that none of these features changes — at least qualitatively — the predictions from partial DCP regarding the asymmetry that worsens the bilateral net exports of EMEs vis-à-vis the RoW we highlight in the baseline version of our model. In order to suggest that the presence of the presence of each additional model feature does not qualitatively change the predictions from partial DCP, we will argue that expenditure switching in the face of an appreciation of the US dollar remains stronger in the economy with the larger export-import DCP pricing share differential. Hence, we focus on the scenario in which a positive (negative) export-import DCP pricing share differential in EMEs (the RoW), i.e. when EMEs price 100% of their exports to the RoW in US dollar while the RoW prices only 50% of its exports to EMEs in US dollar.

C.4.1 Non-constant demand elasticity

Under a non-constant demand elasticity, the elasticity of demand faced by a producer depends on the deviation of the its price from that of its competitors. In particular, Gust et al. (2010) study an environment with PCP and show that with non-constant demand elasticity exporter's prices in the importer's currency are less responsive to exchange rate changes, which exporters achieve by adjusting their mark-ups correspondingly. The goal of the paper by Gust et al. (2010) is to show that non-constant elasticity of demand is sufficient to generate incomplete exchange rate pass-through, independently of exogenously imposed LCP and sticky prices.

To facilitate understanding how non-constant elasticity of demand would affect the implications of partial DCP in our model, consider the case of fixed prices first. Under non-constant elasticity of demand and fixed prices, the appreciation of the US dollar which raises the local-currency price of imports in the RoW (and in EMEs) elicits a *stronger* expenditure switching away from imports towards domestically produced goods than under constant elasticity of demand. Therefore, and because all EME exports to the RoW are priced in US dollar while only 50% of RoW exports to EME are priced in US dollar, the loss of competitiveness is stronger for EME exports to the RoW than vice versa. As a result, in the short term with fixed prices non-constant elasticity of demand amplifies the asymmetry that worsens the bilateral net exports of EME vis-à-vis RoW we highlight in the baseline version of our model.[34] Hence, in the short term when prices are fixed non-constant elasticity of demand even amplifies quantitatively the asymmetry in expenditure switching across EMEs with a positive and the RoW with a negative export-import DCP pricing share differential.

In the medium term when a exporters start to adjust their prices, EME exporters will tend to lower the US dollar price of their exports to RoW in order to limit deviation of their

[34]Notice moreover that non-constant elasticity of demand as introduced in Gust et al. (2010) is irrelevant in a first-order approximation of the model. In the non-linear model, the magnitude of the effect of non-constant demand elasticity depends on the curvature of the demand function. Specifically, only if the curvature is large will a small shock trigger large changes in the elasticity of substitution.

RoW currency price from that of RoW competitors, hence dampening — but not muting completely — the amplification of expenditure switching due to non-constant elasticity of demand in RoW. Therefore, even in the medium term non-constant elasticity of demand even amplifies quantitatively — even though to a somewhat lower degree — the asymmetry in expenditure switching across EMEs with a positive and the RoW with a negative export-import DCP pricing share differential. Overall, thus, non-constant elasticity of demand does not change the prediction of partial DCP regarding the asymmetry that worsens the bilateral net exports of EME vis-à-vis RoW we highlight in the baseline version of our model qualitatively; if anything, non-constant elasticity of demand even strengthens the prediction of DCP quantitatively.

C.4.2 Local distribution services

Under local distribution services local labour is required in order to distribute imported (and domestic) tradable goods to consumers. Corsetti and Dedola (2005) consider an environment with PCP and show that the presence of local distribution services gives rise to different elasticities of demand across countries and hence deviations of the law-of-one-price by limiting the exchange rate pass-through to in particular local consumer prices.

To facilitate understanding how local distribution services would affect the implications of the baseline version of our model we highlight in our paper, consider again the case of fixed prices first. While the appreciation of the US dollar still raises the RoW currency price of imports from EMEs, the rise is smaller than in a model without local distribution costs. This is because the price of an imported good from EMEs that is eventually distributed in the RoW is an average of the RoW currency price of the imports from EMEs and local labour in the RoW. Hence, the use of local labor in distributing imports from EMEs to RoW consumers dampens the rise in RoW consumer prices and hence expenditure switching. However, the mechanism applies symmetrically in the EMEs as well: The use of local labor in distributing imports from the RoW to EMEs consumers dampens the rise in EME consumer prices and hence expenditure switching. And since the rise in the local currency price of imports resulting from the appreciation of the US dollar is stronger in RoW due to the higher DCP import share than in EMEs, in the short term with fixed prices the asymmetry that worsens the bilateral net exports of EME vis-à-vis RoW we highlight in the baseline version of our model continues to prevail even in the presence of local distribution services. For example, suppose that the US dollar appreciates by 10%, which with fixed prices implies an increase in local-currency import prices by 10% in RoW given 100% US dollar import pricing, and 5% in EMEs given 50% US dollar import pricing. Now suppose local distribution services reduce the pass-through of US dollar appreciation by 50%. Then, local-currency import prices rise by 5% in RoW and by 2.5% in EMEs ($10\% \times 50\% \times 50\%$). Hence, even if they are smaller in absolute terms, local-currency import prices still rise twice as much in RoW than in EMEs in the presence of local distribution services, eliciting stronger expenditure switching in RoW than in EMEs.

Because even in the presence of local distribution services marginal costs of EME exporters do not change more than in the baseline version of our model, even when prices adjust in the medium term EME exporters will not lower their prices in a way that would completely annihilate expenditure switching in RoW.

D Additional online appendix

Figure 15: Data plots I

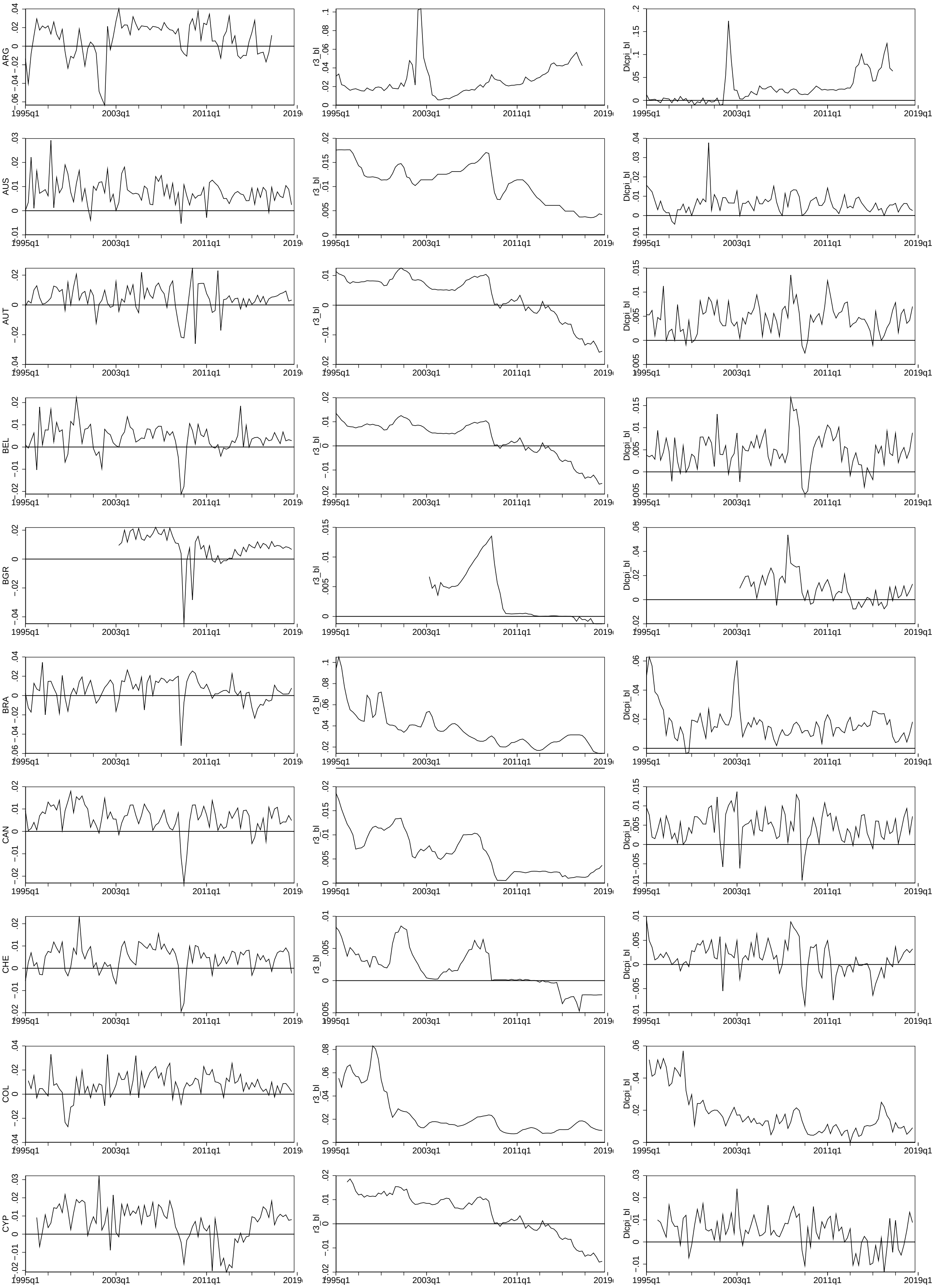


Figure 16: Data plots II

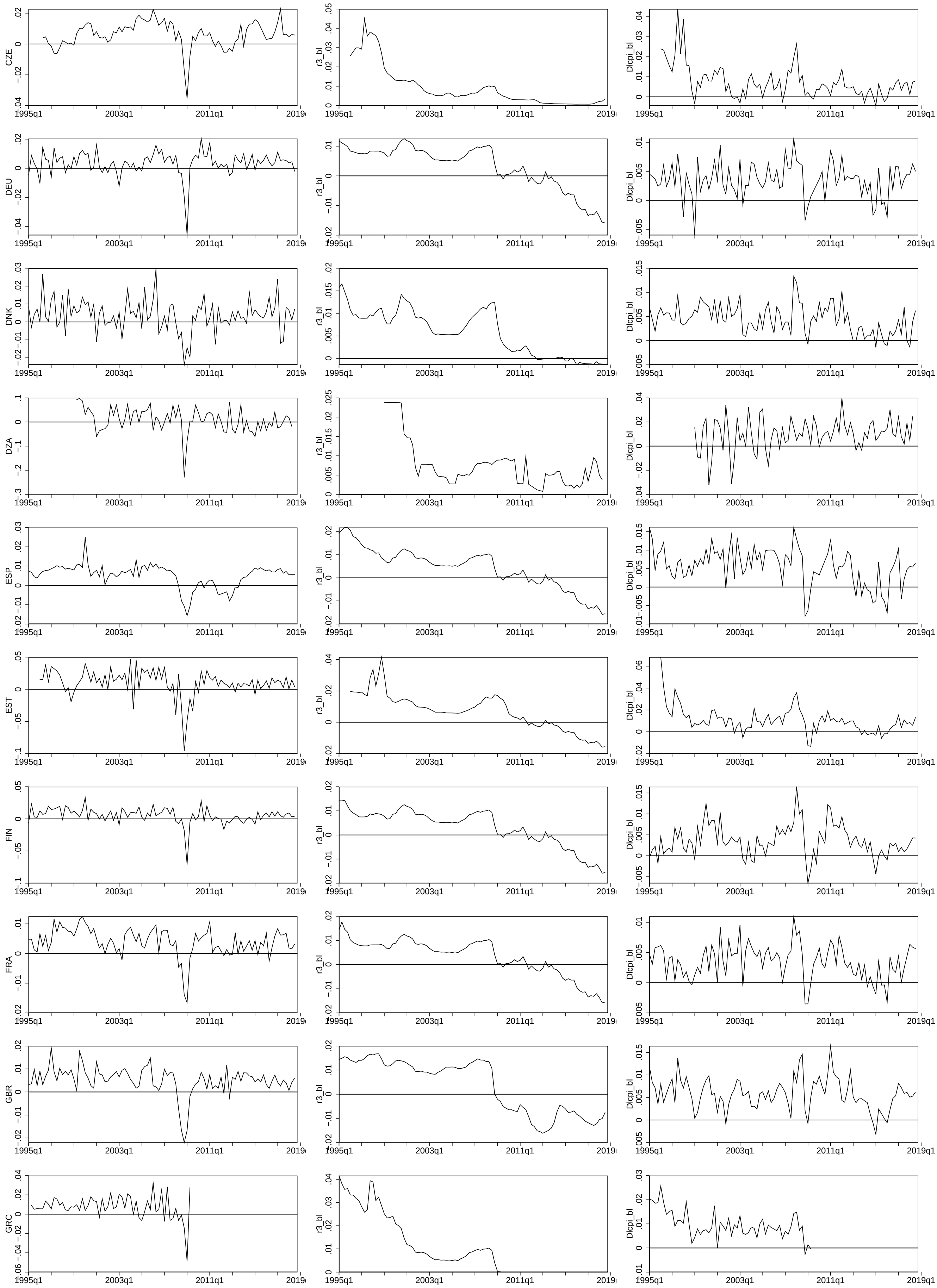


Figure 17: Data plots III

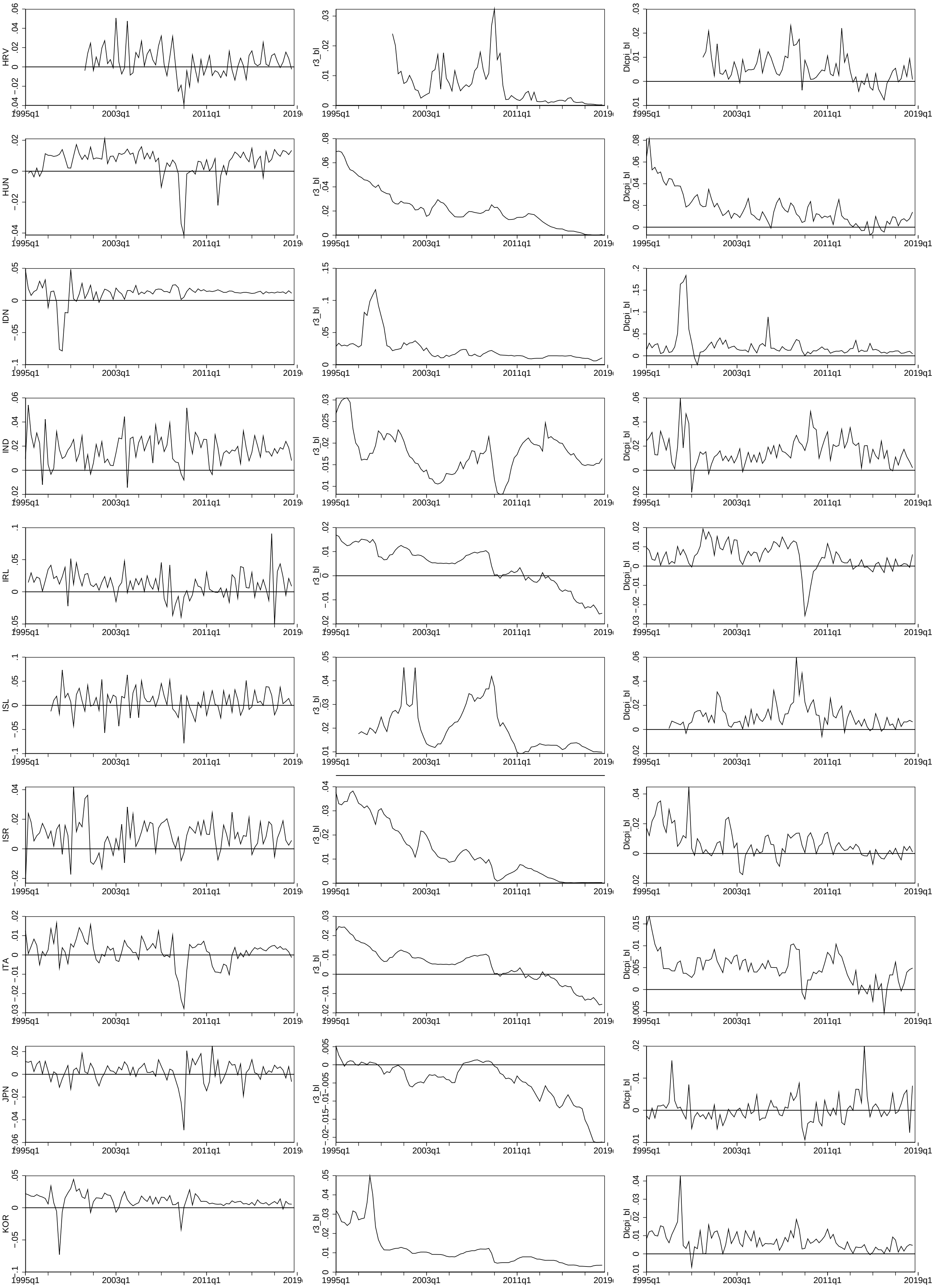


Figure 18: Data plots IV

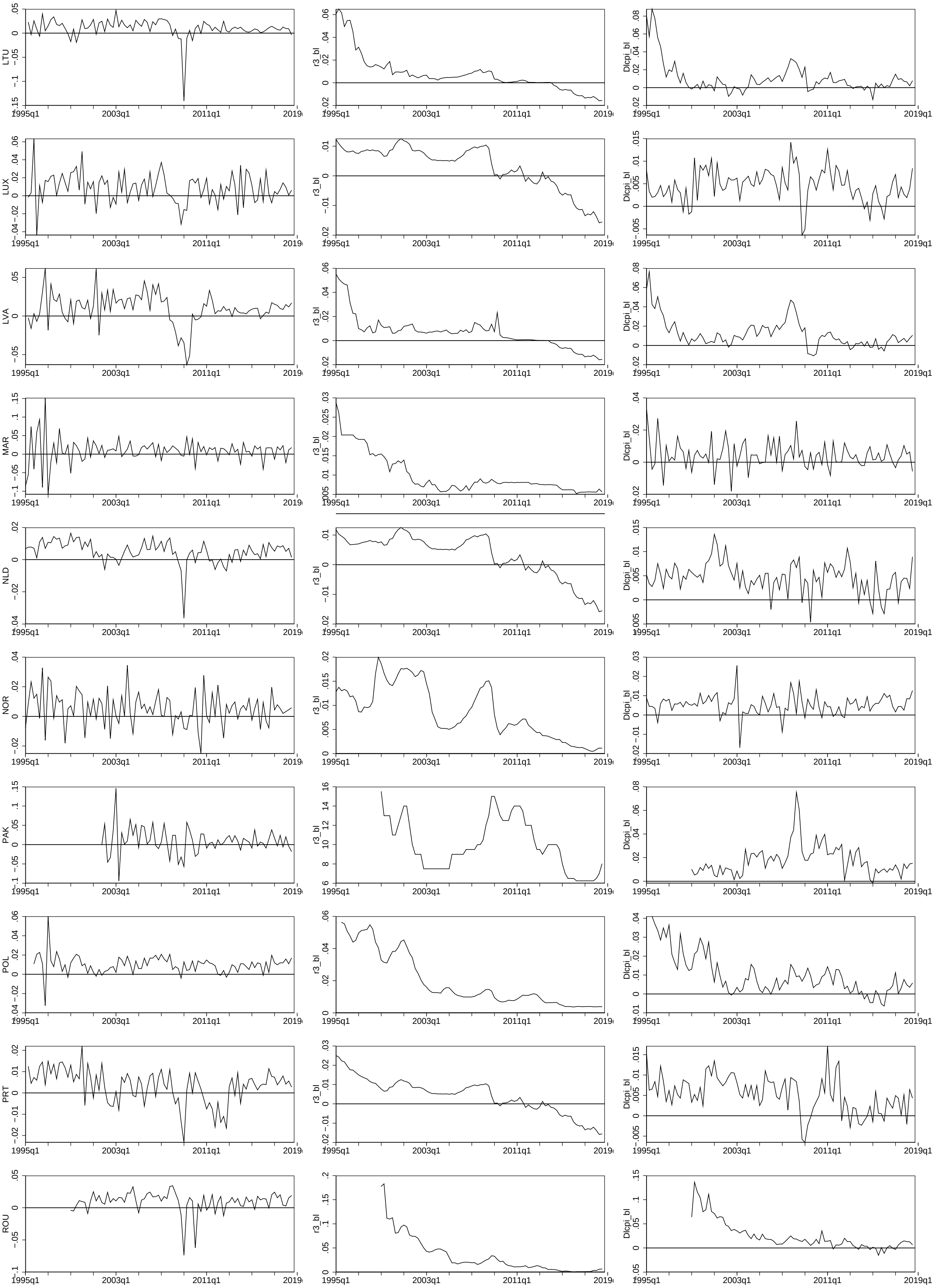


Figure 19: Estimated GDP responses to a positive US demand shock 1

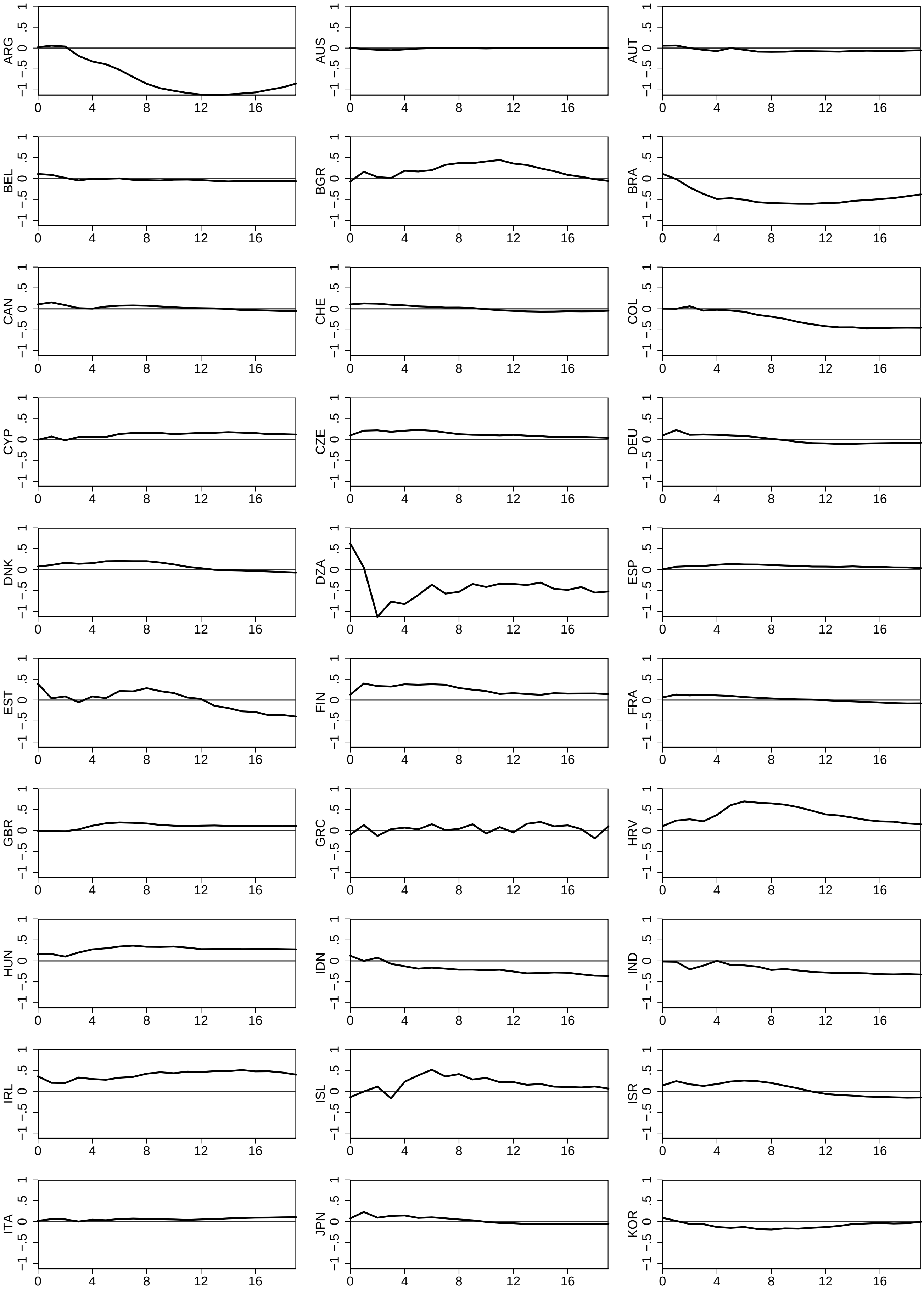


Figure 20: Estimated GDP responses to a positive US demand shock 2

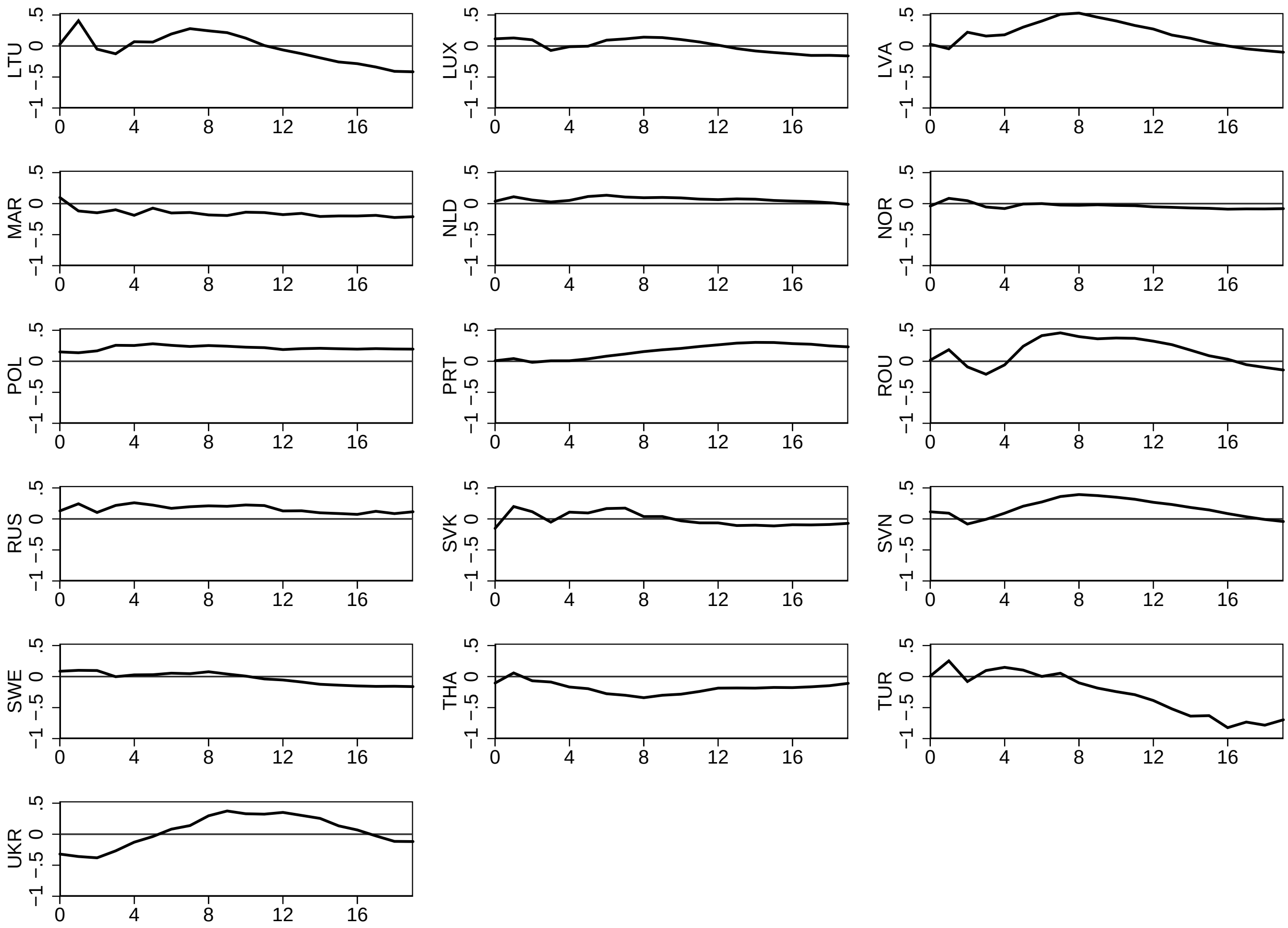
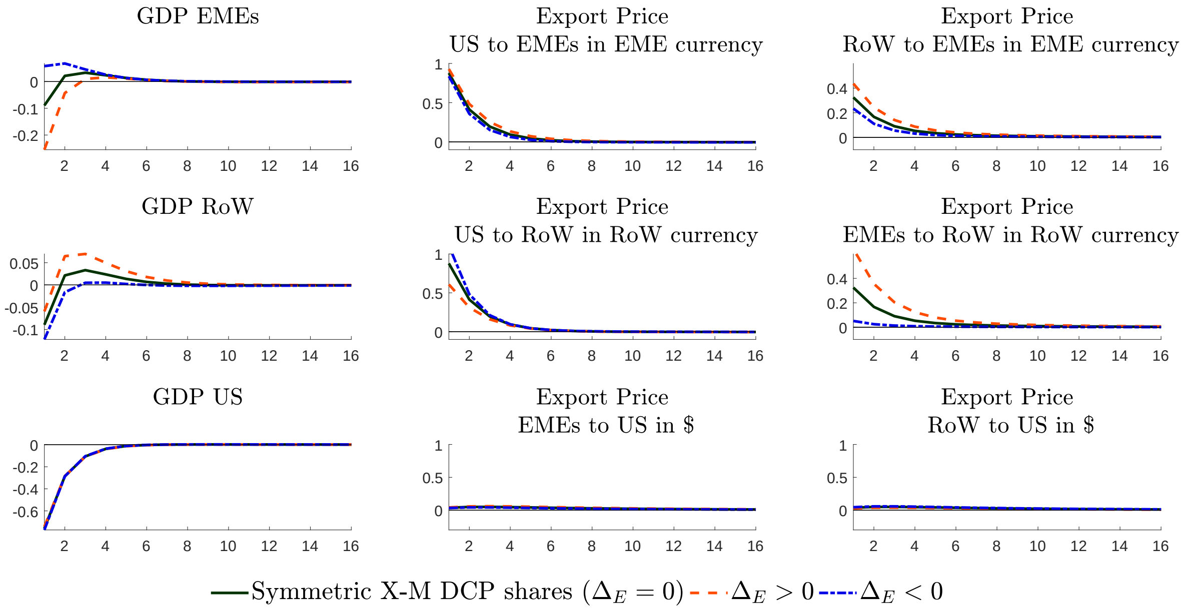
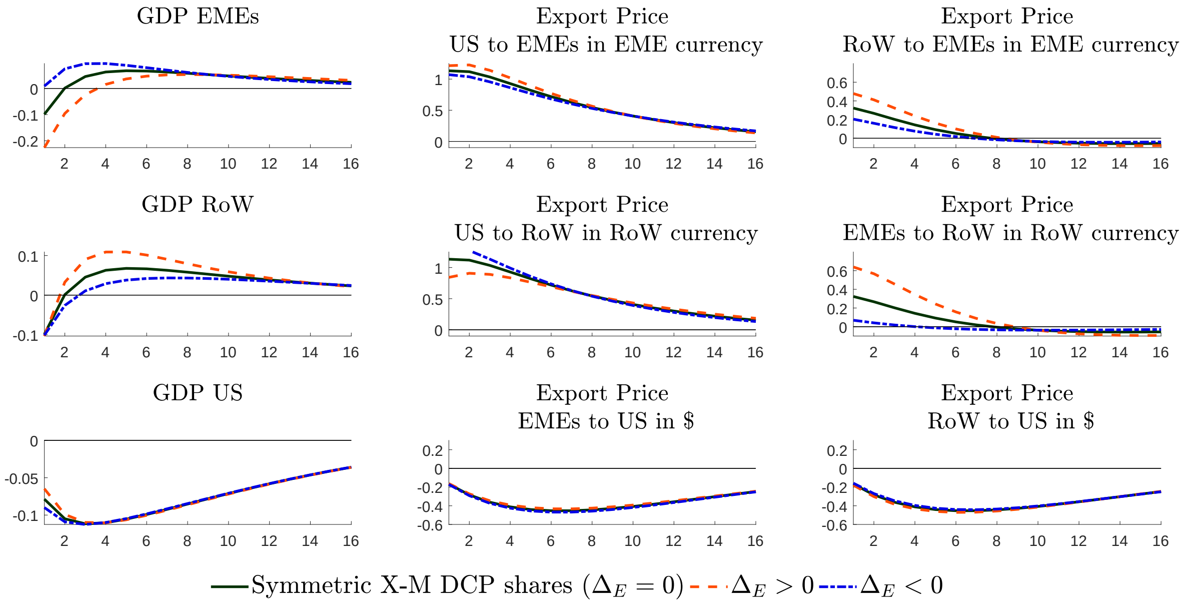


Figure 21: Dynamic effects of a contractionary US monetary policy shock under partial DCP



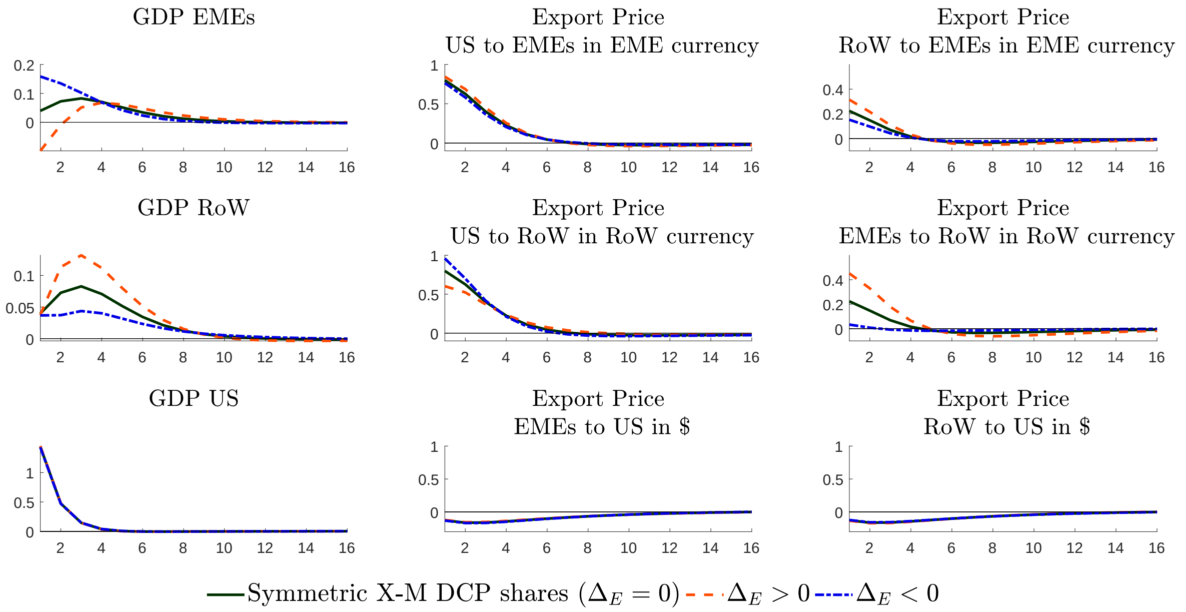
Note: The figure presents the dynamic effects of a contractionary US monetary policy shock on real GDP and bilateral export prices denoted in the currency of the importer for the case of partial DCP. See also the note to Figure 3.

Figure 22: Dynamic effects of a UIP shock under partial DCP



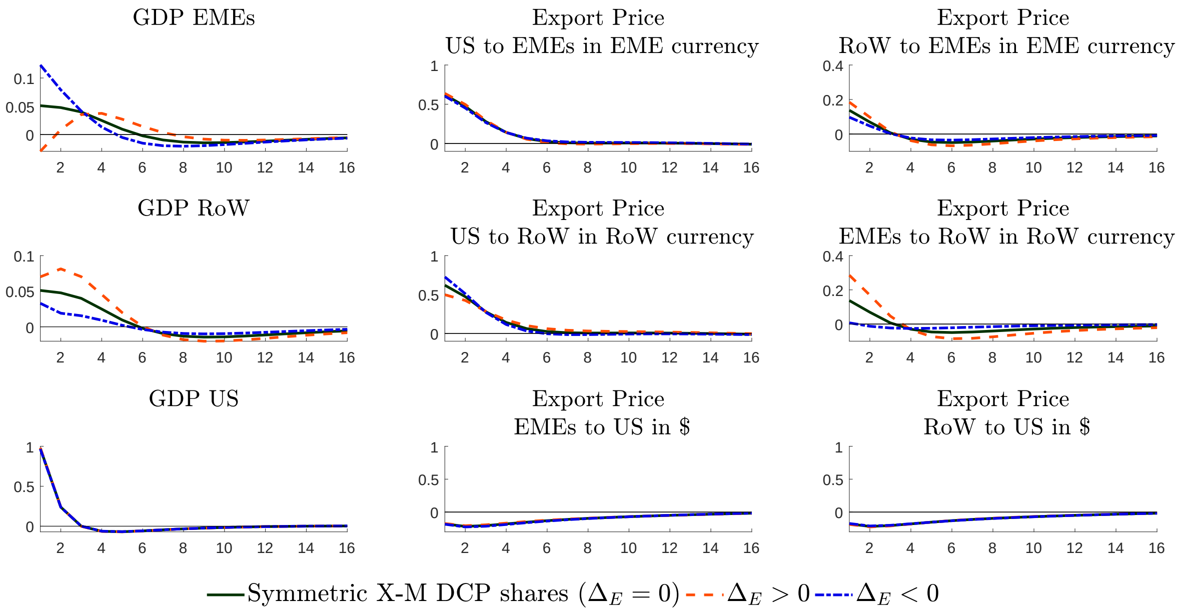
Note: The figure presents the dynamic effects of a UIP shock on real GDP and bilateral export prices denoted in the currency of the importer for the case of partial DCP. See also the note to Figure 3.

Figure 23: Dynamic effects of an US demand shock under partial DCP with trade in intermediate inputs to production



Note: The figure presents the dynamic effects of a positive US demand shock on real GDP and bilateral export prices denoted in the currency of the importer for the case of partial DCP using a model version in which foreign and domestic intermediate inputs are used as means of production (steady state share of intermediate inputs = 0.5). See also the note to Figure 3.

Figure 24: Dynamic effects of an US demand shock under partial DCP in a more elaborate version of the model

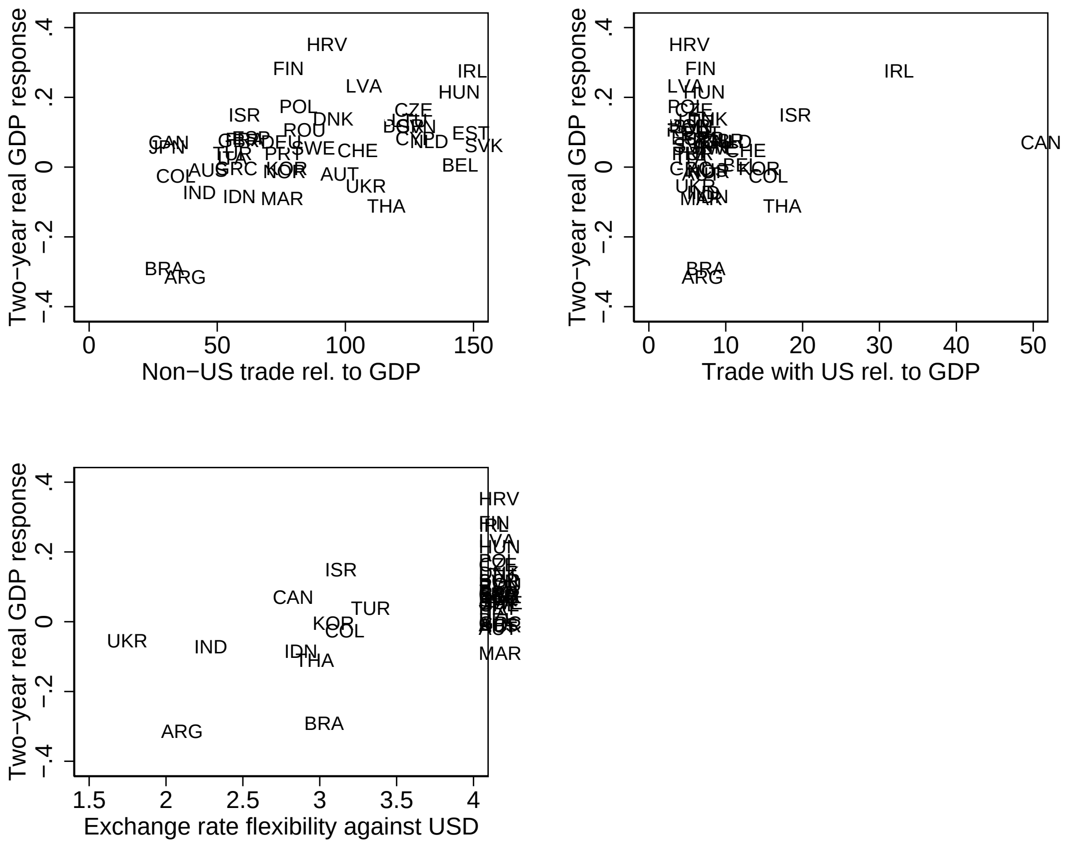


Note: The figure presents the dynamic effects of a positive US demand shock on real GDP and bilateral export prices denoted in the currency of the importer for the case of partial DCP using a more elaborate version of the baseline model with capital, sticky wages and financial frictions. See also the note to Figure 3.

Figure 25: Estimated GDP responses to a positive US demand shock, expanded country sample

Note: The figure shows the averages over eight quarters of the point estimates of the real GDP effects of a positive US demand shock. See also the note to Figure 5.

Figure 26: Relationship between spillovers from a positive US demand shock and country characteristics



Note: The figure depicts the unconditional correlation between the estimated spillovers from a positive US demand shock and control variables variables included in the regression in Equation (25).

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