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US trade policy and the US dollar

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Non-technical summary

Research Question

In 2018 and 2019, the USA imposed additional import tariffs on Chinese goods. We investigate the extent to which the effect on US (post-tariff) import prices was offset by the concurrent appreciation of the US dollar. In addition, we ask whether US trade policy itself triggered the US dollar appreciation.

Contribution

We show that the exchange rate response to a trade policy uncertainty shock is key to assessing the overall impact of trade policies. We identify trade policy uncertainty shocks as well as tariff rate shocks within a structural vector autoregressive (SVAR) model of the US economy. In this framework, we investigate the appreciation of the USD during the height of the trade conflict. We then build an open economy New Keynesian model featuring financial frictions in banks' asset holdings to trace out the channels underlying the link between uncertainty regarding future trade policy and the US dollar. Moreover, we assess the relevance of the induced USD appreciation in 2018 and 2019 for import prices of Chinese products in order to address the question of whether the effects of tariff hikes were (partly) offset.

Results

We find that increases in trade policy uncertainty were the main driver in the USD appreciation in 2018/2019. The theoretical model rationalizes this finding with an increase in the relative demand for safe US assets by risk-averse investors in face of increased trade policy uncertainty. With regard to offsetting effects, we find that Chinese exporters react to a USD appreciation by markedly lowering their US dollar-denominated export prices. This holds in particular for intermediate goods exporters, who had been the main focus of new tariffs. Overall, our results suggests that the trade policy-induced share of the US dollar appreciation in 2018/2019 offset a sizable part of the tariff increase on post-tariff import prices.

Nichttechnische Zusammenfassung

Fragestellung

In den Jahren 2018 und 2019 erhob die USA zusätzliche Zölle auf chinesische Güter. Dieses Forschungspapier untersucht, in welchem Ausmaß die zeitgleiche Aufwertung des US Dollars dem Effekt der Zölle auf US-Importpreise entgegenwirkte. Zusätzlich gehen wir der Frage nach, ob die US-amerikanische Handelspolitik selbst die Aufwertung des Dollars verursachte.

Beitrag

Wir zeigen, dass die Berücksichtigung der Effekte von Handelsunsicherheit auf Wechselkurse zentral für die Beurteilung der Auswirkungen von Handelspolitik ist. Wir identifizieren Handelsunsicherheitsschocks in strukturellen vektorautoregressiven Modellen (SVARs) der US-Wirtschaft und dokumentieren ihren Effekt auf den USD-Wechselkurs. Unsere empirischen Resultate erklären wir in einem Neukeynesianischen Modell, das Finanzfriktionen und die Unsicherheit über die Entwicklung der Handelspolitik abbildet. Zudem betrachten wir die Bedeutung der Dollar-Aufwertung in den Jahren 2018 und 2019 für die Preissetzung chinesischer Exporteure und ermitteln damit Effekte auf US-Importpreise, die den Zollerhöhungen entgegenwirkten.

Ergebnisse

Unsere Analyse ergibt, dass die ansteigende Handelsunsicherheit die Hauptursache hinter der Dollar-Aufwertung in 2018/2019 war. Unser theoretisches Modell erklärt diese mit einem Anstieg der relativen Nachfrage nach sicheren, in US-Dollar denominierten, Wertanlagen seitens risikoaverser Investoren in Zeiten erhöhter Handelsunsicherheit. Darüber hinaus zeigen wir, dass chinesische Exporteure – insbesondere von Vorleistungsgütern, welche das Hauptziel der neuen US-Importzölle waren – mit deutlichen Preissenkungen auf Dollaraufwertungen reagieren. Zusammengenommen legen unsere Ergebnisse nahe, dass der von der Handelspolitik verursachte Anteil der USD-Aufwertung einen großen Teil der durch die Zollerhöhung bewirkten Verteuerung von chinesischen Importgütern wieder wettmachte.

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Abstract

We investigate the extent to which the effect of the 2018/2019 US import tariff hikes on US (post-tariff) import prices was offset by the concurrent appreciation of the US dollar and trace the source of the appreciation back to US trade policy itself. The dollar response to trade policy uncertainty (TPU) is key to assessing the overall impact of trade policies. Within a SVAR framework, identified TPU shocks account for a sizable fraction of the USD appreciation – against a broad currency basket, but also against the Chinese yuan. To rationalize the SVAR evidence, we build an open economy NK model featuring financial frictions, which accounts for uncertainty regarding future trade policy. In the model, an increase in TPU raises the relative demand for safer US assets, triggering an appreciation of the US dollar. Moreover, in assessing the offsetting effects from the exchange rate, we use detailed product data on unit values of manufacturing imports and document that Chinese exporters react to an USD appreciation by markedly lowering their US dollar-denominated export prices. This holds in particular for intermediate goods producers, which had been the main target of US trade policy in 2018 and 2019. Overall, we find that offsetting effects on the newly imposed tariffs were substantial.

Keywords: Trade policy uncertainty, safe-asset currency, two-country model with financial frictions, exchange rate pass-through to import prices, tariffs.

JEL classification: F31, F13, F14, F41, E31.

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1 Introduction

In 2018 and 2019, the US administration took a markedly tighter trade policy stance against some of its major trading partners. Most prominently, duties on imports from China were raised substantially in several steps (see Figure 1). A direct goal of this policy was to increase the post-tariff import price of Chinese goods in order to reduce their competitiveness in the US market. However, Figure 1 shows that the trade conflict was accompanied by a notable appreciation of the US dollar against the Chinese yuan (CNY) and against a broader set of currencies, moving broadly in tandem with the change in the average US tariff rate on Chinese manufacturing imports. The appreciation of the US dollar, in turn, created an opportunity for foreign exporters to lower their prices for exports to the US, thereby improving the competitive position of US trading partners.

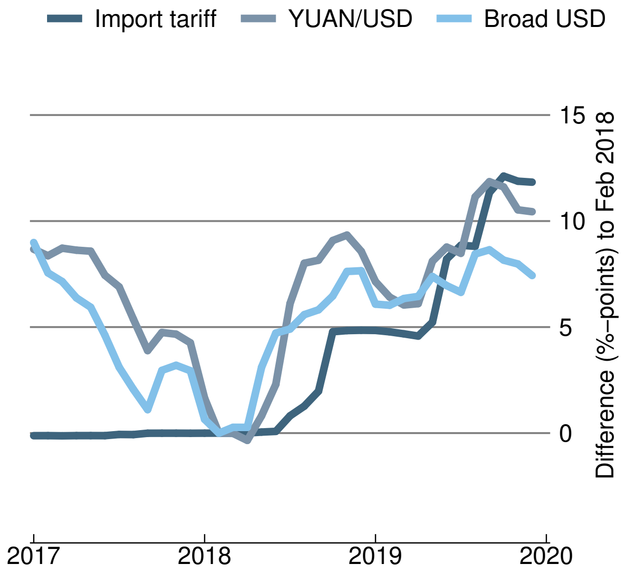

Figure 1: Change in the index of US tariff rates on Chinese manufacturing imports and the USD exchange rate relative to the Chinese renminbi and to a currency basket including major US trading partners in 2018 and 2019. The import tariff index is a weighted average of product-specific duties in the manufacturing sectors where weights are based on import values in 2017. An increase in the nominal USD exchange rate corresponds to an appreciation of the USD. Data sources: US Census, Haver Analytics and own calculations.

Against this background, the following questions arise: a) whether the observed USD appreciation in 2018 and 2019 was driven by changes in US trade policy, and

b) whether the dollar appreciation resulted in a reduction of pre-tariff import prices of Chinese goods, thereby offsetting the effects of the tariff increases. The findings of this paper suggest that the US trade policy was, to some degree, self-defeating.

In addressing the first question, we argue that trade conflicts cannot only be characterized by the increase in tariff rates. The US trade policy in 2018 and 2019, for instance, was shaped by a continuous process of negotiations and disputes with major trading partners. For market participants, it became increasingly difficult to infer the possible future path of policy actions. Desired or not, US trade policy in these episodes was accompanied by elevated levels of uncertainty (cf. Caldara, Iacoviello, Molligo, Prestipino, and Raffo 2020).[1] This increase in trade policy uncertainty itself has macroeconomic consequences. Thus, whereas much of the recent work on the effect of trade conflicts focused on the role of tariff rates (e.g., Furceri, Hannan, Ostry, and Rose, 2019; Lindé and Pescatori, 2019; Jeanne and Son, 2020), we are the first to show – both empirically and theoretically – that the dollar response to a trade policy uncertainty (TPU) shock is key to assessing the overall impact of trade policies.

More specifically, we identify TPU shocks as well as tariff rate shocks, among many other shocks, within a structural vector autoregressive (SVAR) model of the US economy. In this framework, we investigate the appreciation of the USD during the height of the trade conflict against a broad currency basket. Moreover, we estimate a SVAR model for the bilateral CNY/USD nominal exchange rate, employing daily data. Both approaches result in similar conclusions: between 2018 and 2019, TPU shocks account for a sizable fraction of the USD appreciation. Notably, TPU shocks appreciate the US dollar against a broad currency basket (also a basket excluding the yuan) as well as against the yuan exchange rate. In contrast, we find rather small effects of shocks to the level of tariff rates (or news thereof) on the exchange rate, which is in line with the analysis by Jeanne and Son (2020).

We rationalize the SVAR evidence in a two-country New Keynesian model with financial frictions and trace out the channels through which trade policy uncertainty can affect the nominal exchange rate. Crucially, the model captures an asymmetry in the relationship of the US and other countries: the notion that US dollar assets are considered to be relatively safe (see, e.g., Jiang, Krishnamurthy, and Lustig, 2021; He, Krishnamurthy, and Milbradt, 2019; Jiang, Krishnamurthy, and Lustig, 2020). We show that the financial asymmetry is key for driving the appreciation of the US dollar in the model. Moreover, simulating a shock to the uncertainty of future tariff rates, which corresponds to the observed hike in TPU during the trade conflict between the US and China, generates a USD appreciation

[1] Uncertainty about the evolution of policy measures might not be merely the outcome of policy actions but also the of policy tool itself (cf. Ghironi and Ozhan, 2020, in a monetary policy context).

that, in magnitude, broadly matches the empirically observed events.

In the model, in both countries, banks à la Gertler and Karadi (2011) hold domestic and foreign bonds. An agency problem between depositors and banks gives rise to a financial constraint that limits the size of the banks' balance sheet. As non-US bonds in the model are less pledgeable than US bonds, the financial constraint binds tighter in holdings of non-US bonds. This motivates a safety premium on US assets, which constitutes a deviation from the uncovered interest rate parity condition. In this setup, positive TPU shocks trigger a portfolio shift towards relatively safe US assets, raise the safety premium, and thereby result in a USD appreciation.[2] These dynamics are independent of actual tariff hikes. We show that this result is robust to a number of alternative modelling choices pertaining to the presence (or lack) of capital and intermediate goods in the production function, the type of financial market integration (equity market integration or bond market integration), the pricing paradigm (dominant currency pricing or producer currency pricing), or the nature of the shock as representing global trade uncertainty or uncertainty only with regard to the import tariffs levied by the United States.

As a second contribution, we assess the relevance of the induced USD appreciation in 2018/2019 for import prices of Chinese goods in order to address the question of whether the effects of 2018/2019 tariff hikes were (partly) offset. We employ detailed product data for US manufacturing industries and provide novel evidence on the pass-through of the CNY/USD exchange rate into unit values of Chinese exports towards the United States. Our dataset enables us to distinguish between intermediate goods that are processed further after importing, and final goods that are directly consumed.

We find that the exchange rate pass-through to Chinese export prices in USD is somewhere between 75% and close to full for intermediate goods. This compares to a rather limited exchange rate pass-through of around 40-50% for final goods. As additional US tariffs were especially targeted towards intermediate goods, the finding of a higher exchange rate pass-through for these goods suggests a high importance of exchange rate movements for the overall assessment of the effectiveness of US trade policy.[3]

As a vast majority of US imports from abroad is invoiced in USD (cf. Gopinath, 2016), Chinese export prices in USD should not mechanically move one-to-one with

[2] Qualitatively similar dynamics ensue when uncertainty revolves around aggregate total factor productivity (TFP).

[3] The result of a higher pass-through to prices of intermediate goods exports is in line with micro-evidence for Belgium presented by Amiti, Itskhoki, and Konings (2014) who find that the sensitivity of export prices to the nominal exchange rate is higher for exporters who are more upstream in the global value chain (here: intermediate goods exporters) than for firms farther downstream (here: final goods exporters).

an appreciation of the currency such as one would expect if the goods were invoiced in yuan. However, Chinese producers have an incentive to respond to a USD appreciation as their local currency export price increases. In this case, lowering the price is a rational response, especially when local currency marginal costs remain rather stable. Intuitively, this is the case for firms that are located farther upstream in a value chain and that are therefore likely to source fewer imports that are denominated in USD from abroad. Thus their marginal cost varies less in the exchange rate than the marginal cost of firms that source more goods from abroad (cf. Amiti et al. 2014). Higher tariffs on intermediate goods compared to other product categories can therefore result in a configuration in which those goods that face the highest tariffs also face the strongest (pre-tariff) import price decline in response to the exchange rate. This reduces the effectiveness of tariff policy.

But it is not only the focus on intermediate goods with a larger exchange rate pass-through that reduces the effectiveness of tariff hikes on import prices. In addition, our findings suggest that the average exchange rate pass-through over all goods imported from China to the USA is sizable ($\approx$ 60% in our baseline regression), whereas we find that exchange rate pass-through for imports to the USA from the rest of the world (excluding China) is much lower. The latter is in line with evidence in Cavallo, Gopinath, Neiman, and Tang (2021), which indicates that in the USA the exchange rate pass-through to import prices across all trading partners is on average small. A plausible explanation for this difference is again the higher reliance of Chinese producers on Chinese inputs. As China is a large country, Chinese exporters are more likely to source a larger share of their inputs domestically than exporters of other countries, making their costs less sensitive to USD appreciations, thereby creating a larger space to lower export prices (cf. Georgiadis, Gräb, and Khalil, 2020).

Overall, this paper points towards an important role of offsetting effects from the nominal exchange rate on import prices in the 2018/2019 trade war episode. Considering the evolution of the CNY/USD exchange rate in 2018 and 2019, and taking the exchange rate pass-through estimates into account, a simple back-of-the-envelope calculation indicates that the exchange rate response offsets the tariff hikes on US post-tariff import prices fully up to May 2019, and by around one-half up to the end of 2019. Combining the estimates regarding exchange rate pass-through, the 2018/2019 exchange rate path, and the SVAR results suggests that the trade policy-induced US dollar appreciation offset three-quarters of the effect of US tariffs on post-tariff import prices up to May 2019. After the imposition of additional tariffs in mid-2019, the trade policy-induced offsetting effect declines to around one-quarter.

The findings have important implications for understanding the macroeconomic consequences of trade policy. Amiti, Redding, and Weinstein (2019) conclude that their empirical finding regarding Chinese price responses to US import tariff hikes in 2018, among similar findings in the related literature, is puzzlingly small.[4] This hints at an important role of unidentified general equilibrium effects. Our results indicate that prices might have responded little to tariffs directly as Chinese exporters did benefit substantially from a USD appreciation that allowed them to lower prices without incurring an additional burden.

To the extent that we investigate the effects of trade policy uncertainty, we build on Caldara et al. (2020), who construct measures of trade policy uncertainty, which we employ, and who analyze the role of TPU shocks on various macroeconomic variables. We expand on their work by focusing on the role of TPU for the nominal exchange rate. As, in their theoretical model, both countries are fully symmetric, the nominal exchange rate remains unaffected by global TPU shocks. In contrast, our model captures asymmetries between the two countries, allowing us to analyze the effect of global shocks on the exchange rate. In locating the key mechanism in the financial sector, we follow the example set by Gabaix and Maggiori (2015), who investigate the role of financial frictions for the transmission of various level shocks on the exchange rate in an open economy setting. By highlighting the effects of a second moment shock, namely the TPU shock, our analysis is complementary to their work. The role of the safe asset property of USD assets for the nominal exchange rate has previously been illustrated in a small model by Jiang et al. (2020). Our analysis differs from theirs not only by studying the transmission of a TPU shock, but also by adding more details to the model that enhance the realism of the dynamics and allow us to investigate the robustness of our main mechanism to various modeling choices as well as to generate effects on the nominal exchange rate that match the magnitude of the empirical effect of trade policy uncertainty on the USD exchange rate. We also complement empirical contributions that point towards a special role of the US exchange rate and global financial markets for the transmission of US uncertainty shocks and global risk shocks (cf. Bhattarai, Chatterjee, and Park 2020, and Georgiadis, Müller, and Schumann 2021).

The remainder of the paper is organized as follows. We start by assessing micro evidence on the pass-through of the US dollar / Chinese yuan exchange rate on Chinese export prices in Section 2. Section 3 presents evidence on the role of import tariffs and trade policy uncertainty for the broad USD as well as the bilateral CNY/USD exchange rate. In Section 4, we study the role of trade policy uncertainty shocks in an open economy model with financial frictions and a safety premium on US-issued assets. In the last section, we conclude. The appendix contains additional empirical robustness checks and details on the theoretical model.

[4] See, for instance,Amiti et al. (2019), Fajgelbaum, Goldberg, Kennedy, and Khandelwal (2020), Cigna, Meinen, Schulte, and Steinhoff (2021), and Deutsche Bundesbank (2020).

2 Exchange rate pass-through under global value chains: how did Chinese exporters respond to the appreciation of the USD?

To assess the empirical evidence on the pass-through of exchange rates to US import prices, we employ a monthly product-level panel dataset on Chinese manufacturing exports to the US for 2002 to 2019.[5]

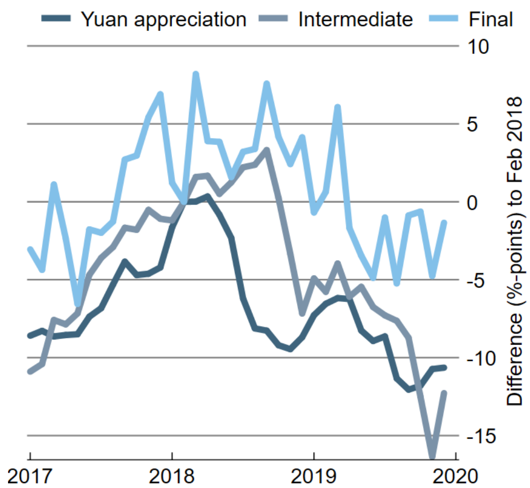

Figure 2: Change in aggregate unit values of US manufacturing imports from China across different product categories (intermediate and final goods) and Chinese yuan appreciation against the US dollar. The unit value indices are weighted averages of product-specific unit values with weights based on the import values in 2017. Unit values with year-over-year and month-over-month changes above 300% are excluded. Final goods include capital and consumption goods. An appreciation of the yuan against the US dollar corresponds to an increase in the variable. Data sources: US Census, Haver Analytics and own calculations.

Figure 2 shows that, at the aggregate level, unit values of intermediate goods fell quite markedly by roughly 10 to 15% between early 2018 and the end of 2019.

[5]The data are from the US Census (https://usatrade.census.gov/). The dataset includes monthly product records of US imports from China for January 2002 to December 2019. It contains measures of import values, import quantities, as well as calculated duties at an HS-10 disaggregated level. We exclude all observations where the HS code does not match a NAICS manufacturing sector in the concordance table of Pierce and Schott (2012). The classification of final, capital, and intermediate goods follows the Broad Economic Categories (Rev.4) classification and is obtained from the Peterson Institute for International Economics.

Over the same time, unit values of final goods declined by about 5%. Notably, unit values of intermediate goods move much more strongly in tandem with the exchange rate than unit values of final goods.

To analyze this relationship at the level of product categories, we start by estimating relatively standard exchange rate pass-through regressions (cf. Burstein and Gopinath, 2014) encompassing import tariffs (similar to Cavallo et al., 2021). More precisely, we run the following regression with monthly data at an HS-6 product level for the period January 2003 to December 2019[6]

$$\Delta \ln P_{X,i,t} = \kappa_i + \sum_{l=t}^{t-(T-1)} \beta_{S,l} \Delta \ln S_l + \sum_{l=t}^{t-(T-1)} \beta_{\tau,l} \Delta \ln(1+\tau_{i,l}) + \sum_{l=t}^{t-(T-1)} \beta'_{X,l} X_t + \varepsilon_{i,t}. \tag{1}$$

On the left-hand side, $P_{X,i,t}$ denotes the USD-denominated pre-tariff unit value of a specific product i produced in China and exported to the US at month t. On the right-hand side, S_t is the CNY/USD nominal exchange rate at month t, where an increase in the variable expresses a USD appreciation relative to the renminbi. $\tau_{i,t}$ is the US import tariff rate imposed on a Chinese product i in period t, and X_t is a (1×2) vector of controls. The vector of controls contains the Chinese producer price index (in order to control for the average inflation trend across all Chinese industries) and the Brent oil price to avoid confounding the effects of USD movements and oil price changes on manufacturing export prices.[7] As with all the other variables, the control variables enter the regression in monthly differences in logs. $\varepsilon_{i,t}$ is an i.i.d error term and κ_i is a product-fixed effect. The exchange rate pass-through and the effect of the tariffs on pre-tariff import prices are computed as $\Sigma_{l=0}^{T-1} \widehat{\beta}_{s,t}$ and $\Sigma_{l=0}^{T-1} \widehat{\beta}_{\tau,t}$, respectively, with hats denominating the estimated coefficients. We choose T = 12, so that the implied estimates characterize the pass-through in the medium run (within a year).

Table 1 reports results of five regression exercises that differ with respect to the sample composition. While column (1) pools all product groups, columns (2) to (4) distinguish between intermediate, final capital and final consumption goods.

[6] We choose to use HS-6 aggregated data as, over the relatively long estimation horizon, the HS-10 classification is subject to many changes with products entering and exiting a classification. In order to detect potential outliers and error reporting, we exclude observations where unit values, quantities, or customs values change by more than 300% within a year. For the same purpose, we exclude observations where the measured tariff rate (expressed as calculated duty value relative to customs value) is above 25%. Additionally, all observations with steel-related products are omitted by detecting the word "steel" in the commodity descriptions, as tariff increases on steel imports affected many countries, not only China.

[7] Kilian and Zhou (2019) provide evidence on links between oil prices and the USD exchange rate.

Column (5) reports the pooled sample of final goods (including capital goods and consumption goods).

	(1) All	(2) Interm.	(3) Capital	(4) Consumption	(5) Final
US dollar	-0.609***	-0.768***	-0.513	-0.372**	-0.448***
	(0.107)	(0.151)	(0.345)	(0.162)	(0.148)
Import tariff	-0.134	-0.279	-0.201	-0.206	-0.137
	(0.259)	(0.328)	(0.585)	(0.728)	(0.418)
PPI	0.885***	1.038***	0.597	0.766***	0.751***
	(0.166)	(0.229)	(0.552)	(0.252)	(0.237)
Nominal Brent	-0.005	-0.020	0.034	-0.007	-0.006
	(0.023)	(0.031)	(0.078)	(0.035)	(0.033)
Products	2769	1589	375	805	1180
N	325726	171190	44409	110127	154536

Table 1: Tariff pass-through and exchange rate pass-through based on regression 1 for US manufacturing imports from China. Pass-through measures the cumulative impact of the current estimate and 11 lags of the coefficient (i.e. within a year).

Across all samples, the estimated effect of import tariffs on pre-tariff import prices has the expected negative sign, but is rather small and statistically not distinguishable from zero. This is consistent with many findings in previous studies (see above) and suggests that Chinese exporters, on average, did not lower their export prices in response to the imposition of import tariffs. For the exchange rate pass-through, we find a different result, namely a statistically significant and sizable coefficient. Taking the pooled sample (all types of goods) in column (1) as a benchmark, the estimates indicate that Chinese export prices expressed in USD decline by around 6% in the case of an appreciation of the US dollar by 10%. We find, however, substantial heterogeneity in the exchange rate pass-through. In the full sample (2003-2019), the exchange rate pass-through is a little below 80% for intermediate goods, while it is around 45% for final goods.[8]

The estimates suggest an important role of the USD exchange rate in offsetting (some of) the effect of US tariffs on prices of Chinese imports. A vast majority of US imports from abroad is invoiced in USD (Gopinath 2016), which is likely to be the case for imports from China, too. Therefore, USD-denominated prices of Chinese imports do not mechanically change with a USD appreciation. The empirical findings rather suggest that Chinese exporters recalculate prices in response

[8]In a robustness check, we restrict the sample by excluding periods before July 2005 when the yuan exchange rate was inflexible with respect to the USD. This yields very similar results. The appendix reports a further robustness analysis based on the period 2017 to 2019 and a different estimation approach where the effect of changes in tariffs and the exchange rate relative to the base period February 2018 on export price inflation are analyzed.

Product category	(1) Cumulative tariff Δ (May 2019)	(2) Cumulative tariff Δ (Dec 2019)	(3) USD Δ(May 2019)	(4) USD Δ(Dec 2019)	(5) Offsetting effect (May 2019)	(6) Offsetting effect (Dec 2019)
All goods	4.9 pp	11.6 pp	8.1 %	10.4 %	≈ 100%	≈ 55%
Intermediate	9.2 pp	18.0 pp			≈ 68%	≈ 44%
Final	3.4 pp	9.2 pp			≈ 107%	≈ 51%

Table 2: Back-of-the envelope calculation of offsetting effects in 2018 and 2019. Columns (5) and (6) combine the USD change (relative to February 2018 in columns 3 and 4) with the point estimates for exchange rate pass-through in Table 1 (columns 1, 2, and 5). "All goods" contains intermediate and final goods.

to changes in the USD exchange rate.

Taking the evolution of the US currency in 2018 and 2019 into account, a simple back-of-the-envelope calculation suggests that, for US customers, the price changes triggered by the USD appreciation offset a large fraction of the effect of US import tariffs imposed on Chinese intermediate imports (see Table 2). For final goods, as they faced lower tariff hikes on average, the offsetting effects were even somewhat larger than 100% in the first rounds of tariffs. At the end of 2019 and after additional steep US import tariff increases, the offsetting effect was still more than one-half.[9]

Notably, Cavallo et al. (2021) find a low average US exchange rate pass-through to import prices of around 20-30% across all trading partners (depending on the empirical specification). When we estimate equation (1) for US imports from the rest of the world (without China), we also obtain a relatively low pass-through of around 40 % (see Table 3). For final goods, the estimate is around 25 %.[10] One

[9] Amiti et al. (2019), who examine the tariff pass-through for 2018, find that the domestic price effects of US import tariff hikes had been surprisingly small, which they interpret as hinting at an important role of general equilibrium effects. The results presented here suggest that final import prices (including tariffs) might have responded little to tariff hikes as Chinese exporters benefited substantially from the USD appreciation that allowed them to lower pre-tariff USD prices without incurring an additional burden in their national currency.

[10] For the trading partner PPI, we use the Dallas Fed's index of World PPI (excl. US) in Haver and subtract the evolution of the Chinese PPIs employing weights in the exchange rate basket from the Federal Reserve Board. Equivalently, we compute a rest-of-the-world exchange rate basket (excluding the Chinese yuan). Note that among other differences, Cavallo et al. (2021) use bilateral import data from many different US trading partners, whereas we consider the rest of the world (without China) as one aggregate. Moreover, import prices are deducted from BLS

possible explanation for the higher coefficient for China compared to the other US trading partners is that the country's economy is large. As trade openness typically declines in country size, the overall exposure to foreign imports in production is more limited for a large country. For China compared to other US trading partners, this would imply a smaller countervailing effect via higher prices of imported input factors and therefore a larger exchange rate pass-through along the lines of the mechanism discussed in Georgiadis et al. (2020).

	(1) All	(2) Interm.	(5) Final
US dollar	-0.427***	-0.551***	-0.252*
	(0.078)	(0.093)	(0.137)
Products	4101	2472	1629
N	605149	368017	237132

Table 3: Exchange rate pass-through based on regression 1 for US imports from the rest of the world (excluding China).

Overall, the evidence presented in this section suggests that in the trade conflict with China, the USD appreciation likely offset a substantial share of the effect of higher US tariff rates on post-tariff import prices.

3 US trade policy (uncertainty) and the US dollar appreciation in 2018 and 2019

We now turn to the question as to whether the appreciation of the dollar was triggered by US trade policy itself, hinting at a potentially self-defeating effect of US trade policy. In this section, we first investigate this question for the multilateral dollar exchange rate and, secondly, for the bilateral exchange rate vis-à-vis the Chinese yuan. To fully capture the effects of trade policy, in addition to the level of tariff rates and news thereof, we also cosndier the uncertainty surrounding trade policy actions as a potential driver of the nominal exchange rate.

3.1 The response of the USD against a broad range of currencies

In order to examine whether the USD appreciation in 2018 and 2019 was triggered by US trade policies, we employ the following structural VAR framework

$$A_0 y_t = \alpha + A_1 y_{t-1} + ... + A_k y_{t-k} + \varepsilon_t \tag{2}$$

price data based on surveys, whereas here we use unit values.

where y_t is the vector of endogenous variables and ε_t is a vector of structural innovations with variance-covariance matrix Ξ. Identification is obtained by Cholesky factorization, i.e. by imposing a lower triangular matrix on $A = A_0^{-1}$ such that $\Sigma = AA'$, where Σ collects the reduced-form VAR residuals. The nine variables in the vector y_t are ordered as follows: (1) the US import tariff index, (2) OECD industrial production, (3) US industrial production, (4) US consumer price index, (5) US trade policy uncertainty, (6) US macroeconomic uncertainty, (7) the US stock market index S&P 500, (8) the index of real commodity prices and (9) the broad trade-weighted US dollar nominal exchange rate.[11] In this setup, the US import tariff index does not respond to any variable contemporaneously, meaning that tariffs are supposed to be set independently of the current state of the economy. Industrial production and consumer prices do not respond to the uncertainty variables within a month, implicitly assuming that real and nominal frictions in the economy hinder a quick adjustment. The financial variables (stock market prices, commodity prices, and the nominal exchange rate) are ordered last as they typically react rather swiftly to shifts in economic conditions. They are also assumed to respond to trade policy uncertainty and macroeconomic uncertainty within a month. In particular, the USD exchange rate is ordered last and responds to all variables contemporaneously.

The choice of variables follows the setup of the structural VAR employed in Bhattarai et al. (2020), who analyze the spillover of US uncertainty shocks to emerging market economies. We borrow this specification to rule out that the effect of trade policy uncertainty on the USD exchange rate is confounded with the effect of macroeconomic uncertainty. Instead of the VIX as in Bhattarai et al. (2020), we, however, include the measure of macroeconomic uncertainty estimated in Jurado, Ludvigson, and Ng (2015).[12] We also include a monthly index of US import tariffs. This aims at separating direct effects of tariffs from trade policy uncertainty shocks.[13] For trade policy uncertainty, we take the news article-based measure

[11] All variables except for the macroeconomic uncertainty measure are expressed in logs. Moreover, all variables enter in first differences except the real commodity price and the nominal exchange rate. The estimation employs the BEAR toolbox (Dieppe, van Roye, and Legrand 2018). Note that the real commodity prices and the nominal exchange rate are stationary variables; transforming the data to first differences is therefore not necessary. Still, if these variables are transformed to first differences as well, the impulse response analysis yields a very similar result. Following earlier contributions, the monthly VAR does not include the interest rate differential between US and non-US bonds. We, however, include this variable in the daily (bilateral) VAR below.

[12] We include more variables in the SVAR than Bhattarai et al. (2020), in particular the US stock market index and an index of US import tariffs. In Bhattarai et al. (2020), the VIX is ordered last, whereas we order the uncertainty measures before the financial market variables.

[13] For this purpose, we compute the index of average monthly import tariffs from the US customs data employed in the previous section, available from January 2002 onwards. We seasonally adjust the data with the X-13ARIMA-SEATS filter. Before 2002, only quarterly growth

from Caldara et al. (2020).[14] The model is estimated for the time period January 1985 to December 2019, and the lag number is set to k = 6. Overall, the estimated model shares similarities with the model estimated in Caldara, Iacoviello, Molligo, Prestipino, and Raffo (2019).[15]

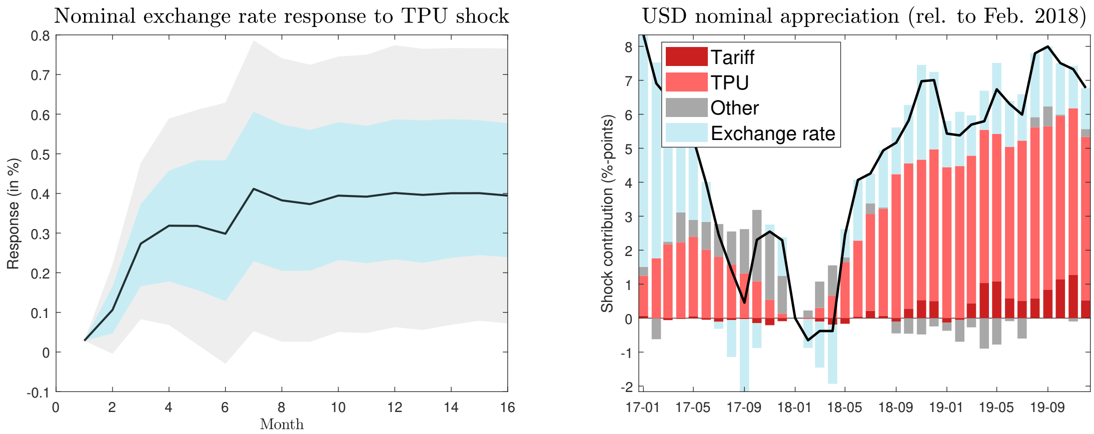

Figure 3: Results from the monthly SVAR model. January 1985 to December 2019. Left panel: impulse response function for the US dollar appreciation given a one-standard-deviation trade policy uncertainty shock in period 1. Grey (blue) area shows the 95% (68%) confidence interval. Right panel: historical decomposition of US dollar movements for various groups of identified shocks: tariff shocks, trade policy uncertainty (TPU) shocks, exchange rate shocks (Exchange rate), as well as remaining shocks and the deterministic component (Other).

Figure 3 plots the results. The left panel shows the impulse response function for the US dollar effective exchange rate given a one-standard-deviation shock to trade policy uncertainty. It indicates a positive and significant effect that is rather persistent. The response is, at first glance, surprisingly sluggish. This finding is,

rates of average tariffs – computed as the customs duties relative to import values – are available. Monthly growth rates are approximated by dividing the quarterly growth rate by three.

[14]There are pros and cons to using this measure to capture trade policy uncertainty (see Deutsche Bundesbank 2020 for a discussion). One appealing advantage of the measure is that it is, by construction, exogenous with respect to macroeconomic developments. Moreover, it corresponds not solely to uncertainty in tariffs but also to uncertainty in a broader array of trade policy actions (such as import bans).

[15]Caldara et al. (2019) – utilizing the dataset introduced in Caldara et al. (2020) – also report a positive response of the nominal exchange rate to a trade policy uncertainty shock. Nevertheless, the focus of their note is neither on exchange rates dynamics, in particular, nor on offsetting effects from trade policy-induced exchange rate shifts.

however, in line with previous studies reporting slow responses of nominal exchange rates to fundamental shocks.[16]

The right panel of Figure 3 plots the historical decomposition for the period January 2017 to December 2019. This exercise reports for each shock in the SVAR, the contribution to the percentage change of the nominal exchange rate in a specific month relative to February 2018. Between February 2018 and the end of 2018, the USD appreciated (compared to a basket of currencies) by around 6% and by one more percentage point up to the end of 2019. Importantly, according to our estimation, trade policy uncertainty shocks account for a large fraction of these dynamics. They explain around five percentage points of the overall change in the exchange rate up to mid-2019. Taking the direct effects of the tariff increases into account as well, US trade policy accounts for an even larger fraction of the total change.

The benchmark results are robust to adjustments of the SVAR specification along several dimensions (see Appendix C for more details): (1) The exclusion of the Chinese yuan exchange rate from the currency basket. This robustness analysis demonstrates that the trade policy-induced multilateral appreciation in 2018 and 2019 was also the consequence of a depreciation of non-Chinese trading partners' currencies against the US dollar. (2) The inclusion of US short-term interest rate measures in the SVAR. (3) An estimation of the model up to the end of 2015, excluding the most recent trade policy uncertainty hikes. This exercise indicates that the role of trade policy uncertainty for the nominal exchange rate is not a peculiar phenomenon of the most recent trade conflict. In Appendix C, we also illustrate the role of deviations of the covered interest rate parity between US and non-US long-term government bonds for the transmission of trade policy uncertainty shocks.

3.2 The Chinese yuan / US dollar bilateral exchange rate response

As an additional exercise, we use daily data on trade policy measures and financial market variables to estimate a structural VAR that includes the bilateral CNY/USD exchange rate.[17] We again use a Cholesky factorization as an identifying restriction. The vector of variables includes, in the following order: (1) a measure quantifying announcements and news regarding US tariffs specifically

[16]For the case of monetary policy shocks, see, for instance, Müller, Wolf, and Hettig 2021 and references therein.

[17]Employing the CNY/USD exchange rate in a VAR with monthly data on a longer sample would face several challenges, as the exchange rate was inflexible throughout many episodes.

on Chinese imports in 2018-2020,[18], (2-3) the Citigroup macroeconomic surprise indices for the US and China, (4) trade policy uncertainty (reported at a daily frequency from Caldara et al. 2020), (5) the CBOE Volatility Index VIX, (6) the difference between the US and Chinese short-term policy rates, (7) the spread between the yields on US and Chinese government bonds with three year maturity, (8) the difference in the growth rates of stock market values in the two countries measured by S&P 500 for the US and the Shanghai SE Composite Index for China as well as (9) nominal oil prices (Brent) and (10) the nominal exchange rate between the USD and the renminbi.[19] As in the monthly VAR, we allow each variable to contemporaneously react to all variables ordered subsequently. In particular, the CNY/USD exchange rate responds to all variables within a day. The model is estimated for the period of 1 January 2014 to 5 of March 2020. We exclude observations in which any data are missing (for instance on weekends). Given the choice of high-frequency financial variables and news indicators, we set the lag number to two working weeks (k = 10).

Figure 4 plots the results. As in the monthly SVAR above, we find a positive and significant response of the CNY/USD nominal exchange rate to US trade policy uncertainty shocks. Despite having a very different set of variables employed in the SVAR and despite analyzing the bilateral CNY/USD exchange rate instead of the multilateral USD exchange rate, the historical decomposition in the right panel suggests a very similar conclusion to the broader analysis above. In particular, between 2018 and 2019, a large fraction of the USD appreciation against the renminbi seems to have been triggered by trade policy uncertainty and actual trade policy shocks. In this specification, tariff news shocks play a more substantial role than the tariff shocks in the monthly model, presumably reflecting the fact that most trade measures taken in this period were directed against China.[20] Nonetheless, the effect of trade policy uncertainty shocks remains dominant. Adding up the contributions of both types of trade-related shocks, we arrive at the conclusion that, between February 2018 and the end of 2019, the USD appreciated against

[18]The measure is computed as follows. We employ the list of tariff news in Jeanne (2020) – based on data from Bown and Kolb (2020) – and calculate for each event the informational content regarding the additionally taxed custom value and the specific tariff rate. We extend the list of Jeanne (2020) by events in 2019 as reported in Bown and Kolb (2020). Multiplying the announced additionally taxed custom value with the specific (or very likely) tariff rate gives the measure of quantified tariff news. Tariff news include tariff announcements, tariff im-position, or very specific threats of future tariffs. The variable takes the value zero before 21 March 2018.

[19]The interest rate spreads (that appear to have downward trends in the sample) as well as the stock market variables are transformed to first differences. All variables except the tariff news measure and the surprise indices enter in logs.

[20]Despite the very limited time series variation of this measure, the effect of a tariff news shock on the nominal exchange rate is – based on 68% error bands – statistically significant over the whole horizon. Within 95% error bands, the effect is still statistically significant for two months.

the renminbi by around 5 to 6% due to US trade policy.[21]

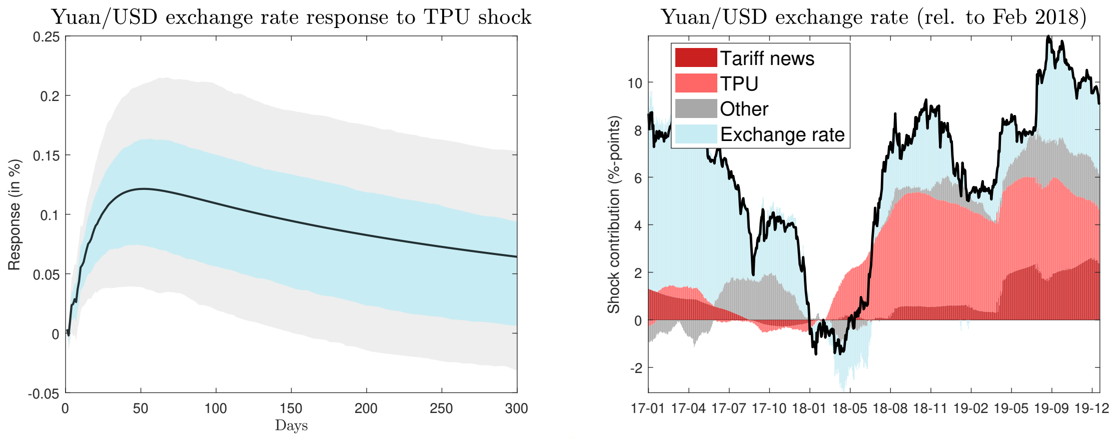

Figure 4: Results from the daily SVAR model. January 2014 to March 2020. Left panel: impulse response function for CNY/USD nominal exchange rate appreciation given a one-standard-deviation trade policy uncertainty shock in period 1. Grey (blue) area shows the 95% (68%) confidence interval. Right panel: historical decomposition of US dollar movements for various groups of identified shocks: tariff shocks, trade policy uncertainty shocks (TPU), exchange rate shocks (Exchange rate), as well as remaining shocks and the deterministic component (Other).

3.3 Quantitative implications of the empirical findings

As outlined above (Table 2), taking the evolution of the CNY/USD exchange rate as well as the micro estimates concerning exchange rate pass-through on unit values of US imports from China into account and doing a simple back-of-the-envelope calculation, the exchange rate response did offset the tariff hikes fully up to May 2019 and by around one-half up to end of 2019. Moreover, the SVAR results suggest that up to around mid-2019, the fraction of the US dollar appreciation that can be attributed to trade policy (measured by the contribution of tariff shocks and trade policy uncertainty shocks) is larger than the hike of US tariff on manufacturing imports from China (see Figure 1).

[21] It is often argued that the CNY/USD exchange rate is, at least to a certain extent, possibly not market driven as Chinese authorities might regularly intervene in the exchange rate market. Such exogenous interventions would be captured by the identified exchange rate shocks (blue bar in Figure 4, right panel). However, these exchange rate shocks are not necessarily exchange rate interventions but can be related to many other not separately identified determinants of the CNY/USD exchange rate.

Combining the SVAR results with the estimates regarding ex-change rate pass-through, the estimates indicate that, up to May 2019, roughly three-quarters of the effect of US import tariffs on (post-tariff) import prices were offset (see Table 4). After the imposition of additional tariffs in mid-2019, the offsetting effect declines to around one-quarter up to December 2019.

Product category	(3) XR Δ(May 2019)	(4) XR Δ(Dec 2019)	(3) Identified effect Δ(May 2019)	(4) Identified effect Δ(Dec 2019)	(5) Trade policy-induced offsetting effect (May 2019)	(6) Trade policy-induced offsetting effect (Dec 2019)
All goods	8.1%	10.4 %	$\approx$ 6%	$\approx$ 5%	$\approx$ 74%	$\approx$ 26%
Intermediate					$\approx$ 50%	$\approx$ 21%
Final					$\approx$ 79%	$\approx$ 25%

Table 4: Back-of-the envelope calculation of offsetting effects from US dollar movements in 2018 and 2019 relative to February 2018. Based on the identified effects of tariff (news) and trade policy uncertainty in Figure 3 and Figure 4 as wells as the calculations reported in Table 2. "All goods" contains intermediate and final goods.

4 A model of trade policy uncertainty and the dollar exchange rate

As our empirical result is novel, this section proposes a theoretical model which rationalizes the link between an increase in trade policy uncertainty and the appreciation of the US dollar. The two-country DSGE model features financial frictions à la Gertler and Karadi (2011) and international trade in government bonds. The key mechanism is based on the notion from the literature on safe assets that assets issued in US dollar are relatively safe by international comparison (see, e.g., Jiang et al., 2021; He et al., 2019; Jiang et al., 2020). In the model, this implies that risk-averse investors shift their asset demand towards US dollar assets in the face of an increase in uncertainty. This portfolio shift supports an appreciation of the US dollar. In addition, we show that in a simplified model without the safe asset channel, the link between trade policy uncertainty and USD appreciation breaks down.

4.1 The model

Both countries' economies feature households, firms, banks, a central bank, and a fiscal authority. Alongside the difference in the safety of assets, we assume as a second asymmetry that US exporters commit to producer currency pricing (PCP), while exporters from the second country follow local currency pricing (LCP). This is motivated by the dominance of the US dollar in international trade.[22] With a few exceptions, we largely stick to discussing the economy of country A, which stands for the US in the model. Features of country B are only discussed in those cases in which they deviate from their country A counterpart. In this section, we discuss only the most important equations. The full model and derivations are delegated to the appendix.

4.1.1 Households

Household i in country A consumes, supplies labor and saves in domestic deposits. Its utility is derived from consumption and leisure

$$U_i^A = E_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{(C_{i,t}^A - hC_{i,t-1}^A)^{1-\sigma_c}}{1-\sigma_c} - \chi \frac{(L_{i,t}^A)^{1+\sigma_l}}{1+\sigma_l} \right], \tag{3}$$

where $C_{i,t}^A$ is consumption by household i in country A and $L_{i,t}^A$ is its supply of labor. Parameter h governs habit formation in consumption, σ_c is the coefficient of relative risk aversion, and σ_l is the inverse of the Frisch elasticity. The household's budget constraint reads

$$C_{i,t}^A + D_{i,t}^A = R_{d,t-1}^A D_{i,t-1}^A + \frac{W_{i,t}^A}{P_t^A} L_{i,t}^A + T_{i,t}^A, \tag{4}$$

where $R_{d,t}^A$ is the real interest rate on the household's deposits with the domestic bank, $D_{i,t}^A$. $W_{i,t}^A$ is the nominal wage set by household i, P_t^A is the consumer price index in country A, and $T_{i,t}^A$ is a term summarizing the net income from transfers, taxes, and firms' profits. In equilibrium, all households in country A have the same first-order conditions for consumption/saving (hence we drop the subscript i)

$$\beta E_t \Lambda_{t+1}^A R_{d,t}^A = 1 \tag{5}$$

with $\Lambda_t^A = \frac{\lambda_t^A}{\lambda_{t-1}^A}$, and $\lambda_t^A = (C_t^A - hC_{t-1}^A)^{-\sigma_c} - \beta h E_t (C_{t+1}^A - hC_t^A)^{-\sigma_c}$.

Each household supplies labor equally to a continuum of unions j, $j \in [0,1]$.

[22] For a discussion of the dominance of the US dollar in trade, see Gopinath, Boz, Casas, Díez, Gourinchas, and Plagborg-Møller (2020).

Monopolistically competitive unions offer differentiated labor services, $L^A_{j,t}$, to firms at wage $W^A_{j,t}$. Wage setting is subject to nominal rigidities à la Calvo (1983) with the probability that a union can reset its wage in any given period being ζ_w. The demand for union $j's$ differentiated labor supply is $L^A_{j,t} = \left(\frac{W^A_{j,t}}{W^A_t}\right)^{-\epsilon_w} L^A_t$. ϵ_w is the elasticity of substitution between different varieties of labor services and L^A_t is the aggregate demand for labor services. The aggregation of labor services follows a Dixit-Stiglitz aggregator. The aggregate wage level in country A hence reads $W^A_t = \left(\int_0^1 (W^A_{i,t})^{1-\epsilon_w} di\right)^{\frac{1}{1-\epsilon_w}}$ These assumptions allow for a tractable aggregation of ideosyncratic labor supply and give rise to a standard wage Philips curve.

4.1.2 Aggregate demand and price indices.

In the baseline model, aggregate demand on the goods market, Y^A_t, is composed of consumption and government spending, G^A_t. Thus, for country A, it holds that $Y^A_t = C^A_t + G^A_t$. The aggregate demand aggregator in country A reads

$$Y^A_t = \left[(1-\mu^T)^{1/\Theta}(Y^{AA}_t)^{\frac{\Theta-1}{\Theta}} + (\mu^T)^{1/\Theta}(Y^{BA}_t)^{\frac{\Theta-1}{\Theta}}\right]^{\frac{\Theta}{\Theta-1}}. \tag{6}$$

Y^{AA}_t denotes the goods produced in A and absorbed in A, while Y^{BA}_t denotes goods produced in country B and imported by A. Parameter μ^T governs the trade openness, and Θ is the elasticity of substitution between goods produced in country A and goods produced in country B. The aggregate price index in country A, P^A_t, is

$$P^A_t = \left[(1-\mu^T)(P^{AA}_t)^{1-\Theta} + \mu^T(\widetilde{P}^{BA}_t)^{1-\Theta}\right]^{\frac{1}{1-\Theta}}, \tag{7}$$

where P^{AA}_t is the price level for goods produced in country A in the domestic market and $\widetilde{P}^{BA}_t$ is the post-tariff price for goods produced in country B and used in country A, in terms of the currency of country A. It holds that $\widetilde{P}^{BA}_t = (1+\tau^{BA}_t)P^{BA}_t$, where τ^{BA}_t is the import tariff rate charged on goods from country B by the customs authority of country A, and P^{BA}_t is the respective pre-tariff price.[23]

[23] Our setup implies a complete pass-through of tariff rate changes to prices of final goods. While this might only apply to select cases of US imports, the results by Caldara et al. (2020) show the importance of trade policy uncertainty also with an incomplete tariff rate pass-through. In their model, tariff rate increases affect the costs of wholesale firms, which purchase domestic and foreign intermediate goods. These firms sell their output domestically setting their prices subject to adjustment costs. In that case, price stickiness reduces the tariff rate pass-through. In contrast, in our model, price setting takes place on the exporters' side. This yields the advantage that we are able to investigate alternative optimal reactions to exchange rate movements by forward-looking price setters (local currency pricing vs. producer currency pricing).

4.1.3 Firms

In the baseline version of the model, firms in each economy employ only labor as input for the production of differentiated final goods.[24] The production function of firm j in country A simply reads

$$Y^A_{p,jt} = A^A_t L^A_{j,t}. \tag{8}$$

Here, $Y^A_{p,jt}$ denotes the production volume and A^A_t denotes the total factor productivity. The real marginal cost of production thus is simply $MC^A_t = \frac{W^A_t}{A^A_t}$. Firms produce for the domestic as well as for the export market, hence

$$Y^A_{p,jt} = Y^{A,A}_{j,t} + Y^{A,B}_{j,t}, \tag{9}$$

where $Y^{A,A}_{j,t}$ denotes the output produced for the domestic market and $Y^{A,B}_{j,t}$ is the goods produced for export to country B. Accordingly, they face the two demand functions for their goods

$$Y^{A,A}_{j,t} = \left(\frac{P^{A,A}_{j,t}}{P^{A,A}_t}\right)^{-\epsilon} Y^{A,A}_t, \qquad Y^{A,B}_{j,t} = \left(\frac{P^{A,B}_{j,t}}{P^{A,B}_t}\right)^{-\epsilon} Y^{A,B}_t, \tag{10}$$

where ϵ is the elasticity of substitution between goods produced in the same country. Their profit function reads

$$P^{A,A}_{j,t} Y^{A,A}_{j,t} + \mathcal{E}^{A,B}_t P^{A,B}_{j,t} Y^{A,B}_{j,t} - W^A_{t+k} L^A_{j,t}. \tag{11}$$

$P^{A,A}_{j,t}$ is the price that firm j sets for its goods sold at home. $P^{A,B}_{j,t}$ is the pre-tariff price for its goods in the export market, in terms of the currency of country B. $\mathcal{E}^{A,B}_t$ is the bilateral nominal exchange rate between country A and country B. Firms are in monopolistic competition and set their prices with a markup over their marginal costs. They face price rigidities à la Calvo (1983) with the probability of not being able to reset the price in any given period being ζ. The first-order condition for the optimally set price $P^{*,AA}_t$ can be derived as

$$\sum_{k=0}^{\infty} (\beta\zeta)^k E_t \left\{ \frac{\lambda^A_{t+k}}{\lambda^A_t} \left(\frac{P^{AA}_t}{P^{AA}_{t+k}}\right)^{-\epsilon} Y^{AA}_{t+k} \left[\frac{P^{*,AA}_t}{P^A_{t+k}} - \frac{\epsilon}{\epsilon - 1} MC^A_{t+k} \right] \right\} = 0.$$

We assume that firms in country A set their optimal export prices in their own currency, according to the producer currency price (PCP) paradigm. The respective

[24] In the appendix, we additionally show that the main result holds in extensions of this model in which firms have access to capital or intermediate goods as inputs in their production function.

first-order condition is

$$\sum_{k=0}^{\infty}(\beta\zeta)^k E_t\left\{\frac{\lambda^A_{t+k}}{\lambda^A_t}\left(\frac{\mathcal{E}^{A,B}_t P^{AB}_t}{\mathcal{E}^{A,B}_{t+k}P^{AB}_{t+k}}\right)^{-\epsilon} Y^{AB}_{t+k}\left[\frac{\mathcal{E}^{A,B}_t P^{*,AB}_t}{P^A_{t+k}}-\frac{\epsilon}{\epsilon-1}MC^A_{t+k}\right]\right\}=0.$$

The dynamic relationship between domestic and export price level and their respective optimal price counterparts are $P^{AA}_t=[(1-\zeta)(P^{*,AA}_t)^{1-\epsilon}+\zeta(P^{AA}_{t-1})^{1-\epsilon}]^{\frac{1}{1-\epsilon}}$ and $P^{AB}_t=[(1-\zeta)(P^{*,AB}_t)^{1-\epsilon}+\zeta(\frac{\mathcal{E}^{A,B}_{t-1}}{\mathcal{E}^{A,B}_t}P^{AB}_{t-1})^{1-\epsilon}]^{\frac{1}{1-\epsilon}}$.

While both countries are symmetric in most respects, here we introduce an asymmetry and assume that firms in country B set their export prices in terms of the currency of the export market, following the local currency price (LCP) paradigm. This asymmetry is motivated by the dominance of the US dollar, the currency of country A, in international goods trade. Hence, the first order condition for prices of goods produced in country B and exported to country A can be derived as

$$\sum_{k=0}^{\infty}(\beta\zeta)^k E_t\left\{\frac{\lambda^B_{t+k}}{\lambda^B_t}\left(\frac{P^{BA}_t}{P^{BA}_{t+k}}\right)^{-\epsilon} Y^{BA}_{t+k}\left[\frac{\mathcal{E}^{B,A}_{t+k} P^{*,BA}_t}{P^B_{t+k}}-\frac{\epsilon}{\epsilon-1}MC^B_{t+k}\right]\right\}=0.$$

Here $\mathcal{E}^{B,A}_t$ is the inverse of $\mathcal{E}^{A,B}_t$. The dynamics of the price index of exporters is hence $P^{BA}_t=[(1-\zeta)(P^{*,BA}_t)^{1-\epsilon}+\zeta(P^{BA}_{t-1})^{1-\epsilon}]^{\frac{1}{1-\epsilon}}$.

4.1.4 Financial sector

The banking sector is modeled in the vein of Gertler and Karadi (2011, 2013). Banks in both countries fund themselves with deposits from domestic households and invest in domestic as well as foreign assets. In the baseline version of the model, the internationally traded assets are long-term government bonds.[25] The balance sheet of bank j in country A reads

$$Q^A_{b,t}B^{AA}_{jt}+\widetilde{Q}^B_{b,t}B^{BA}_{jt}=N^A_{jt}+D^A_{jt}.$$

Here, $B^{AA}_{j,t}$ denotes assets issued in country A and held by banks in country A. $B^{BA}_{j,t}$ are assets issued in country B and held by banks in country A. $Q^A_{b,t}$ is the real price of bonds issued in country A. $\widetilde{Q}^B_{b,t}=RER_tQ^B_{b,t}$ is the real price of bonds issued in country B in terms of goods in country A. $N^A_{j,t}$ is the bank's net worth and D^A_{jt} is its deposits. Banks add the profits that they earn on their assets to

[25]In an alternative version, we consider trade in claims on capital (equity). The choice of asset type does not affect the structure of the banks' optimization problem.

their net worth, which evolves according to

$$N_{jt}^{A} = (R_{bt}^{A} - R_{d,t-1}^{A})Q_{t-1}^{A}B_{j,t-1}^{AA} + (\widetilde{R}_{bt}^{B} - R_{d,t-1}^{A})\widetilde{Q}_{t-1}^{B}B_{j,t-1}^{BA} + R_{d,t-1}^{A}N_{j,t-1}^{A}.$$

R_{bt}^{A} is the real return on bonds issued in country A, R_{dt}^{A} is the return of deposits at banks in country A, and $\widetilde{R}_{bt}^{B} = \frac{RER_t}{RER_{t-1}}R_{bt}^{B}$ is the real return on bonds issued in country B in terms of the currency of country A. Following Woodford (1998, 2001), we model long-term government bonds as geometrically decaying consols with a fixed coupon, c_b, and a decay rate, ρ_b. The average duration of such a bond is $1/(1-\beta\rho_b)$. Accordingly, the real return of long-term government bonds issued in country A is

$$R_{bt}^{A} = \frac{c_b + \rho_b Q_t^{A}}{Q_{t-1}^{A}}.$$

Banks accumulate wealth until they exit the financial sector. Their exit probability is exogenously given by θ and ensures that bankers do not reach the point where they outsave their financial constraint. Bankers choose their asset holdings such as to maximize the expected terminal wealth at the point of exit,

$$V_{jt}^{A} = \beta E_t \Lambda_{t+1}^{A}[(1-\theta)N_{j,t+1}^{A} + \theta V_{j,t+1}^{A}].$$

The terminal net worth of bankers that exit the sector is distributed across households as lump-sum income. In turn, households provide bankers that newly enter the business with initial capital.

The contract between bankers and depositors is subject to a costly enforcement/moral hazard problem. Each period, the banker has the option to divert the assets for private purposes. If a banker does so, she is forced into insolvency by the depositors, who can only recover a fraction of each asset type, depending on its pledgeability. To ensure that bankers abstain from diverting assets, the value of staying in business must always be greater than or equal to the fraction of assets that the banker can divert.[26] The incentive compatibility constraint reads

$$V_{jt}^{A} \geq \lambda_{AA}Q_{b,t}^{A}B_{jt}^{AA} + \lambda_{BA}\widetilde{Q}_{b,t}^{B}B_{jt}^{BA}.$$

Parameters λ_{AA} and λ_{BA} govern the divertibility of the respective assets for banks in country A. Following the literature on safe assets in international finance (see, e.g., Jiang et al., 2021; He et al., 2019; Jiang et al., 2020), we assume that dollar assets, i.e. assets issued in country A are relatively safe and more pledgeable than assets issued in country B, i.e. $\lambda_{AA} < \lambda_{BA}$.[27]

[26] Throughout our experiments we assume that this relationship holds with equality.

[27] Distinguishing assets of different countries in a setting with banks à la Gertler and Karadi (2011) by their pledgeability, goes back to Trani (2015). In the closed economy context, Gertler

To solve the bankers optimization problem, we guess that the value function is linear in holdings of government bonds of both countries as well as net worth

$$V^A_{jt} = \nu^{AA}_{bjt} Q^A_t B^{AA}_{jt} + \nu^{BA}_{bjt} \widetilde{Q}^B_t B^{BA}_{jt} + \nu^A_{njt} N^A_{jt}.$$

In optimum, the coefficients ν^{AA}_{bjt}, nu^{BA}_{bjt}, and ν^A_{njt}, are shadow values for the bank of an additional unit of domestic bonds, foreign bonds or net worth, respectively. In this setting, the first order conditions for holdings of domestic and foreign bonds as well as for the Lagrangian multiplier on the incentive constraint, μ^A_{jt}, can be obtained as

$$\nu^{AA}_{bjt} = \lambda_{AA} \frac{\mu^A_{jt}}{1+\mu^A_{jt}}, \tag{12}$$

$$\nu^{BA}_{bjt} = \lambda_{BA} \frac{\mu^A_{jt}}{1+\mu^A_{jt}}, \tag{13}$$

$$Q^A_t B^{AA}_{jt} = \frac{\nu^{BA}_{bjt} - \lambda_{BA}}{\lambda_{AA} - \nu^{AA}_{bjt}} \widetilde{Q}^B_t B^{BA}_{jt} + \frac{\nu^A_{njt}}{\lambda_{AA} - \nu^{AA}_{bjt}} N^A_{jt}. \tag{14}$$

Verifying the guess for the value function results in

$$\nu^{AA}_{bjt} = \beta E_t \Omega^A_{j,t+1} (R^A_{b,t+1} - R^A_{d,t}), \tag{15}$$
$$\nu^{BA}_{bjt} = \beta E_t \Omega^A_{j,t+1} (\widetilde{R}^B_{b,t+1} - R^A_{d,t}), \tag{16}$$
$$\nu^A_{njt} = \beta E_t \Omega^A_{j,t+1} R^A_{d,t}, \tag{17}$$

where we define $\Omega^A_{j,t} \equiv \Lambda^A_t((1-\theta) + \theta(1+\mu^A_{jt})\nu^A_{njt})$. For aggregation, we assume an equilibrium in which all banks are symmetric (i.e., $\forall j : \nu^{AA}_{bjt} = \nu^{AA}_{bt}, \nu^{BA}_{bjt} = \nu^{BA}_{bt}, \nu^A_{njt} = \nu^A_{nt}, \Omega^A_{jt} = \Omega^A_t$). The optimization problem and its solution for the banks in country B take an analogous form.[28]

4.1.5 Fiscal and monetary authority

Government spending, G_t, is exogenous and follows an AR(1) process with $G^A_t = G^A e^{g^A_t}$ and $g^A_t = \rho_g g^A_{t-1} + \epsilon^{g,A}_t$, where G^A is the steady state government consump-

and Karadi (2013) use this modeling approach to distinguish between riskier capital assets and more pledgeable government bonds. Meeks, Nelson, and Alessandri (2017) specify different divertibility parameters to distinguish the characteristics of standardized asset-backed securities and opaque loans.

[28] The full derivation of the banker's solution and further equations relating to the aggregation of the banking sector are delegated to the appendix.

tion, ρ_g is the auto-correlation of government consumption, and $\epsilon_t^{g^A}$ is a shock to government spending. The government finances its expenditures, by issuing government bonds, which are bought by banks of both countries, as well as by levying import tariffs on and lump sum taxes, T_t^A. The import tariff rate on goods produced in country B and imported by country A, follows an exogenous AR(1) process with persistence parameter ρ_τ and $\epsilon_t^{\tau,BA}$ as a tariff rate shock.

$$\tau_t^{BA} = \rho_\tau \tau_t^{BA} + \epsilon_t^{\tau,BA}. \tag{18}$$

Taxes follow a simple feedback rule, such that they are sensitive to the level of public debt, $T_t^A = T^A + \kappa_\tau(B_{t-1}^A - B^A)$, where T^A and B^A are the steady state levels of tax revenue and government debt, respectively. κ_τ is set to ensure that the real value of debt grows at a rate smaller than the gross real rate on government debt. As shown by Bohn (1998), this rule is a sufficient condition to guarantee the solvency of the government. The flow budget constraint of the government reads

$$G_t^A + R_{b,t}^A Q_{t-1}^A B_{t-1}^A \quad = Q_t^A B_t^A + T_t^A + \tau_t^{BA} P_t^{BA} Y_t^{BA}. \tag{19}$$

The central bank sets the short-term nominal interest rate by the central bank following the Taylor-type rule

$$R_{n,t}^A = (R_{n,t-1}^A)^\rho \left(\left(\frac{\Pi_t^A}{\Pi^A} \right)^{\phi_\pi} \left(\frac{Y_t^A}{Y^A} \right)^{\phi_y} \right)^{(1-\rho)}, \tag{20}$$

where $R_{n,t}^A = R_{d,t}^A E_t[\Pi_{t+1}^A]$. Parameter ρ is the degree of interest rate smoothing. ϕ_π and ϕ_y govern the feedback of the policy rule to inflation and output, respectively.

4.1.6 International linkages

We assume that both countries are the same size. They are linked through trade in goods and assets. The real trade balance of country A reads

$$TB_t^A = Y_t^{AB} P_t^{AB,B} RER_t - Y_t^{BA} P_t^{BA,A}. \tag{21}$$

$P_t^{AB,B}$ is the price of goods exported from A to B relative to the price level in country B. The adjustment by the real exchange rate guarantees that the trade balance of country A is real in terms of its own currency and price level. Conversely, $P_t^{BA,A}$ is the price of goods exported from B to A relative to the aggregate price level in A.

The assumption that government bonds can be traded internationally and are held by banks in both countries implies the market clearing conditions for bonds $B_t^A = B_t^{AA} + B_t^{AB}$ and $B_t^B = B_t^{BA} + B_t^{BB}$, where B_t^A and B_t^B are bonds issued by the government in countries A and B, respectively. B_t^{AA} and B_t^{AB} are bonds that are issued in A and held by banks in countries A and B, respectively. Analogously, B_t^{BA} and B_t^{BB} are bonds issued by government B and held by banks in countries A and B, respectively. The evolution of the net foreign asset position of country A is tied to its trade balance according to

$$(\widetilde{Q}_t^B B_t^{BA} - Q_t^A B_t^{AB}) = (\widetilde{R}_{b,t}^B \widetilde{Q}_{t-1}^B B_{t-1}^{BA} - R_{b,t}^A Q_{t-1}^A B_{t-1}^{AB}) + TB_t^A. \tag{22}$$

4.2 Calibration

With a few exceptions, we calibrate both countries symmetrically. Following Caldara et al. (2020), we set the coefficient of relative risk aversion $\sigma_c = 2$, and the inverse of the Frisch elasticity $\sigma_l = 1$. The discount factor $\beta = 0.995$ implies that the real interest rate of deposits in 2% is annualized in steady state. $h = 0.75$ implies a persistent habit formation in consumption. Likewise, the elasticity of substitution between varieties of goods produced in one country, $\epsilon = 6$, and between varieties of labor, $\epsilon_w = 6$, falls within the range of values commonly adopted in the literature. ζ and ζ_w denote the probabilities for each firm and each union to adjust their prices or wages, respectively, in any given period. The value of 0.75 implies an average duration for prices and wages of one year. In our parametrization of the trade openness and the elasticity of substitution between goods produced in country A and goods produced in country B, we follow Caldara et al. (2020) and set $\mu^T = 0.15$ and $\Theta = 1.5$. The Taylor rules of both central banks are again calibrated symmetrically, with $\rho = 0.8$ implying substantial interest rate smoothing as usually diagnosed in the context of estimations of structural models.[29] $\phi_\pi = 2$ and $\phi_y = 0.125$ are again standard values for the feedback coefficients in the Taylor rule.

In our baseline model, banks' cross-border asset trade is in long-term government bonds. Hence, the model entails a fiscal sector. The share of government spending in output is set to 20%. We assume a debt-to-GDP ratio of 100%, roughly in line with current total public debt in the US at the height of the trade conflict with China.[30] The geometric decay rate of the consol, $\rho_b = 0.96$ implies an average duration of the bond of five years. The coefficient on government debt in the tax rule, κ_τ, is set to ensure determinacy of equilibrium dynamics. μ_A, which governs the openness for trade in assets, implies a substantial home bias in asset holdings. We set the steady state leverage ratio of bankers to 10, which is higher than in the original paper by Gertler and Karadi (2011), who fix it at 4. The authors' choice of a low value for the steady-state leverage for financial intermediaries is

[29] See, e.g., Smets and Wouters (2007) or, in more recent estimations on US data, Kulish, Morley, and Robinson (2017) or Boehl and Strobel (2020).

[30] See, https://fred.stlouisfed.org/series/GFDEGDQ188S.

Symbol	Parameter	Value
σ_c	Coefficient of relative risk aversion	2
σ_l	Inverse Frisch elasticity	1
β	Discount factor	0.995
h	Habit formation	0.75
ϵ	Elasticity of goods demand	6
ϵ_w	Elasticity of labor demand	6
Θ	Elast. of substit. between A-goods and B-goods	1.5
μ^T	Trade openness	0.15
ζ	Price Calvo parameter	0.75
ζ_w	Wage Calvo parameter	0.75
ξ_A	PCP by country A exporters	1
ξ_B	LCP by country B exporters	0
ρ	Taylor rule: interest rate smoothing	0.8
ϕ_π	Taylor rule: inflation coefficient	2
ϕ_y	Taylor rule: output coefficient	0.125
G/Y	Government spending share	0.2
$B/(4Y)$	Debt-to-annual GDP	1
c_b	Coupon on gov. bond	0.2
ρ_b	Decay rate of gov. bond	0.96
κ_τ	Tax rule: coefficient on gov. debt	0.2
μ^A	Asset openness	0.25
LEV	Leverage rate	10
θ	Survival rate of banker	0.95
$R_b^B - R_d$	Spread: return on B-assets over deposit rate	25 bp
$R_b^B - R_b^A$	Spread: return on B-assets over return on A-assets	6.75 bp
ρ_τ	Persistence of tariff shock	0.99
σ_τ	Standard dev. of tariff rate shock	0.01
ρ_{σ_τ}	Persistence of tariff uncertainty shock	0.96

Table 5: Calibration

motivated by an economy-wide average that extends to non-financial firms with a low asset-to-equity ratio as well. In the context of this paper, we deem a higher leverage ratio to be more appropriate as financial institutions are the main players in international asset trade.[31] The survival rate of bankers is set at $\theta = 0.95$. The deposit rate in both countries is symmetric, pinned down by the calibration of β. The choice of the steady-state spread of the return on the riskier government bonds issued in country B over the deposit rate of 100 basis points at an annualized rate is motivated by the steady state spread chosen in Gertler and Karadi (2011, 2013). The spread between the returns on bonds issued in different countries reflects that investors are, on average, willing to give up 25 basis points per annum for holding US treasuries as discussed in Jiang et al. (2021). Given our calibration, equation 22 implies a trade deficit for country A of two percent of its GDP, which is roughly in line with the US trade deficit. The persistence parameters for the shock processes for the tariff rate and the tariff rate uncertainty, ρ_τ and ρ_{σ_τ}, are taken from Caldara et al. (2020).

4.3 The effect of trade policy uncertainty

Trade policy uncertainty is captured in the model by stochastic volatility in the exogenous tariff rate process. Thus, an increase in trade tensions will be represented by an increase in the standard deviation of tariff rates. Motivated by the surge in trade policy uncertainty in the US during the trade conflict in China, Caldara et al. (2020) consider a rise in the standard deviation of the tariff rate of 3 percentage points in their experiments. We follow the authors in this aspect. In order to capture the effects of trade policy uncertainty shocks, we solve the model with a third-order approximation to equilibrium dynamics using the non-linear moving average by Lan and Meyer-Gohde (2013).

Uncertainty shocks in general affect the dynamics through a variety of channels, some of which have ambiguous implications or may cancel each other out in general equilibrium, depending on the calibration.[32] Some of these channels are present in a closed economy setting with sticky prices and wages, too; others are added in an open economy setting and in presence of financial frictions.

In a closed economy, due to a precautionary savings motive, households may consume less and work more in the face of increased uncertainty. On the labor market, the reduction of consumption may reduce the reservation wage of households. At the same time, wage setting unions tend to increase their markup when

[31] The leverage ratio in the model is still below empirically observed values for the leverage ratios of investment banks. However for an asset-to-equity ratio of 15 or 20, the determinacy of equilibrium dynamics would be violated in this type of model.

[32] A good summary of the effects of uncertainty in a closed-economy NK model can be found in Born and Pfeifer (2014).

uncertainty increases. This is due to the convexity of the unions profit curve and the uncertainty over the future reservation wage and labor demand conditions. If future wages are set too high, unions may sell less labor but at a higher markup; if they are too low, unions supply more labor, but run the risk of a lower or even negative markup. Analogously, price-setting firms raise their markups over their marginal costs due to their convex profit curve, thereby dampening aggregate demand. Overall, in a NK-closed economy model, an increase in uncertainty tends to result in a decline in economic activity and potentially raises prices and wages.[33]

In addition to these effects, in an open economy setting, the macroeconomic dynamics are shaped by the movements of the terms of trade and the nominal exchange rate. If both countries were perfectly symmetrical, a global trade policy uncertainty shock would not affect the nominal exchange rate. However, we allow for asymmetries in price setting behavior of exporters (LCP vs PCP) to capture the fact that international goods trade predominantly takes place in US dollar. The blue curves in Figure 5 show the effects of an increase in trade policy uncertainty in a simple 2-country NK model, in which we abstract from financial frictions.[34] In the model, there are no banks and bonds are short term. International trade in assets is reduced to the assumption that households of country A have access to bonds issued by households in country B, which gives rise to a standard uncovered interest rate parity condition

$$E_t\left[\frac{\mathcal{E}_{t+1}^{AB}}{\mathcal{E}_t^{AB}}R_t^B\Pi_{t+1}^B\right] = E_t[R_t^A\Pi_{t+1}^A]. \tag{23}$$

[33]Basu and Bundick (2017) discuss these effects and contrast them with the implications of uncertainty shocks in a model with flexible prices and wages, in which, counterintuitively, an increase in uncertainty may trigger an increase in real activity.

[34]In addition, the model features a debt-elastic interest rate to eliminate a unit root in the dynamics. Strictly speaking, debt elasticity is another asymmetry between countries in the model. However, it is small and we set it such that the movements of the nominal exchange rate in the setting with symmetric price setting (both countries following PCP) are close to zero.

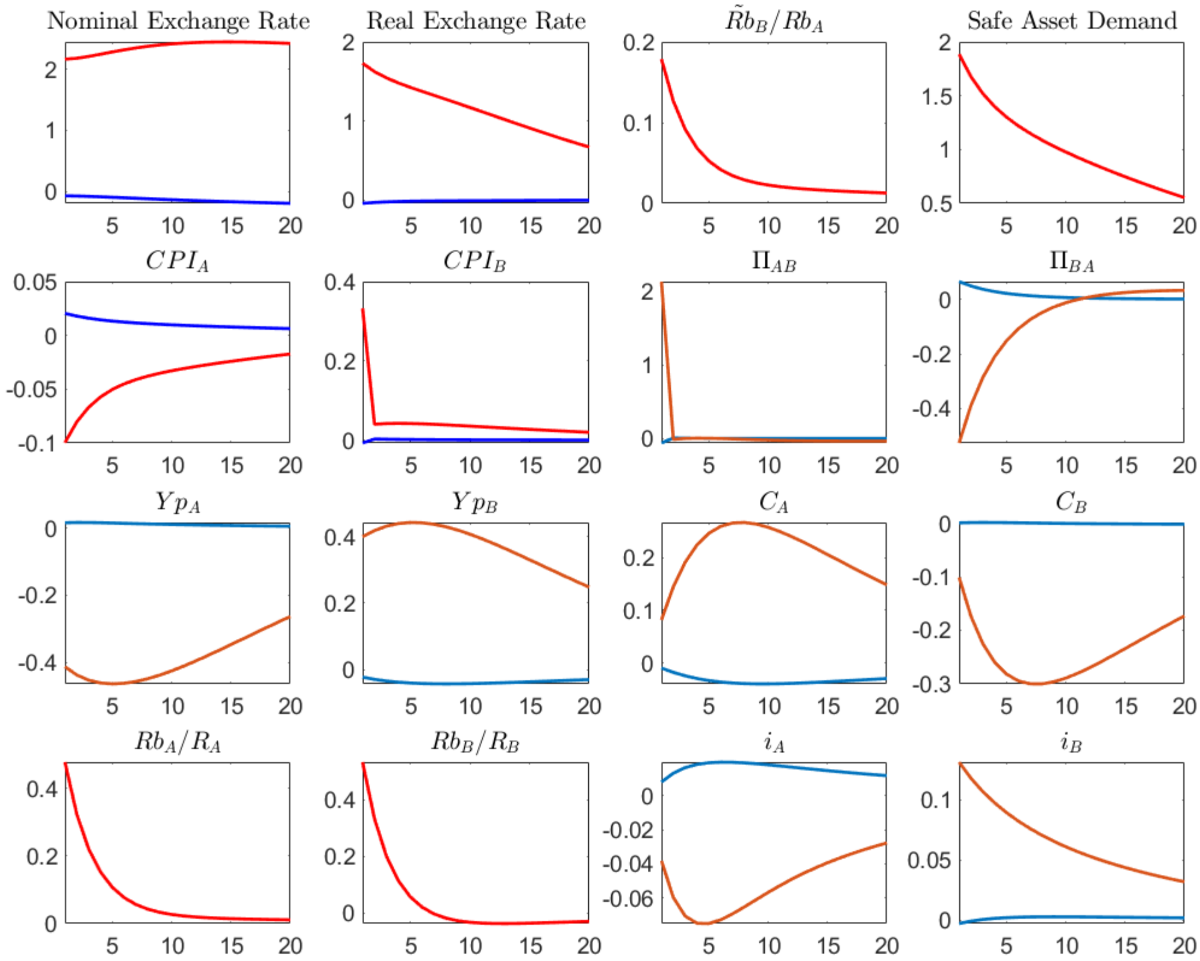

Figure 5: Effects of a trade policy uncertainty shock. y-axis in percent. Blue lines: model without financial frictions. Red lines: model with financial frictions. An increase in the nominal exchange rate denotes an appreciation of the safe asset currency. The price of exports to country B, Π_{AB} is in currency of country B. The price of imports by country A, Π_{BA}, is in currency of country A.

As can be seen in Figure 5, the difference in the timing of the price-adjustment to exchange rate movements between exporters of both countries, induces a slight depreciation of the nominal exchange rate of country A's currency, which represents the dollar in this model. As a result, firms that export their goods from country A to country B lower their prices, resulting in a decrease of country B's import price inflation, Π_{AB} (denoted in country B's currency). Conversely, import price inflation of country A, Π_{BA}, increases. The gradual speed of adjustment of the latter, reflects the local currency pricing behavior by exporters in country B. As a result, the CPI in country A increases, whereas country B's CPI decreases somewhat at first, before the precautionary increase in markup by firms lead it to increase. While global output and consumption decrease, the dynamics of country-specific consumption and production exhibits the importance of the exchange rate channel. While the precautionary motive to reduce consumption is active in both countries, the reduction is far more pronounced in country A where, additionally, imported goods become more expensive. At the same time, the depreciation of country A's currency improves the competitiveness of country A's exporters yielding an increase in overall production in country A. All in all, the effects of trade policy uncertainty on real activity remain small. This is in line with results from the literature on uncertainty shocks in DSGE models, which find that typically very large second-moment shocks are required to generate relevant effects on macroeconomic quantities (see, e.g. Born and Pfeifer, 2014; Bonciani and Roye, 2016; Basu and Bundick, 2017). The results of this exercise show that the asymmetry in price setting does not generate the observed effect of TPU on the nominal exchange rate. Hence, we turn to asymmetry in asset safety.

4.3.1 The safe asset channel and the appreciation of the US dollar

In our baseline model, the presence of financial frictions and the asymmetry between the safety of country-specific assets introduces a channel through which trade policy uncertainty affects economic dynamics. The red lines in Figure 5 display the impulse response functions to the shock in our baseline model. As can be seen, the inclusion of financial frictions and the safe asset channel tilt the response of the nominal exchange rate in the other direction, such that an increase in trade policy uncertainty results in a substantial appreciation of country A's currency, i.e. the US dollar.

In the model, banks inherit the risk aversion of households. An increase in uncertainty has the consequence that risk-averse banks demand higher premiums on their risky assets. Since the return on long-term government bonds depends on the evolution of bond prices, it is not predetermined, but subject to risk. The contraction in overall demand for assets results in a decrease in bond prices and hence in a decrease in the net worth of banks. The bottom row of Figure 5 shows that, as a consequence, the spread between the return on domestic bonds and the deposit rate increases in both countries. As shown by Mikkelsen and Poeschl (2019), whose model also features banks à la Gertler and Karadi (2011), the lending capacity of banks can be expressed as a multiple of their net worth.

With the decrease in net worth, their lending capacity declines as well. The authors dub this the financial constraint channel.[35]

Crucially, in our model, bonds issued in country A are more pledgeable than bonds issued in country B. Hence, with a reduced lending capacity, it becomes more costly to hold country B bonds and the required return on these bonds will increase relative to those issued in country A. This shift in relative demand towards safer assets is displayed in the top row of Figure 5. From the viewpoint of banks in country A, the safety premium on bonds issued in country A increases by roughly 6 bps quarterly. Globally, the demand for safe assets as measured by overall lending to the government in country A relative to lending to country B, increases by roughly 0.5%. While this shift towards safe assets is not large, it suffices to reverse the effect of trade policy uncertainty on the exchange rate and trigger an appreciation of the safe asset currency.

Note that, like in the model without financial frictions, the evolution of the nominal exchange rate in the full model depends on fluctuations of nominal interest rates in both countries. Here, arbitrage takes place in the portfolio decision of banks that have access to assets of both countries. Specifically, equations 15 and 16 describe the marginal values of holding assets from the viewpoint of banks in country A in terms of real spreads. In optimum, banks choose their assets such that the marginal values of holding either asset are equal. Thus, the aforementioned equations together with equations 12 and 13, imply that

$$E_t[\Omega^A_{t+1}(\widetilde{R}^B_{b,t+1} - R^A_{d,t})] = \frac{\lambda_{BA}}{\lambda_{AA}} E_t[\Omega^A_{t+1}(R^A_{b,t+1} - R^A_{d,t})]. \tag{24}$$

Here, the nominal exchange rate is implicit as it is part of $\widetilde{R}^B_{b,t+1}$.

One can show that this equation is related to the standard uncovered interest rate parity (UIP) condition that regulates the dynamics of the nominal exchange rate in a standard two-country NK model. Dividing both sides of the equation by $E_t[\Omega_{t+1}]$ adding R^A_t and using the relations $\widetilde{R}^B_{b,t} = \frac{RER_t}{RER_{t-1}}$ and $\frac{RER_t}{RER_{t-1}} = \frac{\mathcal{E}^{A,B}_t}{\mathcal{E}^{A,B}_{t-1}} \frac{\Pi^B_t}{\Pi^A_t}$ one can obtain

$$\frac{E_t[\mathcal{E}^{A,B}_{t+1}]}{\mathcal{E}^{A,B}_t} = \frac{(\frac{\lambda_{BA}}{\lambda_{AA}}(E_t[R^A_{b,t+1}\Pi^A_{t+1}] - R^A_{d,t}E_t[\Pi^A_{t+1}]) + R^A_{d,t}E_t[\Pi^A_{t+1}])}{E_t[R^B_{b,t+1}\Pi^B_{t+1}]} + Cov_t, \tag{25}$$

where Cov_t collects several covariance terms that arise in the course of dividing and multiplying expectations of variables and which we do not explicitly list here

[35] Mikkelsen and Poeschl (2019) discuss this channel in a model, in which banks hold claims on productive capital instead of bonds. In the appendix, we discuss a model, in which international trade in assets takes place in capital claims and document that the effects of trade policy uncertainty are very similar to those in the model with bonds.

for the sake of providing intuition in a simplified setting. Consider an increase in the relative demand for safe US assets. This results in a decrease of the expected return on these assets relative to the return on assets issued in country B. Equation 25 shows that in this scenario, $\frac{E_t[\mathcal{E}_{t+1}]}{\mathcal{E}_t}$ decreases. That is, the currency of country A, which stands for the US dollar, appreciates. If we were to abstract from the safe asset property of US government bonds, and consider the case in which both assets are equally pledgeable (i.e. $\lambda_{AA} = \lambda_{BA}$), we would arrive at

$$\frac{E_t[\mathcal{E}_{t+1}^{A,B}]}{\mathcal{E}_t^{A,B}} = \frac{E_t[R_{b,t+1}^A \Pi_{t+1}^A]}{E_t[R_{b,t+1}^B \Pi_{t+1}^B]} + Cov_t. \tag{26}$$

Equation 26 already has the standard UIP structure, where the relevant interest rates are those pertaining to risky government bonds of both countries. If we were to assume the absence of financial frictions altogether, the spreads between the returns on long-term government bonds and the returns on deposits would disappear. In that case, it holds that $E_t[R_{b,t+1}^B] = R_{d,t}^B$ and $E_t[R_{b,t+1}^A] = R_{d,t}^A$, and we would arrive at the traditional UIP condition

$$\frac{E_t[\mathcal{E}_{t+1}^{AB}]}{\mathcal{E}_t^{A,B}} = \frac{R_{d,t}^A E_t[\Pi_{t+1}^A]}{R_{d,t}^B E_t[\Pi_{t+1}^B]}. \tag{27}$$

Hence, the relation between interest rates and the nominal exchange rate is fundamentally similar in the model with and without financial frictions. However, the introduction of financial frictions allows us to introduce assets for which the financial constraint binds differently, and which therefore have a distinct reaction to shocks. In the model, this allows for a role of safe asset demand for the propagation of trade policy uncertainty shocks and is key for explaining our SVAR results.

4.3.2 Different shades of trade policy uncertainty

The effect of the safe asset channel is very robust. In the appendix, we investigate the robustness with respect to the presence of capital in production and trade in equity (see, D.2.1) and alternative assumptions on price setting (see, D.2.2). In this section, we highlight the robustness with respect to the type of trade policy uncertainty.

In most of our experiments, we consider an increase in global trade policy uncertainty. The implication is that in the trade conflict any increase in import tariffs by one country will be met by retaliatory actions by the other country, and import tariff rates in both countries are equally uncertain. This can be justified by the observation that in the trade conflict between the USA and China, both countries levied several rounds of additional tariffs on imports from the other country. In contrast, this section considers the case in which trade policy uncertainty is unilateral. While it is unlikely that in a trade conflict only one party raises tariffs, this can be seen as a simplified extreme case of a scenario in which the uncertainty is predominantly about the tariff rate of one country. The circled line in Figure 6 shows that an increase in policy uncertainty regarding only import tariffs levied by country A strengthens the appreciation of country A's currency. In this scenario, the increase in uncertainty primarily affects the demand for country B's exports and gives rise to precautionary markups on the price of these goods. Conversely, the demand for country A's exports is only affected by second-round effects. However, price adjustments are sizable for exporters of both countries. This highlights that it is not uncertainty per se that is the largest driver of prices in the model. After all, the unilateral shock introduces less uncertainty than a global trade policy uncertainty shock. Instead, the adjustment of prices and capital flows rather reacts to exchange rate movements, amplifying them in the process.

Another feature of the baseline model is that trade takes place in final goods only. Hence, trade policy uncertainty affects the stochastic volatility of the tariff rate on final goods imports. How do the implications of an increase in trade uncertainty change if we focus on uncertainty surrounding import tariffs on intermediate goods? In order to address this question, we introduce a simple value chain in our basic model. Final goods firms now employ labor and intermediate goods in their production. In country A, the production function is therefore

$$Y_{p,t}^A = A_t^A (M_t^A)^{\alpha} (L_{f,t}^A)^{1-\alpha}, \tag{28}$$

where M_t^A denotes intermediate goods employed in production in country A. Now the marginal cost of production of final goods producers reads $MC_t^A = (1-\alpha)\frac{Y_{p,t}^A}{L_{f,t}^A}$. $L_{f,t}^A$ is the labor input in production in the final goods sector. In this context, α is the output elasticity with respect to intermediate goods inputs. In turn, intermediate goods producers employ labor, $L_{m,t}^A$, in their production.

$$M_{p,t}^A = A_{m,t}^A (L_{m,t}^A)^{1-\alpha_m}, \tag{29}$$

Analogous to final goods producers, intermediate goods firms produce for the domestic as well as for the export market, hence $M_{p,t}^A = M_t^{A,A} + M_t^{A,B}$, where $M_t^{A,A}$ denotes the intermediate goods produced for the domestic market and $M_t^{A,B}$ are exported to country B. We assume that half of a country's produced output is in final goods and the other half in intermediate goods. Analogous to the final goods aggregator (Equation 6), domestic demand for intermediates M_t^A comprises intermediate goods produced domestically, M_t^{AA}, and imported intermediate goods M_t^{BA}, $M_t^A = \left[(1-\mu^{Tm})^{1/\Theta_m}(M_t^{AA})^{\frac{\Theta_m-1}{\Theta_m}} + (\mu^{Tm})^{1/\Theta_m}(M_t^{BA})^{\frac{\Theta_m-1}{\Theta_m}}\right]^{\frac{\Theta_m}{\Theta_m-1}}$. Param-

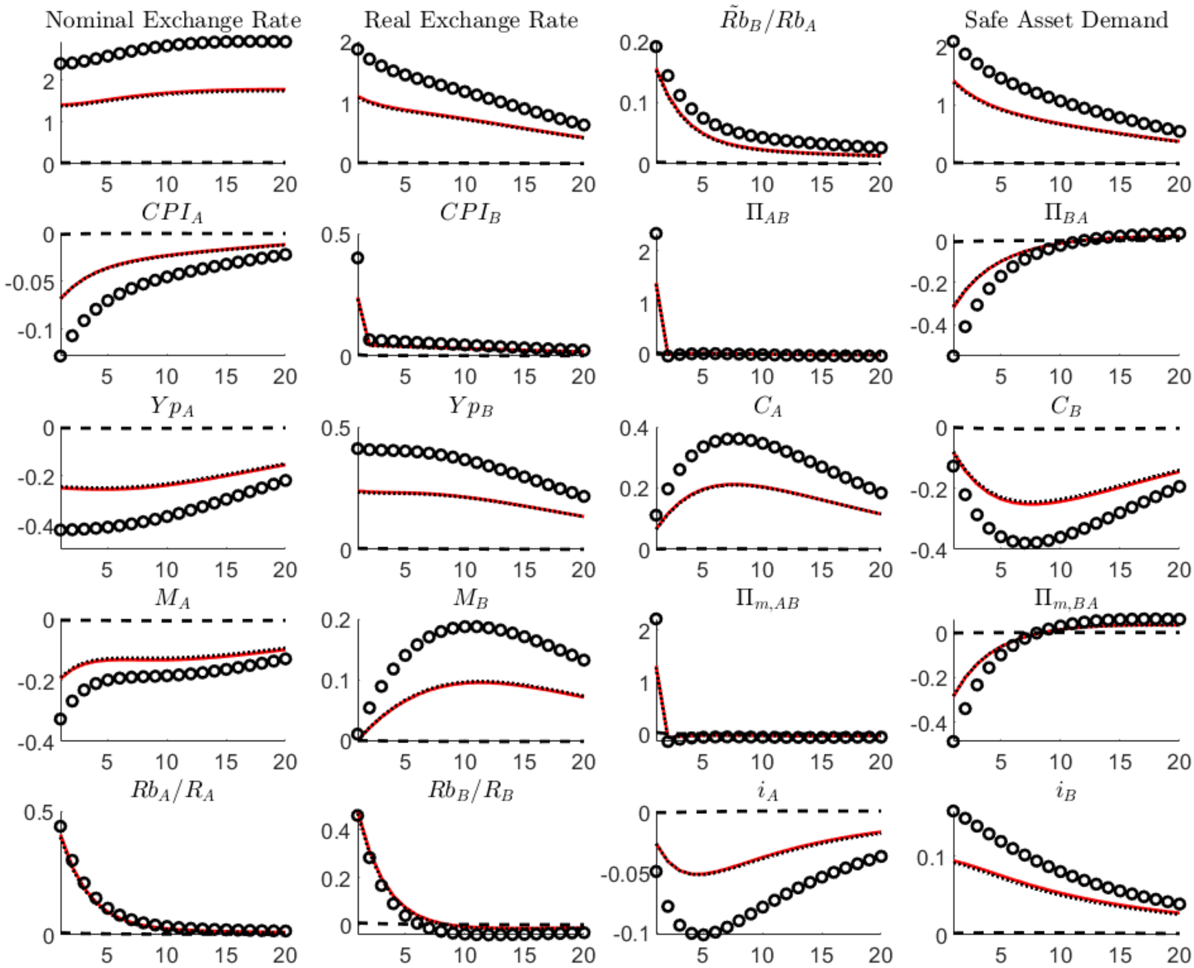

Figure 6: Effects of different types of trade policy uncertainty shocks. y-axis in percent. Red lines: Global TPU shock concerning import tariffs for both types of goods. Circled lines: Unilateral TPU shock concerning import tariffs by country A on both types of goods. Dotted Lines: Global shock, final goods. Dotted Lines: Global shock, intermediate goods.

eters μ^{Tm} and Θ_m denote the trade openness in the trade of intermediate goods and the elasticity of substitution between intermediate goods produced in different countries. For simplicity, we assume that they take the same value as their counterparts for final goods trade. The price level of intermediate goods demanded in country A is $P^{A}_{m,t} = \left[(1-\mu^{Tm})(P^{AA}_{m,t})^{1-\Theta_m} + \mu^{Tm}(\widetilde{P}^{BA}_{m,t})^{1-\Theta_m}\right]^{\frac{1}{1-\Theta_m}}$, where $P^{AA}_{m,t}$ is the price level for intermediate goods produced in country A for the domestic market and $\widetilde{P}^{BA}_{m,t}$ is the post-tariff price for intermediate goods produced in country B and used in country A, in terms of the currency of country A. It holds that $\widetilde{P}^{BA}_{m,t} = (1+\tau^{BA}_{m,t})P^{BA}_{m,t}$, where $\tau^{BA}_{m,t}$ is the import tariff rate charged on intermediate goods from country B by the customs authority of country A, and P^{BA}_{t} is the respective pre-tariff price. As for final goods producers, intermediate goods producers are monopolistically competitive and set their prices subject to Calvo-type pricing frictions. We calibrate demand elasticity and the degree of pricing friction to the same values as for final goods. The full extended model is delegated to the appendix.

As Figure 6 shows, the effects of tariff rate uncertainty for intermediate goods imports (dashed lines) are on a much smaller scale than the effects of an increase of uncertainty concerning final goods import tariff rates (dotted lines). This result highlights the key role that the stochastic discount factor (SDF) of households plays in generating effects of uncertainty shocks. The households' SDF not only affects the valuation of future consumption streams for households, but also features in the valuation of future profits by firms and the valuation of profit streams by financial intermediates. As the SDF is driven by changes in consumption of final goods and hence primarily affected by prices of final goods, the uncertainty of tariff rates on final goods imports has a more immediate effect on the SDF than uncertainty regarding tariff rates on intermediate goods imports. Uncertainty regarding tariff rates on intermediate goods, and hence the demand for them, affects consumption only very indirectly via shifts in the input structure in the production function of final goods producers.

5 Conclusion

This paper argues that a large fraction of the effect of the 2018/2019 US-imposed import tariffs on Chinese goods on US (post-tariff) import prices was offset by a trade policy induced appreciation of the US dollar against the Chinese yuan and other currencies.

A main contribution of our analysis is to show that the dollar response to trade policy uncertainty (TPU) shocks is key to assessing the overall impact of trade policies. Using SVAR models, we find that a sudden increase in trade policy uncertainty persistently strengthens the USD against a broad currency basket and against the Chinese renminbi. Such shocks account for a sizable fraction of the USD appreciation between 2018 and 2019. We trace out the channels underlying this finding in an open economy New Keynesian model featuring financial frictions in banks' asset holdings and a different pledgeability of US and non-US assets that gives rise to a safety premium for US assets. We show that, in this setting, trade policy uncertainty shocks trigger an increase in the relative demand for safer US assets thereby causing an appreciation of the US dollar.

Secondly, in assessing the offsetting effects from the exchange rate response to trade policy actions during 2018 and 2019, we provide novel evidence on the pass-through of CNY/USD exchange rate movements to unit values of US imports from China by using detailed product data for manufacturing imports. We find that Chinese exporters react to a USD appreciation by markedly lowering their US dollar-denominated export prices. This is especially the case for intermediate goods producers that face higher tariffs. Combining the estimates with the SVAR results, our findings suggest that the trade policy-induced US dollar appreciation did offset three-quarters of the effect of US tariffs on post-tariff import prices up to May 2019. After the imposition of additional tariffs in mid-2019, the trade policy induced offsetting effect declines to around one-quarter.

While we focus on trade policy in the US, the link between higher trade policy uncertainty and a nominal exchange rate appreciation likely generalizes to other assets considered as a safe haven. Moreover, the theoretical channels highlighted in this paper apply to macroeconomic uncertainty more generally.

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Appendix

A Data sources SVAR

Time series	Data source
US import tariff news	See text.
Citigroup macroeconomic surprise index	Citigroup and Haver Analytics.
US trade policy uncertainty	Caldara et al. (2020)
CBOE volatility index (VIX)	Wall Street Journal, Haver Analytics.
US short-term policy rate	Federal Reserve Board, Haver Analytics.
Chinese short-term policy rate	Bank for International Settlements, Haver Analytics.
US government bond yields (3y)	Federal Reserve Board, Haver Analytics.
Chinese government bond yields (3y)	Tullett Prebon Information, Haver Analytics.
US stock market index S&P 500	Standard & Poors, Haver Analytics.
Shanghai SE Composite Index	Shanghai Stock Exchange, Haver Analytics.
Nominal oil prices	Financial Times, Haver Analyics.
Nominal exchange rate Chinese yuan / USD	Federal Reserve Board, Haver Analytics.

Table 6: Data sources daily SVAR.

Time series	Data source
US import tariff index	US census bureau. See text.
OECD industrial production	OECD, Haver Analytics.
US industrial production	Federal Reserve Board, Haver Analytics.
US consumer price index	Bureau of Labor Statistics, Haver Analytics.
US trade policy uncertainty	Caldara et al. (2020)
US macroeconomic uncertainty	Jurado et al. (2015)
US stock market index S&P 500	Standard & Poors , Haver Analytics.
Index of real commodity prices (GSCI Nearby index)	Standard & Poors, Haver Analytics.
Broad trade-weighted dollar index	Federal Reserve Board, Haver Analytics.

Table 7: Data sources monthly SVAR.

B Alternative exchange rate pass-through regression

As a robustness check, an alternative specification that shares some similarities with the approach in Amiti et al. (2019) is employed. Amiti et al. (2019) examine the tariff pass-through up to December 2018 based on changes in unit values relative to a pre-tariff level. We choose February 2018 as the base period t = 0. At this point in time, no new tariffs specifically targeted against China had been imposed. Then, we assess how the change in the nominal exchange rate and a number of control variables relative to the base period affected year-on-year changes (Δ_{12}) of log unit values of US imports from China (in USD, before tariffs).

$$\Delta_{12} \ln P_{X,i,t} = \beta_S (\ln S_t - \ln S_0) + \beta_\tau (\ln(1 + \tau_{CHN,i,t}) - \ln(1 + \tau_{CHN,i,0})) + \\ + \beta'_X (\ln X_{CHN,t} - \ln X_{CHN,0}) + \varepsilon_{i,j,t} + \kappa_i \quad (30)$$

For the estimation, we employ HS-10 data for the period January 2017 to December 2019. Table 8 reports the results. In the first column, in order to compare the results to the specification to the regression of Amiti et al. (2019), we only re-port the tariff-pass-through estimates. The coefficients are small, but in contrast to the previous specification statistically significant. This indicates that tariff burden was at least to some extent taken by Chinese exporters. Adding the log change of nominal exchange rates and the vector of controls (log change in aggregate Chinese producer prices and Brent oil prices), the estimate on tariffs does not change substantially. This indicates that these variables capture an important fraction of the time fixed effect included in column (1).

Importantly, also in these regressions the exchange rate pass-through is substantially larger for intermediates compared to final goods. The coefficients are roughly in line with the standard pass-through regression reported in Table 1. The last three columns experiment by only including products that have above average import values. This aims at capturing only products that shape the aggregate dynamics. Exchange rate pass-through for intermediates is around 90% in this subgroup; exchange rate pass-through for final goods is around 50%.

	(1) All	(2) All	(3) Interm.	(4) Capital	(5) Consumpt.	(6) All (HS)	(7) Interm (HS)	(8) Final (HS)
US dollar		-0.384***	-0.737***	0.0932	-0.295**	-0.594***	-0.898***	-0.519**
		(0.0997)	(0.149)	(0.322)	(0.145)	(0.154)	(0.267)	(0.204)
Import tariff	-0.260***	-0.296***	-0.128	-0.526***	-0.319***	-0.129	-0.00507	-0.0484
	(0.0672)	(0.0606)	(0.0857)	(0.168)	(0.102)	(0.113)	(0.138)	(0.151)
CHN PPI		2.031***	3.160***	0.883	1.794*	2.947***	2.340	2.534*
		(0.687)	(1.015)	(2.065)	(1.033)	(0.998)	(1.640)	(1.395)
Nominal Brent		0.0486	0.128**	-0.0458	-0.00972	0.00528	0.140	-0.0224
		(0.0413)	(0.0616)	(0.129)	(0.0621)	(0.0565)	(0.0905)	(0.0788)
Observ.	115571	115571	52035	12747	50789	19405	10576	10284
Products	8254	8254	4140	1011	3103	1311	757	662
Time FE	X							

Table 8: Estimation tariff pass-through and exchange rate pass-through 2018-2019 based on regression (30). Changes in RHS variables relative to 2018m2. Last three columns (high share "HS"): only products that have import values above the sample mean import value in the specific product group (based on 2017 averages).

C Additional SVAR results

C.1 Further robustness analysis to Section 3

Excluding the yuan from the currency basket: In a robustness exercise to the monthly SVAR results presented in Section 3.1 we exclude the yuan from the USD currency basket. This demonstrates that the trade policy uncertainty shock affected the US dollar exchange rate multilaterally and not solely through a depreciation of the yuan (see Figure 7).

Inclusion of US short-term interest rates: In the benchmark monthly SVAR model, following Bhattarai et al. (2020) – and to keep the number of variables limited, we do not include short-term interest rates. The results are, nevertheless, robust to the inclusion of the US policy rates. This can be seen in Figure 8 where we add the Wu and Xia (2016) US shadow short rate (transformed to first-differences). The variable is ordered before the financial market variables – including the nominal exchange rate – and after the macroeconomic variables (US and OECD industrial and production and US inflation) as well as before the

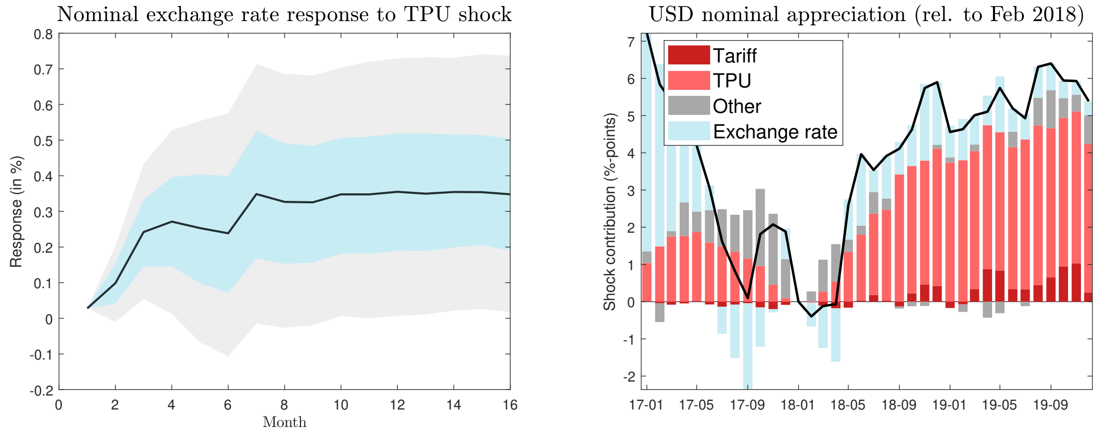

Figure 7: Results from the monthly SVAR model (excl. yuan). January 1984 to December 2019. Left panel: impulse response function for the US dollar appreciation given a one-standard-deviation trade policy uncertainty shock in period 1. Grey (blue) area shows the 95% (68%) confidence interval. Right panel: historical decomposition of US dollar movements (excl. yuan) for various groups of identified shocks: tariff shock, trade policy uncertainty (TPU) shocks, exchange rate shocks (Exchange rate), as well as remaining shocks and the deterministic component (Other).

uncertainty measures.[36]

Restricting the sample to 1985-2015: When the model is estimated up to end of 2015 (before the most recent trade conflict), the response of the nominal exchange rate in Figure 3 is statistically significant and the quantitatively roughly unchanged. The response in the medium term (after 10 month) to a one standard deviation shocks is around 0.32 % compared to 0.39 % in the benchmark model. Given that the standard deviation of a trade policy uncertainty shock is 0.92 in the shorter sample and 0.93 in the benchmark sample, the response is only slightly smaller in the shorter sample. The role of trade policy uncertainty for the nominal exchange rate is therefore not a peculiar phenomenon of the most recent trade conflict. For instance, in the early 1990s trade policy uncertainty increased against

[36] The results from the benchmark model are also robust if we instead of the US shadow short rate include the difference between the non-US short-term interest rate and the US short-term interest rate at three month maturity. This series is based on the data of Du, Im, and Schreger (2018) and Du and Schreger (2016). We use currency weights reported by the Federal Reserve Bank of New York to construct a weighted average across individual US partner countries. The constructed time series is, however, not available for the full benchmark sample.

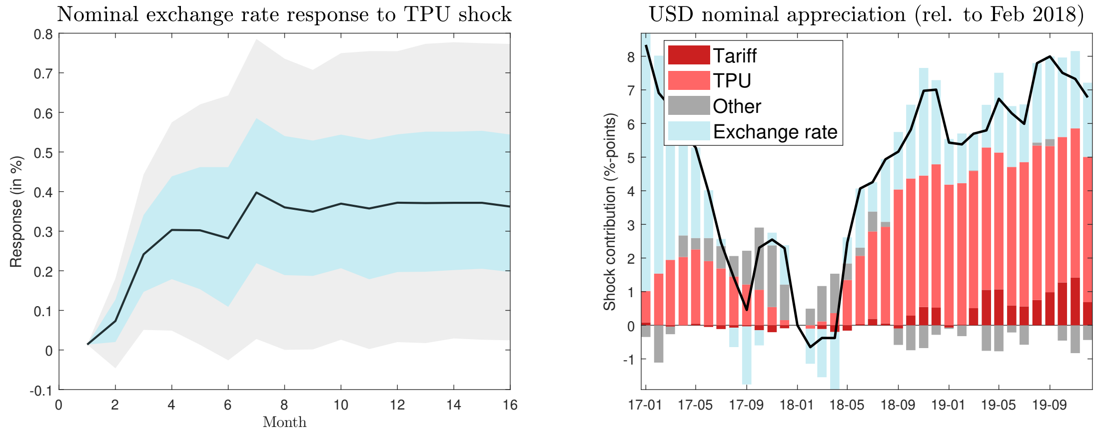

Figure 8: Results from the monthly SVAR model (including the Wu and Xia (2016)) US shadow short rate). January 1984 to December 2019. Left panel: impulse response function for the US dollar appreciation given a one-standard-deviation trade policy uncertainty shock in period 1. Grey (blue) area shows the 95% (68%) confidence interval. Right panel: historical decomposition of US dollar movements (excl. yuan) for various groups of identified shocks: tariff shock, trade policy uncertainty (TPU) shocks, exchange rate shocks (Exchange rate), as well as remaining shocks and the deterministic component (Other).

the background of NAFTA negotiations, which led to a marked USD appreciation. Nevertheless, trade policy uncertainty shocks are not the main reason for the USD appreciation at that time. Notably, the magnitude of the USD appreciation in 2018 and 2019 is small compared to historical swings in the USD exchange rate.

C.2 The role of empirical deviations from the covered interest rate parity

In the theoretical model, the underlying mechanism translating exogenous shifts in trade policy uncertainty to movements in the US dollar exchange rate operates via adjustments in the global safety premia on US dollar assets. In the benchmark model with financial frictions, positive trade policy uncertainty shocks induce a larger safety premia on US dollar-denominated assets, which raises the value of the US dollar. As in Jiang et al. (2021), a rise in the safety premia causes an widening of the deviation from the uncovered interest rate parity.

In the following, we employ the dataset on deviations of the covered interest rate parity (CIP) between non-US and US government bonds provided by Du et al. (2018) and Du and Schreger (2016) to assess the role of CIP deviations in 2018 and

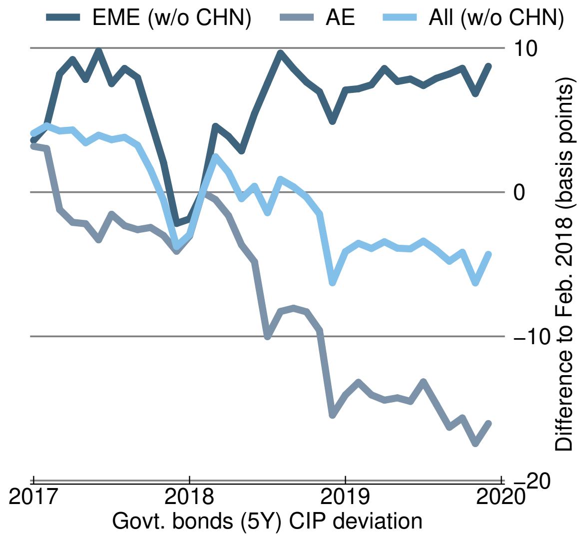

Figure 9: Deviations in the covered interest rate parity condition between five-year government bonds issued by non-US governments relative to US five-year government bonds. Weighted by shares in the broad US dollar basket. All values are relative to January 2018. Chinese government bonds are excluded from the sample. Data sources: Du and Schreger (2016), Du et al. (2018), Federal Reserve Bank of New York, Haver Analytics and own calculations.

2019. [37] To construct aggregated measures, we weight currencies for which there is data on CIP deviations available by their shares in the exchange rate basket of the broad USD dollar as defined by the Federal Reserve Bank of New York. We focus solely on a sample excluding Chinese government bonds, motivated by our empirical finding that in 2018 and 2019 US trade policy uncertainty and to some extent US import tariffs can explain a multilateral US dollar appreciation and are not solely associated with a yuan depreciation (see section C.1). Figure 9 shows the evolution of CIP deviation between non-US and US government bonds with a maturity of five years (in comparison to January 2018). The figure shows that especially the CIP deviation of the country group only including emerging markets widened markedly and persistently. For advanced economies, the CIP deviation hiked up to April 2018 and declined afterwards. Overall, the CIP deviation is nevertheless rather stable but faces pronounced upward pressure in some periods.

[37] The datafile can be obtained from the author's webpage: https://sites.google.com/site/wenxindu/data/govt-cip

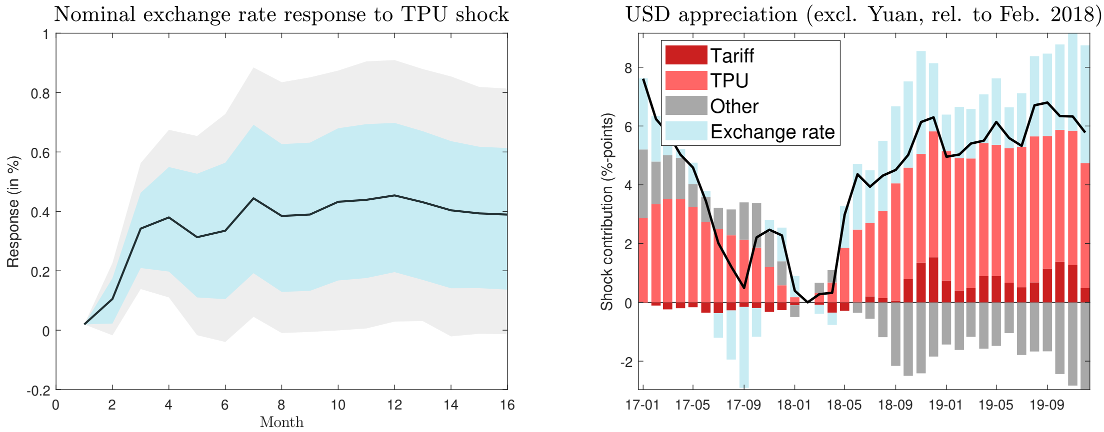

Figure 10: Results from the monthly SVAR model. February 1997 to December 2019. Left panel: impulse response function for the US dollar appreciation (excl. yuan) given a one-standard-deviation trade policy uncertainty shock in period 1. Grey (blue) area shows the 90% (68%) confidence interval. Right panel: historical decomposition of US dollar movements (excl. yuan) for various groups of identified shocks: tariff shock, trade policy uncertainty (TPU) shocks, exchange rate shocks (Exchange rate), as well as remaining shocks and the deterministic component (Other).

To identify the role of trade policy uncertainty on government bond CIP deviations we augment the benchmark SVAR model in section 3.2 by the aggregate CIP deviation of non-US and US government five-year bonds. We also include as a control variable also the change in the Wu-Xia US shadow short-term nominal rates in this specification (cf. Wu and Xia 2016).[38] We exclude the yuan from the USD exchange rate basket and consider movements in the remaining currencies. Figure 10 shows that the observed USD appreciation in 2018 and 2019 was multilateral, which can be rationalized by trade policy uncertainty shocks and to some extent tariff shocks. Moreover, the figure shows that the findings in Section 3 are robust to the inclusion of a covered interest rate parity measure and the US shadow short rate in the SVAR model.

More importantly, Figure 11 shows the impulse response function of the government bond CIP deviation for a one standard deviation shock to trade policy uncertainty. The CIP deviation widens in response to a trade policy uncertainty shock, the response is – at 68% confidence bands – statistically significant for the

[38]The CIP deviation is ordered second last before the USD exchange rate. The change in the US shadow rate is positioned after the tariff variable, industrial production in the US and OECD, the CPI and the uncertainty measures but before the financial market variables. Due to data limitations, the sample is shorter than the baseline sample (starting in February 1997).

first three and in the sixth month. The historical decomposition indicates that, in 2018, trade policy uncertainty adds up to above 5 basis points to the CIP deviation between non US and US government bonds, at the end of 2019 the effect is still around 2 1/2 basis points.

Overall, the results provide supportive empirical evidence that trade policy uncertainty transmits to nominal exchange rate changes via changes in the safety premia on US dollar-denominated assets. The descriptive evidence in Figure 9 indicates that emerging market have played a larger role for upwards pressure on government bond CIP deviations. This would be in line with evidence in Bhattarai et al. (2020) who particularly report an increase of emerging market bond spreads in response to uncertainty shocks originating in the US. A caveat of this analysis is that deviations from covered interest rate parity for US issued corporate bonds relative to foreign counterparts are not considered.

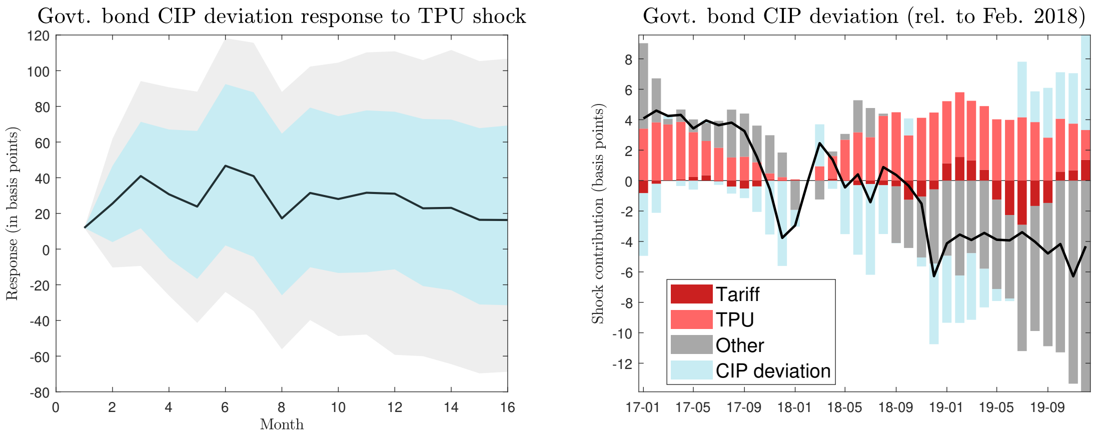

Figure 11: Results from the monthly SVAR model. February 1997 to December 2019. Left panel: impulse response function for non US government bond CIP deviations relative to US govt bonds (excl. China) at five-year maturity given a one-standard-deviation trade policy uncertainty shock in period 1. Grey (blue) area shows the 90% (68%) confidence interval. Right panel: historical decomposition of government bond CIP deviation (excl. Chinese govt. bonds) for various groups of identified shocks: tariff shock, trade policy uncertainty (TPU) shocks, CIP deviation shocks, (CIP deviation), as well as remaining shocks and the deterministic component (Other).

D US trade policy in a model with dollar asset dominance

D.1 The full set of model equations

D.1.1 Households

$$1 = \beta E_t[\frac{i_t^A}{\Pi_{t+1}^A}\Lambda_{t+1}^A] \tag{31}$$

$$1 = \beta E_t[\frac{i_t^B}{\Pi_{t+1}^B}\Lambda_{t+1}^B] \tag{32}$$

$$\Lambda_t^A = \frac{\lambda_t^A}{\lambda_{t-1}^A} \tag{33}$$

$$\Lambda_t^B = \frac{\lambda_t^B}{\lambda_{t-1}^B} \tag{34}$$

$$\lambda_t^A = (C_t^A - hC_{t-1}^A)^{-\sigma_c} - \beta h(E_t[C_{t+1}^A] - hC_t^A)^{-\sigma_c} \tag{35}$$

$$\lambda_t^B = (C_t^B - hC_{t-1}^B)^{-\sigma_c} - \beta h(E_t[C_{t+1}^B] - hC_t^B)^{-\sigma_c} \tag{36}$$

i_t is the short-term nominal interest rate set by the central bank, Π_t the consumer price inflation, and $\beta\Lambda_t$ the stochastic discount factor of households. λ_t is the marginal utility of consumption, with h and σ_c being the degree of habit formation and the coefficient of relative risk aversion.

D.1.2 Wage setting

Optimal wage setting implies the following first order conditions

$$1 = \frac{\epsilon_w}{\epsilon_w - 1}\frac{Z1_{w,t}^A}{Z2_{w,t}^A} \tag{37}$$

$$1 = \frac{\epsilon_w}{\epsilon_w - 1}\frac{Z1_{w,t}^B}{Z2_{w,t}^B} \tag{38}$$

$$Z1_{w,t}^A = \left(\frac{W_t^A}{W_t^{*A}}\right)^{\epsilon_w(1+\sigma_l)} \chi^A \frac{(L_t^A)^{1+\sigma_l}}{\lambda_t^A} + \beta\zeta_w E_t\left[\left(\frac{W_{t+1}^{*A}}{W_t^{*A}}\Pi_{t+1}^A\right)^{\epsilon_w(1+\sigma_l)} Z1_{w,t+1}^A\right] \tag{39}$$

$$Z1_{w,t}^B = \left(\frac{W_t^B}{W_t^{*B}}\right)^{\epsilon_w(1+\sigma_l)} \chi^B \frac{(L_t^B)^{1+\sigma_l}}{\lambda_t^B} + \beta\zeta_w E_t\left[\left(\frac{W_{t+1}^{*B}}{W_t^{*B}}\Pi_{t+1}^B\right)^{\epsilon_w(1+\sigma_l)} Z1_{w,t+1}^B\right] \tag{40}$$

$$Z2_{w,t}^A = (W_t^{*A})^{1-\epsilon_w}(W_t^A)^{\epsilon_w} L_t^A + \beta\zeta_w E_t\left[\left(\frac{W_{t+1}^{*A}}{W_t^{*A}}\Pi_{t+1}^A\right)^{\epsilon_w - 1} Z2_{w,t+1}^A\right] \tag{41}$$

$$Z2_{w,t}^B = (W_t^{*B})^{1-\epsilon_w}(W_t^B)^{\epsilon_w} L_t^B + \beta\zeta_w E_t\left[\left(\frac{W_{t+1}^{*B}}{W_t^{*B}}\Pi_{t+1}^B\right)^{\epsilon_w - 1} Z2_{w,t+1}^B\right] \tag{42}$$

W_t is the real wage and W_t^* is the optimal real wage. $Z1_{w,t}$ and $Z2_{w,t}$ are auxiliary variables, which allow for a recursive formulation of the wage Phillips curve. ϵ_w is the elasticity of substitution between varieties of labor, χ the weight on the disutility of labor in the households' preferences, σ_l the inverse of the Frisch elasticity, and ζ_w the probability that a union updates its price in any given period. The dynamics of the aggregate wage index and wage dispersion, $\Delta_{w,t}$, are captured by

$$1 = \zeta_w \left(\frac{W_t^A}{W_{t-1}^A}\Pi_t^A\right)^{\epsilon_w-1} + (1-\zeta_w)\left(\frac{W_t^A}{W_t^{*A}}\right)^{\epsilon_w-1} \tag{43}$$

$$1 = \zeta_w \left(\frac{W_t^B}{W_{t-1}^B}\Pi_t^B\right)^{\epsilon_w-1} + (1-\zeta_w)\left(\frac{W_t^B}{W_t^{*B}}\right)^{\epsilon_w-1} \tag{44}$$

$$\Delta_{w,t}^A = \zeta_w \Delta_{w,t-1}^A \left(\frac{W_t^A}{W_{t-1}^A}\Pi_t^A\right)^{\epsilon_w} + (1-\zeta_w)\left(\frac{W_t^{*A}}{W_t^A}\right)^{-\epsilon_w} \tag{45}$$

$$\Delta_{w,t}^B = \zeta_w \Delta_{w,t-1}^B \left(\frac{W_t^B}{W_{t-1}^B}\Pi_t^B\right)^{\epsilon_w} + (1-\zeta_w)\left(\frac{W_t^{*B}}{W_t^B}\right)^{-\epsilon_w} \tag{46}$$

$$L_t^A = L_{f,t}^A \Delta_{w,t}^A \tag{47}$$

$$L_t^B = L_{f,t}^B \Delta_{w,t}^B \tag{48}$$

L_t is the labor supplied by households and $L_{f,t}$ is the the amount of labor employed by firms. These measures differ due to wage dispersion.

D.1.3 Production, price setting and good market clearing

Production function and marginal cost in the baseline model take the simple form

$$Yp_t^A = A_t^A Lf_t^A, \tag{49}$$

$$Yp_t^B = A_t^B Lf_t^B, \tag{50}$$

$$MC_t^A = \frac{W_t^A}{A_t^A}, \tag{51}$$

$$MC_t^B = \frac{W_t^B}{A_t^B}. \tag{52}$$

Firms set different optimal prices for the domestic market and for exports

$$p_t^{*,A,A} = \frac{\epsilon}{\epsilon-1}\frac{Z_{2,t}^{A,A}}{Z_{1,t}^{A,A}}, \tag{53}$$

$$p_t^{*,A,B} = \frac{\epsilon}{\epsilon-1}\frac{Z_{2,t}^{A,B}}{Z_{1,t}^{A,B}}, \tag{54}$$

$$p_t^{*,B,A} = \frac{\epsilon}{\epsilon-1}\frac{Z_{2,t}^{B,A}}{Z_{1,t}^{B,A}}, \tag{55}$$

$$p_t^{*,A,A} = \frac{\epsilon}{\epsilon-1}\frac{Z_{2,t}^{B,B}}{Z_{1,t}^{B,B}}. \tag{56}$$

Here, p_t^* is the optimal price relative to the overall price level in a given segment. The superscript A, A stands for prices related to goods produced in A and sold in A, A, B for goods produced in A and sold in B, B, A for goods produced in B and sold in A, and B, B for goods produced in B and sold in B. $Z1_t$ and $Z2_t$ are auxiliary variables to facilitate recursive price Phillips curves with Calvo pricing.

$$Z_{1,t}^{A,A} = Y p_t^{A,A} p_t^{AA,A} + \beta\zeta E_t \left\{ \frac{\lambda_{t+1}^A}{\lambda_t^A} (\Pi_{t+1}^{A,A})^{\epsilon-1} Z_{1,t+1}^{A,A} \right\} \tag{57}$$

$$Z_{1,t}^{A,B} = Y p_t^{A,B} RER_t^{A,B} p_t^{AB,B} + \beta\zeta E_t \left\{ \frac{\lambda_{t+1}^A}{\lambda_t^A} (\Delta_{\mathcal{E},t+1}^{A,B} \Pi_{t+1}^{A,B})^{\epsilon-1} Z_{1,t+1}^{A,B} \right\} \tag{58}$$

$$Z_{1,t}^{B,A} = Y p_t^{B,A} \frac{1}{RER_t^{A,B}} p_t^{BA,A} + \beta\zeta E_t \left\{ \frac{\lambda_{t+1}^B}{\lambda_t^B} (\Pi_{t+1}^{B,A})^{\epsilon-1} Z_{1,t+1}^{B,A} \right\} \tag{59}$$

$$Z_{1,t}^{B,B} = Y p_t^{B,B} p_t^{BB,B} + \beta\zeta E_t \left\{ \frac{\lambda_{t+1}^B}{\lambda_t^B} (\Pi_{t+1}^{B,B})^{\epsilon-1} Z_{1,t+1}^{B,B} \right\} \tag{60}$$

$$Z_{2,t}^{A,A} = Y p_t^{A,A} MC_t^A + \beta\zeta E_t \left\{ \frac{\lambda_{t+1}^A}{\lambda_t^A} (\Pi_{t+1}^{A,A})^{\epsilon} Z_{2,t+1}^{A,A} \right\} \tag{61}$$

$$Z_{2,t}^{A,B} = Y p_t^{A,B} MC_t^A + \beta\zeta E_t \left\{ \frac{\lambda_{t+1}^A}{\lambda_t^A} (\Delta_{\mathcal{E},t+1}^{A,B} \Pi_{t+1}^{A,B})^{\epsilon} Z_{2,t+1}^{A,B} \right\} \tag{62}$$

$$Z_{2,t}^{B,A} = Y p_t^{B,A} MC_t^B + \beta\zeta E_t \left\{ \frac{\lambda_{t+1}^B}{\lambda_t^B} (\Pi_{t+1}^{B,A})^{\epsilon} Z_{2,t+1}^{B,A} \right\} \tag{63}$$

$$Z_{2,t}^{B,B} = Y p_t^{B,B} MC_t^B + \beta\zeta E_t \left\{ \frac{\lambda_{t+1}^B}{\lambda_t^B} (\Pi_{t+1}^{B,B})^{\epsilon} Z_{2,t+1}^{B,B} \right\} \tag{64}$$

Π^{AA}, Π^{AB}, Π^{BA} and Π^{BB} stand for the inflation rate in the respective segments. $p_t^{AA,A}$ stands for price of goods produced in A and sold domestically relative to the overall price level in country A, $p_t^{AB,B}$ for the price of goods produced in A and exported to B relative to the overall price level in country B, etc.. $RER_t^{A,B}$ is the real exchange rate between country A and B, and $\Delta_{\mathcal{E},t+1}^{A,B}$ is the change in nominal exchange rate. The nominal exchange rate features in price setting of country A exports, due to producer currency pricing. ϵ is the elasticity of substitution between varieties of goods and ζ is the probability that a firm can update its price in any given period. The dynamics of the four inflation rates and the respective price dispersion measures, Δ_t, are

$$
\begin{aligned}
1 =&(1-\zeta)(p_t^{*,A,A})^{1-\epsilon} + \zeta(\Pi_t^{A,A})^{\epsilon-1} && (65)\\
1 =&(1-\zeta)(p_t^{*,A,A})^{1-\epsilon} + \zeta(\Delta_{\mathcal{E},t}^{A,B}\Pi_t^{A,B})^{\epsilon-1} && (66)\\
1 =&(1-\zeta)(p_t^{*,B,A})^{1-\epsilon} + \zeta(\Pi_t^{B,A})^{\epsilon-1} && (67)\\
1 =&(1-\zeta)(p_t^{*,B,B})^{1-\epsilon} + \zeta(\Pi_t^{B,B})^{\epsilon-1} && (68)\\
\Delta_t^{AA} =&\zeta\Delta_{t-1}^{AA}(\Pi_t^{A,A})^{\epsilon} + (1-\zeta)\left(\frac{1-\zeta(\Pi_t^{A,A})^{\epsilon-1}}{(1-\zeta)}\right)^{\frac{\epsilon}{\epsilon-1}} && (69)\\
\Delta_t^{AB} =&\zeta\Delta_{t-1}^{AB}(\Delta_{\mathcal{E},t}^{A,B}\Pi_t^{A,B})^{\epsilon} + (1-\zeta)\left(\frac{1-\zeta(\Delta_{\mathcal{E},t}^{A,B}\Pi_t^{A,B})^{\epsilon-1}}{(1-\zeta)}\right)^{\frac{\epsilon}{\epsilon-1}} && (70)\\
\Delta_t^{BA} =&\zeta\Delta_{t-1}^{BA}(\Pi_t^{B,A})^{\epsilon} + (1-\zeta)\left(\frac{1-\zeta(\Pi_t^{B,A})^{\epsilon-1}}{(1-\zeta)}\right)^{\frac{\epsilon}{\epsilon-1}} && (71)\\
\Delta_t^{BB} =&\zeta\Delta_{t-1}^{BB}(\Pi_t^{B,B})^{\epsilon} + (1-\zeta)\left(\frac{1-\zeta(\Pi_t^{B,B})^{\epsilon-1}}{(1-\zeta)}\right)^{\frac{\epsilon}{\epsilon-1}} && (72)
\end{aligned}
$$

Accounting for price dispersion, the production of final goods in either country equals the demand for these goods at home and abroad

$$
\begin{aligned}
Yp_t^A =&Y_t^{A,A}\Delta_t^{AA} + Y_t^{A,B}\Delta_t^{AB}, && (73)\\
Yp_t^B =&Y_t^{B,A}\Delta_t^{BA} + Y_t^{B,B}\Delta_t^{BB}. && (74)
\end{aligned}
$$

Demand for domestic or imported final goods in turn depends on relative prices, including import prices and the overall demand in a country, Y_t, which includes private consumption and government spending, G_t.

$$
\begin{aligned}
Y_t^{A,A} =&(1-\mu^T)(p_t^{AA,A})^{-\Theta}Y_t^A && (75)\\
Y_t^{A,B} =&\mu^T((1+\tau_t^{A,B})p_t^{AB,B})^{-\Theta}Y_t^B && (76)\\
Y_t^{B,A} =&\mu^T((1+\tau_t^{B,A})p_t^{BA,A})^{-\Theta}Y_t^A && (77)\\
Y_t^{B,B} =&(1-\mu^T)(p_t^{BB,B})^{-\Theta}Y_t^B && (78)\\
Y_t^A =&C_t^A + G_t^A && (79)\\
Y_t^A =&C_t^B + G_t^B && (80)\\
& && (81)
\end{aligned}
$$

The aggregate price indices in each country give rise to

$$1 = (1-\mu^T)(p_t^{AA,A})^{1-\Theta} + \mu^T((1+\tau_t^{B,A})p_t^{BA,A})^{1-\Theta} \tag{82}$$
$$1 = (1-\mu^T)(p_t^{BB,B})^{1-\Theta} + \mu^T((1+\tau_t^{A,B})p_t^{AB,B})^{1-\Theta} \tag{83}$$

The the CPI and the development of production prices are linked via

$$\Pi_t^A = \Pi_t^{A,A}\frac{p_{t-1}^{AA,A}}{p_t^{AA,A}}, \tag{84}$$
$$\Pi_t^B = \Pi_t^{A,B}\frac{p_{t-1}^{AB,B}}{p_t^{AB,B}}, \tag{85}$$
$$\Pi_t^A = \Pi_t^{B,A}\frac{p_{t-1}^{BA,A}}{p_t^{BA,A}}, \tag{86}$$
$$\Pi_t^B = \Pi_t^{B,B}\frac{p_{t-1}^{BB,B}}{p_t^{BB,B}}. \tag{87}$$

D.1.4 Financial sector

The banking sector is modeled in the vein of Gertler and Karadi (2011, 2013). Banks in both countries fund themselves with deposits by domestic households and invest in domestic as well as in foreign assets. The aggregate bank balance sheets read

$$Q_{b,t}^A B_t^{AA} + \widetilde{Q}_{b,t}^B B_t^{BA} = N_t^A + D_t^A, \tag{88}$$
$$\widetilde{Q}_{b,t}^A B_t^{AB} + Q_{b,t}^B B_t^{BB} = N_t^B + D_t^B. \tag{89}$$

B_t^{AA} are assets issued by the government in country A and held by banks in country A. B_t^{BA} are assets issued in country B and held by banks in country A. B_t^{AB} are assets issued in country A and held by banks in country B. B_t^{BB} are assets issued in country B and held by banks in country B. $Q_{b,t}^A$ and $Q_{b,t}^B$ are real bond prices. $\widetilde{Q}_{b,t}^B = RER_t^{A,B}Q_{b,t}^B$ and $\widetilde{Q}_{b,t}^B = \frac{Q_{b,t}^B}{RER_t^{A,B}}$ are the real bond prices corrected for the real exchange rate. N_t and D_t are the bank's net worth and its deposits. The banks net worth evolves according to

$$N_t^A = (R_{bt}^A - R_{d,t-1}^A)Q_{t-1}^A B_{t-1}^{AA} + (\widetilde{R}_{bt}^B - R_{d,t-1}^A)\widetilde{Q}_{t-1}^B B_{t-1}^{BA} + R_{d,t-1}^A N_{t-1}^A,$$
$$N_t^B = (\widetilde{R}_{bt}^A - R_{d,t-1}^B)Q_{t-1}^A B_{t-1}^{AB} + (R_{bt}^B - R_{d,t-1}^B)Q_{t-1}^B B_{t-1}^{BB} + R_{d,t-1}^B N_{t-1}^B.$$

R_{bt}^A and R_{bt}^B are real return on long-term government bonds, R_{dt}^A and R_{dt}^B are the return of bank deposits. $\widetilde{R}_{bt}^B = \frac{RER_t^{AB}}{RER_{t-1}^{AB}}R_{bt}^B$ and $\widetilde{R}_{bt}^A = \frac{RER_{t-1}^{AB}}{RER_t^{AB}}R_{bt}^A\Psi_t$ are the real bond return corrected for real exchange rate movements. $\Psi_t = \left(\frac{NFA_t^A}{NFA^A}\right)^{-\psi}$ with $\psi = 0.0001$ eliminates the unit root in equilibrium dynamics akin to the debt-elastic interest rate in Schmitt-Grohe and Uribe (2003). The return on long-term government bonds depends on its coupon, c_b, and a decay rate ρ_b and reads

$$R_{bt}^A = \frac{c_b + \rho_b Q_t^A}{Q_{t-1}^A}. \tag{90}$$

$$R_{bt}^A = \frac{c_b + \rho_b Q_t^A}{Q_{t-1}^A}. \tag{91}$$

The bankers optimization problem, discussed in the main body of the text, gives rise to the following first order conditions for optimal asset holdings

$$\nu_{bt}^{AA} = \lambda_{AA}\frac{\mu_t^A}{1+\mu_t^A}, \tag{92}$$

$$\nu_{bt}^{BA} = \lambda_{BA}\frac{\mu_t^A}{1+\mu_t^A}, \tag{93}$$

$$\nu_{bt}^{AB} = \lambda_{AB}\frac{\mu_t^B}{1+\mu_t^B}, \tag{94}$$

$$\nu_{bt}^{BB} = \lambda_{BB}\frac{\mu_t^B}{1+\mu_t^B}, \tag{95}$$

The Parameters λ_{AA}, λ_{BA}, λ_{AB}, λ_{BB} govern the divertibility of the respective assets for banks. We assume that assets issued in country A are relatively safe and more pledgeable than assets issued in country B, i.e. $\lambda_{AA} < \lambda_{BA}$ and $\lambda_{AB} < \lambda_{BB}$. ν_t^{AA}, ν_t^{BA}, ν_t^{AB} and ν_t^{BB} are the shadow values of the different asset holdings for banks. μ_t^A and μ_t^B are the Lagrangian multipliers of the incentive constraints. The re-arranged first-order condition for these multipliers are

$$Q_t^A B_t^{AA} = \frac{\nu_{bt}^{BA} - \lambda_{BA}}{\lambda_{AA} - \nu_{bt}^{AA}}\widetilde{Q}_t^B B_t^{BA} + \frac{\nu_{nt}^A}{\lambda_{AA} - \nu_{bt}^{AA}}N_t^A, \tag{96}$$

$$\widetilde{Q}_t^A B_t^{AB} = \frac{\nu_{bt}^{BB} - \lambda_{BB}}{\lambda_{AB} - \nu_{bt}^{AB}}Q_t^B B_t^{BB} + \frac{\nu_{nt}^B}{\lambda_{AB} - \nu_{bt}^{AB}}N_t^B. \tag{97}$$

ν_{nt}^A and ν_{nt}^B are shadow values for the bank of an additional unit of net worth. The shadow values of asset holdings and net worth are related to the spreads in the following way

$$\nu_{bt}^{AA} = \beta E_t \Omega_{t+1}^{A}(R_{b,t+1}^{A} - R_{d,t}^{A}), \tag{98}$$

$$\nu_{bt}^{BA} = \beta E_t \Omega_{t+1}^{A}(\widetilde{R}_{b,t+1}^{B} - R_{d,t}^{A}), \tag{99}$$

$$\nu_{nt}^{A} = \beta E_t \Omega_{t+1}^{A} R_{d,t}^{A}, \tag{100}$$

$$\nu_{bt}^{AB} = \beta E_t \Omega_{t+1}^{B}(\widetilde{R}_{b,t+1}^{A} - R_{d,t}^{B}), \tag{101}$$

$$\nu_{bt}^{BB} = \beta E_t \Omega_{t+1}^{B}(R_{b,t+1}^{B} - R_{d,t}^{B}), \tag{102}$$

$$\nu_{nt}^{B} = \beta E_t \Omega_{t+1}^{B} R_{d,t}^{B}, \tag{103}$$

where we have defined

$$\Omega_t^A \equiv \Lambda_t^A((1-\theta) + \theta(1+\mu_t^A)\nu_{nt}^A) \tag{104}$$

$$\Omega_t^B \equiv \Lambda_t^B((1-\theta) + \theta(1+\mu_t^B)\nu_{nt}^B) \tag{105}$$

Note that there is a turnover of bankers in the financial sector. Therefore, one can distinguish between the net worth of new and old bankers, $N_{o,t}$ and $N_{n,t}$, respectively.

$$N_{o,t}^{A} = \theta(R_{bt}^{A} Q_{t-1}^{A} B_{t-1}^{AA} + \widetilde{R}_{bt}^{B} \widetilde{Q}_{t-1}^{B} B_{t-1}^{BA} - R_{d,t-1}^{A} D_{t-1}^{A}), \tag{106}$$

$$N_{o,t}^{B} = \theta(\widetilde{R}_{bt}^{A} Q_{t-1}^{A} B_{t-1}^{AB} + R_{bt}^{B} Q_{t-1}^{B} B_{t-1}^{BB} - R_{d,t-1}^{B} D_{t-1}^{B}), \tag{107}$$

$$N_{n,t}^{A} = \omega^{A}(Q_{t-1}^{A} B_{t-1}^{AA} + \widetilde{Q}_{t-1}^{B} B_{t-1}^{BA}), \tag{108}$$

$$N_{n,t}^{B} = \omega^{B}(\widetilde{Q}_{t-1}^{A} B_{t-1}^{AB} + Q_{t-1}^{B} B_{t-1}^{BB}), \tag{109}$$

where ω^A and ω^B are set such the initial wealth of entering bankers offsets the wealth that exits with bankers which leave the sector.

D.1.5 Monetary and fiscal policy

Monetary policy in both countries follows a Taylor rule.

$$i_t^A = \left[\frac{1}{\beta}\left(\frac{\Pi_t^A}{\Pi^A}\right)^{\phi_\pi}\left(\frac{Y_t^A}{Y^A}\right)^{\phi_y}\right]^{1-\rho}(i_{t-1}^A)^{\rho} \tag{110}$$

$$i_t^B = \left[\frac{1}{\beta}\left(\frac{\Pi_t^B}{\Pi^B}\right)^{\phi_\pi}\left(\frac{Y_t^B}{Y^B}\right)^{\phi_y}\right]^{1-\rho}(i_{t-1}^B)^{\rho} \tag{111}$$

$$\tag{112}$$

The nominal policy rate in each country is tied to the real deposit rate via the Fisher Equation

$$i_t^A = R_t^A E_t[\Pi_{t+1}^A], \tag{113}$$
$$i_t^B = R_t^B E_t[\Pi_{t+1}^B]. \tag{114}$$

The fiscal authority has exogenous spending needs G_t, raises import tariffs and lump-sum taxes, and has access to debt financing. Its budget constraint reads

$$G_t^A + R_{b,t}^A Q_{t-1}^A B_{t-1}^A = Q_t^A B_t^A + T_t^A + \tau_t^{BA} P_t^{BA,A} Y_t^{BA}, \tag{115}$$
$$G_t^B + R_{b,t}^B Q_{t-1}^B B_{t-1}^B = Q_t^B B_t^B + T_t^B + \tau_t^{AB} P_t^{AB,B} Y_t^{AB}. \tag{116}$$

Government spending, is exogenous and follows an AR(1) process with

$$G_t^A = G^A e^{g_t^A}, \tag{117}$$
$$G_t^B = G^B e^{g_t^B}, \tag{118}$$
$$g_t^A = \rho_g g_{t-1}^A + \epsilon_t^{g,A}, \tag{119}$$
$$g_t^B = \rho_g g_{t-1}^B + \epsilon_t^{g,B}, \tag{120}$$

where G^A is the steady state government consumption, ρ_g is the auto-correlation of government consumption, and $\epsilon_t^{g^A}$ is a shock to government spending. Taxes follow a simple feedback rule, such that they are sensitive to the level of public debt,

$$T_t^A = T^A + \kappa_\tau (B_{t-1}^A - B^A), \tag{121}$$
$$T_t^B = T^B + \kappa_\tau (B_{t-1}^B - B^B), \tag{122}$$

where T^A and B^A are the steady state levels of tax revenue and government debt, respectively. The import tariff rate on goods produced in country B and imported by country A (and vice versa), follow exogenous AR(1) processes

$$\tau_t^{BA} = \rho_\tau \tau_t^{BA} + \sigma^B A_{\tau,t} \epsilon_t^{\tau,BA} \tag{123}$$
$$\tau_t^{AB} = \rho_\tau \tau_t^{AB} + \sigma^A B_{\tau,t} \epsilon_t^{\tau,AB}, \tag{124}$$

with persistence parameter ρ_τ and ϵ_t^τ as a tariff rate shock. $\sigma_{\tau,t}$ is the standard deviation of the tariff rate shock and itself time-varying. The stochastic volatility shock on the tariff rate is

$$\sigma^B A_{\tau,t} = \rho_{\sigma_\tau} \sigma^B A_{\tau,t-1} + \epsilon_t^{\sigma_\tau,BA} + \epsilon_t^{\sigma_\tau} \tag{125}$$

$$\sigma^A B_{\tau,t} = \rho_{\sigma_\tau} \sigma^A B_{\tau,t-1} + \epsilon_t^{\sigma_\tau,AB} + \epsilon_t^{\sigma_\tau} \tag{126}$$

Throughout most simulations, we consider the consequences of a global trade policy uncertainty shock $\epsilon_t^{\sigma_\tau}$. $\epsilon_t^{\sigma_\tau,BA}$ and $\epsilon_t^{\sigma_\tau,AB}$ represent shocks to unilateral trade policy uncertainty.

D.1.6 International linkages

Both countries have the same size and are linked through trade in goods and assets. The real trade balance of country A reads

$$TB_t^A = Y_t^{AB} P_t^{AB,B} RER_t - Y_t^{BA} P_t^{BA,A}. \tag{127}$$

International bond market clearing implies

$$B_t^A = B_t^{AA} + B_t^{AB}, B_t^B = B_t^{BA} + B_t^{BB}. \tag{128}$$

The evolution of the net foreign asset position of country A is tied to its trade balance according to

$$(\widetilde{Q}_t^B B_t^{BA} - Q_t^A B_t^{AB}) = (\widetilde{R}_{b,t}^B \widetilde{Q}_{t-1}^B B_{t-1}^{BA} - R_{b,t}^A Q_{t-1}^A B_{t-1}^{AB}) + TB_t^A. \tag{129}$$

We capture the relative demand for safe assets by

$$\frac{Q_t^A B_t^A}{\widetilde{Q}_t^B B_t^B}. \tag{130}$$

Lastly, the real and the nominal exchange rate are linked by

$$\frac{RER_t^{A,B}}{RER_{t-1}^{A,B}} = \frac{\Pi_t^B}{\Pi_t^A} \Delta_{\mathcal{E},t}^{A,B}. \tag{131}$$

D.2 Robustness

In this appendix, we discuss the robustness of our results to alternative modelling choices.

D.2.1 Trade in equity

Our assumption of international trade in government bonds abstracts from a direct of cross-border capital flows, investment into productive capital and hence the marginal cost of production. In this section, we discuss the effects of trade policy uncertainty in an alternative model, in which financial intermediates trade in claims on the capital stock, or equity. The balance sheet of bank j in country A reads

$$Q_t^A K_{jt}^{AA} + \widetilde{Q}_t^B K_{jt}^{BA} = N_{jt}^A + D_{jt}^A.$$

Here, Q_t^A is the real price of capital in country A, $K_{j,t}^{AA}$ are bank j's holdings of equity issued in country A, $\widetilde{Q}_t^B = RER_t Q_t^B$ is the real price of capital in country B in terms of country A's currency, and $K_{j,t}^{BA}$ are holdings of equity issued in country B by bank j. Apart from the type of asset held by financial intermediates the optimization problem of banks is unaltered in its structure. Introducing capital into the model, adds investment into physical capital, I_t^A into the aggregate demand equation: $Y_t^A = C_t^A + I_t^A + G_t^A$. The production function of firms now reads

$$Y_{p,t}^A = A_t^A (K_t^A)^\alpha (L_t^A)^{1-\alpha}, \tag{132}$$

and the marginal costs of production are $MC_t^A = (1-\alpha)\frac{Y_{p,t}^A}{L_t^A}$. α is the output elasticity with respect to capital goods. The law of motion of capital is

$$K_t^A = (1-\delta)K_{t-1}^A + I_t^A, \tag{133}$$

with δ being the depreciation rate. We adopt the assumption by Gertler and Karadi (2011) that producing firms buy capital at the beginning of the period, and re-sell it after using it. Capital producing firms buy the used capital, repaired it and build new capital. The new and refurbished capital is then sold again to final goods producers at the price Q_t^A. The demand for capital by final goods producers thus depends on the marginal product of capital and the variations in the price of capital

$$R_{k,t}^A = \frac{MC_t^A \alpha \frac{Y_t^A}{K_{t-1}^A} + (1-\delta)Q_t^A}{Q_{t-1}^A}. \tag{134}$$

The production of capital is subject to investment adjustment cost, which create a dynamic investment decision for capital good producers, and which gives rise to the investment Euler equation

$$Q_t^A = 1+\phi_K\left(\frac{I_t^A}{I_{t-1}^A}-1\right)\frac{I_t^A}{I_{t-1}^A}+\frac{\phi_K}{2}\left(\frac{I_t^A}{I_{t-1}^A}-1\right)^2-\beta\phi_K E_t\left[\Lambda_{t+1}^A\left(\frac{I_{t+1}^A}{I_t^A}-1\right)\left(\frac{I_{t+1}^A}{I_t^A}\right)^2\right] \tag{135}$$

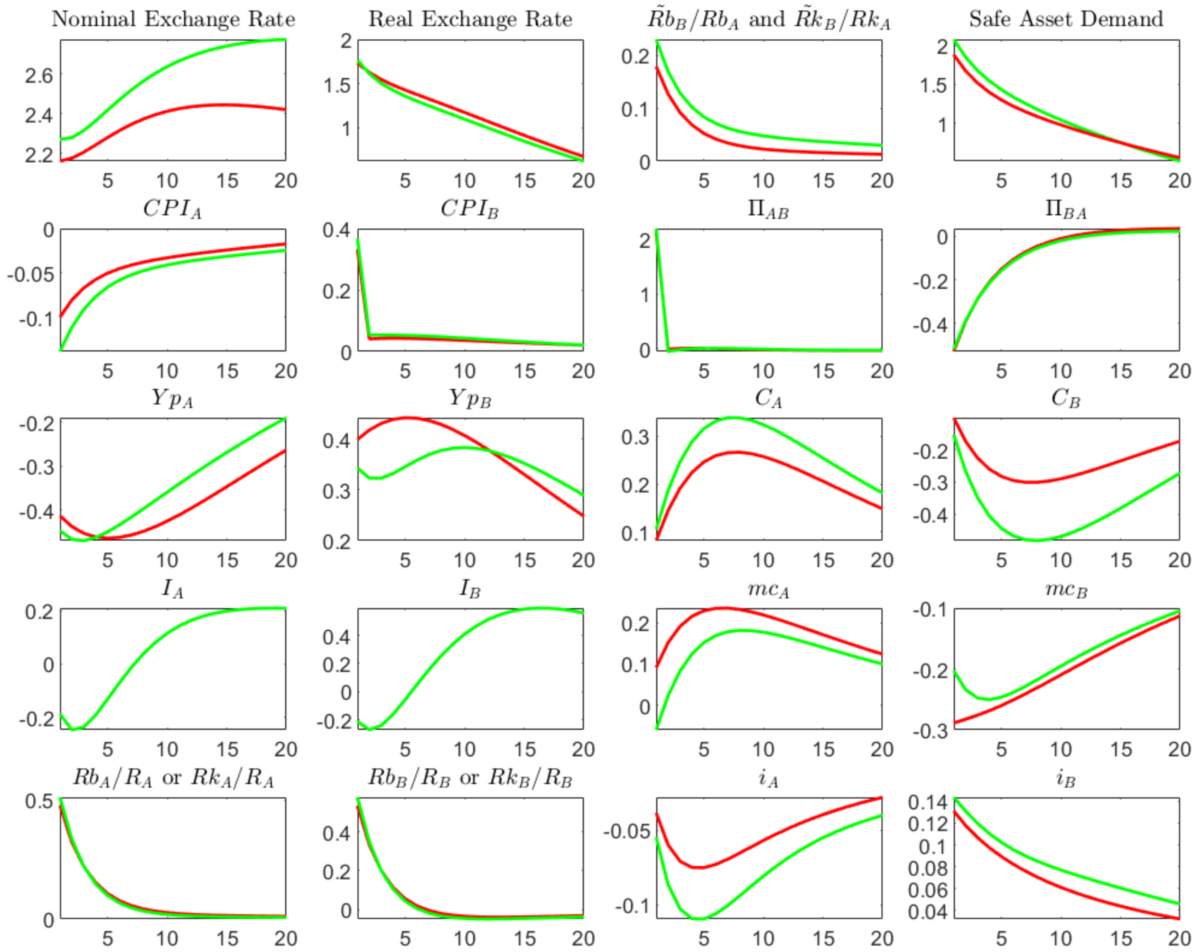

Figure 12: Effects of a trade policy uncertainty shock. y-axis in percent. Red lines: Model with government bonds as internationally traded assets. Green lines: Model with claims on capital stock as internationally traded assets.

International asset market clearing and the evolution of net foreign asset positions are now written in terms of equity claims as well. In this exercise, we calibrate the additional parameters to the values chosen in Caldara et al. (2020). Hence, $\alpha = 0.36$, $\delta = 0.025$ and $\phi_K = 10$. Figure 12 shows that given the calibration, the effects of a trade policy uncertainty shock are very similar in the model with trade in equity and the model with trade in bonds. In particular, the increase in the return of risky assets and the associated increase in the spread over the deposit rates are shared in both models. Consequently, the safety premium on assets issued in country A and the increase in safe asset demand are present in both models, and the appreciation of the nominal exchange rate of the safe currency is similar.

D.2.2 Alternative assumptions on price setting

In this section, we discuss the role of alternative assumption on the price setting for the propagation of trade policy uncertainty shocks. In the baseline model, we assume Calvo pricing. Exporters in country A follow producer currency pricing (PCP), and exporters in country B follow local currency pricing (LCP). Here, we explore the robustness of our results to alternative assumption on price setting. Overall, we find that qualitatively the link between an expansion of safe asset demand and the appreciation of the safe assets currency holds up.

The black dotted lines in Figure 13 show the impulse responses to a trade policy uncertainty shock in the model, when exporters in both countries symmetrically adhere to PCP. In that case, the appreciation of country A's currency is associated with an instantaneous adjustment of import prices in both countries. The sharp decline of the CPI in country A is met by a more immediate decline in the central banks policy rate in country A. This, initially more expansionary time profile of monetary policy is associated with a smaller increase in the term premia in both countries, and hence a smaller role for financial frictions. By extension, the safe asset demand expands by less than in the baseline scenario and lends less support to the appreciation of country A's currency.

In the US, it appears that the Phillips Curve has flattened in the last decades. Accordingly, estimates of ζ that were generated in the context of structural estimations on US data of the last decades tend to be higher (see, e.g., Kulish et al., 2017; Boehl and Strobel, 2020).[39] To gauge the effects of a flatter Phillips curve on the transmission of the trade policy uncertainty shock, we use a version of the baseline model, in which we set $\zeta = 0.85$. The black dashed lines in Figure 13 show that this change results in a slightly stronger appreciation of country A's nominal exchange rate. Reducing the frequency of price adjustment, strengthens the motive for raising precautionary markups and leads to a slightly higher CPI in both countries. However, the difference to the baseline results effects is very small.

[39] A discussion of the flat Phillips curve in the US and inflation dynamics in the aftermath of the Great Recession can be found in (see, e.g., Ball and Mazumder, 2011; Del Negro, Giannoni, and Schorfheide, 2015).

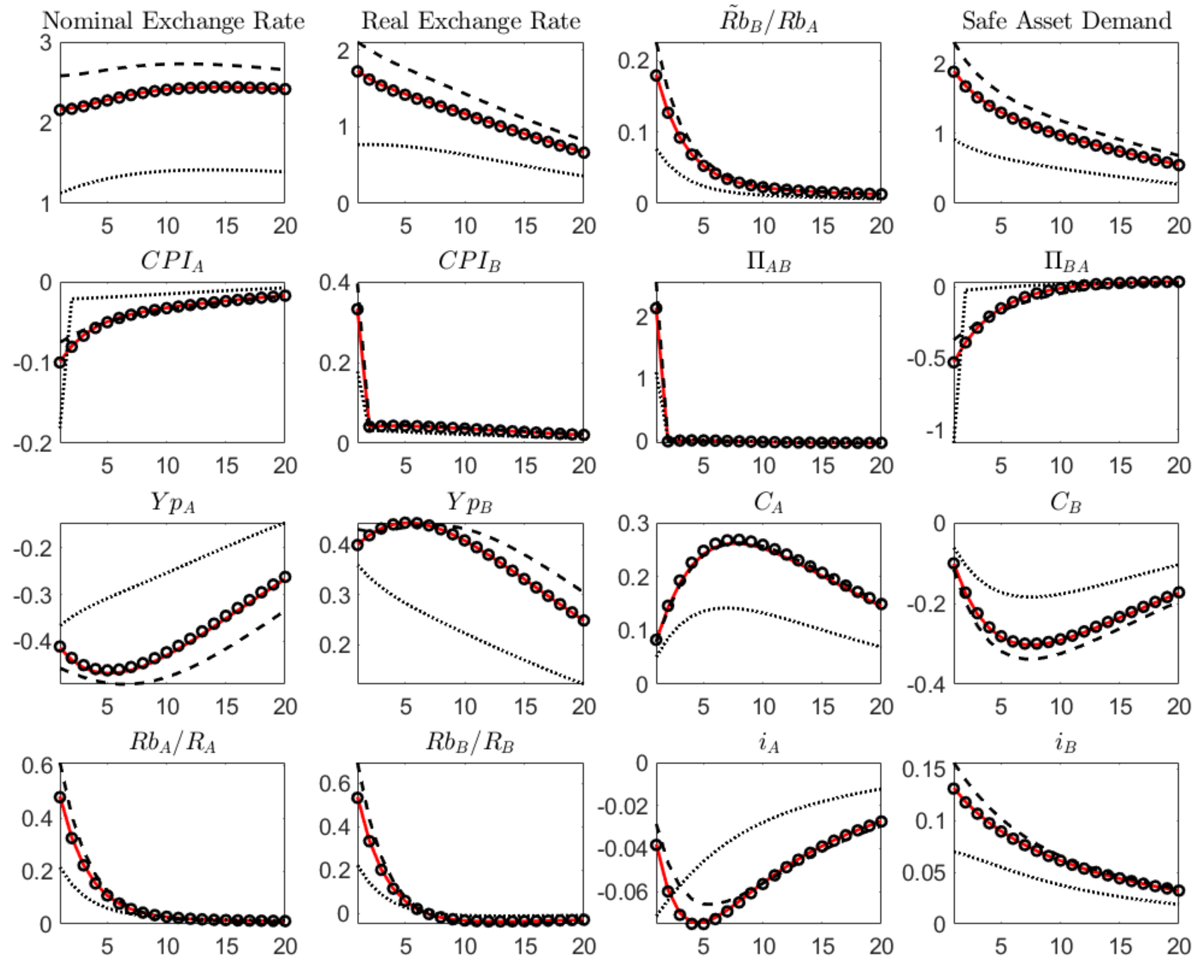

Figure 13: Effects of a trade policy uncertainty shock. y-axis in percent. Red lines: baseline model. Black dotted lines: both countries with producer currency pricing. Black dashed line: flat Phillips curve ($\zeta = 0.85$). Black circled line: Rotemberg pricing.

Oh (2020) documents that in a closed economy, the effect of uncertainty shocks on inflation depend on whether price setting is subject to Calvo frictions or quadratic adjustment costs as in Rotemberg (1982). In contrast to Calvo pricing, all firms in the Rotemberg setting choose the same price, removing the convexity of the profit function in the relative price and hence the motive for a precautionary increase in markups in the face of higher uncertainty. Figure 13 shows that in our open-economy setting, the choice of the specific type of price setting friction is not as relevant. The black lines show the impulse responses to the shock in a model with Rotemberg pricing in which the adjustment cost parameter is chosen such as to match the slope of the Calvo Phillips curve in a linearized setting. As we see, the dynamics in both models are virtually identical. In contrast to the closed economy setting, here the profit curve of firms remains convex in the relative price, as the demand for goods produced in one country depend on the prices set in this country relative to prices set by firms in the other country. Hence the motives for precautionary markups exists in both settings.