Dominant Currency Pricing Transition

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Abstract

We explore an episode of aggregate transition to dominant currency pricing in a large developed economy, relying on transaction-level data on the universe of UK trade between 2010 and 2022. Until 2016, the majority of UK non-EU exports were invoiced in British pounds, the "producer" currency. However, in the aftermath of the June 2016 Brexit referendum and the subsequent depreciation of the pound, the share of non-EU UK exports invoiced in pounds started to sharply decrease – by more than 20 percentage points. This was mirrored by an increase of similar magnitude in the share of US dollar invoicing, which by 2019 overtook the pound as the main non-EU export invoicing currency. Using shift-share and event-study identification strategies, we show that large foreign-exchange movements can generate a transition in invoicing choices for firms with low levels of operational hedging, that is whose exports are not denominated in the same currency as their import. We find that that this currency-mismatch valuation channel accounts for most of the transition away from producer currency pricing, above and beyond effects from strategic complementarities and market power. Finally, we show that this shift in export pricing paradigm has important aggregate consequences for export pass-through and the allocative effects of price rigidities. Exports exhibit significantly higher elasticity to USD exchange-rate movements after the Brexit referendum: a USD dollar appreciation depresses demand for exports by twice as much than before this 'dominant currency pricing transition'.

JEL Codes: F14, F31, F41

Key Words: Invoicing currency of trade; Dominant currency pricing; Foreign-exchange mismatch; Firm-level data; Exchange-rate pass-through.

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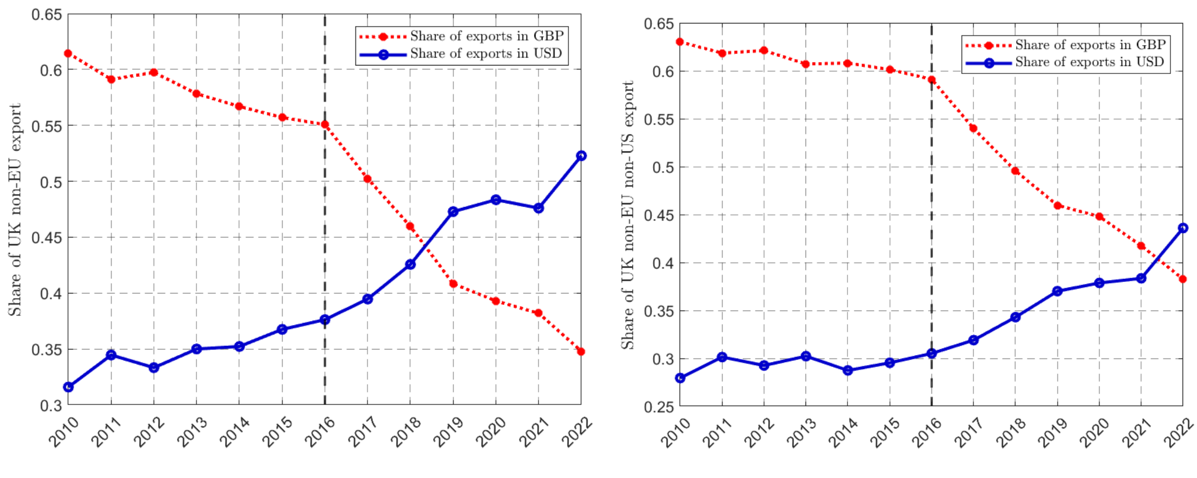
1 Introduction

The currency of invoicing of international trade is a defining question in international macroeconomics. The fact that a large share of international transactions are denominated in US dollars under a Dominant Currency Paradigm (DCP) (Gopinath & Itskhoki, 2022) is central to understanding the international propagation of shocks and the international financial system. At the same time, invoicing choice patterns appear to be very persistent, as many recent empirical studies have consistently shown (Amiti et al., 2022; Boz et al., 2022).

This paper is motivated by a unique episode of rapid aggregate shift in export pricing patterns in a large developed economy, the United Kingdom (UK). Until 2016, the majority of UK non-EU exports[1] were invoiced in the "producer" currency, the British pound. However, in the aftermath of the June 2016 Brexit referendum and the subsequent depreciation of the pound, the share of non-EU UK exports invoiced in pounds started to sharply decrease. It went from about 55% in 2015 to 35% in 2022. At the same time US Dollar (USD) invoicing has surged from around one third to nearly 55% (Figure 1).[2] Thus, the majority of extra-EU UK exports is now invoiced in USD, the dominant vehicle currency of international trade (Boz et al., 2022): a *dominant currency pricing transition.*



(a) Including exports to US.

(b) Excluding exports to US.

Figure 1: Currency shares of UK non-EU exports.

Source: HMRC administrative datasets, UK non-EU exports, 2010–2022.

The conditions under which new equilibria in the use of international currencies might emerge are a key but relatively unexplored question in the DCP literature (Gopinath & Itskhoki, 2022) and one that is increasingly relevant as questions are raised on the sustainability of current levels of Dollar dominance in a more multi-polar world (Frankel, 2023). Our study

[1]As per EU statistical regulations, the currency of invoicing for UK-EU trade was not recorded by the UK customs. Similarly to other studies relying on firm-level evidence in EU countries, such as Amiti et al. (2022), we therefore focus on non-EU trade.

[2]We also report headline results excluding the US as a non-EU destination to control for the fact that the USD is a producer rather than vehicle currency for that country. The invoicing change is similarly large when we exclude exports to the US: the GBP value share of UK exports to non-EU non-US countries has fallen from about 63% before 2015 to 38% by 2022, with USD invoicing increasing from one third to 45% (Figure 1).

provides a unique empirical setting to study aggregate changes in international trade pricing paradigms, using granular firm-level data. Although we know from history that abrupt shifts in the international monetary system can occur (Eichengreen et al., 2018; Vicquéry, 2022), transitions such as the one we study in this paper have been remarkably rare in recent decades. The stability of aggregate invoicing patterns is apparent in the cross-country dataset compiled by Boz et al. (2022) and, a fortiori, in the existing firm-level data studies focusing on a selected group of countries. As an example, the transition we study is faster and either larger or comparable in magnitude to the one experienced by Eastern European countries that shifted their invoicing from dollars to euros as part of EU accession in the early 2000s (Mehl & Mlikota, 2023).

Why did this *Dominant Currency Pricing Transition* materialise? A remarkable feature of our empirical setting is that the transition took place in the aftermath of a large depreciation, driven by unexpected, exogenous political developments. In this paper we exploit this to identify a novel currency-mismatc driven channel of dynamic currency invoicing choice.

In a nutshell, we show that the depreciation generated a transition in invoicing choices for firms exhibiting larger currency mismatches in the wake of the depreciation, i.e. with most of their exports invoiced in GBP while most of their imports invoiced in other currencies. Intuitively, with prices sticky in the currency of invoicing, the sudden GBP depreciation sharply reduced revenues and increased marginal costs for such firms, prompting them to revise their invoicing preferences. Our estimates suggest that this channel may have accounted for most of the dominant currency pricing transition. We find this novel channel to operate over and above classical determinants of invoicing choice such as strategic complementarities and market power.

Finally, we find that this large transition has important aggregate consequences for export pass-through (ERPT) and the allocative effects of price rigidities. UK exports exhibit significantly higher elasticity to USD exchange rate movements after the Brexit referendum, with a USD dollar appreciation estimated to depress demand for exports by twice as much than before this transition.

We begin our analysis by describing our empirical setting and dataset in Section 2. Specifically, we investigate the firm-level patterns of currency mismatch in the wake of the Brexit referendum. We document a clear pattern, whereby the more firms were operationally exposed to the post-referendum depreciation the more they reduced their invoicing in pounds (and conversely increased vehicle currency pricing, particularly in USD) after June 2016.

In Section 3 we then study this "currency-mismatch valuation" channel relying on two main empirical specifications. First, we present a shift-share identification strategy where the effect of currency mismatches on invoicing decisions is given by an exposure index composed of a destination-specific shift (in the exchange-rate) and a firm-specific share (pre-shock net currency exposure). Second, we turn to a dynamic empirical exercise with a firm-product-destination level event-study approach. Both approaches confirm that the exposure to the depreciation driven by pre-shock operational hedging patterns played a key role in driving the firm-level shift away from GBP invoicing. We provide a simple partial equilibrium quantitative exercise to show that the lion share of the UK transition can be accounted for by this novel mismatch valuation channel of invoice currency choice.

Finally, the dominant currency transition we observe raises the question of whether such a large shift in invoicing changed aggregate trade elasticities to exchange-rate movements, and the USD in particular. Our results in Section 5 point to important macroeconomic consequences of dominant currency transition. We show that USD invoicers' export values are indeed more sensitive to USD exchange rate movements than non-USD invoicers. To do this, we exploit the granularity of UK trade transactions at the firm-destination level to construct a novel measure of idiosyncratic exchange-rate movements, in the spirit of Gabaix and Koijen (2020). We then plug this into a micro-to-macro local projection methodology already employed in the context of households' heterogeneity by Holm et al. (2021). Following this approach, we find evidence that a USD appreciation causes a larger drop in export values for USD compared to non-USD invoicers. Furthermore, we test directly for changes before and after 2016 in the "allocativity" of prices, i.e. the latter's ability to drive demand to or away from quantities as they decrease or increase, using a two stage procedure analogous to Amiti et al. (2022) for both our pre- and post-2016 sample. Our results confirm expected expenditure-switching pattern of a decline in quantities demanded following an increase in their prices in local currency. Notably though, we find that this drop in demand is significantly larger after than before 2016, specifically by a factor of two.

Related literature. This paper draws on and contributes to four main strands of the literature.

First, our study follows a flourishing literature on currency invoicing decisions and exchange-rate pass-through using disaggregated microdata (Amiti et al., 2022; Auer et al., 2021; Barbiero, 2022; Chen et al., 2022; Corsetti et al., 2022; Crowley et al., 2022; Devereux et al., 2017; Goldberg & Tille, 2016). A distinguishing feature of our data setting is the presence of a large aggregate transition in invoicing patterns, driven by a large exogenous shock. This allows us to investigate the dynamics of currency invoicing choice. Previous studies, constrained by the remarkably stable nature of aggregate invoicing patterns they observe, looked at determinants of currency invoicing in a *static* framework. As a prominent example, Amiti et al. (2022), looking at Belgian trade micro-data, find evidence in favour of DCP being driven by strategic complementarities and the willingness of firms to match the currency they pay their inputs in. In their sample, switches in invoicing represent only 2.6% of firm-product-destination-months observations over four years. Previous studies relying on UK micro-data up to the Brexit referendum paint a similar picture. In their analysis of ERPT around that event, Corsetti et al. (2022) report a slow-moving aggregate trend towards more USD pricing.[3]

Closely related to our study, Crowley et al. (2022) analyse the firm-level determinants of invoicing choice for UK exporters, looking at the pre-Brexit part of the sample we consider. They highlight prior experience in the use of the dollar, as well as strategic complementarities, as key determinants of DCP in the cross-section. Similarly to the empirical setting we examine, the work of Auer et al. (2021) relies on a large exogenous movement in exchange rates. They investigate the implications of invoicing in different currencies amid the de-pegging of the Swiss

[3]We show the pre-2016 trend towards USD pricing for export invoicing is entirely due to trade flows towards the US, while the share of USD invoicing towards non-EU, non-US destinations remained stable until 2016.

franc in 2015, which led to a sharp appreciation. In contrast with our study, only 2.5% of observations switch their invoicing pattern in the period considered. Our key finding that invoicing patterns can endogenously respond to foreign-exchange movements relates and borrows from some of the tools used in Barbiero (2022) to study the cash-flow effects of currency mismatches for French firms.

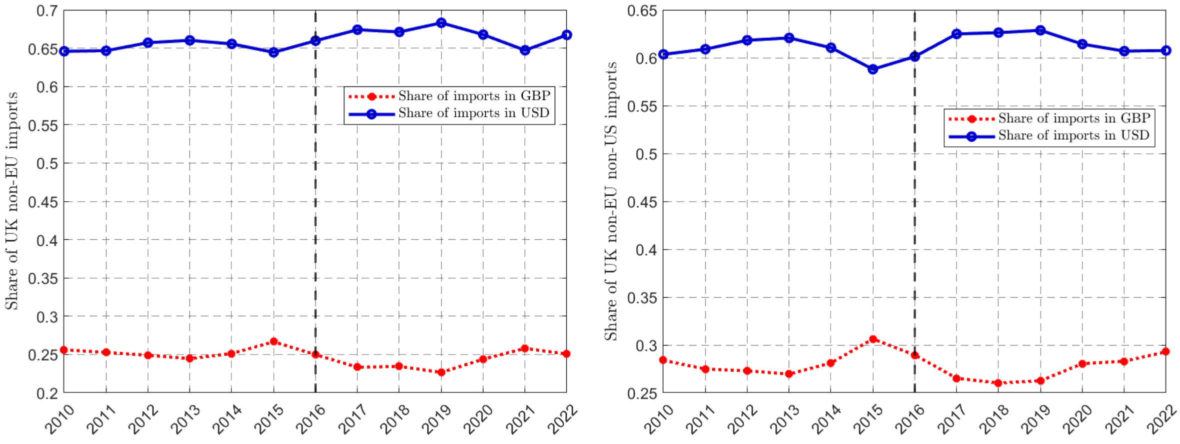
In line with previous literature, we also investigate the macroeconomic implications of invoicing in different currencies for export prices and quantities. Amiti et al. (2022) found a causal relationship between currency invoicing, prices and quantities of exports. We confirm in our study that changes in prices are allocative, but additionally show that, as the composition of the basket of invoicing currencies changes, aggregate quantities elasticity also changes.

Second, our study relates to the literature on endogenous currency choice. Mukhin (2022) provides a general equilibrium model of the international price system where dominant currencies arise endogenously as a result of input-output linkages, and variances and covariances of exchange rates. Furthermore, Amiti et al. (2022) draw on previous contributions from Engel (2006) and Gopinath et al. (2010) to provide a static framework for studying determinants of currency of invoicing.

Third, our study follows a large literature on "original sin" (Eichengreen & Hausmann, 1999) and the role of foreign-exchange mismatches and in international borrowing. The effect of currency mismatches in international trade has received comparatively less attention but recent contributions have examined the role of valuation effects (Barbiero, 2022) and the extent to which firms involved in international trade are able to rely on derivative instruments to hedge their currency risk (Alfaro et al., 2023).

Finally, our paper speaks to the literature concerned with discontinuities in the international monetary system. An important body of historical work (Chiţu et al., 2014; Eichengreen & Flandreau, 2009; Flandreau, 2012; Vicquéry, 2022) has highlighted how shifts in past patterns of dominant currencies have not been gradual nor rare. As summarised by Eichengreen et al. (2018), network externalities have not prevented rapid shifts in dominant currency status in the past, nor can explain the transition from pound to dollar dominance that occurred as soon as the interwar period. This historical literature has inspired models of global currency status characterised by multiple equilibria in the international monetary system (Farhi & Maggiori, 2018; Krugman, 1980; Rey, 2001). Our paper also relates to a debate on whether the euro or the renminbi might play a more prominent role in the future, and which policies are more likely to foster their use as vehicle currencies (Bahaj & Reis, 2022; Maggiori et al., 2019). Recent geopolitical events have in particular raised the prospects of moves towards de-dollarisation of sanctioned countries, which Berthou (2023) and Chupilkin et al. (2023) find some evidence of looking at invoicing microdata. Closely related to our paper, Mehl and Mlikota (2023) consider rare episodes, related to the EU enlargement process in the early 2000s, of aggregate invoicing transitions from the dollar to the euro, and evaluate theoretical predictions on the relevant channels of dominant currency transition. In contrast to our study, they rely on cross-country evidence at the annual frequency.

The rest of this paper is organised as follows. Section 2 presents our dataset and highlights the new stylised facts about currency choice and its key mechanisms. Then in Section 3 we



(a) Including imports from the US. (b) Excluding imports from the US

Figure 2: Currency share of UK non-EU imports.

Source: HMRC administrative datasets, UK non-EU imports, 2010–2022.

describe our baseline empirical specifications and in Section 4 our results. In Section 5, we explore the question of aggregate ERPT using both empirical specifications described above. Finally, Section 6 concludes.

2 Data and key mechanism

In this section, we describe our dataset and investigate the firm-level drivers of the transition documented in Figure 1. Recent contributions on endogenous currency choice (Amiti et al., 2022; Mukhin, 2022) identify the desire to reduce the volatility of desired prices (due to underlying exchange rates) as the main influence on a firm's steady-state invoicing decision. The steady-state we observe prior to the 2016 Brexit referendum shock is one where large firms are mostly 'long' GBP and stably so for many years. The Brexit depreciation of the pound drives a dynamic invoicing response leading to a different equilibrium. In other words, a sharp depreciation meant that many firms experienced unprecedented losses, and, as long as risks to the future value of the GBP remained tilted to the downside, further expected losses. We find that these firms are those that account for the bulk of the transition to USD invoicing of the UK economy. We dub this mechanism 'currency-mismatch valuation channel'.

2.1 Data

HMRC (His Majesty's Revenue and Customs) collects data on the universe of exports and imports recording the day (when the product enters or clears UK customs), the UK trader identifier, Combined Nomenclature (CN) 8-digits product, country of destination or origin, value in pound, quantity and, for non-EU transactions (from firms whose yearly exports are above the threshold of £100,000), the currency of invoicing. This data on currency of invoicing are available from January 2010 up to and including December 2022 (our latest data-point available), thus spanning an interval of six years on either side of the 2016 EU referendum.

We follow Freeman et al. (2023) to set up and clean the dataset, in particular in aggregating HMRC trader identifiers at the level of VAT units, so as to have a clearer interpretation of what constitutes a "firm" in our data. Finally, since USD pricing considerations for exports towards the US represent a "special" case, as USD pricing should be classified as local currency pricing (LCP) for exports towards the US, we will always indicate and justify whether the empirical analysis includes or not exports/imports to/from the US. We give further details on our dataset in Appendix A.1.

2.2 Currency mismatch, sudden exchange-rate depreciation and valuation effects

In the benchmark case of fully flexible import and export prices, the denomination of transactions should not matter (Gopinath & Stein, 2021). However, a large literature (Amiti et al., 2022; Auer et al., 2021; Corsetti et al., 2022) finds that international prices are sticky in general and, crucially, in the currency of denomination. That is, if a British company sells a good to Japan at a unit price of £2, they will not immediately adjust the sterling price when faced with a JPY/GBP exchange-rate movement. Thus, if the GBP appreciates this will amount to an increase in the price observed by the foreign customer, and vice versa for a JPY appreciation. Specifically, for the case of the Brexit-related GBP depreciation, Corsetti et al. (2022) find that export prices for GBP-invoiced transactions went up gradually and converged to the rate of the sterling depreciation after about 72 weeks. The same holds on the import side. If a British firm is importing the inputs for its good in USD, bilateral movements in the USD/GBP exchange rate will have a direct effect on its marginal cost.

Accordingly, a firm might try to match the denomination of its imports and exports; in this case, it is said to be *operationally hedged*. In other words, the business is less exposed to exchange-rate movements. If instead a firm is exporting in its own currency more (less) than it is importing, we can say it is 'long' ('short') the domestic currency, i.e. set to lose (gain) money from a domestic depreciation. As shown by Figure 1 and Figure 2 in our data, the UK economy before 2016 in the aggregate found itself in this position, with around 60% of exports invoiced in GBP and 60% of imports in USD. Similarly, looking at the firm-level positions, we see that not only the UK as a whole but also UK firms found themselves in this situation pre-2016, as the majority (86%) of firms exported in GBP much more than they imported in GBP (Figure 3). More formally, we define a measure of currency mismatch (net exposure) as

$$Exposure_{f,2015} = \frac{\sum_j (\mathcal{E}^{£}_{fj,2015} - \mathcal{I}^{£}_{fj,2015})}{Total\ Trade_{f,2015}} \tag{1}$$

where $\mathcal{E}^{£}_{fj,2015}$ are exports of firm f to country j invoiced in GBP, and $\mathcal{I}^{£}_{fj,2015}$ imports of firm f from country j in GBP in 2015. The sum across all destination/origin countries is normalised by total gross trade (exports plus imports) of a firm in the same year in order to make net exposure comparable in the cross-section. Figure 3 sets $Exposure_{f,2015}$ on the x-axis, and shows that indeed the vast majority of UK firms, around 86%, exhibited a long GBP position.

With sticky prices, firms with such a long position are thus set to lose from a sharp and unexpected depreciation. Figure 4 shows that indeed this is what happened in 2016 with sharp GBP downward movements in the aftermath of Brexit. Figure 4 takes the exposure measure in (2) and enriches it by looking at bilateral depreciations of the GBP vis-a-vis all destination j currency. Formally,

$$s_{f,t} = \frac{\sum_j \left[(\mathcal{E}^{£}_{fj,2015} - \mathcal{I}^{£}_{fj,2015}) \times \Delta e^{£/j}_{j,t} \right]}{Total\ Trade_{f,2015}} \tag{2}$$

where $\Delta e^{£/j}_{j,t}$ is the change in the bilateral GBP-country j exchange rate.[4] For example, a positive $\Delta e^{£/\$}_{t}$ indicates a depreciation of the GBP vis-a-vis the USD. Intuitively, $s_{f,t}$ captures the gains/losses from unhedged positions of firms vis-a-vis exchange rates movements.[5] For example, assume that a firm has a net exposure to the GBP of 10% of gross trade in its trade to Argentina. If a 1% depreciation of the GBP against the peso occurs, the firm makes a loss of 0.1% of gross trade in the absence of price adjustment. Figure 3 shows that the depreciation of 2016 translated into an unprecedented negative shock for exposed firms (average loss of 4% of gross trade). A similar time-series picture would emerge if we were to look at the total losses across firms. It seems natural to wonder whether such a big shock could be a candidate trigger for the transition occurred after 2016.

Going back to Figure 3 we can see that indeed firms with larger $Exposure_{f,2015}$ (that hence suffered a larger shock) are those that reduced their GBP invoicing by more. This hedging channel appears a candidate explanation for the aggregate invoicing shift observed in Figure 1. To recap, firms who were exporting more than importing in the domestic currency were a vast majority (86%, Figure 3) before the depreciation. This long position, together with the Brexit depreciation, meant an unprecedented shock (Figure 4). Finally larger shock exposure is associated with larger move away from invoicing in the domestic currency (Figure 3). We aim to test this 'currency-mismatch valution channel' formally in the next section.

3 Transaction-level empirical analysis

In this section we explicitly test whether a currency-mismatch valuation effects drove firm-level transitions from producer to dominant currency pricing, above and beyond the determinants of invoicing currency choice commonly considered by the literature. We identify the currency-mismatch channel by comparing - at the firm-destination-product level -the invoicing decision of firms with high operational exposure to the Brexit-GBP shock, relative to firms with more operational hedging. We first present results in a a static regression setting based on a shift-share identification strategy. We then turn to a dynamic setting, relying on an event study approach performed around the date of the the Brexit referendum and the ensuing devaluation of the GBP. Our results confirm the relevance of this operational hedging channel. We show it

[4] With a slight abuse of notation, a superscript j indicates the currency of the destination while a subscript j indicates the country itself.

[5] In the sticky prices limit, as in Barbiero, 2022.

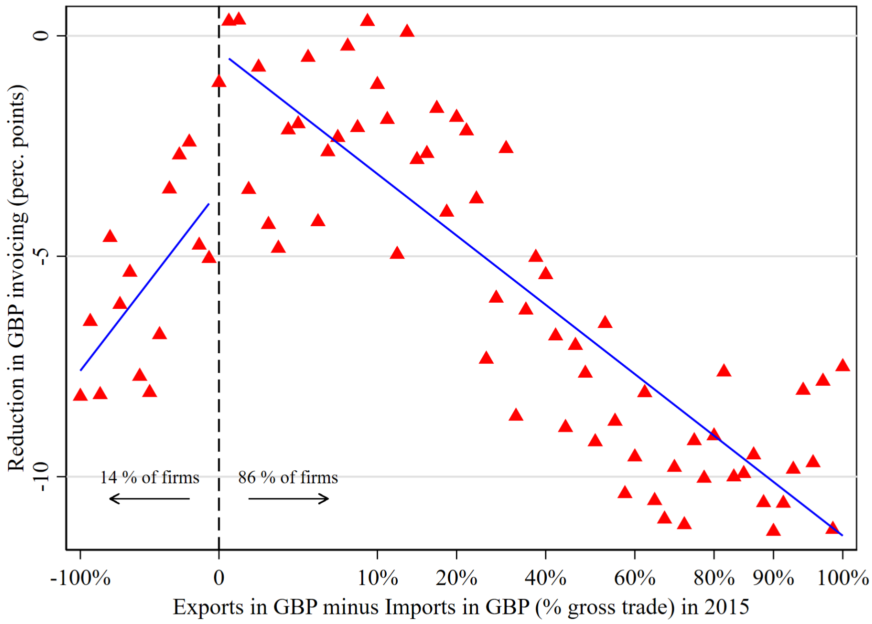


Figure 3: Firm level currency mismatches and reduction in GBP invoicing.

Note. – On the y-axis is plotted the firm-level change in GBP share of exports btw 2015 and 2019 in p.p. The x-axis plots bins of 'exposure to gbp' i.e. firms' exports in GBP minus imports in GBP. Each bin is labelled with the corresponding level of exposure as a percent of gross trade. The arrows as well as the density of bins on the right tail of the distribution indicate that many more firms are 'long' GBP than 'short' or hedged.

Source: HMRC administrative datasets, UK non-EU non-US exports, 2010–2022.

can quantitatively account for the lion share of the UK transition to dominant currency pricing by conducting a back-of-the-envelope exercise based on our estimates.

3.1 Static regression analysis

3.1.1 Empirical Specification

We estimate the effect of currency-mismatches on currency choice relying on the following benchmark specification

$$y_{ft}^{h} = \beta_k \ s_{f,t} + Controls_{f,t} + \alpha_f + \delta_t \times \Delta_t + u_{ft} \qquad \text{for h=\{\$, €, £\}} \tag{3}$$

where $y_{f,t}^{h}$ is the share of exports by firm f of product p to destination j invoiced in currency h in quarter t, $\delta_t \times \Delta_t$ is a quarter fixed effect interacted with a measure of the gap since the firm last exported so that we control for potential informativeness of the trade patterns, α_f is a firm fixed effect, $s_{f,t}$ is the exposure-weighted exchange-rate measure we presented in Section 2.[6] Standard errors are clustered at the firm level.

Equation 3 includes several controls. Strategic complementeraties are shown to play a key role in currency invoicing decisions (Amiti et al., 2022; Mukhin, 2022; Rey, 2001). That is, an

[6]Notice that, given the sporadic pattern of exporting, i.e. the fact that firms might not export every quarter, we consider here exchange-rate changes from the last time the firm exported, rather than the change against the previous quarter.

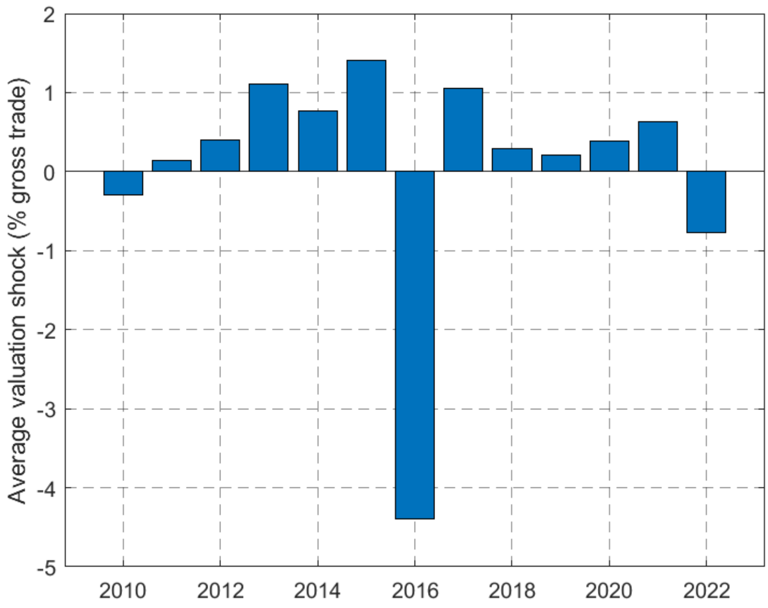


Figure 4: Exchange rate gains/losses from firms' currency mismatches.

Note. – The graph plots the depreciation shock $s_{f,t}$ defined in equation (2), averaged across firms. It expresses how much on average firms gain/lose from GBP exchange rate movements in the sticky prices limit. Negative values represent losses.

Source: HMRC administrative datasets, UK non-EU non-US exports, 2010–2022.

exporter's optimal markup might depend strategically on the prices, and therefore currency of invoicing, of its competitors in the destination. To account for these channels, we include: (a.) the average share of exports invoiced in currency h in that specific HS4 sector in quarter t and (b.) the share of exports invoiced in h at t for the largest firm in the sector.Finally, we include the product-destination firm-level market share as a further control. We will detail this choice and the reason behind it in Section 4.4.

We also consider additional measures of net currency mismatch exposure at the firm level. These include the long and short position of firms in the currency of the destination country and in US dollars, capturing revaluation effects not accounted for by the GBP net position; for example, firms that were operationally long USD, might want to invoice even more in USD following their post-Brexit depreciation gains in GBP terms. In the interest of space, we provide more details on these measures in Appendix A.1.3.

3.1.2 Identification

Borusyak et al. (2022) show that for coefficents β in Equation (3) to be consistently estimated, i.e. $\hat{\beta} \xrightarrow{p} \beta$, and uncover a causal effect, we need an exclusion restriction to hold. In particular, if we interpret our indices as composed of a destination-specific shift - the exchange-rate change - and a firm-specific share - the pre-shock net currency exposure from 1 -, we can express the key orthogonality condition needed for identification as

$$\text{Cov}[I_{ft}, u_{ft}] = \sum_j Exposure_{fjt} \Delta e_{jt} \phi_{jt} \rightarrow 0 \tag{4}$$

where $Exposure_{fjt} = \mathbb{E}[s_{fjt}]$ is the expected exposure to destination country j and $\phi_{jt} = \mathbb{E}[Exposure_{fjt} u_{ft}]/\mathbb{E}[Exposure_{fjt}]$ is the exposure-weighted expectation of unobserved drivers of currency choice.

If we had share exogeneity as in Goldsmith-Pinkham et al. (2020), that is $\mathbb{E}[s_{fjt} u_{ft}] = 0$ then the above would be satisfied for any Δe_{jt}, that is for any distribution of exchange-rate innovations. It is, however, unlikely that firm net currency exposure - itself a function of currency invoicing - would be uncorrelated with unobserved components of the firm currency invoicing decision. Thus, we will in general not satisfy $\phi_{jp} = 0$.

However, Borusyak et al. (2022) provide two conditions under which consistency of the estimator can be proven in absence of shares exogeneity:

1. $\mathbb{E}[\Delta e_{jt} | \phi_{jt}] = \mu \quad \forall t$ (*Quasi-random shock assignment*)
2. $\mathbb{E}[\Delta e_{jt} \Delta e_{jt-l} | \phi_{jt}, \phi_{jt-l}] = 0 \quad \forall l$ (*Many independent shocks*)

The first condition states that more exposed firms should not have a systematically stronger response of the component of currency invoicing choice not explained by I_{ft}. Alternatively, each firm f is expected to face the same shock μ regardless of its ϕ. The second condition requires that we observe a sufficiently long time series of non-serially correlated shocks.

Let us examine how plausible it is that these two conditions hold. The unpredictable behaviour of exchange rates, together with the length of our sample make condition (2.) plausible. Condition (1.) is supported by the fact that the first large shock in our sample is driven by the election result, well before the realisation of any fundamental shock. Furthermore, UK firms's exposure to dollar funding is not large, in line with other European counterparts (BIS, 2020). In addition to this, two observations are in order. First, we partially relax the two conditions by including firm and time fixed effects. Adding α_f eliminates time-varying unobservables from ϕ_{jt}, so that exchange rate shocks can systematically correlate with time-invariant unobservables without violating the exclusion restrictions. By adding δ_t to the specification we allow for period specific shock means, that is μ can become μ_t. Secondly, we hold exposure shares fixed to a pre-shock period, namely 2015. As shares are likely to be affected by lagged shocks and shocks might be serially correlated, this is a way for the *quasi-random shock assignment* condition to be satisfied, by measuring the shares from a period before the serially correlated period starts.

3.2 Dynamic event-study analysis

3.2.1 Empirical specification

We also estimate the fine-grained dynamic effects of currency mismatch exposure on invoicing decisions relying on the following specification at the fpj (firm-product-destination) level and at monthly frequency:

$$y_{fpj,t} = \alpha_{fpj} + \delta_t + \sum_{m \neq Jan\ 2016} [\beta_m \ (s_{f,2016}) \times \mathbf{1}_{m=t}] + \epsilon_{fpj,t} \tag{5}$$

where $y_{fpj,t}$ is again the share of exports by firm f of product p to destination j invoiced in GBP, δ_t is a time fixed effect, α_{fpj} is a firm-product-destination fixed effect and $\mathbf{1}_{m=t}$ is an indicator equal to 1 in month m and 0 otherwise. $s_{f,2016}$ is a special case of the more general $s_{f,t}$, defined as

$$s_{f,2016} = \frac{\sum_j \left[(\mathcal{E}^{£}_{fj,2015} - \mathcal{I}^{£}_{fj,2015}) \times \Delta e^{£/j}_{j,2016} \right]}{Total\ Trade_{f,2015}} \tag{6}$$

Where we fix the exposure at the 2015 (pre-shock) level and we interact it with the 2016 depreciation. As FX movements took place already prior to the post-referendum depreciation, we take $\Delta e^{£/j}_{j,2016}$ to be the average of the monthly movements between January 2016 and June 2016, but results are robust to using only June 2016. In sum, this measure captures the intensity of the shock suffered by a firm f around the event in 2016. Finally, we also conduct robustness estimating separately the share of 2015 imports in GBP and the share of 2015 exports in GBP, rather than $s_{f,t}$ net exposure. We show that both these gross margins matter individually.[7]

3.2.2 Identification

Our identification strategy for the event study is straightforward. We are interested in isolating the potential effects of the Brexit-related depreciation in 2016 through the hedging channel described above. We thus rely on the unexpected nature of the referendum's outcome for the exogeneity of the exchange-rate shock considered. The (continuous) treatment is provided by the heterogeneous incidence of this shock on UK firms based on their pre-shock net exposure to GBP, as captured by higher and lower levels of $s_{f,2016}$.

We sharpen this identification by saturating the regression with firm-product-destination and time fixed effects, and by focusing on a narrow window for exchange-rate movement going from January to June in 2016. We thus check in the next section for any pre-trend and anticipation effects, although Brexit was a largely unexpected outcome.

4 Main Results

4.1 Static regression analysis

The results from Equation 3 are presented in Table 1. First, we notice that more exposed firms decrease their GBP invoicing share. Intuitively, an opposite effect of similar magnitude, albeit slightly larger, is found for USD invoicing. Third, the effect on the euro is smaller and slightly less significant.

How to interpret the magnitude of the coefficients? The valuation shock $s_{f,t}$ is expressed in percentage of gross trade, while the dependent variable is in percentage points. Therefore, a firm long GBP by 100% of its gross trade and facing a 10% GBP depreciation will reduce its pound invoicing by 1 percentage point and shift it towards USD by a similar amount.

These headline results are robust to controlling for the effect of strategic complementarities. Once we account for the currency choice of competitors and market leaders, we find the

[7] See Appendix A.2.2.

Table 1: Results from baseline specification.

	Value share of exports in					
	GBP	GBP	USD	USD	EUR	EUR
Panel a. Baseline specification	(1)	(2)	(1)	(2)	(1)	(2)
Valuation shock $s_{f,t}$	-0.01***	-0.01***	0.007***	0.01***	0.003***	0.003**
	(-6.37)	(-6.02)	(4.73)	(4.82)	(3.85)	(3.13)
Panel b. Strategic complementarities						
Invoicing of largest firm in HS4		0.02***		0.02***		0.02***
		(16.79)		(17.06)		(12.60)
Average invoicing in HS4		0.09***		0.09***		0.15***
		(10.64)		(17.06)		(8.94)
Additional valuation controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Time x Gap FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,322,378	724,482	1,322,378	724,482	1,322,378	724,482

Note. – The coefficients in Panel a. are the βs from the baseline static specification $y^h_{ft} = \beta\ s_{f,t} + Controls_{f,t} + \alpha_f + \delta_t \times \Delta_t + u_{f,t}$. They show that a firm being 'long' GBP+GBP depreciation drives the firm to reduce its GBP invoicing. In panel b. are the coefficients on the strategic complementaritites controls. They indicate that the market leader's decision as well as average sector decision matter.

Source: HMRC administrative datasets, UK non-EU exports and imports, 2010–2019.

coefficients do not change and even increase in magnitude in the case of the USD.

Moving to the coefficients on strategic complementarities, we find a role for both the currency choice of the largest player in the HS4 sector, as well as a relevant effect for the average invoicing choice in the sector.

Finally, these results are robust to extending the sample of estimation to include both the Covid and post-Covid period to 2022. Furthermore, we show that our findings are also robust to using trade quantities instead of values as dependent variable.[8]

Notice that all the regression outputs considered so far included also controls for the other hedging indices mentioned in Section 3.1, and for market power. In the interest of space and clarity, we relegate those results to Appendix A.2.1 and Section 4.4, respectively.

4.2 Dynamics

How did this identified currency-mismatch channel unfold over our sample and especially around the large depreciation episode of 2016? We use our specification in Equation 5 to assess this. Figure 5 presents the result from the event-study set-up discussed above.

First, notice how GBP invoicing decisions before 2016 appear to be similar for more and less GBP exposed firms, leading us to assess that we do not seem to observe any pre-trend or anticipation effect that could potentially undermine our empirical approach.

Second, taking January 2016 as our reference point for the valuation shock, we observe a marked reduction in GBP invoicing by more exposed firms relative to less exposed firms. The effect of the operational hedging channel in response to the large depreciation in 2016 seems

[8]See for more details Appendix A.2.1.

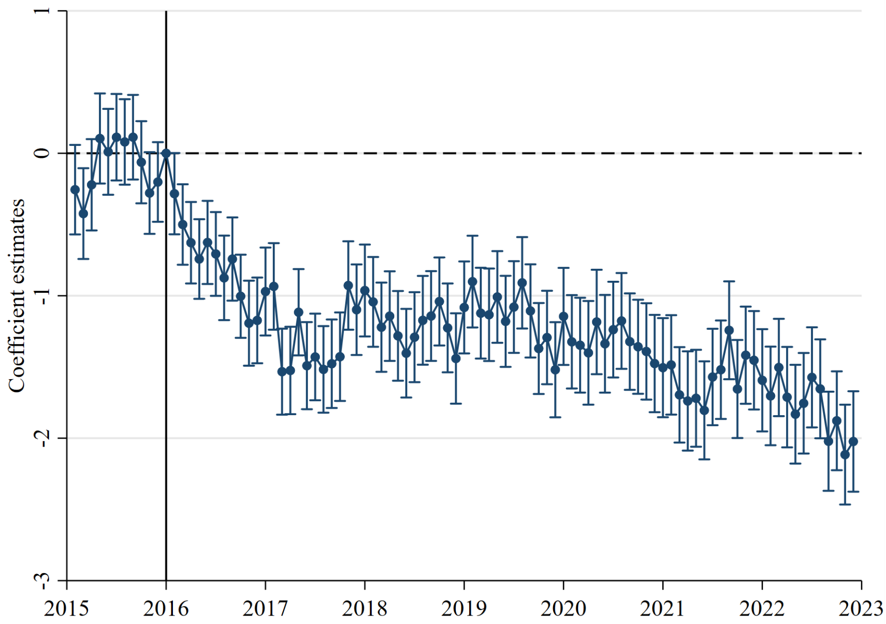


Figure 5: Event study: effect of currency mismatch-weighted GBP depreciation on GBP invoicing

Note.– The graph plots the coefficients β_m from dynamic specification over time, capturing the differential reduction in GBP invoicing by treated (highly exposed) firms.

Source: HMRC administrative datasets, UK non-EU exports and imports, 2010–2022.

to build quickly over that year, to then assume a more gradual pace over the more recent part of the sample. Importantly though, its impact appears to be persistent and monotonically dragging on GBP invoicing shares.

In the Appendix A.2.2 we include equivalent results for USD and EUR invoicing, showing the expected monotonic boost to invoicing in those currencies.[9]

Furthermore, in the Appendix A.2.2 we also check whether our results are robust to considering only the share of 2015 imports in GBP or the share of 2015 exports in GBP rather than net exposure. We find that both margins play a role. More GBP exports as a share of total trade drive a decrease and increase in GBP as opposed to USD and EUR invoicing, respectively. Conversely, more GBP imports lead to an increase in GBP invoicing and a decrease in USD and EUR invoicing. This change of sign of the impact is to be expected: as GBP imports increase, everything else given, then the net exposure becomes more negative and thus the positive coefficient leads to a larger drag on GBP invoicing.

4.3 Quantitative importance

Having established the importance of the operational hedging channel in the previous sections, we now turn to assess its contribution to explain the novel stylised fact in Figure 1 motivating our analysis.

To do this we perform a simple back-of-the-envelope calculation underpinned by our baseline

[9]As well as robustness versions of the three event studies at quarterly rather than monthly frequency.

event-study results. We on purpose resort to this partial equilibrium approach to keep our analysis parsimonious, and leave to future research a complete quantitative assessment through a fully specified model that would be able to comprehensively take into account potential general equilibrium (indirect) effects.

Our approach follows a thee-step procedure. First, we retrieve our estimates for the interaction terms between the month fixed effects and the GBP exposure pre-2016 from Figure 5, and multiply them for the contemporaneous value of the exposure variable. Given the specification of the event study which uses the first month of 2016 as reference point, this allows us to have an estimate of the change in the firm-level GBP invoicing share since that month for every month after, until the end of 2022. Second, we can add those changes to the starting GBP share in January 2016 to obtain a counterfactual share for each month afterwards, where the change would be a function of the hedging channel as capture by our specification 5. Finally, we can multiply these counterfactual shares by the total firm-level exports to have a counterfactual level of GBP for every business, and then add everything up at the desired frequency. We can then compare the resulting counterfactual series with the corresponding one from the actual data, in order to gauge the importance of the channel we have identified for the aggregate change in the UK invoicing shares.

Figure 6 shows the results of this back-of-the-envelope exercise. We show this at annual frequency in order to speak directly to the main novel stylised fact and motivation in Figure 1, and include versions at monthly frequency in Appendix A.2.3. The hedging channel appears to be able to explain most of the remarkable drop in GBP invoicing observed since 2016. As expected with the stickiness in invoicing decisions from the literature and the lagged responses identified by our own empirical work above, the effect builds gradually together with the aggregate change away from GBP and into USD and, to a smaller extent, EUR.

4.4 The role of market power

We have so far analysed the fall in GBP share of UK exports only from the point of view of UK firms. Invoicing decisions, however, just like pricing ones, arise from the interaction of a buyer and a seller. While in the literature the invoicing decision is mainly thought to belong to the exporter, the role of a foreign importer on the UK transition could be ambiguous. On the one hand, there is the convenience of using a vehicle currency given the network of international trade (Gopinath & Stein, 2021). This might mean that importers have a preference for being invoiced in USD. On the other hand, an importer's situation vis-a-vis the Brexit shock is the mirror image of that of its UK counterpart: as the GBP depreciates, this implies an immediate discount on the importer's purchases; as the GBP may be expected to weaken further, this might make GBP invoicing desirable in the eyes of foreign customers. In spite of the powerful network effects that underpin the stickiness in invoicing choices, we could expect that importers would at the margin prefer to continue being invoiced in GBP. If this was the case, the outcome we observe might be driven by firms with high market power succeeding in imposing a shift in invoicing patterns towards a 'harder' currency.

We thus investigate this channel by considering a simple measure for firm-level market power commonly used in the trade literature (Crowley et al., 2023), namely a firm's market

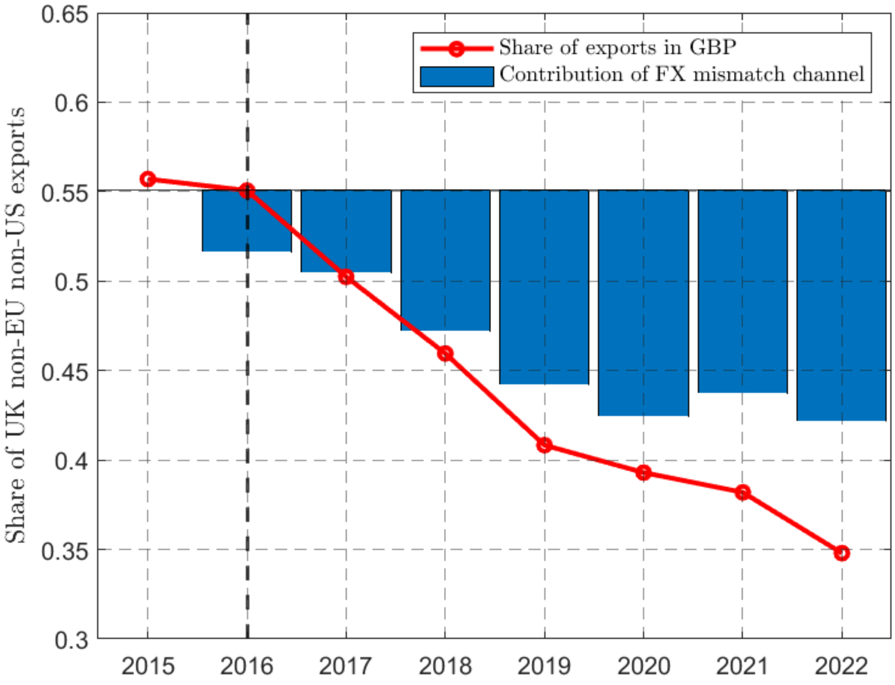


Figure 6: Currency mismatch channel: contribution to aggregate shift in GBP

Note. – The red line is the aggregate share of exports invoiced in GBP as in Figure 1, and the blue bars show how much of the dynamics of the red line can be explained by the dynamic hedging channel.

Source: HMRC administrative datasets, UK non-EU exports, 2010–2022.

share for a certain product in a given destination. We collect total imports by origin country, destination country and 6-digit product classification from UN Comtrade. We can therefore compute destination j's UK share of imports for product p,

$$UK\ Share_{pj,t} = \frac{\mathcal{I}^{UK}_{pj,t}}{\sum_{all\ origins} \mathcal{I}^{i}_{pj,t}} \tag{7}$$

Similarly, from the microdata we can construct the UK market share of a firm for product p and destination j

$$Firm\ share_{fpj,t} = \frac{\mathcal{E}_{fpj,t}}{\sum_{all\ UK\ firms} \mathcal{E}_{fpj,t}} \tag{8}$$

where, of course, $\sum_{all\ UK\ firms} \mathcal{E}_{fpj,t} = \mathcal{I}^{UK}_{pj,t}$.

We can then combine the two to obtain a firm's market share $\omega_{fpj,t}$ in a given destination and product market

$$\omega_{fpj,t} = Firm\ share_{fpj,t} \times UK\ Share_{pj,t} \tag{9}$$

With these measures at hand, we can then divide firms by percentiles of market share to identify three groups: low (below the 75th percentile of the distribution of market shares),

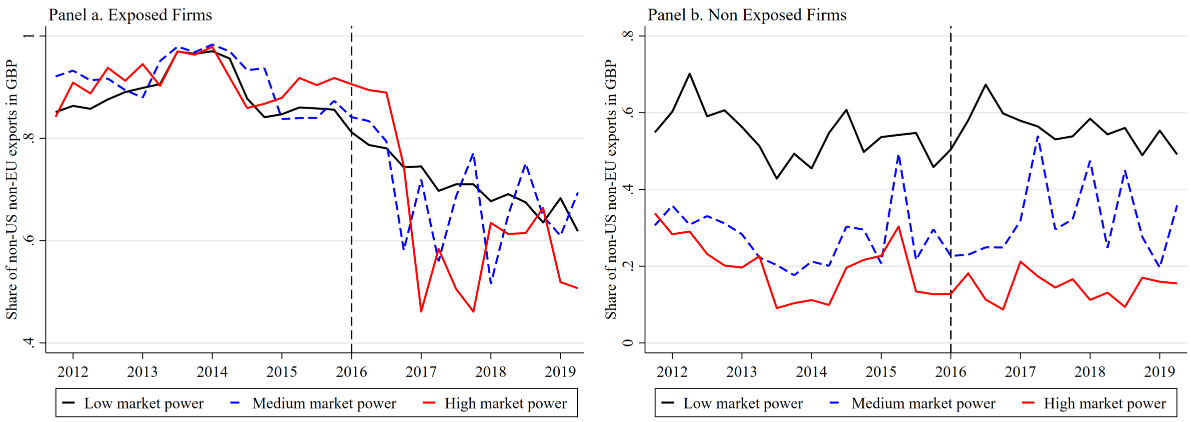


Figure 7: GBP invoicing by GBP exposure and market power

Note. – Firms are divided into three market power quantiles based on their market share in each product-destination market. Then, aggregate GBP share of exports analogous to those in Fig.1 are plotted for each quantile. In red are firms with high market shares, in dashed blue medium, and in red firms with low market shares. This exercise is conducted separately, considering only firms with above the median (Panel a.) and below the median (Panel b.) $Exposure_{f,t}$.

Source: HMRC administrative datasets, UK non-EU exports and imports, 2010–2022.

medium (between the 75th and 90th percentile) and high (above 90th percentile) market power firms.[10] Figure 7 shows the evolution of GBP invoicing shares by these groupings, separately for exposed ($s_{f,t}$ above median) and non-exposed ($s_{f,t}$ below median) firms.

Two main considerations emerge from inspecting Figure 7. First, if UK firms did not suffer from the 2016 valuation shock and therefore had no hedging motive to shift away from the pound according to our framework, we should not expect to see the significant change in GBP usage from the pre-shock period that we observe in panel a. Second, since we know UK businesses *did* suffer from the valuation shock, then we would expect their market power to matter at the margin to resolve the clash of the two opposing forces described above: (i.) the incentive for UK exporters to operationally hedge more and thus shift to the USD; and (ii.) the motive for foreign importers to keep GBP invoicing on their transactions with UK exports, as foreign buyers might perceive the GBP as a ‘soft’ currency after the large 2016 depreciation. Our results seem to support to some extent this enabling role played by market power, with panel a indeed showing that exposed firms did reduce their GBP invoicing, but to a somewhat larger extent for those with larger market shares.

In the light of this evidence, we test for the relevance of market power formally by estimating specification 3 enriched by our measure of market power $\omega_{fpj,t}$, as mentioned above already included in the control variables.

Table 2 reveals a mixed picture on the role played by market power. On the one hand, as expected from the discussion above, our results suggest that higher market share leads to more GBP invoicing and less need to using vehicle currencies. On the other hand, the interaction with the valuation shock is always insignificant, suggesting that during adjustments after valuation shocks the degree of market power might not exert effects over and above its average impact.

[10]See Figure A.6.

Table 2: Relevance of market power.

	Value share of exports in					
	GBP	GBP	USD	USD	EUR	EUR
Panel a. Baseline specification	(1)	(2)	(1)	(2)	(1)	(2)
Valuation shock $s_{f,t}$	-0.01***	-0.01***	0.007***	0.01***	0.003***	0.003**
	(-6.37)	(-6.02)	(4.73)	(4.82)	(3.85)	(3.13)
Panel b. Strategic complementarities						
Invoicing of largest firm in HS4		0.02***		0.02***		0.02***
		(16.79)		(17.06)		(12.60)
Average invoicing in HS4		0.09***		0.09***		0.15***
		(10.64)		(17.06)		(8.94)
Panel c. Firm Market Power						
Market Power		0.04***		-0.05***		0.01
		(5.33)		(-7.67)		(1.95)
Market power × valuation shock		0.03		-0.04		0.03
		(0.46)		(-0.75)		(1.16)
Additional valuation controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Time x Gap FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,322,378	724,482	1,322,378	724,482	1,322,378	724,482

Note. – The coefficients in Panel a. and in panel b. are analogous to those in the previous table. In panel c. are the coefficients on the market share variable $\omega_{fpj,t}$ and on the interaction of market share $\omega_{fpj,t}$ with exposure $s_{f,t}$.

Source: HMRC administrative datasets, UK non-EU exports and imports, 2010–2019.

We further investigate the potential effects of market power on invoicing by adjusting our event study set-up in Equation 5 to account for it in the following way:

$$y^h_{fpj,t} = \alpha_{fpj} + \delta_t + \omega_{fpj,t} + \sum_{m \neq Jan\ 2016} \gamma_m \ \ \omega_{fpj,t} \times \mathbf{1}_{m=t} + [\beta_m \ \ (\omega_{fpj,t} \times s_{f,t}) \times \mathbf{1}_{m=t}] + \epsilon_{fpj,t} \quad (10)$$

Figure 8 shows the results of estimating equation 10 which exploits the potential variation between the behaviour of exposed firms with high market share vis-a-vis exposed firms with low market shares. The estimation for the coefficients of interest β_m is quarterly to more directly unpack the relationship estimated in the quarterly static regression 3. As it is clear from the chart, only from 2019 onwards we start seeing a gradual and significant reduction in GBP usage by firms with stronger market power.

To conclude, we found mixed evidence on the role played by market power in the determination of invoicing currency. In particular, our results do not seem to consistently support the contribution of this additional channel in combination to operational hedging motive in response to the 2016 depreciation, to the large shift in invoicing away from the GBP that we documented in Figure 1.

After had documented and characterised the potential channels behind the sizable reduction in GBP invoicing, we now turn our attentions to the macroeconomic implications of this dominant currency pricing transition.

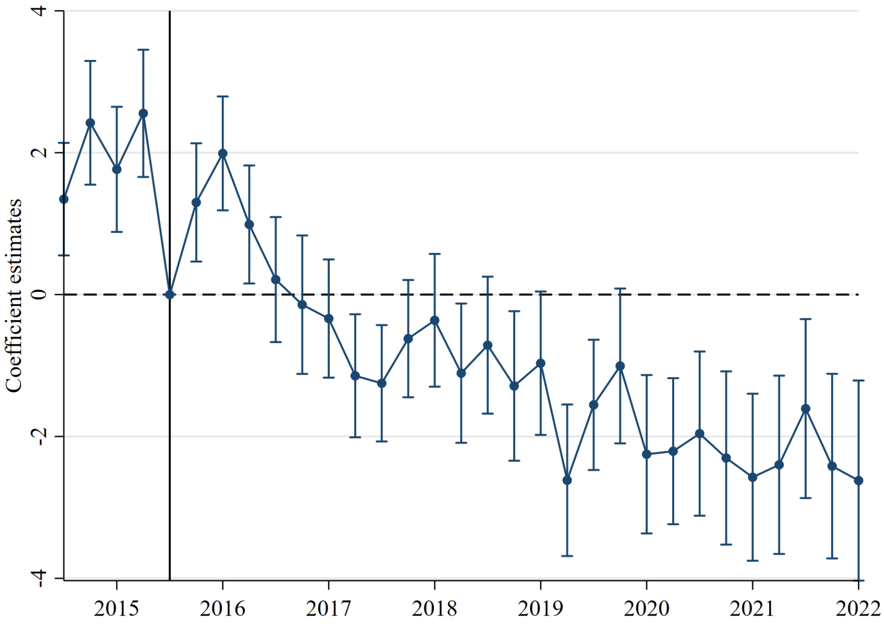


Figure 8: Event study: effect of market power at the margin with high exposure to GBP depreciation.

Note. – The graph plots the coefficients β_m from dynamic specification enriched with market power $y^h_{fpj,t} = \alpha_{fpj} + \delta_t + \omega_{fpj,t} + \sum_{m \neq Jan\ 2016} \gamma_m\ \omega_{fpj,t} \times \mathbf{1}_{m=t} + \left[\beta_m\ (\omega_{fpj,t} \times s_{f,t}) \times \mathbf{1}_{m=t}\right] + \epsilon_{fpj,t}$ over time, capturing the differential reduction in GBP invoicing by treated (highly exposed) firms which have a relatively higher market share.

Source: HMRC administrative datasets, UK non-EU exports and imports, 2010–2022.

5 Macroeconomic implications of dominant currency pricing transition

Amiti et al. (2022) show that a firm's currency choice has a direct causal effect on the exchange rate pass-through into prices and quantities. Has the structural change in currency choice that we documented in section 2 and analysed empirically in section 3 altered this causal link? Are UK exporters more exposed to the dollar cycle now than they were before 2016?

In order to shed light on these questions, we estimate the dynamic responses of exported quantities before and after the shift. In order to study how export quantities of UK firms respond to GBP-destination and USD-destination exchange rate movements, we employ two econometric strategies.

First, we construct an empirical specification at the firm level, where we exploit differential exposure of firms to different destination currencies and the granularity thereof (i.e. the fact that only few destinations account for a large share of a firm's exports[11]). We construct firm-level "granular" effective exchange rates, by aggregating the idiosyncratic components of destination/USD exchange rates, weighted by the export share of that destination for the firm. We then use this measure in our micro-to-macro local projection regressions (Jordà, 2005) to estimate the aggregate response of export values to exchange rate movements. We interact this dynamic response with the invoicing status of the firm, namely whether the firm is a USD or

[11] See Figure A.7 in Appendix A.1.

non-USD invoicer. We then measure the differential response by invoicing type. We observe that while export values of non-USD exporters hardly respond to USD exchange rate movements, USD exporters have a negative significant and persistent response. This establishes at the granular level that USD invoicers respond more to USD movements than non-USD invoicers.

Importantly, we know that the relative weight of USD invoicers has significantly increased in the sample after 2016. Paired with the detected larger sensitivity discussed above, this could suggest the conclusion that after 2016 UK exports in the *aggregate* have become more sensitive to dominant currency movements.

Second, we ask: has the micro elasticity of quantities to exchange rate movements changed? In order to test this hypothesis, we employ a second econometric specification in the spirit of the work by Amiti et al. (2022). It is a a two-stage procedure, where a regression of export prices in foreign currency onto exchange rates represents the first stage, while a regression of quantities on (fitted) prices is the second stage. In both stages, we control for detailed firm, destination-product and time fixed effects. We thus capture the elasticity of quantities to price pass-through of USD exchange rate movements. We compute this dynamic measure for the pre 2016 sample and the post 2016 sample.

5.1 Granular effective exchange rates

The goal of our empirical analysis is to identify the elasticity of export quantities to exchange rate movements vis-a-vis destination currencies. We can exploit the fact that different firms have different exposure to destinations; and that firms tend to be highly exposed to one specific destination. Indeed, the average highest-share destination accounts for approximately 60% of a firm's exports (Figure A.7). In general, firm f's total exposure to USD exchange rate movements in a period is

$$X_{ft} = \sum_j s_j e_t^{\$/j} \tag{11}$$

where s_j is the trade share of country j. This can be time-varying or fixed. Furthermore, we can express a bilateral exchange rate as

$$e_t^{\$/j} = \eta_t + \epsilon_{jt} \tag{12}$$

where η_t is a component common to all bilateral USD exchange rates, whereas ϵ_{jt} is idiosyncratic to a specific currency. Following the granular instrumental variable approach of Gabaix and Koijen (2020) and Aldasoro et al. (2023), we identify ϵ_{jt} in the data by estimating the following panel regression

$$e_t^{\$/j} = a_t + v_{jt} \tag{13}$$

where $v_{jt} = \Lambda_j F_{jt} + \epsilon_{jt}$. We adopt a non-parametric approach and estimate the factors in F_{jt} by principal component analysis (PCA) for each destination. Given estimated values for the factors and their loadings, we obtain the residual $\epsilon_{j,t}$ as the idyosincratic movement of currency j against the dollar. We can then aggregate this idyosincractic components at the firm level in order to create granular effective exchange rates as

$$X_{ft} = \sum_j s_{t-1,j}\epsilon_{jt} \tag{14}$$

where, in practice, we use previous period shares rather than contemporaneous to limit endogenous movements. We compute in our data export shares in quarter t for firm f and we drop firms that trade with two or less destination countries in a period. We then use this firm-level measure to compute the aggregate responses.

5.2 Micro-macro dynamic export pass-through

We obtain "macro" responses based on our firm-level data by using the effective exchange rate measure just obtained in the following specification:

$$\frac{y_{f,t+h} - y_{f,t-1}}{\bar{y}_{t-1}} = \beta^h \epsilon_{\$,t} + \alpha_f + \delta_t + u^h_{f,t} \tag{15}$$

where $y_{f,t}$ is the export value of firm f in quarter t and α_f and δ_t are fixed effects. The dependent variable is therefore the change in export values betwen $t+h$ and $t-1$, divided by the average export size across firms in $t-1$. As Holm et al. (2021) illustrate, this makes β_h comparable to coefficients estimated on aggregate data as opposed to the average response across firms (obtained by dividing the left-hand-side by $y_{f,t-1}$), which could be driven by outliers. The specification is estimated for the period from 2010 to 2016 (excluded) and for the period 2017-2019. We define USD invoicers as firms invoicing more than half of their trade in USD, and non-USD invoicers as the complement. We present the impulse responses depicting the dynamic behaviour of export values to movements in the USD exchange rate in Figure 9, in blue for non-USD invoicers and in red for USD inovicers. The results show a negative and significant response of export values to USD movements for USD invoicers, while a negligible and not always signifcant response for non-USD invoicers.

5.3 Have allocative properties of export price rigidity changed?

Exchange rate pass-through into export prices, or lack thereof, might have a sizeable impact on quantities. For example, suppose a firm exports components with a unit price set in GBP of £100. With full price rigidity, a 1% GBP depreciation vis-a-vis the destination currency will be equivalent to a 1% discount. The extent to which this affects quantities is not obvious, as import-export relationship tend to be recurrent and with long-established partners, so that short-run price changes might not be enough to drive significant shifts in quantities. Furthermore, if we look at aggregate exports, and we acknwoledge the shift in invoicing occurred out of the GBP and into the USD, it is interesting to explore whether this affected relative allocative properties of pass-through across the two currencies of invoicing. Namely, we would expect that quantitities respond via price rigidity more strongly to movements in the USD exchange rate than before 2016, as we found in the previous subsection.

In order to test this hypothesis, we adopt a two stage empirical specification akin to Amiti et al. (2022), where the first stage is

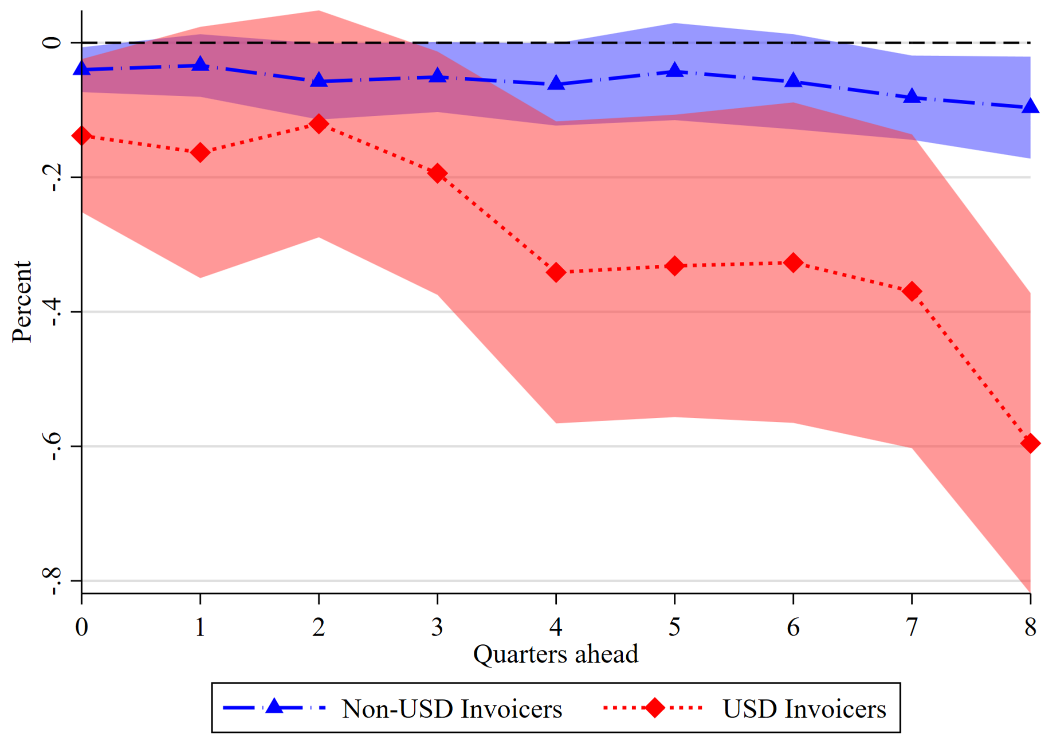


Figure 9: Dynamic response of export value to appreciation of USD granular exchange rate.

Note. – The two lines represent the response of UK export values to movements in the granular firm-level USD exchange rate, in blue for non-USD invoicers (<50% of exports in USD) and in red for USD invoicers (>50% of exports in USD). Shaded areas are 95% confidence intervals. The line in red is by month 4 almost three times as large in absolute value as the blue line, indicating that a USD appreciation depresses UK exports of USD invoicers more than those of non-USD invoicers.

Source: HMRC administrative datasets, UK non-EU exports, 2010–2019.

$$p^*_{fpj,t+h} - p^*_{fpj,t-1} = \beta^h \Delta e^{\$/j}_t + \alpha_j + \delta_{pj} + \nu_t + u_{fpj,t} \tag{16}$$

where the dependent variable is the change in log unit prices expressed in foreign currency between period $t+h$ and $t-1$ for firm f selling product p to destination j and $\Delta e^{\$/j}_t$ is the change in the log exchange rate between the USD and the currency of destination j. We introduce firm, time, and product-destination fixed effects. Thus, the main source of variation are the time series changes in the USD/destination exchange rates. We could also introduce firm-destination-time fixed effects, which would absorb exchange rate fluctuations and would rely on cross-sectional difference (say, invoicing) as source of identification. But we have already tested this dimension in our previous econometric specification. Here, instead, we are interested in the dynamic change in elasticity and are thus interested in the variation at the firm-destination-time level. After estimating (16), we employ the fitted values in

$$q_{fpj,t+h} - q_{fpj,t-1} = \theta^h \Delta_{t-1}\hat{p}^*_{fpj,t+h} + \alpha_j + \delta_{pj} + \nu_t + u_{fpj,t} \tag{17}$$

where the dependent variable is the change in log quantities between period $t+h$ and $t-1$ for firm f selling product p to destination j, and $\Delta_{t-1}\hat{p}^*_{fpj,t+h}$ is the fitted value from the

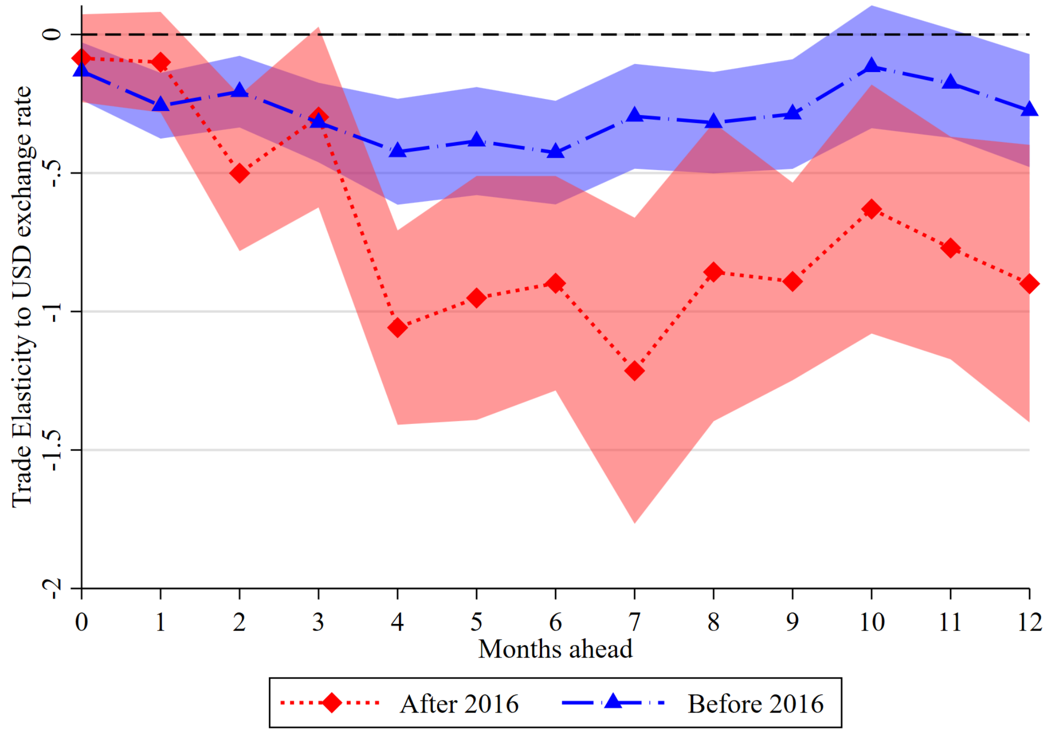


Figure 10: Dynamic elasticity of export quantities to appreciation of USD.

Note. – The two lines represent the dynamic elasticities of UK export quantities to movements in USD exchange rates, in blue for the pre-2016 (pre transition) period and in red for post-2016. The line in red is by month 4 almost twice as large in absolute value as the blue line, indicating that a USD appreciation depresses UK exports by more than twice than before 2016.

Source: HMRC administrative datasets, UK non-EU exports, 2010–2019.

first stage. We estimate this specification for the pre-2016 and post-2016 period[12] and obtain the results in Figure 10, plotted alongside 95% confidence intervals, based on standard errors clustered at the firm-product-destination level. We find that, as intuition would suggest, the elasticity is always negative. This considerably increases in magnitude going from the pre-2016 period (blue line) to the post-2016 sample (red line), where after 4 months it stabilises around 1 in absolute value.

In conclusion, our additional empirical analyis finds that both (i.) the aggregate response of USD invoicers to USD granular exchange rate movements are stronger than for non-USD invoicers, and that (ii.) the elasticity of export quantities to USD exchange rate movements doubled from the pre-2016 to the post-2016 period, both in the short and medium run.

6 Conclusion

In this paper we use transaction-level data on the universe of imports and exports for UK firms to document a striking fact about aggregate currency invoicing. We show how UK exports, dominated by producer currency (GBP) invoicing pre-2016 have quickly transitioned to

[12] Observations for the year 2016 are excluded from both samples.

a dominant currency paradigm after the large GBP depreciation in the aftermath of the EU referendum. More than half of extra-EU exports are now invoiced in USD.

We support an explanation for this dramatic shift in invoicing driven by operational hedging motives of UK firms in response to the losses generated by the pound depreciation in combination with their long GBP positions.

We do this using two empirical specifications. First, employing a shift-share Bartik strategy relying on the differential currency exposure of firms. Our empirical estimates find that the larger the net exposure of a firm to GBP and the larger the latter's depreciation vis a vis the local currency of the foreign buyer, the more pronounced the firm-level shift away from the GBP and towards the dominant currency, namely USD. Second, using an event-study approach we show that this identified channel has contributed to a persistent decrease in GBP invoicing since 2016.

Finally, we show that this structural transition in currency invoicing has important aggregate consequences for export pass-through and allocative effects of price rigidities. UK exports exhibit significantly higher elasticity to USD exchange rate movements after than before this dominant currency pricing transition.

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1 Appendix

A.1 Data: additional figures and tables

A.1.1 Summary statistics

Year	Firms	Products	Countries	Firm-Product	Firm-Country	Product-Country	Firm-Product-Country
2010	48274	7953	192	263542	198888	149652	477489
2011	48985	7842	190	258510	202327	149463	474933
2012	48967	7837	190	266872	206190	153695	498471
2013	50241	7882	190	284149	216679	162145	543557
2014	50203	7885	189	284407	216366	163106	554732
2015	51276	7886	190	293045	223708	165699	577206
2016	53728	7943	191	321708	240759	172630	642223
2017	54627	8020	190	330714	245015	175787	656254
2018	54739	8016	190	336776	246450	177946	674418
2019	52733	7976	190	340441	246733	180310	695218
2020	48647	7861	189	306495	227597	168088	633182
2021	47905	7843	190	306829	234998	174199	657181
2022	47153	7993	190	315648	236950	179301	683218

Table A.1: Summary statistics (Count).

Source: HMRC administrative datasets, UK non-EU exports, 2010–2022.

A.1.2 Additional facts

In contrast to the exports' patterns shown in Figure 1, but in line with what originally reported by Corsetti et al. (2022) for the period until 2017, we continue not to observe aggregate behaviour of currency switching when looking at imports up to and including 2022 (Figure 2). The GBP value share of UK imports to non-EU countries remained broadly stable at about one third from 2010 to 2022, with USD accounting for 60%. When looking at non-EU non-US imports, shares are unchanged. Importantly, notice how this means that before 2016 the UK was holding a net positive differential position in GBP exports and imports, while net negative in USD. After 2016, the UK now exhibits a considerably less positive and less negative net position in GBP and USD, respectively.[13]

Fact 1. *The aggregate fall in the GBP invoicing is driven by the intensive rather than extensive margin at firm-product-destination level.*

We investigate what the relevant margins of this change in GBP export invoicing are, that is whether the latter is due to compositional effects or rather it is broad-based across firms. We compute in Figure A.2 how much of the reduction in GBP invoicing share is due to the extensive margin (or *between* effects) at firm-product-destination level, and how much of it happened because of the intensive margin (or *within* effects). Using the definition of an average, we can define the total export value (in all currencies) in period t as

$$V_t = \bar{V}_t N_t^{fpj} \tag{18}$$

where N_t^{fpj} is the number of individual firm-product-destination triplets, the unit of observation of our dataset, and where $\bar{V}_t$ is the average export value per triplet. Similarly, total export value in GBP in period t is

$$V_t^{£} = \bar{V}_t^{£} N_t^{fpj} \tag{19}$$

Taking logs and first differences on both sides yields the decomposition

$$\Delta \ln(V_t) = \underbrace{\Delta \ln(\bar{V}_t)}_{\text{Intensive}} + \overbrace{\Delta \ln(N_t^{fpj})}^{\text{Extensive}} \tag{20}$$

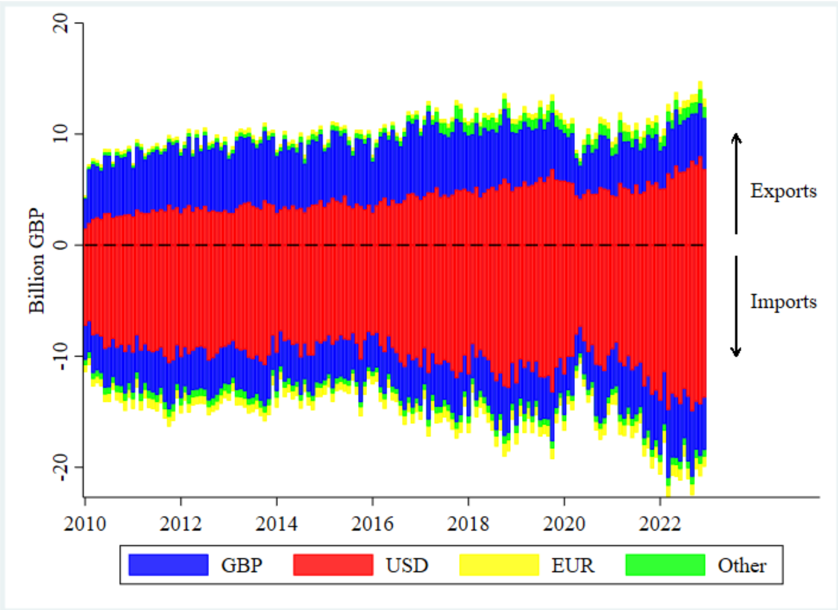
and similarly

$$\Delta \ln(V_t^{£}) = \Delta \ln(\bar{V_t^{£}}) + \Delta \ln(N_t^{fpj}) \tag{21}$$

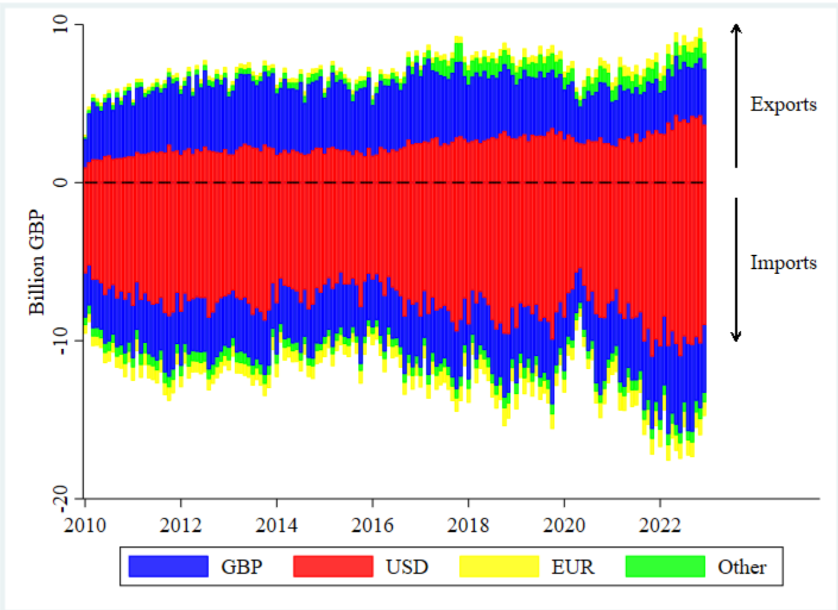
We can further decompose the extensive component in its individual elements (change in destinations, change in product composition, firm entry/exits), but we find that these individual margins do not contribute much respectively. Therefore, for clarity of exposition we plot their aggregate version in Figure A.2, which presents the contribution of intensive and extensive margins to GBP value drop since 2016.

The main message from Figure A.2 is clear. The reduction in the share of GBP invoicing is a result of firm-product-destination triplet flows switching away from pounds, rather than a

[13] See Figure A.1 for some additional visualisations of this fact.



(a) Including exports and imports from the US.



(b) Excluding exports and imports from the US

Figure A.1: Level of UK non-EU exports (positive) and imports (negative).

Source: HMRC administrative datasets, UK non-EU exports and imports, 2010–2022.

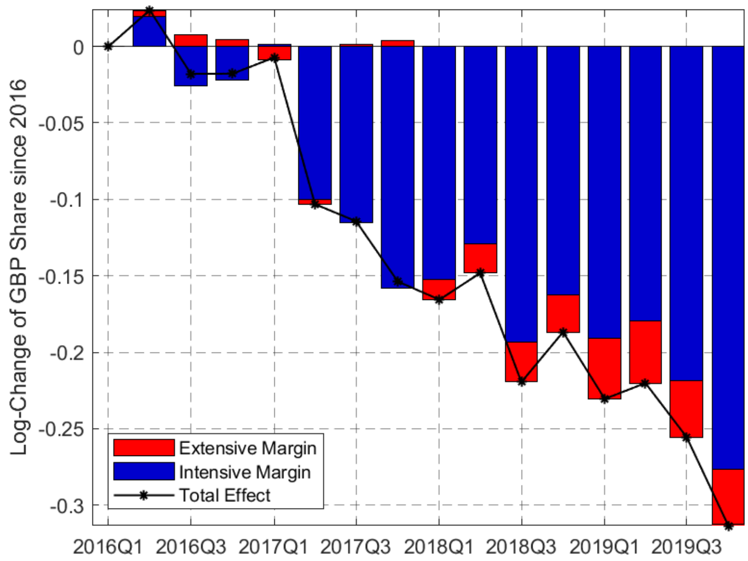


Figure A.2: Intensive/extensive margin decomposition of GBP invoicing shift.

Source: HMRC administrative datasets, UK non-EU exports, 2010–2019.

compositional artefact of our sample. This is important for our empirical identification strategy below which relies on firms actively deciding to change their currency of invoicing, as we will show in Section 3.

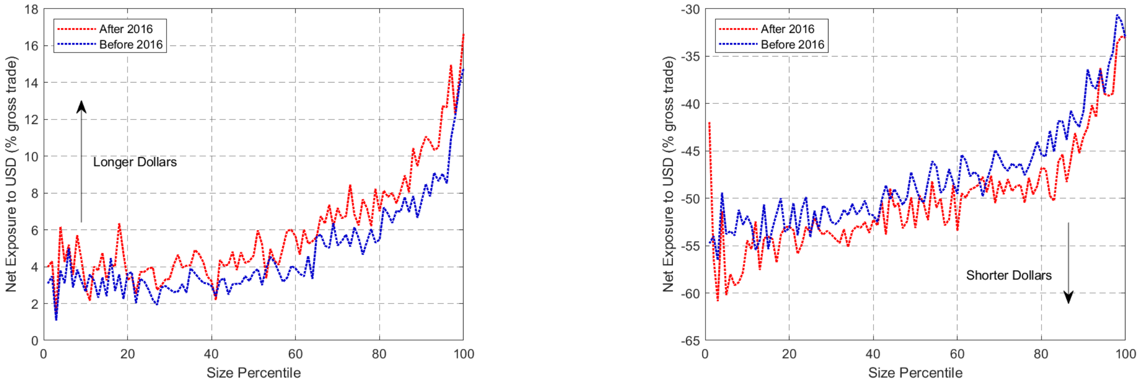
Fact 2. *The shift towards USD invoicing occurs along the entire firm size distribution, although bigger shifts are associated with larger firms and higher pre-2016 GBP exposure.*

Let us define the net exposure of a firm to the USD as its exports in USD minus imports in USD in a period, as a proportion of total gross trade. Furthermore, let us dub as (mainly) exporters the firms whose exports in a given period exceed imports. Figure A.3 plots net exposure as a function of firm size (total export value) percentiles, separately for exporters and non-exporters. We see that, in general, the average exporter in each bin is positively exposed to the USD, meaning that its USD exports exceed imports. We also see that the bigger the exporter, the larger the exposure. Crucially, after 2016 (blue line) we observe an upward parallel shift of the distribution, as firms of all sizes have increased their exposure to the USD.

Interestingly, Figure A.3a paints a picture rather different compared to the case of France as described by Barbiero (2022). French exporters at the left tail of the size distribution tend to exhibit perfect hedging, with net exposure to the USD hovering around 0.

In contrast to the case of exporters, Figure A.3b shows very little change occurring for non-exporters, as they lack the margin of adjustment on the side of revenues, where a firm can exercise its currency decision, while on the inputs' side a firm is usually currency-taker. Furthermore, we see that net exposure is negative at every percentile of the distribution for non-exporters. This follows from the fact that imports are predominantly invoiced in USD, and that for these firms imports exceed exports.

Finally, we ask how size and exposure correlate with the observed reduction in GBP share



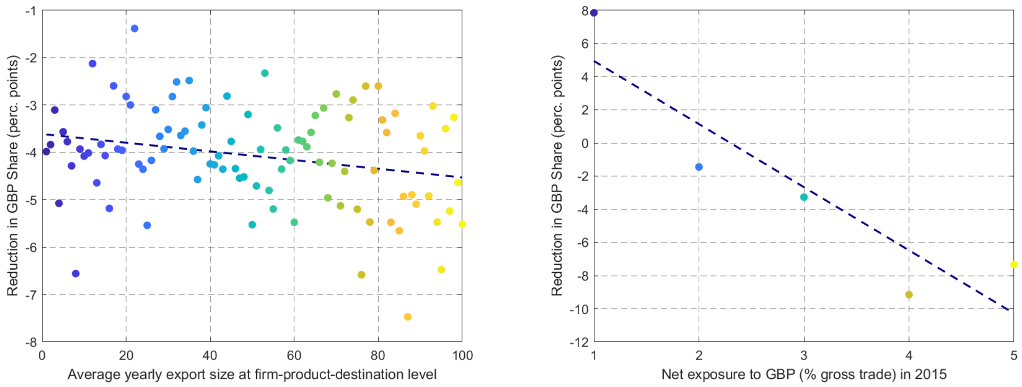
(a) Firms whose exports > imports.

(b) Firms whose imports > exports.

Figure A.3: Net exposure to USD (in % of gross trade) by trade size distribution.

Source: HMRC administrative datasets, UK non-EU exports and imports, 2010–2019.

of invoicing. Is the shift more marked for larger or previously more exposed firms? Figure A.4a and A.4b shed light on this question. We can observe a clearly negative relationship between average size/GBP exposure in 2015 and GBP invoicing reduction.[14] Thus, leaders were the ones changing their invoicing away from GBP more markedly. Furthermore, firms exhibiting a more positive exposure to GBP in 2015, that is before the Brexit referendum and the consequent large pound depreciation, switched away from pound the most with respect to other exporters.



(a) Invoicing shift vs firm size.

(b) Invoicing shift vs firm GBP exposure.

Figure A.4: Correlates of the invoicing shift.

Source: HMRC administrative datasets, UK non-EU exports and imports, 2010–2019.

Fact 3. *The EUR value share of UK exports to non-EU countries increased from about 4% in 2015 to 8% in 2022.*

We report in Figure A.5 the shares of UK exports accounted by the euro. Over our whole sample, the role played by the euro as a vehicle currency is small compared to the USD. However, we observe a twofold increase in the euro share since 2016, from 4% to 8% towards non-EU destinations.

[14] These findings are robust to adding one variable as a control for the other before plotting the residuals.

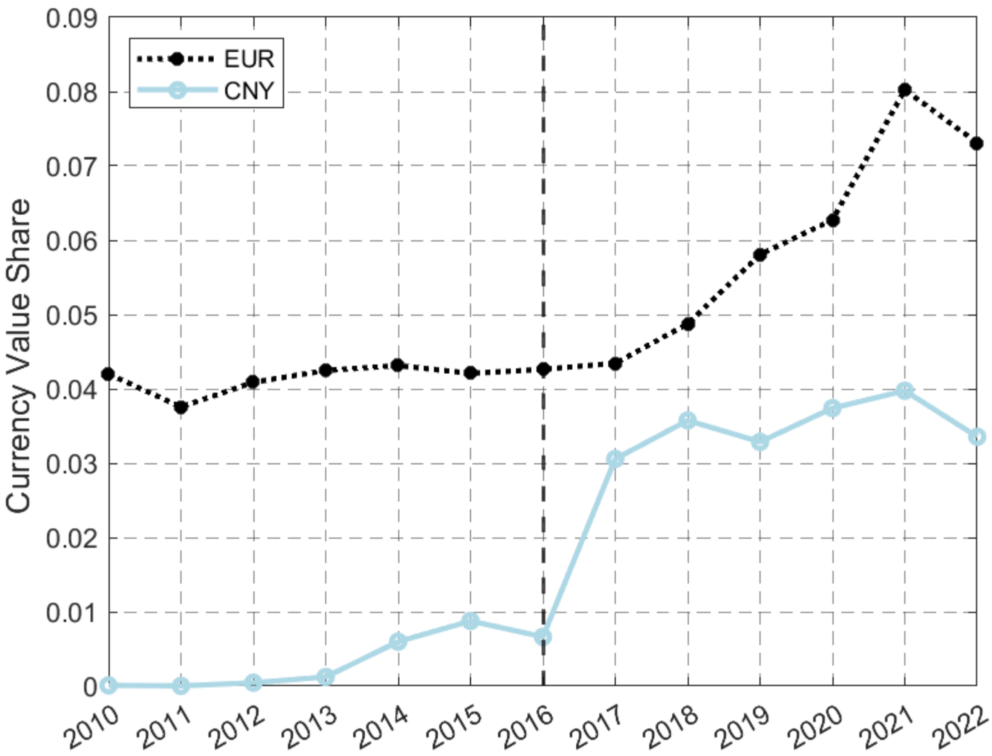


Figure A.5: Currency share of UK non-EU non-US exports.

Source: HMRC administrative datasets, UK non-EU non-US exports, 2010–2022.

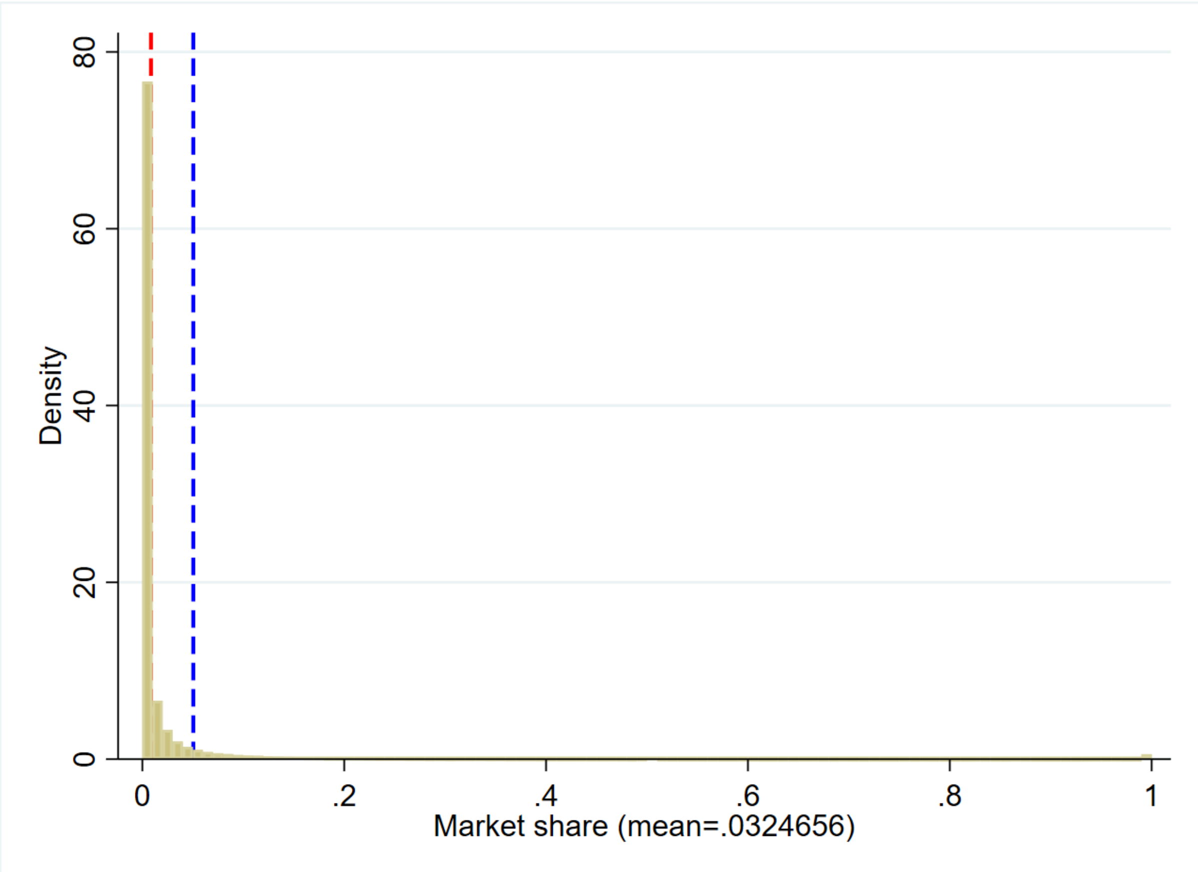


Figure A.6: Distribution market shares.

Source: UN Comtrade and HMRC administrative datasets, UK non-EU exports, 2010–2022.

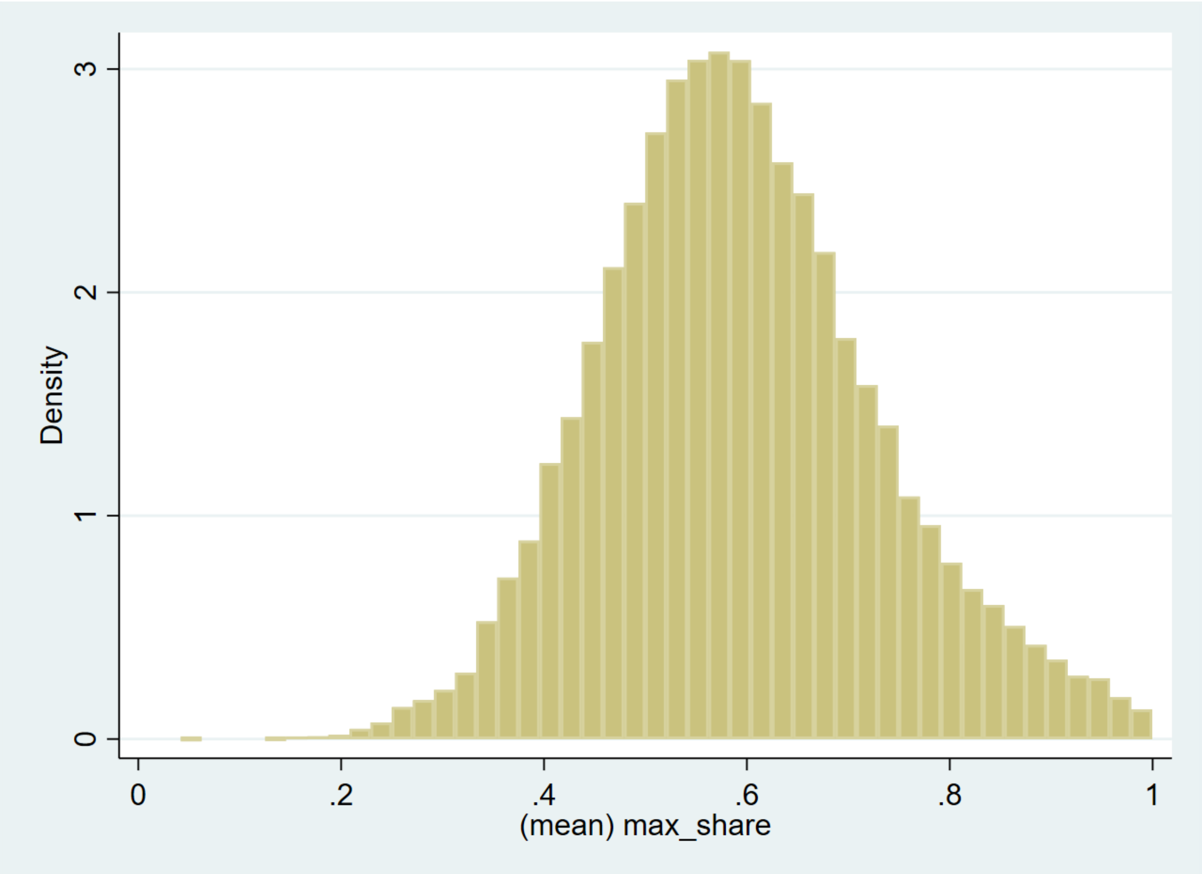


Figure A.7: Distribution top shares.

Source: BIS and HMRC administrative datasets, UK non-EU exports, 2010–2019.

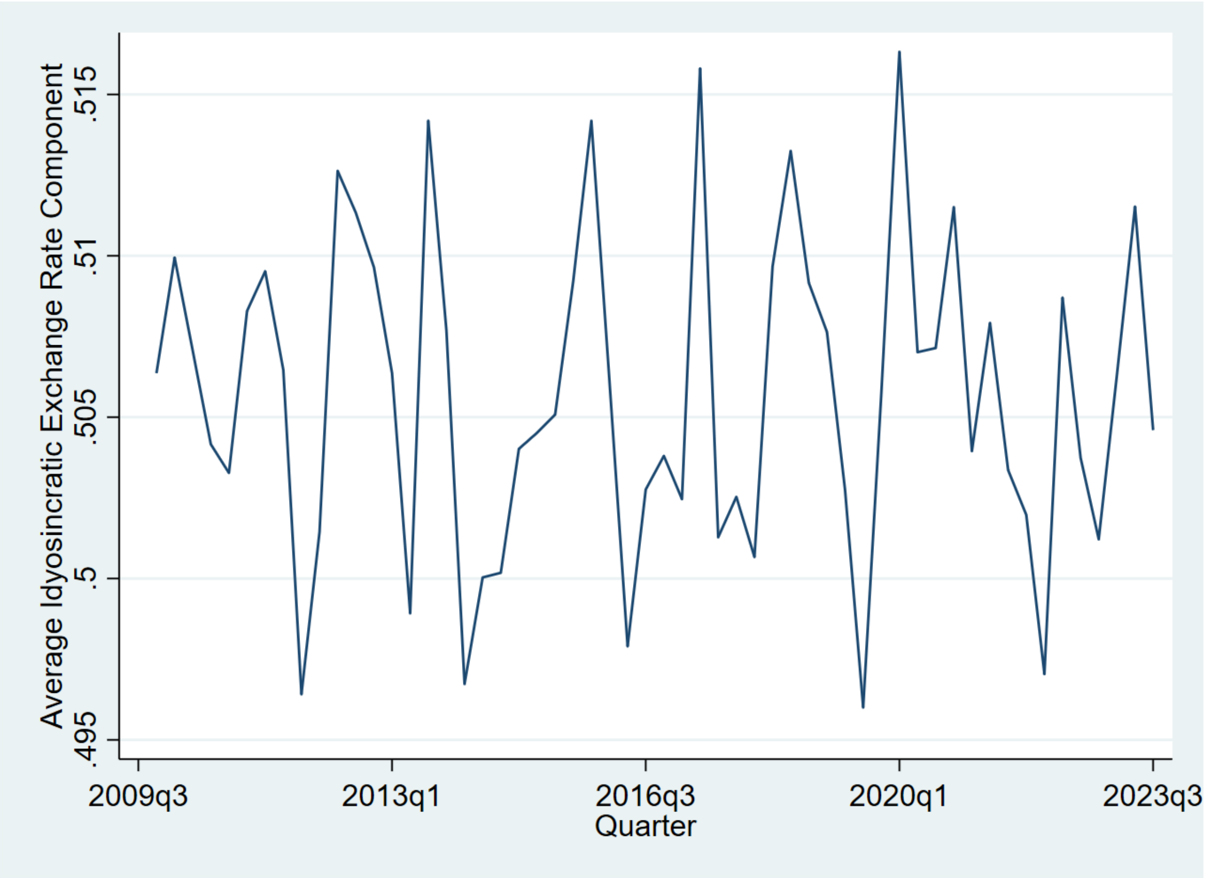


Figure A.8: Shocks GIV.

Source: BIS and HMRC administrative datasets, UK non-EU exports, 2010–2019.

A.1.3 Additional exposure measures

We can construct additional exposure indeces looking at the difference between currencies other than GBP and/or GBP exchange rate with other currencies:

$$s^{j}_{ft} = \frac{\sum_j (exp^{j}_{fj,2015} - imp^{j}_{fj,2015}) \times \Delta e^{£/j}_{t}}{Total\ Trade_{f,2015}} \qquad (Local\ Weighted\ Index)$$

$$s^{\$}_{ft} = \frac{\sum_j (exp^{\$}_{fj,2015} - imp^{\$}_{fj,2015}) \times \Delta e^{£/\$}_{t}}{Total\ Trade_{f,2015}} \qquad (Dominant\ Weighted\ Index)$$

$$s^{\$j}_{ft} = \frac{\sum_j (exp^{\$}_{fj,2015} - imp^{\$}_{fj,2015}) \times \Delta e^{\$/j}_{t}}{Total\ Trade_{f,2015}} \qquad (Dominant\text{-}Local\ Weighted\ Index)$$

where $exp^{\$}_{fj}$ and $imp^{\$}_{fj}$ indicates respectively the exports and imports of firm f to destination j in 2015 denominated in USD, as a share of gross trade of that firm in that year. With a slight abuse of notation, a superscript j indicates the currency of the destination while a subscript j indicates the country itself. A positive $\Delta e^{£/\$}_{t}$ indicates a depreciation of the GBP vis-a-vis the USD. The indices capture the gains/losses from unhedged positions of firms vis-a-vis exchange rates movements. In order to obtain the indices we aggregate across all destination countries.

A.2 Empirics: robustness checks

A.2.1 Static regressions

Table A.2: Baseline with controls spelt out.

	Value share of exports in					
	GBP	GBP	USD	USD	EUR	EUR
	(1)	(2)	(1)	(2)	(1)	(2)
Panel a. Baseline specification						
Valuation shock $s_{f,t}$	-0.01***	-0.01***	0.007***	0.01***	0.003***	0.003**
	(-6.37)	(-6.02)	(4.73)	(4.82)	(3.85)	(3.13)
Panel b. Strategic complementarities						
Invoicing of largest firm in HS4		0.02***		0.02***		0.02***
		(16.79)		(17.06)		(12.60)
Average invoicing in HS4		0.09***		0.09***		0.15***
		(10.64)		(17.06)		(8.94)
Panel c. Firm Market Power						
Market Power		0.04***		-0.05***		0.01
		(5.33)		(-7.67)		(1.95)
Market power × valuation shock		0.03		-0.04		0.03
		(0.46)		(-0.75)		(1.16)
Additional valuation controls						
Destination-weighted	0.04**	0.03	-0.01	0.001	0.002	0.006
	(2.92)	(1.44)	(-0.89)	(-0.04)	(0.29)	(0.74)
Dominant-weighted	-0.03***	-0.03***	0.04***	0.04***	-0.005*	-0.004
	(-5.04)	(-4.71)	(6.68)	(5.80)	(-2.32)	(-1.23)
Dominant-destination weighted	-0.04***	-0.04***	0.04***	0.05***	-0.001	-0.001
	(-8.08)	(-6.60)	(7.14)	(6.18)	(-0.57)	(-0.73)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Time x Gap FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,322,378	724,482	1,322,378	724,482	1,322,378	724,482

Source: HMRC administrative datasets, UK non-EU exports and imports, 2010–2019.

Table A.3: Baseline up to 2022

	Value share of exports in					
	GBP	GBP	USD	USD	EUR	EUR
	(1)	(2)	(1)	(2)	(1)	(2)
Panel a. Baseline specification						
Valuation shock $s_{f,t}$	-0.01***	-0.01***	0.007***	0.01***	0.001	0.0006
	(-4.76)	(-5.20)	(4.99)	(4.82)	(3.85)	(0.60)
Panel b. Strategic complementarities						
Invoicing of largest firm in HS4		0.02***		0.02***		0.02***
		(20.16)		(20.74)		(15.82)
Average invoicing in HS4		0.10***		0.09***		0.15***
		(12.03)		(12.92)		(9.82)
Panel c. Firm Market Power						
Market Power		0.05***		-0.06***		0.01*
		(5.33)		(-7.67)		(1.95)
Market power × valuation shock		-0.001		-0.01*		0.03
		(-0.02)		(-0.34)		(1.02)
Additional valuation controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Time x Gap FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,751,049	1,015,652	1,751,049	1,015,652	1,751,049	1,015,652

Source: HMRC administrative datasets, UK non-EU exports and imports, 2010–2019.

Table A.4: Baseline with quantity share instead of value share.

	Value share of exports in					
	GBP	GBP	USD	USD	EUR	EUR
	(1)	(2)	(1)	(2)	(1)	(2)
Panel a. Baseline specification						
Valuation shock $s_{f,t}$	-0.01***	-0.01***	0.004***	0.01***	0.003***	0.0006
	(-4.44)	(-5.20)	(2.71)	(4.82)	(3.95)	(0.60)
Panel b. Strategic complementarities						
Invoicing of largest firm in HS4		0.02***		0.02***		0.02***
		(14.92)		(14.99)		(11.74)
Average invoicing in HS4		0.09***		0.10***		0.14***
		(10.79)		(11.70)		(8.26)
Panel c. Firm Market Power						
Market Power		0.04***		-0.05***		0.01
		(5.22)		(-7.43)		(1.74)
Market power × valuation shock		0.03		0.02		0.01
		(0.43)		(-0.34)		(0.44)
Additional valuation controls	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Time x Gap FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,301,000	714,229	1,301,000	714,229	1,751,049	714,229

Source: HMRC administrative datasets, UK non-EU exports and imports, 2010–2019.

A.2.2 Dynamic event-study

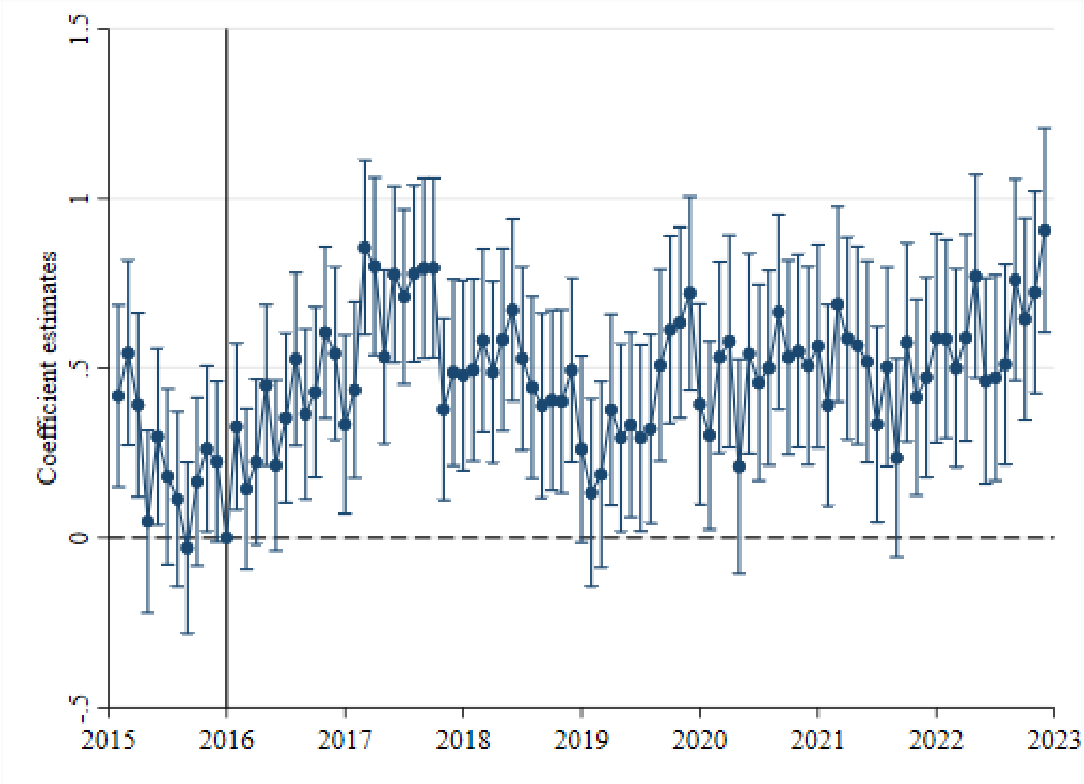


Figure A.9: Event study USD

Source: HMRC administrative datasets, UK non-EU exports and imports, 2010–2022.

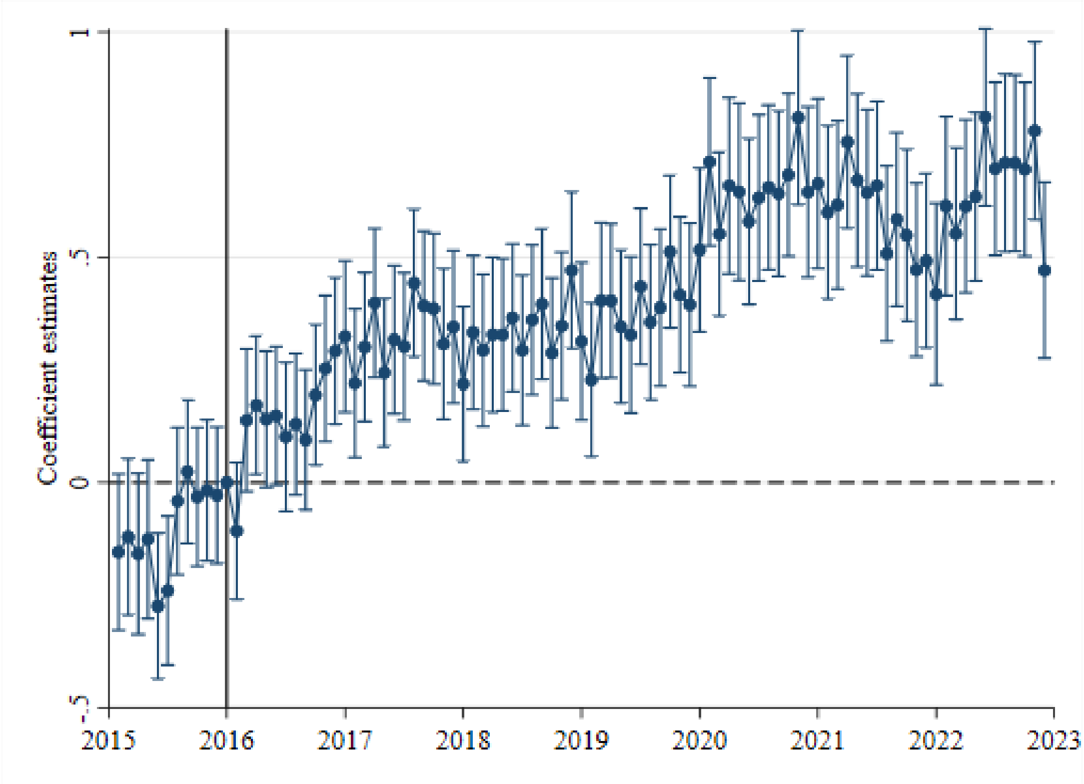


Figure A.10: Event study EUR

Source: HMRC administrative datasets, UK non-EU exports and imports, 2010–2022.

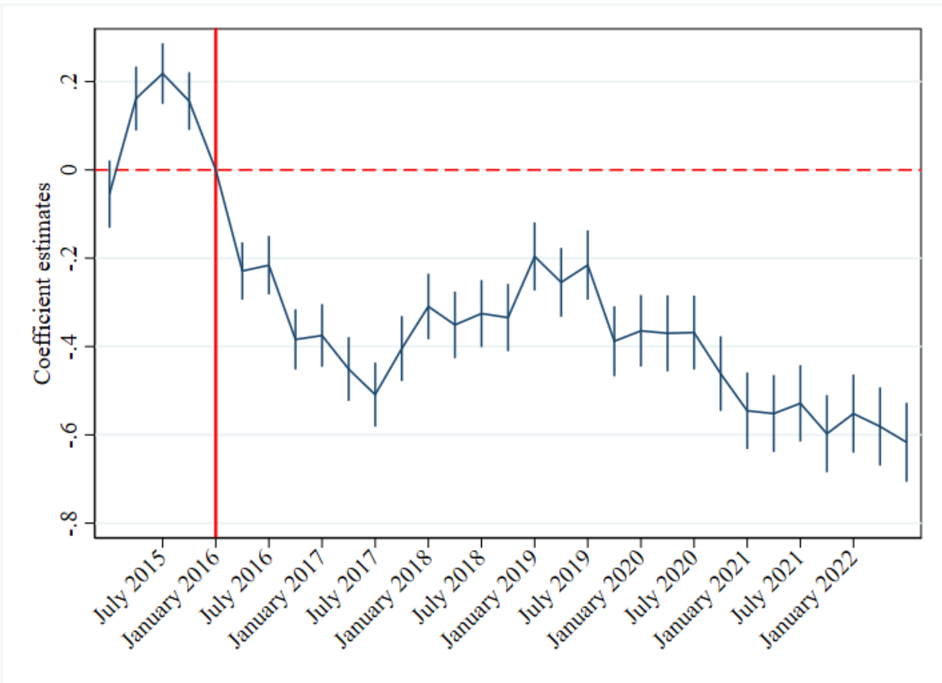


Figure A.11: Event study GBP - quarterly

Source: HMRC administrative datasets, UK non-EU exports and imports, 2010–2022.

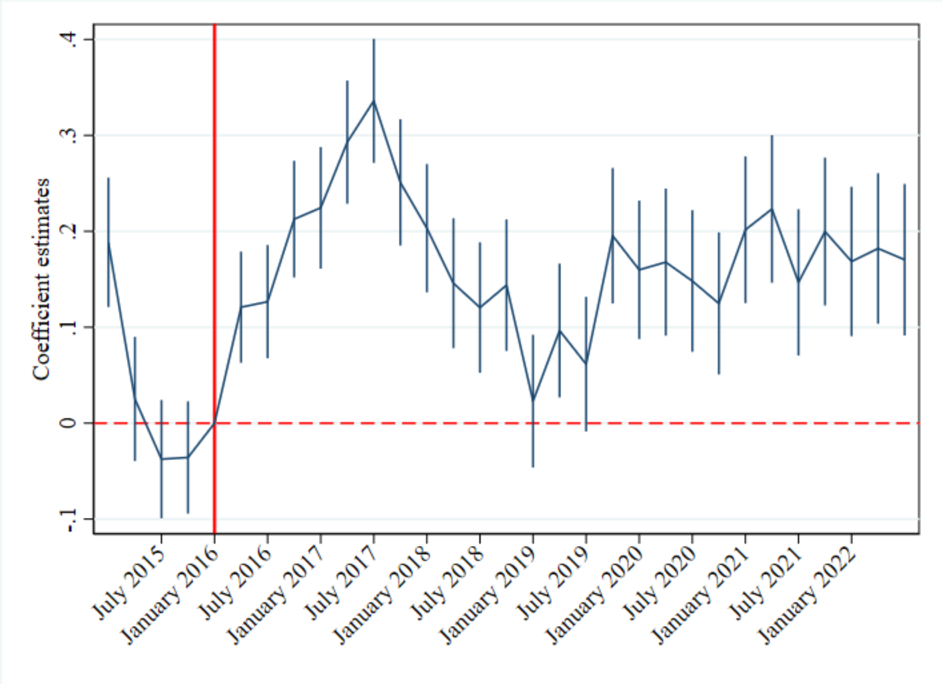


Figure A.12: Event study USD - quarterly

Source: HMRC administrative datasets, UK non-EU exports and imports, 2010–2022.

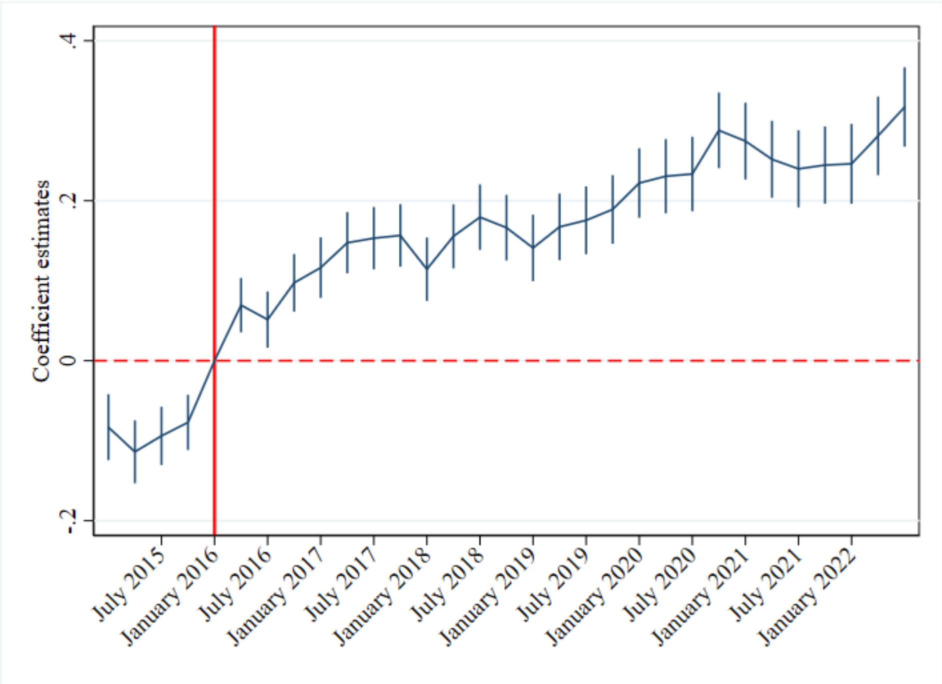


Figure A.13: Event study EUR - quarterly

Source: HMRC administrative datasets, UK non-EU exports and imports, 2010–2022.

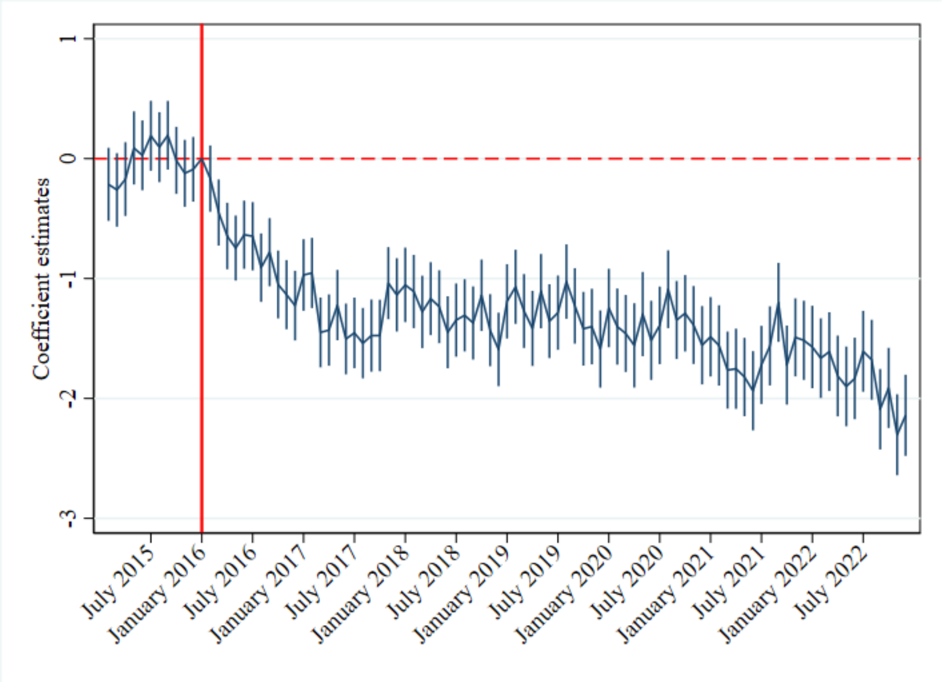


Figure A.14: Event study with exposure in GBP and exports only

Source: HMRC administrative datasets, UK non-EU exports and imports, 2010–2022.

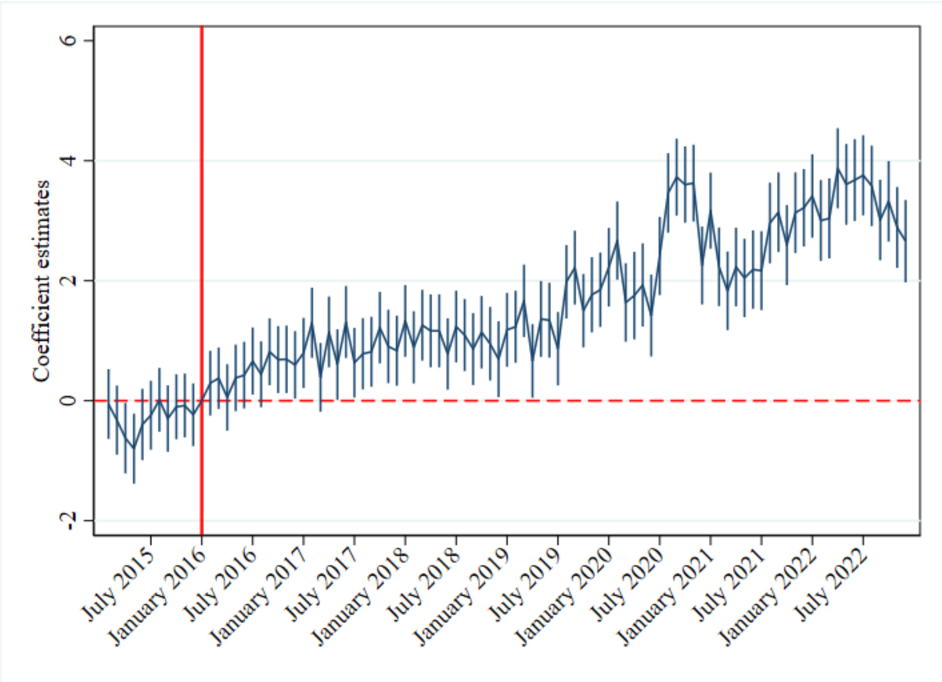


Figure A.15: Event study with exposure in GBP and imports only

Source: HMRC administrative datasets, UK non-EU exports and imports, 2010–2022.

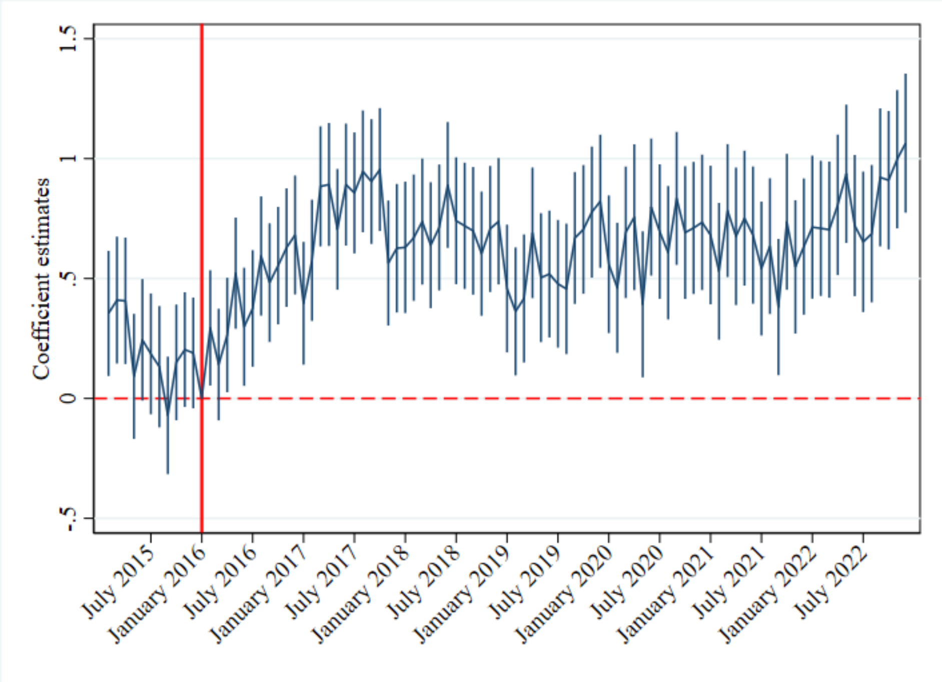


Figure A.16: Event study with exposure in USD and exports only

Source: HMRC administrative datasets, UK non-EU exports and imports, 2010–2022.

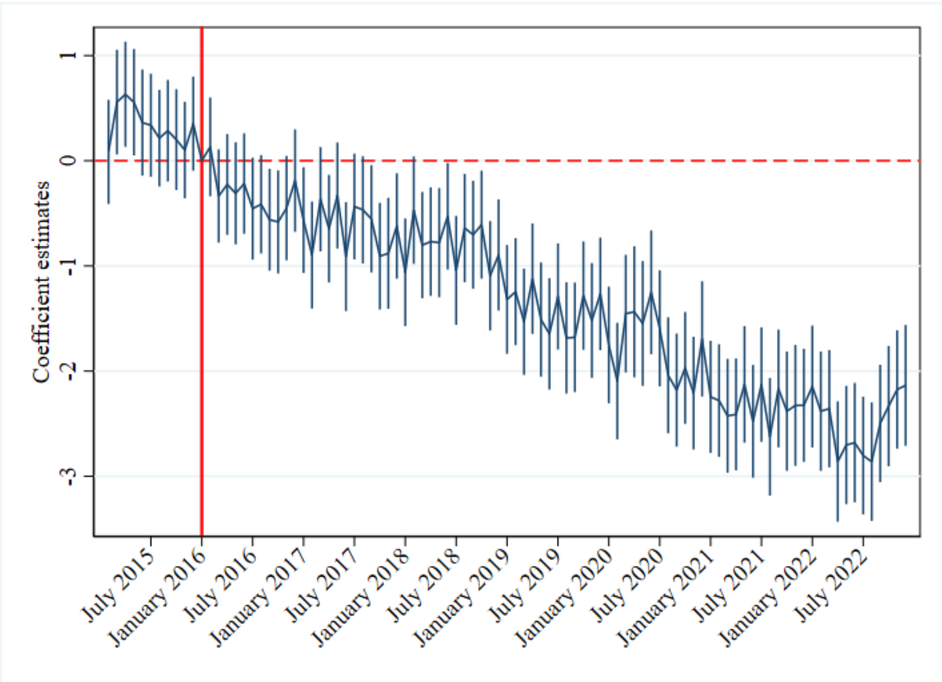


Figure A.17: Event study with exposure in USD and imports only

Source: HMRC administrative datasets, UK non-EU exports and imports, 2010–2022.

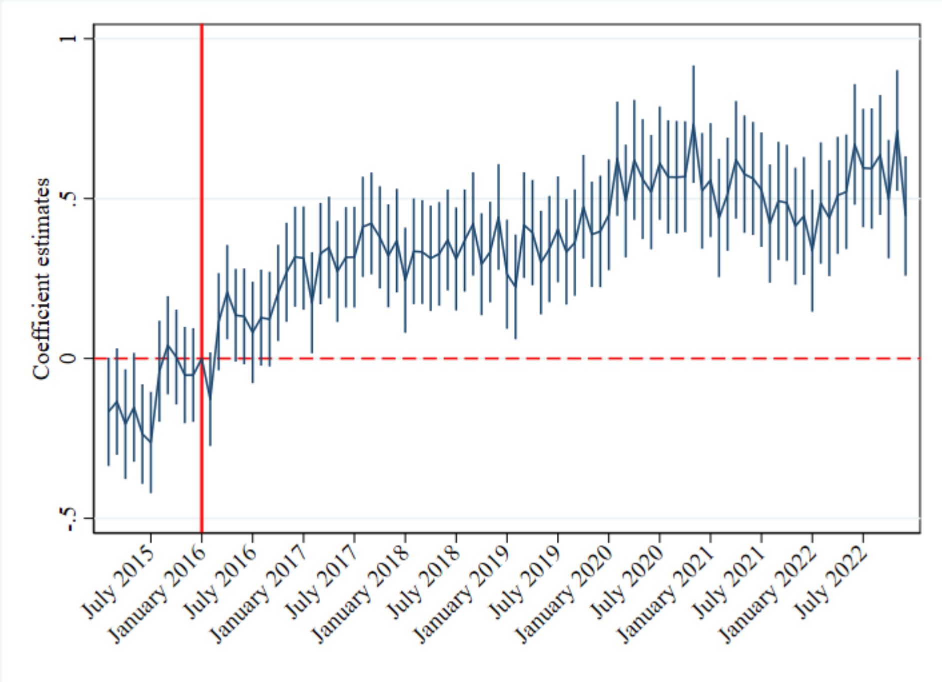


Figure A.18: Event study with exposure in EUR and exports only

Source: HMRC administrative datasets, UK non-EU exports and imports, 2010–2022.

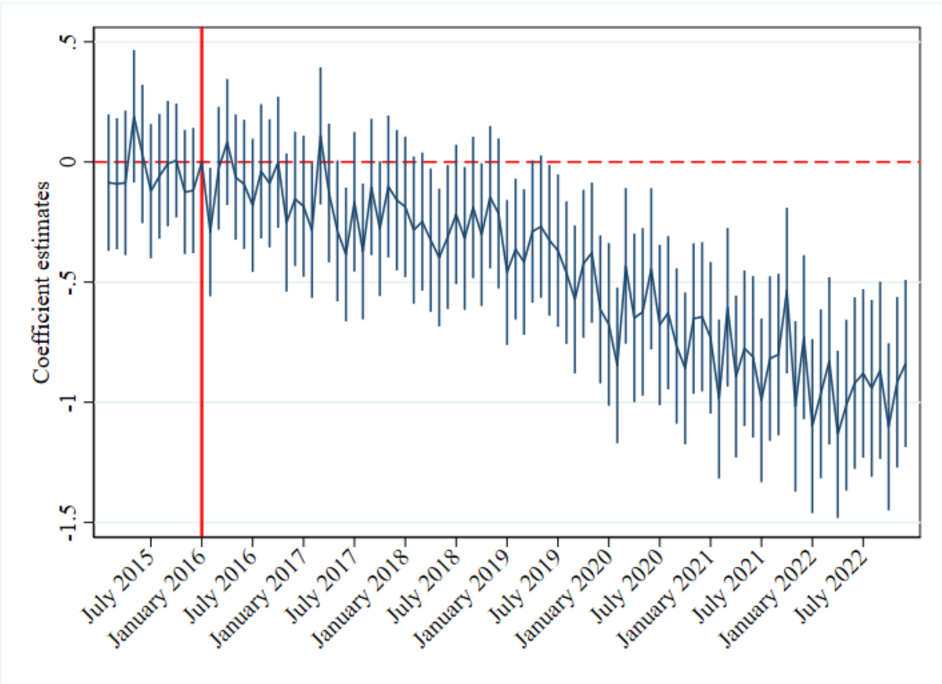


Figure A.19: Event study with exposure in EUR and imports only

Source: HMRC administrative datasets, UK non-EU exports and imports, 2010–2022.

A.2.3 Back of the envelope

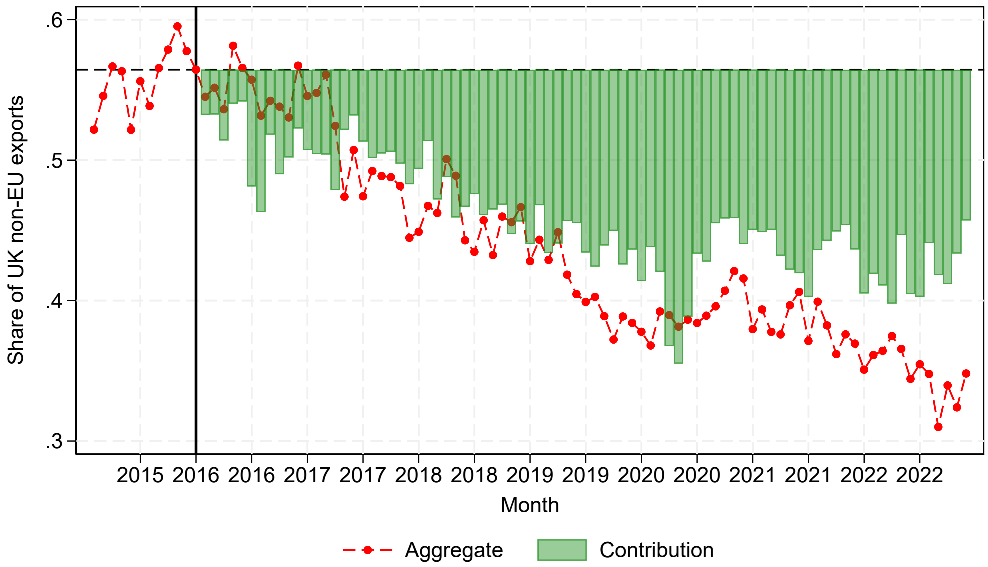


Figure A.20: Hedging channel: contribution to aggregate shift in GBP

Source: HMRC administrative datasets, UK non-EU exports, 2010–2022.

A.2.4 Macroeconomic implications

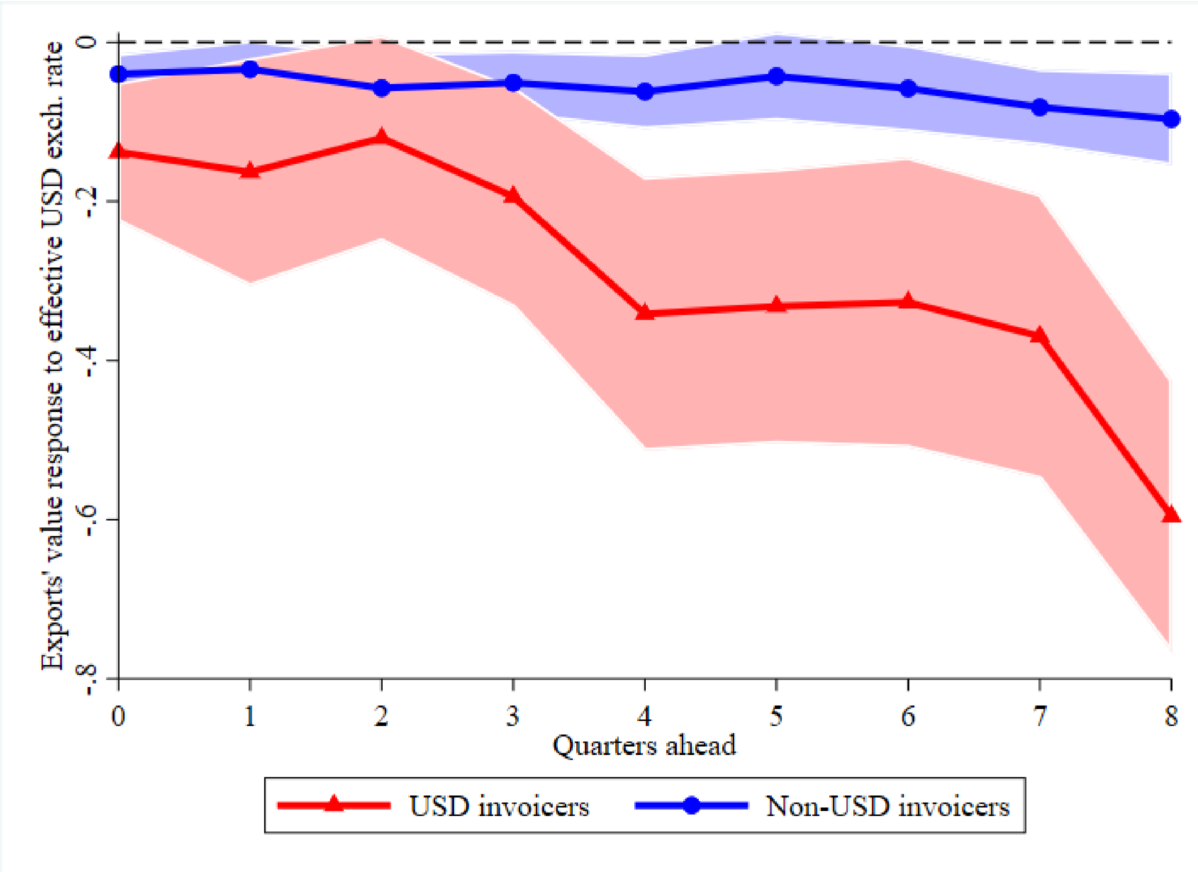


Figure A.21: Dynamic response of export value to appreciation of USD granular exchange rate.

Notes: We exclude US as destination here. **Source**: HMRC administrative datasets, UK non-EU exports, 2010–2022.

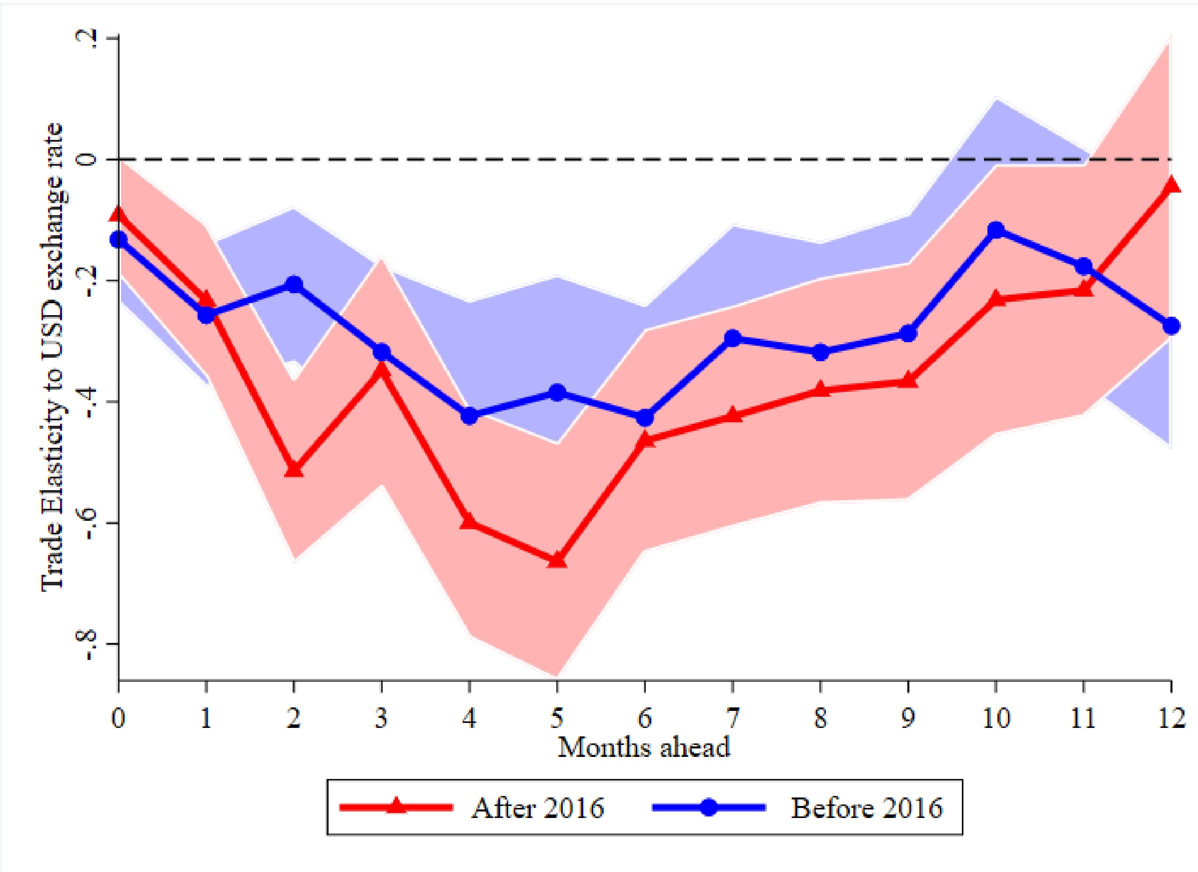


Figure A.22: Dynamic elasticity of export quantities to appreciation of USD.

Notes: We exclude US as destination here. **Source**: HMRC administrative datasets, UK non-EU exports, 2010–2022.