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INVOICING AND PRICING-TO-MARKET

A STUDY OF PRICE AND MARKUP ELASTICITIES OF UK EXPORTERS

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(revised 29 October 2018)

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Abstract

In this paper, we provide novel micro evidence that the currency in which exports and imports are invoiced is a good proxy for the currency in which firms set prices. Using detailed data on UK customs transactions, we document that destination-specific markup adjustment is substantial only for export shipments which are invoiced in the destination market's currency, consistent with the view that firms invoicing in local currency price to market. Conversely, we find no destination-specific markup adjustments by firms that invoice a shipment in either their own currency or a vehicle currency, consistent with a firm setting one price either in their own or in a vehicle currency. However, we also document that, while the aggregate shares of invoicing currencies for the UK's exports and imports are stable over time, there is substantial heterogeneity at the firm-product-destination level. A firm's shipments of the same product to the same destination are often invoiced in multiple currencies, with a non-trivial degree of switching from one invoicing currency to another within a twelve-month period. This is more pronounced for firms that are multi-product and serve several destinations, pointing to a potentially important margin of adjustment so far understudied in the literature.

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1 Introduction

Global trade flows are the cumulation of millions of individual transactions conducted in a variety of different currencies. Firms engaged in exporting can pursue a number of different invoicing schemes: producer currency invoicing, i.e., using the currency of the country in which production occurs; local currency invoicing, i.e., using the currency of the destination country; or vehicle currency invoicing, i.e., using a major, third-country, currency. Recent studies have shown that the currency in which exports and imports are invoiced is a key predictor of the extent of price responses to exchange rate movements.[1] This matters because it implies that the stability of import prices and the international transmission of the business cycle are, to varying extents, dependent upon the currencies in which these transactions take place.[2]

In this paper, we provide novel micro evidence from UK customs transactions over 2010-2016 which supports the view that the currency in which exports and imports are invoiced is a good proxy for the currency in which firms set prices. Unlike previous contributions, we rely on a new methodological framework, drawing on Corsetti, Crowley, Han and Song (2018), that allows us to correlate the use of a currency of invoicing directly with pricing-to-market behaviour, i.e. to the use of destination-specific market adjustments in reaction to exchange rate fluctuations. Complementary to the literature on local stability of import prices, we derive a more direct measure of the extent to which invoicing currencies matter for price discrimination. Intuitively, if a firm chooses to set prices in either its own producer currency or a vehicle currency, we may expect that the extent of destination-specific markup adjustments will be lower, relative to a case in which a firm sets its prices in the local currencies of the markets to which it exports. We verify that these intuitive predictions are borne out by granular empirical evidence on UK exporters.

In addition, however, we document a novel set of key facts concerning invoicing. First, at the aggregate level, the share of producer currency invoicing (PCI), local currency invoicing (LCI), and vehicle currency invoicing (VCI) is remarkably stable over time.[3] Second,

[1] Among recent contributions, see the seminal papers by Gopinath, Itskhoki and Rigobon (2010) and Gopinath (2015). For example, Gopinath, Itskhoki and Rigobon (2010) find that there exists a significant difference in the average pass-through of the US imports priced in dollars versus in non-dollars.

[2] Burstein and Gopinath (2014) and Corsetti, Dedola and Leduc (2010) provide a recent review of the empirical and policy literature. Related questions raised in analyses of the currency of pricing range from imported inflation and the consequences of large depreciations to efficiency losses from currency misalignments to the design of stabilization policy in an open economy (see, e.g., Corsetti, Dedola and Leduc (2007), Engel (2011), Corsetti and Pesenti (2015) and Corsetti, Dedola and Leduc (2018)).

[3] A number of studies (Goldberg and Tille (2008), Goldberg and Tille (2016), Chung (2016) and Devereux, Dong and Tomlin (2017)) have analyzed the determinants of invoicing choices including macroeconomic conditions and policies, market- and product-specific features, firm- or transaction-level factors such as the size of transactions and bargaining power of firms.

firms selling more than one product and to more than one destination are more likely to invoice in vehicle and local (destination market) currencies, rather their invoicing in their own producer's currency. Third, when we examine a firm's shipments within a destination, we observe a substantial share of invoicing using different currencies for different shipments of the same product, and a non-trivial degree of switching from one invoicing currency to another within a twelve-month period.

UK transaction-level data are particularly suitable for conducting an analysis of invoicing currencies. Unlike other countries that have transaction-level data, there is no dominant invoicing pattern: UK imports and exports are invoiced in pounds, euros and other vehicle currencies (e.g., US dollar, Swiss franc), as well as local (destination market) currencies. The currency of invoicing is more diversified than what is found in, for example, Canadian firm level data—recent studies indeed document that most Canadian imports and exports are invoiced in US dollars (Goldberg and Tille (2016) and Devereux, Dong and Tomlin (2017)). In the UK customs data, the currency of invoicing is specified at the transaction level for non-EU exports and imports.[4] Because 99% of UK exports to non-EU countries originate from multi-destination exporters, we can conduct our study using the Trade Pattern Sequential Fixed Effect (TPSFE) estimator developed in Corsetti, Crowley, Han and Song (2018), which allows us to study destination-specific markup elasticities to bilateral exchange rates and local market CPI changes.

The TPSFE estimator reveals interesting new findings. For non-EU transactions, we evaluate the degree of pricing-to-market conditional on the observed invoicing currency and estimate price and markup elasticities under different invoicing currency schemes. We find that, conditional on a price change in the invoicing currency, prices unambiguously react to bilateral exchange rate movements under every invoicing currency scheme (LCI, PCI, VCI), but markup adjustments differ across markets (i.e., there are market-specific adjustments) only if goods are invoiced in local currency. Specifically, for LCI goods, we document substantial markup adjustments not only to the bilateral exchange rate, but also to local CPI changes (40-55%). Interestingly, CPI changes are not relevant to pricing when firms use PCI and VCI. Remarkably, these results do not depend on the time frequency of the analysis, that is, the findings are similar at the monthly, quarterly and annual frequencies.

For the analysis of UK exports to the EU, for which we do not observe the invoicing currency, we examine the evolution of sterling unit values for export transactions in response

[4] HMRC holds information on the invoicing currency for non-EU trade transactions from January 2010 onwards. All import transactions are required to report their currency of invoicing. Export transactions whose value exceeds £100,000 must report the invoicing currency. In 2015, the share of non-EU exports from the UK with no reported invoicing currency accounts for around 7.5% of trade value and 31.0% of trade transactions. No invoicing information is reported for UK-EU transactions.

to the bilateral euro-sterling exchange rate and destination market CPIs. Remarkably, we find a price elasticity to bilateral exchange rates of 37%, and significant and high price (around 100%) and markup elasticities (around 80%) to destination CPI changes. Although we do not observe the invoicing choices of firms exporting to the EU, we can compare our EU estimates to the results of the three invoicing schemes used for non-EU transactions. We find the estimates of price and markup elasticities of EU transactions are most similar to those of local currency invoiced non-EU transactions. This is suggestive evidence that most UK firms exporting to the EU are unlikely to be engaging in vehicle or producer currency pricing.

Our contribution to the literature is fourfold. First, we document that a substantial proportion of firms use multiple invoicing currencies for the same product sold to the same destination and that there is a non-negligible amount of switching of the invoicing currency over time at the firm-product-destination level—important facts that add to the theoretical challenges to modelling firms in the international economy.

Second, our findings on destination-specific markup elasticities shows that invoicing matters for pricing-to-market. In this respect, our contribution is closely related to theoretical open macro models featuring variable markups (see, e.g., Krugman (1986), Dornbusch (1987), Corsetti and Dedola (2005), Atkeson and Burstein (2008), Corsetti, Dedola and Leduc (2008)) as well as to empirical studies of firms' pricing strategies which exploit the increasing availability of high-dimensional administrative customs databases (see, e.g., Berman, Martin and Mayer (2012), Chatterjee, Dix-Carneiro and Vichyanond (2013), Amiti, Itskhoki and Konings (2014), Fitzgerald and Haller (2014), De Loecker, Goldberg, Khandelwal and Pavcnik (2016), Auer and Schoenle (2016), and Fitzgerald and Haller (2018)). Beyond the many determinants of pricing-to-market revealed in existing research, we document a specific role of currency invoicing in shaping market-specific adjustment.

Third, the recent literature has established a relationship among invoicing currency, exchange rate pass through and import intensity (see e.g., Goldberg and Tille (2008), Amiti, Itskhoki and Konings (2014), and Chung (2016)). The main finding of this literature is that firms are likely to price in the currency of their imported inputs to mitigate the impact of exchange rate fluctuations on marginal costs. However, these studies face two empirical hurdles. On the one hand, it is often difficult to distinguish whether the recorded imported goods in the data are for domestic sales or used as production inputs. On the other hand, international trade is dominated by multi-product firms but imported inputs are only observed at the firm-level. Therefore, it is difficult to tell which imported inputs are used to produce which products, and whether the exported product has used any imported inputs at all. To the extent that our TPSFE estimator is successful in differencing out marginal costs at the product level, our estimates overcome these empirical difficulties. After controlling for firm-product specific factors, we find no destination-specific markup adjustments for producer or vehicle currency invoiced transactions but an economically significant destination-specific markup elasticity for transactions invoiced in local currency. These estimates help in characterizing "strategic complementarity" in relation to firms' invoicing decisions, which has been extensively discussed in theoretical models of endogenous currency choice (see, e.g., Devereux, Engel and Storgaard (2004), Engel (2006), Gopinath, Itskhoki and Rigobon (2010) and more recently Mukhin (2017)).

Fourth, and most importantly, our results contribute to the recent debate on the role of vehicle currencies in international shock transmission (see, e.g., Gopinath (2015), Casas, Diez, Gopinath and Gourinchas (2017), and Chen, Chung and Novy (2018)). At the heart of this discussion is the idea that firms invoicing in a vehicle currency, say dollars, also price their goods in the vehicle currency. A further logical step is that these firms would then set one, global, dollar price for their product—maximizing their profits relative to global demand taken as a whole. Indeed, one possible (extreme) implication of what Gopinath has dubbed the 'International Price System' (IPS) is that pricing in dollars overcomes market segmentation and translates into a 'Reference Price System,' by which firms do not exploit market-specific demand elasticities, but price in relation to global demand. Irrespective of nominal rigidities, our estimates suggest UK firms invoicing in vehicle currencies do not make destination-specific markup adjustments, and thus, provides micro-level empirical evidence in support of Gopinath's IPS hypothesis. At the same time, we provide nuanced evidence that some firms follow a different strategy of invoicing in local currency and adjusting markups to local market conditions.

The rest of the paper is organized as follows. Section 2 provides a brief discussion on the relationship between the invoicing currency and pricing-to-market. Section 3 describes our data and presents three new stylized facts for firm and transaction level invoicing choices. Section 4 presents the estimated price and markup estimates conditional on invoicing schemes. Section 5 concludes.

2 Invoicing Currency and Pricing-to-Market

In this section, we briefly discuss the theoretical relationship between invoicing currencies and firm's pricing decisions. While this issue has been extensively studied by the literature, especially in recent times, most of the work that has been conducted relates invoicing to the price elasticity with respect to exchange rates. In a sense, we refine our understanding by focusing attention on the markup elasticity, instead of the price, as prices include both markup and marginal costs movements, potentially blurring any results.

In a nutshell, the idea is the following. Suppose a firm invoices and prices in own currency, that is, PCI is the same as PCP, or producer currency pricing. Any movement in the bilateral exchange rate, or any shock to marginal costs, policy, or market conditions (e.g., changes that are reflected in the destination market CPI), will not lead to any market-specific adjustment in the markup regardless of whether or not the price in the producer's currency is adjusted. Hence, our first hypothesis. If PCI is the same as PCP, there will be no market-specific (relative) adjustments in markups across destinations.

Similarly, suppose a firm invoices and prices in a vehicle currency, that is, VCI is the same as VCP, or vehicle currency pricing. Once again, given a single 'global' price, any movement in bilateral exchange rates, or any shock to marginal costs, policy, or market conditions will not lead to any market-specific adjustment in markups regardless of whether or not the price in the vehicle currency is adjusted. Hence, our second hypothesis. If VCI is the same as VCP, there will be no market-specific (relative) adjustment in markups across destinations.

Alternatively, suppose a firm invoices and prices in local currency, that is, LCI is the same as LCP, or local currency pricing. Any movement in the bilateral exchange rate, or any shock to marginal costs, policy or market conditions, is likely to translate into market-specific adjustments to markups. This will hold unless prices are very flexible so that the firms 'undo' the change in their relative marginal costs when measured in local currency relative to own currency. Buyers abroad are likely to face different prices, implying different markups, *measured in the currency of the producers.* Hence, our last hypothesis. If LCI is the same as LCP, we should expect significant market-specific (relative) adjustment in markups across destinations.

In light of these hypotheses, we provide two sets of related evidence in the following two sections. In particular, section 3 documents a substantial share of firms invoicing in more than one currency. Moreover, at the firm-product-destination level, we find a non-negligible switching of invoicing currency over time for British exporters. This evidence seems to suggest these firms may have used the invoicing currency as an instrument to implement different pricing strategies to different markets and over different time periods. Section 4 directly verifies these hypotheses and presents estimates of price and markup elasticities to bilateral exchange rates and local market CPI rates conditional on the invoicing currency of the transaction.

3 New Micro Level Evidence on Firms' Choice of Invoicing Currency

In this section, we carry out an extensive analysis of invoicing by British importers and exporters. Given data availability, our sample includes only transactions with non-EU markets. Approximately 53% of UK exports were sent to non-EU destinations over 2010-2016.[5] To preview our key findings, we show that, at the aggregate level, the share of each invoicing pattern (PCI, VCI, LCI) is remarkably stable over time. However, there are frequent switches across invoicing currencies over time by firms that ship the same product to the same destination.

HMRC holds information on the invoicing currency for non-EU trade transactions since January 2010. All importers must report their currency of invoicing for every transaction. Only exporters whose annual exports exceed a value of £100,000 must report the invoicing currency for each transaction. Given data availability, our analysis covers the time period 2010-2016. Firms are identified by a firm-specific anonymised identifier. Products are defined by an 8-digit CN code. Details on how our database is constructed are in Appendix B.

3.1 Measures of Currency Invoicing

To carry out our analysis, we start by classifying each transaction in our dataset according to the invoicing currency, as well as the destination/origin of the trade.

For UK **exports**, transactions are classified as PCI (producer currency invoicing) if invoiced in pounds sterling, the currency of the UK. They are LCI (local currency invoicing) if invoiced in the currency of the destination country of the UK exports. For example, LCI includes UK exports to Mexico invoiced in Mexican pesos and UK exports to the US invoiced in US dollars. Finally, transactions are VCI (vehicle currency invoicing) if UK imports are invoiced in a third currency other than pounds sterling or the currency of the destination country. This includes, for example, UK exports to Mexico invoiced in US dollars or UK exports to Cote D'Ivoire invoiced in euros.

For UK **imports**, the three classification bins are symmetrically defined. A transaction is defined as LCI if invoiced in pounds sterling; as PCI if invoiced in the currency of the origin country (e.g. yen for imports from Japan); and as VCI if invoiced in a currency other than sterling and other than the currency of the origin. For example, UK imports from Mexico invoiced in dollars are VCI transactions.

[5]Author's calculation from HMRC Overseas Trade Statistics: https://www.uktradeinfo.com/Statistics/Pages/Annual-Tables.aspx.

When the currency of invoicing is not reported, we drop the corresponding observation. For instance, in 2015, the share of non-EU exports from the UK with no-reported invoicing currency accounts for around 7.5% of trade value and 31.0% of transactions. For non-EU imports, observations for which no invoicing currency is reported account for a small fraction of transactions (less than 5%) and a trivial share of import value (0.1% or lower).

3.2 The Relative Share of Invoicing Currency is Stable at the Aggregate Level

We start our analysis by focusing on the universe of British import/export transactions to non-EU destinations over 2010-2016. For all transactions, we define the unit of observation as the quintuplet comprised of a (1) firm, (2) product, (3) country of origin (imports) or destination (exports), (4) quantity measure, and (5) currency. This precise definition of the unit of observation is necessary because, over the same year, some firms importing/exporting a product from Britain will use different invoicing currencies for the same source/destination country. In the graphs below, for each invoicing currency scheme, the dark bars—labelled "transactions"—refer to shares of (quintuplets or) observations; the light grey bars—labelled "value"—refer to the share of export value.

A key fact highlighted by the graphs is that, in the aggregate, the share of each invoicing currency scheme is stable across all years in the sample. In Figure 1, we observe that UK exports are primarily invoiced in producer currency, the pound sterling: PCI accounts for between 68 and 72% of transactions and 56 and 62% of export value. The second-most important scheme for UK exporters is VCI; between 20-25% of UK export transactions are invoiced in vehicle currencies. We also note that, although not reported in the figure, the share of exports to non-EU destinations invoiced in euros is rather small during the sample period. Over the six years between 2010 and 2015, the share of transactions invoiced in euros creeps up slightly, from 3.4% to 4.5%. The share of export value remains stable, hovering around 3.0% over the period. Local currency invoicing is the quantitatively least important scheme, yet between 14.5 and 19.5% of export value is invoiced in the currency of the destination country.

In Figure 2, which reports the corresponding shares for UK imports, the invoicing choice is dominated by vehicle currencies with over half of transactions and import value invoiced in a vehicle currency. The import value shares of LCI and PCI are around 24% and 20%, respectively.

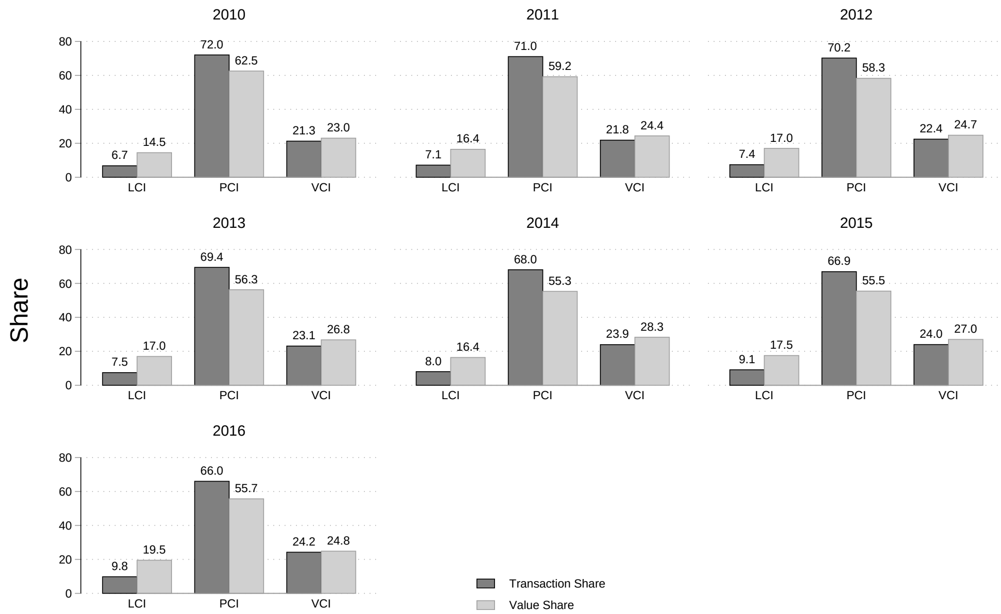

Figure 1: Aggregate composition of invoicing schemes – UK exports to non-EU destinations

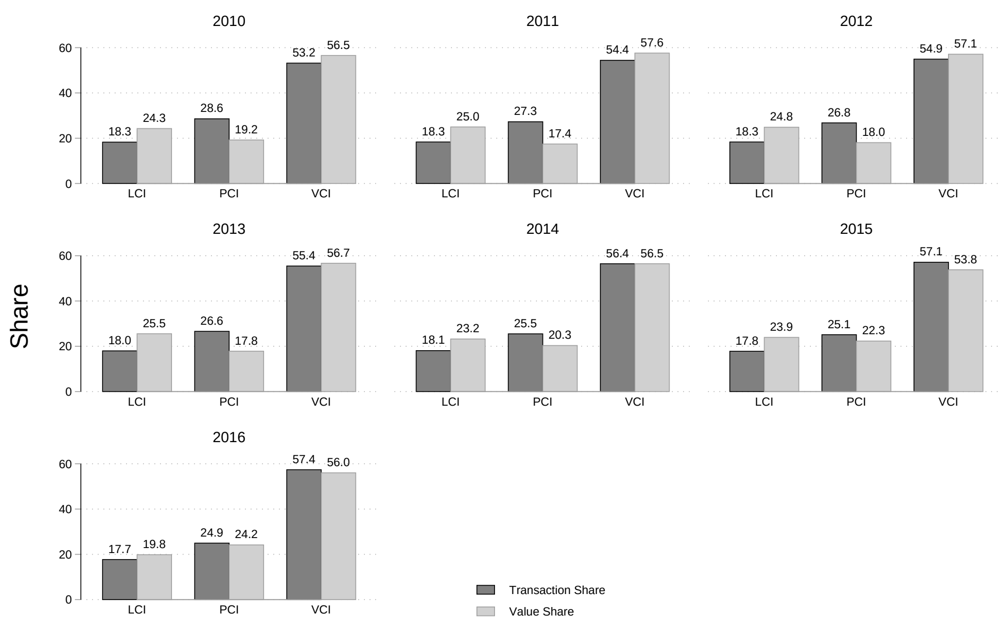

Figure 2: Aggregate composition of invoicing schemes – UK imports from non-EU sources

3.3 Destinations, Products and Invoicing Choices

Our data have five panel dimensions, firm, product, invoicing currency, origin/destination, and time. We count the number of destinations, the number products, and the number of invoicing currencies at the firm level over all trading periods for a firm. After calculating the relevant statistics, we aggregate the data to the firm level and count the proportion of firms that fall into a particular category. We calculate the trade-weighted statistics by weighting each firm by its total trade value (denominated in sterling) over all trading periods across all destinations, products and invoicing currencies.

Tables 1- 4 show the distribution of invoicing choices by the number of destinations served and products exported by a firm. In each table, the top panel show the proportion of firms, the bottom panel show results weighted by trade value. As our primary goal is to analyze whether the choice of the invoicing currency is related to pricing-to-market, we will focus the discussion in the text on the invoicing choices of exporters. Results for imports are discussed in the appendix.

Table 1: Number of Destinations vs. Invoicing Currencies (Non-EU Exports)

	No. of Invoicing Currencies				
No. of Destinations	1	2-5	6-10	10+	Total
(a) Share of Firms					
1	34.8	6.4	0.0	0.0	41.2
2-5	7.8	25.6	0.0	0.0	33.5
6-10	0.3	10.6	0.1	0.0	11.0
10+	0.1	12.8	1.4	0.2	14.4
Total	43.1	55.3	1.4	0.2	100.0
(b) Trade-weighted					
1	0.4	0.6	0.0	0.0	1.0
2-5	0.4	3.0	0.0	0.0	3.5
6-10	0.0	5.1	0.1	0.0	5.2
10+	0.0	32.9	26.8	30.6	90.3
Total	0.9	41.6	26.9	30.6	100.0

For non-EU exports, Table 1 shows the joint distribution of the number of invoicing currencies and the number of destinations at the firm level. As can be seen from the table, 43.1% of exporters sell their products invoicing in a single currency—around one third of trade transactions are conducted by single-destination and single-invoicing currency firms. Remarkably, however, 15.5% (6.4/41.2) of firms exporting to just one destination invoice in more than one currency. Focusing on multi-destination exporters (rows "2-5", "6-10" and "10+"), we can see that only 14% ((7.8+0.3+0.1)/(33.5+11.0+14.4)) of multi-destination firms invoice their products in a single currency.

Comparing the top and the bottom panel, it is apparent that the picture changes quite dramatically if observations are weighted with trade values: 99.1% of trade value weighted transactions are conducted by firms invoicing in multiple currencies—most of them selling to more than 10 destinations.

Table 2: Number of Products v.s. Invoicing Currencies (Non-EU Exports)

	No. of Invoicing Currencies				
No. of Products	1	2-5	6-10	10+	Total
(a) Share of Firms					
1	29.5	2.1	0.0	0.0	31.6
2-5	11.9	19.7	0.0	0.0	31.6
6-10	1.2	11.3	0.0	0.0	12.6
10+	0.4	22.2	1.4	0.2	24.2
Total	43.1	55.3	1.4	0.2	100.0
(b) Trade-weighted					
1	0.6	0.3	0.0	0.0	0.8
2-5	0.2	1.9	0.0	0.0	2.2
6-10	0.1	3.4	0.9	0.3	4.7
10+	0.0	36.0	26.0	30.2	92.2
Total	0.9	41.6	26.9	30.6	100.0

Table 2 shows the distribution of the number of products sold by firms by the number of invoicing currencies. The pattern is similar to the one found in Table 1. Notably, most single-product firms invoice in a single currency—with only 6.6% (2.1/31.6) using multiple currencies.

Table 3: Number of Products v.s. Destinations (Non-EU Exports)

	No. of Destinations				
No. of Products	1	2-5	6-10	10+	Total
(a) Share of Firms					
1	29.5	2.0	0.1	0.0	31.6
2-5	9.8	20.2	1.3	0.3	31.6
6-10	1.2	7.0	3.4	0.9	12.6
10+	0.7	4.3	6.2	13.1	24.2
Total	41.2	33.5	11.0	14.4	100.0
(b) Trade-weighted					
1	0.4	0.4	0.0	0.0	0.8
2-5	0.5	1.0	0.5	0.3	2.2
6-10	0.1	0.8	1.9	2.0	4.7
10+	0.1	1.3	2.9	88.0	92.2
Total	1.0	3.5	5.2	90.3	100.0

Table 3 shows the product-destination distributions of firms, in the same vein as Mayer, Melitz and Ottaviano (2014). The lion's share of exports is by multi-destination and multi-product firms. Interestingly, we find a higher share of multi-product firms in the UK, relative to France (see Mayer, Melitz and Ottaviano (2014)) and China (see Corsetti, Crowley, Han and Song (2018)).

Table 4: Invoicing Scheme and Number of Destinations/Products (Non-EU Exports)

	Invoicing Scheme			
No. of Destinations	LCI	PCI	VCI	Total
(a) Share of Firms				
1	3.9	23.8	4.6	32.4
2-5	6.4	20.2	8.4	35.1
6-10	3.6	6.2	4.5	14.3
10+	5.4	6.6	6.1	18.2
Total	19.3	56.9	23.7	100.0
(b) Trade-weighted				
1	0.3	1.5	0.3	2.1
2-5	0.7	4.0	0.8	5.5
6-10	1.0	5.1	2.4	8.4
10+	17.2	43.8	23.0	84.0
Total	19.1	54.3	26.5	100.0

No. of Products	LCI	PCI	VCI	Total
(a) Share of Firms				
1	3.0	19.4	4.3	26.7
2-5	6.9	22.6	8.5	38.1
6-10	3.9	7.4	4.6	15.8
10+	5.5	7.6	6.3	19.5
Total	19.3	56.9	23.7	100.0
(b) Trade-weighted				
1	0.2	1.0	0.3	1.4
2-5	1.1	4.5	1.3	6.9
6-10	1.2	5.4	2.1	8.7
10+	16.7	43.5	22.8	83.0
Total	19.1	54.3	26.5	100.0

Table 4 provides a further breakdown by invoicing schemes. In this table, we focus on transactions for which we can detect a price change. Hence we drop all firm-product-destination triplets that appear only once in our sampling period. As can be seen from Table 4, small (single-product, single-destination) exporters are more likely to invoice in their own producer currency. This is true both in terms of transactions and trade values.

Large (multi-product, multi-destination) exporters invoice significantly more in local and vehicle currencies. However, note that sterling is still the dominant currency in terms of trade values.

3.4 Granular Analysis: Multi-currency invoicing and the transition matrix

We now exploit the highly disaggregated information in our dataset to explore the structure of invoicing patterns at the most refined level, firm-product-destination-time. We construct an identifier that combines firm identifiers, 8-digit commodity codes, destination/origin and the year of trade, and aggregate monthly information to the annual frequency. For conciseness, we refer to a firm-product-destination-year quartet as a "FPDT unit".

Table 5: Number of invoicing currencies for each firm-product-destination-year quartet

No. of Currencies	No. of Transactions	Share (Transaction %)	Share (Trade %)
1	10,257,447	86.1	60.8
2	1,424,096	12.0	28.8
3	184,083	1.5	6.7
4 plus	42,277	0.4	3.8
Total	11,907,903	100.0	100.0

As is apparent from table 5, the fraction of multi-currency FPDT units is surprisingly high. Invoicing in two or more currencies account for 13.9% of FPDT transactions and nearly 40% of trade-weighted FPDT transactions. In other words, for a nontrivial share of trade in the same product, reaching the same destination, originating from a single firm, invoicing is done in more than one currency. This is a key fact that, to our knowledge, has not been documented in the literature. Multi-currency invoicing within a firm, product, destination and time period presents a challenge to theoretical models which often assume that a firm invoices in only a single currency to a given destination.

3.4.1 Breakdown of the number of invoicing currencies for imports and exports

We can further breakdown our sample distinguishing UK imports and UK exports. As shown by the tables below, importers and exporters display a similar invoicing pattern. For export FPDT units, Table 6 shows that around 16% (1-0.841) of the transactions and 48% (1-0.516) of trade value reflects invoicing in more than one currency.

Table 6: Number of invoicing currencies for each firm-product-destination-year quartet (Exports only)

No. of Currencies	No. of Transactions	Share (Transaction %)	Share (Trade %)
1	4,355,750	84.1	51.6
2	737,868	14.2	39.0
3	77,538	1.5	7.9
4+	8,261	0.2	1.5
Total	5,179,417	100.0	100.0

Table 7: Number of invoicing currencies for each firm-product-destination-year quartet (Imports only)

No. of Currencies	No. of Transactions	Share (Transaction %)	Share (Trade %)
1	5,901,697	87.7	67.0
2	686,228	10.2	21.8
3	106,545	1.6	5.9
4+	34,016	0.5	5.3
Total	6,728,486	100.0	100.0

3.4.2 The Transition Matrix of Invoicing Currency Schemes

An important question is whether an exporter's choice of invoicing currency is stable or changes over time at the firm-product-destination level. When a UK exporter sells a product in a specific destination and we observe transactions in two or more invoicing currencies, it is possible that the firm is using different currencies for different customers. Or, it might be that the exporting firm is switching the invoicing currency for a single customer over time. Strictly speaking, we are not able to distinguish between these possibilities because we have no information on the buyers. This means that changes in invoicing shares over time might reflect reflect changes in the share of products sold to different buyers. But either possibility is quite intriguing—and we can and do try to gain insight from our evidence.

Table 8: Transition Matrix of Invoicing Schemes (Non-EU Exports)

		To		
		LCI	PCI	VCI
From	LCI	81.26	17.10	1.63
	PCI	1.99	92.68	5.34
	VCI	0.64	17.34	82.02
Conditional on large transactions (top quarter by trade value)				
		To		
		LCI	PCI	VCI
From	LCI	88.40	10.49	1.11
	PCI	1.95	93.48	4.56
	VCI	0.61	12.81	86.58

Note: This transition matrix is generated conditional on single invoicing currency transactions at the exporter-product-destination level.

To gain an insight into the extent to which invoicing shares are variable within any given time span, we start with the sample from table 5, then drop multi-currency invoiced FPDT units to focus on single-currency FPDT units. For these single-currency FPDT units, we estimate the probability of invoicing currency switching. Results are shown in Table 8. Each cell represents the probability a FPDT unit switches from one currency scheme to another from year t to year $t+1$ conditional on each FDPT union being classified as PCI, LCI or VCI in year t.

For non-EU exports, a switch in the invoicing currency is more likely for firm-product-destination triplets for which the currency of invoicing is local and vehicle. When there is a switch, the most likely switch is into producer currency invoicing. For around 7% of PCI firm-product-destination triplets, we observe a switch into other currencies, with about 70% of these switches going into a vehicle currency.

We repeat the analysis focusing only on large transactions. Specifically, we rank all transactions by their trade values at the CN08-product level in each year and then only keep the transactions in the top quarter of the distribution. The bottom panel shows the estimated transition matrix based on these large transactions. It can be seen from the table that firms wiht large value transactions are slightly more likely to stay with the same currency scheme used in the previous period. The increase in the staying probability is particularly large for local currency invoiced transactions. These estimates provide supportive evidence of Goldberg and Tille (2016) which argues that the size of the transaction plays an important role in the invoicing choice.

Table 9 presents the same information for UK imports. Overall, the probability of switching is much lower for importers compared to exporters.

Table 9: Transition Matrix of Invoicing Schemes (Non-EU Imports)

		To		
		LCI	PCI	VCI
From	LCI	92.79	1.68	5.53
	PCI	1.46	97.24	1.30
	VCI	1.81	0.51	97.68
Conditional on large transactions (top 25 percentile by trade value)				
		To		
		LCI	PCI	VCI
From	LCI	94.71	1.26	4.03
	PCI	1.35	97.61	1.04
	VCI	1.47	0.37	98.16

Note: This transition matrix is generated conditional on single invoicing currency transactions at the importer-product-source level.

4 Price and Markup Elasticities: How Do They Differ Depending on the Choice of Invoicing Currency?

In this section, we address the core issue in our paper, that is, whether invoicing matters for pricing. Subsection 4.1 discusses our empirical strategies. Subsection 4.2 reports our main results.

4.1 Empirical Strategies

4.1.1 Price Elasticity

We estimate the price elasticity to exchange rates and CPI changes following Gopinath, Itskhoki and Rigobon (2010).

$$\Delta_{s_{|ifcdt}} p_{ifcdt} = \beta_1 \Delta_{s_{|ifcdt}} e_{dt} + \beta_2 \Delta_{s_{|ifcdt}} cpi_{dt} + \Delta_{s_{|ifcdt}} \epsilon_{ifcdt} \tag{1}$$

where i, f, c, d, t represent product, firm, invoicing currency, destination country, time respectively; p_{ifcdt} represents the unit value denominated in sterling[6]; e_{dt} is the sterling-destination rate where an increase of e_{dt} means an appreciation of the destination country currency; *cpi* is the CPI index in the destination country. Bilateral exchange rates and destination CPI data are taken from International Financial Statistics database from the International Monetary Fund. All variables enter our estimation equation in logarithms. $\Delta_{s_{|ifcdt}}$ denotes a time difference operation at the product-firm-invoicing currency-destination level, where s is the number of periods between two observed trading records or price changes.

4.1.2 Markup Elasticity: Trade Pattern Sequential Fixed Effects (TPSFE)

We carry out our analysis of the markup elasticity using "trade pattern sequential fixed effects" (TPSFE). The method is discussed at length in our previous work, Corsetti, Crowley, Han and Song (2018); we briefly describe the key concepts and procedures here. Our estimation strategy consists of differencing out the unobserved marginal costs by expressing all the observations on product i sold by firm f to multiple destinations at time t invoiced in currency c, in terms of deviations from their average. At each point in time, this average will be conditional on the set of destination markets chosen by the firm. Hence, if we compare the observations obtained in our first step across time, the comparison will generally confound genuine cross-market changes in prices andmarkups across destinations, with variation due to recalculating the mean conditional on different sets of destinations. This is not necessarily a problem for a markup estimator. If the variation in the set of destinations is not driven by the exchange rate, it can be shown that an estimator that works in a balanced panel also works in an unbalanced one (see appendix). However, if the set of destination is systematically related to the exchange rate, the estimates will be biased. It is for this second case that the use of the TPSFE estimator is critical.

One difference in terms of the implementation of TPSFE with British rather than Chinese data (used by Corsetti, Crowley, Han and Song (2018)) is that the richness of British transaction level data allows us to create trade patterns conditional not only on the exporting firm and product but also on the invoicing currency. TPSFE are implemented in three steps.

1. Demean each variable in the dataset at the firm-product-invoicing currency-time level, so to express each variable as a destination-specific deviation from the mean. This step

[6] HMRC reports the value of transactions denominated in sterling and two quantity measures (net mass and quantity). We aggregate the total quantity and value at the firm-CN08product-currency-destination-year level and calculate the unit value as total value divided by the quantity with reported quantities (net mass in kilos, units, pairs, etc) and as the total sterling value divided by the net mass (in kilos) for products for which there is no specific quantity units reported.

strips out the firm's time-varying marginal production cost at the product level, as well as any global factor that is common across all the destinations a firm-product-invoicing triplet serves.

(a) For each firm-product-invoicing currency-time triplet, calculate the mean of each dependent and independent variable over all destinations the firm serves, i.e., calculate:

$$\frac{1}{n^D_{ifct}} \sum_{d \in D_{ifct}} x_{ifcdt} \quad \forall x \in \{p_{ifcdt}, e_{dt}, X_{dt}\} \tag{2}$$

where n^D_{ifct} is the number of foreign destinations for each firm-product-invoicing currency-time quartet.

(b) Remove the mean over all destinations in order to obtain the residual variation in the variable by destination:

$$\widetilde{x}_{ifcdt,D_{ifct}} = x_{ifcdt} - \frac{1}{n^D_{ifct}} \sum_{d \in D_{ifct}} x_{ifcdt} \quad \forall x \in \{p_{ifcdt}, e_{dt}, X_{dt}\} \tag{3}$$

2. Identify the trade pattern for each product sold by a firm in each time period conditional on the invoicing currency; turn this information into a "trade pattern fixed effect" that incorporates information about the destination associated with each observation as well as the set of all destinations reached by the firm-product-invoicing currency triplet in that period.

For each firm-product-invoicing currency-time (f, i, c, t) quadruple:

(a) Collect the set of destinations served:

$$\{d : p_{i'f'c'dt'} \text{ is observed} : i' = i, f' = f, c' = c, t' = t\}. \tag{4}$$

(b) Generate a string variable that identifies this set of destinations. For example, VN-KR-JP is attached to a firm f which exports product i to Vietnam, Korea, and Japan invoiced in sterling in a year t. Notationally, denote this string as D_{ifct}.

(c) Create a trade pattern fixed for each $ifcdt$ observation by appending the destination country for that observation to the front of its trade pattern string. For example, for the trade pattern fixed effects VN-VN-KR-JP, KR-VN-KR-JP and JP-VN-KR-JP, the first string is associated with a firm's shipment to Vietnam in a year in which the firm sells to Vietnam, Korea and Japan. The second string is associated with that firm's shipment to Korea in the same year, etc. Notationally, denote this trade pattern fixed effect as $TP_{d,D_{ifct}}$

3. Run a regression using destination-demeaned variables and the trade pattern fixed effects.

$$\widetilde{p}_{ifcdt,D_{ifct}} = \kappa_0 + \kappa_1 \widetilde{e}_{dt,D_{ifct}} + \widetilde{X}'_{dt,D_{ifct}} \kappa_2 + TP_{d,D_{ifct}} + \widetilde{u}_{ifcdt,D_{ifct}} \tag{5}$$

We regress prices in deviations from means on exchange rates and destination CPI with the trade-pattern fixed-effect. By doing so, we effectively 'demean' observations one more time—to make sure that, when we compare observations over time, these are always calculated as deviations from a mean from an identical set of destination markets. In other words, the comparison is 'apples-to-apples' across sets of firm-product prices in different periods.

4.2 Estimation Results

Table 10 highlights a core finding of our paper: bilateral exchange rates and local CPI movements impinge on destination-specific markup adjustment only in transactions for which the currency of invoicing is local. Conversely, exchange rates and CPI do not lead to any destination-specific adjustment when transactions fall in either the PCI or the VCI bin.

The first column, under the headline "all", shows estimates for the full sample, without conditioning on invoicing choices. In column (2), under the headline "PCI," the estimation sample is restricted to firm-product-destination transactions that are invoiced in British pounds. Similarly, in column (3) and (4), the estimation sample is restricted to firm-product-destination transactions that, respectively, are invoiced in the local, destination market currency—under the headline "LCI"; and are invoiced in a vehicle currency (VCI), primarily US dollars or euros.[7]

[7] Out of the firm-product-destination-year combinations in our regression sample that are classified as vehicle currency invoicing, 68% are invoiced in dollars and 29% are invoiced in euros. In the sample, the number of transactions that use other vehicle currencies like the Swiss franc or Japanese yen is small.

Table 10: Price and Markup Elasticities by Invoicing Currency Schemes

		(1) All	(2) PCI	(3) LCI	(4) VCI
Price	Bil. exchange rates	0.141***	0.0978***	0.529***	0.173***
		(0.0100)	(0.0121)	(0.0454)	(0.0198)
	Dest. CPI	0.232***	0.197***	1.140***	0.237***
		(0.0198)	(0.0247)	(0.270)	(0.0341)
Markup	Bil. exchange rates	0.0611***	0.0299	0.453***	-0.00456
		(0.0222)	(0.0275)	(0.0694)	(0.0535)
	Dest. CPI	0.0569	0.0445	0.698**	-0.101
		(0.0421)	(0.0533)	(0.275)	(0.0909)
	Observations	2,627,778	1,826,450	241,847	559,481

Note: This table presents price and markup elasticity estimates based on HMRC administrative customs data of UK exports to non-EU destinations during 2010-2016. Transactions are aggregated at the annual frequency; the corresponding procedures in constructing the estimation sample is detailed in the appendix. The dependent variable is the unit value denominated in pounds sterling. The bilateral exchange rate is defined as units of sterling per destination currency; an increase in the bilateral exchange rate is a depreciation of sterling. Price elasticity estimates are obtained by regressing S-period accumulated changes in sterling unit values on S-period accumulated changes in nominal bilateral exchange rates and destination CPI rates. Markup elasticities are estimated using our TPSFE estimator. Both the "Price" and the "Markup" results are estimated based on the same estimation sample. Note that constructing S-period time differenced variables may result in a smaller number of effective observations compared to fixed effect approaches as the initial year of each firm-product-invoicing currency-destination quadruple becomes a missing value when we take time differences. Robust standard errors are reported in parentheses. Statistical significance at the 1, 5 and 10 percent level is indicated by ***, **, and *.

These strong results on price elasticities and invoicing are validated by evidence on relative markups shown in the bottom panel of table 10. Here, the relevance of exchange rate and CPI changes is captured by the estimated pass through to prices. The message is unambiguous. While the effects of the exchange rate and CPI on prices are significantly different from zero for all invoicing schemes, they are much stronger for LCI transactions, compared to PCI and VCI transactions.

Comparing the two panels of table 10 highlights an advantage of our methodology for markup estimation. By controlling for the effects of marginal costs via the TPSFE, we are able to test more directly the three hypotheses spelled out at the beginning of this section—and provide more direct and unambiguous evidence in support of the view that the currency of invoicing is a good proxy for the currency in which firms set their export prices.

4.2.1 Price and Markup Elasticities at Different Time Frequencies

Relying on the TPSFE estimator, we can study whether markup elasticities depend on the frequency of our observations. In this subsection, we show results for price and markup elasticities assessed at the monthly, quarterly and annual frequencies. We do so both conditional and not conditional on a price change.

Throughout our analysis, we keep track of our estimates and compare them across the following three samples. First, we show estimates based on the "full sample" including all available transactions—whether or not we detect a product price change between successive trades, or the trade is single- or multiple-destination. Second, we restrict the sample to include only transactions that are conditional on a price change. Specifically, we filter out observations for firm-product-destination triplets (and invoicing currency when relevant) for which the absolute price change is less than 5%. We refer to this sample as "conditional on price changes." Third, starting from the latter sample, we restrict the analysis to products that are exported to at least two destinations in any time period. We refer this sample as "conditional on price changes and multi-destination trade flows."

For the sake of clarity and conciseness, we summarize our key results graphically—the tables showing the underlying estimation results are reported in the appendix. In each figure, the first three estimates refer to the entire sample (All), showing result for the annual (AllA), quarterly (AllQ) and monthly frequency (AllM). The following sets of three estimates refer to LCI, PCI and VCI, respectively, again at the three (A,Q,M) relevant frequencies.

Figure 3 presents estimates conditional on a price change in the invoicing currency. Figure 4 provides unconditional estimates for the whole sample. The graphs show that, unequivocally, elasticities within each currency-invoicing bin are not statistically different across time frequencies. The only substantial deviations from zero concern, as expected, trade invoiced in local currency. Note that in this case averages are slightly higher in the sample of transactions conditional on a price change.

Figure 3: Price and Markup Elasticities at Different Time Frequencies
(Conditional on a Price Change)

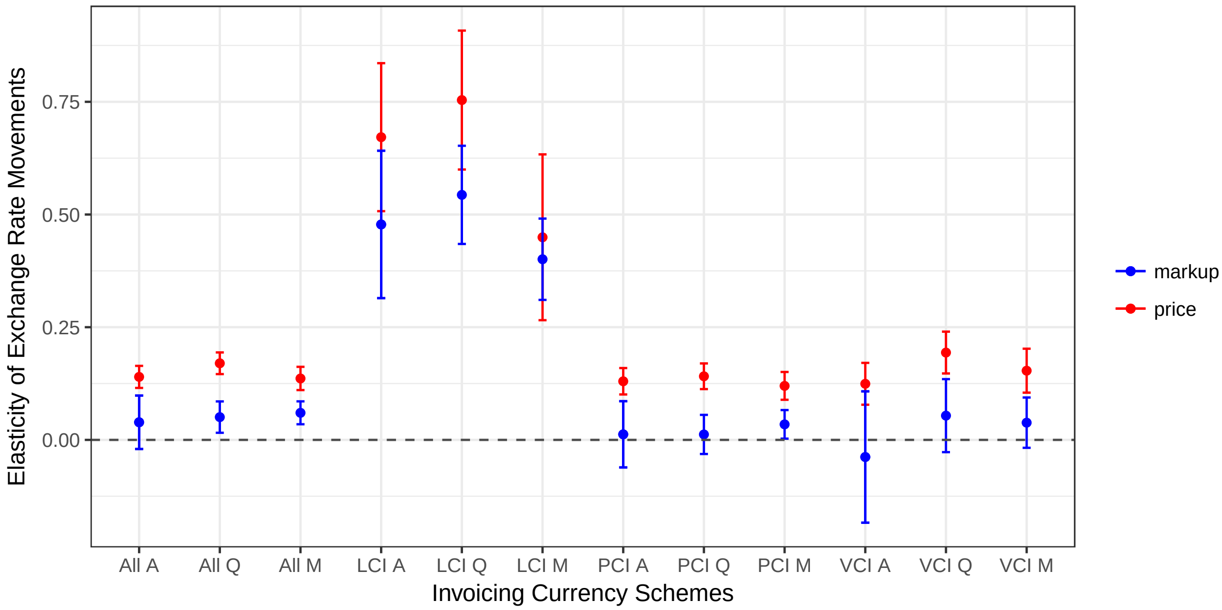

Figure 4: Price and Markup Elasticities at Different Time Frequencies
(Not Conditional on a Price Change)

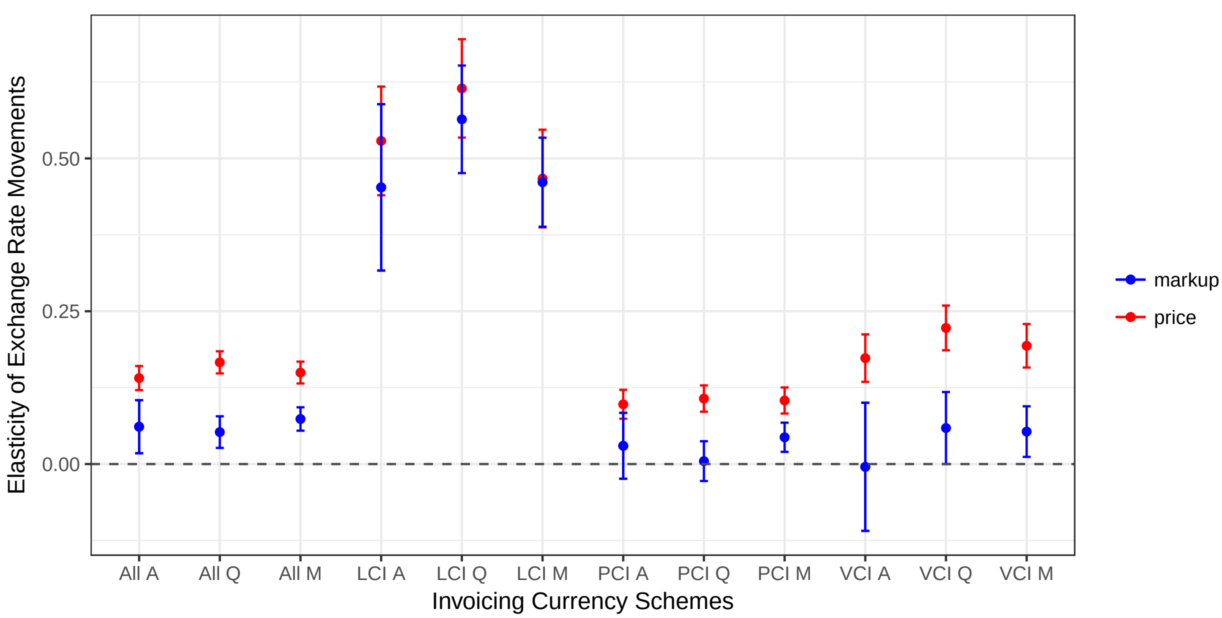

Table 11 presents the estimates for non-EU transactions, conditional on a price change. Confirming the results shown above, destination-specific markups react significantly to the exchange rate only for LCI transactions. Importantly, these LCI transactions also react to local CPI.

Table 11: Non-EU Exports: Not Conditional on a Price Change - All Destinations

		Price		Markup		
Freq.	Invoicing	NEX	CPI	NEX	CPI	n. of obs
Annual	All	0.12***	0.23***	0.06***	0.04	4,012,102
	PCI	0.10***	0.20***	0.03	0.04	1,826,450
	VCI	0.17***	0.24***	-0.01	-0.10	560,647
	LCI	0.53***	1.14***	0.45***	0.70***	241,847
Quarterly	All	0.14***	0.29***	0.05***	0.01	8,027,936
	PCI	0.11***	0.24***	0.00	-0.00	3,630,749
	VCI	0.22***	0.29***	0.06*	0.08*	1,156,735
	LCI	0.61***	0.95***	0.56***	0.69***	530,898
Monthly	All	0.13***	0.28***	0.07***	0.02	11,262,051
	PCI	0.10***	0.23***	0.04***	0.01	5,035,833
	VCI	0.19***	0.28***	0.05***	0.01	1,680,880
	LCI	0.47***	0.85***	0.46***	0.38***	844,708

Note: Estimates based on HMRC administrative customs data of UK exports to non-EU destinations during 2010-2016. The construction of the estimation sample is explained in the appendix. Statistical significance is based on robust standard errors. ***,**,* stand for 1%, 5%, and 10% significance level respectively.

We note that the statistical significance of CPI coefficients of price and markup elasticities is sensitive to the estimation sample and whether the estimates are conditioned on a price change. Table 12 shows the estimates of multi-destination exporters conditional on a price change. In general, we find the price and markup of local currency invoiced transactions consistently react more to destination market CPI changes compared to producer and vehicle currency invoiced transactions.

Table 12: Non-EU Exports: Conditional on a Price Change - Multi-destination

		Price		Markup		
Freq.	Invoicing	NEX	CPI	NEX	CPI	n. of obs
Annual	All	0.12***	0.21***	0.04**	0.03	2,452,617
	PCI	0.13***	0.23***	0.01	0.02	1,113,515
	VCI	0.13***	0.19***	-0.04	-0.20	364,795
	LCI	0.67***	1.09***	0.48***	0.27	41,202
Quarterly	All	0.15***	0.28***	0.05***	0.02	4,320,523
	PCI	0.14***	0.27***	0.01	0.02	1,926,274
	VCI	0.19***	0.28***	0.05	0.06	656,467
	LCI	0.75***	0.57	0.54***	0.81***	80,821
Monthly	All	0.12***	0.28***	0.07***	0.01	5,147,450
	PCI	0.12***	0.27***	0.03**	0.00	2,267,261
	VCI	0.15***	0.31***	0.03	0.00	820,516
	LCI	0.45***	0.29	0.40***	0.34**	96,624

Note: Estimates based on HMRC administrative customs data of UK exports during 2010-2016. The construction of the estimation sample is explained in the appendix. Statistical significance is based on robust standard errors. ***,**,* stand for 1%, 5%, and 10% significance level respectively.

4.2.2 Price and Markup Elasticities of exports to EU destinations

The EU dispatches data includes monthly records of export value and quantity at the firm-product-destination-time level for UK firms whose exports to the EU exceed £250,000 in a given calendar year. The requirement to report exports at the detailed product level applies to firms whose total value of exports exceeds the reporting threshold. A comparison with official statistics indicates that these companies account for around 96-98% of the total value of UK exports to the EU.

In constructing the estimation sample, we note that the bilateral exchange rates of EU countries that do not use euro are highly correlated with euro exchange rates. The variation of bilateral exchange rates of these countries is presented in Figure 17 in Appendix A.4. To avoid possible spurious estimates due to small deviations from the euro, the euro-sterling exchange rate is used for all EU countries, including those not in the eurozone.[8]

[8]Using bilateral exchange rates of non-eurozone countries in the EU gives very similar results on price elasticities to both bilateral exchange rate and CPI movements. It also generates consistent estimates of the markup elasticity to destination CPI movements. However, it may result in spurious negative markup

Table 13: EU Destinations: Conditional on a Price Change - Multi-destination

	Price		Markup		
Freq.	NEX	CPI	NEX	CPI	n. of obs
Annual	0.39***	1.01***	-	0.81***	6,337,540
Quarterly	0.39***	1.13***	-	0.83***	15,682,483
Monthly	0.34***	1.13***	-	0.92***	29,256,147

Note: Estimates based on HMRC administrative customs data of UK exports to EU destinations during 2010-2016. Euro exchange rates are used for all EU destinations. The construction of the estimation sample is explained in the appendix. Statistical significance is based on robust standard errors. ***,**,* stand for 1%, 5%, and 10% significance level respectively.

Table 13 shows the estimates based on the sample of EU transactions by multi-destination exporters conditional on a price change. As can be seen in the table, the price elasticities to both the bilateral exchange rate and destination markets' CPI changes are significantly higher than the estimates of non-EU transactions pooling together all invoicing choices (the "All" row of Table 12). In fact, we find these EU estimates of price elasticities show a pattern that is very similar to those of local currency invoiced non-EU transactions. More importantly, when we apply our TPSFE estimator to estimate the markup elasticities, the destination-specific markup adjustments to a local market's CPI changes are high. Moreover, they resemble the estimated values of the markup elasticities to local market CPI changes for non-EU transactions invoiced in local currency. A similar pattern is found for the sample of observations that is not conditional on multi-destination exporters and price changes (see Table 15 in the appendix).

Our last exercise is to understand how much the estimates would differ if only non-EU transactions were used to infer aggregate price and markup elasticities. Table 14 shows estimates based on transactions to non-EU countries versus all destinations. As can be seen in the table, including EU countries in the estimation sample almost doubles the price elasticities. Similarly, while including EU countries only has a small impact on the estimated markup elasticity to exchange rates, the markup response to a local market's CPI changes increases dramatically.

coefficients on exchange rates.

Table 14: Non-EU versus All Destinations
Estimation Sample: Conditional on a Price Change - Multi-destination

		Price		Markup		
Freq.	Exports	NEX	CPI	NEX	CPI	n. of obs
Annual	Non-EU	0.12***	0.21***	0.04**	0.03	2,452,617
	All countries	0.26***	0.47***	0.01	0.21***	8,790,157
Quarterly	Non-EU	0.15***	0.28***	0.05***	0.02	4,320,523
	All countries	0.27***	0.53***	0.04***	0.31***	20,003,006
Monthly	Non-EU	0.12***	0.28***	0.07***	0.01	5,147,450
	All countries	0.25***	0.60***	0.09***	0.48***	34,403,597

Note: Estimates based on HMRC administrative customs data of UK exports during 2010-2016. The construction of the estimation sample is explained in the appendix. Statistical significance is based on robust standard errors. ***,**,* stand for 1%, 5%, and 10% significance level respectively.

5 Conclusion

In this paper, we study the relationship between firms' invoicing and pricing decisions using highly disaggregated transaction-level data of UK firms. On the invoicing side, we document three new facts. First, the aggregate share of each invoicing scheme (i.e., PCI, VCI and LCI) is stable over time. Second, firms which sell more products and to more destinations use vehicle currencies and local currencies relatively more often. Relatedly, the majority of trade values are conducted by multi-currency exporters. Third, at the highly disaggregated level, we find a substantial degree of switching between invoicing currencies for exports but not for imports.

On the pricing side, we provide supporting evidence that the choice of invoicing currencies is closely related to firms' pricing strategies. We find that neither vehicle nor producer currency invoiced transactions do destination-specific markup adjustments. In contrast, for local currency invoiced transactions, we find large and significant markup adjustments to changes in bilateral exchange rates and CPI indices of the destination market.

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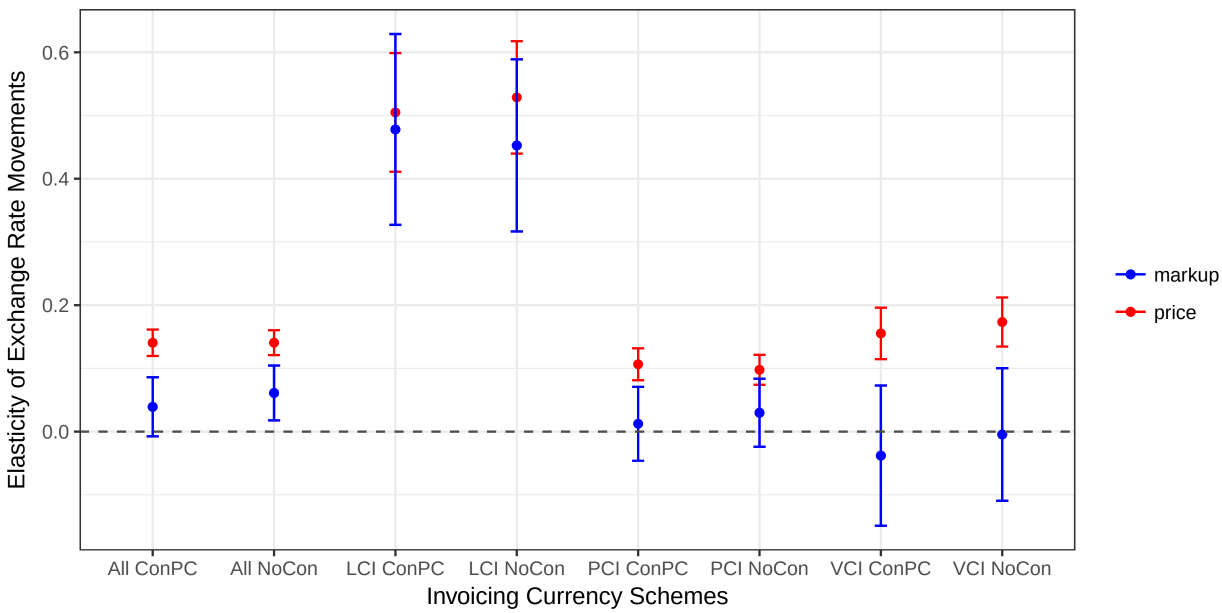
A Robustness Checks and Additional Statistics

A.1 Estimates not conditional on price changes

This appendix provides a direct comparison among estimates conditional and not conditional on a price change in the currency of invoicing. The main finding is that estimates are quantitatively very similar. Essentially, our comparisons show that dropping these ‘sticky price’ (no-price change) transactions has no substitutional impact on exchange rate pass through estimations.[9]

Figure 5: Conditional versus Not Conditional on Prices Changes - Annual Frequency



[9]Even if some price changes arise from compositional errors associated with using unit values in lieu of prices, transactions with no price change from the previous period most likely reflect nominal or real rigidities. Note that the change in composition over time may not necessarily bias the our TPSFE estimator. As discussed in Corsetti, Crowley, Han and Song (2018), the compositional error only has second order effects on exchange rate pass through estimates and the predicted bias is zero for a large number of cases.

Figure 6: Conditional versus Not Conditional on Prices Changes - Quarterly Frequency

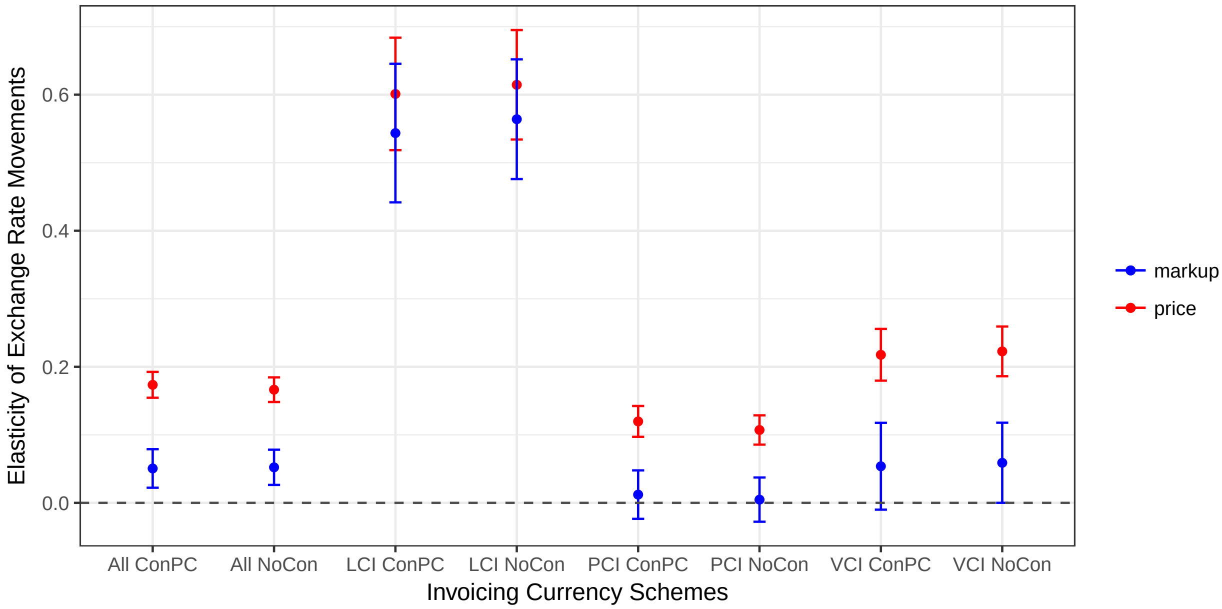


Figure 7: Conditional versus Not Conditional on Prices Changes - Monthly Frequency

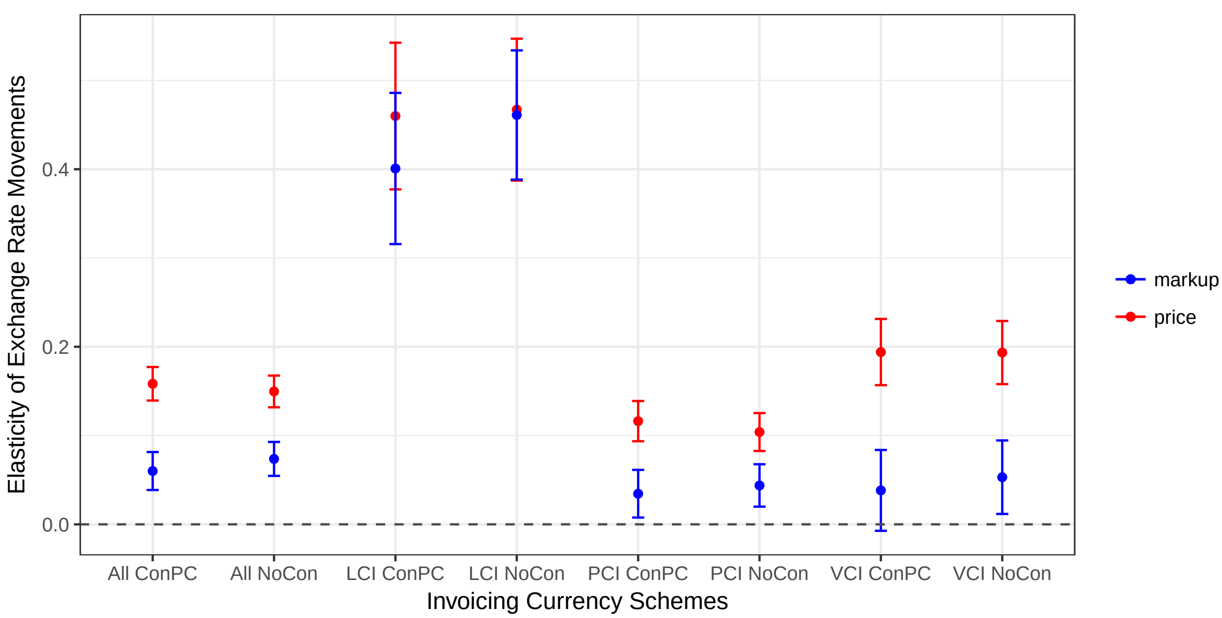


Table 15: EU versus Non-EU Exports: Not Conditional on a Price Change - All Destinations

		Price		Markup		
Freq.	Exports	NEX	CPI	NEX	CPI	n. of obs
Annual	EU	0.32***	0.98***	-	0.80***	8,025,030
	Non-EU	0.12***	0.23***	0.06***	0.04	4,012,102
	All	0.22***	0.42***	0.00	0.12***	12,037,132
Quarterly	EU	0.35***	0.98***	-	0.81***	21,623,598
	Non-EU	0.14***	0.29***	0.05***	0.01	8,027,936
	All	0.23***	0.46***	0.01	0.18***	29,651,534
Monthly	EU	-	-	-	-	-
	Non-EU	0.13***	0.28***	0.07***	0.02	11,262,051
	All	-	-	-	-	-

Estimates based on HMRC administrative customs data of UK exports during 2010-2016. The trade pattern is created based on firm-product patterns not conditional on the invoicing choice. The construction of each estimation sample is explained in the appendix. Statistical significance is based on robust standard errors. ***,**,* stand for 1%, 5%, and 10% significance level respectively.

Note that some categories of the monthly sample could not be estimated, because the memory required for the estimation process exceeded the 32GB available on HMRC Datalab computers at the time of the work.

A.2 Distribution of Prices Changes

Table 16: Invoicing Scheme and Magnitude of Price Changes (Non-EU Exports)

	Invoicing Scheme			
Magnitude of price changes	LCI	PCI	VCI	Total
Non-weighted				
No Change	0.0	1.7	0.0	1.0
Less than 1%	3.4	5.8	5.1	5.2
1% to 5%	8.8	11.3	10.7	10.8
5% to 10%	9.5	12.1	11.2	11.4
10% to 30%	17.7	18.5	18.2	18.3
30% to 50%	16.3	15.7	16.3	15.9
50% to 100%	20.4	17.5	18.7	18.3
Larger than 100%	23.8	17.4	19.8	19.0
Total	100.0	100.0	100.0	100.0
Trade-weighted				
No Change	0.0	0.1	0.0	0.1
Less than 1%	2.2	2.6	2.8	2.6
1% to 5%	4.9	9.9	9.3	8.8
5% to 10%	7.3	10.5	8.7	9.4
10% to 30%	16.1	24.2	21.2	21.9
30% to 50%	16.0	15.9	19.8	16.9
50% to 100%	21.8	17.2	19.8	18.7
Larger than 100%	31.8	19.7	18.4	21.7
Total	100.0	100.0	100.0	100.0

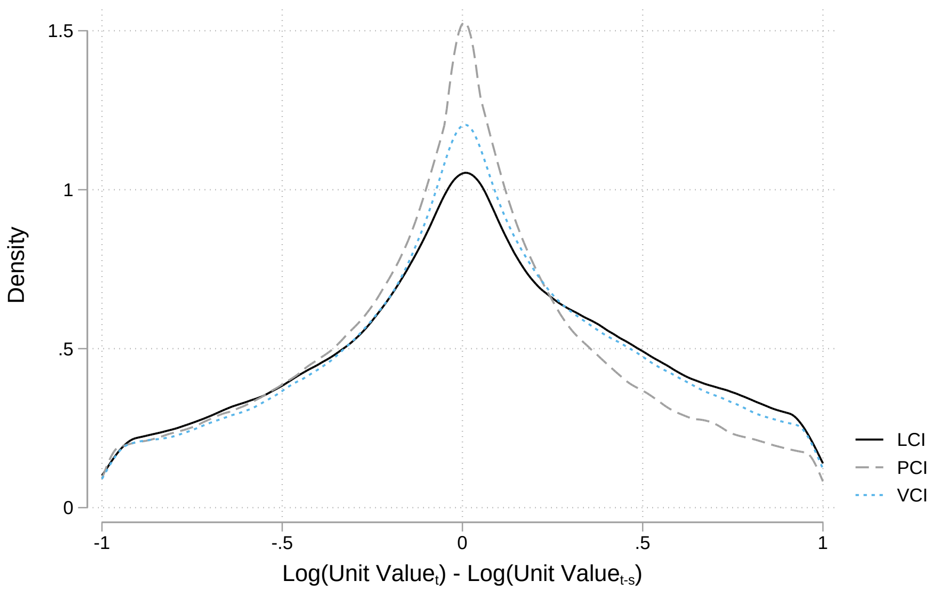
Table (16) shows the magnitude of price changes (measured by the invoicing currency) by invoicing currency schemes. All transactions in the HMRC customs data are recorded in sterling. We calculate the corresponding unit value denominated in the invoicing currency using the bilateral exchange rate between sterling and the recorded invoicing currency for the month/year in which the transaction is logged. In all our calculations, the unit value is calculated using trade value divided by quantity[10]

A few features of the data deserve attention. First, the probability of no price change is marginally higher for PCI transactions. Second, note the asymmetry of price changes

[10] Supplementary units are used as the measure of quantity, i.e., units, pairs, cubic meters, etc., for products that report both supplementary units and netmass. Netmass is used as the quantity measure if not supplementary units are reported.

across invoicing currency schemes. On the negative side of the chart (price decreases), the distribution nicely overlaps for LCI PCI and VCI. On the positive side of the graph, PCI and VCI transactions have marginally more mass than LCI. These patterns are confirmed by all the following density graphs. In particular, when we plot densities controlling for time "gaps" between trades, the peak of density at no price change become smaller disappears with the size of the gap. Also, the distributions flatten out—without however becoming symmetric.

Figure 8: Distribution of Annual Price Changes of Non-EU Exports



Note: Density is calculated only if -1 < Log(Unit Value$_t$) - Log(Unit Value$_{t-s}$) < 1

Figure 9: Distribution of Annual Price Changes of Non-EU Exports by Gaps between Two Trade Observations, $s = 1, 2, ...$

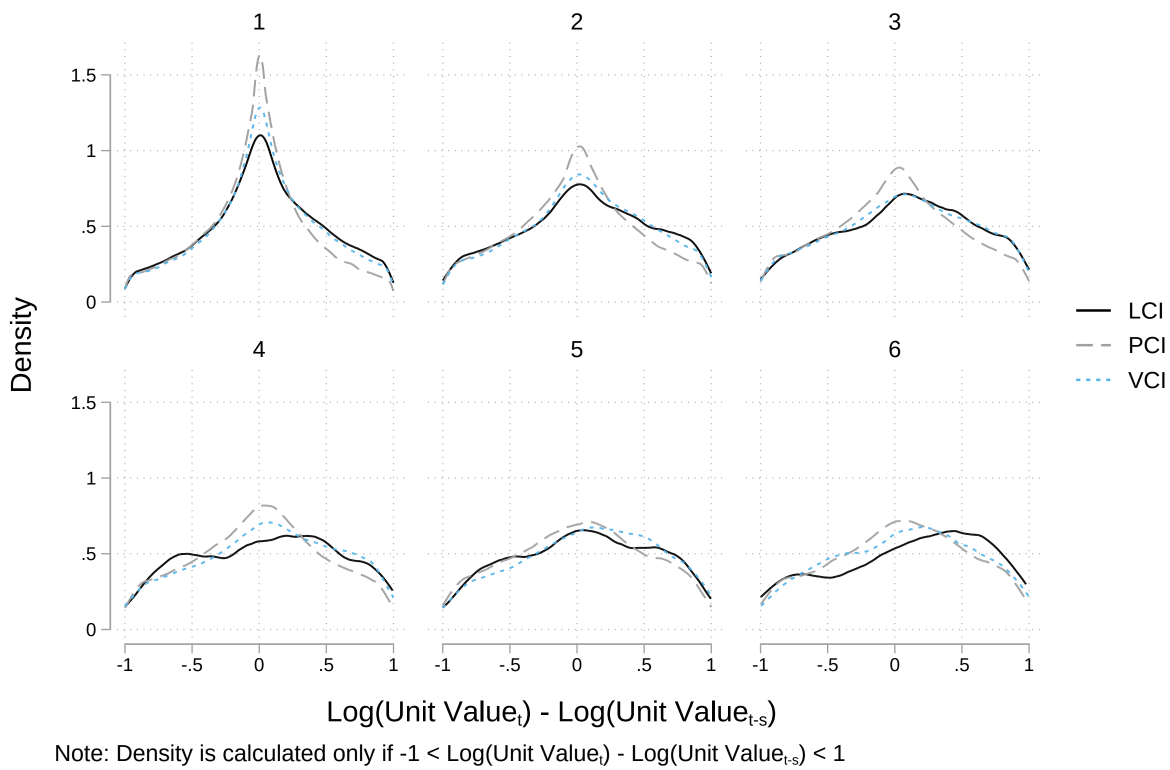


Figure 10: Distribution of Monthly Price Changes of Non-EU Exports

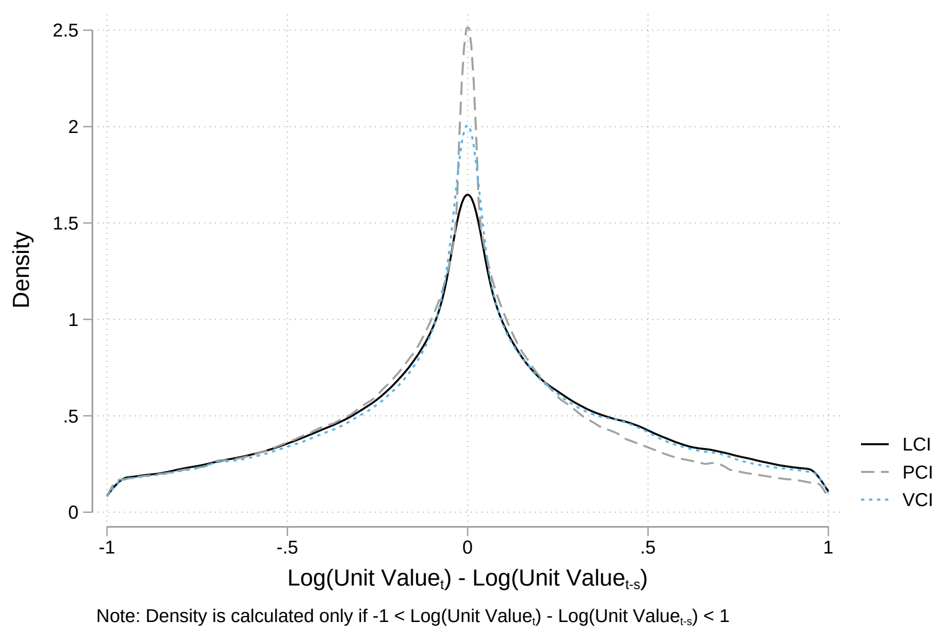


Figure 11: Distribution of Monthly Price Changes of Non-EU Exports by Gaps between Two Trade Observations, $s = 1, 2, \ldots$

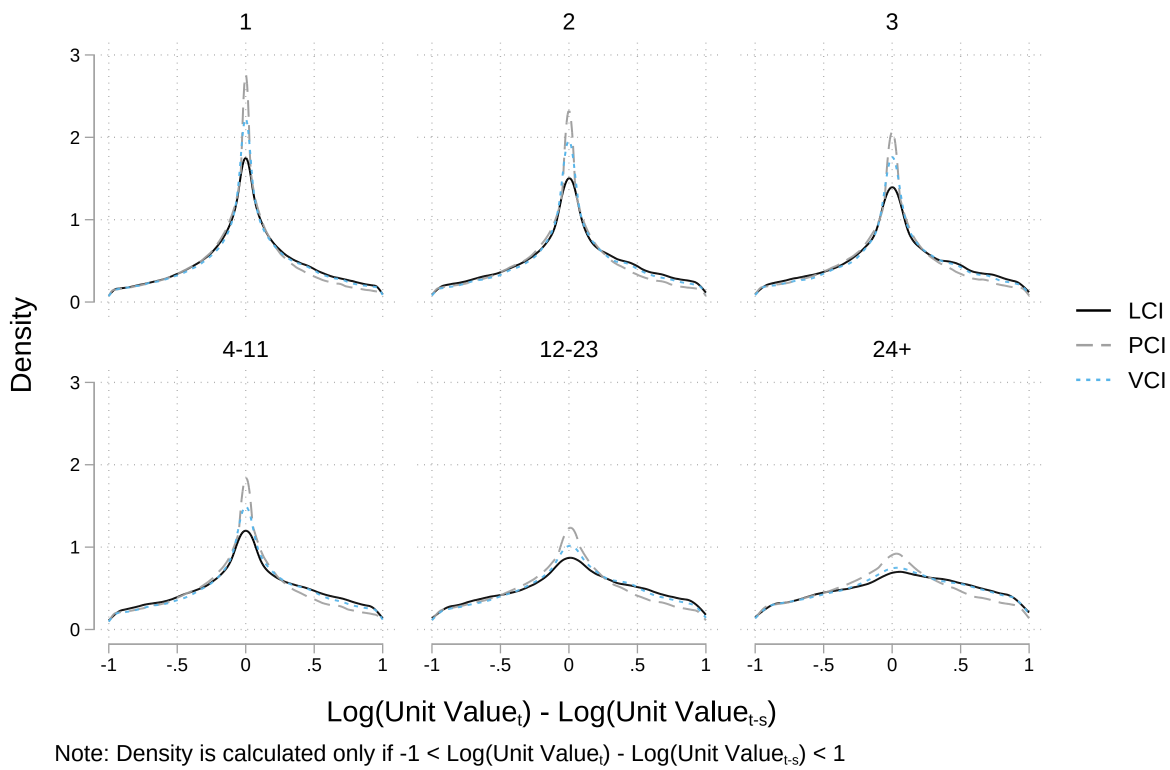


Figure 12: Distribution of Annual Price Changes of non-EU Imports

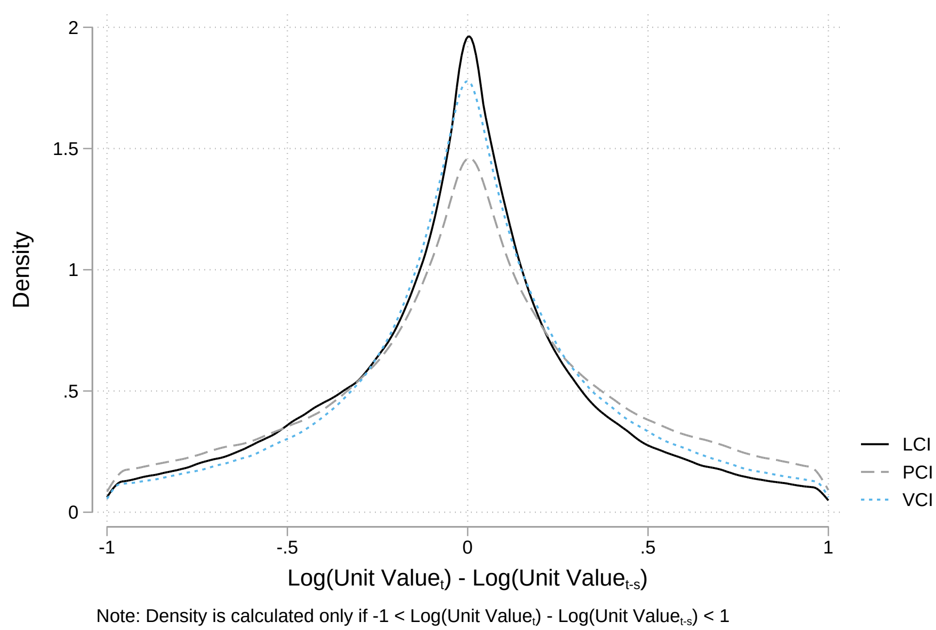


Figure 13: Distribution of Monthly Price Changes of non-EU Imports

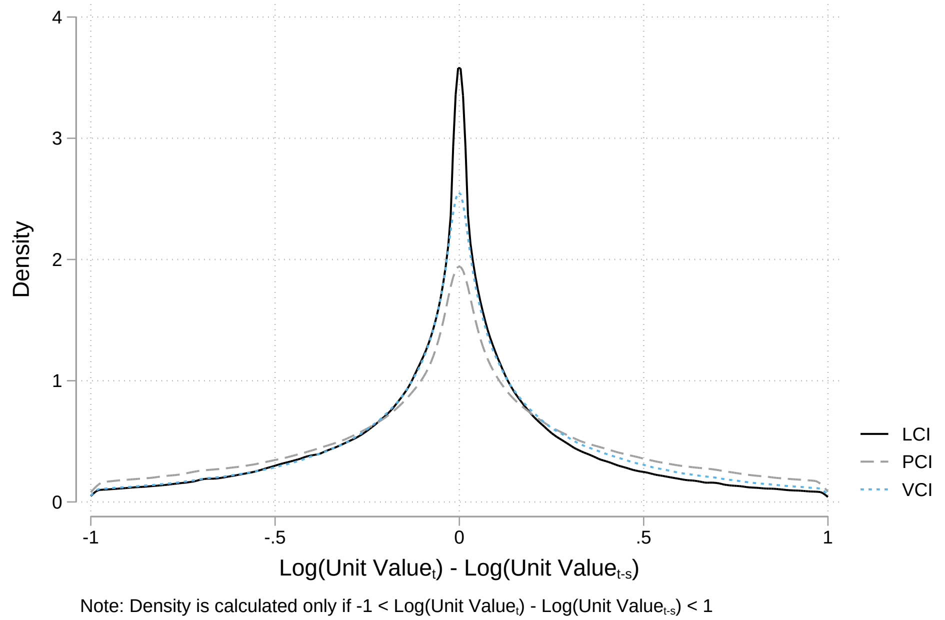


Figure 14: Distribution of Annual Price Changes of non-EU Imports by Gaps between Two Trade Observations, $s = 1, 2, ...$

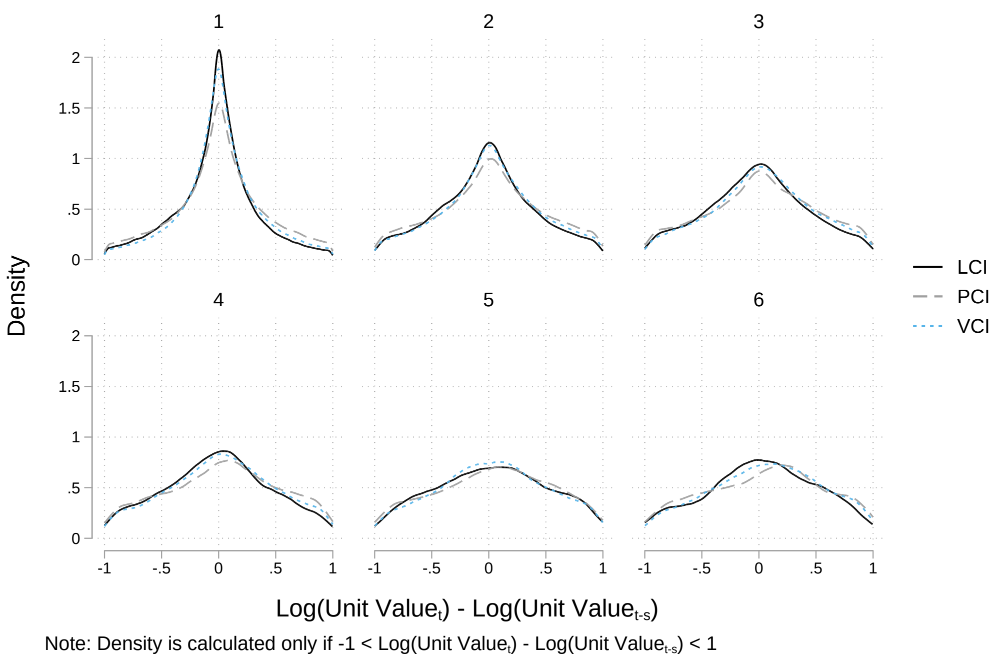
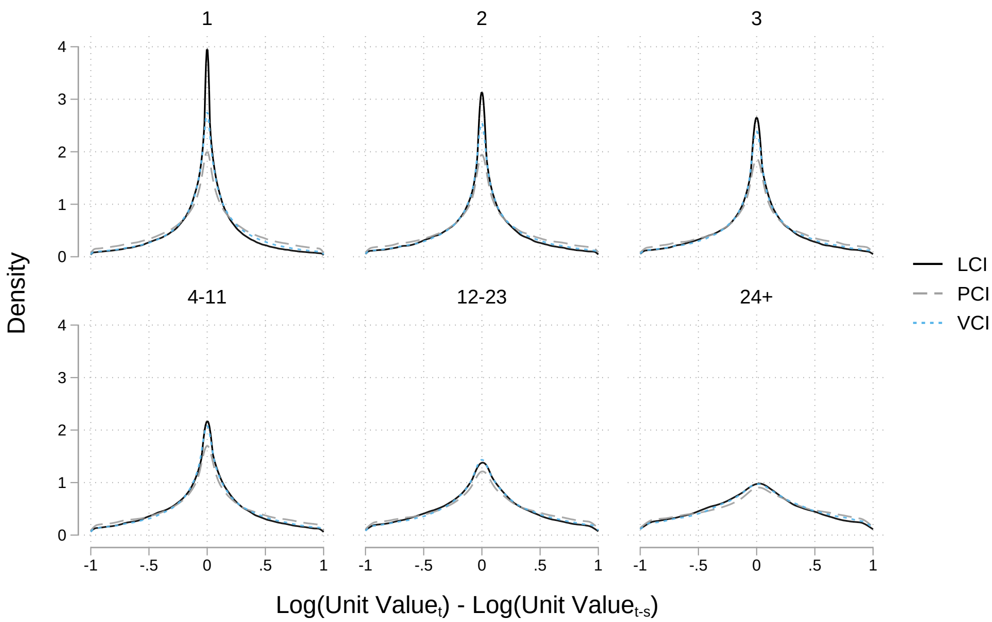


Figure 15: Distribution of Monthly Price Changes of non-EU Imports by Gaps between Two Trade Observations, $s = 1, 2, ...$



Note: Density is calculated only if -1 < Log(Unit Value$_t$) - Log(Unit Value$_{t\text{-}s}$) < 1

A.3 Additional Statistics on Invoicing Currencies

Figure 16 presents top invoicing currencies for non-EU exports during 2010-2016.

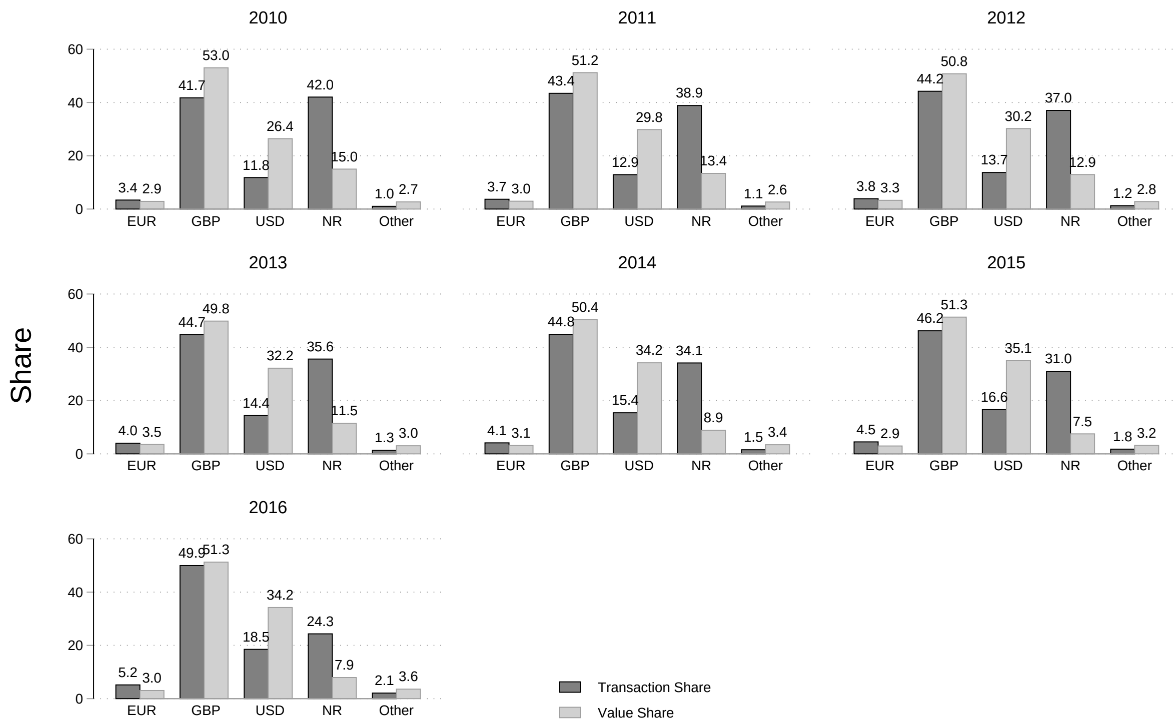


Figure 16: Top invoicing currencies for non-EU exports

Note: Black bars indicate the invoicing share by the number of transactions. Grey bars indicate the share by total trade values.

The share of export value invoiced in US dollars appears to rise from 26.4% in 2010 to 34.2% in 2016. The share of export transactions invoiced in dollars has also crept up over this time period, from 11.8% in 2010 to 18.5% in 2016. The rise in the share of dollar-invoiced exports and the decline in the share of export transactions with no reported currency appear to be related. The rise in relative importance of dollar invoicing is likely due to more and more transactions hitting the £100,000 requirement to report their invoicing currency. It is possible that the majority, if not all, of the transactions for which no currency is reported were invoiced in dollars, but the exported did not report this fact until the size of the shipments hit the £100,000 reporting threshold. Over 2010-2016, the value of British exports reportedly invoiced in US dollars or not reported is stable around 42%.

Table 17: Invoicing currency table (exports)

	LCI	%	PCI	%	VCI	%	Total	%
2010	43,280.0	0.8	462,987.0	8.9	136,668.0	2.6	642,935.0	12.4
2011	45,793.0	0.9	456,673.0	8.8	140,302.0	2.7	642,768.0	12.4
2012	50,081.0	1.0	475,508.0	9.2	151,903.0	2.9	677,492.0	13.1
2013	55,027.0	1.1	512,586.0	9.9	170,558.0	3.3	738,171.0	14.3
2014	61,187.0	1.2	518,185.0	10.0	182,165.0	3.5	761,537.0	14.7
2015	73,614.0	1.4	540,385.0	10.4	193,701.0	3.7	807,700.0	15.6
2016	88,857.0	1.7	599,777.0	11.6	220,180.0	4.3	908,814.0	17.5
Total	417,839.0	8.1	3,566,101.0	68.9	1,195,477.0	23.1	5,179,417.0	100.0

Table 18: Invoicing currency table (imports)

	LCI	%	PCI	%	VCI	%	Total	%
2010	175,083.0	2.6	273,845.0	4.1	509,616.0	7.6	958,544.0	14.2
2011	162,829.0	2.4	242,392.0	3.6	483,587.0	7.2	888,808.0	13.2
2012	164,700.0	2.4	240,586.0	3.6	493,691.0	7.3	898,977.0	13.4
2013	170,465.0	2.5	252,525.0	3.8	526,415.0	7.8	949,405.0	14.1
2014	176,742.0	2.6	249,094.0	3.7	551,706.0	8.2	977,542.0	14.5
2015	178,232.0	2.6	251,448.0	3.7	572,356.0	8.5	1,002,036.0	14.9
2016	186,378.0	2.8	262,616.0	3.9	604,180.0	9.0	1,053,174.0	15.7
Total	1,214,429.0	18.0	1,772,506.0	26.3	3,741,551.0	55.6	6,728,486.0	100.0

A.3.1 Breakdown of Invoicing Choices of Non-EU Imports

Table 19: Number of Destinations v.s. Invoicing Currencies (Non-EU Imports)

	No. of Invoicing Currencies				
No. of Destinations	1	2-5	6-10	10+	Total
Share of Firms					
1	49.2	5.1	0.0	0.0	54.3
2-5	13.3	22.3	0.0	0.0	35.6
6-10	0.3	5.8	0.4	0.0	6.6
10+	0.0	1.8	1.4	0.2	3.5
Total	62.9	35.0	1.9	0.2	100.0
Trade-weighted					
1	1.5	0.9	0.0	0.0	2.4
2-5	1.4	9.0	0.0	0.0	10.4
6-10	0.3	9.2	2.5	0.0	12.0
10+	0.4	17.3	25.1	32.5	75.3
Total	3.5	36.3	27.7	32.5	100.0

Table 20: Number of Products v.s. Invoicing Currencies (Non-EU Imports)

	No. of Invoicing Currencies				
No. of Products	1	2-5	6-10	10+	Total
Share of Firms					
1	33.3	1.4	0.0	0.0	34.7
2-5	21.4	12.2	0.0	0.0	33.6
6-10	4.7	7.1	0.1	0.0	11.8
10+	3.5	14.3	1.8	0.2	19.8
Total	62.9	35.0	1.9	0.2	100.0
Trade-weighted					
1	1.1	0.6	0.0	0.0	1.8
2-5	0.9	3.8	0.0	0.0	4.7
6-10	0.5	2.9	0.1	0.0	3.6
10+	0.9	29.0	27.6	32.4	89.9
Total	3.5	36.3	27.7	32.5	100.0

Table 21: Number of Products v.s. Destinations (Non-EU Imports)

	No. of Destinations				
No. of Products	1	2-5	6-10	10+	Total
Share of Firms					
1	33.1	1.6	0.0	0.0	34.7
2-5	16.8	16.6	0.2	0.0	33.6
6-10	2.8	8.2	0.8	0.1	11.8
10+	1.6	9.3	5.6	3.4	19.8
Total	54.3	35.6	6.6	3.5	100.0
Trade-weighted					
1	1.0	0.3	0.4	0.1	1.8
2-5	0.6	3.3	0.5	0.2	4.7
6-10	0.3	1.4	1.0	0.8	3.6
10+	0.4	5.3	10.1	74.2	89.9
Total	2.4	10.4	12.0	75.3	100.0

Table 22: Invoicing Scheme and Number of Destinations (Non-EU Imports)

	Invoicing Scheme			
No. of Destinations	LCI	PCI	VCI	Total
Share of Firms				
1	9.9	12.4	20.0	42.3
2-5	12.2	12.5	20.4	45.2
6-10	2.9	2.9	3.3	9.1
10+	1.1	1.1	1.2	3.5
Total	26.2	29.0	44.8	100.0
Trade-weighted				
1	2.6	0.7	2.0	5.3
2-5	5.0	2.8	9.5	17.3
6-10	3.1	2.6	9.7	15.5
10+	13.1	14.3	34.5	61.9
Total	23.8	20.4	55.7	100.0

Table 23: Invoicing Scheme and Number of Products (Non-EU Imports)

	Invoicing Scheme			
No. of Products	LCI	PCI	VCI	Total
Share of Firms				
1	5.5	7.5	12.6	25.6
2-5	9.2	10.6	16.8	36.5
6-10	4.3	4.3	6.5	15.1
10+	7.3	6.6	9.0	22.9
Total	26.2	29.0	44.8	100.0
Trade-weighted				
1	1.6	0.2	1.6	3.3
2-5	2.1	1.2	4.2	7.5
6-10	2.1	1.2	3.8	7.0
10+	18.1	17.9	46.2	82.2
Total	23.8	20.4	55.7	100.0

A.4 Bilateral Exchange Rate and CPI variation of the EU sample

Figure 17: Bilateral exchange rates of EU countries that do not use Euro

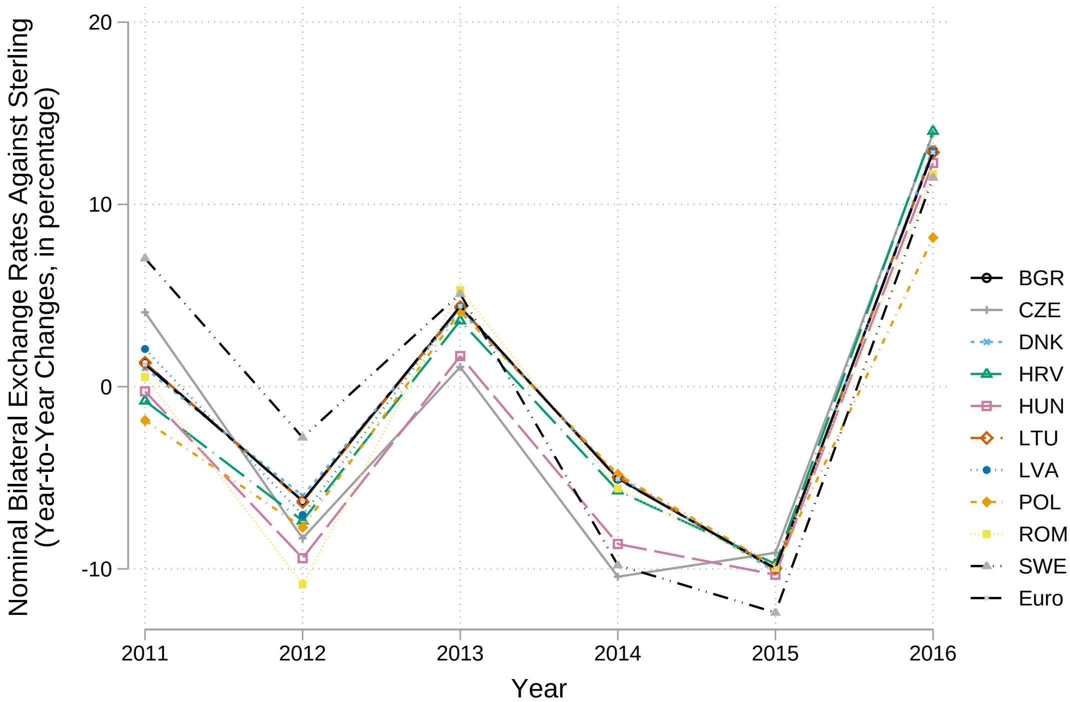
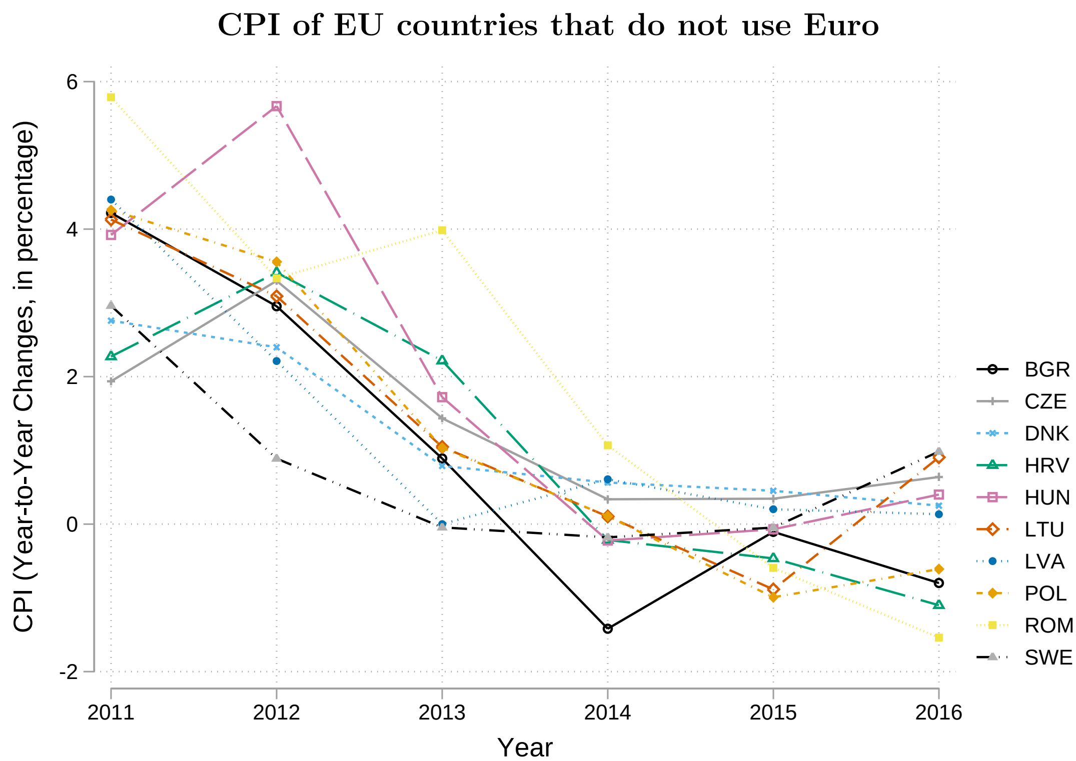
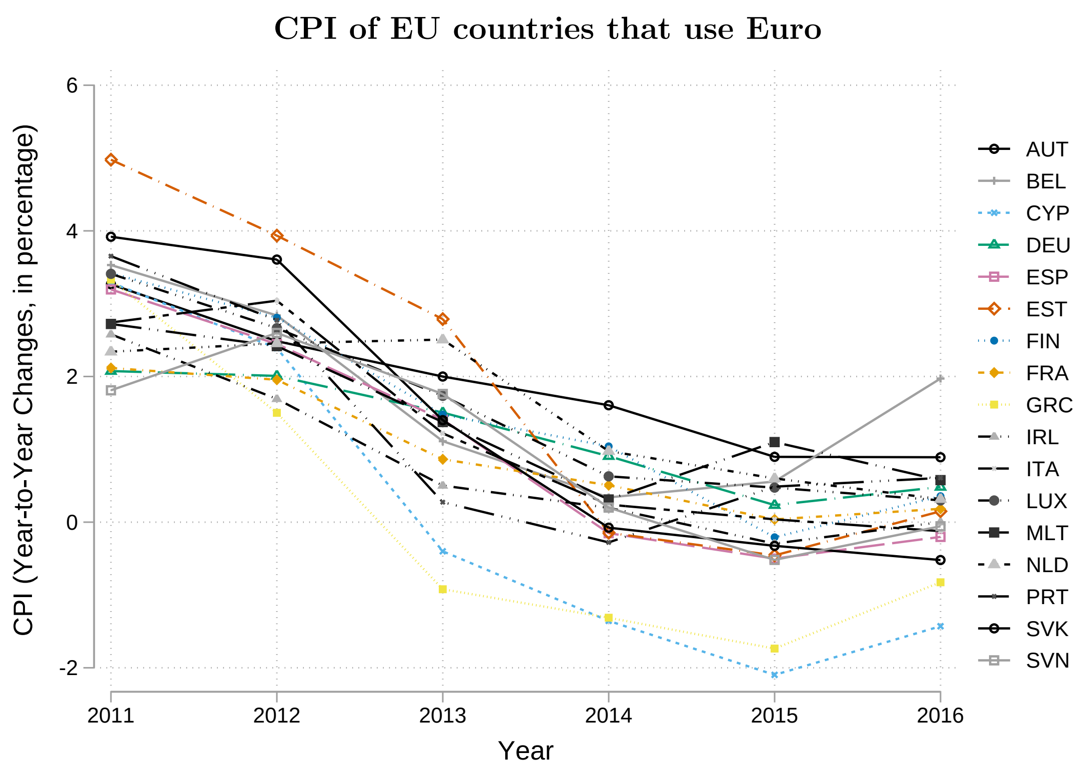


Figure 18: CPI of EU countries are less synchronized compared to their exchange rates





B Note on the construction of estimation samples

1. Starting from the universe of trade transactions

   - For constructing annual and quarterly samples, transactions are aggregated at the firm-commode-destination-support unit-invoicing currency-time level. The corresponding number of observations is reported in the next subsection.

2. Match with the country concordance tables:

   - HMRC uses its internal country coding system which is different from the ISO standard adopted by most international organizations. To import external macroeconomic series (such as exchange rates, CPI, etc.), we need to match the internal coding system of HMRC with international standard country codes. Specifically, we create the concordance table by matching strings of countries names between these two coding systems.

3. Merge with series of bilateral exchange rates (defined as LCU per sterling)

   - In the matching process, 29 destinations are not matched: Ceuta and Mellila[11], Vatican City (code 45), Western Sahara (code 206, affected years 2013-2016), South Sudan (code 225, affected years 2013-2016), Ivory Coast (code 272, affected years 1996-2016), St Helena (code 329, affected years 1996-2016), Mayotte (code 377, affected years 1996-2013), Bonaire (code 475, affected years 2013-2016), Curacao (code 476, affected years 2013-2016), Saint Maarten (477, affected years 2013-2016), Saint Bartholomew (478 and 479, affected years 1996-2016), Timur-Leste (code 699, affected years 2001-2016), Austral Oceania (code 802, affected years 1996-2000), US Oceania (code 810, affected years 1996-2000), French Polynesia (code 822, affected years 1996-2016), Guam (code 831, affected years 2001-2016), US Minor Islands (code 832, affected years 2001-2016), Heard & McDonald (code 835, affected years 2001-2016), Polar Regions (code 890, affected years 1997-2000), Antarctica (code 891, affected years 2001-2016), Bouvet Island (code 892, affected years 2001-2016), South Georgia Island (code 893, affected years 2001-2012), French Southern Territory (code 894, affected years 2001-2016), Abu Dhabi (code 914, affected years 1996-2016), Dubai (code 917, affected years 1996-2016), Sharjah Etc (code 920, affected years 1996-2016), Niue Island (code 923, affected

[11] No match is found from the ISO coding system. In addition, the internal code for these two destinations has changed in the year 1999. Ceuta and Mellila shared the same code (21) during the period 1996-1998. From 1999 onwards, the internal code of Ceuta and Mellila is 22 and 23 respectively.

years 2001-2016), Cook Islands (code 926), Stores & Provis. (code 951 and 952, affected years 2015-2016).

4. Merge with other macro variables, e.g., CPI, real GDP and import-to-GDP ratio; Handle formats of comcodes
   - Some datasets report comcodes as a numeric variable, while others report comcodes at a string variable. We use string formats and add zero in front of the numeric variables if necessary.
   - The comcodes in earlier years are reported as 8-digits and those in later years are reported with 15-digits. Those 15-digit codes do not contain more information on the substance of the product but merely add details on the tax and tariff codes of the related product. We use 8-digit measures throughout our analysis.
5. Convert concordance tables; Drop inconsistent product definitions; Detailed procedures to be added.
6. Checking for entry errors; integrate information on exchange rates of the reported invoicing currency of the transaction; Drop Non-EU exports with no invoicing currency reported; Allocate transactions into bins of invoicing currency schemes.
7. Drop duplicates at the firm-comcode-country-invoicing scheme-time level.
8. Drop the observation if its unit value or associated bilateral exchange rates or CPI is missing.
9. Drop firm-comcode-destination-invoicing scheme quartets that do not survive over two time periods. .
10. Same as above. This step constructs variables necessary for the TPSFE estimator. Save as the "full sample."
11. Starting from stage 9, filter out absolute price changes that are less than 5% at the firm-comcode-destination-invoicing scheme level.
12. Same as above. This step constructs variables necessary for the TPSFE estimator. Save as "the sample conditional on price changes."
13. Starting from stage 11, drop firm-comcode-invoicing scheme-time quartets that sell to less than two destinations.

14. Same as above. This step constructs variables necessary for the TPSFE estimator. Save as "the sample conditional on price changes and multi-destination trade flows."

B.1 Note on the observations in each stage of the data cleaning process

Table 24: Non-EU Exports – Annual Sample

Stage	Observations	Trade Value (million)	Firms	Comcodes	Countries	Currencies	Years
1	7,932,705	991,386	159,512	10,126		132	7
2	7,905,089	989,980	159,328	10,122	191	132	7
3	7,891,780	989,355	159,212	10,122	173	131	7
4	7,891,780	989,355	159,212	10,032	173	131	7
5	7,797,074	955,528	158,688	9,018	173	129	7
6	5,111,705	850,373	133,712	8,918	173	127	7
7	5,043,959	821,023	133,684	8,918	173	118	7
8	4,772,069	806,463	130,472	8,890	153	118	7
9	2,628,944	718,028	56,002	7,946	153	87	7
10	2,628,944	718,028	56,002	7,946	153	87	7
11	2,437,591	605,287	56,002	7,946	153	87	7
12	2,437,591	605,287	56,002	7,946	153	87	7
13	1,519,512	447,357	22,559	5,947	153	78	7
14	1,519,512	447,357	22,559	5,947	153	78	7

Table 25: Non-EU Exports – Quarterly Sample

Stage	Observations	Trade Value (million)	Firms	Comcodes	Countries	Currencies	Years
1	11,905,551	991,386	159,512	10,126		132	7
2	11,868,253	989,980	159,328	10,122	191	132	7
3	11,838,437	988,523	159,157	10,122	168	131	7
4	11,838,437	988,523	159,157	10,032	168	131	7
5	11,688,448	954,700	158,633	9,018	168	129	7
6	7,733,815	849,653	133,669	8,918	168	127	7
7	7,666,600	834,999	133,657	8,918	168	120	7
8	7,277,246	820,734	130,506	8,890	155	120	7
9	5,318,382	762,816	64,845	8,169	155	95	7
10	5,318,382	762,816	64,845	8,169	155	95	7
11	4,747,788	590,516	64,845	8,169	155	95	7
12	4,747,788	590,516	64,845	8,169	155	95	7
13	2,663,562	388,755	23,053	5,987	155	86	7
14	2,663,562	388,755	23,053	5,987	155	86	7

Table 26: Non-EU Exports – Monthly Sample

Stage	Observations	Trade Value (million)	Firms	Comcodes	Countries	Currencies	Years
1	15,987,198	991,386	159,512	10,126		132	7
2	15,941,259	989,980	159,328	10,122	191	132	7
3	15,898,746	988,152	159,121	10,121	166	131	7
4	15,898,746	988,152	159,121	10,031	166	131	7
5	15,690,921	954,330	158,596	9,017	166	129	7
6	10,487,625	849,326	133,637	8,918	166	127	7
7	10,425,024	841,279	133,630	8,918	166	124	7
8	9,354,802	803,446	127,002	8,876	148	123	7
9	7,561,421	754,037	65,757	8,205	148	100	7
10	7,561,421	754,037	65,757	8,205	148	100	7
11	6,603,149	557,650	65,757	8,205	148	100	7
12	6,603,149	557,650	65,757	8,205	148	100	7
13	3,184,401	319,293	19,761	5,652	148	88	7
14	3,184,401	319,293	19,761	5,652	148	88	7

Table 27: EU Exports – Annual Sample

Stage	Observations	Trade Value (million)	Firms	Comcodes	Countries	Currencies	Years
1	9,594,936	997,039	35,751	10,249		1	7
2	9,594,884	996,694	35,751	10,249	27	1	7
3	9,594,884	996,694	35,751	10,249	27	1	7
4	9,594,884	996,694	35,751	10,249	27	1	7
5	9,446,542	949,702	35,513	9,126	27	1	7
6	9,446,542	949,702	35,513	9,126	27	1	7
7	9,406,767	944,428	35,511	9,126	27	1	7
8	9,386,396	944,178	35,454	9,126	27	1	7
9	8,025,030	916,433	27,054	8,802	27	1	7
10	8,025,030	916,433	27,054	8,802	27	1	7
11	7,241,934	724,675	27,054	8,802	27	1	7
12	7,241,934	724,675	27,054	8,802	27	1	7
13	6,337,540	640,892	21,586	8,123	27	1	7
14	6,337,540	640,892	21,586	8,123	27	1	7

Table 28: EU Exports – Quarterly Sample

Stage	Observations	Trade Value (million)	Firms	Comcodes	Countries	Currencies	Years
1	23,139,761	997,039	35,751	10,249		1	7
2	23,139,632	996,694	35,751	10,249	27	1	7
3	23,139,632	996,694	35,751	10,249	27	1	7
4	23,139,632	996,694	35,751	10,249	27	1	7
5	22,765,833	949,702	35,513	9,126	27	1	7
6	22,765,833	949,702	35,513	9,126	27	1	7
7	22,708,415	946,944	35,512	9,126	27	1	7
8	22,658,638	946,521	35,455	9,126	27	1	7
9	21,623,598	933,654	30,122	8,902	27	1	7
10	21,623,598	933,654	30,122	8,902	27	1	7
11	18,507,721	609,900	30,122	8,902	27	1	7
12	18,507,721	609,900	30,122	8,902	27	1	7
13	15,682,483	502,846	23,655	8,208	27	1	7
14	15,682,483	502,846	23,655	8,208	27	1	7

Table 29: EU Exports – Monthly Sample

Stage	Observations	Trade Value (million)	Firms	Comcodes	Countries	Currencies	Years
1	44,820,935	997,039	35,751	10,249		1	7
2	44,820,592	996,694	35,751	10,249	27	1	7
3	44,820,592	996,694	35,751	10,249	27	1	7
4	44,820,592	996,694	35,751	10,249	27	1	7
5	44,062,035	949,702	35,513	9,126	27	1	7
6	44,062,035	949,702	35,513	9,126	27	1	7
7	43,986,691	948,071	35,512	9,126	27	1	7
8	43,891,024	947,567	35,455	9,126	27	1	7
9	42,951,095	937,258	30,754	8,934	27	1	7
10	42,951,095	937,258	30,754	8,934	27	1	7
11	36,014,786	561,711	30,754	8,934	27	1	7
12	36,014,786	561,711	30,754	8,934	27	1	7
13	29,256,147	430,862	23,741	8,159	27	1	7
14	29,256,147	430,862	23,741	8,159	27	1	7

C Selected Estimation Tables (Based on the Non-EU Sample)

C.1 Not Conditional on Price Changes

Table 30: Price Elasticity (prices are denominated in sterling, frequency A) - AllProducts

VARIABLES	(1) All	(2) PCI	(3) LCI	(4) VCI
Bil. exchange rates	0.141***	0.0978***	0.529***	0.173***
	(0.0100)	(0.0121)	(0.0454)	(0.0198)
Dest. CPI	0.232***	0.197***	1.140***	0.237***
	(0.0198)	(0.0247)	(0.270)	(0.0341)
Observations	1,780,387	1,242,176	166,652	371,559
Con price change	no	no	no	no
Con multi dest	no	no	no	no
FE	no	no	no	no
SE	Robust	Robust	Robust	Robust

Table 31: Markup Elasticity (prices are denominated in sterling, frequency A) - AllProducts

VARIABLES	(1) All	(2) PCI	(3) LCI	(4) VCI
Bil. exchange rates	0.0611***	0.0299	0.453***	-0.00456
	(0.0222)	(0.0275)	(0.0694)	(0.0535)
Dest. CPI	0.0569	0.0445	0.698**	-0.101
	(0.0421)	(0.0533)	(0.275)	(0.0909)
Observations	2,627,778	1,826,450	241,847	559,481
Con price change	no	no	no	no
Con multi dest	no	no	no	no
FE	TPSFE	TPSFE	TPSFE	TPSFE
SE	Robust	Robust	Robust	Robust

Table 32: Price Elasticity (prices are denominated in the invoicing currency, frequency A) - AllProducts

VARIABLES	(1) All	(2) PCI	(3) LCI	(4) VCI
Bil. exchange rates	0.00812	0.0978***	-0.471***	-0.108***
	(0.00998)	(0.0121)	(0.0454)	(0.0199)
Dest. CPI	0.121***	0.197***	1.140***	0.00705
	(0.0198)	(0.0247)	(0.270)	(0.0342)
Observations	1,780,387	1,242,176	166,652	371,559
Con price change	no	no	no	no
Con multi dest	no	no	no	no
FE	no	no	no	no
SE	Robust	Robust	Robust	Robust

Table 33: Price Elasticity (prices are denominated in sterling, frequency Q) - AllProducts

VARIABLES	(1) All	(2) PCI	(3) LCI	(4) VCI
Bil. exchange rates	0.166***	0.107***	0.615***	0.223***
	(0.00924)	(0.0110)	(0.0410)	(0.0186)
Dest. CPI	0.280***	0.237***	0.952***	0.293***
	(0.0196)	(0.0234)	(0.207)	(0.0368)
Observations	4,275,870	2,921,116	439,131	915,623
Con price change	no	no	no	no
Con multi dest	no	no	no	no
FE	no	no	no	no
SE	Robust	Robust	Robust	Robust

Table 34: Markup Elasticity (prices are denominated in sterling, frequency Q) - AllProducts

VARIABLES	(1) All	(2) PCI	(3) LCI	(4) VCI
Bil. exchange rates	0.0523***	0.00479	0.564***	0.0589**
	(0.0132)	(0.0166)	(0.0449)	(0.0300)
Dest. CPI	0.0390	-0.00191	0.695***	0.0840*
	(0.0248)	(0.0321)	(0.176)	(0.0496)
Observations	5,315,351	3,630,749	530,898	1,153,704
Con price change	no	no	no	no
Con multi dest	no	no	no	no
FE	TPSFE	TPSFE	TPSFE	TPSFE
SE	Robust	Robust	Robust	Robust

Table 35: Price Elasticity (prices are denominated in the invoicing currency, frequency Q) - AllProducts

VARIABLES	(1) All	(2) PCI	(3) LCI	(4) VCI
Bil. exchange rates	0.0298***	0.107***	-0.385***	-0.0826***
	(0.00919)	(0.0110)	(0.0410)	(0.0184)
Dest. CPI	0.157***	0.237***	0.952***	0.00166
	(0.0196)	(0.0234)	(0.207)	(0.0363)
Observations	4,275,870	2,921,116	439,131	915,623
Con price change	no	no	no	no
Con multi dest	no	no	no	no
FE	no	no	no	no
SE	Robust	Robust	Robust	Robust

Table 36: Price Elasticity (prices are denominated in sterling, frequency M) - AllProducts

VARIABLES	(1) All	(2) PCI	(3) LCI	(4) VCI
Bil. exchange rates	0.150***	0.104***	0.467***	0.193***
	(0.00911)	(0.0109)	(0.0408)	(0.0182)
Dest. CPI	0.268***	0.234***	0.851***	0.278***
	(0.0191)	(0.0228)	(0.196)	(0.0358)
Observations	6,521,358	4,337,231	752,266	1,431,861
Con price change	no	no	no	no
Con multi dest	no	no	no	no
FE	no	no	no	no
SE	Robust	Robust	Robust	Robust

Table 37: Markup Elasticity (prices are denominated in sterling, frequency M) - AllProducts

VARIABLES	(1) All	(2) PCI	(3) LCI	(4) VCI
Bil. exchange rates	0.0737***	0.0438***	0.461***	0.0531**
	(0.00975)	(0.0122)	(0.0371)	(0.0211)
Dest. CPI	0.0306*	0.0135	0.376***	0.0181
	(0.0184)	(0.0237)	(0.135)	(0.0362)
Observations	7,555,675	5,035,833	844,708	1,675,134
Con price change	no	no	no	no
Con multi dest	no	no	no	no
FE	TPSFE	TPSFE	TPSFE	TPSFE
SE	Robust	Robust	Robust	Robust

Table 38: Price Elasticity (prices are denominated in the invoicing currency, frequency M) - AllProducts

VARIABLES	(1) All	(2) PCI	(3) LCI	(4) VCI
Bil. exchange rates	0.00670	0.104***	-0.533***	-0.128***
	(0.00909)	(0.0109)	(0.0408)	(0.0180)
Dest. CPI	0.133***	0.234***	0.851***	-0.0486
	(0.0191)	(0.0228)	(0.196)	(0.0354)
Observations	6,521,358	4,337,231	752,266	1,431,861
Con price change	no	no	no	no
Con multi dest	no	no	no	no
FE	no	no	no	no
SE	Robust	Robust	Robust	Robust

C.2 Conditional on S-period Price Changes

Table 39: Price Elasticity (prices are denominated in sterling, frequency A) - AllProducts

VARIABLES	(1) All	(2) PCI	(3) LCI	(4) VCI
Bil. exchange rates	0.141***	0.107***	0.505***	0.155***
	(0.0107)	(0.0129)	(0.0479)	(0.0208)
Dest. CPI	0.242***	0.213***	1.189***	0.231***
	(0.0202)	(0.0251)	(0.267)	(0.0347)
Observations	1,589,034	1,102,553	152,004	334,477
Con price change	yes	yes	yes	yes
Con multi dest	no	no	no	no
FE	no	no	no	no
SE	Robust	Robust	Robust	Robust

Table 40: Markup Elasticity (prices are denominated in sterling, frequency A) - AllProducts

VARIABLES	(1) All	(2) PCI	(3) LCI	(4) VCI
Bil. exchange rates	0.0392	0.0124	0.478***	-0.0380
	(0.0238)	(0.0298)	(0.0770)	(0.0566)
Dest. CPI	0.0174	0.0204	0.269	-0.195**
	(0.0449)	(0.0576)	(0.294)	(0.0955)
Observations	2,436,425	1,686,827	227,199	522,399
Con price change	yes	yes	yes	yes
Con multi dest	no	no	no	no
FE	TPSFE	TPSFE	TPSFE	TPSFE
SE	Robust	Robust	Robust	Robust

Table 41: Price Elasticity (prices are denominated in the invoicing currency, frequency A) - AllProducts

VARIABLES	(1) All	(2) PCI	(3) LCI	(4) VCI
Bil. exchange rates	0.0112	0.107***	-0.495***	-0.110***
	(0.0106)	(0.0129)	(0.0479)	(0.0209)
Dest. CPI	0.133***	0.213***	1.189***	0.0151
	(0.0202)	(0.0251)	(0.267)	(0.0348)
Observations	1,589,034	1,102,553	152,004	334,477
Con price change	yes	yes	yes	yes
Con multi dest	no	no	no	no
FE	no	no	no	no
SE	Robust	Robust	Robust	Robust

Table 42: Price Elasticity (prices are denominated in sterling, frequency Q) - AllProducts

VARIABLES	(1) All	(2) PCI	(3) LCI	(4) VCI
Bil. exchange rates	0.174***	0.120***	0.601***	0.218***
	(0.00970)	(0.0116)	(0.0422)	(0.0194)
Dest. CPI	0.309***	0.273***	1.088***	0.305***
	(0.0200)	(0.0239)	(0.208)	(0.0375)
Observations	3,705,274	2,520,359	389,257	795,658
Con price change	yes	yes	yes	yes
Con multi dest	no	no	no	no
FE	no	no	no	no
SE	Robust	Robust	Robust	Robust

Table 43: Markup Elasticity (prices are denominated in sterling, frequency Q) - AllProducts

VARIABLES	(1) All	(2) PCI	(3) LCI	(4) VCI
Bil. exchange rates	0.0506***	0.0121	0.544***	0.0538*
	(0.0145)	(0.0182)	(0.0519)	(0.0326)
Dest. CPI	0.0464*	0.0170	0.813***	0.0728
	(0.0269)	(0.0350)	(0.198)	(0.0531)
Observations	4,744,755	3,229,992	481,024	1,033,739
Con price change	yes	yes	yes	yes
Con multi dest	no	no	no	no
FE	TPSFE	TPSFE	TPSFE	TPSFE
SE	Robust	Robust	Robust	Robust

Table 44: Price Elasticity (prices are denominated in the invoicing currency, frequency Q) - AllProducts

VARIABLES	(1) All	(2) PCI	(3) LCI	(4) VCI
Bil. exchange rates	0.0364***	0.120***	-0.399***	-0.0843***
	(0.00964)	(0.0116)	(0.0422)	(0.0193)
Dest. CPI	0.186***	0.273***	1.088***	0.0188
	(0.0200)	(0.0239)	(0.208)	(0.0369)
Observations	3,705,274	2,520,359	389,257	795,658
Con price change	yes	yes	yes	yes
Con multi dest	no	no	no	no
FE	no	no	no	no
SE	Robust	Robust	Robust	Robust

Table 45: Price Elasticity (prices are denominated in sterling, frequency M) - AllProducts

VARIABLES	(1) All	(2) PCI	(3) LCI	(4) VCI
Bil. exchange rates	0.158***	0.116***	0.460***	0.194***
	(0.00963)	(0.0116)	(0.0421)	(0.0190)
Dest. CPI	0.304***	0.276***	1.007***	0.298***
	(0.0196)	(0.0234)	(0.198)	(0.0366)
Observations	5,563,079	3,678,499	660,131	1,224,449
Con price change	yes	yes	yes	yes
Con multi dest	no	no	no	no
FE	no	no	no	no
SE	Robust	Robust	Robust	Robust

Table 46: Markup Elasticity (prices are denominated in sterling, frequency M) - AllProducts

VARIABLES	(1) All	(2) PCI	(3) LCI	(4) VCI
Bil. exchange rates	0.0601***	0.0345**	0.401***	0.0383*
	(0.0109)	(0.0137)	(0.0434)	(0.0232)
Dest. CPI	0.0117	0.000736	0.339**	0.0127
	(0.0204)	(0.0263)	(0.151)	(0.0401)
Observations	6,597,396	4,377,101	752,573	1,467,722
Con price change	yes	yes	yes	yes
Con multi dest	no	no	no	no
FE	TPSFE	TPSFE	TPSFE	TPSFE
SE	Robust	Robust	Robust	Robust

Table 47: Price Elasticity (prices are denominated in the invoicing currency, frequency M) - AllProducts

VARIABLES	(1) All	(2) PCI	(3) LCI	(4) VCI
Bil. exchange rates	0.0151	0.116***	-0.540***	-0.124***
	(0.00958)	(0.0116)	(0.0421)	(0.0188)
Dest. CPI	0.170***	0.276***	1.007***	-0.0215
	(0.0195)	(0.0234)	(0.198)	(0.0361)
Observations	5,563,079	3,678,499	660,131	1,224,449
Con price change	yes	yes	yes	yes
Con multi dest	no	no	no	no
FE	no	no	no	no
SE	Robust	Robust	Robust	Robust

C.3 Conditional on S-period Price Changes and Multi-destination Exporters

Table 48: Price Elasticity (prices are denominated in sterling, frequency A) - AllProducts

VARIABLES	(1) All	(2) PCI	(3) LCI	(4) VCI
Bil. exchange rates	0.140***	0.130***	0.672***	0.124***
	(0.0125)	(0.0149)	(0.0838)	(0.0237)
Dest. CPI	0.230***	0.234***	1.088**	0.187***
	(0.0231)	(0.0291)	(0.444)	(0.0381)
Observations	978,388	723,149	25,633	229,606
Con price change	yes	yes	yes	yes
Con multi dest	yes	yes	yes	yes
FE	no	no	no	no
SE	Robust	Robust	Robust	Robust

Table 49: Markup Elasticity (prices are denominated in sterling, frequency A) - AllProducts

VARIABLES	(1) All	(2) PCI	(3) LCI	(4) VCI
Bil. exchange rates	0.0392	0.0124	0.478***	-0.0380
	(0.0302)	(0.0375)	(0.0834)	(0.0743)
Dest. CPI	0.0174	0.0204	0.269	-0.195
	(0.0569)	(0.0723)	(0.319)	(0.125)
Observations	1,518,510	1,113,515	41,202	363,793
Con price change	yes	yes	yes	yes
Con multi dest	yes	yes	yes	yes
FE	TPSFE	TPSFE	TPSFE	TPSFE
SE	Robust	Robust	Robust	Robust

Table 50: Price Elasticity (prices are denominated in the invoicing currency, frequency A) - AllProducts

VARIABLES	(1) All	(2) PCI	(3) LCI	(4) VCI
Bil. exchange rates	0.0466***	0.130***	-0.328***	-0.130***
	(0.0124)	(0.0149)	(0.0838)	(0.0242)
Dest. CPI	0.145***	0.234***	1.088**	-0.00427
	(0.0231)	(0.0291)	(0.444)	(0.0384)
Observations	978,388	723,149	25,633	229,606
Con price change	yes	yes	yes	yes
Con multi dest	yes	yes	yes	yes
FE	no	no	no	no
SE	Robust	Robust	Robust	Robust

Table 51: Price Elasticity (prices are denominated in sterling, frequency Q) - AllProducts

VARIABLES	(1) All	(2) PCI	(3) LCI	(4) VCI
Bil. exchange rates	0.170***	0.141***	0.754***	0.194***
	(0.0123)	(0.0145)	(0.0786)	(0.0237)
Dest. CPI	0.286***	0.273***	0.574	0.282***
	(0.0252)	(0.0299)	(0.396)	(0.0464)
Observations	2,072,676	1,507,749	63,418	501,509
Con price change	yes	yes	yes	yes
Con multi dest	yes	yes	yes	yes
FE	no	no	no	no
SE	Robust	Robust	Robust	Robust

Table 52: Markup Elasticity (prices are denominated in sterling, frequency Q) - AllProducts

VARIABLES	(1) All	(2) PCI	(3) LCI	(4) VCI
Bil. exchange rates	0.0506***	0.0121	0.544***	0.0538
	(0.0177)	(0.0221)	(0.0556)	(0.0413)
Dest. CPI	0.0464	0.0170	0.813***	0.0728
	(0.0330)	(0.0426)	(0.212)	(0.0674)
Observations	2,661,193	1,926,274	80,821	654,098
Con price change	yes	yes	yes	yes
Con multi dest	yes	yes	yes	yes
FE	TPSFE	TPSFE	TPSFE	TPSFE
SE	Robust	Robust	Robust	Robust

Table 53: Price Elasticity (prices are denominated in the invoicing currency, frequency Q) - AllProducts

VARIABLES	(1) All	(2) PCI	(3) LCI	(4) VCI
Bil. exchange rates	0.0653***	0.141***	-0.246***	-0.101***
	(0.0122)	(0.0145)	(0.0786)	(0.0236)
Dest. CPI	0.185***	0.273***	0.574	0.0157
	(0.0251)	(0.0299)	(0.396)	(0.0454)
Observations	2,072,676	1,507,749	63,418	501,509
Con price change	yes	yes	yes	yes
Con multi dest	yes	yes	yes	yes
FE	no	no	no	no
SE	Robust	Robust	Robust	Robust

Table 54: Price Elasticity (prices are denominated in sterling, frequency M) - AllProducts

VARIABLES	(1) All	(2) PCI	(3) LCI	(4) VCI
Bil. exchange rates	0.136***	0.120***	0.449***	0.154***
	(0.0132)	(0.0157)	(0.0938)	(0.0249)
Dest. CPI	0.286***	0.270***	0.286	0.308***
	(0.0257)	(0.0312)	(0.452)	(0.0456)
Observations	2,686,004	1,919,909	83,764	682,331
Con price change	yes	yes	yes	yes
Con multi dest	yes	yes	yes	yes
FE	no	no	no	no
SE	Robust	Robust	Robust	Robust

Table 55: Markup Elasticity (prices are denominated in sterling, frequency M) - AllProducts

VARIABLES	(1) All	(2) PCI	(3) LCI	(4) VCI
Bil. exchange rates	0.0601***	0.0345**	0.401***	0.0383
	(0.0130)	(0.0162)	(0.0460)	(0.0285)
Dest. CPI	0.0117	0.000736	0.339**	0.0127
	(0.0242)	(0.0310)	(0.160)	(0.0491)
Observations	3,180,085	2,267,261	96,624	816,200
Con price change	yes	yes	yes	yes
Con multi dest	yes	yes	yes	yes
FE	TPSFE	TPSFE	TPSFE	TPSFE
SE	Robust	Robust	Robust	Robust

Table 56: Price Elasticity (prices are denominated in the invoicing currency, frequency M) - AllProducts

VARIABLES	(1) All	(2) PCI	(3) LCI	(4) VCI
Bil. exchange rates	0.0284**	0.120***	-0.551***	-0.153***
	(0.0131)	(0.0157)	(0.0938)	(0.0246)
Dest. CPI	0.176***	0.270***	0.286	0.00803
	(0.0256)	(0.0312)	(0.452)	(0.0449)
Observations	2,686,004	1,919,909	83,764	682,331
Con price change	yes	yes	yes	yes
Con multi dest	yes	yes	yes	yes
FE	no	no	no	no
SE	Robust	Robust	Robust	Robust