Invoicing and Pricing-to-Market

A Study of Price and Markup Elasticities of UK Exporters

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Motivation

- International trade is founded on micro transactions in different currencies, the choices of which naturally influence
  - $\Rightarrow$ relative prices of international traded goods
  - $\Rightarrow$ terms of trade among countries

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- Yet, less is known about invoicing currency and markup adjustments:
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  - $\Rightarrow$ Exchange rate movements impact on marginal costs through imported inputs
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- Separating markup and marginal cost channels enables
  - $\Rightarrow$ a deeper understanding of firms' global pricing strategy
  - $\Rightarrow$ a complete picture of international shock transmissions

What does this paper do?

We use a unique micro dataset covering the universe of UK trade to countries outside the EU to examine the relationship between a firm's pricing strategy and its invoicing currency.

UK Customs Data (2010-2017):

- Highly disaggregated: including the invoicing currency and the date of the transaction for extra-EU exports
- Covers an exogenous shock: Brexit referendum
- Currency usage is diversified: large share of vehicle currency invoicing (34% of extra-EU exports excluding the US)

Two approaches to testing whether a firm's pricing strategy is related to its invoicing currency

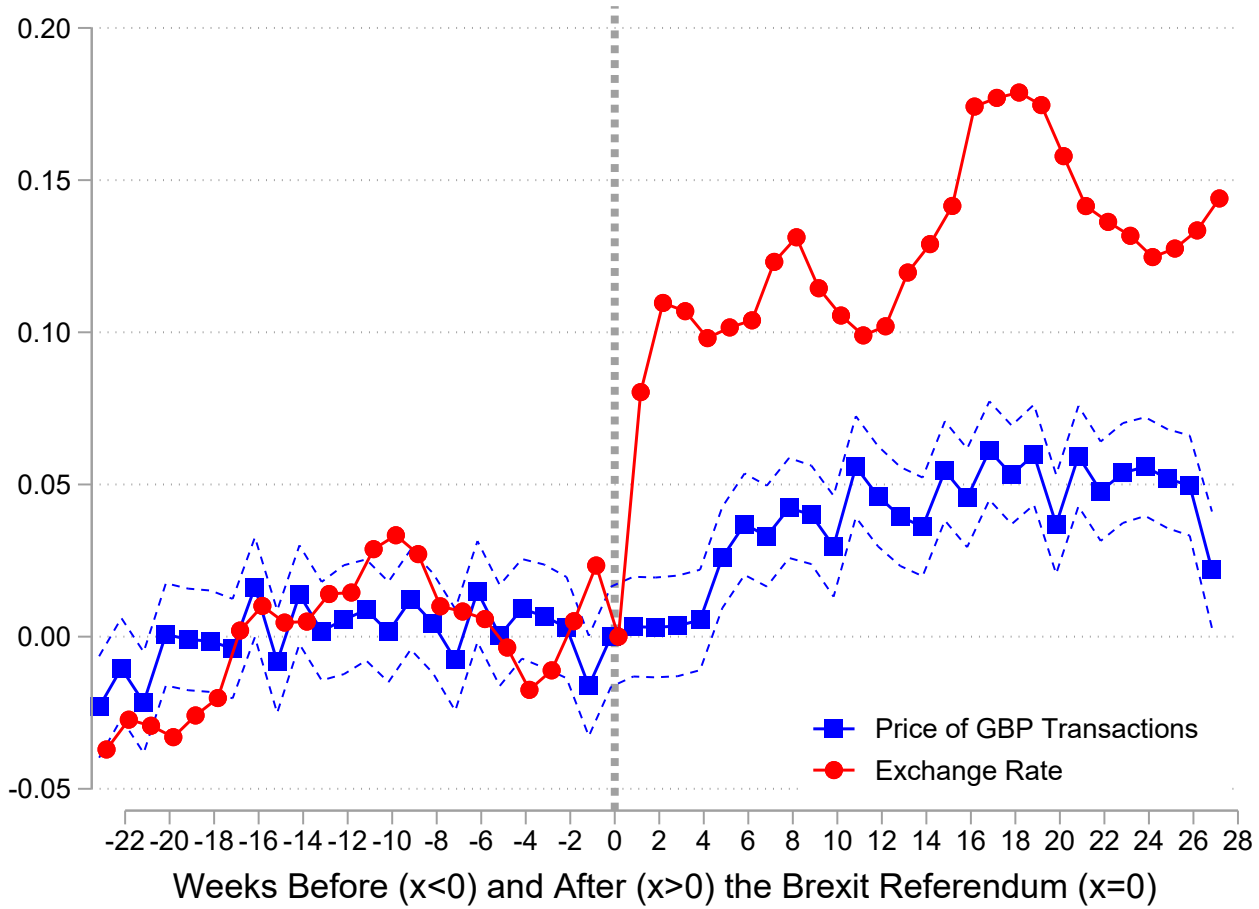
Price changes = (a) global markup adjustments +
(b) destination-specific markup adjustments +
(c) changes in marginal costs

1. **Event study:** investigates markup adjustments in response to the large depreciation after the Brexit referendum
   ⇒ Marginal cost does not change in the very short run.
   ⇒ Captures (a) and (b)

2. **Fixed effects approach:** exploits destination variation to control for unobserved marginal cost
   ⇒ Deals with endogenous selection of markets using the TPSFE estimator developed by CCHS (2018)
   ⇒ Captures (b), i.e., pricing-to-market

Preview of Results: Event Study

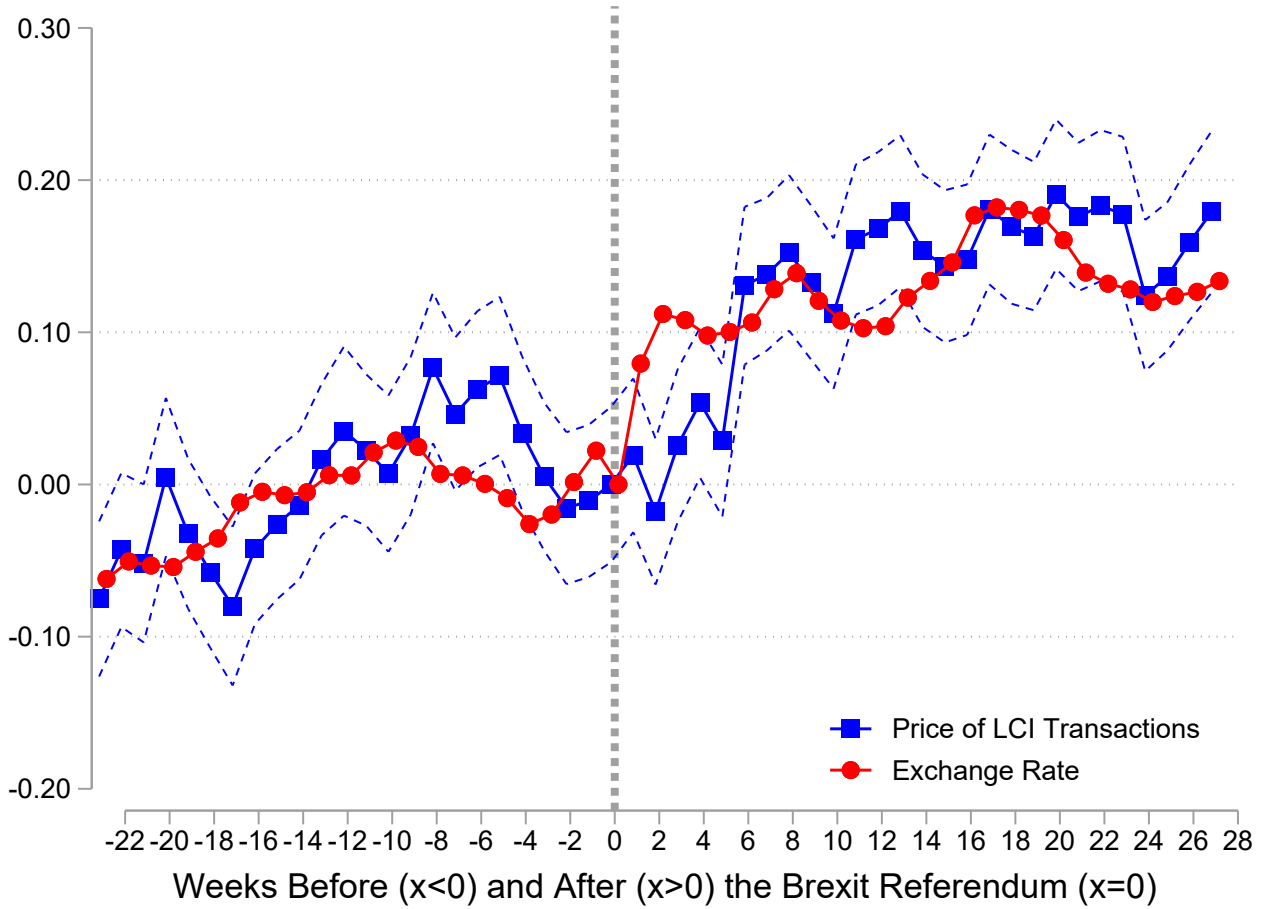
Weekly Price Changes of **Sterling** Invoiced Transactions



- Stable producer price $\Rightarrow$ Local currency price goes down.
- Markup (in producer currency) is stable if marginal cost does not move in the short run

Preview of Results: Event Study

Weekly Price Changes of **Local Currency** Invoiced Transactions

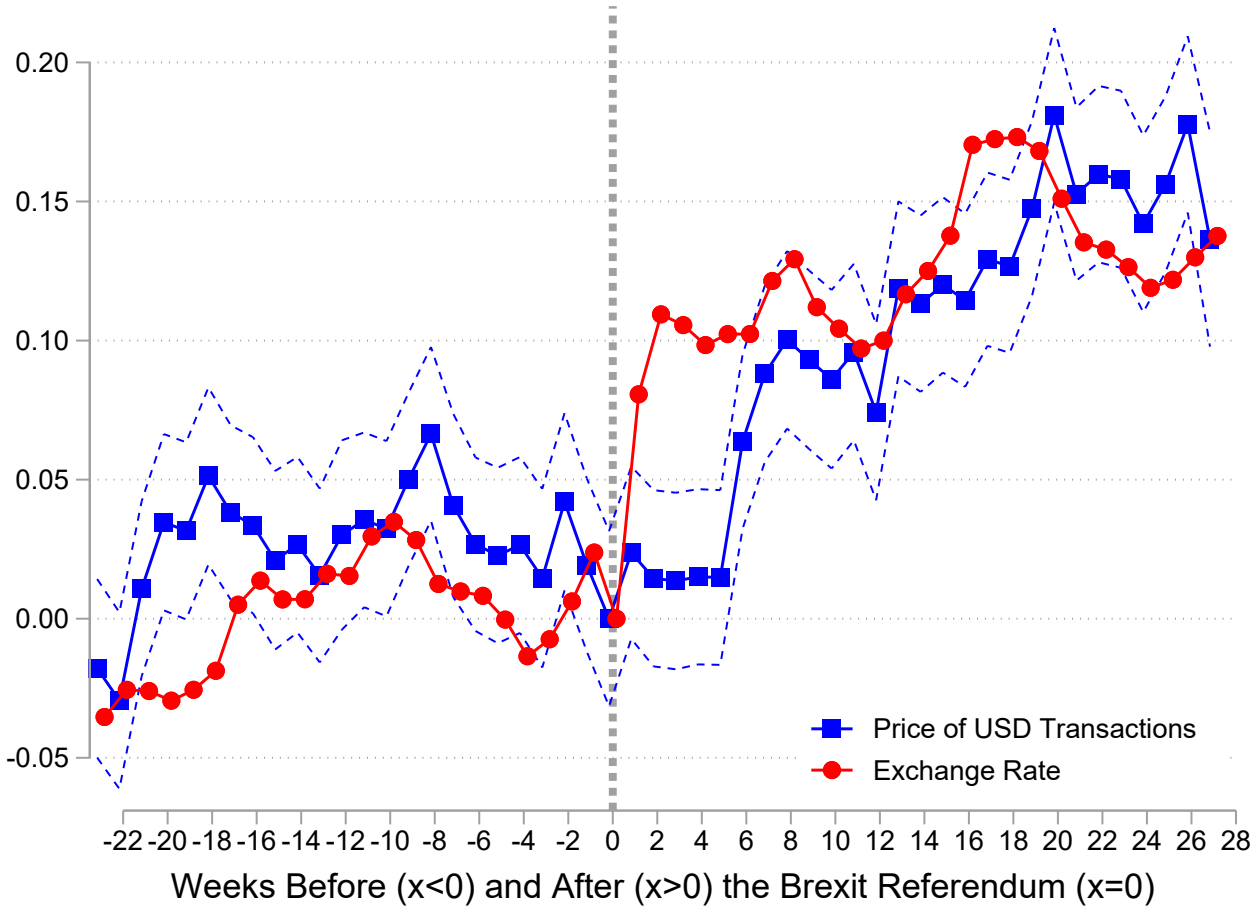


Markup (in producer currency) goes up

$\Rightarrow$ Local currency price is stable

Preview of Results: Event Study

Weekly Price Changes of **Dollar** Invoiced Transactions



- Similar to local currency pricing (fast catching up)
- Markup (in producer currency) goes up
  $\Rightarrow$ Local currency price is relatively stable.

Preview of Results: Fixed Effects Approach

- (a+b+c) Export price elasticity to the exchange rate (ERPT):
  - Producer currency (£) invoiced transactions: 0.23*** (77%)
  - Vehicle currency ($) invoiced transactions: 0.42*** (58%)
  - Local currency invoiced transactions: 0.51*** (49%)

  Both vehicle and local currency invoiced transactions demonstrate highly incomplete exchange rate pass through.

- (b) Destination-specific markup elasticity to exchange rate (DSME):
  - Producer currency (£) invoiced transactions: 0.03
  - Vehicle currency ($) invoiced transactions: 0.08
  - Local currency invoiced transactions: 0.44***

  Only local currency invoiced transactions demonstrate destination-specific markup adjustments.

Literature

- **Invoicing currency and pass through**

  Friberg (1998); Goldberg and Tille (2008, 2016); Gopinath and Rigobon (2008); Gopinath, Itskhoki and Rigobon (2010); Fitzgerald and Haller (2014); Gopinath (2015); Casas et al. (2017); Chen, Chung and Novy (2018); Amiti, Itskhoki and Konings (2018), Bonadio, Fischer and Saure (2019)

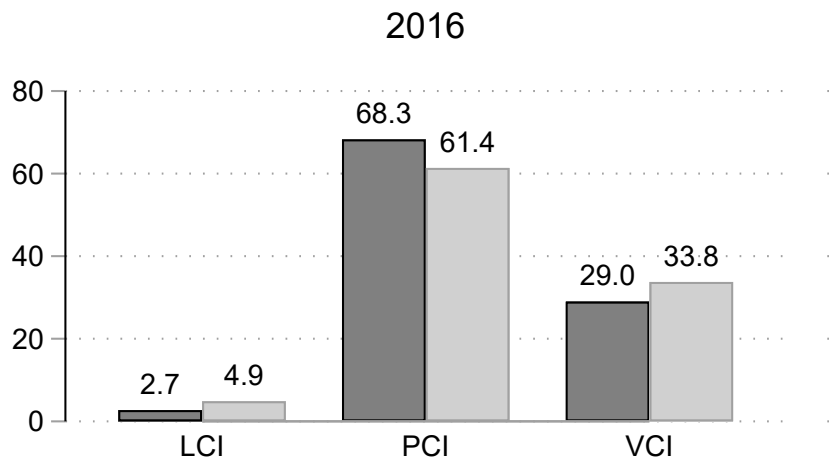
- **Pricing-to-market**

  e.g., Knetter (1989); Knetter (1993); Goldberg and Verboven (2001); Berman, Mayer and Martin (2012); Amiti, Itskhoki and Konings (2014); Auer and Schoenle (2016); Fitzgerald and Haller (2018); Corsetti, Crowley, Han, and Song (2018)

Aggregate Shares of Invoicing Schemes

Extra-EU exports excluding the US in 2016

- 5% of UK exports invoiced in destination (local) currency (LCI)
- 61% of UK exports invoiced in sterling (PCI)
- 34% of UK exports invoiced in vehicle currency (VCI) ($, €, ¥)

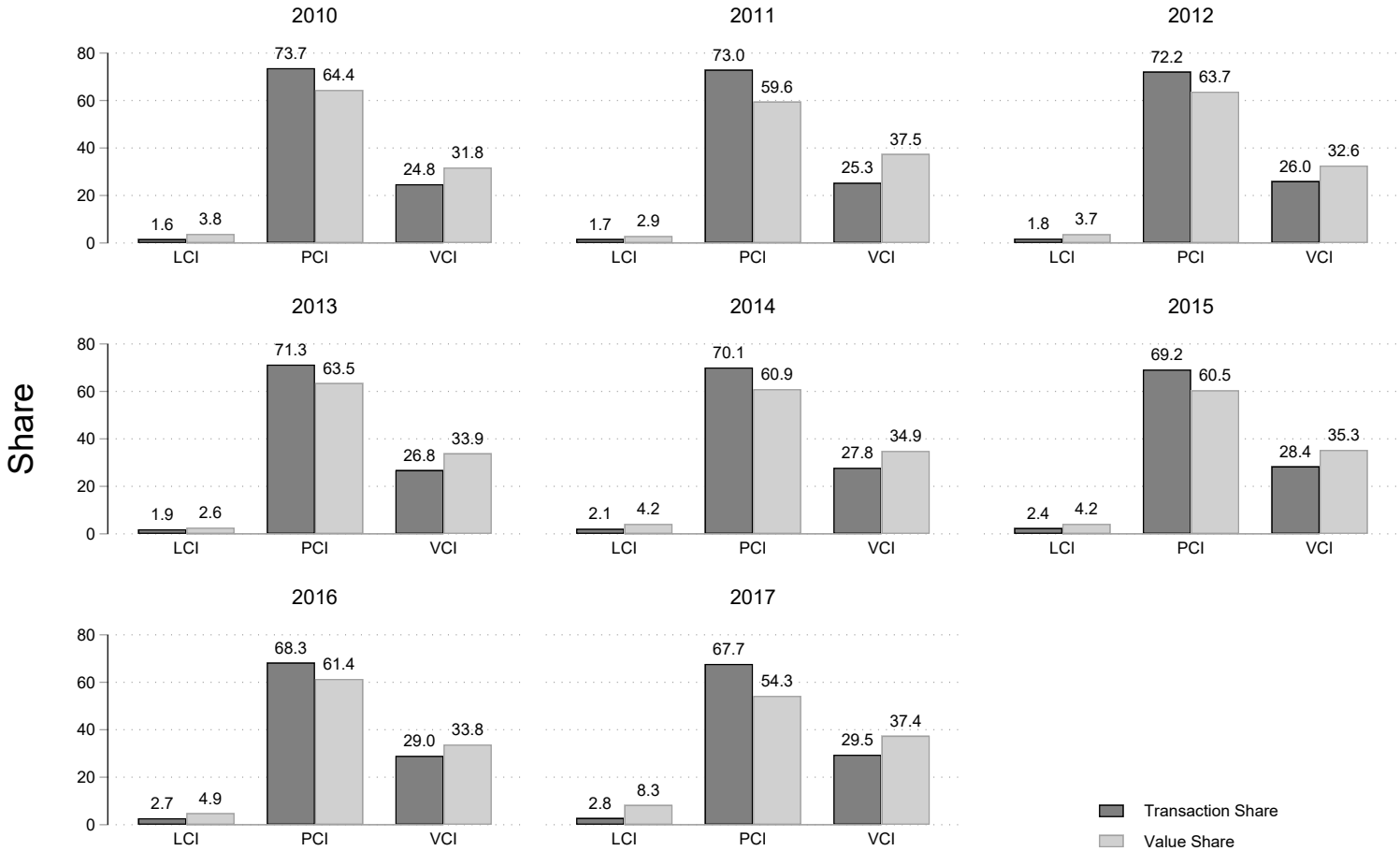


Dark: transaction share; Light: value share

Value share for UK imports: LCI (23%), PCI (8%), VCI (69%)

Aggregate Shares of Invoicing Schemes

Extra-EU exports excluding the US (2010-2017)



The aggregate transaction share of each invoicing scheme is stable.

Distribution: Destinations vs. Invoicing Currencies

Extra-EU exports (2010-2017)

	No. of Destinations	No. of Invoicing Currencies 1	2-5	6-10	10+	Total
by Share of Firms	1	35.2	6.4	0.0	0.0	41.6
	2-5	7.8	25.3	0.0	0.0	33.1
	6-10	0.4	10.4	0.1	0.0	10.9
	10+	0.1	12.7	1.5	0.2	14.4
	Total	43.4	54.8	1.5	0.2	100.0
by Share of Exports	1	0.4	0.6	0.0	0.0	1.0
	2-5	0.2	3.0	0.0	0.0	3.2
	6-10	0.0	3.9	0.1	0.0	4.1
	10+	0.0	30.4	26.7	34.5	91.7
	Total	0.7	38.0	26.9	34.5	100.0

$\Rightarrow$ 99.3% of export value originates from multi-currency exporters

Notes: Top panel shows the share of UK exporters that falls under the relevant description. Bottom panel presents the corresponding value of exports.

Distribution: Destinations vs. Invoicing Schemes

Extra-EU exports excluding the US (2010-2017)

	No. of Destinations	Invoicing Scheme LCI	PCI	VCI	Total
by Share of Firm	1	0.8	26.2	6.9	33.8
	2-5	1.5	22.0	10.4	33.9
	6-10	1.2	7.0	5.3	13.5
	10+	3.3	8.0	7.5	18.8
	Total	6.8	63.2	30.0	100.0
by Share of Exports	1	0.0	1.9	0.5	2.4
	2-5	0.1	3.5	1.0	4.6
	6-10	0.2	4.9	2.6	7.6
	10+	4.5	48.8	32.1	85.4
	Total	4.8	59.1	36.2	100.0

⇒ **Producer currency invoicing dominates UK exports**

⇒ **LCI and VCI observed for firms exporting to many destinations**

Notes: Top panel shows the share of UK exporters that falls under the relevant description. Bottom panel presents corresponding value of exports.

Multi-currency Invoicing

for each firm-product-destination-year quartet

	No. of Currencies	No. of Transactions	Share (%) Transactions	Share (%) Trade
UK Exports	1	5,134,053	84.0	49.4
	2	872,124	14.3	41.1
	3	92,631	1.5	8.0
	4 plus	9,833	0.2	1.5
	Total	6,108,641	100.0	100.0
UK Imports	1	6,804,261	87.7	66.1
	2	793,630	10.2	22.8
	3	122,946	1.6	6.0
	4 plus	40,464	0.5	5.1
	Total	7,761,301	100.0	100.0

$\Rightarrow$ 50.6% of exports by a firm to the same country with the same product within a year use multiple currencies

$\Rightarrow$ 33.9% of imports by f-p-d-t use multiple currencies

Transition Matrix of Invoicing Schemes

Extra-EU exports excluding the US (2010-2017)

		To		
		LCI	PCI	VCI
From	LCI	76.44	18.11	5.45
	PCI	0.53	93.32	6.14
	VCI	0.52	17.07	82.41

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

A substantial share of UK exporters switch their invoicing scheme from year to year.

Two approaches to testing whether a firm's pricing strategy is related to its currency of invoicing

Price changes = (a) global markup adjustments +
(b) destination-specific markup adjustments +
(c) changes in marginal costs

1. Event study: Captures (a) and (b)
2. Fixed effects approach: Captures (b), i.e., pricing-to-market

Event Study

Weekly Pass Through after the Brexit Referendum

Capture weekly responses (in line with Bonadio, Fischer and Saure (2019)):

$$y_{ifdt} = \sum_{\tau=1}^{52} \lambda_\tau + \delta_{ifd} + u_{ifdt} \quad y \in \{p_{ifdt}, e_{dt}\}$$

where

- i, f, d, t represent product, firm, destination country, and time (*week*) respectively.
- $\sum_{\tau=1}^{52} \lambda_\tau$ is a bunch of week dummies capturing the average price/quantity/exchange rate changes
- δ_{ifd}: firm-product-destination fixed effects

$\Rightarrow$ Separately estimated for each invoicing currency schemes

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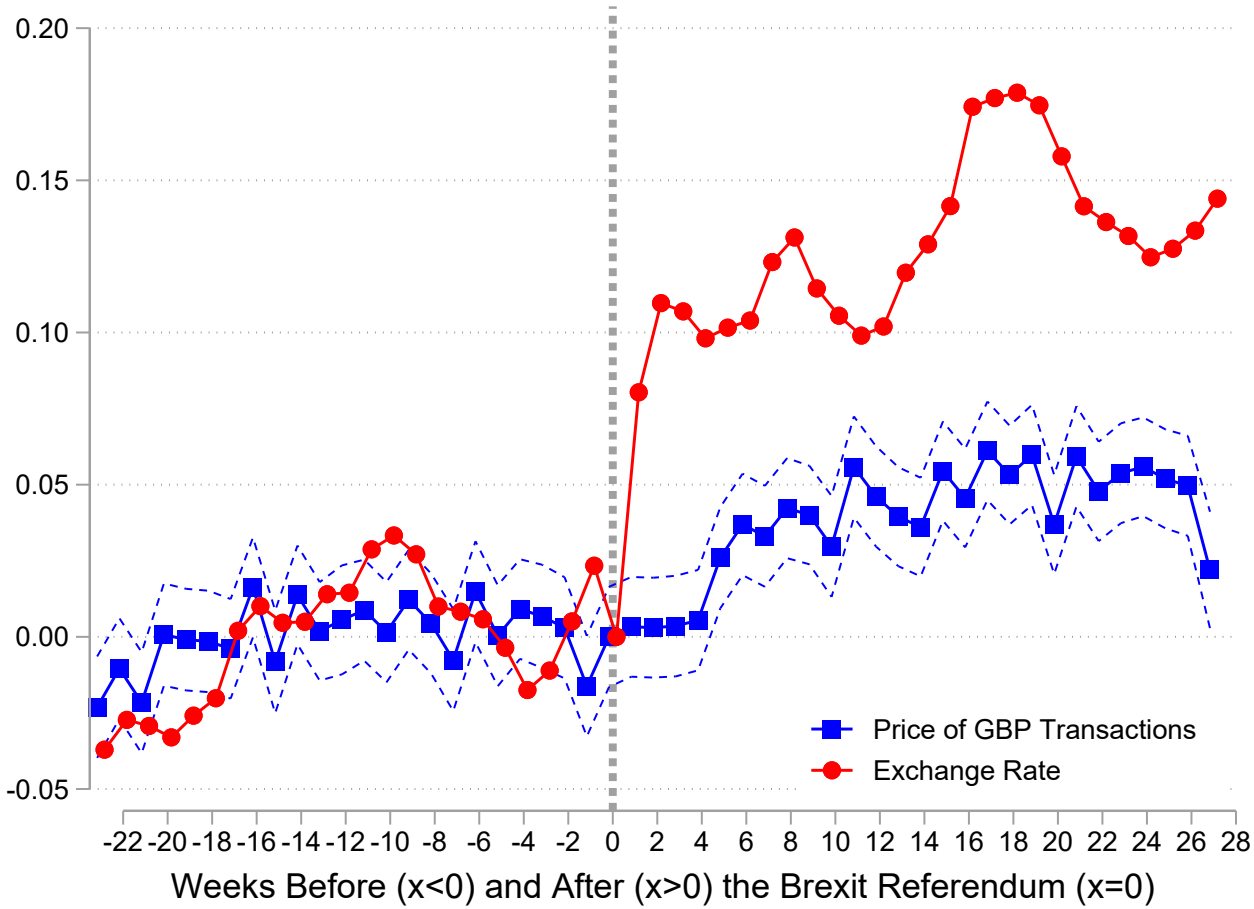
Weekly Pass Through after the Brexit Referendum

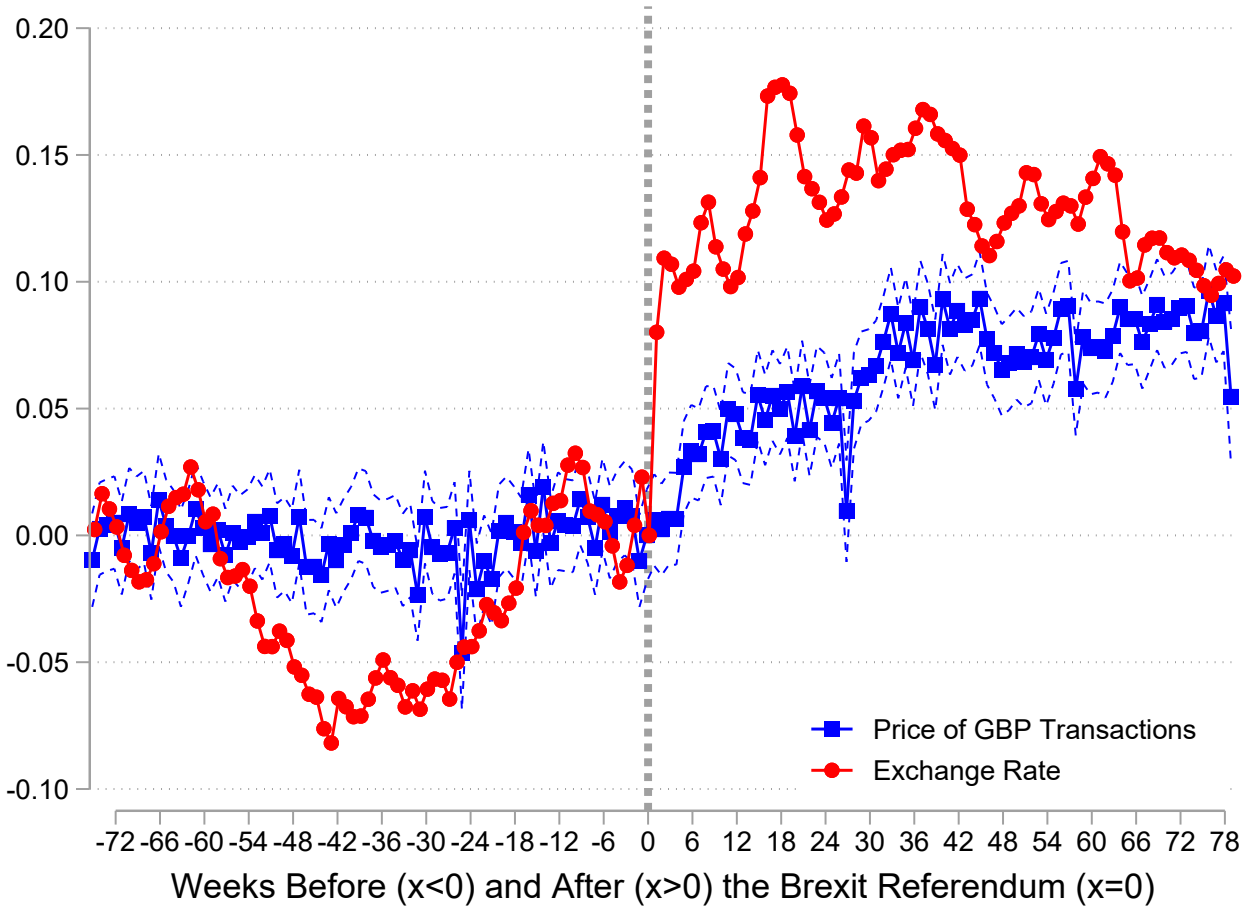
Weekly Price Changes of **Sterling** Invoiced Transactions



Event Study

Weekly Pass Through after the Brexit Referendum

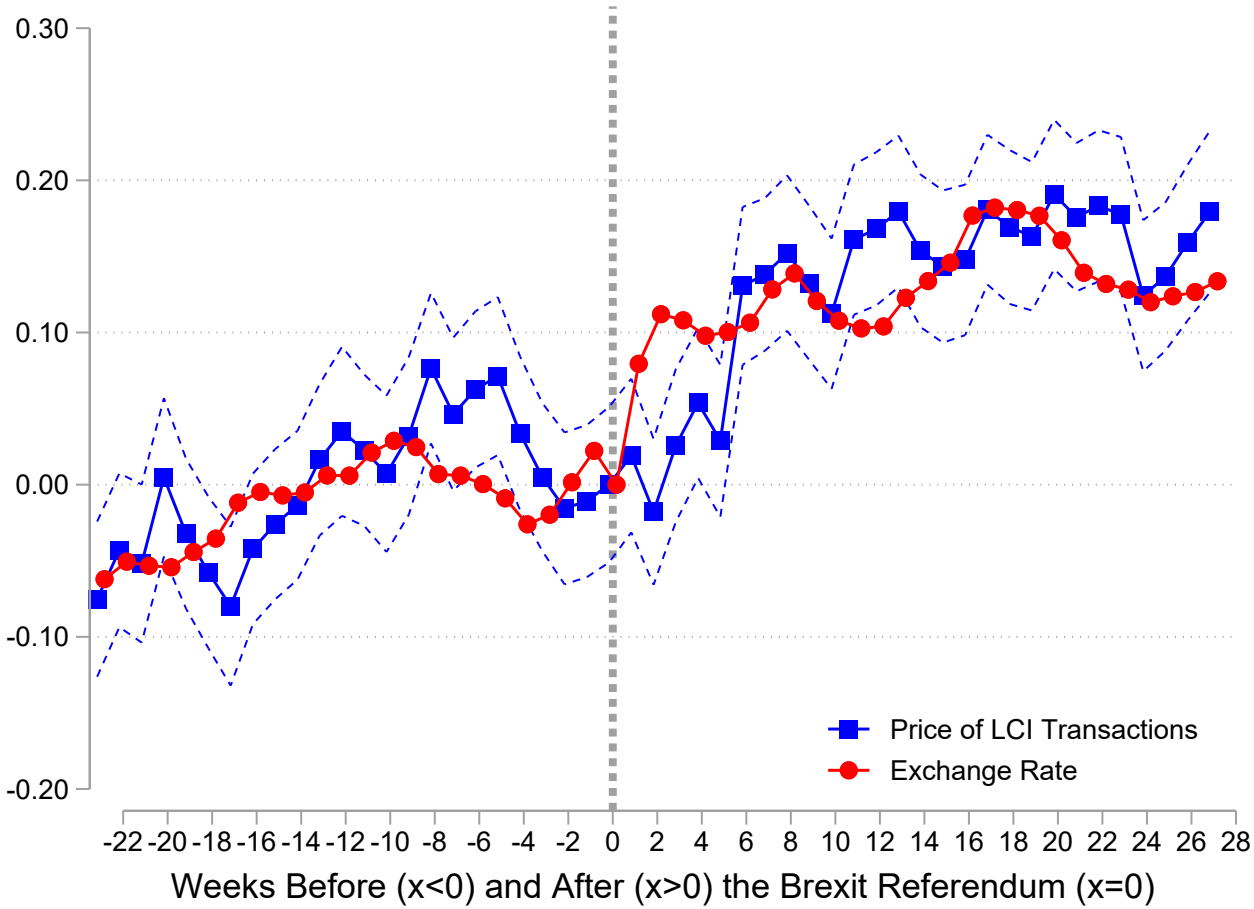
Weekly Price Changes of **Sterling** Invoiced Transactions **2015-2017**



Event Study

Weekly Pass Through after the Brexit Referendum

Weekly Price Changes of **Local Currency** Invoiced Transactions



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Weekly Pass Through after the Brexit Referendum

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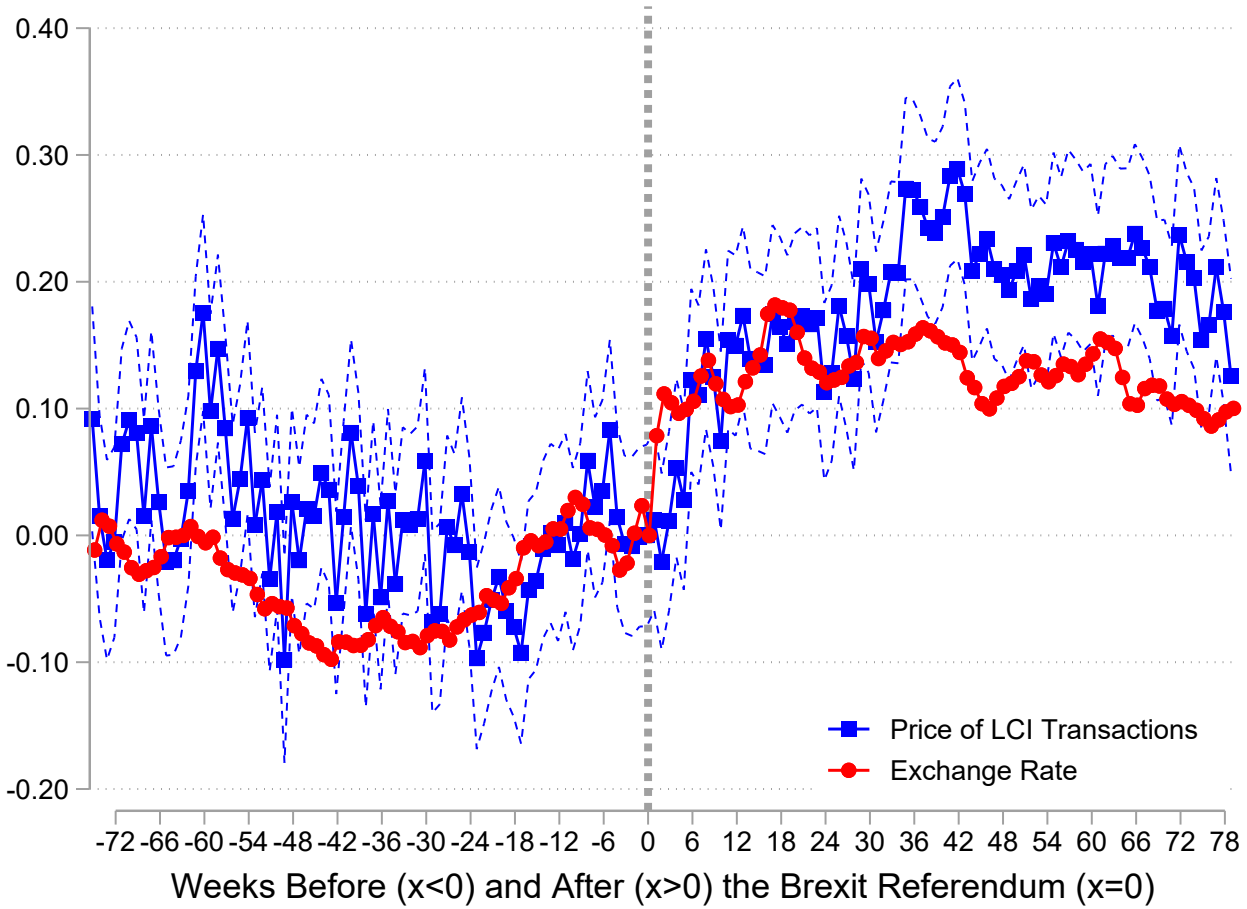
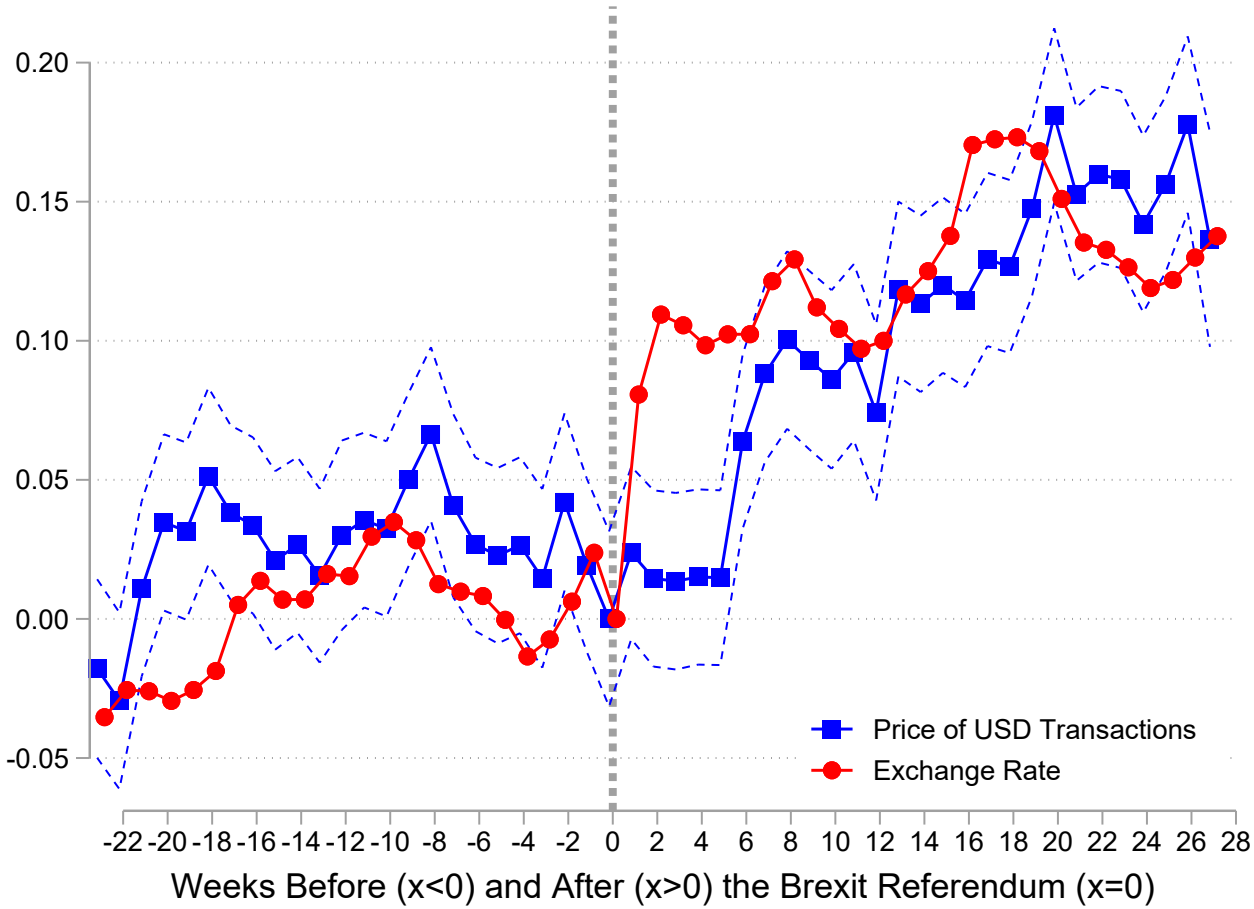


Event Study

Weekly Pass Through after the Brexit Referendum

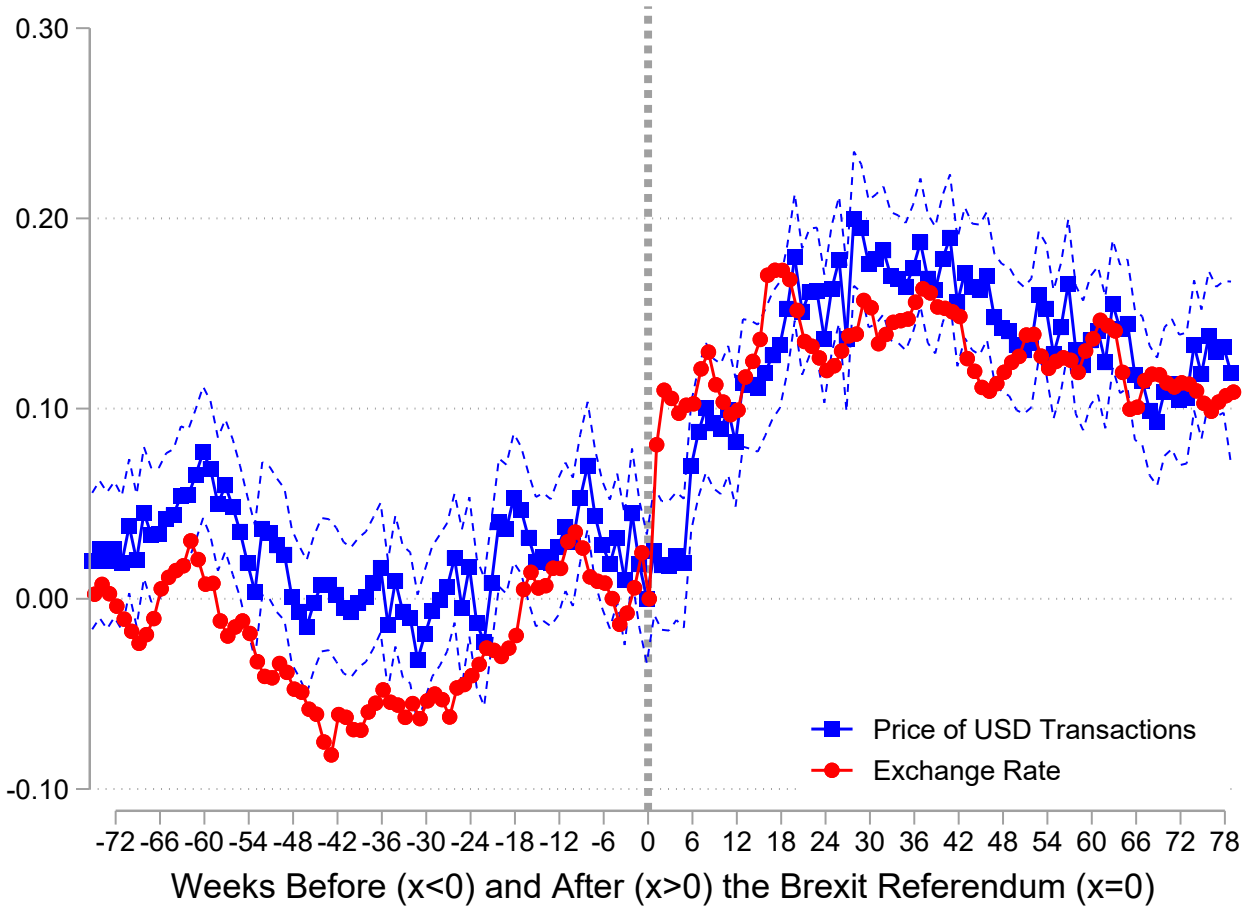
Weekly Price Changes of **Dollar** Invoiced Transactions



Event Study

Weekly Pass Through after the Brexit Referendum

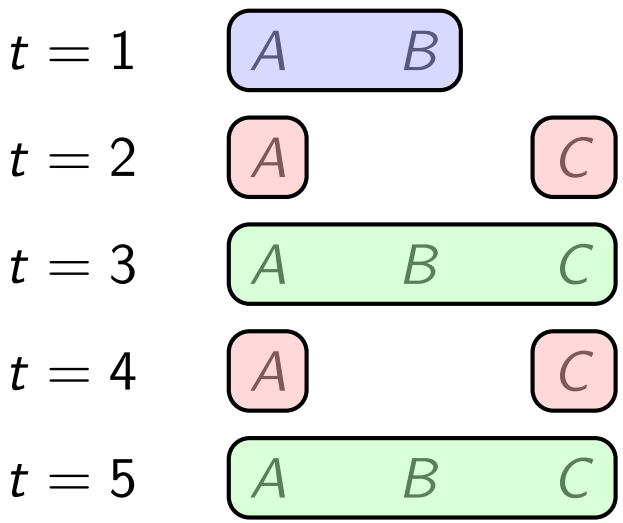
Weekly Price Changes of **Dollar** Invoiced Transactions **2015-2017**



Fixed Effect Approach

Trade Pattern Sequential Fixed Effects: Example

Consider a firm exporting a product to four countries, A through C, over 5 time periods. Empty elements in the matrix indicate that there was no trade.



To estimate the markup elasticity, we compare price residuals at $\mathbf{t = 2}$ with $\mathbf{t = 4}$ and $\mathbf{t = 3}$ with $\mathbf{t = 5}$.

Fixed Effect Approach

Trade Pattern Sequential Fixed Effects: Intuition

$$\begin{bmatrix} p_{A,1} & p_{B,1} & \cdot \\ p_{A,2} & \cdot & p_{C,2} \\ p_{A,3} & p_{B,3} & p_{C,3} \\ p_{A,4} & \cdot & p_{C,4} \\ p_{A,5} & p_{B,5} & p_{C,5} \end{bmatrix} = \begin{bmatrix} \widetilde{p}_{A,1}+\overline{p}_1 & \widetilde{p}_{B,1}+\overline{p}_1 & \cdot \\ \widetilde{p}_{A,2}+\overline{p}_2 & \cdot & \widetilde{p}_{C,2}+\overline{p}_2 \\ \widetilde{p}_{A,3}+\overline{p}_3 & \widetilde{p}_{B,3}+\overline{p}_3 & \widetilde{p}_{C,3}+\overline{p}_3 \\ \widetilde{p}_{A,4}+\overline{p}_4 & \cdot & \widetilde{p}_{C,4}+\overline{p}_4 \\ \widetilde{p}_{A,5}+\overline{p}_5 & \widetilde{p}_{B,5}+\overline{p}_5 & \widetilde{p}_{C,5}+\overline{p}_5 \end{bmatrix}$$

$$= \begin{bmatrix} \mu_{A,1}+(\mu+mc)_{AB,1} & \mu_{B,1}+(\mu+mc)_{AB,1} & \cdot \\ \mu_{A,2}+(\mu+mc)_{AC,2} & \cdot & \mu_{C,2}+(\mu+mc)_{AC,2} \\ \mu_{A,3}+(\mu+mc)_{ABCD,3} & \mu_{B,3}+(\mu+mc)_{ABCD,3} & \mu_{C,3}+(\mu+mc)_{ABCD,3} \\ \mu_{A,4}+(\mu+mc)_{AC,4} & \cdot & \mu_{C,4}+(\mu+mc)_{AC,4} \\ \mu_{A,5}+(\mu+mc)_{ABCD,5} & \mu_{B,5}+(\mu+mc)_{ABCD,5} & \mu_{C,5}+(\mu+mc)_{ABCD,5} \end{bmatrix}$$

- We will isolate the destination-specific component of the price *within the product-level trade pattern of the firm*.
- We will then control for the product-level trade pattern of the firm to reduce unobservable variation associated with market participation.
- Finally, we will estimate the elasticity.

Step 1: Isolate the destination-specific component of the price

Within a period t, subtract the component of each variable that is *common* across all destinations d reached by firm f with product i:

$$\widetilde{x}_{ifdtD} \equiv x - \frac{1}{n^D_{ift}} \sum_{d \in D_{ift}} x \quad \forall x \in \left\{ p_{ifdt}, e_{dt}, \boldsymbol{x}_{dt} \right\}$$

- D_{ift} denotes the set of destinations in period t;
- n^D_{ift} is the number of active destinations in in period t;
- e_{dt} is the bilateral exchange rate ($£/d$); and
- $\boldsymbol{x}_{dt}$ is a vector of control variables.

$\Rightarrow \widetilde{p}_{ifdtD}$ is the destination-residual price *conditional on set of destinations* D_{ift}

Step 2: Reduce unobservable variation by controling for the trade pattern

Within each destination & trade pattern, subtract the component of each destination-residual variable that is *time-invariant*:

$$\ddot{x}_{ifdtDT} \equiv \widetilde{x}_{ifdtD} - \frac{1}{n^{T}_{ifdD}} \sum_{t \in T_{ifdD}} \widetilde{x}_{ifdtD} \quad \forall x \in \left\{ p_{ifdt}, e_{dt}, \boldsymbol{x}_{dt} \right\}$$

- T_{ifdD} denotes the set of time-varying destination-trade patterns,
- and n^{T}_{ifdD} is the number of time periods for each destination-trade pattern.

$\Rightarrow \ddot{p}_{ifdtDT}$ is time variation in the destination-residual price *conditional on firm-product-destination-trade pattern ifdD*

Step 3: Estimate destination-specific markup elasticity

Regress price residuals on twice-demeaned variables and the trade pattern fixed effects.

$$\ddot{p}_{ifdtDT} = \beta_0 + \beta_1 \ddot{e}_{dtDT} + \ddot{\boldsymbol{x}}'_{dtDT}\boldsymbol{\beta}_2 + \ddot{v}_{ifdtDT}$$

- β_1 is the destination-specific markup elasticity to the bilateral exchange rate,
- the subscript D_{ift} denotes conditioning on a set of destinations, e.g. VN-KR-JP.
- the subscript T_{ifdD}, denotes conditioning on the time periods within a firm-product-destination-trade pattern.

Estimating Equation for Price Elasticity

Regress price on exchange rates and the trade pattern fixed effects.

$$\dot{p}_{ifdtT} = \alpha_0 + \alpha_1 \dot{e}_{ifdtT} + \dot{\boldsymbol{x}}'_{ifdtT} \boldsymbol{\alpha}_2 + \dot{v}_{ifdtT}$$

where

- α_1 is the price elasticity $\equiv 1 - ERPT$,
- $\dot{p}_{ifdtT}$, $\dot{e}_{ifdtT}$, and $\dot{\boldsymbol{x}}'_{ifdtT}$ are variables demeaned at the firm-product-destination-trade pattern level, i.e., residuals from the average over time conditional upon being observed

Price and Destination-Specific Markup Elasticities

by Invoicing Currency Schemes: 2015-2017

	All Currencies
Price Elasticity	0.332***
	(0.0106)
DSME	0.0670***
	(0.0224)
Observations	5,216,947

Notes: Export prices denominated in £. Exchange rates in £ per foreign currency; increase ⇒ foreign currency appreciation.

A 1% increase in foreign currency

- ⇒ export prices in sterling rise by 0.33%,
- ⇒ export prices in foreign currency fall by 1-0.33=0.67%. (ERPT is 67%.)
- ⇒ the destination-specific markup (in £) increases by 0.07%.
- 21% (=0.07/0.33) of incomplete pass through due to destination specific markup adjustments.

Price changes = (a) global markup adjustments +
(b) destination-specific markup adjustments +
(c) changes in marginal costs

Price and DSME: 2015-2017

Variation in ERPT by invoicing currency scheme

	(1) All	(2) PCI	(3) LCI	(4) VCI (Dollar)	(5) VCI (Euro)
Price Elasticity	0.332***	0.227***	0.512***	0.417***	0.568***
	(0.0106)	(0.0155)	(0.0395)	(0.0329)	(0.0400)
Implied ERPT	**67%**	**77%**	**49%**	**58%**	**43%**
DSME	0.0670***	0.0298	0.438***	0.0838	0.0114
	(0.0224)	(0.0320)	(0.0646)	(0.0686)	(0.0861)
Observations	5,216,947	2,635,740	293,511	811,671	290,658

⇒ **Higher ERPT for PCI compared to LCI and VCI**

Notes: Export prices denominated in £. Exchange rates in £ per foreign currency; increase ⇒ foreign currency appreciation.

Different Frequency EU destinations

Price and DSME: 2015-2017

Variation in DSME by invoicing currency scheme

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Observations	5,216,947	2,635,740	293,511	811,671	290,658

⇒ **No destination specific markup adjustments for PCI and VCI**

Notes: Export prices denominated in £. Exchange rates in £ per foreign currency; increase ⇒ foreign currency appreciation.

Different Frequency EU destinations

Price and DSME: 2015-2017

Destination-specific markup adjustments and incomplete ERPT

	(1) All	(2) PCI	(3) LCI	(4) VCI (Dollar)	(5) VCI (Euro)
Price Elasticity	0.332***	0.227***	0.512***	0.417***	0.568***
	(0.0106)	(0.0155)	(0.0395)	(0.0329)	(0.0400)
DSME	0.0670***	0.0298	0.438***	0.0838	0.0114
	(0.0224)	(0.0320)	(0.0646)	(0.0686)	(0.0861)
Observations	5,216,947	2,635,740	293,511	811,671	290,658
Percent of incomplete ERPT due to destination-specific markup adjustments					
	20.2	**0**	**85.5**	**0**	**0**

Notes: Export prices denominated in £. Exchange rates in £ per foreign currency; increase ⇒ foreign currency appreciation.

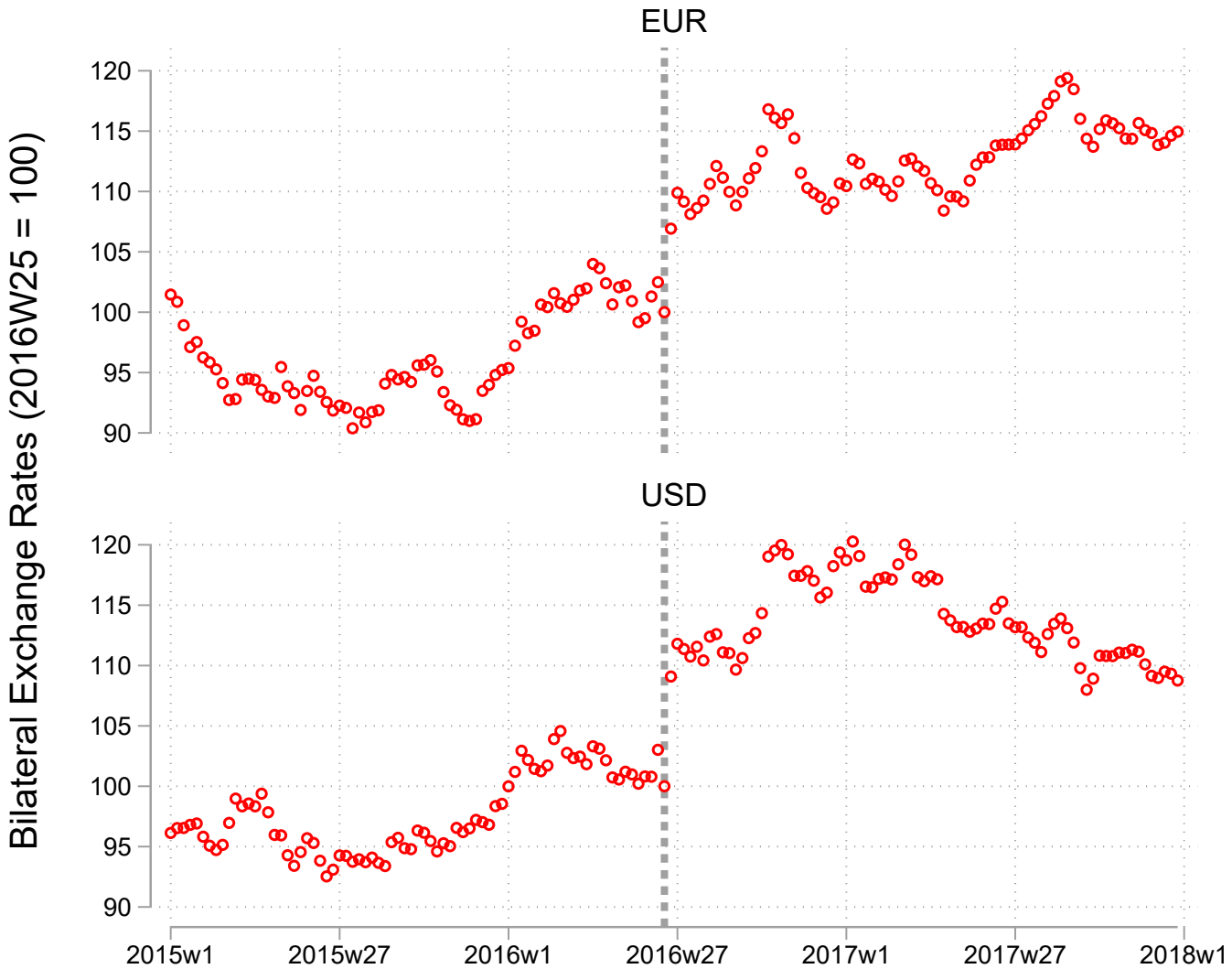
Conclusions

Firms use invoice currencies as an instrument to implement their pricing strategies:

1. The lion's share (99%) of trade is conducted by firms invoicing in multiple currencies.
2. In response to the large sterling depreciation after the Brexit referendum, local and vehicle currency invoiced transactions demonstrate faster markup adjustments than producer currency invoiced transactions.
3. Only local currency invoiced transactions demonstrate destination-specific markup adjustments $\Rightarrow$ Firms price discriminate by invoicing their products in local currencies.

Appendix

Brexit Referendum and Exchange Rates



Transition Matrix of Invoicing Schemes

Extra-EU imports excluding the US (2010-2017)

		To		
		LCI	PCI	VCI
From	LCI	90.05	1.29	8.66
	PCI	4.66	87.52	7.81
	VCI	2.34	0.66	97.00

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

The invoicing scheme choice for UK importers is more persistent than that for UK exporters.

Number of Products vs. Destinations

Extra-EU exports (2010-2017)

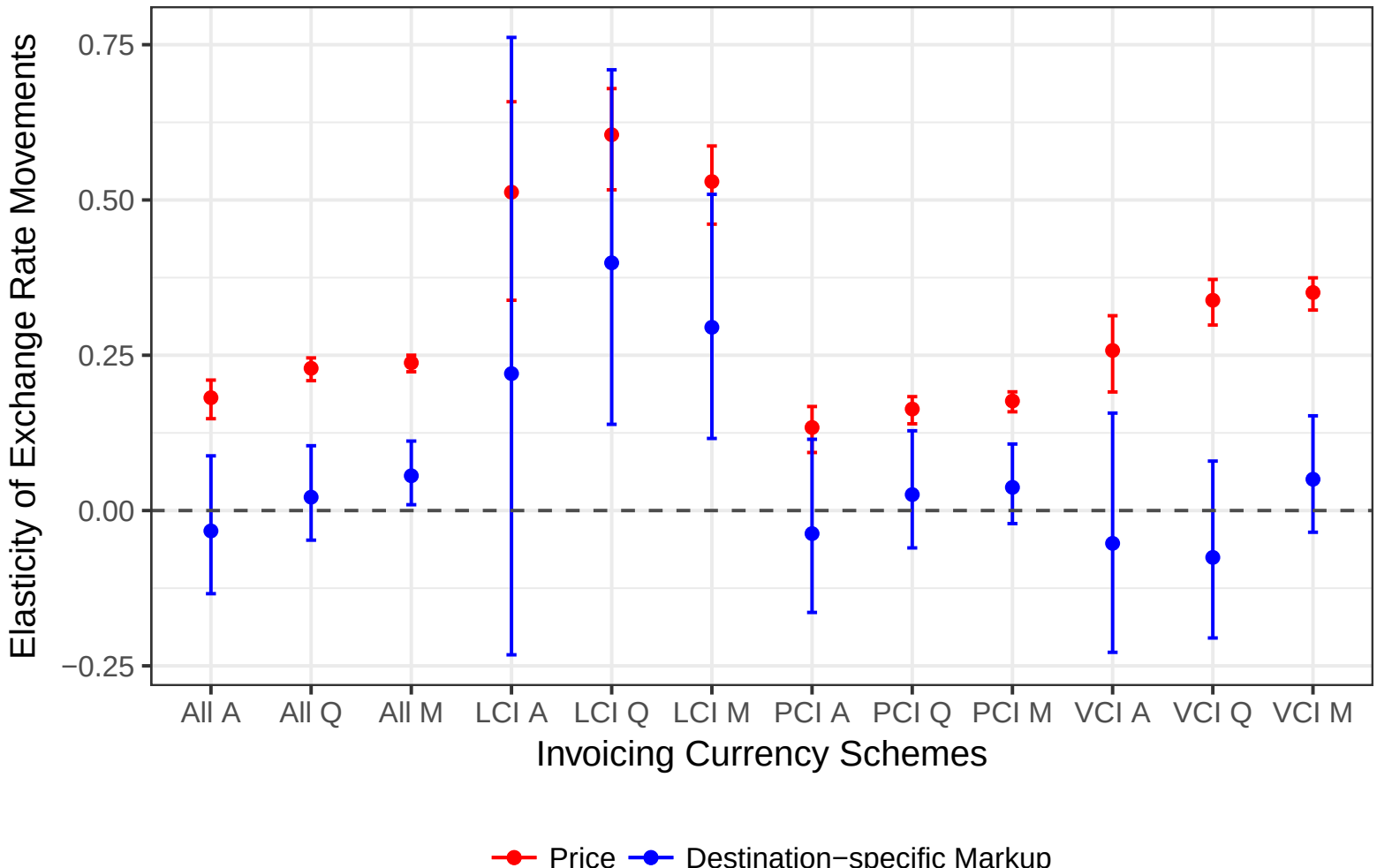
	No. of Products	No. of Destinations 1	2-5	6-10	10+	Total
by Share of Firms	1	29.7	2.0	0.1	0.0	31.8
	2-5	9.9	19.9	1.3	0.3	31.4
	6-10	1.2	6.9	3.2	0.9	12.3
	10+	0.7	4.3	6.2	13.2	24.5
	Total	41.6	33.1	10.9	14.4	100.0
by Share of Exports	1	0.5	0.5	0.0	0.0	1.0
	2-5	0.3	1.0	0.4	0.3	1.9
	6-10	0.1	0.6	1.0	1.6	3.3
	10+	0.1	1.2	2.7	89.8	93.8
	Total	1.0	3.2	4.1	91.7	100.0

⇒Multi-product, multi-destination firms originate 98.7% of UK exports to countries outside the EU.

Notes: Top panel shows the share of UK exporters that falls under the relevant description. Bottom panel presents corresponding value of exports.

Price and Destination-specific Markup Elasticities at Different Time Frequencies

Estimates Conditional on a Price Change 2010-2017



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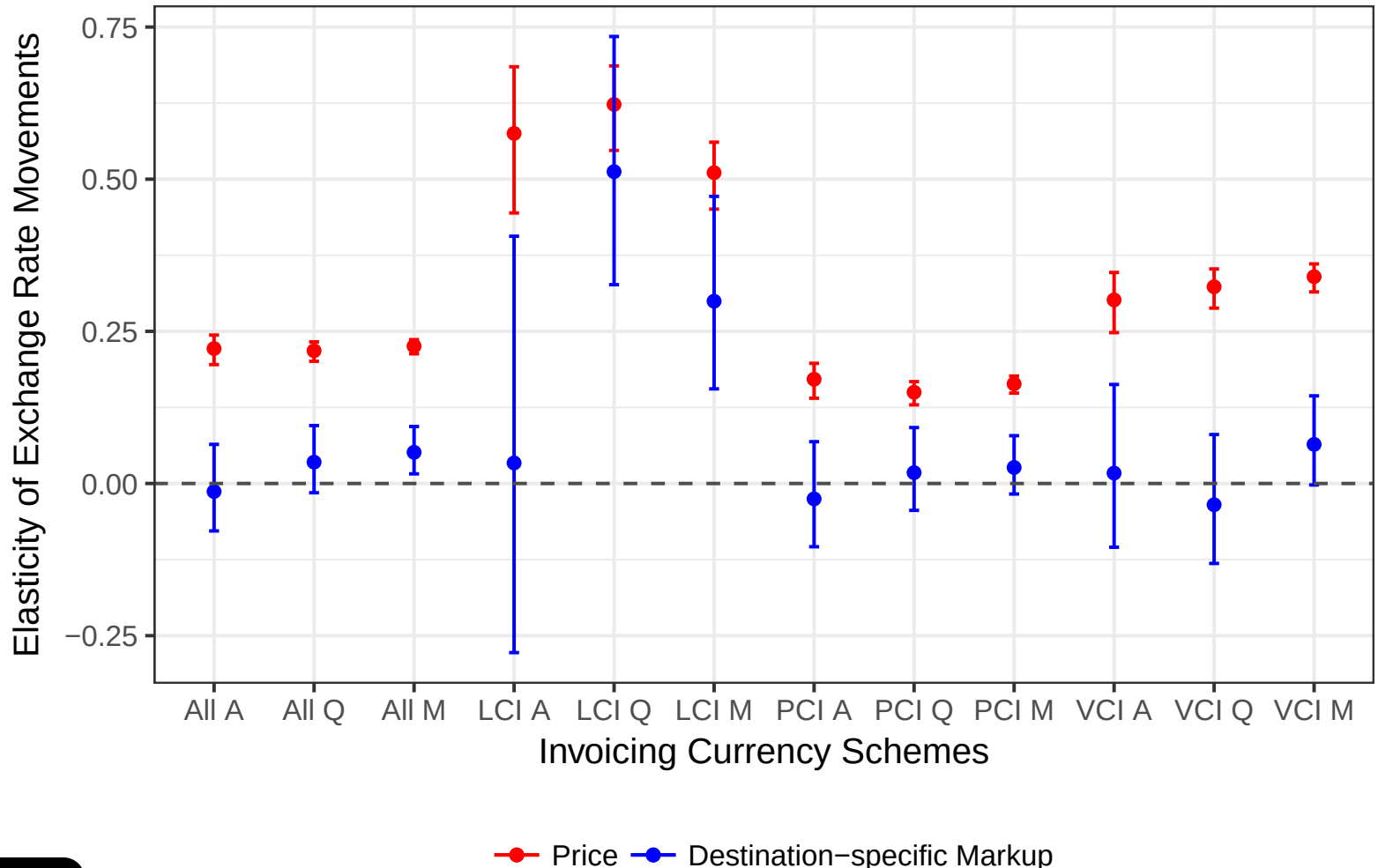
Price and Destination-specific Markup Elasticities at Different Time Frequencies

Estimates Not Conditional on a Price Change 2010-2017



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Price and Destination-Specific Markup Elasticities

to EU destinations 2010-2017

	Price		DSM		
Freq.	NEX	CPI	NEX	CPI	n. of obs
Annual	0.35***	1.43***	-	0.69***	8,425,218
Quarterly	0.34***	1.44***	-	0.67***	21,643,526
Monthly	0.35***	1.41***	-	0.63***	42,172,525

- For exports to EU, we do not know the invoicing currency.
- The pattern for price elasticities on sales to EU are similar to those for LCI exports to countries outside the EU.
- Destination-specific markup elasticity to local CPI in EU countries is high.

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Price and Destination-Specific Markup Elasticities

to destinations outside the EU and the US: 2010-2017

Freq.	Invoicing	Price		DSM		n. of obs
		NEX	CPI	NEX	CPI	
Annual	PCI	0.13***	0.34***	-0.04	0.11	1,529,583
	VCI	0.26***	0.45***	-0.05	0.01	559,184
	LCI	0.51***	0.81***	0.22	1.05	49,873
Quarterly	PCI	0.16***	0.36***	0.03	-0.05	3,106,318
	VCI	0.34***	0.55***	-0.08	-0.10	1,177,315
	LCI	0.61***	1.08***	0.40***	0.76*	121,045
Monthly	PCI	0.18***	0.35***	0.04	0.03	4,167,771
	VCI	0.35***	0.53***	0.05	-0.03	1,693,494
	LCI	0.53***	0.71***	0.30***	-0.07	164,595

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Price and Destination-Specific Markup Elasticities

to Non-EU versus All Destinations: 2010-2017

		Price		DSM		
Freq.	Exports	NEX	CPI	NEX	CPI	n. of obs
Annual	Non-EU	0.18***	0.38***	-0.03	0.11	2,138,640
	All countries	0.25***	0.62***	-0.02	0.18*	10,563,858
Quarterly	Non-EU	0.23***	0.43***	0.02	-0.02	4,404,678
	All countries	0.29***	0.71***	0.23***	0.37***	26,048,204
Monthly	Non-EU	0.24***	0.41***	0.06**	0.02	6,025,860
	All countries	0.32***	0.78***	0.19***	0.35***	48,198,385

Notes: Estimates conditional on a price change. Statistical significance is based on robust standard errors. ***,**,* stand for 1%, 5%, and 10% significance level respectively.