# Invoicing and Pricing-to-Market

## Evidence on the "International Price System" from UK Exporters

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# Introduction

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- Import prices at the border are known to be "excessively stable" – they do not move with currencies as much as economists would expect given changes in relative production costs.

$\Rightarrow$ Understanding why is important for economic policy design.

**Export value (blue) and volume (yellow) grew post-referendum when sterling fell 20%... but, this was a blip rather than a boom.**
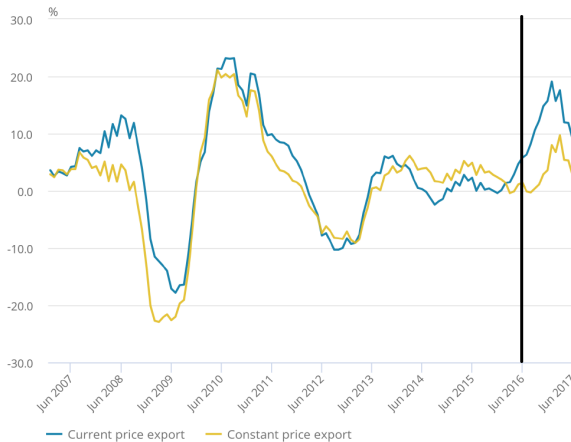


Source: Office for National Statistics

Source: ONS report, September 2017, Figure 9

## Invoicing currencies and exchange rate pass through

Recently, attention has turned to the **currency of invoicing** of trade transactions: is it a good indicator of the degree of price adjustment to exchange rate fluctuations?

Gopinath's *International Price System* (2015) stresses that asymmetries in exchange rate pass through indicate the dominant role of the US dollar in goods trade.

Differences in ERPT into import prices after 2 years,

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Differences in ERPT into import prices after 2 years,

- US – 44%; Japan – 90%; Turkey – 100%

reflect the share of imports invoiced in dollars, which are:

- US – **93%**; Japan – **71%** (only 13% from the US); Turkey – **60%** (only 6% from US).

# The research questions

What can we learn from analyses of invoicing currencies in transaction-level data on British exports?

- What do we know about firms' invoicing currency usage? How many currencies does each firm use and does the firm switch currencies over time?

- Do we find a close relationship between price adjustments and invoicing currency in British data?

- Price adjustments incorporate both markup and marginal cost changes. Is the invoicing choice related to firms' strategic markup adjustments?

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  ⇒ **Estimate pricing-to-market using the TPSFE estimator**

# Outline

- 4 stylized facts

- Brexit event study

- Pricing-to-market and invoicing currency (TPSFE approach)

# Data: UK-based firms engaged in exporting

- The universe of export transactions from HMRC Overseas Trade Statistics databases.

- Extra-EU transactions recorded daily; aggregate to week, month, quarter or year.

- EU-transactions are recorded monthly and are limited to firms exporting more than £250,000 per year.

Annual data on exports to the EU by firms exporting $> £250,000$ per year.

| | Export value (£mil.) | Firms | Firm-product exporters | Firm-product entrants | Firm-product exiters |
|------|------|--------|---------|---------|--------|
| 2013 | 146 | 21,263 | 337,072 | 96,328 | 87,407 |
| 2014 | 142 | 20,884 | 350,259 | 98,180 | 84,993 |
| 2015 | 129 | 21,092 | 367,107 | 102,002 | 85,154 |
| 2016 | 139 | 21,074 | 383,669 | 105,862 | 89,300 |

Source: Calculations based on HMRC administrative datasets.

# Stylized facts about invoicing currencies

1. The UK's trade is dominated by firms invoicing in more than one currency.
   ⇒ 99% of UK exports to destinations outside the EU originate from such firms

2. UK exporters invoice in multiple currencies in the same destination for the same product.
   ⇒ Nearly 50% of UK exports to extra-EU destinations are conducted by such firms

3. UK exporters switch the currency of invoicing over time.

4. The aggregate pattern of invoicing currencies is different for exports and imports, but stable over time.

# Fact 1: UK exporters use more than one currency

### UK exports, excluding the EU, 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 |

⇒ **99.3% of export value originates from multi-currency exporters**
⇒ **only .7% of export value (43% of transactions) uses one currency.**

Top panel: share of UK exporters. Bottom panel: share of export value.

# Fact 2: Multi-currency invoicing
**for same product-firm-destination-year (ifdt) quartet**

|            | No. of Currencies | No. of Transactions | Share (%) Transactions | Share (%) Trade |
|------------|-------------------|---------------------|------------------------|-----------------|
|            | 1                 | 5,134,053           | 84.0                   | 49.4            |
| UK Exports | 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           |

⇒ **50.6% of exports of the same "ifdt" invoiced in multiple currencies**

# Fact 3: Transition matrix of invoicing schemes
### UK exports, excluding EU, 2010-2017

Matrix calculated from single invoicing currency transactions (row 1 of previous table):

|      |     | 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 |

- LCI - local currency invoicing, e.g., Korean won for Korea.
- PCI - producer currency invoicing, i.e., sterling.
- VCI - vehicle currency invoicing, e.g., US dollars for Canada.

# Fact 4: Share of invoicing currencies in UK exports
### excluding trade to the US and EU
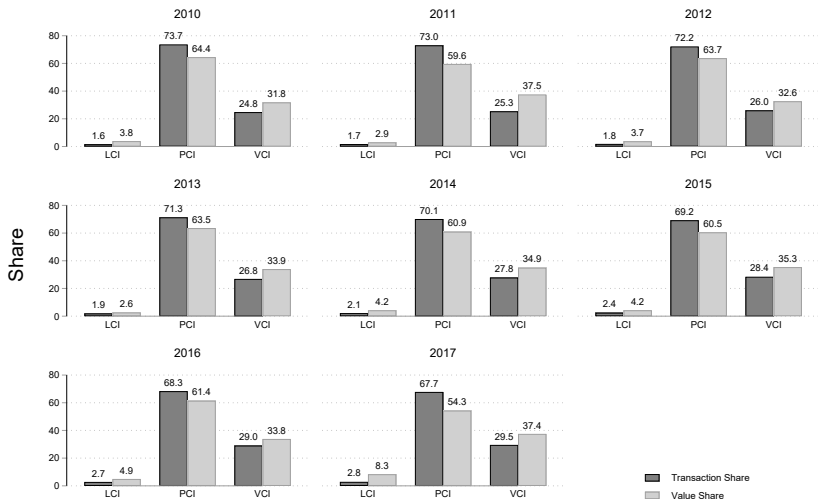
# Brexit event study

Against the large depreciation following Brexit-referendum, we find:

- Export prices in sterling rise immediately in VCI and LCI transactions.
- For PCI transactions, prices are initially unresponsive, then they rise steadily.
- Differences across VCI LCI and PCI narrow over 6 quarters from the referendum.

# ERPT after the Brexit referendum

An international price embodies three components, each of which may respond differently to an exchange rate movement.

Price changes = (a) global markup adjustments +

(b) destination-specific markup adjustments +

(c) changes in marginal costs

- Event study: Captures (a), (b) and (c) in response to a specific (although) complex shock.

- However, if one thinks that marginal costs remain temporary unresponsive to Brexit depreciation in the very short run (evidence on import prices...), one may consider the event study informative about (a) and (b) as well.
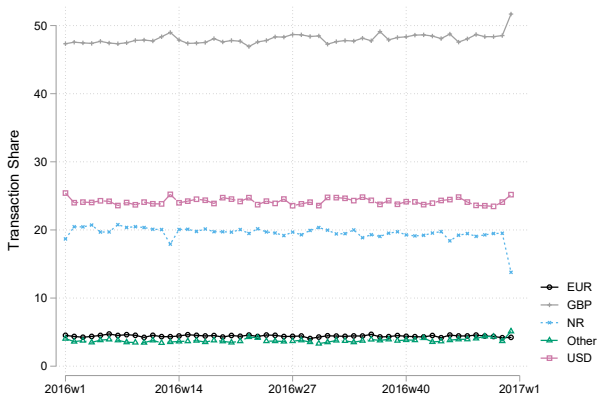
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## The pound around the Brexit referendum
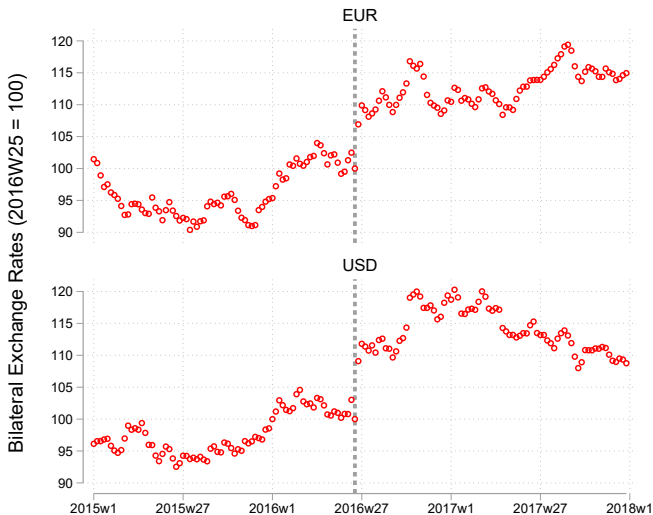
# Brexit event study

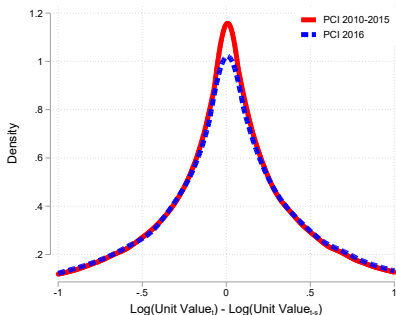### Aggregate shares of invoicing currencies in 2016



Transaction share of different invoicing currencies for extra-EU exports did not respond to the Brexit depreciation.

Note: "NR" stands for not reported.

# Brexit event study

### Distribution of export price changes: 2016-2017 vs 2010-2015
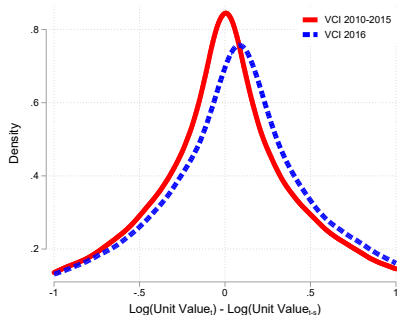### Prices measured in sterling

**Producer Currency** Invoiced (PCI) Transactions



Note: Density is calculated based on all unit value changes including those > 1 or < -1.

**No Shift ⇒ High ERPT**
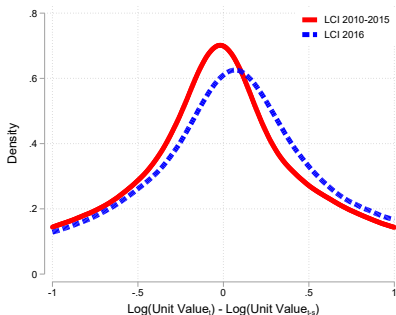
**Vehicle Currency** Invoiced (VCI) Transactions



Note: Density is calculated based on all unit value changes including those > 1 or < -1.

**Shift to the right ⇒ Low ERPT**
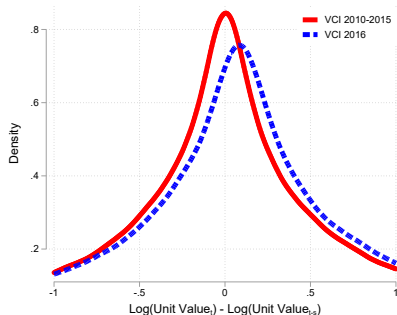
# Brexit event study

### Distribution of export price changes: 2016-2017 vs 2010-2015
### Prices measured in sterling

**Local Currency** Invoiced (LCI)
Transactions



Note: Density is calculated based on all unit value changes including those > 1 or < -1.

**Vehicle Currency** Invoiced (VCI)
Transactions



Note: Density is calculated based on all unit value changes including those > 1 or < -1.

**Shift to the right ⇒ Low ERPT**

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# Brexit event study

### Estimation equation

Econometric analysis of weekly ERPT:

$$y_{ifdt} = \sum_{\tau=1}^{156} \lambda_\tau + \delta_{ifd} + u_{ifdt} \quad y \in \{p_{ifdct}, q_{ifdt}, e_{dt}\} \tag{1}$$

where

- $i, f, d, t$ represent product, firm, destination country, and *week* respectively.
- $\sum_{\tau=1}^{156} \lambda_\tau$ is a bunch of week dummies capturing the average price/quantity/exchange rate changes
- $\delta_{ifd}$: firm-product-destination fixed effects

$\Rightarrow$ Equation (1) is separately estimated for each invoicing currency scheme.

# Brexit event study
## Weekly pass through after the Brexit referendum
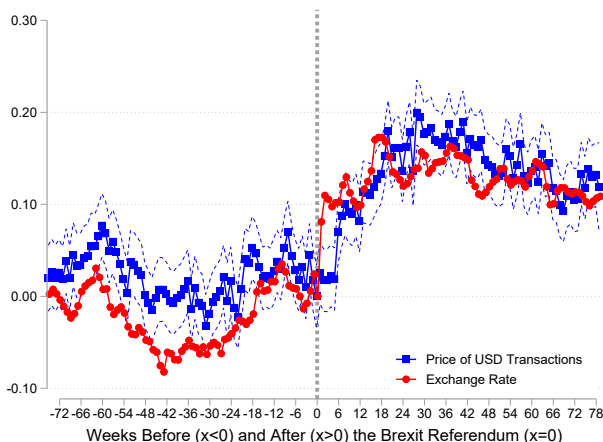
Weekly Price Changes of **Sterling** Invoiced Transactions **2015-2017**
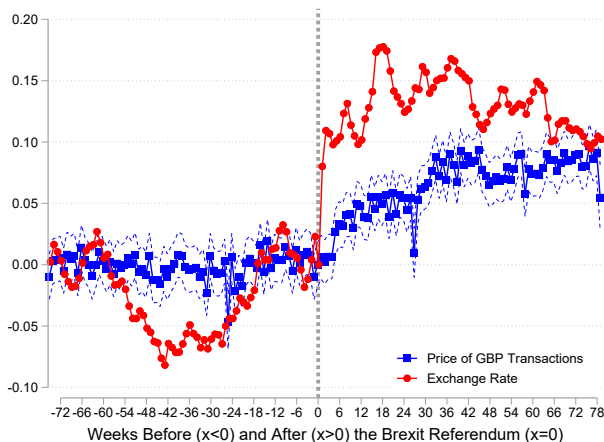
# Brexit event study

## Weekly pass through after the Brexit referendum

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

# Brexit event study
## Weekly pass through after the Brexit referendum

Weekly Price Changes of **Local Currency** Invoiced Transactions **2015**-**2017**
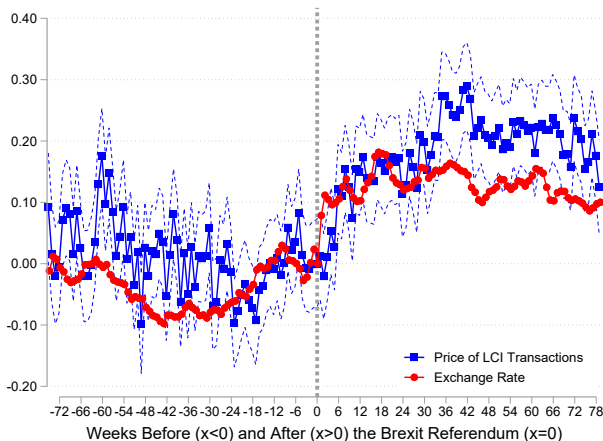
# Trade Pattern Sequential Fixed Effect (TPSFE) Approach

An international price embodies three components, each of which may respond differently to an exchange rate movement.

Price changes = (a) global markup adjustments +

(b) destination-specific markup adjustments+

(c) changes in marginal costs

1. Similar to the event study, ERPT regressions: Capture (a), (b) and (c).

2. TPSFE approach: Captures (b), i.e., pricing-to-market

## Firm pricing: optimal markup and marginal cost

The observed export price (in logs) of a firm $f$ selling identical products $i$ in destinations $d$ at time $t$ can be written as

$$p_{ifdt} = \mu_{ifdt}(e_{dt}) + mc_{ift}(\boldsymbol{e_t}) \tag{2}$$

$$s_{ifdt} = \left\{ \eta_{ifdt}(\boldsymbol{e_t}) > 0 \right\} \tag{3}$$

where

- $\mu_{ifdt}$ - unobserved optimal markup,
- $mc_{ift}$ - unobserved product-level marginal cost within the firm,
- $e_{dt}$ is the bilateral exchange rate expressed as $d$'s currency per exporter's currency, a shifter a demand in destination $d$, and
- $\boldsymbol{e_t}$ is the vector of exchange rates relevant to the firm's imported inputs, a shifter of marginal cost.

# Goal: measure pricing-to-market

**Estimate destination-specific markup elasticity to the exchange rate**

The observed export price (in logs) of a firm $f$ selling identical products $i$ in destinations $d$ at time $t$ can be written as

$$p_{ifdt} = \mu_{ifdt}(e_{dt}) + mc_{ift}(\boldsymbol{e_t})$$
$$s_{ifdt} = \left\{ \eta_{ifdt}(\boldsymbol{e_t}) > 0 \right\}$$

Issues:

1. Product-level mc is unobserved and is (potentially) a function of multiple bilateral exchange rates.

2. Market participation (potentially) depends on multiple bilateral exchange rates.

## Trade Pattern Sequential Fixed Effects Approach

To obtain an unbiased estimator of the destination-specific markup elasticity requires

**1 controling for time-varying product-level marginal cost**

**2 addressing the endogenous selection of markets.**

We will implement a 3 step procedure that is equivalent to sequentially applying two sets of fixed effects that

1 cleanly isolate the destination-specific component of the price of a product sold by a firm and

2 reduce selection bias associated with unobservables that drive market participation .

# Exporters have time-varying trade patterns

framesubtitleExample from the universe of Chinese Customs Transactions

Sales of wheeled tractors (HS 87019011)
by a Chinese exporter with (ID 3301962621)

| | | | |
|------|----|-----------|--------|
| 2007 | UK | Australia | |
| 2008 | UK | Australia | Canada |
| 2009 | UK | Australia | Canada |
| 2010 | UK | | |
| 2011 | UK | Australia | Canada |
| 2012 | UK | Australia | |

# Example: Trade Pattern Fixed Effects

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 **t = 2** with **t = 4** and **t = 3** with **t = 5**.

# Intuition: Trade Pattern Fixed Effects

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

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

- 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 $i$:

$$\widetilde{x}_{ifdtD} \equiv x - \frac{1}{n_{ift}^{D}} \sum_{d \in D_{ift}} x \quad \forall x \in \{p_{ifdt}, e_{dt}, \mathbf{x}_{dt}\} \tag{4}$$

- $D_{ift}$ denotes the set of destinations in period $t$;
- $n_{ift}^{D}$ is the number of active destinations in in period $t$;
- $e_{dt}$ is the bilateral exchange rate ($rmb/d$); and
- $\mathbf{x}_{dt}$ is a vector of local CPI and real GDP.
  $\Rightarrow \widetilde{p}_{ifdtD}$ 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*:

$$\ddot{x}_{ifdtDT} \equiv \widetilde{x}_{ifdtD} - \frac{1}{n_{ifdD}^T} \sum_{t \in T_{ifdD}} \widetilde{x}_{ifdtD} \quad \forall x \in \{p_{ifdt}, e_{dt}, \boldsymbol{x}_{dt}\} \quad (5)$$

- $T_{ifdD}$ denotes the set of time-varying destination-trade patterns,
- and $n_{ifdD}^T$ 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 destination and trade pattern $T_{ifdD}$*

# Step 3: Estimate destination-specific markup elasticity

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

$$\ddot{p}_{ifdtDT} = \beta_0 + \beta_1 \ddot{e}_{dtDT} + \ddot{x}'_{dtDT}\beta_2 + \ddot{v}_{ifdtDT} \tag{6}$$

- $\beta_1$ 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 a destination and its set of destinations $D_{ift}$.
  e.g. VN-VN-KR-JP, KR-VN-KR-JP and JP-VN-KR-JP.

# Estimating equation for price elasticity (1-ERPT)

We also regress prices (not price residuals) on exchange rates and the trade pattern fixed effects.

$$p_{ifdt} = \beta e_{dt} + TP_{ifd,D_{ift}} + \widetilde{u}_{ifdt}$$

where

- $\beta$ is the price elasticity $\equiv 1 - ERPT$.
- The trade pattern dummies, $TP_{ifd,D_{ift}}$, capture the observation's destination (JP) and its trade pattern (VN-KR-JP).

# Pricing-to-market by British exporters: Results

- Export price elasticity to the exchange rate=1-ERPT:
  - ⇒ Producer currency (£) invoiced transactions: 0.24***
    (ERPT: 76%)
  - ⇒ Vehicle currency ($) invoiced transactions: 0.41***
    (ERPT: 59%)
  - ⇒ Local currency invoiced transactions: 0.58***
    (ERPT: 42%)

  Local currency invoice → lower ERPT.

- Destination-specific markup elasticity to exchange rate (DSME):
  - ⇒ Producer currency (£) invoiced transactions: 0.04
  - ⇒ Vehicle currency ($) invoiced transactions: 0.06
  - ⇒ Local currency invoiced transactions: 0.48***

  Only LCI implies pricing to market: Most (.48/.58=84%) of the incomplete pass through of LCI transactions is due to the exporter adjusting the markup in the destination markets.

# Price and markup elasticities
### UK extra-EU, extra-US exports 2015-2017, weekly frequency

|                  | (1) All |
| ---------------- | ------- |
| **Price**        | 0.333*** (0.0118) |
| **Markup**       | 0.0733*** (0.0267) |
| Observations     | 4,854,264 |

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

Against 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 incomplete = 67%

⇒ the destination-specific markup (in £) increases by 0.07%

22% (=0.073/0.33) due to destination specific markup adjustments.

# Price and markup elasticities: 2015-2017
**UK extra-EU, extra-US exports by invoicing currency, weekly frequency**

## ERPT

|  | (1) All | (2) PCI | (3) LCI | (4) VCI (Dollar) | (5) VCI (Euro) |
|---|---|---|---|---|---|
| **Price** | 0.333*** (0.0118) | 0.241*** (0.0177) | 0.577*** (0.0453) | 0.406*** (0.0365) | 0.520*** (0.0448) |
| Implied ERPT | **67%** | **76%** | **42%** | **59%** | **48%** |
| **Markup** | 0.0733*** (0.0267) | 0.0435 (0.0384) | 0.482*** (0.0778) | 0.0591 (0.0779) | 0.0506 (0.106) |
| Observations | 4,854,264 | 2,438,368 | 258,970 | 765,993 | 277,611 |

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

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

# Price and markup elasticities: 2015-2017
### UK extra-EU, extra-US exports by invoicing currency, weekly frequency

## Destination Specific Markup Elasticity (DSME)

|  | (1)<br>All | (2)<br>PCI | (3)<br>LCI | (4)<br>VCI (Dollar) | (5)<br>VCI (Euro) |
|---|---|---|---|---|---|
| **Price** | 0.333*** | 0.241*** | 0.577*** | 0.406*** | 0.520*** |
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|  | (0.0267) | (0.0384) | (0.0778) | (0.0779) | (0.106) |
| Observations | 4,854,264 | 2,438,368 | 258,970 | 765,993 | 277,611 |

⇒ **Substantial pricing-to-market for LCI during Brexit depreciation**

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

## Price and Markup Elasticities
**to destinations outside the EU and the US: 2010-2017**

| Freq. | Invoicing | Price | | Markup | | 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 |

⇒ **Substantial pricing-to-market for LCI confirmed over a longer time period**

## Price and Markup Elasticities
### to Non-EU versus All Destinations: 2010-2017

| Freq. | Exports | Price | | Markup | | n. of obs |
|-------|---------|-------|------|--------|------|-----------|
|       |         | NEX   | CPI  | NEX    | CPI  |           |
| Annual | Non-EU | 0.32*** | 0.55*** | 0.10* | 0.15 | 2,936,692 |
|        | All countries | 0.28*** | 0.65*** | -0.02 | -0.04 | 11,502,814 |
| Quarterly | Non-EU | 0.34*** | 0.56*** | 0.09*** | 0.00 | 5,635,328 |
|           | All countries | 0.31*** | 0.71*** | 0.24*** | 0.29*** | 27,397,833 |
| Monthly | Non-EU | 0.35*** | 0.54*** | 0.09*** | -0.02 | 7,808,005 |
|         | All countries | 0.34*** | 0.79*** | 0.23*** | 0.21*** | 50,129,917 |

⇒ **Pricing-to-market averaged over all currencies is much stronger when US and EU, the UK's two largest markets, are included**

# Conclusions

We find supporting evidence on *International Price System* and that 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.