Vehicle Currency Pricing and Exchange Rate Pass-Through

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Motivation

- **When exchange rates move, prices move**
  - Biggest impact on import prices
  - Ultimately feeds through to consumer prices
  - Depends on the currency of invoicing

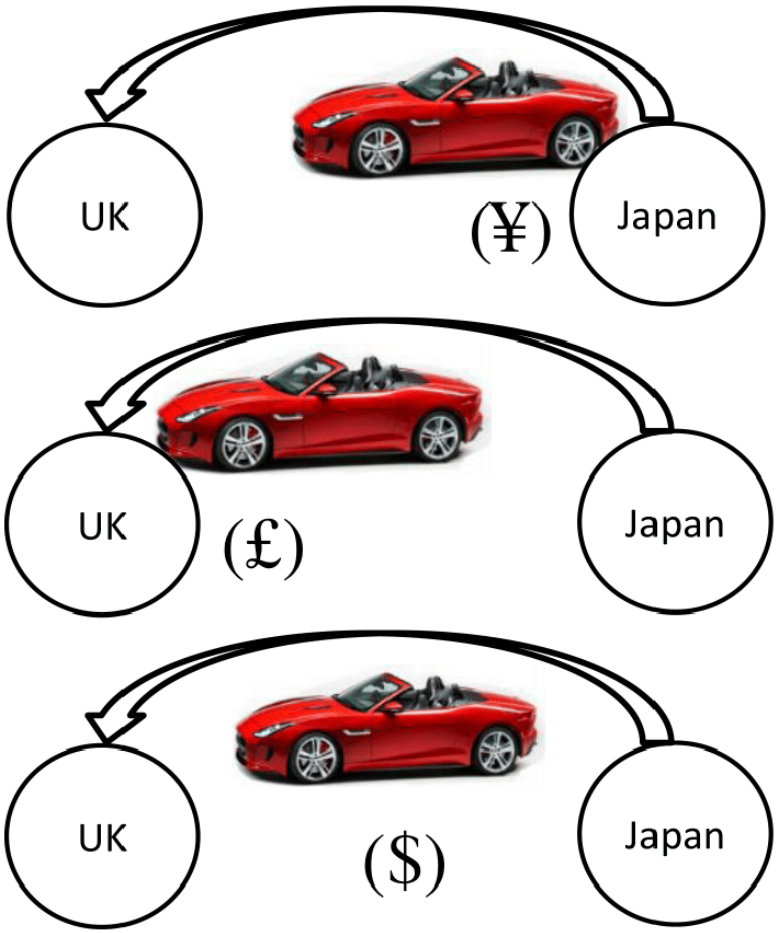
- **Important for policy**
  - Inflation
  - Forecasting
  - Conduct of monetary policy
  - International role of the US dollar and euro

Our Focus

- **Empirical regularity**
  - International trade transactions are not always priced in the producer's currency (PCP)
  - Nor in the currency of the consumer (LCP)
  - Often in a "vehicle" (or third) currency (VCP)
- **Exchange rate disconnect puzzle**
  - The prices of internationally traded goods only react modestly to exchange rate movements

Invoicing Currency and Pass-Through

The UK imports a car from Japan (prices are sticky in the currency of invoice)



Producer Currency Pricing (PCP)

UK import prices (in sterling) respond one-to-one to exchange rate changes

Full pass-through (100%)

Local Currency Pricing (LCP)

UK import prices (in sterling) do not respond to exchange rate changes

Zero pass-through (0%)

Vehicle Currency Pricing (VCP)

Pass-through?

Research Questions

1) How important is VCP in the data? Accounts for **55 percent** of UK imports from non-EU countries (and for 24 percent of non-EU exports)

- First paper to investigate the implications of three invoicing choices (LCP, PCP, VCP) for the response of import prices to exchange rate movements

- Data from Her Majesty's Revenue and Customs (HMRC): firm-level data for UK imports with non-EU countries 2010–2017 (also exports)

- Sterling floats freely

- Large shares of imports invoiced in vehicle currencies (VCP typically low for countries like the US, and data rarely available bilaterally)

2) What are the implications of VCP for the response of import prices to exchange rate changes (**exchange rate pass-through**)?

- To evaluate pass-through, are we looking at the "right" exchange rates?

  Example: when the UK imports from Japan, researchers typically use the bilateral sterling/yen exchange rate even if the goods are priced in US dollars

- Can we alleviate the exchange rate disconnect puzzle?
  - Estimated pass-through for the VCP transactions more than doubles
  - Intuition: using *bilateral* instead of *vehicle* exchange rates leads to omitted variable bias

3) What are the implications for consumer price inflation?

Implications for monetary policy: construct an effective exchange rate based on invoicing weights, not trade weights

4) How should we model exchange rate pass-through conceptually?

Theory based on Engel (2006) to explain pass-through under VCP

Key Findings

- **Bilateral exchange rates**: short-run pass-through is **24%** (VCP), 62% (PCP), 0% (LCP)
- **Vehicle exchange rates**: short-run pass-through is **59%** (VCP)
- Bilateral exchange rates are **inappropriate** for the VCP transactions: the pass-through of vehicle currency exchange rates is more than double (exchange rate disconnect puzzle)
- Similar results in the long run
- Effect on UK CPI forecast: higher inflation impact due to VCP

Implications for UK Import Price Inflation

We look at three quarterly episodes of large sterling fluctuations to show that accounting for the invoicing currency helps to explain the response of import price (and therefore of consumer price) inflation to changes in exchange rates

- **Brexit Referendum**
  - June–August 2016: sterling depreciated by 7.09% on average, and by 6.34% and 7.66% against the US dollar and the euro
  - Bilateral exchange rates: inflation rises on impact and after 2 years by **1.27pp** and **2.93pp**
  - VCP exchange rates: inflation rises on impact and after 2 years by **2.79pp** and **3.16pp**

"Inflation jumped to 2.9 percent in May," which is "above analysts' consensus forecasts" (The Financial Times, 13 June 2017)

- **Great Recession**
  - November 2008–January 2009: sterling depreciated by 12.94% on average, and by 19.43% and 12.34% against the US dollar and the euro
  - Bilateral exchange rates: inflation rises on impact and after 2 years by **2.32pp** and **5.34pp**
  - VCP exchange rates: inflation rises on impact and after 2 years by **7.10pp** and **7.77pp**

  The surprising high inflation "is likely to reflect stronger, or faster, exchange rate pass-through following the fall in sterling" (Bank of England Inflation Report, May 2009)

- **EU Sovereign Debt Crisis**
  - January–March 2015: sterling appreciated by 2.66% and 6.24% on average and against the euro, but depreciated by 4.76% against the US dollar
  - Bilateral exchange rates: inflation **falls** on impact and after 2 years by **0.48pp** and **1.10pp**
  - VCP exchange rates: inflation **rises** on impact and after 2 years by **0.62pp** and **0.47pp**

  "The earlier appreciation will be associated with less of a fall in import prices than previously assumed" (Bank of England Inflation Report, August 2015)
- By decomposing pass-through by invoicing currency, we can explain the higher pass-through into import prices after the Brexit vote and during the Great Recession, and the lower pass-through after the EU Sovereign Debt Crisis
- Implications for monetary policy

Related Literature

- Incomplete pass-through and pricing-to-market (Campa and Goldberg, 2005, 2010; Gopinath and Rigobon, 2008). Firm-level (Amiti et al., 2014; Berman et al., 2012; Chen and Juvenal, 2016)

- Invoicing currency and pass-through: little evidence due to limited data
  - Auer et al. (2021); Bonadio et al. (2020); Corsetti et al. (2018); Devereux et al. (2017); Fabling and Sanderson (2015); Gopinath et al. (2010)
  - "Dominant Currency Paradigm": Gopinath et al. (2020); Gopinath (2016)
  - Theory: Betts and Devereux (2000); Devereux et al. (2004)

- Determinants of currency of invoicing choices (Chung, 2016; Goldberg and Tille, 2008, 2016; Lyonnet et al., 2016)

Data

Data from Her Majesty's Revenue and Customs

- For each CIF import transaction (2010–2017)
  - Unique trader identifier
  - Country of origin
  - 10-digit comcode product code (the first 8 digits correspond to the CN)
  - Transaction date
  - 5-digit SITC Rev. 3 and 4-digit HS Rev. 2007 classifications
  - The value (in sterling), the mass (in kilograms)
  - The currency of invoicing for **non-EU** transactions only
- Compute import unit values at quarterly frequency
- Drop the "Not classified" industry (SITC9) and 1% of the sample with the largest/smallest unit value changes

Table 1: Summary Statistics

	Imports
Sample period	2010–2017
Importers	120,429
Products	16,219
Origin countries	138
Mean products per importer	6.9
Mean origin countries per importer	2
Mean unit value (sterling/kg)	760.7
Mean change in log unit values (~%)	0.8
Mean transaction value (sterling)	213,630
Observations	5,792,400

Source: HMRC administrative data sets

Table 2: Import Shares by Invoicing Currency Choice (%)

	2010–2017
LCP	27.13
PCP	18.33
VCP	54.54
VCP (USD)	88.50
VCP (Euro)	10.95
VCP (Other)	0.55

Source: HMRC administrative data sets

A total of 91 different vehicle currencies are used (also, the Hong Kong dollar, the Japanese yen, the Australian dollar, the Swiss franc, etc.)

Table 3: Invoicing Currency Shares by Industry and Region (%)

Industry (SITC)	PCP	LCP	VCP
Food, live animals	12.68	35.63	51.69
Beverages, tobacco	19.17	70.13	10.70
Crude materials	30.86	28.57	40.57
Mineral fuels	5.15	6.10	88.75
Animal, vegetable oils	11.01	3.63	85.36
Chemicals	28.78	29.68	41.54
Manufactured goods	12.92	22.23	64.85
Machinery	25.67	28.15	46.18
Miscellaneous manufacturing	13.39	35.80	50.81
Origin	PCP	LCP	VCP
US	85.67	12.75	1.58
China	0.77	22.59	76.64
East/South East Asia	5.65	43.86	50.49
Europe excluding EU	5.35	26.64	68.01
Other Americas	9.32	24.87	65.81
All Others	3.76	19.92	76.32

Source: HMRC administrative data sets

Empirical Analysis

Pass-Through into Import Unit Values

Pass-through regression

$$\Delta \ln UV_{ijk,t} = \sum_{n=0}^{N} \beta_n \Delta \ln e_{ij,t-n} + \sum_{n=0}^{N} \alpha_n \pi^*_{j,t-n} + D_{i,t} + D_{jk} + \epsilon_{ijk,t}$$

- $UV_{ijk,t}$ is the import unit value of product k (comcode level) imported by firm i from country j in quarter t (sterling per kilogram)
- $e_{j,t}$ is the **bilateral** exchange rate (an increase is a depreciation of sterling)
- $\pi^*_{j,t}$ is the quarterly foreign CPI inflation rate; $N = 8$ (two years)
- $D_{i,t}$ firm-quarter, D_{jk} product-origin fixed effects; cluster by origin-year

Exchange Rate

- LCP and PCP transactions: **bilateral** exchange rate
- VCP transactions: exchange rate with **vehicle currency**
- Decompose the bilateral exchange rate

$$\Delta \ln e_{ij,t} = \Delta \ln e_{iV,t} + \Delta \ln e_{Vj,t},$$

  where V denotes the vehicle currency

- If prices are sticky in the VCP currency and are measured in sterling, we would expect the $e_{iV,t}$ exchange rate to matter for pass-through

Estimation

For the full sample of import transactions we estimate

$$\begin{aligned}\Delta \ln UV_{ijk,t} &= \sum_{n=0}^{N} \zeta_n \Delta \ln e_{ij,t-n} \times D_{PCP} + \sum_{n=0}^{N} \lambda_n \Delta \ln e_{ij,t-n} \times D_{LCP} \\ &+ \sum_{n=0}^{N} \kappa_n \Delta \ln e_{iV,t-n} \times D_{VCP} + \sum_{n=0}^{N} \psi_n \Delta \ln e_{Vj,t-n} \times D_{VCP} \\ &+ \sum_{n=0}^{N} \chi_n \pi^*_{j,t-n} + D_{i,t} + D_{jk} + D_{PCP} + D_{VCP} + \nu_{ijk,t},\end{aligned}$$

where D_{PCP}, D_{LCP}, and D_{VCP} are dummy variables for the PCP, LCP, and VCP transactions

We also estimate a simpler version where we omit the change in the exchange rate between the vehicle and the origin country's currency $e_{Vj,t}$

Results

Short-Run Pass-Through

Table 5: Pass-Through into Import Unit Values

	(1)	(2)	(3)	(4)
$\Delta \ln e_{ij,t}$	0.179*** (0.028)	–	–	–
$\Delta \ln e_{ij,t} \times D_{PCP}$	–	0.445*** (0.044)	0.649*** (0.049)	0.620*** (0.051)
$\Delta \ln e_{ij,t} \times D_{LCP}$	–	−0.066 (0.040)	0.031 (0.035)	0.002 (0.036)
$\Delta \ln e_{ij,t} \times D_{VCP}$	–	0.242*** (0.031)	–	–
$\Delta \ln e_{iV,t} \times D_{VCP}$	–	–	0.649*** (0.056)	0.592*** (0.058)
$\Delta \ln e_{Vj,t} \times D_{VCP}$	–	–	0.108*** (0.036)	–
Observations	5,212,592	5,212,592	5,212,592	5,212,592

*** indicates significance at the 1% level. Firm-quarter and origin-product fixed effects are included. Invoicing choice fixed effects are also included in (2) to (4)

Source: HMRC administrative data sets

Recall that in theory, full pass-through for PCP, zero pass-through for LCP

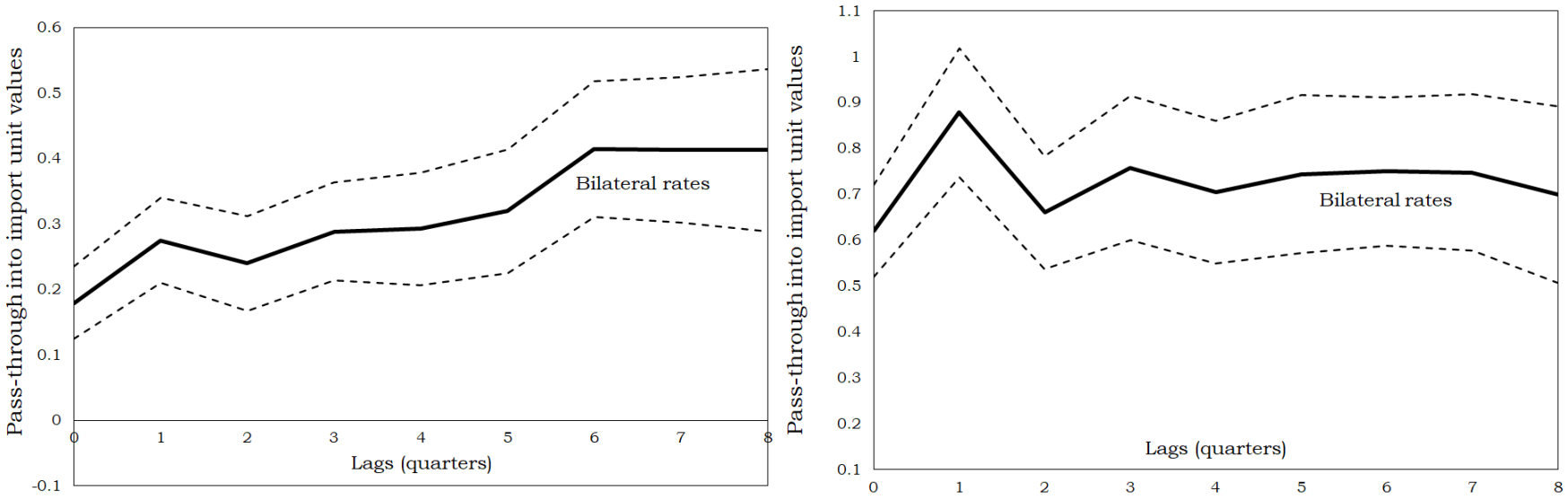
Table 6: Pass-Through into Import Unit Values by Industry

	(1)	(2)			(3)		(4)
Invoicing currency	All	PCP	LCP	VCP	VCP	VCP	VCP
Exchange rate	$\Delta \ln e_{ij,t}$	$\Delta \ln e_{ij,t}$	$\Delta \ln e_{ij,t}$	$\Delta \ln e_{ij,t}$	$\Delta \ln e_{iV,t}$	$\Delta \ln e_{Vj,t}$	$\Delta \ln e_{iV,t}$
Food, live animals	0.140***	0.476***	0.012	0.186***	0.728***	0.061	0.692***
	(0.047)	(0.113)	(0.047)	(0.062)	(0.090)	(0.062)	(0.089)
Beverages, tobacco	0.124	0.590***	−0.155*	0.384**	1.168***	−0.033	1.187***
	(0.091)	(0.147)	(0.090)	(0.173)	(0.295)	(0.207)	(0.274)
Crude materials	0.161***	0.594***	0.005	0.138*	0.475***	0.128	0.394***
	(0.061)	(0.177)	(0.089)	(0.082)	(0.154)	(0.088)	(0.151)
Mineral fuels	0.066	0.213	0.223	0.010	0.392	0.006	0.418
	(0.172)	(0.305)	(0.417)	(0.173)	(0.486)	(0.190)	(0.461)
Animal, vegetable oils	0.155	0.292	0.060	0.273	0.550*	0.453*	0.261
	(0.167)	(0.385)	(0.406)	(0.201)	(0.315)	(0.261)	(0.337)
Chemicals	0.188***	0.551***	−0.157	0.227***	0.713***	0.067	0.653***
	(0.061)	(0.095)	(0.106)	(0.077)	(0.097)	(0.095)	(0.095)
Manufactured goods	0.130***	0.352***	−0.110**	0.221***	0.582***	0.126***	0.518***
	(0.034)	(0.073)	(0.052)	(0.040)	(0.067)	(0.044)	(0.070)
Machinery	0.244***	0.490***	0.042	0.249***	0.646***	0.139**	0.582***
	(0.041)	(0.059)	(0.075)	(0.055)	(0.074)	(0.065)	(0.072)
Miscellaneous	0.169***	0.377***	−0.093*	0.267***	0.657***	0.077	0.611***
	(0.034)	(0.065)	(0.052)	(0.044)	(0.071)	(0.067)	(0.073)
Observations	5,212,592	5,212,592			5,212,592		5,212,592

***, **, and * indicate significance at the 1%, 5%, and 10% levels. Firm-quarter and origin-product fixed effects are included. Invoicing choice fixed effects are also included in (2) to (4)

Source: HMRC administrative data sets

Long-Run Pass-Through



(a) All transactions

Short-run PT: 17.9%

Long-run PT: 41.3%

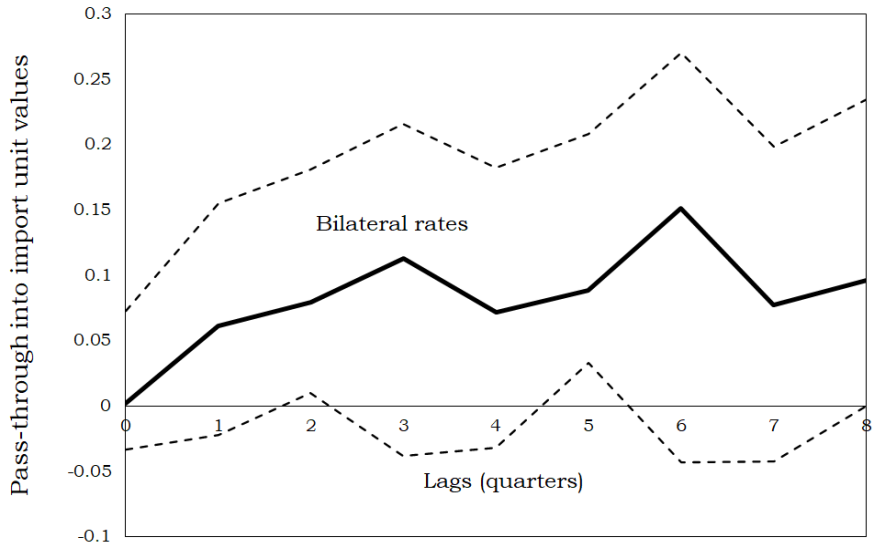
(b) PCP transactions

Short-run PT: 62.0%

Long-run PT: 70.0%

Figure 1: Cumulative exchange rate pass-through into import unit values

Long-Run Pass-Through



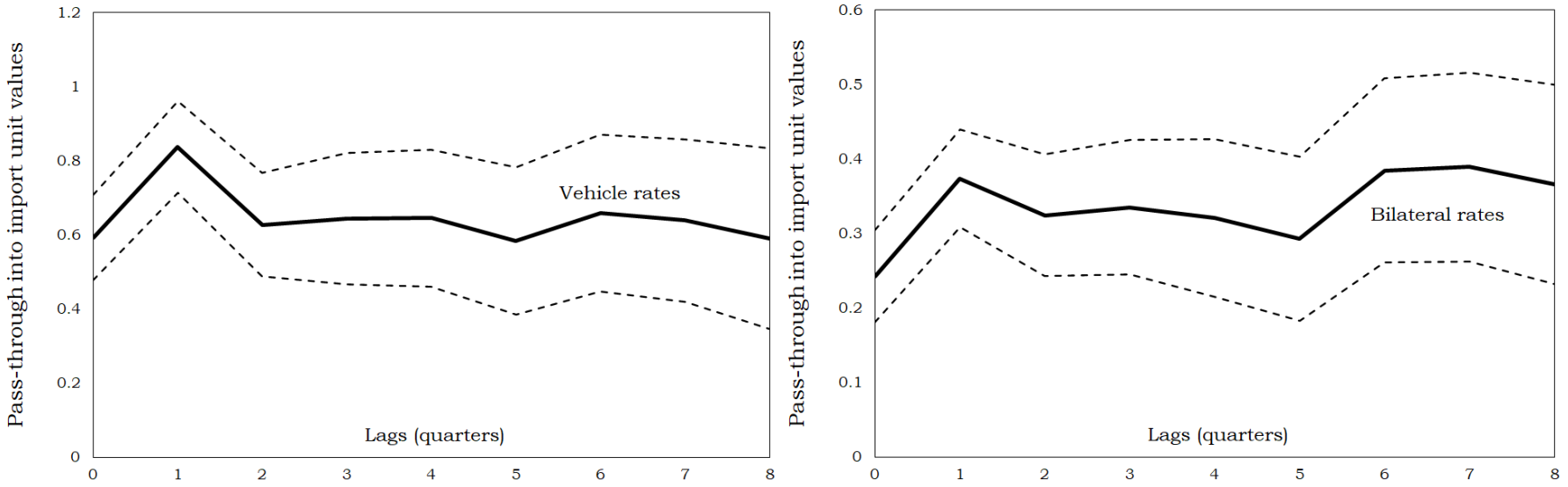
(c) LCP transactions

Short-run PT: 0%

Long-run PT: 9.6% (insig.)

Figure 1: Cumulative exchange rate pass-through into import unit values

Long-Run Pass-Through



(d) VCP transactions (VCP exchange rates)

Short-run PT: 59.2%

Long-run PT: 59.0%

(e) VCP transactions (bilateral exchange rates)

Short-run PT: 24.2%

Long-run PT: 36.6%

Figure 1: Cumulative exchange rate pass-through into import unit values

Vehicle Currency Pricing and Dominant Currency Pricing

- Although VCP and DCP both imply that bilateral exchange rates are inappropriate in pass-through regressions, they are conceptually different
  - In contrast to DCP, VCP distinguishes between the US dollar as a producer currency and a vehicle currency
  - VCP also considers other vehicle currencies than the US dollar in explaining pass-through
  - But there is a strong overlap between DCP and VCP because the US dollar, which is the dominant currency, is also the main vehicle currency

- In our sample, 88.5% of VCP transactions are invoiced in US dollars, 10.9% in euros, and 0.6% in 89 other currencies

Table 7: Pass-Through for US Dollar versus Non-US Dollar Currencies

	(1)	(2)
$\Delta \ln e_{ij,t} \times D_{PCP}$	0.631***	–
	(0.050)	
$\Delta \ln e_{ij,t} \times D_{PCP} \times D_{USD}$	–	0.624***
		(0.069)
$\Delta \ln e_{ij,t} \times D_{PCP} \times D_{non-USD}$	–	0.617***
		(0.053)
$\Delta \ln e_{ij,t} \times D_{LCP}$	0.013	0.014
	(0.036)	(0.037)
$\Delta \ln e_{iV,t} \times D_{VCP} \times D_{USD}$	0.483***	0.488***
	(0.105)	(0.106)
$\Delta \ln e_{iV,t} \times D_{VCP} \times D_{non-USD}$	0.591***	0.590***
	(0.059)	(0.061)
Observations	5,212,592	5,212,592

*** indicates significance at the 1% level. Firm-quarter, origin-product, invoicing choice fixed effects, and a dummy variable for the US are included

Source: HMRC administrative data sets

Table 8: Vehicle Currency Import Shares in Euros 2010–2017

Origin country	VCP import share	Percentage in euros	Non-EU import share
Largest Euro VCP Shares			
Bosnia and Herzegovina	78.12	99.06	0.01
Haiti	100.00	98.19	0.01
Croatia	52.21	95.32	0.02
Serbia	74.85	94.94	0.07
Armenia	57.34	91.66	0.01
Large Euro VCP Shares (Selected Countries)			
Morocco	58.08	89.58	0.28
Senegal	82.96	83.79	0.01
Turkey	40.22	70.05	3.76
Japan	32.59	47.39	5.51
South Korea	40.05	32.97	2.35

Source: HMRC administrative data sets

US Dollar versus Euro

To compare the relevance of the US dollar and euro exchange rates in explaining pass-through, we estimate (Gopinath et al., 2020)

$$\begin{aligned}\Delta \ln UV_{ijk,t} &= \sum_{n=0}^{N} \Psi_n \Delta \ln e_{ij,t-n} + \sum_{n=0}^{N} \Phi_n \Delta \ln e_{i\$,t-n} + \sum_{n=0}^{N} \Upsilon_n \Delta \ln e_{i€,t-n} \\ &\quad + \sum_{n=0}^{N} \Pi_n \pi^*_{j,t-n} + D_{i,T} + D_{jk} + \tau_{ijk,t},\end{aligned}$$

where in addition to bilateral exchange rates $e_{ij,t}$, we also control for the sterling exchange rates against the US dollar $e_{i\$,t}$ and the euro $e_{i€,t}$ ($D_{i,T}$ are firm-year fixed effects)

Table 9: Pass-Through for Dominant Currencies (US Dollar and Euro)

	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta \ln e_{ij,t}$	0.446*** (0.037)	0.247*** (0.028)	0.234*** (0.028)	–	–	–
$\Delta \ln e_{i\$,t}$	–	0.401*** (0.037)	0.604*** (0.059)	–	–	–
$\Delta \ln e_{i€,t}$	–	–	0.266*** (0.048)	–	–	–
$\Delta \ln e_{ij,t} \times D_{PCP}$	–	–	–	0.703*** (0.043)	0.781*** (0.059)	0.735*** (0.041)
$\Delta \ln e_{i\$,t} \times D_{PCP}$	–	–	–	–	0.154 (0.101)	–
$\Delta \ln e_{i€,t} \times D_{PCP}$	–	–	–	–	0.300*** (0.059)	–
$\Delta \ln e_{ij,t} \times D_{LCP}$	–	–	–	0.130*** (0.026)	0.109*** (0.029)	0.122*** (0.024)
$\Delta \ln e_{i\$,t} \times D_{LCP}$	–	–	–	–	0.374*** (0.073)	–
$\Delta \ln e_{i€,t} \times D_{LCP}$	–	–	–	–	0.167*** (0.049)	–
$\Delta \ln e_{ij,t} \times D_{VCP}$	–	–	–	0.499*** (0.050)	0.144*** (0.028)	–
$\Delta \ln e_{i\$,t} \times D_{VCP}$	–	–	–	–	0.756*** (0.060)	–
$\Delta \ln e_{i€,t} \times D_{VCP}$	–	–	–	–	0.341*** (0.057)	–
$\Delta \ln e_{iV,t} \times D_{VCP}$	–	–	–	–	–	0.707*** (0.028)

*** indicates significance at the 1% level. Firm-year and origin-product fixed effects are included. Invoicing choice fixed effects also included in (4) to (6). Source: HMRC administrative data sets

Implications for UK Import Price Inflation

- Back-of-the-envelope estimates for the effects of world imports on UK import price inflation
- Three quarterly episodes of large sterling fluctuations
  - **Brexit Referendum** (June–August 2016: sterling depreciated by 7.09% on average, and by 6.34% and 7.66% against the US dollar and the euro)
  - **Great Recession** (Nov 2008–January 2009: sterling depreciated by 12.94% on average, and by 19.43% and 12.34% against the US dollar and the euro)
  - **EU Sovereign Debt Crisis** (January–March 2015: sterling appreciated by 2.66% and 6.24% on average and against the euro, but depreciated by 4.76% against the US dollar)

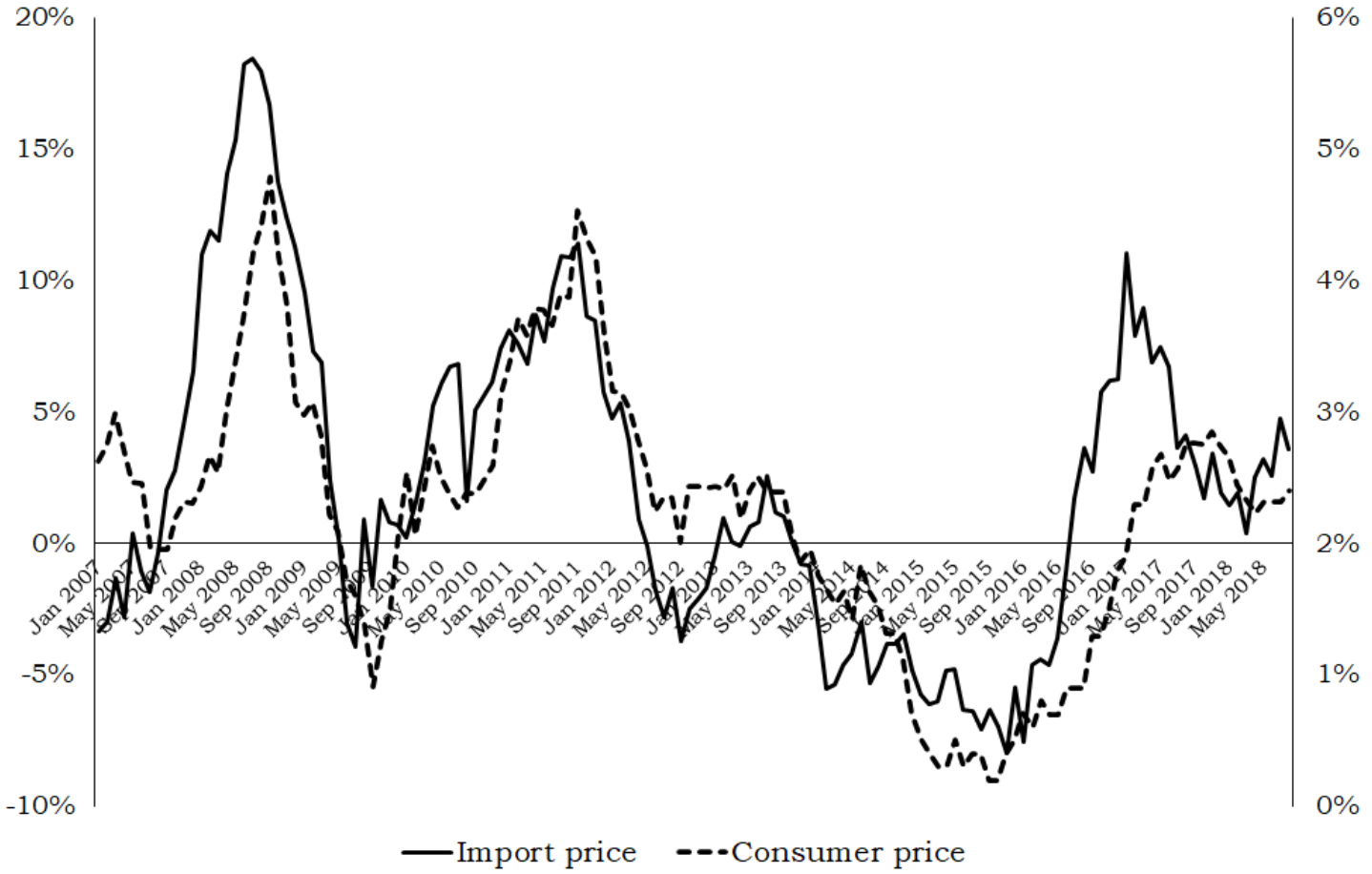


Figure 2: Consumer (right axis) and import (left axis) price inflation for the UK economy (% change over 12 months)

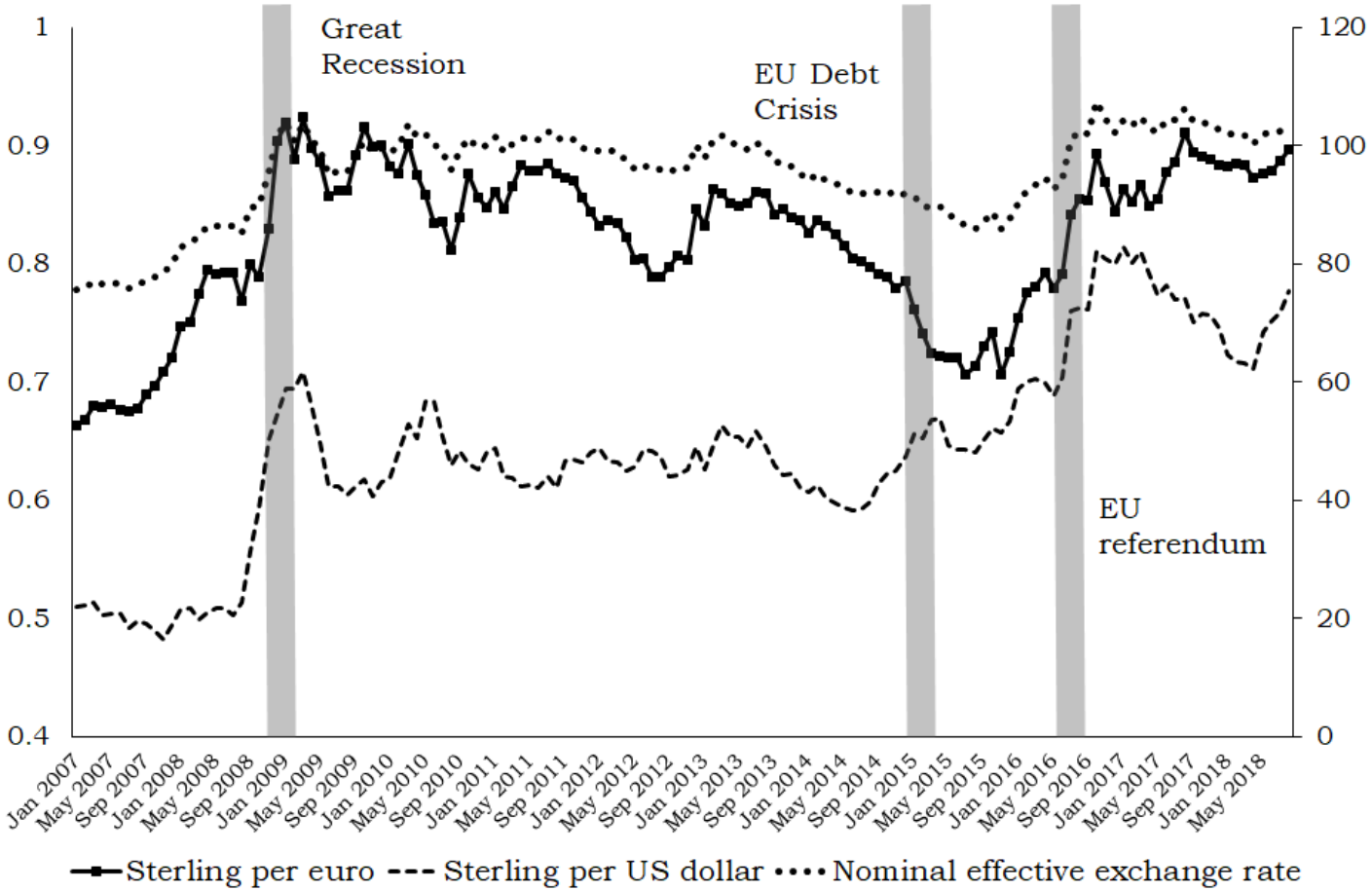


Figure 3: Sterling per euro and sterling per US dollar nominal exchange rates (left axis), and nominal effective sterling exchange rate index (right axis)

- To derive the invoicing shares for UK world imports, we combine our data set for non-EU imports with data from Gopinath (2016)

- For each episode, we measure the change of all exchange rates in the quarter of the shock relative to the previous quarter. We then weight the bilateral exchange rate changes with bilateral import shares for LCP and PCP transactions, and the VCP exchange rate changes with each vehicle currency's import share

- For each invoicing choice we evaluate the effects of these weighted exchange rate changes on import price inflation, which we aggregate using the invoicing shares for world imports

- We also derive predictions that only capture the effects of bilateral exchange rate changes (weighted by bilateral import shares)

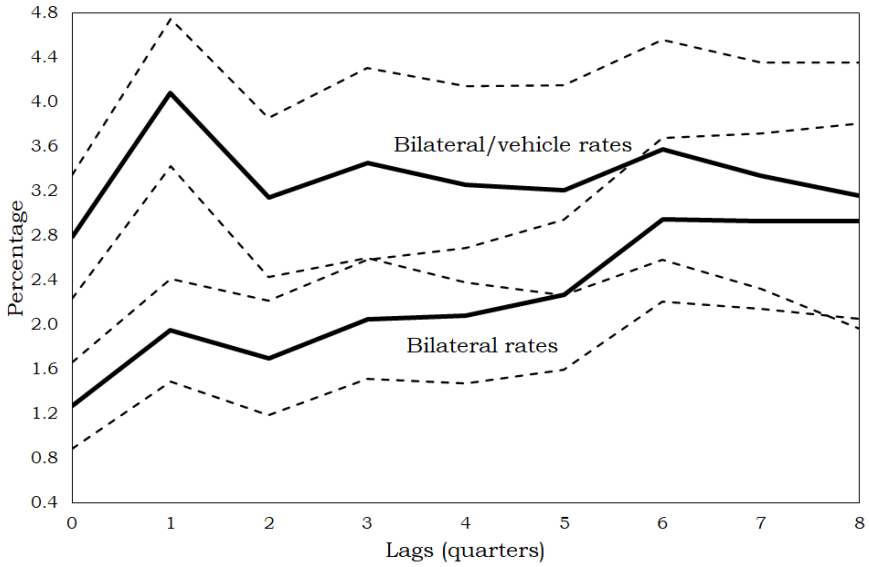
Table 10: The Effects of Exchange Rate Shocks on UK Import Price Inflation

		(1)	(2)	(3)	(4)	(5)	(6)
		EU Referendum		**Great Recession**		**EU Debt Crisis**	
Exchange rates	Currencies	$t = 0$	$t = 8$	$t = 0$	$t = 8$	$t = 0$	$t = 8$
Bilateral	All	1.271^{***} (0.199)	2.927^{***} (0.447)	2.321^{***} (0.363)	5.343^{***} (0.815)	-0.477^{***} (0.075)	-1.098^{***} (0.167)
	USD	0.105^{***} (0.016)	0.243^{***} (0.037)	0.323^{***} (0.050)	0.744^{***} (0.113)	0.079^{***} (0.012)	0.182^{***} (0.028)
	Euro	0.668^{***} (0.104)	1.537^{***} (0.235)	1.076^{***} (0.168)	2.477^{***} (0.378)	-0.544^{***} (0.085)	-1.252^{***} (0.191)
Bilateral/vehicle	All	2.788^{***} (0.283)	3.157^{***} (0.609)	7.100^{***} (0.690)	7.772^{***} (1.489)	0.619^{***} (0.076)	0.466^{***} (0.146)
	USD	1.775^{***} (0.162)	1.812^{***} (0.348)	5.435^{***} (0.497)	5.550^{***} (1.065)	1.330^{***} (0.122)	1.358^{***} (0.261)
	Euro	0.876^{***} (0.105)	1.113^{***} (0.217)	1.411^{***} (0.169)	1.793^{***} (0.350)	-0.713^{***} (0.085)	-0.906^{***} (0.177)
Exchange rate shock		2016M6–2016M8		2008M11–2009M1		2015M1–2015M3	
Sterling (trade-weighted)		+7.09%		+12.94%		-2.66%	
Sterling against US dollar		+6.34%		+19.43%		+4.76%	
Sterling against euro		+7.66%		+12.34%		-6.24%	

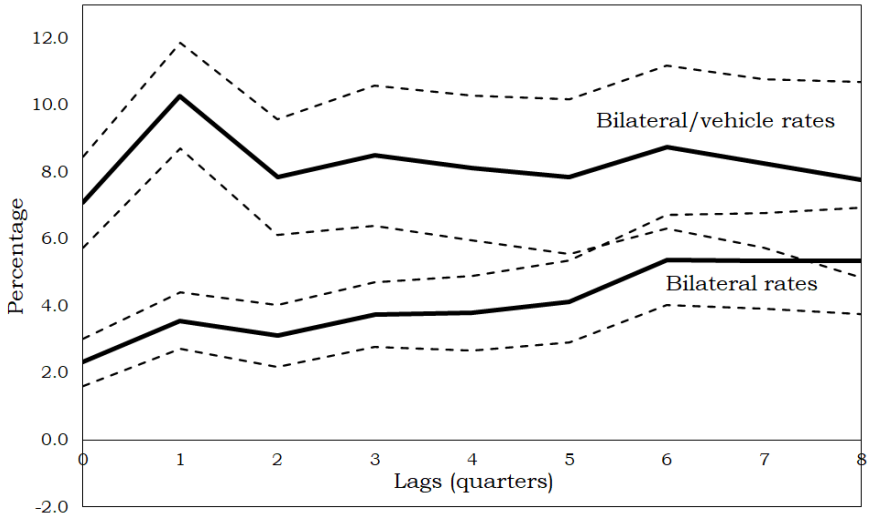
*** indicates significance at the 1% level. All estimates are in percentage points

Source: HMRC administrative data sets

Cumulative Effects



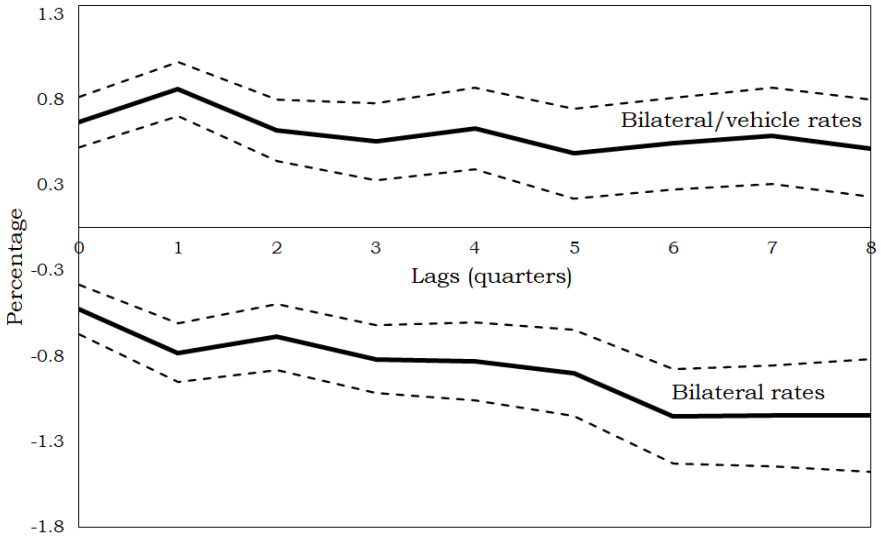
(a) EU Referendum



(b) Great Recession

Figure 4: Cumulative effects of sterling exchange rate shocks on import price inflation

Cumulative Effects



(c) EU Sovereign Debt Crisis

Figure 4: Cumulative effects of sterling exchange rate shocks on import price inflation

Discussion:
Exchange Rate Disconnect

A Simple Conceptual Framework

- Exchange rate pass-through is substantially higher once we account for vehicle currencies

- As a simple conceptual framework, we outline a model of exchange rate pass-through under vehicle currency pricing

- Helps to explain why researchers often find a weak relationship or "disconnect" between exchange rates and prices when not accounting for vehicle currencies

A Simple Conceptual Framework

- We extend Engel (2006) to a vehicle currency setting with three countries
- Monopolistic exporters are based in foreign country j and sell to the domestic country i (the UK)
- They set the price in a vehicle currency V
- As in Engel (2006), firms can commit to setting their prices as a log-linear function of the exchange rate and optimally choose the pass-through rate

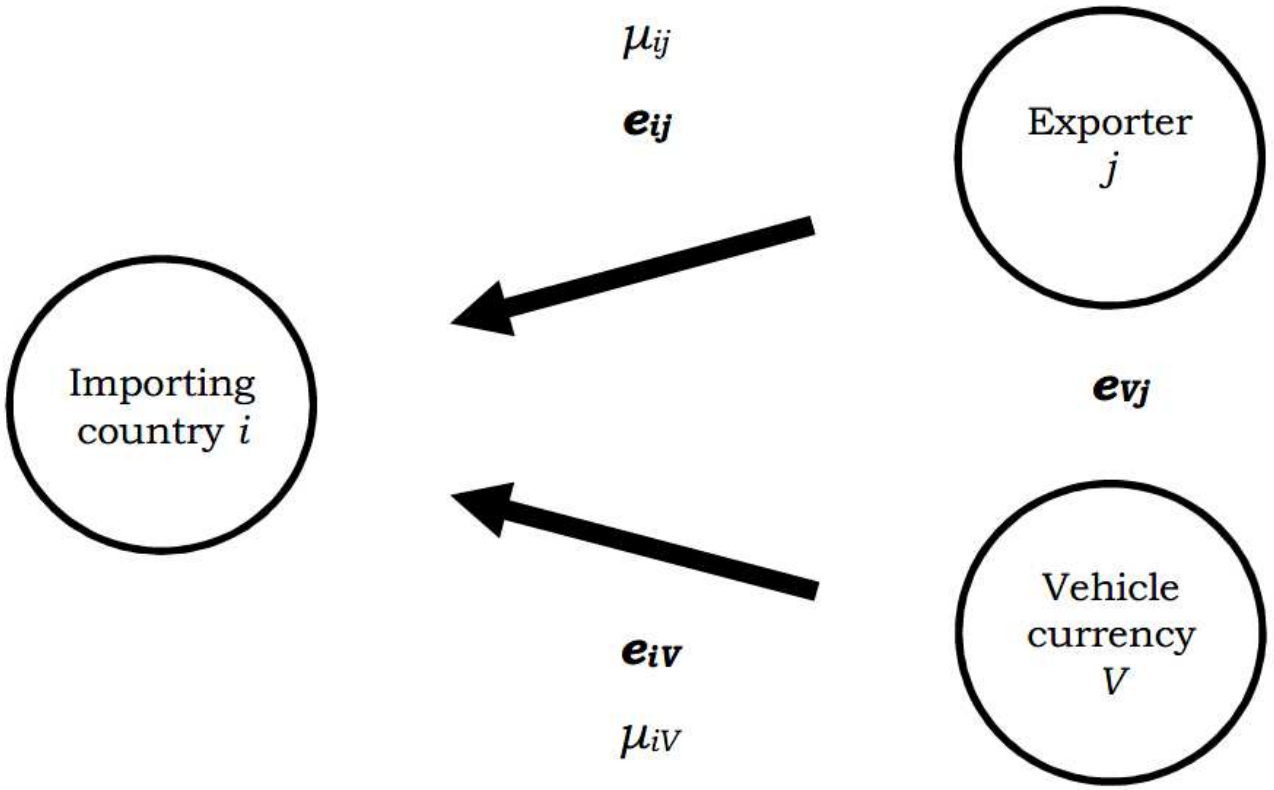


Figure 5: Exporters price in vehicle currency and react to either e_{ij} or e_{iV}

- Assume two types of exporting firms
  - A fraction θ of firms react to the bilateral exchange rate e_{ij}
  - A fraction $(1-\theta)$ react to the vehicle currency exchange rate e_{iV}

- Their corresponding log-linear pricing equations follow as

$$\begin{aligned} \Delta \ln p_V^{ij} &= \mu_{ij} \Delta \ln e_{ij} \\ \Delta \ln p_V^{iV} &= \mu_{iV} \Delta \ln e_{iV} \end{aligned}$$

- Since we cannot distinguish the two types of firms in the data (we only observe whether transactions are invoiced in a vehicle currency), we define a weighted price

$$\Delta \ln p_V \equiv \theta \Delta \ln p_V^{ij} + (1-\theta) \Delta \ln p_V^{iV}$$

- Since consumers in the domestic country face prices in sterling, we have to convert p_V into the sterling price p_i

$$\Delta \ln p_i = \Delta \ln p_V + \Delta \ln e_{iV}$$

- This yields the pass-through relationship

$$\Delta \ln p_i = \varphi_1 \Delta \ln e_{ij} + \varphi_2 \Delta \ln e_{iV}$$

with $\varphi_1 = \theta \mu_{ij}$ and $\varphi_2 = (1 - \theta)\, \mu_{iV} + 1$. For transactions invoiced in a vehicle currency, we thus have a link between the sterling price change and two exchange rate changes

Table 11: Pass-Through into Import Unit Values for the VCP Subsample

	(1)	(2)	(3)	(4)	(5)
$\Delta \ln e_{ij,t}$	0.094^{***} (0.035)	0.123^{***} (0.033)	–	0.612^{***} (0.149)	–
$\Delta \ln e_{iV,t}$	0.518^{***} (0.158)	–	0.535^{***} (0.155)	–	0.612^{***} (0.149)
$\Delta \ln e_{Vj,t}$	–	–	–	-0.518^{***} (0.158)	0.094^{***} (0.035)
Observations	2,599,543	2,599,543	2,599,543	2,599,543	2,599,543

*** indicates significance at the 1% level. Firm-quarter and origin-product fixed effects are included

Source: HMRC administrative data sets

- Column (1): the vehicle currency exchange rate displays substantially higher pass-through ($\varphi_2 = 0.518$) than the bilateral exchange rate ($\varphi_1 = 0.094$)
  - Bilateral exchange rates therefore hardly matter for pass-through
  - But since vehicle currency exchange rates are important, it would be misleading to describe the overall results as "exchange rate disconnect"
- Columns (2) and (3): coefficients hardly change when estimated in isolation
  - No obvious omitted variable bias when we drop one exchange rate regressor
  - Only holds when we are able to separately identify VCP transactions as in Table 11. Does not hold once pooled with PCP and LCP transactions as in Table 9
- Columns (4) and (5) clarify the role of triangular exchange rate arbitrage: coefficients "add up" as expected

Concluding Remarks

- Pass-through into import prices varies strongly across invoicing choices
- For VCP transactions, import unit values react most to changes in the sterling to vehicle currency exchange rate
- Ignoring the role of invoicing currencies therefore leads to mismeasurement of the exchange rate impact on import price and consumer price inflation
- Policymakers should take into account that when vehicle currency pricing is pervasive, bilateral exchange rates are inappropriate for determining the impact of exchange rate changes on prices. They should construct an effective nominal exchange rate that is based on invoicing currency weights, not trade weights