

ONLINE APPENDIX

**New Dawn Fades:
Trade, Labour and the Brexit Exchange Rate Depreciation**

Rui Costa, Swati Dhingra and Stephen Machin

Appendix A

Timeline

Thursday June 23, 2016:

10 PM - The last votes are cast and polling stations across the country close at the end of a day on which a record 46.5 million people were eligible to have their say. Ballot boxes are sent to 382 counting centres nationwide.

10 PM - A YouGov opinion poll released at the same time suggests Remain are on course for victory with 52% and Leave on 48%.

10-15 PM - Ukip's Nigel Farage concedes the Brexit campaign may be beaten and Remain "will edge it" - but promises "Ukip and I are going nowhere".

10-30 PM - Sterling surges against the US dollar on the back of the favourable opinion poll for Remain and Farage's comments, rocketing to 1.5 dollars, its strongest performance in 2016.

11-25 PM - Gibraltar is the first area to declare, with a predictable landslide for Remain at 96% of the vote.

Friday, June 24, 2016:

12-04 AM - The first big result is declared, with a narrow win in Newcastle for Remain with 50.7% against Leave on 49.3%. It was an expected win in Newcastle, but not by the margin many suspected.

12-20 AM - Sunderland votes to Leave by a significant margin, with 61% in the Tyne and Wear town in favour of Brexit compared with 39% backing Remain.

12-21 AM - Sterling instantly tumbles against the US dollar as jitters over a possible swing to Leave wipe earlier gains off the pound, with a near 4.7% drop - greater than the Black Wednesday crash in 1992.

1-30 AM – People started to sense that Leave would win, and it showed in their Google searches.

1-55 AM - The City of London count is announced as vote to Remain in the EU.

2-01AM - Swansea votes to Leave, with 61,936 backing a Brexit against 58,307 voting to remain.

2-17 AM - Nigel Farage, who earlier said he sensed Remain would take victory, tweeted that he is "so happy with the results in North East England".

2-30 AM – Remain went back ahead for the first time since the Sunderland announcement after big wins in Lambeth and Glasgow.

3-44 AM – But over the next hour the Leave campaign enjoyed gain across Wales, Northern Ireland, Yorkshire and the Midlands to dwarf the majority of Remain's support in Scotland and London.

3.27am - Sheffield comes out for Leave, backing an exit from the EU by little over 5,000 votes.

3-51 AM - Leave's lead stretches to 500,000 votes as results pass 200 out of 382.

3-57 AM - Sterling's precipitous slide against the dollar continues after victories consolidate a lead for Leave. Trading figures show the pound at 1.37 dollars, down from a high last night of over 1.5 dollars.

6-02 AM - The Leave campaign officially passes the estimated winning post 16,763,272 in the EU referendum.

7-01 AM - The Bank of England says it will take "all necessary steps" to ensure monetary and financial stability in the wake of the Brexit vote.

7-04 AM - The final count of the EU referendum shows Leave won 51.9% of the total vote to Remain's 48.1%.

8-08 AM - The FTSE 100 falls more than 7% within minutes of the markets opening following Britain's decision to leave the EU.

8-50 AM - Bank of England governor Mark Carney says "some market and economic volatility can be expected" in the wake of the Brexit vote, but the Bank is well prepared. It also has £250bn to support the UK economy.

Appendix B

Data Description

Exchange Rates

The minute-by-minute exchange rates shown in Figures 1a and 1b for the Euro and Dollar against sterling are from HistData.

For the depreciation measures, daily exchange rates are from Reuters Datastream and refer to the spot price at 4pm UK time.¹ Sterling overnight depreciation therefore refers to the drop in the value of the pound between 4pm on June 23, 2016 to 4pm on June 24, 2016. In the few cases for which no exchange rate against the pound was available, suitable conversion is based on its reported dollar exchange rate. Mapping of currencies to country of use is based on the official UN Operational Currency correspondence. The final dataset used in the empirical analysis is composed of 229 countries (or territories) and 148 currencies. After trimming currency shares of below 1 percent in an industry, 98 countries and 81 currencies are used to construct the exports weighted depreciation measure and 71 countries and 52 currencies are used to construct the intermediate imports weighted measure.

To account for vehicle currency invoicing, $\ln D_o^{j,veh} = \sum_c S_{co}^j \ln \Delta \bar{E}_c$. Note that local currency pricing would have a depreciation of zero so it is not included in the vehicle currency definition. The invoicing shares are taken from Chen et al. (2022) for China, East and Southeast Asia, Eurozone, Europe excluding the EU, India, United States, Other Americas and Others. Japan is proxied with the United States shares.

Trade Prices

Quarterly time-series of goods import and export trade values (current price measure) and volumes (chained volume measure) are made available by ONS for 2 digit UK SIC industries in sections A, B and C: Agriculture, Forestry and Fishing; Mining and Quarrying; and Manufacturing. Those are supplemented by services trade values and volumes for 14 aggregates of services product-industry: Manufacturing and Maintenance, Sea Transport, Air Transport, Other Transport, Postal & Courier, Travel, Construction, Insurance, Financial, Intellectual Property, Telecommunications, Computer & Information, Other Business Services, Personal, Cultural & Recreational and Government. Import Price Indexes (IPI) and Export Price Indexes (EPI) are calculated as the weighted average of the product-specific IPIs and EPIs after mapping them to their industries of export and import use.

Price indices are derived from price quotes collected by the statistical agency from firm-level surveys, with a number of checks to ensure the same unit and quality of good/service is being referred to. The mapping is from CPA to SIC. We put in a Freedom of Information request to the Office of National Statistics to provide us with indices that conform to the SIC categories. This is done by the ONS through disaggregated product categories mapped to SIC, which are not publicly available. The base year is 2015.

Import and export flows are collected from the annual import values for 2015 taken from UN COMTRADE for goods and from the International Trade in Services Survey (ITIS) of the ONS for services. For services and industries that are not covered by the ITIS, trade flows by country and product are obtained through freedom of information requests to the ONS for the same time period.

The International Trade in Services Survey is a unique source of data on international trade in services. ITIS collects yearly data on import and export services trade at firm level for a range of 52 services products by trade partner. ITIS includes around 16,000 businesses each year, including a panel of core contributors and larger firms. The sampling inclusion criteria

¹ According to Reuters Datastream, the WM Refinitiv Closing Spot rates are fixings calculated by Refinitiv based on Refinitiv Matching, EBS, Currenex and Refinitiv multi-contributor data over a five minute fixing window around 16:00 in London. This time reflects the middle of the 'global day' and the time of highest liquidity in the foreign exchange market. Daily updates are published in Refinitiv Datastream product series by 16:45 each day. The rates are based on snapshots of U.S. dollar market data, or Euro for a subset of the currencies. The Euro subset includes Czech Koruna, Danish Krone, Hungarian Forint, Norwegian Kroner, Polish Zloty, Romanian Leu, Swedish Krona, and Swiss Franc. The snapshots are taken from the Refinitiv Market Data system during the five minute fixing window around 16:00 and median rates are then calculated for each currency. This is done independently for bid and offer rates. When the rates have been validated WMR derive cross rates to GBP and EUR (or GBP and USD). Mid rates are calculated as the arithmetic mean of bids and offers.

ensures that firms reporting a total value of services trade above a certain threshold are surveyed in following years. Some industries are not part of the sample of ITIS: financial, transport, travel and higher education sectors are not sampled. However, trade in products produced in these industries and imported by UK firms in other industries will be recorded: for example, records of a UK based R&D firm that imports financial service products from France will be present. The focus of the survey is on producer services, particularly, on the import flows which in the case of our analysis is of most relevance in studying the intermediate import cost channel. The remainder uncovered services and industries are recorded separately and obtained from the ONS.

Trade barriers data for tariffs is from WITS and from the OECD for services trade restrictiveness indices for 2015. Industry-level trade barriers are arrived at in the same way as the depreciation measures with country trade shares as weights. Correspondence between COMTRADE HS-2012 (Harmonized Code 2012) product codes and UK SIC 2007 industry codes was obtained using a two-step crosswalk procedure. Firstly, we use Peter Schott's HS-2012 to NAICS 2012. Secondly we map NAICS 2012 to NACE 2 using the Eurostat official correspondence table. ITIS is matched directly to the UK firm register hence identifying the industry of activity of the firm exporting or importing the services.

Input-Output Tables

Import use of services is from the 2015 ITIS microdata which identifies the using industry. Data on import use for goods and uncovered services or industries is from the import use tables (product by industry) of the ONS for 2015. Intermediate import shares, intermediate shares and export shares in demand are from the detailed 2015 IO tables published by the ONS.

Labour Force Survey Data

Labour force data refer to all employed individuals aged 18 to 65 working in the private sector and not in fulltime education, and are taken from the UK Quarterly Labour Force Survey (QLFS) 2012Q3 to 2019Q2.

Wages are defined for full-time private sector workers, based upon the wage questions asked in quarter 1 of the QLFS (Quarter 5 wage responses are not included to avoid attrition bias). Hours worked is the weekly hours for private sector workers, including part-time workers. The focus is on fulltime workers because of the well-known concerns over measurement error in wages of part-time workers, though we later also examine hourly wages for all workers.

Top-coded wages in the QLFS are adjusted using the mean weekly wages above the LFS top-coding threshold by sex-region-year cells from Annual Survey of Hours and Earnings (ASHE). When measuring hourly wages, we use directly reported hourly rates by individuals in LFS, if no hourly rate is reported then the hourly wage is calculated as the ratio between weekly wages and total weekly hours worked. The hourly wages are censored at the lowest UK minimum wage (the minimum wage applicable to workers under 18 years of age in the relevant quarter). Wage measures are deflated to be expressed in real terms using the Consumer Prices Index including owner occupiers' housing costs (CPIH).

The QLFS interviews the same individual for 5 consecutive quarters, so inflows of individuals into an industry and outflows of individuals from an industry can also be computed. An inflow is a worker who enters the industry after having been employed in a different industry or having been unemployed or inactive in the previous quarter. The inflow rate is defined as the weighted number of inflows divided by the employment count in the previous quarter. Similarly, an outflow is a worker who leaves the industry to either work in a different industry or to become unemployed or inactive in the next quarter. The outflow rate is defined as the weighted number of outflows divided by the employment count in the current quarter.

Industry Classification

The industry classification follows the UK 2007 Standard Industrial Classification (SIC) which is based on the International Standard Industrial Classification of All Economic Activities (ISIC) Rev 4 and NACE Rev 2. We exclude section T "Activities of households as employers; Undifferentiated goods and services-producing activities of households for own use" and section U "Activities of extraterritorial organisations and bodies" due to their small samples. Additionally, to avoid small sample measurement errors, we follow ONS official statistics and aggregate industry divisions 6 - Extraction of crude petroleum and natural gas and 7- Mining of metal ores, and 11 - Manufacture of beverages and 12 - Manufacture of tobacco products into two aggregate industries (6&7 and 11&12). As a result of these sample restrictions and aggregations the number of industries used in analysis totals 83 distinct industries.

Migrant and FDI Shares

Migrant shares are calculated from the QLFS for 2013-2015 based on industry of the main job and country of birth. FDI shares are calculated from the Annual Inquiry into Foreign Direct Investment (AFDI) microdata of the ONS for 2015.

Business expectations

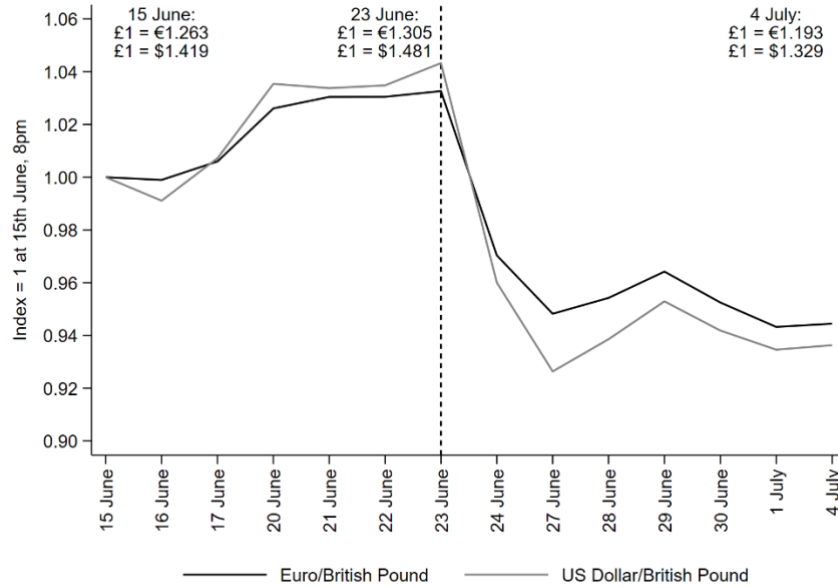
The Confederation of British Industry (CBI) is a UK business organisation that represents 190,000 businesses in total and whose trade associations account for one third of private sector employment. It undertakes monthly and quarterly surveys of its members and non-members in four broad industrial groupings: Industrial Trends Survey (ITS); Service Sector Survey (SSS); Financial Services Survey (FSS); Distributive Trades Survey (DTS). The quarterly surveys have larger sample sizes and greater question coverage and are used in this paper for the period 2012Q3 to 2019Q2. The quarterly ITS takes place in January, April, July and October; the quarterly SSS and DTS in February, May, August and November; and the quarterly FSS in March, June, September and December. The following question is consistently asked in three of the four surveys, the ITS, SSS and FSS: “Are you more, or less optimistic than you were three months ago about the overall business situation in your sector?”. Three responses are permitted in a tick box set up: More; Same; Less. Coverage compared to the analysis of the rest of the paper is reduced, because the DTS does not have a comparable question on optimism and because the CBI does not survey some industries (notably in agriculture, mining, waste recycling, construction and largely public sector industries). The answers to the question are used to determine changes in business expectations, which Bloom et al. (2019) show is a better measure of economic uncertainty during this episode. They use the Bank of England Decision Makers’ Panel (DMP) to measure uncertainty in a similar way, but the DMP does not have pre-referendum observations so cannot be used for our pre/post referendum analysis.

Appendix C:

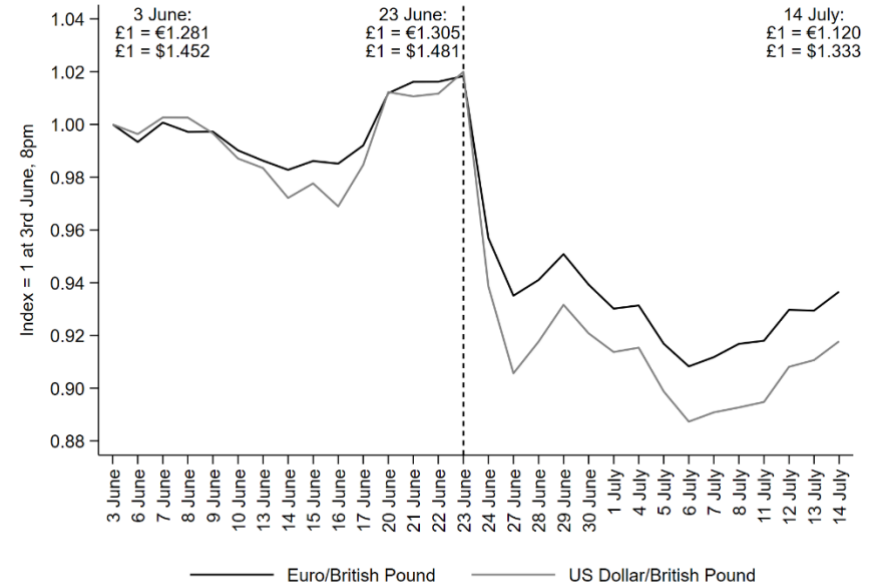
Additional Tables and Figures

Figure A1: Exchange Rate Movements over Time

A. 7 days window

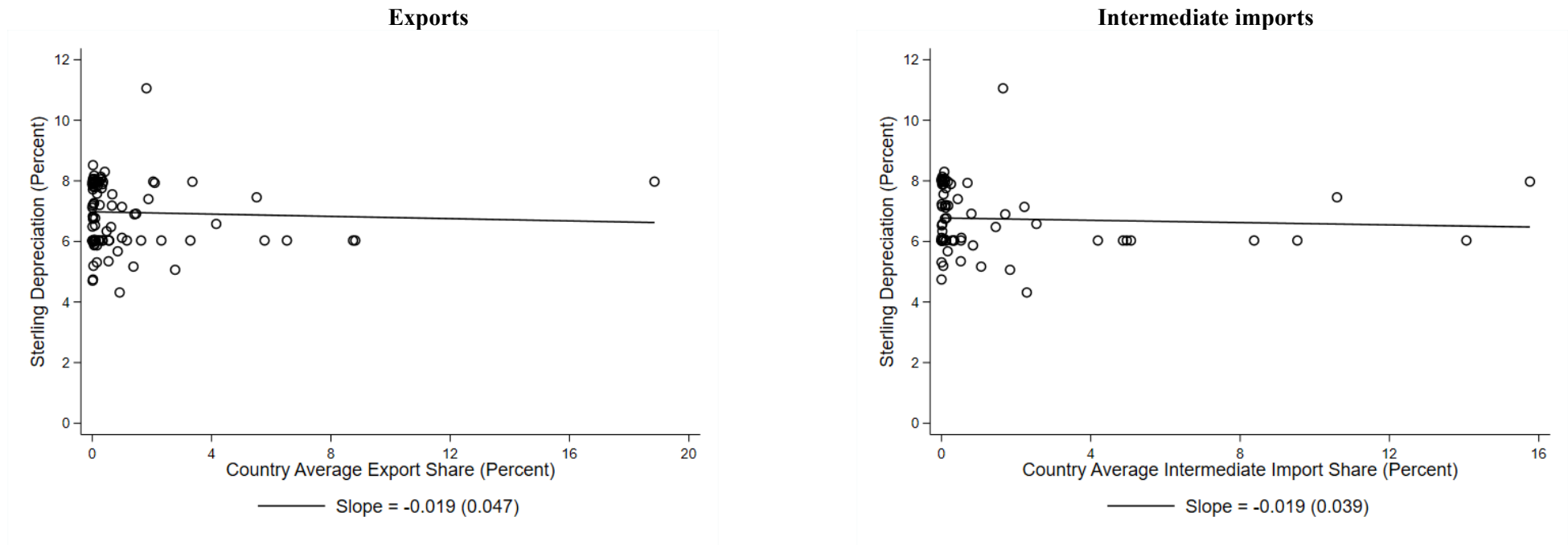


B. 15 days window



Notes: Daily Euro/British Pound and US Dollar/British Pound exchange rates from Datastream Reuters June 3 2016 to on July 14 2016. The exchange rates are indexed to 1 at beginning of the time window.

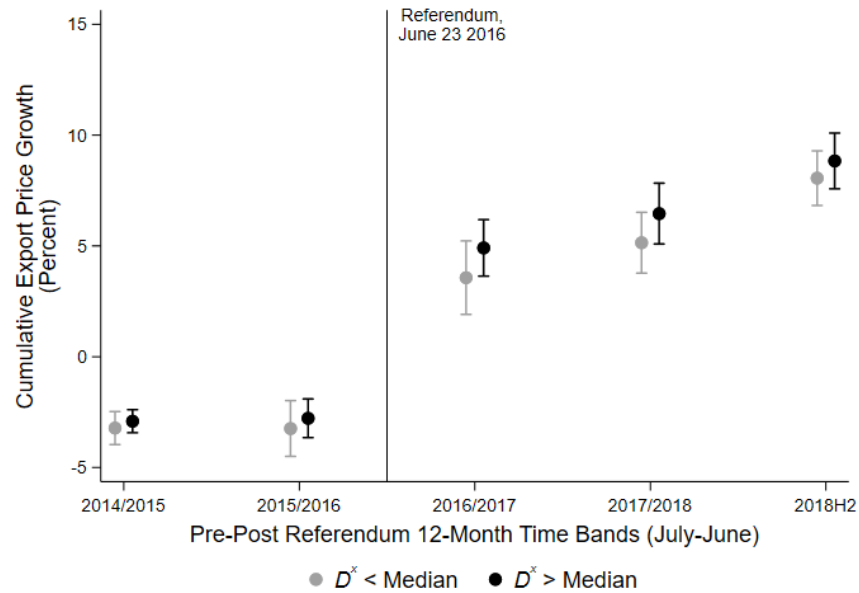
Figure A2: Currency Depreciation Shocks and Average Trade Shares by Country



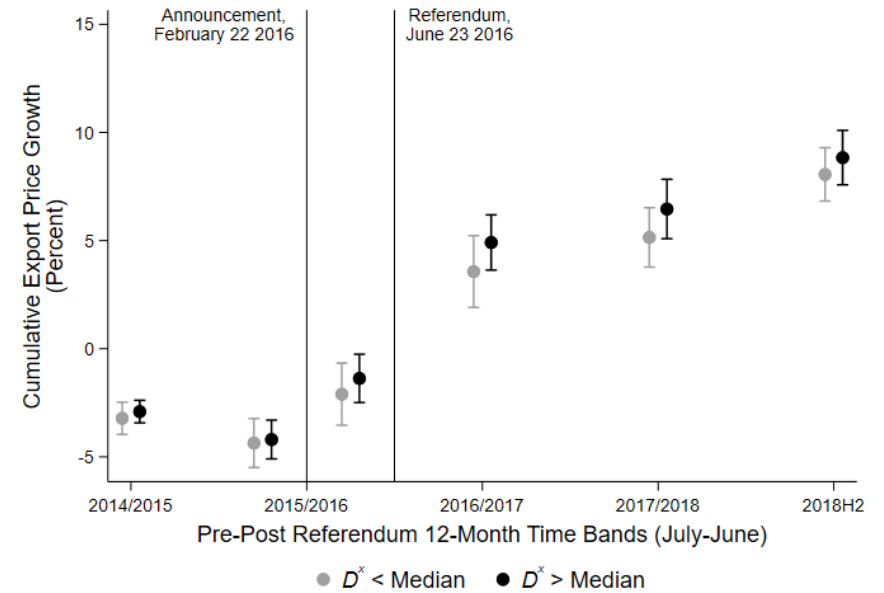
Notes: Depreciations on the y-axis are measured by country (and respective currency) specific sterling depreciations, and trade shares on the x-axis measured as the average country-level pre-referendum shares. The left chart for exports is based on 98 countries with 81 currencies, and the right chart for intermediate imports for 71 countries and 52 currencies.

Figure A3: Event Study – Export Prices And Exports Weighted Depreciation

Pre/Post Referendum

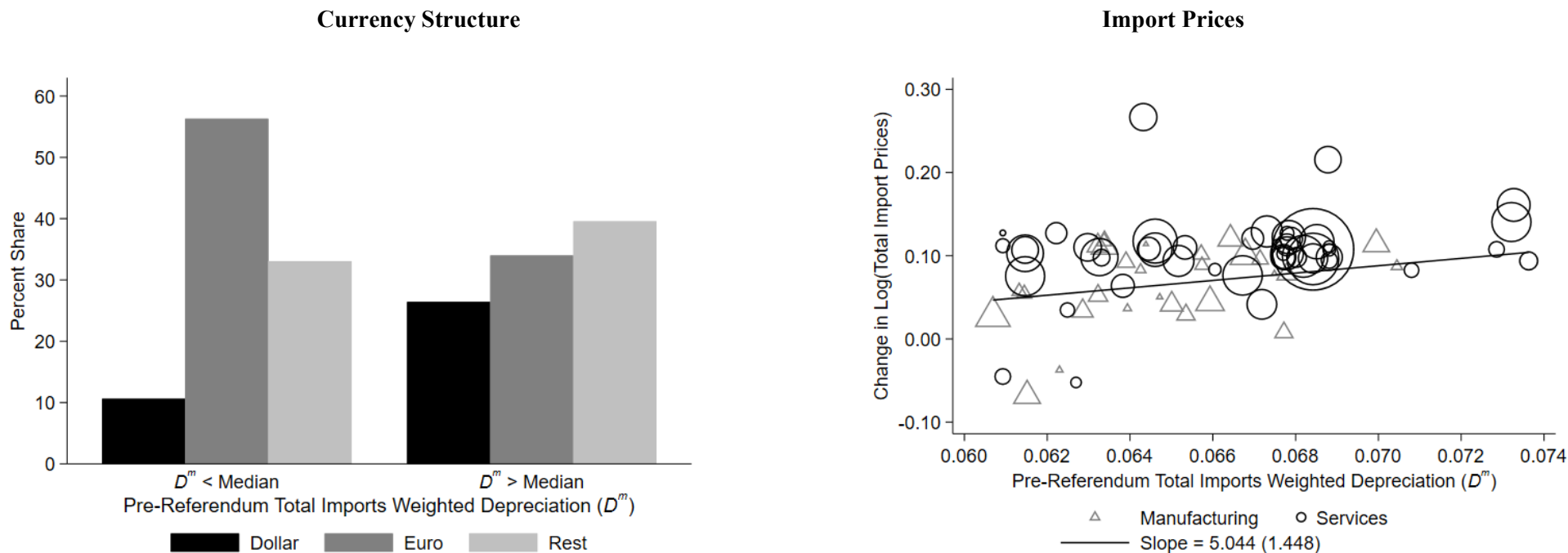


Pre/Post Announcement and Referendum



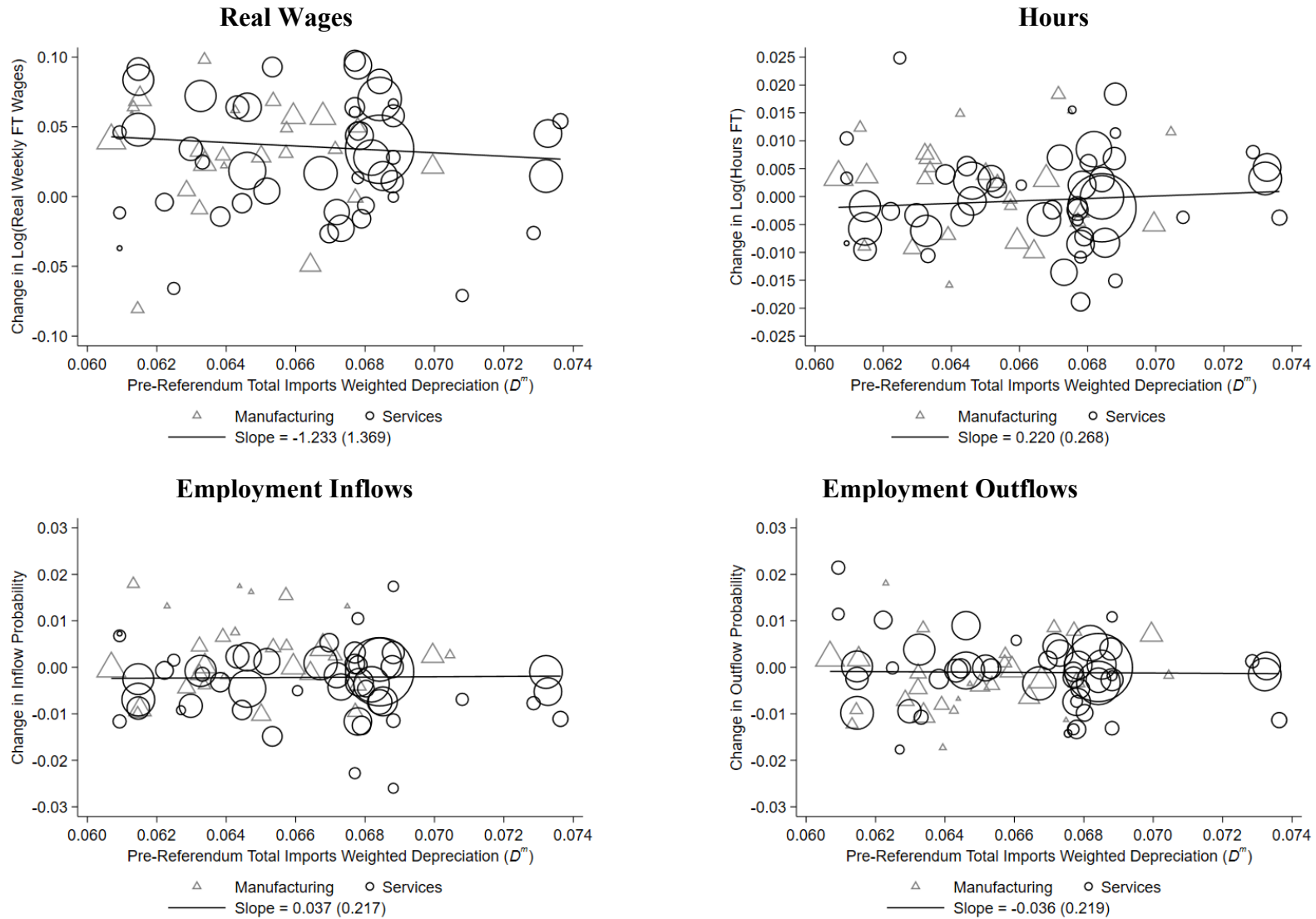
Notes: Event study estimates of equation (3) in the main text of the paper for export prices, where the DiD estimates vary in the left chart with pre and post referendum 12 month time bands (defined from July to June for Q3 in a year to Q2 in the following year) and in the right chart where they vary in the same way, but with an additional variation within the year before the referendum (July to December for 2015 Q3 and Q4, and January to June for 2016 Q1 and Q2).

Figure A4a: Currency Structure, Import Competition Depreciation, and Import Prices



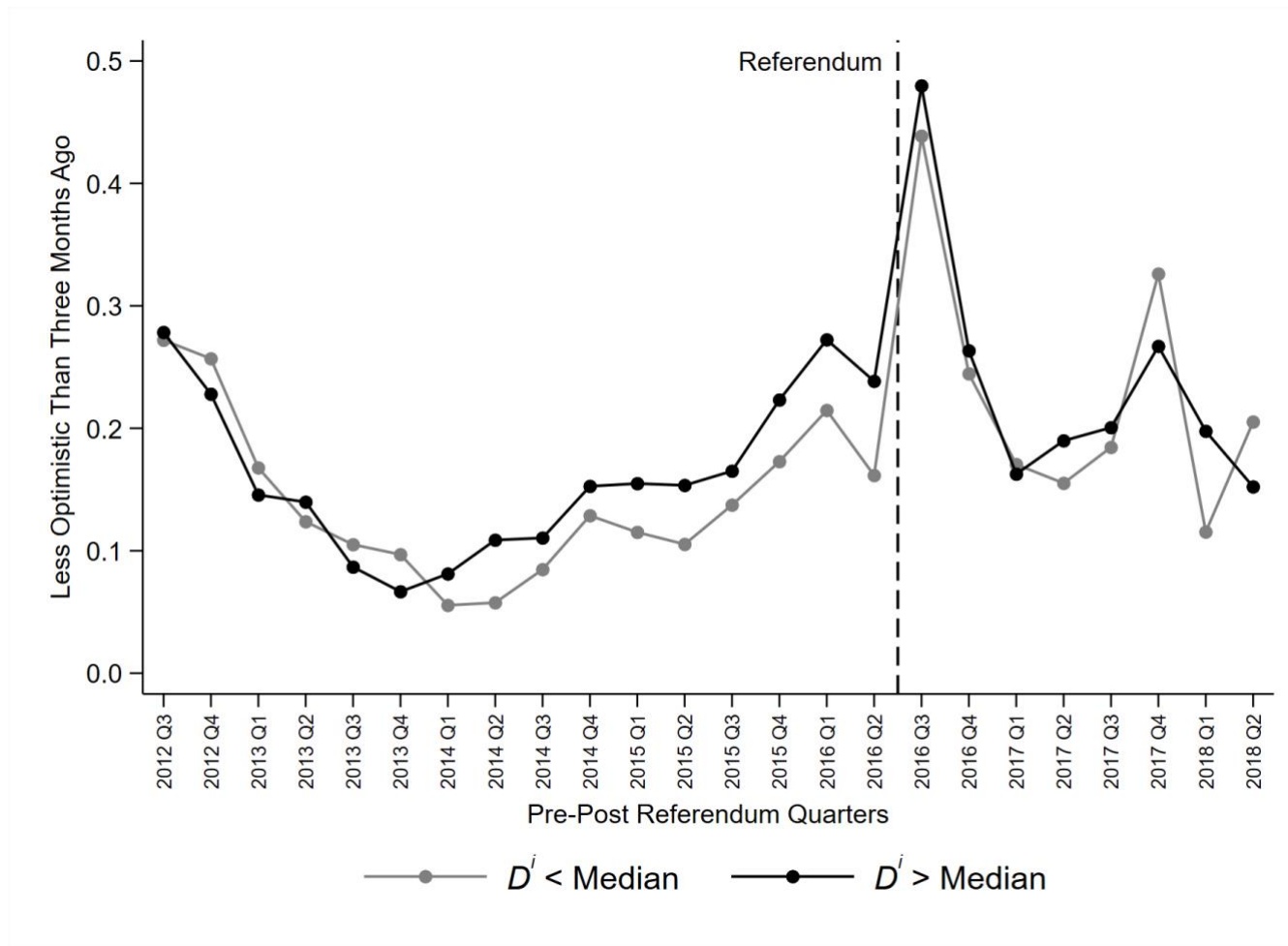
Notes: Left chart is as for Figure 2 in the paper and shows currency shares of the Dollar, Euro and the Rest broken down into above and below median sterling depreciations for the 24 hour window from 4 PM June 23 2016 to 4 PM June 24 2016 for total import share weighted depreciations (78 importing industries). Right chart is as for Figure 3 in the paper and shows a scatterplot of the post-pre referendum change in total import prices (measured between the post quarters 2016Q3-2018Q4 and pre quarters 2012Q3-2016Q2) and the pre-referendum total imports weighted depreciation (78 importing industries).

Figure A4b: Scatters – Real Wages, Hours And Employment, Imports Weighted Depreciation



Notes: Scatterplots of the post-pre referendum change in labour market outcomes (measured between the post quarters 2016Q3-2019Q2 and pre quarters 2012Q3-2016Q2) and the pre-referendum weighted depreciation (79 importing industries).

Figure A5: Event Study, Business Expectations and Intermediate Imports Weighted Depreciation



Notes: The y-axis plots the share of firms with less optimistic expectations of business conditions by above/below median intermediate imports weighted depreciation for their main industry. Source: Quarterly surveys of the Confederation of Business and Industry (CBI).

Table A1: EU Referendum Depreciation Of Sterling For Major Currencies, Spot and Forward

Country	Currency	Depreciation (Percent)	
		Spot	Forward 1 year
Japan	Japanese Yen	11.1	10.9
United States	US Dollar	8.0	8.5
Saudi Arabia	Saudi Riyal	8.0	7.7
Hong Kong	Hong Kong Dollar	7.9	7.7
Thailand	Thai Baht	7.6	7.4
China	Chinese Yuan	7.5	7.3
Singapore	Singapore Dollar	7.4	7.1
Taiwan	Taiwan Dollar	7.2	7.1
Russia	Russian Ruble	7.2	6.8
India	Indian Rupee	7.1	7.0
New Zealand	New Zealand Dollar	7.1	7.0
Australia	Australian Dollar	6.9	6.7
Canada	Canadian Dollar	6.9	6.7
Israel	New Israeli Sheqel	6.8	6.6
Switzerland	Swiss Franc	6.6	6.9
Turkey	Turkish Lira	6.5	6.1
Malaysia	Malaysian Ringgit	6.3	6.2
Denmark	Danish Krone	6.1	6.0
Euro Zone	Euro	6.0	5.9
Czech Republic	Czech Koruna	5.9	5.7
South Korea	Korean Won	5.7	5.5
South Africa	South African Rand	5.3	5.0
Hungary	Hungarian Forint	5.2	5.0
Norway	Norwegian Krone	5.2	5.0
Sweden	Swedish Krona	5.1	4.9
Poland	Polish Zloty	4.3	4.2

Notes: Sterling depreciations for the 24 hour window from 4 PM June 23 2016 to 4 PM June 24 2016, daily spot and forward exchange rates from Reuters Datastream for the Bank of England's 26 major currencies.

Table A2: Real Wages With Exports, Imports and Intermediate Imports-Weighted Depreciations

	(1)	(2)
$\ln D^x$ x Post-Referendum		0.059 (0.065)
$\ln D^i$ x Post-Referendum		-0.510 (0.120)
$\ln D^m$ x Post-Referendum	-0.116 (0.065)	0.016 (0.046)
Industry and Time Dummies	Yes	Yes
Sample Size	86108	86108

Notes: Estimates of equation (1) defined in the main text of the paper for real wages in column (1) with the total imports depreciation measure and extended in column (2) to include all three depreciations, with individual level LFS data for quarters 2012Q3 to 2019Q2 for 83 industries (including a dummy interacted with Post-T for the five non-exporter industries). Standard errors (BHHJ adjusted) in parentheses.

Table A3: Real Wages and Alternative Depreciation Measures

	(1)
A. Migrant Source Weighted Depreciation	
$\ln D^i$ x Post-Referendum	-0.409 (0.089)
$\ln D^{mig}$ x Post-Referendum	-0.074 (0.059)
Industry and Time Dummies	Yes
Sample Size	86108
B. Inward and Outward FDI Weighted Depreciation	
$\ln D^i$ x Post-Referendum	-0.421 (0.083)
$\ln D^{fdi,in}$ x Post-Referendum	-0.010 (0.023)
$\ln D^{fdi,out}$ x Post-Referendum	-0.012 (0.011)
Industry and Time Dummies	Yes
Sample Size	86108
C. Upstream and Downstream Weighted Depreciation	
$\ln D^i$ x Post-Referendum	-0.421 (0.094)
$\ln D^{up}$ x Post-Referendum	0.003 (0.004)
$\ln D^{down}$ x Post-Referendum	-0.006 (0.009)
Industry and Time Dummies	Yes
Sample Size	86108

Notes: Estimates of equation (1) defined in the main text of the paper for real wages in augmented with additional depreciation measures, with individual level LFS data for quarters 2012Q3 to 2019Q2 for 83 industries. Standard errors (BHJ adjusted) in parentheses.

Table A4: Real Wages and Alternative Trade Share Trims

	(1)	(2)	(3)
	No Trim	Trim 1% (Baseline)	Trim 2%
$\ln D^i \times \text{Post-Referendum}$	-0.561 (0.104)	-0.459 (0.088)	-0.387 (0.069)
Number of Countries	229	71	53
Number of Currencies	148	52	38
Industry and Time Dummies	Yes	Yes	Yes
Sample Size	86108	86108	86108

Notes: Estimates of equation (1) defined in the main text of the paper for real wages for trim 0%, 1% and 2%, with individual level LFS data for quarters 2012Q3 to 2019Q2 for 83 industries. Standard errors (BHHJ adjusted) in parentheses.

Table A5: Real Wages and Additional Controls

	(1)
A. Share of EU in Trade (S_{EU}^j)	
$\ln D^i$ x Post-Referendum	-0.474 (0.169)
S_{EU}^i x Post-Referendum	0.010 (0.040)
S_{EU}^x x Post-Referendum	-0.026 (0.017)
Industry and Time Dummies	Yes
Sample Size	86108
B. Share of EU and non-EU in Migration ($\lambda^{mig} S_{EU}^{mig}, \lambda^{mig} S_{Non-EU}^{mig}$)	
$\ln D^i$ x Post-Referendum	-0.451 (0.103)
$\lambda^{mig} S_{EU}^{mig}$ x Post-Referendum	0.031 (0.120)
$\lambda^{mig} S_{Non-EU}^{mig}$ x Post-Referendum	0.038 (0.097)
Industry and Time Dummies	Yes
Sample Size	86108
C. Share of EU in Inward and Outward FDI ($S_{EU}^{fdi,in}, S_{EU}^{fdi,out}$)	
$\ln D^i$ x Post-Referendum	-0.408 (0.084)
$S_{EU}^{fdi,in}$ x Post-Referendum	-0.003 (0.019)
$S_{EU}^{fdi,out}$ x Post-Referendum	0.016 (0.014)
Industry and Time Dummies	Yes
Sample Size	86108

Notes: Estimates of equation (1) defined in the main text of the paper for real wages in augmented with additional share measures, with individual level LFS data for quarters 2012Q3 to 2019Q2 for 83 industries. Standard errors (BHHJ adjusted) in parentheses.

Table A6: Real Wages and Trade Policy

	(1)
A. Hard Brexit	
$\ln D^i$ x Post-Referendum	-0.376 (0.086)
τ_{hard}^x x Post-Referendum	-0.151 (0.082)
τ_{hard}^i x Post-Referendum	1.403 (0.335)
η_{hard}^x x Post-Referendum	0.341 (0.166)
η_{hard}^i x Post-Referendum	-0.380 (0.193)
Industry and Time Dummies	Yes
Sample Size	86108
B. Soft Brexit	
$\ln D^i$ x Post-Referendum	-0.366 (0.045)
τ_{soft}^x x Post-Referendum	1.372 (0.583)
τ_{soft}^i x Post-Referendum	2.917 (1.338)
η_{soft}^x x Post-Referendum	0.076 (0.145)
η_{soft}^i x Post-Referendum	-0.515 (0.183)
Industry and Time Dummies	Yes
Sample Size	86108
B. Hard-Soft Brexit	
$\ln D^i$ x Post-Referendum	-0.371 (0.115)
$\tau_{hard-soft}^x$ x Post-Referendum	-0.156 (0.089)
$\tau_{hard-soft}^i$ x Post-Referendum	1.576 (0.320)
$\eta_{hard-soft}^x$ x Post-Referendum	0.198 (0.337)
$\eta_{hard-soft}^i$ x Post-Referendum	0.121 (0.236)
Industry and Time Dummies	Yes
Sample Size	86108

Notes: Estimates of equation (1) defined in the main text of the paper for real wages in augmented with additional trade policy measures, with individual level LFS data for quarters 2012Q3 to 2019Q2 for 83 industries (including a dummy interacted with Post-T for industries with missing trade barriers). Standard errors (BHH adjusted) in parentheses.

Table A7: Real Wages and Vehicle Currency Adjustments

	(1)
A. Vehicle Currency Adjustment	
$\ln D^{i,veh}$ x Post-Referendum	-0.311 (0.117)
Industry and Time Dummies	Yes
Sample Size	86108
B. Vehicle Currency Adjustments for All Depreciations	
$\ln D^{x,veh}$ x Post-Referendum	0.026 (0.082)
$\ln D^{i,veh}$ x Post-Referendum	-0.311 (0.157)
$\ln D^{m,veh}$ x Post-Referendum	-0.021 (0.116)
Industry and Time Dummies	Yes
Sample Size	86108

Notes: Estimates of equation (1) defined in the main text of the paper for real wages with depreciations redefined with vehicle currency adjustments, in Panel A for intermediate imports weighted depreciation and in Panel B for all depreciation measure, with individual level LFS data for quarters 2012Q3 to 2019Q2 for 83 industries (including a dummy interacted with Post-T for the five non-exporter industries). Standard errors in parentheses.

Table A8: Top Four Intermediate Imports of High Intermediate Import Depreciation Industries

Intermediate Imports, D_o^i		
Depreciation	Top Four Industries (SIC)	Top Four Intermediate Imports (%)
7.39	Activities aux. to financial and insurance services (66)	Financial services (46), Other business services (36), Telecom, computer and information services (6), Insurance services (4)
7.03	Programming and broadcasting (60)	Intellectual property services (39), Personal, recreational and cultural services (16), Goods from Creative, arts and entertainment activities (10), Goods from Motion picture, video and television programme production, sound recording and music publishing activities (6)
6.96	Scientific research and development (72)	Other business services (54), Other transport equipment (9), Computer, electronic and optical products (7), Machinery and equipment n.e.c. (5)
6.90	Architectural and engineering services (71)	Other business services (47), Other transport equipment (14), Government services (8), Construction services (4)
Depreciation	Bottom Four Industries (SIC)	Bottom Four Intermediate Imports (%)
6.25	Electricity, gas and other energy supply (35)	Extraction of crude and natural gas (40), Mining of coal (14), Electrical equipment (8), Electricity, gas, steam and air conditioning supply (8)
6.24	Manufacture of coke and petroleum products (19)	Extraction of crude and natural gas (73), Mining of metal ores (10), Chemicals and chemical products (9), Machinery and equipment n.e.c. (3)
6.23	Manufacture of paper and paper products (17)	Paper and paper products (66), Chemicals and chemical products (11), Machinery and equipment n.e.c. (7), Rubber and plastic products (4)
6.22	Accommodation (55)	Beverages and tobacco (63), Food Products (6), Other business services (4), Air transport services (4)

Notes: Four highest and lowest intermediate imports weighted depreciations and their top and bottom four intermediate imports. D_o^i is defined in the text, and the data sources used in Appendix B.

Table A9: Robustness of Actual and Counterfactual Standardised Difference-in-Differences Estimates

	(1)	(2)
	$\ln P^i$	\ln (FT real weekly wage)
A. Market Access Rank with Trade Elasticity $\theta = -5$		
$\ln D^i x$ Post-Referendum	0.015 (0.008)	-0.018 (0.006)
$\ln \widetilde{D}^i x$ Post-Referendum	0.001 (0.007)	-0.003 (0.006)
B. BH with Trade Elasticity $\theta = -5$		
$\ln D^i x$ Post-Referendum	0.012 (0.018)	-0.020 (0.011)
$\ln \widetilde{D}^i x$ Post-Referendum	0.003 (0.026)	0.008 (0.019)
C. Log Distance Rank		
$\ln D^i x$ Post-Referendum	0.015 (0.009)	-0.022 (0.008)
$\ln \widetilde{D}^i x$ Post-Referendum	0.000 (0.005)	0.011 (0.007)
Industry and Time Dummies	Yes	Yes
Sample Size	2158	86108

Notes: As for Table 3 for column (1) and as for Table 7 in column (2). Standard errors (BHHJ adjusted) in parentheses.

Appendix D: Theory

Profits are $\Pi_o = \Pi \left(W_o, P_o^i(P_{ico}(E_c)), P_o^h(P_{i,uk}(1)), P_o^x(P_{co}(E_c)), P_o^{uk} \left(P_o^m(P_{co}(E_c)) \right) \right)$ where W_o are sectoral wages. P_o^i and P_o^h are intermediate input prices from abroad and at home. The former in turn depends on the prices of input i from source country c , labelled $P_{ico}(E_c)$. The intermediate import prices depend on prices which are converted into sterling through the source currency exchange rate E_c . The domestic input price depends on the value of sterling which is normalised to one. P_o^x and P_o^{uk} are output prices for exports and domestic sales of the output. The export prices depend on the prices received in sterling when they have been converted from the destination-denominated prices through the exchange rate E_c . Domestic output competes with imports of that output coming into the UK. Home output prices for the industry therefore depend on the prices of competing importers, summarised by the import price index P_o^m , which consists of source-specific import prices P_{co} that are converted into sterling through the source country exchange rate with sterling E_c .

The partial derivative $\partial \ln P_o^i(P_{ico}(E_c))/\partial \ln E_c$ denotes the passthrough of the sterling depreciation (with respect to the currency of a source country s) to the intermediate import price index. Similarly, the partial $\partial \ln P_o^x(P_{co}(E_c))/\partial \ln E_c$ is the passthrough of sterling's depreciation with respect to the currency of destination d into prices received in sterling by UK firms. Finally, when sterling depreciates, it affects the import prices charged by foreign competitors of UK's output industry o and the partial $\partial \ln P_o^{uk} \left(P_o^m(P_{co}(E_c)) \right)/\partial \ln E_c$ is the indirect passthrough of sterling's depreciation to output prices charged by UK firms in that industry. This is the import competition channel faced domestically by UK producers.

By Hotelling's Lemma, labour demand in the sector is $L_o^D = -\Pi_W \left(W_o, P_o^i(P_{ico}(E_c)), P_o^{uk}, P_o^x(P_{co}(E_c)), P_o^{uk} \left(P_o^m(P_{co}(E_c)) \right) \right)$. Denote the cross-price elasticity between factors i and j as $\varepsilon_{ij} \equiv \Pi_{P_i P_j} P^j / \Pi_{P_i} = Q^{i'} P^j / Q^i$ where Q^i is the quantity of input i demanded. The Hotelling elasticity of substitution is $\sigma_{ij} \equiv -\Pi \Pi_{P_i P_j} / \Pi_{P_i} \Pi_{P_j}$. Therefore, the Hotelling elasticity is $\sigma_{ij} = \varepsilon_{ij} / S_{j\Pi}$ where $S_{j\Pi} \equiv P^j Q^j / \Pi$ is the share of input costs for j in profits. Labour demand must equal the supply of labour to the sector: $L_o^S = L(W_o)$. Denote the labour supply elasticity by $\varepsilon_{WW}^S \equiv W L'(W) / L(W)$ which would be zero in a specific factors model. More generally, let ε_{WW}^S summarise the labour supply elasticity which is weakly positive. Labour market clearing implies that labour demand of an industry must equal the labour supply to the industry.

Totally differentiating the labour market clearing condition $L(W_o) = -\Pi_W$ and suppressing the o subscripts for brevity then gives:

$$\begin{aligned}
 (\varepsilon_{WW}^S - \Pi_{WW} W / \Pi_W) d \ln W &= \sum_C \sum_i (\Pi_{WP^i} P_{ic} / \Pi_W) d \ln P_{ic} + \sum_C (\Pi_{WP^x} P_C / \Pi_W) d \ln P_C \\
 &\quad + \sum_C (\Pi_{WP^{uk}} \Pi_{P^{uk} P^m} P_C / \Pi_W) d \ln P_C \\
 (\varepsilon_{WW}^S - \varepsilon_{WW}) d \ln W &= \sum_C \sum_i \varepsilon_{WP^i} d \ln P_{ic} + \sum_C \varepsilon_{WP^x} d \ln P_C + \varepsilon_{WP^{uk}} \sum_C \varepsilon_{P^{uk} P^m} d \ln P_C \\
 (\sigma_{WW}^S S_{WC} - \sigma_{WW} S_{WC}) d \ln W &= \sigma_{WP^i} \sum_C \sum_i S_{P_{ic} C} d \ln P_{ic} + \sigma_{WP^x} \sum_C S_{P_C R} d \ln P_C \\
 &\quad + \sigma_{WP^{uk}} S_{P_{uk} R} \sigma_{P^{uk} P^m} \sum_C S_{P_C Z} d \ln P_C
 \end{aligned}$$

The subscripts C , R and Z in the last line denote total costs, revenues, and expenditures on the industry. S_{WC} is therefore the labour share in total costs C and $S_{P_{ic} C}$ is the share of input i from source c in total costs. On the revenue side, $S_{P_C R}$ is the share of exports to destination d in total revenues R while $S_{P_{uk} R}$ is the share of domestic sales in revenues of the industry. UK firms compete with foreign firms for outputs produced by the industry. $S_{P_C Z}$

is the share of UK expenditure on industry outputs from source country c . Summing across all foreign sources, the share of imports in UK expenditures on the industry is $S_{P^mZ} = \sum_c S_{P_cZ}$ where the sum is taken over all foreign sources.

Let β denote the price passthrough of the composite exchange rate. Then solving for the wage change, it can be re-written in terms of Hotelling elasticities and currency shocks as:²

$$\begin{aligned} d \ln W &= \frac{\sigma_{WP^i} S_{P^iC}}{\sigma_{WW}^S S_{WC} - \sigma_{WW} S_{WC}} d \ln P^i + \frac{\sigma_{WP^x} S_{P^xR}}{\sigma_{WW}^S S_{WC} - \sigma_{WW} S_{WC}} d \ln P^x + \frac{\sigma_{WP^{uk}} S_{P^{uk}R} \sigma_{P^{uk}P^m} S_{P^mZ}}{\sigma_{WW}^S S_{WC} - \sigma_{WW} S_{WC}} d \ln P^m \\ &\equiv \frac{\sigma_{WP^i} S_{P^iC}}{\sigma_{WW}^S S_{WC} - \sigma_{WW} S_{WC}} \beta^i (\sum_c S_{P_{ci}C} d \ln E_c) + \frac{\sigma_{WP^x} S_{P^xR}}{\sigma_{WW}^S S_{WC} - \sigma_{WW} S_{WC}} \beta^x (\sum_c S_{P_{cR}} d \ln E_c) \\ &\quad + \frac{\sigma_{WP^{uk}} S_{P^{uk}C} \sigma_{P^{uk}P^m} S_{P^mZ}}{\sigma_{WW}^S S_{WC} - \sigma_{WW} S_{WC}} \beta^m (\sum_c S_{P_{cZ}} d \ln E_c) \end{aligned}$$

For firms that are cost minimisers, the cost function is $C_o = C(W_o, P_o^i(P_{ico}(E_c)), P_o^h, Q_o^x(Q_{co}), Q_o^{uk}(Q_o^m(Q_{co})))$. Then the change in wages is similarly derived from Shephard's Lemma as $d \ln W \equiv \frac{\varepsilon_{WP^i}}{\varepsilon_{WW}^S - \varepsilon_{WW}} d \ln P^i + \frac{\varepsilon_{WQ^x}}{\varepsilon_{WW}^S - \varepsilon_{WW}} d \ln Q^x + \frac{\varepsilon_{WQ^{uk}}}{\varepsilon_{WW}^S - \varepsilon_{WW}} d \ln Q^m$. Letting ε_{QP} denote the demand elasticity, the change in wages can also be re-written as $d \ln W \equiv \frac{\varepsilon_{WP^i}}{\varepsilon_{WW}^S - \varepsilon_{WW}} d \ln P^i + \frac{\varepsilon_{WQ^x} \varepsilon_{QP}}{\varepsilon_{WW}^S - \varepsilon_{WW}} d \ln P^x + \frac{\varepsilon_{WQ^{uk}} \varepsilon_{QP}}{\varepsilon_{WW}^S - \varepsilon_{WW}} d \ln P^{uk}$. Comparing with changes in wages from Hotelling's Lemma, the elasticities in the cost minimisation wage change comes from the cost functions instead of the profit function. Finally, for firms that must satisfy zero profits, the change in wages is

$$d \ln W \equiv - \left(\frac{S_{P^iC}}{S_{WC}} \right) d \ln P^i + \left(\frac{S_{P^xR}}{S_{WC}} \right) d \ln P^x + \left(\frac{S_{P^{uk}R}}{S_{WC}} \right) d \ln P^{uk}.$$

² In the presence of output effects from exports, competing imports and domestic sales, equation (1) would include industry output measures to allow for scale effects in the labour demand equation. Entering real gross value added (GVA) on the RHS of equation (1), the coefficient on intermediate imports weighted depreciation is almost unchanged at -0.451 (with an associated standard error of 0.084) and the coefficient on real GVA is small and statistically insignificant at -0.031 (with an associated standard error of 0.027).