

# Online Appendix for “The Brexit Vote, Inflation and UK Living Standards”

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## A Data appendix

### A.1 Import share calculations

To measure  $\lambda_g$ , the share of expenditure on distribution services at purchasers’ prices net of product taxes, we combine data from the input-output tables with additional information from the UK Supply and Use Tables for 2013. Let  $H_g$  be total household expenditure on product group  $g$  at purchasers’ prices. We can decompose  $H_g$  into the components accounted for by imported goods  $H_{Mg}$ , domestic goods  $H_{Dg}$ , distribution services  $H_{Sg}$  and taxes less subsidies on products  $H_{\tau g}$  giving  $H_g = H_{Mg} + H_{Dg} + H_{Sg} + H_{\tau g}$ .  $H_g$  can be retrieved from the Combined Use Table at purchasers’ prices, while  $H_{Dg}$  and  $H_{Mg}$  are taken from the Domestic and Imported Use Tables at basic prices. However, expenditure on distribution services,  $H_{Sg}$ , and taxes less subsidies on products,  $H_{\tau g}$ , cannot be inferred from the input-output tables.

Instead, we use the Supply of products table in the Supply and Use Tables to obtain measures of Distributors’ trading margins  $D_g$  and Taxes less subsidies on products  $T_g$  for product group  $g$ . We then assume:

$$\frac{H_{Sg}}{H_{Sg} + H_{\tau g}} = \frac{D_g}{D_g + T_g},$$

which implies  $H_{Sg}$  is given by:

$$H_{Sg} = \frac{D_g}{D_g + T_g} (H_g - H_{Mg} - H_{Dg}).$$

Given  $H_{Sg}$  we then calculate  $\lambda_g$  as:

$$\lambda_g = \frac{H_{Sg}}{H_{Mg} + H_{Dg} + H_{Sg}}.$$

## A.2 Consumer prices

A detailed explanation of how UK CPIs are compiled can be found in the ONS “Consumer Prices Indices Technical Manual”.<sup>1</sup> We provide a brief overview. About 700 individual prices for products and services (“items”) are assigned to COICOP classes, which can then be further aggregated into COICOP divisions and the aggregate CPI. Our empirical analysis of consumer prices is carried out at the level of 84 COICOP classes (see Table A1 for a list), which is the level of aggregation that most closely matches the UK input-output tables. We do not use individual product prices.

The COICOP system, centred on household consumption, is the basis for defining which expenditures appear in the CPI. For example, COICOP division 01 contains Food and non-alcoholic beverages, and COICOP class 01.1.1 contains Bread and cereals. The CPI is constructed in stages, with indices derived at each stage (such as a class) and then weighted to produce the next stage (such as a division) using expenditure shares based on the allocation of household final consumption expenditure. UK CPIs are Lowe-type indices. These are fixed basket indices with quantities taken from a different period (the weight reference period, which is typically before the base period) to the index period in which prices are observed. This is in contrast to a Laspeyres index where the weight reference period and the base period coincide. At the lowest level of aggregation, weights are typically not available and an unweighted Jevons index of item prices is primarily applied.

CPI data is collected monthly. Quarterly and annual indices are arithmetic averages of the underlying monthly information. Individual price collection happens around the middle of each month, except for seasonal items. Prices for around 500 items are collected in roughly 150 lo-

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<sup>1</sup>The 2019 manual can be downloaded from <https://www.ons.gov.uk/economy/inflationandpriceindices/methodologies/consumerpricesindicestechicalmanual2019>.

cations throughout the UK, typically in store or by telephone. Prices for around 200 items are obtained from central sources, including online. If a brand or variety of a particular product is available at the start of the year but not in later months (for example, due to technological progress in electronic goods or changing consumer tastes in clothing), this item is replaced, when possible, with a new version that is comparable either directly (such that the same base price applies) or after quantity/quality adjustments (for instance, with the help of hedonic regressions). When replacement is not possible, the item’s price is imputed by assuming the same price change as for similar products.

The shopping basket underlying the CPI is fixed for a period of twelve months. At the beginning of each year, updates are made due to “changing markets, fashions and new products.” This includes brand-new and deleted products as well as updated weights. These updates are decided based on household spending surveys, external market research and feedback from price collectors. They are typically phased in with a two-year lag. For example, the 2018 weights would normally be based on expenditure patterns for 2016.

### A.3 Oil price variable

To compute the oil price variable, we start by using the framework developed in Section 3 and the UK Input-Output Analytical Tables for 2013 to calculate the share of consumer expenditure spent on imported oil (CPA code 06&07) by product group, which we denote  $OilShare_g$ . We allow for both direct oil consumption and indirect consumption via the use of oil as an imported intermediate input. However, it turns out that oil consumption only has an indirect component because households do not directly consume imported oil (i.e.,  $\gamma_{oil} = 0$ ). As with import shares, we first compute oil shares for the 105 CPA products in the input-output tables and then use the ONS concordance to map CPA products to COICOP classes.

The exposure of COICOP class  $g$  to oil price changes in period  $t$  is then given by:

$$Oil_{gt} = OilShare_g \times \hat{p}_{Oil,t}^M,$$

where  $\hat{p}_{Oil,t}^M$  is the log difference in the US dollar denominated price of oil between period  $t - 1$  and period  $t$ . We measure the oil prices using the average petroleum spot price Crude Oil index from the IMF's Commodity Prices database, which is an average of the prices of Brent Crude, Dubai Crude and West Texas Intermediate Crude. The index is not available for 2018, so we extrapolate prices using changes in the price of West Texas Intermediate Crude obtained from the Federal Reserve Bank of St. Louis.

## **B Additional results**

Tables 10 and 11 in the paper only report the sum  $\beta = \sum_{s=0}^T \beta_s$  of the pass-through coefficients. For completeness, Tables A2 and A3 show the estimated coefficients for each exchange rate lag. Table A2 corresponds to the specifications estimated in Table 10, where the exchange rate change and its lags are interacted with the import share. The estimated pass-through coefficient is positive for all lags other than two and eight and is generally largest and most statistically significant for lags one, four and seven.

Table A3 corresponds to Table 11, where the exchange rate terms enter without interaction. In this case, only lags four and five are ever individually significant, but lags zero, one, three and six also make quantitatively important contributions to the long-run pass-through estimate.

Table A1: Import shares by COICOP class

Table A1 — *Continued on next page*

COICOP class		(1)	(2)	(3)	(4)
		Direct	Indirect	Total	Distribution services share $\lambda_g$
01.1.1	Bread and cereals	21.63	15.62	37.25	28.20
01.1.2	Meat	30.58	15.33	45.91	31.14
01.1.3	Fish	33.70	11.60	45.31	45.41
01.1.4	Milk, cheese and eggs	22.33	15.50	37.83	49.87
01.1.5	Oils and fats	36.48	11.39	47.87	49.56
01.1.6	Fruit	32.12	14.70	46.82	23.81
01.1.7	Vegetables including potatoes and other tubers	35.83	11.88	47.70	37.37
01.1.8	Sugar, jam, syrups, chocolate and confectionery	30.42	11.67	42.09	54.59
01.1.9	Food products (nec)	31.29	12.26	43.54	46.77
01.2.1	Coffee, tea and cocoa	31.18	11.31	42.49	55.08
01.2.2	Mineral waters, soft drinks and juices	21.27	14.24	35.50	37.56
02.1.1	Spirits	11.36	12.57	23.93	77.09
02.1.2	Wine	11.36	12.57	23.93	77.09
02.1.3	Beer	11.36	12.57	23.93	77.09
02.2	Tobacco	11.36	12.57	23.93	77.09
03.1.2	Garments	45.38	7.29	52.68	53.10
03.1.3	Other clothing and clothing accessories	31.75	9.46	41.20	65.19
03.1.4	Cleaning, repair and hire of clothing	0.60	10.67	11.27	0.00
03.2	Footwear including repairs	26.33	10.43	36.76	22.56
04.1	Actual rentals for housing	0.02	7.61	7.63	0.00
04.3.1	Materials for maintenance and repair	32.09	11.98	44.07	54.23
04.3.2	Services for maintenance and repair	0.00	16.26	16.26	0.00
04.4.1	Water supply	0.00	10.72	10.72	0.00
04.4.3	Sewerage collection	0.00	7.51	7.51	0.00
04.5.1	Electricity	0.12	44.36	44.49	0.00
04.5.2	Gas	0.73	32.34	33.07	0.11
04.5.3	Liquid fuels	44.79	36.68	81.47	9.73

Table A1 — *Continued from previous page*

04.5.4	Solid fuels	0.00	33.33	33.33	21.23
05.1.1	Furniture and furnishings	27.77	12.23	40.00	51.65
05.1.2	Carpets and other floor coverings	21.02	11.35	32.37	74.08
05.2	Household textiles	21.02	11.35	32.37	74.08
05.3.1/2	Major appliances and small electric goods	42.47	7.55	50.02	57.48
05.3.3	Repair of household appliances	0.08	14.40	14.47	0.00
05.4	Glassware, tableware and household utensils	31.85	10.46	42.31	60.38
05.5	Tools and equipment for house and garden	32.63	9.41	42.04	64.29
05.6.1	Non-durable household goods	26.96	10.29	37.24	68.47
05.6.2	Domestic services and household services	0.65	0.36	1.02	0.00
06.1.1	Pharmaceutical products	38.89	10.97	49.85	37.08
06.1.2/3	Other medical and therapeutic equipment	42.10	8.24	50.34	53.84
06.2.1/3	Medical services & paramedical services	14.96	2.49	17.45	0.00
06.2.2	Dental services	14.96	2.49	17.45	0.00
06.3	Hospital services	14.96	2.49	17.45	0.00
07.1.1A	New cars	56.52	7.23	63.75	28.74
07.1.1B	Second-hand cars	n.a.	n.a.	n.a.	n.a.
07.1.2/3	Motorcycles and bicycles	42.74	14.77	57.52	15.41
07.2.1	Spare parts and accessories	65.06	6.09	71.14	30.60
07.2.2	Fuels and lubricants	44.89	36.55	81.44	9.81
07.2.3	Maintenance and repairs	0.05	18.59	18.64	11.85
07.2.4	Other services	0.53	14.88	15.41	0.00
07.3.1	Passenger transport by railway	0.74	14.76	15.50	0.00
07.3.2/6	Passenger transport by road and other transport services	0.06	14.40	14.46	0.00
07.3.3	Passenger transport by air	4.70	26.67	31.37	0.00
07.3.4	Passenger transport by sea and inland waterway	0.06	21.34	21.40	0.00
08.1	Postal services	0.81	16.45	17.25	0.00
08.2/3	Telephone and telefax equipment and services	18.03	16.69	34.71	30.25
09.1.1	Reception and reproduction of sound and pictures	36.01	9.04	45.05	60.50
09.1.2	Photographic, cinematographic and optical equipment	36.01	9.04	45.05	60.50
09.1.3	Data processing equipment	31.62	9.58	41.19	65.25
09.1.4	Recording media	17.23	12.66	29.89	17.81

Table A1 — *Continued from previous page*

09.1.5	Repair of audio-visual equipment & related products	0.08	14.40	14.47	0.00
09.2.1/2/3	Major durables for in/outdoor recreation and their maintenance	26.00	11.42	37.42	34.22
09.3.1	Games, toys and hobbies	22.11	11.04	33.15	65.20
09.3.2	Equipment for sport and open-air recreation	39.64	8.34	47.98	57.72
09.3.3	Gardens, plants and flowers	26.01	17.51	43.53	30.83
09.3.4/5	Pets, related products and services	10.17	13.93	24.09	20.06
09.4.1	Recreational and sporting services	5.55	19.99	25.55	0.00
09.4.2	Cultural Services	13.23	12.98	26.21	0.00
09.5.1	Books	14.84	12.59	27.43	52.14
09.5.2	Newspapers and periodicals	14.84	12.59	27.43	52.14
09.5.3/4	Misc. printed matter, stationery, drawing materials	27.07	11.38	38.45	49.84
09.6	Package holidays	0.26	8.51	8.77	0.00
10.0	Education	0.82	4.14	4.96	0.00
11.1.1	Restaurants and cafes	0.00	16.60	16.60	0.01
11.1.2	Canteens	0.00	16.60	16.60	0.01
11.2	Accommodation services	0	18.42	18.42	0.00
12.1.1	Hairdressing and personal grooming establishments	0.72	10.24	10.96	0.00
12.1.2/3	Appliances and products for personal care	33.65	9.13	42.79	63.77
12.3.1	Jewellery, clocks and watches	25.60	10.15	35.75	67.08
12.3.2	Other personal effects	32.17	11.40	43.57	54.44
12.4	Social Protection	3.14	12.45	15.58	0.00
12.5.2	House contents insurance	0.02	16.19	16.20	0.00
12.5.3/5	Health insurance and other insurance	0.02	16.19	16.20	0.00
12.5.4	Transport insurance	0.02	16.19	16.20	0.00
12.6.2	Other financial services (nec)	0.05	15.13	15.19	0.00
12.7	Other services (nec)	1.00	10.78	11.78	0.00

Notes: Column (1) reports the direct import share in percent. Column (2) reports the indirect import share in percent. Column (3) reports the total import share. The sum of direct and indirect import shares might not equal the total import share due to rounding errors. Column (4) reports the share of distribution services in expenditure,  $\lambda_g$ , in percent.

Table A2: Import cost pass-through showing full set of coefficient estimates

	(1)	(2)	(3)	(4)	(5)
	Inflation	Inflation	Inflation	Inflation	Inflation
Import cost pass-through	0.819*** (0.236)	0.972*** (0.281)	1.111*** (0.365)	1.412*** (0.434)	1.209*** (0.350)
Test: Import cost pass-through=1					
F-stat	0.57	0.01	0.09	0.90	0.36
p-value	0.45	0.92	0.76	0.34	0.55
Decomposition of Import cost pass-through:					
Contemporaneous	0.120 (0.186)	0.122 (0.186)	0.109 (0.181)	0.147 (0.186)	0.088 (0.165)
Lag 1	0.298* (0.159)	0.320** (0.161)	0.345** (0.165)	0.357** (0.168)	0.402** (0.180)
Lag 2	0.189 (0.159)	0.232 (0.164)	0.234 (0.165)	0.209 (0.170)	0.171 (0.171)
Lag 3	-0.084 (0.123)	-0.116 (0.124)	-0.071 (0.106)	-0.081 (0.106)	-0.045 (0.101)
Lag 4	0.296** (0.124)	0.208 (0.129)	0.173 (0.125)	0.318** (0.141)	0.258* (0.135)
Lag 5		0.205 (0.124)	0.134 (0.107)	0.085 (0.105)	0.072 (0.106)
Lag 6			0.187 (0.143)	0.004 (0.147)	0.049 (0.165)
Lag 7				0.374** (0.160)	0.384** (0.163)
Lag 8					-0.171 (0.132)
Number of lags	4	5	6	7	8
Observations	2250	2250	2250	2250	2250
R-squared	0.601	0.601	0.601	0.603	0.603
Class×season fixed effects	YES	YES	YES	YES	YES
Quarter fixed effects	YES	YES	YES	YES	YES

Notes: The dependent variable is the quarterly UK inflation rate at the COICOP class level. The sample covers 2011Q1 to 2018Q2. The main regressor is the exchange rate change, contemporaneous and including lags as specified, interacted with import shares by COICOP class. Import cost pass-through is the sum of the coefficients on all import share interaction terms, which are also reported separately. Euro area inflation rates by COICOP class and exposure to oil price changes are included as controls (coefficients not reported). Season fixed effects refer to the same quarter every year. OLS estimation. Standard errors in parentheses are clustered by COICOP class. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1.



Table A3: Exchange rate pass-through without import share interactions showing full set of coefficient estimates

	(1)	(2)	(3)	(4)	(5)
	Inflation	Inflation	Inflation	Inflation	Inflation
Exchange rate pass-through	0.120*** (0.032)	0.150*** (0.033)	0.158*** (0.036)	0.150*** (0.038)	0.138*** (0.041)
Decomposition of Exchange rate pass-through					
Contemporaneous	0.025 (0.019)	0.025 (0.019)	0.025 (0.019)	0.023 (0.019)	0.020 (0.018)
Lag 1	0.029 (0.024)	0.033 (0.025)	0.035 (0.024)	0.035 (0.024)	0.037 (0.025)
Lag 2	-0.024 (0.035)	-0.017 (0.035)	-0.016 (0.035)	-0.016 (0.036)	-0.018 (0.037)
Lag 3	0.042 (0.025)	0.036 (0.025)	0.038 (0.025)	0.039 (0.025)	0.041 (0.026)
Lag 4	0.051** (0.022)	0.035 (0.024)	0.033 (0.025)	0.029 (0.023)	0.025 (0.024)
Lag 5		0.038** (0.018)	0.034* (0.020)	0.035* (0.019)	0.035* (0.020)
Lag 6			0.010 (0.020)	0.015 (0.023)	0.018 (0.025)
Lag 7				-0.011 (0.019)	-0.010 (0.020)
Lag 8					-0.010 (0.027)
Number of lags	4	5	6	7	8
Observations	2250	2250	2250	2250	2250
R-squared	0.591	0.592	0.592	0.592	0.592
Class×season fixed effects	YES	YES	YES	YES	YES
Quarter fixed effects	NO	NO	NO	NO	NO

Notes: The dependent variable is the quarterly UK inflation rate at the COICOP class level. The sample covers 2011Q1 to 2018Q2. The main regressor is the exchange rate change, both contemporaneous and including lags as specified. Exchange rate pass-through is the sum of the coefficients on all exchange rate terms, which are also reported separately. Euro area inflation rates by COICOP class and exposure to oil price changes are included as controls (coefficients not reported). Season fixed effects refer to the same quarter every year. OLS estimation. Standard errors in parentheses are clustered by COICOP class. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1.