CESifo WORKING PAPERS

8001
2019

December 2019

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CESifo

Impressum:

CESifo Working Papers
ISSN 2364-1428 (electronic version)
Publisher and distributor: Munich Society for the Promotion of Economic Research - CESifo GmbH
The international platform of Ludwigs-Maximilians University's Center for Economic Studies and the ifo Institute
Poschingerstr. 5, 81679 Munich, Germany
Telephone +49 (0)89 2180-2740, Telefax +49 (0)89 2180-17845, email office@cesifo.de
Editor: Clemens Fuest
www.cesifo-group.org/wp

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CESifo *Working Paper No. 8001*
Category 8: Trade Policy

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Abstract

This paper studies how the depreciation of sterling following the Brexit referendum affected consumer prices in the United Kingdom. Our identification strategy uses input-output linkages to account for heterogeneity in exposure to import costs across product groups. We show that, after the referendum, inflation increased by more for product groups with higher import shares in consumer expenditure. This effect is driven by both direct consumption of imported goods and the use of imported inputs in domestic production. Our results are consistent with complete pass-through of import costs to consumer prices and imply an aggregate exchange rate pass-through of 0:29. We estimate the Brexit vote increased consumer prices by 2:9 percent, costing the average household £870 per year. The increase in the cost of living is evenly shared across the income distribution, but differs substantially across regions.

JEL-Codes: E310, F150, F310.

Keywords: Brexit, exchange rate pass-through, import costs, inflation.

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December 2019
This research was supported by the Economic and Social Research Council through the UK in a Changing Europe initiative under Brexit Priority Grant ES/R001804/1. We are grateful for helpful comments from seminar participants at the Bank of England, Groningen, LSE, the Office for National Statistics, Strathclyde, Tübingen, Warwick, the 2017 Brussels European Employee Relations Group (BEERG) Brexit Forum, RES 2018 and ASSA 2019. All four authors are affiliated with the Centre for Economic Performance at the London School of Economics.

1 Introduction

The impact of exchange rate movements on consumer prices plays a central role in determining how open economies adjust to economic shocks. The extent of exchange rate pass-through matters for optimal monetary policy design (Corsetti and Pesenti 2005), international shock transmission (Corsetti and Dedola 2005) and the welfare consequences of exchange rate changes (Devereux, Engel and Tille 2003). High pass-through facilitates adjustment, but also implies the domestic economy is more exposed to exchange rate fluctuations.

In this paper, we study the consumer price effects of the depreciation of sterling after the United Kingdom (UK) voted to leave the European Union (EU) in June 2016. Brexit is the most important policy shock to hit the UK economy in recent decades and the depreciation offers an attractive setting for analyzing the price consequences of an exchange rate shock. The fall in sterling was unanticipated, sharp and persistent and, unlike most sudden depreciations, affected the currency of a major industrialized economy.

Moreover, the depreciation was not caused by a shock to contemporaneous economic conditions that could directly affect consumer prices holding the exchange rate fixed. Instead, it resulted from a political event that changed expectations about future economic policy. The Brexit vote led currency investors to anticipate that barriers to trade and immigration between the UK and the EU would rise at some unknown future date, while also increasing economic uncertainty in the UK. This shift in expectations led to the depreciation of the pound. As Forbes, Hjortsoe and Nenova (2018) highlight, pass-through from exchange rate movements to inflation depends on why the exchange rate changes. We are not aware of previous studies that have estimated pass-through using an exchange rate shock comparable to the UK's vote to leave the EU.

In addition to providing new evidence on exchange rate pass-through to consumer prices, our analysis sheds light on how the decision to leave the EU has affected the UK economy. Recent increases in protectionism around the world have provided fresh impetus to efforts aimed at understanding the consequences of raising trade barriers (Evenett 2019). We contribute to this objective by studying how adopting a policy of international disintegration affects economic outcomes in advance of the policy coming into effect.

Economic theory suggests pass-through will vary across countries and over time depending on an economy's openness to imports (Goldberg and Campa 2010), the distribution costs of bringing goods to market (Burstein, Neves and Rebelo 2003), the source of exchange rate movements (Campa and Goldberg 2005; Corsetti, Dedola and Leduc 2008; Forbes, Hjortsoe and Nenova 2018), the currency in which trade is invoiced (Gopinath, Itskhoki and Rigobon 2010; Auer, Burstein and Lein 2018; Chen, Chung and Novy 2018) and whether mark-ups adjust in response to exchange rate variation (Dornbusch 1987, Krugman 1987).[1] Motivated by this literature, our empirical strategy uses product-level differences in exposure to import costs to isolate price variation caused by the exchange rate decline.

We start by developing a model of consumer prices that includes both direct import consumption and indirect expenditure on imports used as intermediate inputs in domestic production and takes into account input-output linkages across sectors as well as distribution margins that drive a wedge between basic prices and purchaser prices. The model shows how the elasticity of consumer prices to the exchange rate depends upon the share of import costs in consumer expenditure. Exchange rate movements lead to larger price changes in product groups with higher import shares. Guided by the model, we use UK input-output tables for 2013 to calculate the import share for each of the product groups that comprise the consumer expenditure basket.[2]

The share of imports in aggregate UK consumer expenditure is 0.29, of which 16 percentage points is directly consumed imports, while the remainder is imported intermediates used in domestic production. The aggregate import share masks substantial heterogeneity across product groups with tradable products mostly having higher import shares than services. For example, the import share of Education is 0.05, while that of New cars is 0.64.

Using the import share variable, we estimate the consumer price effects of the Brexit depreciation from two alternative specifications. First, we consider an event study specification that regresses the log difference of consumer prices by product group on the import share interacted with a treatment dummy that switches on after the Brexit referendum. We find that following the referendum the increase in inflation was higher for product groups with larger import shares. This not only shows that the Brexit vote led to higher consumer prices, but also confirms the empirical relevance of distribution costs and non-traded goods in shaping heterogeneity across products in consumer price pass-through. We also find that producer price index inflation was higher in sectors with a larger share of imported intermediates in production costs. This result supports Goldberg and Campa's (2010) argument that the extent of imported input use by domestic producers affects the magnitude of exchange rate pass-through.

We cannot use the event study specification to estimate pass-through because it does not control for exchange rate variation in the periods before and after the referendum. Therefore, we also estimate a second specification where we interact the import share with the log difference of the exchange rate and its lags. We estimate the pass-through specification on a window around the Brexit vote using quarterly data from 2011Q1 to 2018Q2 and including between four and eight exchange rate lags. Summing the estimated coefficients on the exchange rate-import share inter-

[1] See Burstein and Gopinath (2014) for a comprehensive review of the exchange rate pass-through literature.

[2] Goldberg and Campa (2010) use a similar import share measure to undertake an accounting decomposition of exchange rate pass-through in OECD countries. By contrast, we show how import shares can be combined with disaggregated price data to identify pass-through empirically.

actions gives a measure of pass-through conditional on import shares, which we refer to as *import cost pass-through*.[3]

We find robust evidence of high pass-through. In particular, we cannot reject the hypothesis of complete import cost pass-through, meaning that a 10 percent depreciation increases consumer prices by 1 percent for each 10 percentage point rise in the import share. In contrast to our estimates, most exchange rate pass-through studies find incomplete pass-through to border prices and import costs (Burstein and Gopinath 2014). For example, in a study of the 2015 appreciation of the Swiss franc, Auer, Burstein and Lein (2018) find incomplete border price pass-through due, in large part, to the price stickiness of imports invoiced in Swiss francs.

However, studies of recent US tariff increases have found evidence of complete pass-through to import prices (Amiti, Redding and Weinstein 2019; Fajgelbaum et al. 2019) and, in the case of washing machines, a consumer price elasticity to tariffs in excess of 100 percent (Flaaen, Hortaçsu and Tintelnot 2019). Burstein, Eichenbaum and Rebelo (2005) also find evidence of high pass-through to import costs following several large devaluation episodes and show that price changes following large devaluations are driven by tradeable products, whereas smaller exchange rate fluctuations lead to deviations from relative purchasing power parity for traded goods. Our results are consistent with these findings.

Complete import cost pass-through implies that pass-through to consumer prices equals the import share, both at the product group level and on aggregate. This means that aggregate pass-through to consumer prices equals the aggregate import share of 0.29. Since the Brexit vote led sterling to depreciate by around 10 percent, our results imply the Brexit depreciation raised consumer prices by 2.9 percent by June 2018. This is equivalent to an increase in the cost of living for the average UK household of £870 per year. As there is no evidence of a countervailing increase in nominal incomes, our findings imply the Brexit depreciation has had a substantial negative effect on real wages and living standards in the UK.

We also analyze the distributional consequences of the Brexit depreciation by calculating how the increase in the cost of living varies across households with different expenditure patterns. Households that spend more on product groups with higher import shares are harder hit. We find that a household at the 75th percentile of the distribution of cost of living increases experienced a one percentage point larger increase in inflation from the Brexit depreciation than a household at the 25th percentile.

Comparing households in different deciles of the income distribution shows that the costs are evenly shared across income levels because there is no systematic correlation between income and

[3] To avoid the possibility of confusion, note that import cost pass-through is not the same as pass-through to import prices at the border. Instead, it equals the elasticity of consumer prices to the exchange rate, when exchange rate changes are scaled by the share of imports in consumer expenditure. Consequently, it depends upon both pass-through at the border and how border prices feed through to consumer prices.

the share of imports in household expenditure. However, the inflation impact differs considerably across regions. Households in Northern Ireland and Wales fared worst since they spend a relatively higher fraction of income on high import share products such as food and drink, clothing and fuel. By contrast, households in London were least affected due to their relatively larger expenditure on rent, which has a low import share.

Our estimate that pass-through to consumer prices equals 0.29 is larger than estimates obtained without accounting for import share heterogeneity across product groups. Pass-through to consumer prices is most frequently estimated by regressing log changes in the aggregate consumer price index on log changes in the trade-weighted exchange rate and its lags, while controlling for foreign production costs. Goldberg and Campa (2010) report that using this approach actually delivers a negative pass-through estimate for the UK after four quarters, while Burstein and Gopinath (2014) estimate pass-through of 0.14 after eight quarters for a consumer price measure that excludes services. Forbes, Hjortsoe and Nenova (2018) estimate pass-through for the UK using a structural vector autoregression framework. They find that pass-through varies depending upon the source of the exchange rate shock, but the average pass-through to consumer prices in their sample after eight quarters is 0.13.

Similarly, using our estimation specification and data, but not interacting the exchange rate terms with the import share, delivers a pass-through estimate of around 0.15. This estimate is biased downwards because, without including the interactions terms, we cannot control for quarter fixed effects to capture other time-varying inflationary pressures that may be correlated with exchange rate movements. The comparison illustrates the importance of using data on import share heterogeneity across products to estimate pass-through to consumer prices.

In addition to shedding new light on the relationship between exchange rates and consumer prices, our results contribute to the emerging literature that uses Brexit to analyze the effects of economic disintegration.[4] Prior to the referendum, most research predicted that leaving the EU would reduce the UK's long-run income per capita because it would increase barriers to trade and immigration (Dhingra et al. 2017, Sampson 2017). These long-run forecasts cannot yet be evaluated. However, our analysis shows that, even though the UK currently remains part of the EU, voters are already paying a price for Brexit because of the cost of living increase caused by the post-referendum depreciation.

In related work, Born et al. (2019) use the synthetic control method to estimate that the Brexit vote had reduced UK GDP at the end of 2018 by between 1.7 and 2.5 percent. Interestingly, they find that most of this effect is driven by lower consumption growth. Our results suggest that the

[4]See, for example, Costa, Dhingra and Machin (2019) on nominal wages, Bloom et al. (2019) on investment and productivity, Breinlich et al. (2019) on foreign investment, and Crowley, Exton and Han (2018) on the extensive margin of trade.

Brexit depreciation contributed to the reduction in GDP growth documented by Born et al. by driving up consumer prices leading to lower consumption growth.

The remainder of the paper is organized as follows. The next section provides more background on the Brexit referendum and the subsequent depreciation of sterling. Section 3 develops a simple model of how import costs affect consumer prices, which we use to define our import share measure. Section 4 then introduces our data and explains how the import share is calculated from input-output tables. Section 5 presents results from the event study estimates, while Section 6 covers the pass-through specification. Section 7 then uses the results to quantify how the Brexit depreciation has affected the cost of living in the UK. Finally, Section 8 offers some concluding remarks.

2 The Brexit vote and sterling

Prior to the Brexit referendum, opinion polls predicted a close vote. By contrast, betting markets implied around an 85 percent probability that the UK would choose to remain in the EU (The Economist 2016), reflecting the conventional wisdom that undecided voters would opt for the status quo. However, on 23 June 2016, 52 percent of UK voters supported leaving the EU.

The Brexit vote did not lead to any immediate changes in the UK's economic relationships with the EU or the rest of the world. The UK only officially notified the EU of its intention to leave the union in March 2017 and, as of November 2019, the UK remains part of the EU. However, the leave vote did affect expectations about the UK's economic future. The shift in expectations had two components. First, there was an increase in uncertainty over the future of UK economic policy and trade agreements (Bloom et al. 2018). Second, the referendum led to a decline in the expected future openness of the UK to trade and immigration with the EU.

Because economic behavior is forward looking, these changes in expectations had an immediate impact on financial markets. On 24 June 2016, after the result was known, the FTSE 100 stock market index fell by 3.8 percent and sterling depreciated by 8.1 percent against the US dollar and 5.8 percent against the euro.[5] Stock prices soon recovered, supported by the Bank of England's decision in August 2016 to cut interest rates by 25 basis points and undertake renewed quantitative easing. But the fall in sterling proved to be persistent. Figure 1 shows the import-weighted effective UK exchange rate at daily frequency from the start of 2016 until the middle of 2017.[6] In the week after the referendum the effective exchange rate depreciated by 9.2 percent and it fluctuated around 10 percent below its pre-referendum value over the following two years.

[5] Breinlich et al. (2018) and Davies and Studnicka (2018) analyze share price movements in the days after the referendum.

[6] See Section 4.2 for a description of how the exchange rate index is constructed.

Figure 1: The depreciation of sterling after the 2016 referendum

Notes: Import-weighted effective exchange rate index calculated using daily data and normalized to 100 on the day of the referendum (23 June 2016, indicated by the vertical line). An increase in the exchange rate corresponds to a depreciation of sterling.

We use the Brexit depreciation to estimate the relationship between the value of sterling and consumer prices. The Brexit depreciation has several features that make it attractive for this purpose. Not only was it unanticipated, but it is a rare example of a sudden, large, persistent shock to a major currency. Moreover, the depreciation was caused by the UK's decision to change future policy, not by a shock to domestic or foreign economic conditions. This feature of the depreciation simplifies, though does not eliminate, the identification challenge that arises when estimating exchange rate pass-through using exchange rate movements caused by supply and demand shocks that themselves affect equilibrium prices.

A challenge in using the Brexit depreciation for identification is that the referendum may have affected prices through channels other than the fall in sterling. For example, through the Bank of England's decision to loosen monetary policy after the vote, or through changes in consumer and firm behaviour in anticipation of Brexit. As explained in detail below, we address this challenge by using the share of imports in consumer expenditure to measure products' exposure to exchange rate movements. Our identifying assumption is that, conditional on the exchange rate, price effects of the leave vote are uncorrelated with pre-referendum import share variation across products.

3 Import costs and consumer prices

To inform our empirical analysis we develop a model of how exchange rate movements affect consumer prices through changes in import costs. The model builds upon elements from Burstein, Eichenbaum and Rebelo (2005), Goldberg and Campa (2010) and Berlingieri, Breinlich and Dhingra (2018). Consumers purchase both domestic and foreign goods, which come bundled with locally produced distribution services that capture the cost of bringing goods to market. Producers use both domestic and imported inputs and we take input-output linkages between sectors into account when modelling intermediate input use.

3.1 Consumption and production

Suppose consumers purchase a basket of G product groups indexed by g. Within each product group, consumers purchase a domestic good D_g, an imported good M_g and distribution services S_g. The consumption aggregate C_g for group g is given by:

$$C_g = \left(M_g^{\gamma_g} D_g^{1-\gamma_g}\right)^{1-\lambda_g} S_g^{\lambda_g}, \tag{1}$$

where λ_g gives the share of distribution services in expenditure on group g and γ_g gives the share of imports in expenditure net of distribution costs.[7]

Production of domestic good g uses a bundle v_g of primary factors (e.g. labour and capital) together with aggregates of domestic and imported intermediate inputs. Output Y_g is given by:

$$Y_g = \phi_g \left(X_{Mg}^{\delta_g} X_{Dg}^{1-\delta_g}\right)^{\alpha_g} v_g^{1-\alpha_g}, \tag{2}$$

where ϕ_g denotes the productivity of sector g, X_{Mg} denotes imported intermediate usage and X_{Dg} denotes domestic intermediate usage. Here α_g is the share of intermediate inputs in production costs and δ_g is the share of imports in intermediate input costs.

The imported intermediate bundle used by domestic producers in sector g is an aggregate of imports of all G product groups:

$$X_{Mg} = \prod_{j=1}^{G} x_{Mgj}^{\mu_{gj}}, \tag{3}$$

where x_{Mgj} denotes the quantity of imported good j used to produce the sector g imported intermediate input and μ_{gj} gives the cost share of j in imported intermediate expenditure by sector g. Likewise, the domestic intermediate bundle is an aggregate of all G domestic goods:

[7] Corsetti and Dedola (2005) consider an alternative specification of distribution services in which distribution costs are additive.

$$X_{Dg} = \prod_{j=1}^{G} x_{Dgj}^{\psi_{gj}}, \tag{4}$$

where x_{Dgj} denotes the quantity of domestic good j used to produce the sector g domestic intermediate input and ψ_{gj} gives the cost share of j in domestic intermediate expenditure by sector g.

Lastly, we assume that distribution services are produced by the domestic wholesale and retail sectors according to:

$$S_g = X_{Wg}^{\xi} X_{Rg}^{1-\xi}, \tag{5}$$

where X_{Wg} denotes wholesale output used in sector g and X_{Rg} is retail output. The share of distribution services expenditure spent on wholesale is ξ, while the expenditure share of retail is $1 - \xi$. Since ξ does not vary with g, distribution services are homogeneous and the price of distribution services will be constant across product groups.[8] The production technologies for wholesale and retail goods have the same structure as for all other goods and are given by equations (2)-(4) with $g = W$ for wholesale and $g = R$ for retail.

3.2 Prices

We solve for consumption and intermediate good prices under the assumption that all markets are competitive. Let p^S be the price of distribution services, p_g^M be the price of imported good g and p_g^D be the price of domestic good g. Cost minimization using equation (1) implies that the consumption price index p_g^C for product group g is:

$$p_g^C = \left[\frac{1}{1-\lambda_g} \left(\frac{p_g^M}{\gamma_g} \right)^{\gamma_g} \left(\frac{p_g^D}{1-\gamma_g} \right)^{1-\gamma_g} \right]^{1-\lambda_g} \left(\frac{p^S}{\lambda_g} \right)^{\lambda_g}.$$

Distribution services introduce a wedge between basic prices (obtained by letting $\lambda_g \to 0$ in the expression above) and the purchasers' prices paid by consumers. Purchasers' prices may also depend upon the level of taxes and subsidies on products. Although we do not model taxes and subsidies explicitly, we adjust for their presence when mapping the model to consumer expenditure data.

We are interested in how consumer prices change over time following an exchange rate movement. For any variable z let $\hat{z}$ be the log difference of z between period t and the previous period:

[8] In principle, ξ could vary by product group, but in our data we do not observe wholesale and retail expenditure shares at the product group level.

$\hat{z} \equiv \log z_t - \log z_{t-1}$. Then we can write the change in the group g price index as:

$$\hat{p}_g^C = (1-\lambda_g)\gamma_g \hat{p}_g^M + (1-\lambda_g)(1-\gamma_g)\hat{p}_g^D + \lambda_g \hat{p}^S. \tag{6}$$

This expression allows us to decompose the impact of a change in import costs on consumer prices into direct and indirect effects. The *direct effect* is given by the first term on the right hand side of (6), which shows that higher import prices feed into consumer prices directly through consumer expenditure on imported goods. The magnitude of the direct effect is determined by the share of imports in consumer expenditure $(1-\lambda_g)\gamma_g$.

In addition, import costs may affect consumer prices indirectly through their impact on the domestic good price p_g^D and the price of distribution services p^S. The second and third terms on the right hand side of (6) capture this *indirect effect*. The magnitude of the indirect effect depends upon the extent to which imports are used in domestic production and the share of domestic production in consumer expenditure.

To calculate the indirect effect we use (2)-(4) to analyze how changes in import costs affect domestic prices. From (2), assuming constant productivity and factor prices, cost minimization by domestic producers yields:

$$\hat{p}_g^D = \alpha_g \delta_g \hat{p}_{Mg}^X + \alpha_g(1-\delta_g)\hat{p}_{Dg}^X, \tag{7}$$

where p_{Mg}^X and p_{Dg}^X denote the prices of the imported and domestic intermediate input bundles, respectively. Using (3) and (4) we can write changes in the prices of these intermediate bundles as:

$$\hat{p}_{Mg}^X = \sum_{j=1}^{G} \mu_{gj} \hat{p}_j^M, \qquad \hat{p}_{Dg}^X = \sum_{j=1}^{G} \psi_{gj} \hat{p}_j^D,$$

and substituting these expressions into (7) yields:

$$\hat{p}_g^D = \alpha_g \delta_g \sum_{j=1}^{G} \mu_{gj} \hat{p}_j^M + \alpha_g(1-\delta_g) \sum_{j=1}^{G} \psi_{gj} \hat{p}_j^D.$$

Since we have G such equations (one per product group), we can solve the linear system to obtain domestic price changes in terms of import cost variation. This gives:

$$\hat{P}^D = (I - \Omega^D)^{-1} \Omega^M \hat{P}^M, \tag{8}$$

where $\hat{P}^D$ is the $G \times 1$ vector of domestic price changes $\hat{p}_g^D$, $\hat{P}^M$ is the vector of import price changes $\hat{p}_g^M$, Ω^D is a $G \times G$ matrix with elements $\omega_{gj}^D = \alpha_g(1-\delta_g)\psi_{gj}$ where g denotes the row and j the column, Ω^M is a $G \times G$ matrix with elements $\omega_{gj}^M = \alpha_g \delta_g \mu_{gj}$ and I is the $G \times G$ identity matrix.

Recall that equations (2)-(4) with $g = W$ and $g = R$ define the production technologies for wholesale and retail, respectively. Consequently, we also obtain from (8) the effect of import prices on domestic wholesale and retail prices. Using (5) we can then write the change in the price of distribution services as:

$$\hat{p}^S = \xi \hat{p}_W^D + (1-\xi)\hat{p}_R^D, \tag{9}$$

where p_W^D denotes the price of wholesale services and p_R^D the retail price. Finally, substituting (8) and (9) back into equation (6) allows us to express the indirect effect in terms of changes in import costs.

3.3 Import share

We are interested in how consumer prices respond to exchange rate movements. Suppose an exchange rate depreciation causes all import prices to increase by the same proportion $\hat{p}_g^M = \hat{e}$ for all $g = 1, \ldots, G$ where $\hat{e}$ is the magnitude of the depreciation. In this case, combining equations (6), (8) and (9) implies that the change in the group g price index is:

$$\hat{p}_g^C = \left[(1-\lambda_g)\gamma_g + (1-\lambda_g)(1-\gamma_g)\sum_{j=1}^{G}\theta_{gj} + \lambda_g\left(\xi\sum_{j=1}^{G}\theta_{Wj} + (1-\xi)\sum_{j=1}^{G}\theta_{Rj}\right)\right]\hat{e}, \tag{10}$$

where θ_{gj} denotes the element in row g and column j of the $G \times G$ matrix $(I - \Omega^D)^{-1}\Omega^M$ that appears in equation (8).

The term in square brackets on the right hand side of (10) gives the elasticity of consumer prices to the exchange rate. We will call this elasticity the *import share* of group g (denoted as $ImportShare_g$) since it equals the cost share of imports in domestic consumer expenditure on product group g, accounting for both direct import consumption and indirect consumption of imports embodied in domestically produced goods and distribution services. The expenditure share of directly consumed imports equals $(1-\lambda_g)\gamma_g$, which we label the *direct import share*, while the remaining terms represent the *indirect import share*. Of course, the total import share is the sum of the direct and indirect shares.

The import share is determined by the consumption and production function parameters defined in equations (1)-(5). Because these parameters govern consumers' expenditure shares and producers' cost shares, they can be calculated from input-output tables, which implies that the import share is observable for each product group g. Consequently, we use equation (10) as the basis of our empirical analysis. The model predicts that products with larger import shares will experience faster inflation following an exchange rate depreciation. In Section 5 we test this prediction in an event study framework by regressing changes in inflation rates following the Brexit referendum on import shares at the product group level.

In Section 6 we use equation (10) to estimate exchange rate pass-through. This is a two-step process. First, we regress $\hat{p}_g^C$ on $ImportShare_g$ interacted with the exchange rate movement $\hat{e}$ to estimate the elasticity of product group prices to the exchange rate conditional on import shares. We will refer to this elasticity as *import cost pass-through* since it gives the pass-through of exchange rate movements to consumer prices conditional on import shares. Our model predicts that import cost pass-through equals one, i.e., there is complete import cost pass-through. Second, we aggregate across product groups to obtain an estimate of pass-through to the consumer price index p^C. Suppose import cost pass-through equals β and η_g is the share of product group g in consumer expenditure. Then equation (10) implies:

$$\frac{\hat{p}^C}{\hat{e}} = \beta \sum_{g=1}^{G} \eta_g \times ImportShare_g. \tag{11}$$

The ratio $\hat{p}^C/\hat{e}$ is the elasticity of consumer prices to the exchange rate, which equals aggregate exchange rate pass-through.

3.4 Discussion

Our model provides a simple framework for understanding how exchange rate movements affect consumer prices. Like any model it involves a number of useful abstractions. Two are worth highlighting at this stage.

First, we assume that the elasticity of substitution between the domestic and imported good within each product group, and between alternative inputs to production, is unity. This implies that the expenditure and cost shares are fixed by the model's technological parameters and are insensitive to price changes. For example, the share of distribution services in consumer expenditure is always λ_g. Relaxing this assumption and allowing for constant elasticity of substitution consumption and production functions with an elasticity other than one would not change how we implement the model empirically.

To see why, note that the price change equations (6)-(10) would continue to hold locally in the generalized model provided the coefficients, such as λ_g and γ_g, were interpreted as equilibrium cost and expenditure shares rather than underlying technology parameters. It follows that the local elasticity of consumer prices to the exchange rate would still be given by the import share in equation (10). Since our empirical import share measure does not vary over time (see Section 4.1

for details), this implies that the mapping we use to calculate the import share from observable input-output data would be unchanged in the generalized model.

Allowing for non-unitary elasticities of substitution would affect how prices are aggregated into product group price indices. However, because we observe prices at the product group level we do not undertake any such aggregation. We do aggregate across product groups using equation (11) to convert estimated import cost pass-through into a measure of aggregate exchange rate pass-through. Section 5.5 provides evidence that supports using constant expenditure shares to aggregate across product groups.

The second point to highlight is that the model assumes perfect competition. Consequently, exchange rate changes pass through one-to-one into import prices and import price changes pass through one-to-one into the prices consumers and producers pay for imported goods. One-to-one pass-through is the key condition that implies equation (10) holds and there is complete import cost pass-through. Departing from perfect competition by allowing producers to charge a constant mark-up over marginal costs would affect price levels, but with constant mark-ups there would still be complete import cost pass-through and the price change equations (6)-(10) would not be affected.

However, complete import cost pass-through does not hold in an environment with variable mark-ups. Suppose, for example, that producers face downward sloping demand elasticities as found by Berman, Martin and Mayer (2012). In this case, an increase in import costs would lead to a reduction in mark-ups implying less than complete pass-through. Similarly, if there are nominal price rigidities then pass-through depends upon the currency in which prices are set and the frequency of price adjustment (Gopinath, Itskhoki and Rigobon 2010). Although we do not explicitly model variable mark-ups or sticky prices, we will use our results to compare estimated import cost pass-through with the model's prediction that pass-through equals one. This comparison will shed light on the extent to which allowing for incomplete pass-through of exchange rate changes to import costs is important for understanding consumer price changes following the Brexit depreciation.

4 Data

This section provides a brief overview of the data used in the empirical analysis, focusing on the calculation of import shares. A complete description of the data used and how variables are constructed is given in Appendix A.

4.1 Import shares measure

Consumer prices are reported using the Classification of Individual Consumption According to Purpose (COICOP). We work with product groups defined at the level of COICOP classes, which is the most disaggregated level for which import shares can be calculated using UK input-output tables. The full list of COICOP classes we use is given in Appendix A. Examples include Bread and cereals, Wine, Electricity, Pharmaceutical products, and Restaurants and cafes.

The import share of class g is defined in equation (10). Other than λ_g, all the parameters needed to calculate import shares can be inferred from the UK Input-Output Analytical Tables published by the Office for National Statistics (ONS). We use the 2013 tables and take advantage of the fact that the ONS publishes separate tables for domestically produced and imported products. Using 2013 data means that the import shares are time-invariant and pre-determined with respect to the Brexit referendum, which ensures our estimates do not suffer from endogeneity bias that could arise if inflation rates are correlated with changes in import shares.

The parameter λ_g is given by the expenditure share of distribution services. To calculate λ_g we need to adjust consumer expenditure at purchasers' prices reported in the input-output tables to account for net product taxes. We do this using the UK Supply and Use Tables for 2013 from the ONS, which include product-level data on expenditure on taxes less subsidies. See Appendix A.1 for further details of how the import share parameters are calculated.

The Input-Output Analytical Tables and the Supply and Use Tables report data using the Classification of Products by Activity (CPA) for 105 products. Consequently, we first compute import shares for the 105 CPA products and then use a concordance provided by the ONS to map CPA products to COICOP classes. This enables us to calculate import shares for 84 COICOP classes.[9]

Table 1 provides summary statistics for the import share variable. We report the average import share for classes in each of the twelve divisions of the COICOP classification. Column (1) gives the direct import share, column (2) the indirect import share and column (3) the total import share. There is substantial variation in import shares across divisions. Total import shares range from 5 percent in Education to 49 percent in Clothing and footwear. Unsurprisingly, tradable goods such as food and drinks have higher import shares than services such as restaurants and utilities. But even services have positive total import shares because services firms use imported intermediate inputs. For example, the Restaurants and hotels division has a zero direct import share but an indirect import share of 17 percent.[10]

The import share of aggregate consumption equals the weighted average of the class-level

[9] The ONS publishes consumer price data for 85 COICOP classes. Our method does not given an the import share for Second-hand cars, which we drop from the empirical analysis.

[10] Table A1 in the appendix lists the import share for each of the 84 COICOP classes and shows that there is considerable variation in import shares within divisions.

import shares, where the weight of each class g is given by its share in consumer expenditure η_g. We use expenditure shares for the year 2016 reported by the ONS. Table 1 reports that the aggregate import share is 29 percent, which is fairly evenly divided between direct and indirect imports with 16 percent and 14 percent, respectively. This illustrates the importance of accounting for indirect import consumption when measuring exposure to import costs.

4.2 Other variables

To measure inflation we use UK consumer price indices (CPIs) by COICOP class from the ONS (dataset MM23). As additional price outcomes, we collect from the ONS producer price indices (PPIs) that we match to 42 CPA sectors (mainly manufacturing industries) and an import price index for intermediate inputs (dataset MM22). For data on household expenditure patterns we use the ONS Living Costs and Food Survey. We also obtain wage growth data from the ONS Average Weekly Earnings dataset.

In order to estimate exchange rate pass-through, we construct an effective exchange rate index for the UK. The index e is calculated as a weighted average of log differences in bilateral exchange rates. An increase in e corresponds to a depreciation of sterling. The weights are given by the share of UK imports by trading partner calculated using UN Comtrade data for 2013. We obtain period average bilateral exchange rates for 169 countries from the International Monetary Fund's International Financial Statistics database and Thompson Reuters. We calculate effective exchange rate indices at daily, monthly and quarterly frequencies.

Finally, there are two additional variables that will be used as controls in our empirical analysis. The first is inflation in the Euro area. We obtain the consumer price index for each COICOP class in the Euro area from the Harmonized Index of Consumer Prices (HICP) provided by Eurostat. This cross-country aggregate is computed from the HICP of the 19 Euro area countries. For the UK, the HICP is the same as the CPI produced by the ONS. We also obtain Euro area PPIs from Eurostat for NACE Revision 2 sectors, which map directly into CPA sectors.

Second, we use data on oil prices in US dollars from the IMF Commodity Prices database, together with the UK Input-Output Analytical Tables for 2013, to construct a variable Oil_{gt} that captures the effect of oil price changes on intermediate input costs by COICOP class in the UK. The oil price variable is an interaction of the share of consumer expenditure on class g that is (indirectly) spent on imported oil with changes in the US dollar price of oil (see Appendix A for details). Conditional on the oil price change, classes where production is more oil intensive have a higher value of Oil_{gt}.

5 Event study

This section undertakes an event study analysis of how the sterling depreciation following the Brexit referendum affected prices in the UK. Section 6 then uses the period around the Brexit vote to estimate exchange rate pass-through to consumer prices.

5.1 Descriptive evidence

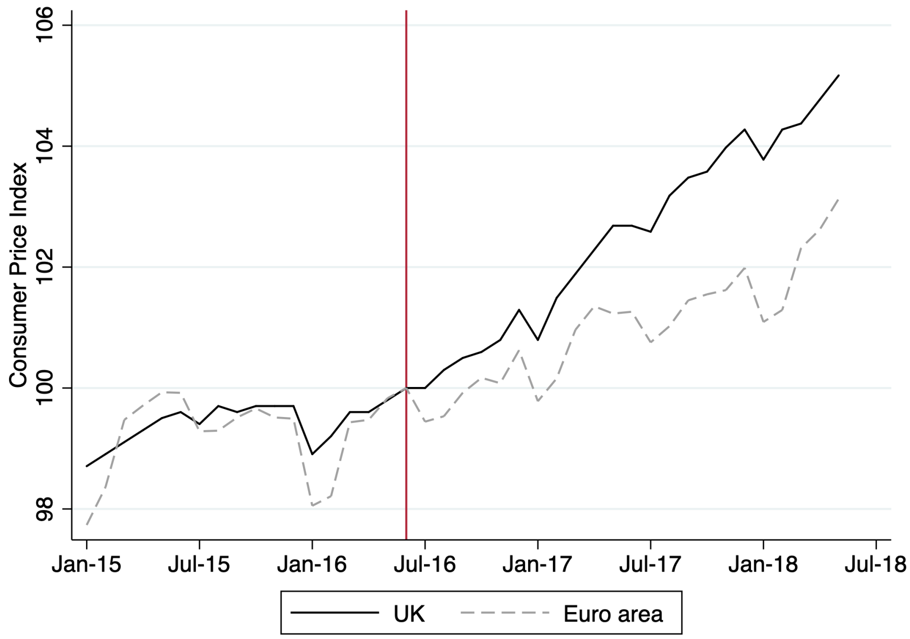
Before turning to regressions, we present some descriptive evidence on how the post-Brexit depreciation affected UK prices. Figure 2 plots the evolution of intermediate input import prices and our effective exchange rate index from 2015 to 2018. Import prices rose sharply following the referendum and by mid-2017 the import price index was approximately 10 percent higher than at the time of the vote, while sterling depreciated by around 10 percent over the same period. These movements are consistent with complete pass-through from the post-referendum depreciation to import prices.

Figure 2: Intermediate input import prices and the value of sterling, 2015-2018

Notes: Monthly data. The indices are normalized to 100 at the time of the referendum (June 2016, indicated by the vertical line). An increase in the exchange rate index corresponds to a depreciation of sterling.

Looking at consumer prices, Figure 3 shows the aggregate CPI in the UK and the Euro area from 2015 to the middle of 2018. Both indices are normalized to 100 at the time of the referendum in June 2016. We see that following the vote prices rose more quickly in the UK than the Euro area, which is suggestive evidence that the depreciation of sterling increased UK inflation. Between June 2016 and June 2018 UK prices increased by 1.9 percentage points more than prices in the Euro area.

Figure 3: Consumer prices in the UK and the Euro area, 2015-18

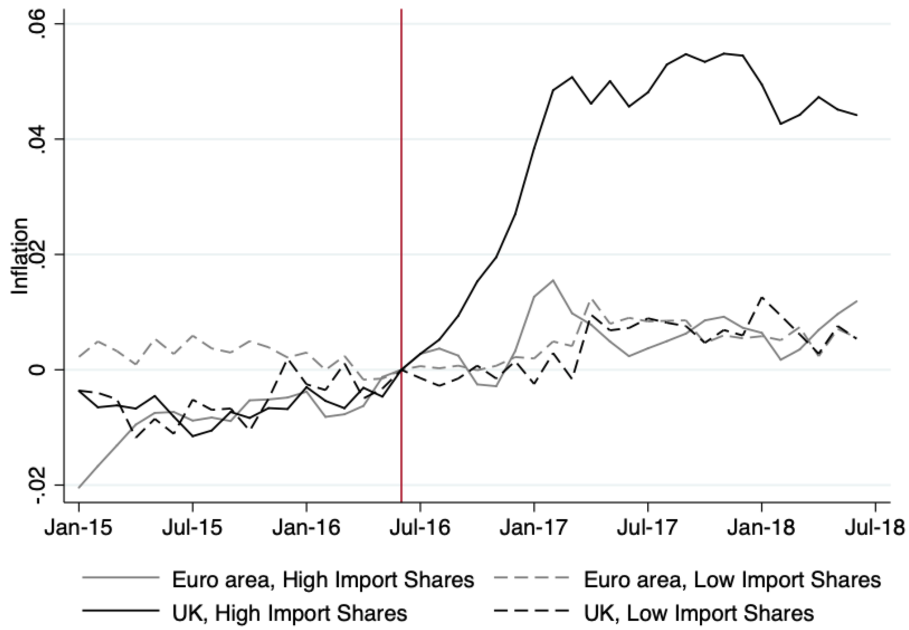


Notes: Monthly data. The indices are normalized to 100 at the time of the referendum (June 2016, indicated by the vertical line).

Figure 4 provides a more detailed look at what drove these price changes. For both the UK and the Euro area, the figure shows how inflation changed following the referendum for high import share COICOP classes compared to low import share classes. Classes are divided into high and low import share groups depending on whether their import share is above or below the median import share. The dark solid line is the average inflation rate in the UK for high import share classes, while the dark dashed line is average UK inflation for low import share classes. The grey lines provide the same data for the Euro area. Inflation is defined as the log difference in prices over the previous year and is normalized to zero in June 2016 for all groups.

We see that following the referendum there is a sharp increase in UK inflation among high import share classes and that inflation remains high throughout 2017 before starting to decline in 2018. However, there is no comparable trend for low import share classes in the UK or for either group in the Euro area. This suggests that the referendum increased inflation in the UK by raising the cost of products with high import shares. To formally test this hypothesis, we now introduce our empirical model.

Figure 4: Inflation rates in the UK and Euro area by import shares, 2015-2018



Notes: COICOP classes with above median import shares are allocated to the high import share group and those with below median import shares to the low import share group. For each of the four groups, inflation is expressed as the average log consumer price difference over the previous 12 months relative to the average group inflation rate in June 2016. Monthly data. The vertical line indicates the referendum date (June 2016).

5.2 Event study specification

We estimate an event study model that, motivated by our theoretical framework, exploits variation in import shares across COICOP classes. The baseline specification is:

$$Inflation_{gt} = \chi Post_t \times ImportShare_g + Z_{gt} + \nu_g + \nu_t + \varepsilon_{gt}. \qquad (12)$$

The dependent variable $Inflation_{gt}$ is the inflation rate (i.e., the log change in the price index from the previous period) for a given COICOP class g in period t. $Post_t$ is a dummy variable that takes the value one for all periods after the referendum and zero otherwise. $ImportShare_g$ is our measure of the cost share of imports in consumer expenditure on class g as described in Sections 3.3 and 4.1.

Z_{gt} is a vector of additional variables that may affect inflation at the class level. Specifically, we include in Z_{gt} Euro area inflation for class g in period t and the oil price exposure variable Oil_{gt} described in Section 4.2. Euro area inflation is a proxy for inflationary pressures that differ across classes, but are not UK specific, while Oil_{gt} controls for the effect of changes in oil prices. We also include COICOP class fixed effects and period fixed effects. The former control for time invariant differences in inflation across classes, while the latter capture changes in aggregate inflationary pressures over time. Any price effects of the leave vote that are uncorrelated with $ImportShare_g$ will be captured by the period fixed effects. Finally, the error term is ε_{gt}.

The coefficient of interest is the $Post_t \times ImportShare_g$ interaction effect χ, which is a differences-in-differences estimate of how inflation changes after the referendum varied across classes with different import shares. A positive estimate of χ implies that the increase in inflation following the referendum was greater for classes where the cost share of imports in consumer expenditure $ImportShare_g$ is higher.

We estimate specification (12) using a sample from June 2014 to June 2018, and we define a period to be either one year or two years long. Since the referendum occurred on 23 June 2016, we define the two-year periods to be June 2014 to June 2016 and June 2016 to June 2018, while the one-year periods are defined to end in June of each year. We choose the sample to include a two-year window after the referendum because the exchange rate pass-through literature usually allows up to two years for exchange rate movements to feed through to consumer prices (Burstein and Gopinath 2014), a finding we confirm in our pass-through estimates in Section 6 below. Table 2 shows descriptive statistics for the time-varying estimation variables. The statistics in panel A are calculated using two-year periods, while those in panel B use one-year periods.

5.3 Consumer prices

We start by estimating specification (12) using two-year periods with CPI inflation as the dependent variable. Table 3 presents the results. All columns include COICOP class and period fixed effects, although in column (1) we do not use any other controls. The estimated import share interaction effect is positive and significant at the ten percent level. In column (2) we add Oil_{gt} to control for oil price changes. The oil price effect is positive though imprecisely estimated. More importantly, controlling for Oil_{gt} reduces the estimate of χ. However, the standard error of the estimate also falls and its statistical significance actually increases.

Our preferred specification is in column (3) where we also control for Euro area inflation, which, as expected, has a positive association with UK inflation. The estimated coefficient on the import share interaction in column (3) is 0.211 and is significant at the one percent level. This confirms that, following the referendum, classes with higher import shares experienced larger rises in inflation. The magnitude of the estimate implies that for each ten percentage point rise in the import share, prices in the two years following the referendum increased by 2.1 log points, or about 2.1 percentage points.[11]

[11] We have also experimented with controlling for inflation in France, Germany and the US instead of Euro area

It is possible that the depreciation of sterling following the Brexit vote directly affected Euro area inflation. Therefore, in column (4) we include the difference between UK and Euro area inflation by COICOP class as our dependent variable. The estimated import share interaction effect is statistically indistinguishable from column (3). In sum, products with higher exposure to import costs saw greater increases in consumer prices following the referendum.

Table 4 reports the results of estimating equation (12) using one-year periods. The specifications in columns (1)-(4) are the same as those in the corresponding columns of Table 3. Our preferred specification is again in column (3) where we control for both oil price changes and Euro area inflation. The coefficient on the import share interaction term stands at 0.110. Since this is roughly half the value estimated using two-year periods, it is both qualitatively and quantitatively consistent with our earlier results.

In column (5) of Table 4 we interact the import share measure with annual dummies as opposed to the post-referendum indicator. The 2016 dummy takes the value one for the year ending in June 2016, and the 2017 and 2018 dummies are analogously defined (the reference period is the year up to June 2015). This specification allows us to estimate how the post-referendum effect varies over time and to test for pre-trends in the year before the referendum. We estimate positive import share interaction effects for both 2017 and 2018, and the estimated coefficients have similar magnitudes. This implies that the increase in inflation among classes with higher import shares that occurred after the referendum did not subside after the first year but continued through June 2018. This finding is consistent with the literature on the timing of exchange rate pass-through into import and consumer prices (see Burstein and Gopinath 2014). Reassuringly, we also find no evidence of pre-trends in the data. The estimated import share interaction effect for 2016 is close to zero and statistically insignificant, implying that classes with higher import shares did not witness greater inflation increases in the year before the vote.

Our import share variable measures the import cost share at purchasers' prices. As discussed in Section 4.1, the expenditure share on distribution services λ_g is not reported in the UK input-output tables, and to calculate import shares at purchasers' prices we estimate λ_g indirectly using the UK Supply and Use Tables. Therefore, as an additional robustness check, we also report results when import shares are measured at basic prices. Basic prices do not include distribution services nor net product taxes. In our theory this corresponds to letting $\lambda_g \to 0$. Table 5 presents the same set of two-year period specifications estimated in Table 3, except that $ImportShare_g$ is defined as the share of imports in consumer expenditure at basic prices. Again, we find that classes with higher import shares experienced greater increases in inflation after the Brexit vote.[12]

inflation. We obtain very similar estimates.

[12] The import share interaction coefficient is smaller when the basic price measure is used because not accounting for distribution services overestimates variation in import shares across classes. The overestimation results from the expenditure share of distribution services being relatively high (average $\lambda_g = 0.28$) and positively correlated with the

5.4 Producer prices

To shed further light on the price effects of the Brexit referendum, we also analyze producer prices. We have PPI data for 42 CPA sectors. The producer price of sector g corresponds to the domestic good price p_g^D in our model, meaning that producer price inflation is given by equation (8). Therefore, if we define $ProducerImportShare_g = \sum_{j=1}^{J} \theta_{gj}$ to be the share of imported inputs in domestic production costs for sector g, we have:

$$\hat{p}_g^D = ProducerImportShare_g \times \hat{e}.$$

Motivated by this expression, we estimate the event study specification (12) with PPI inflation as the dependent variable and the $Post_t$ dummy interacted with $ProducerImportShare_g$ on the right hand side. In this case the oil price exposure variable is measured at the CPA sector level, and we control for PPI inflation in the Euro area.

Table 6 presents the producer price regression results using two-year periods. Although the estimates are less precise than for consumer prices, we find strong evidence that the producer import share interaction effect is positive. This implies that sectors where imported intermediate inputs account for a greater share of production costs experienced larger increases in inflation following the referendum. These estimates support Goldberg and Campa's (2010) argument that the effect of exchange rate movements on consumer prices depends not only on the direct import share of consumer expenditure, but also on indirect import consumption through consumer purchases of goods produced domestically using imported inputs. Recall from Table 1 that the import share of aggregate UK consumer expenditure is almost evenly divided between direct and indirect imports. It follows that failing to account for indirect import consumption would severely understate the exposure of consumer prices to import costs.

We also use the producer price specification to look for evidence of strategic complementarities in domestic price setting. In our theoretical framework prices are competitively determined, meaning that domestic producer prices p_g^D are unaffected by the price of sector g imports p_g^M after controlling for indirect import use. However, in models with strategic complementarities in price setting, producer prices also depend on the prices of competing goods, such as imports of the same product group.[13] Since imports became more expensive following the referendum, strategic complementarity in pricing would lead domestic producer prices to rise by more in sectors where the share of imports in expenditure at basic prices γ_g is higher. Auer, Burstein and Lein (2018) find evidence consistent with such behavior following the 2015 appreciation of the Swiss franc.

To test for strategic complementarities, we estimate producer price regressions analogous to

basic price import share (correlation 0.83), together with distribution services having a low import share of 0.13.

[13] See Amiti, Itskhoki and Konings (2019) for firm-level evidence of strategic complementarities in Belgian manufacturing.

those reported in Table 6, but we also include the interaction of the $Post_t$ dummy with the direct import share at basic prices γ_g on the right hand side. This interaction is a proxy for the change in competitors' prices following the referendum and, if there are strategic complementarities in pricing, we expect the interaction to have a positive effect on domestic producer prices. The results are shown in Table 7. In columns (1)-(3) we also control for the $Post_t \times ProducerImportShare_g$ interaction used in Table 6, while in columns (4)-(6) we drop this interaction. In all cases the estimated effect of the direct import share at basic prices interaction term is close to zero and statistically insignificant. Therefore, we do not find evidence of strategic complementarities in price setting following the Brexit referendum. However, we caution that our results do not rule out the existence of strategic complementarities at more disaggregated levels.

5.5 Consumer expenditure

How did the increase in prices following the referendum affect consumer expenditure patterns? To address this question we estimate the event study specification (12) using data on the share of consumer expenditure by COICOP class. We obtain consumer expenditure for 75 COICOP classes from the Living Costs and Food Survey and use the log difference of expenditure shares over two-year periods as the dependent variable.[14]

The results of estimating the consumer expenditure regressions are shown in Table 8. Regardless of whether or not the Oil and Euro area inflation controls are included, we estimate that the import share interaction term is uncorrelated with changes in consumer expenditure. These estimates are consistent with consumer demand having a unit elasticity of substitution between COICOP classes. Consequently, they provide a rationale for using constant expenditure shares to aggregate price changes across classes when estimating the aggregate impact of the Brexit depreciation on consumer prices, as we do in Section 7.1. They also imply that real consumer expenditure growth in the two years after the referendum was lower for classes with higher import shares, suggesting that the Brexit depreciation reduced real consumption growth.

6 Exchange rate pass-through

We have shown that the Brexit vote led to faster price increases for products with higher import shares. Building upon this finding, we now use changes in the value of sterling around the time of the referendum to estimate exchange rate pass-through into consumer prices. To do this, we

[14] During our sample the Living Costs and Food Survey switched from collecting data on a calendar year basis to using the UK financial year, which ends in March (e.g. the 2015 survey covers April 2015 to March 2016). For the pre period we use the difference between the 2013 calendar year survey and the 2015 financial year survey, while for the post period we use the difference between the 2015 and 2017 financial year surveys.

modify our estimation equation to control for observed exchange rate movements both before and after the referendum. Specifically, we estimate a distributed lag version of equation (10) given by:

$$Inflation_{gt} = \sum_{s=0}^{T} \beta_s ImportShare_g \times \hat{e}_{t-s} + Z_{gt} + \nu_{gq} + \nu_t + \varepsilon_{gt}, \tag{13}$$

where $\hat{e}$ is the log difference in the sterling effective exchange rate index. This specification allows for the effect of exchange rate movements on consumer prices to take up to T quarters and, consistent with the theoretical model, assumes the elasticity of consumer prices to the exchange rate varies across classes with different import shares. Consequently, estimating this equation gives what we defined in Section 3.3 as import cost pass-through. Our estimate of import cost pass-through β equals the sum of the coefficients of all the $ImportShare$ times exchange rate interaction terms, $\beta = \sum_{s=0}^{T} \beta_s$. Recall that the theory features complete import cost pass-through implying $\beta = 1$. Having obtained β, we can use equation (11) to aggregate across COICOP classes and estimate aggregate exchange rate pass-through.

We estimate equation (13) using quarterly data from 2011Q1 to 2018Q2 with CPI inflation by COICOP class as the dependent variable. As in the event study, we control for Euro area inflation and exposure to oil price changes. We also include quarter fixed effects ν_t and class-season fixed effects ν_{gq}, where the seasons q are the four quarters of the year. That is, we include four fixed effects per COICOP class, each of which turns on in a different quarter. The class-season effects control for seasonal variation in product-specific inflation rates. The identifying assumption is that changes in inflation captured by the error term ε_{gt} that are correlated with the timing of exchange rate movements are uncorrelated with import share variation across classes.

Panel C of Table 2 shows descriptive statistics for the estimation variables at quarterly frequency and Table 9 presents the regression results. For each regression we report estimated import cost pass-through $\beta = \sum_{s=0}^{T} \beta_s$. In column (1) we include four exchange rate lags and estimate that import cost pass-through equals 0.82. This estimate is statistically different from zero, confirming that exchange rate depreciations lead to higher inflation in classes with higher import shares. However, it is insignificantly different from one, implying that we cannot reject the hypothesis of complete import cost pass-through.

In columns (2)-(5) we add additional exchange rate lags going from five lags in column (2) up to eight lags in column (5). Although the point estimate of import cost pass-through varies somewhat across specifications, it is always positive and significant, but not statistically different from one. Therefore, the evidence in Table 9 is consistent with complete import cost pass-through to consumer prices in the period around the Brexit referendum. However, neither can we rule out the possibility that import cost pass-through is high, but below 100 percent.

Much of the pass-through literature estimates incomplete pass-through to border prices and import costs (Burstein and Gopinath 2014). But there are notable exceptions. For example, the set of large devaluation episodes analyzed by Burstein, Eichenbaum and Rebelo (2005) are associated with complete pass-through into import prices and recent work has found evidence of complete pass-through to import prices following President Trump's tariff increases (Amiti, Redding and Weinstein 2019; Fajgelbaum, Goldberg, Kennedy and Khandelwal 2019). Our findings provide further evidence that large, salient shocks such as the Brexit vote are associated with high levels of exchange rate pass-through.

With complete import cost pass-through, using equation (11) to weight import shares across classes implies that pass-through to the aggregate consumer price index equals 0.29, which is the import share of aggregate consumption reported in Table 1. This is our preferred estimate of exchange rate pass-through in our sample.

We have estimated pass-through using a two-step process that accounts for heterogeneity in import shares across classes. By contrast, pass-through is usually estimated by regressing price changes on exchange rate movements (and controls) without including import share interactions. For comparison, Table 10 reports the results from estimating a conventional pass-through specification using our sample. In particular, we estimate a modified version of equation (13) where the exchange rate terms are not interacted with import shares. We also drop the quarter fixed effects as they are collinear with the exchange rate movements. In this case, estimated exchange rate pass-through to consumer prices is around 0.15 and is not sensitive to the number of lags included. This result is consistent with existing estimates of pass-through in the UK that do not control for import share differences across classes (Goldberg and Campa 2010; Burstein and Gopinath 2014; Forbes, Hjortsoe and Nenova 2018).

Our preferred pass-through estimate is roughly twice as large as the estimates of around 0.15 reported in Table 10. This difference illustrates the advantage of allowing for exchange rate exposure to vary across product groups when estimating consumer price pass-through. Formally, not including the import share interaction terms in specification (13) can generate heterogeneity bias if import shares are correlated with consumer expenditure shares, and omitted variable bias from not including time fixed effects. In our data the correlation between import shares and expenditures shares is -0.09, which generates a negligible heterogeneity bias. Instead, negative correlation between the quarter fixed effects and exchange rate changes is responsible for the downwards bias evident in Table 10.

7 Cost of living

In this section we use the empirical results reported above to provide indicative estimates of how Brexit has affected the cost of living and real wages in the UK. We consider both aggregate effects and distributional consequences across households with different expenditure patterns. The analysis sheds light on the welfare effects of exchange rate movements and on how the referendum has affected UK living standards prior to Brexit occurring. However, because our identification strategy isolates price changes driven by the exchange rate, the results only capture the effects of the referendum that operate through the depreciation of sterling. Any independent effects of Brexit on prices, for example due to monetary policy easing by the Bank of England or domestic demand and supply shocks, are outside the scope of our analysis.

Throughout this section we assume that, consistent with the estimates in Table 9, there is complete import cost pass-through. We also assume that the referendum led to a 10 percent depreciation of sterling. As shown in Figure 1, the effective sterling exchange rate depreciated by around 10 percent immediately following the vote. There was also a more modest and gradual depreciation in the first half of 2016. To the extent that this pre-referendum depreciation was driven by uncertainty regarding the outcome of the vote, our analysis will underestimate the magnitude of the Brexit depreciation and the resulting price rises.

7.1 Aggregate effects

Combining a 10 percent fall in the value of sterling with pass-through of 0.29 implies the Brexit depreciation increased the UK consumer price index by around 2.9 percent by June 2018. This calculation holds the expenditure weight for each COICOP class fixed at 2016 levels. However, using 2018 weights instead also delivers an estimated effect of 2.9 percent, as the weights vary little over time and the correlation between the 2016 and 2018 weights is 0.99. Comparing our estimate to the approximately 2 percentage point gap between UK and Euro area inflation in the two years after the referendum shown in Figure 3 implies that inflationary pressures not linked to the exchange rate were more muted in the UK than the Euro area following the referendum.

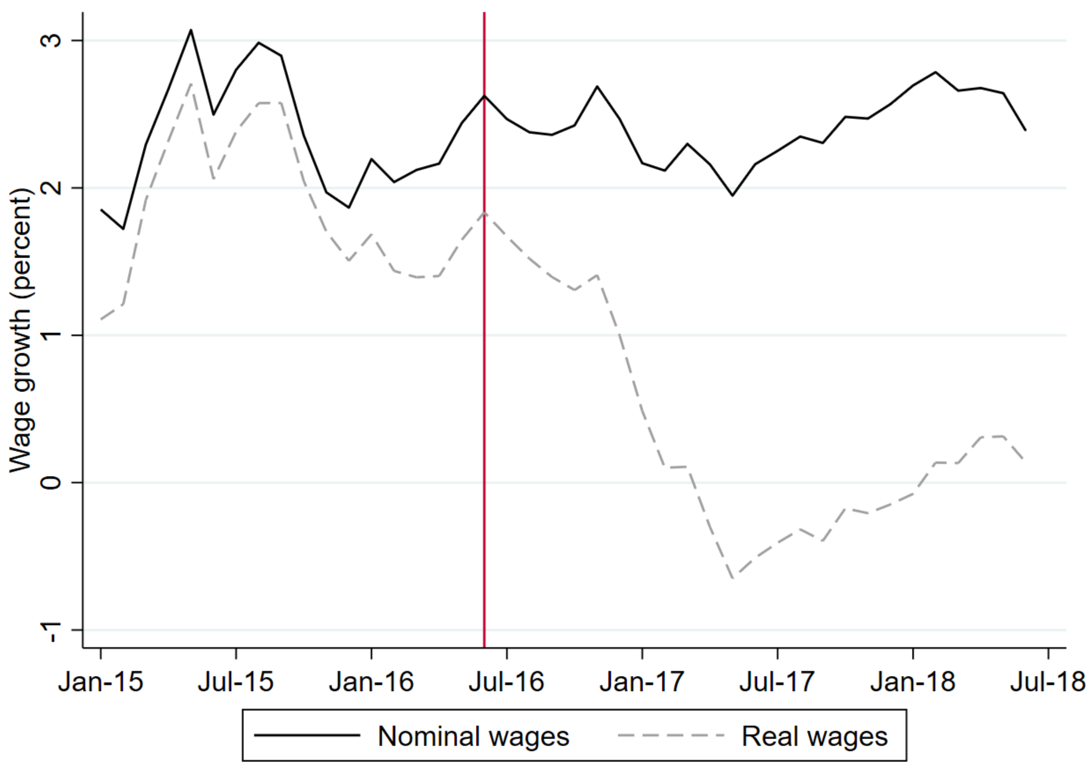
A 2.9 percent price rise is equivalent to a £870 per year increase in the cost of living for the average household. In aggregate, this corresponds to £23.5 billion per year additional expenditure for the UK, or £450 million per week.[15]

Figure 5 shows nominal and real wage growth before and after the referendum. There is no evidence of a trend break in nominal wage growth around the time of the referendum, while real wage growth declined sharply and became negative in 2017. Costa, Dhingra and Machin (2019) estimate that, if anything, the depreciation of sterling following the referendum reduced nominal wage growth. Based on this evidence, we conclude that the 2.9 percent increase in consumer prices caused by the fall in sterling led to a decline in real wage growth of a similar magnitude. Thus, by June 2018 the average UK household had to spend around 1.4 additional weeks' wages to afford

[15] Average annual UK household expenditure in 2018 was £29,900 and there were 27.2 million households.

the same consumption basket. Through this channel the Brexit vote delivered a swift negative shock to UK living standards.

Figure 5: Wage growth in the UK, 2015-18



Notes: Wage growth is the percentage change year on year in the three-month average of Average Weekly Earnings - Total Pay. Series KAC3 for nominal wages, A3WW for real wages. The vertical line indicates the referendum date (June 2016).

7.2 Distributional consequences

We have shown that the referendum led to larger price increases for COICOP classes with higher import shares. Consequently, households that spend relatively more on classes with greater import shares faced larger cost of living increases. To shed light on the magnitude of this distributional effect of the Brexit depreciation, we use data on the composition of household expenditure from the ONS Living Costs and Food Survey for the financial year ending March 2016.

We start by computing the expenditure share of each COICOP class by household for 4912 households in Great Britain (i.e., the UK excluding Northern Ireland).[16] Let η_g^h denote the expenditure share of household h on class g. We then calculate the effect of a 10 percent depreciation

[16]The data is reported at the level of COICOP items. We map items to classes using a concordance provided by the ONS.

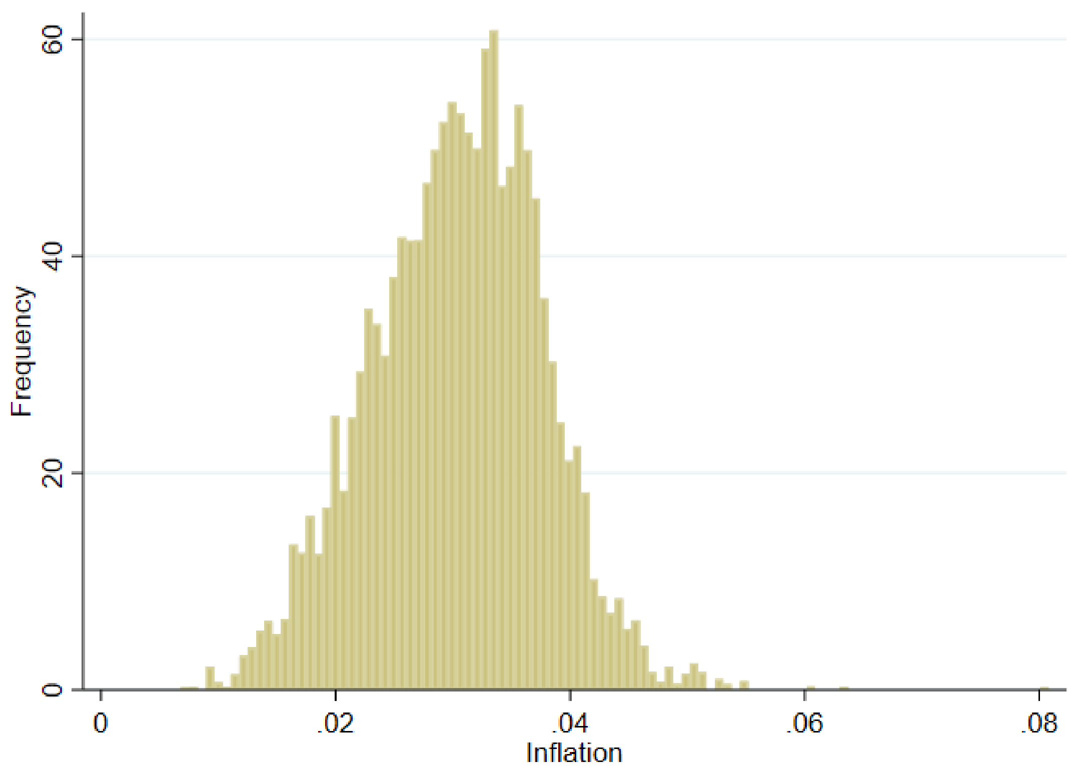
on the price of each household's consumption basket by using the household-specific expenditure weights to aggregate class-level price changes. That is, we calculate:

$$\hat{p}^{C,h} = \sum_{g=1}^{G} \eta_g^h \times ImportShare_g \times 0.1,$$

where $\hat{p}^{C,h}$ is the inflation effect on household h due to the Brexit depreciation.

Figure 6 plots the histogram of inflation effects across households, where the households are weighted such that the distribution is representative across all households in Great Britain. The bulk of the distribution is concentrated in the range from 2 percent to 4 percent, and the median is close to our aggregate inflation impact. A household at the 75th percentile of the distribution experienced a one percentage point higher price increase than a household at the 25th percentile. This shows that there was considerable heterogeneity across households in how the depreciation affected the cost of living.

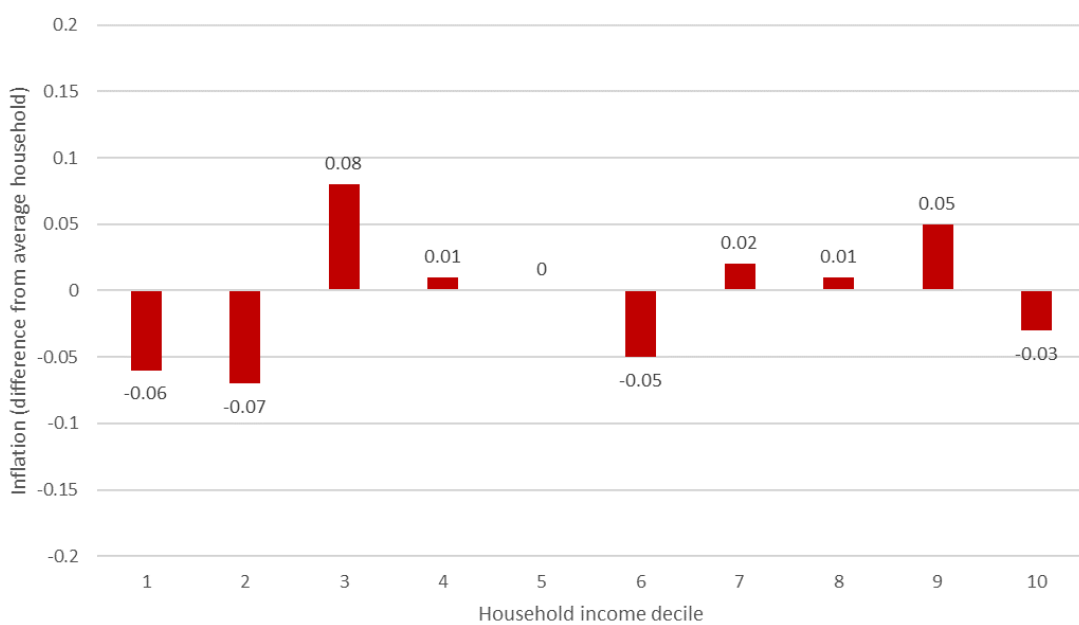
Figure 6: Distribution of inflation effects due to the Brexit depreciation across British households



Notes: This histogram plots the distribution of inflation effects due to the Brexit depreciation across 4912 households in Great Britain. The households are weighted such that the distribution is representative across all British households. The effects are computed using household-level expenditure weights across COICOP classes assuming complete import cost pass-through and a 10 percent depreciation due to the Brexit vote. See text for further details.

How did the distributional consequences of the referendum vary across different types of household? To address this question, we repeat the exercise above using the expenditure weights for household aggregates by income decile and by region. Figure 7 presents inflation effects by decile of the household income distribution. For each decile we show the estimated inflation increase due to the Brexit depreciation relative to the 2.9 percent effect for the average UK household. Decile one is the poorest households, decile ten the richest. Overall, inflation varies little across income deciles, implying that the cost of living rises due to the referendum shock are evenly shared throughout the income distribution. This result differs from Cravino and Levchenko (2017) who find that the 1994 Mexican peso devaluation was anti-poor, to a large extent because poorer Mexican households spend relatively more on tradeable product categories. By contrast, in our data there is no systematic correlation between household income and the expenditure share of imports.[17]

Figure 7: Inflation effects by income decile due to the Brexit depreciation

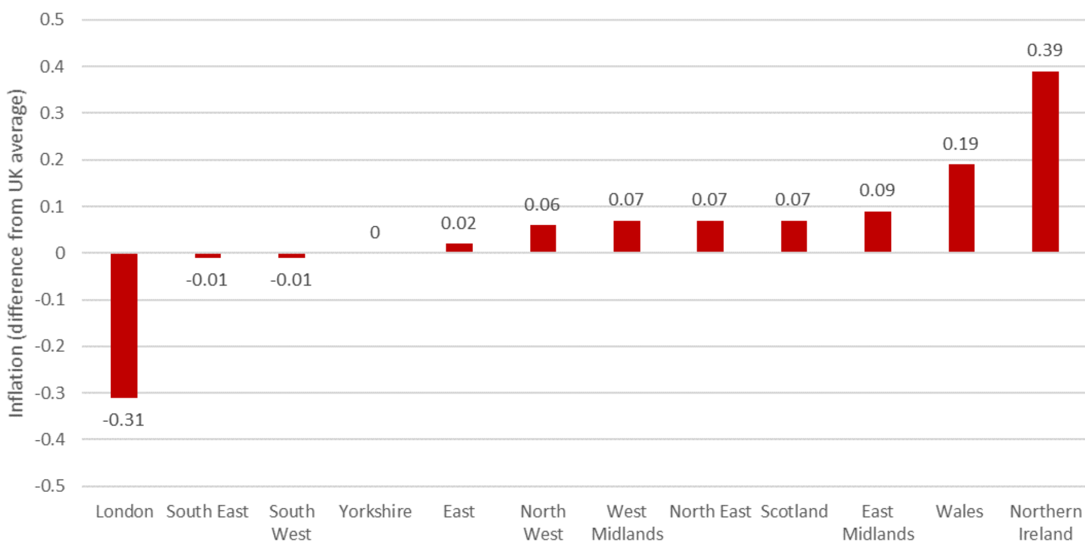


Notes: For each decile of the disposable household income distribution we show the estimated inflation increase due to the Brexit depreciation minus the increase for the average UK household (in percentage points). Decile 1 captures the poorest households, decile 10 the richest. The increase for the average UK household is 2.9 percentage points. The effects are computed using household expenditure weights across COICOP classes by income decile assuming complete import cost pass-through and a 10 percent depreciation due to the Brexit vote. See text for further details.

[17] Cravino and Levchenko (2017) also show that poorer Mexican households consume lower-priced varieties within product categories, and those faced steeper price increases. We do not have data on cross-household variation in exposure to import costs within COICOP classes for the UK.

Figure 8 shows the estimated inflation effects by region, again relative to the average UK household. Exposure to higher import costs varies considerably across regions.[18] The effect is smallest for London (0.31 percentage points below average) because households in London tend to spend relatively more on classes with low import shares, such as rent. Households in Northern Ireland, however, face a considerably larger rise in inflation (0.39 percentage points above average) because they spend a relatively greater fraction of their income on higher import share classes such as food and drink, clothing and fuel. Welsh households also face a notable above-average inflation increase, while differences across the remaining regions are more muted.

Figure 8: Inflation effects by region due to the Brexit depreciation



Notes: For each region we show the estimated inflation increase due to the Brexit depreciation minus the increase for the average UK household (in percentage points). The increase for the average UK household is 2.9 percentage points. The effects are computed using household expenditure weights across COICOP classes by region assuming complete import cost pass-through and a 10 percent depreciation due to the Brexit vote. See text for further details.

8 Conclusions

The UK's surprise vote in favor of Brexit in June 2016 led to a sharp and unanticipated depreciation in the value of sterling. We use the period around this depreciation to study exchange rate pass-through to consumer prices. Our identification strategy is based on the fact that exposure to exchange rate movements varies across products depending upon both the share of household expenditure directly allocated to imported goods and the extent to which imported intermediates are

[18] Similarly, Cravino and Levchenko (2018) document important inflation differences across Mexican regions in the wake of the 1994 peso devaluation, with the smallest price increases occurring in Mexico City.

used in domestic production. To implement this strategy we develop a simple theoretical model of price determination that shows how to calculate the import share of consumer expenditure using input-output tables.

Consistent with the model we find that in the two years following the referendum, consumer price inflation rose more for products with higher import shares and that producer price inflation rose more for products where imported inputs account for a larger share of production costs. We also show how our approach can be used to estimate exchange rate pass-through while accounting for differences in import shares across products and controlling for time fixed effects. We cannot reject the hypothesis that there is complete pass-through of import costs into consumer prices which, for the UK, implies an aggregate exchange rate pass-through of 0.29. This is roughly double the estimate obtained using the same data from a pass-through specification that does not account for import share heterogeneity.

We use our pass-through estimates to quantify how the roughly 10 percent depreciation of sterling in the immediate aftermath of the Brexit referendum affected living costs in the UK. Our preferred estimate is that the depreciation increased consumer prices by 2.9 percent and that this led to a comparable decline in real wage growth. Increases in the cost of living were similar across households in different deciles of the income distribution, but not across regions. London suffered least, while Northern Ireland and Wales were worst hit.

The decision to leave the EU is the most important change in UK economic policy for a generation. There is a broad consensus among economists that the long-run welfare effects of Brexit will be negative, but it will be years, if not decades, before these predictions can be tested. However, as with other financial assets, exchange rate movements are forward looking and our results document that the Brexit depreciation has already had a sizable negative effect on UK households.

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Table 1: Import shares by COICOP division

COICOP Division	(1) Direct	(2) Indirect	(3) Total
	%	%	%
Food and non-alcoholic beverages	29	14	43
Alcoholic beverages and tobacco	11	13	24
Clothing and footwear	41	8	49
Housing, water, electricity, gas and other fuels	1	17	18
Furniture, household equipment and maintenance	25	9	34
Health	27	6	33
Transport	22	18	40
Communication	17	17	34
Recreation and culture	15	12	27
Education	1	4	5
Restaurants and hotels	0	17	17
Miscellaneous goods and services	14	12	25
Aggregate	16	14	29
Standard deviation	0.17	0.07	0.17

Notes: The aggregate import share is a weighted average across COICOP classes using 2016 CPI expenditure weights. The standard deviation is unweighted and calculated across COICOP classes.

Table 2: Descriptive statistics

VARIABLES	Mean	Median	Standard deviation	Min	Max
PANEL A: Two-year periods					
CPI inflation	0.021	0.027	0.080	-0.459	0.427
PPI inflation	0.026	0.032	0.096	-0.445	0.396
Oil	-0.005	0.000	0.041	-0.262	0.120
CPI Euro area inflation	0.018	0.019	0.056	-0.426	0.264
PPI Euro area inflation	0.010	0.009	0.063	-0.352	0.259
PANEL B: Annual					
CPI inflation	0.011	0.014	0.045	-0.296	0.325
Oil	-0.002	0.000	0.024	-0.181	0.130
CPI Euro area inflation	0.009	0.010	0.032	-0.219	0.256
PANEL C: Quarterly					
CPI inflation	0.004	0.003	0.033	-0.428	0.266
Oil	0.000	0.000	0.009	-0.116	0.100
CPI Euro area inflation	0.003	0.003	0.024	-0.329	0.272
Exchange rate index	-0.001	-0.009	0.025	-0.028	0.084

Notes: Panel A reports summary statistics for the two-year period sample using periods from June 2014 to June 2016 and June 2016 to June 2018. Panel B reports summary statistics for the annual sample using data from 2015-18 for years ending in June. Panel C reports summary statistics for the quarterly sample from 2011Q1 to 2018Q2. CPI inflation, Oil and CPI Euro area inflation are computed at the level of 84 COICOP classes. PPI inflation and PPI Euro area inflation are computed at the level of 42 CPA sectors.

Table 3: Consumer price event study estimates with two-year periods

VARIABLES	(1) Inflation	(2) Inflation	(3) Inflation	(4) Inflation difference
Post $\times$ Import Share	0.384*	0.248***	0.211***	0.194***
	(0.207)	(0.090)	(0.066)	(0.061)
Oil		0.792	0.212	-0.041
		(0.519)	(0.278)	(0.175)
Euro area inflation			0.696*	
			(0.391)	
Observations	168	168	168	168
R-squared	0.642	0.755	0.828	0.665
Number of classes	84	84	84	84
Class fixed effects	YES	YES	YES	YES
Period fixed effects	YES	YES	YES	YES

Notes: The dependent variable in columns (1)-(3) is the UK inflation rate at the COICOP class level. The dependent variable in column (4) is the difference between the UK and Euro area inflation rates. Post is a dummy variable for the two-year post-referendum period (June 2016-June 2018). The pre-referendum period also covers two years (June 2014-June 2016). OLS estimation. Standard errors in parentheses are clustered by COICOP class. *** p<0.01, ** p<0.05, * p<0.1.

Table 4: Consumer price event study estimates with one-year periods

VARIABLES	(1) Inflation	(2) Inflation	(3) Inflation	(4) Inflation difference	(5) Inflation
Post × Import Share	0.192**	0.128***	0.110***	0.088***	
	(0.073)	(0.033)	(0.023)	(0.020)	
2016 × Import Share					0.001
					(0.024)
2017 × Import Share					0.116***
					(0.027)
2018 × Import Share					0.105***
					(0.030)
Oil		0.739**	0.438**	0.067	0.442**
		(0.344)	(0.201)	(0.115)	(0.204)
Euro area inflation			0.447*		0.449*
			(0.239)		(0.243)
Observations	336	336	336	336	336
R-squared	0.335	0.492	0.559	0.191	0.560
Number of classes	84	84	84	84	84
Class fixed effects	YES	YES	YES	YES	YES
Period fixed effects	YES	YES	YES	YES	YES

Notes: The dependent variable in columns (1)-(3) and (5) is the UK inflation rate at the COICOP class level. The dependent variable in column (4) is the difference between the UK and Euro area inflation rates. Post is a dummy variable for post-referendum periods (the years up to June 2017 and June 2018). The pre-referendum period covers the years up to June 2015 and June 2016. OLS estimation. Standard errors in parentheses are clustered by COICOP class. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 5: Consumer price event study estimates with two-year periods using basic price import shares

VARIABLES	(1) Inflation	(2) Inflation	(3) Inflation	(4) Inflation difference
Post × Import Share	0.143**	0.125***	0.116***	0.113***
	(0.061)	(0.037)	(0.031)	(0.030)
Oil		0.967*	0.329	0.091
		(0.565)	(0.295)	(0.179)
Euro area inflation			0.728*	
			(0.393)	
Observations	168	168	168	168
R-squared	0.562	0.760	0.840	0.692
Number of classes	84	84	84	84
Class fixed effects	YES	YES	YES	YES
Period fixed effects	YES	YES	YES	YES

Notes: The dependent variable in columns (1)-(3) is the UK inflation rate at the COICOP class level. The dependent variable in column (4) is the difference between the UK and Euro area inflation rates. Import shares are measured in terms of basic prices. Post is a dummy variable for the two-year post-referendum period (June 2016-June 2018). The pre-referendum period also covers two years (June 2014-June 2016). OLS estimation. Standard errors in parentheses are clustered by COICOP class. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 6: Producer price event study estimates with two-year periods

VARIABLES	(1) PPI inflation	(2) PPI inflation	(3) PPI inflation
Post $\times$ Producer Import Share	1.044***	0.534**	0.459**
	(0.355)	(0.202)	(0.210)
Oil		0.746***	0.544
		(0.145)	(0.369)
PPI Euro area inflation			0.330
			(0.488)
Observations	84	84	84
R-squared	0.762	0.870	0.880
Number of sectors	42	42	42
Sector fixed effects	YES	YES	YES
Period fixed effects	YES	YES	YES

Notes: The dependent variable is the UK PPI inflation rate for 42 CPA sectors. Post is a dummy variable for the two-year post-referendum period (June 2016-June 2018). The pre-referendum period also covers two years (June 2014-June 2016). OLS estimation. Standard errors in parentheses are clustered by CPA sector. *** p<0.01, ** p<0.05, * p<0.1.

Table 7: Producer price event study estimates with two-year periods – strategic complementarities

VARIABLES	(1) PPI Inflation	(2) PPI Inflation	(3) PPI Inflation	(4) PPI Inflation	(5) PPI Inflation	(6) PPI Inflation
Post × Producer Import Share	1.023**	0.515***	0.448**			
	(0.379)	(0.189)	(0.199)			
Post × Direct Import Share at basic prices	-0.032	-0.031	-0.024	-0.097	-0.047	-0.034
	(0.056)	(0.044)	(0.049)	(0.069)	(0.057)	(0.058)
Oil		0.745***	0.555		1.095***	0.719
		(0.135)	(0.360)		(0.088)	(0.465)
PPI Euro area inflation			0.311			0.496
			(0.492)			(0.532)
Observations	84	84	84	84	84	84
R-squared	0.766	0.873	0.882	0.391	0.822	0.847
Number of sectors	42	42	42	42	42	42
Sector fixed effects	YES	YES	YES	YES	YES	YES
Period fixed effects	YES	YES	YES	YES	YES	YES

Notes: The dependent variable is the UK PPI inflation rate for 42 CPA sectors. Post is a dummy variable for the two-year post-referendum period (June 2016-June 2018). The pre-referendum period also covers two years (June 2014-June 2016). OLS estimation. Standard errors in parentheses are clustered by CPA sector. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 8: Consumer expenditure share event study estimates with two-year periods

VARIABLES	(1) Consumer Expenditure Share	(2) Consumer Expenditure Share	(3) Consumer Expenditure Share
Post $\times$ Import Share	0.058	-0.098	-0.194
	(0.519)	(0.544)	(0.564)
Observations	150	150	150
R-squared	0.380	0.390	0.396
Oil	NO	YES	YES
Euro area inflation	NO	NO	YES
Number of classes	75	75	75
Class fixed effects	YES	YES	YES
Period fixed effects	NO	NO	NO

Notes: The dependent variable is the consumer expenditure share at the COICOP class level. Post is a dummy variable for the two-year post-referendum period. OLS estimation. Standard errors in parentheses are clustered by COICOP class. *** p<0.01, ** p<0.05, * p<0.1.

Table 9: Import cost pass-through estimates

VARIABLES	(1) Inflation	(2) Inflation	(3) Inflation	(4) Inflation	(5) Inflation
Import cost pass-through	0.819***	0.972***	1.111***	1.412***	1.209***
	(0.236)	(0.281)	(0.365)	(0.434)	(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
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. 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 10: Exchange rate pass-through estimates without import share interactions

VARIABLES	(1) Inflation	(2) Inflation	(3) Inflation	(4) Inflation	(5) Inflation
Exchange rate pass-through	0.120***	0.150***	0.158***	0.150***	0.138***
	(0.032)	(0.033)	(0.036)	(0.038)	(0.041)
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. 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. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

A Data appendix

A.1 Import share calculations

Equation (10) shows that the import share of product group g depends upon the parameters λ_g, γ_g, ζ and θ_{ij} for $i = g, W, R$ and $j = 1, \ldots, G$. We calculate γ_g, ζ and θ_{ij} using the UK Input-Output Analytical Tables for 2013. The share of imports in expenditure net of distribution costs, γ_g, is computed as the ratio of household expenditure on imports of good g to total household expenditure (domestic and imported) on good g at basic prices. The share of distribution services expenditure spent on wholesale, ξ, is computed as the ratio of household expenditure on the wholesale sector (CPA code 46) to household expenditure on the wholesale and retail (CPA code 47) sectors at basic prices.

The element in row i and column j of the $G \times G$ matrix $(I - \Omega^D)^{-1}\Omega^M$ is θ_{ij}. To calculate Ω^D and Ω^M we need to know α_g, δ_g, ψ_{gj} and μ_{gj} for $g, j = 1, \ldots, G$. We compute the share of intermediate inputs in production costs, α_g, as total intermediate consumption (domestic and imported) by domestic producers of product g over total domestic output of product g. The share of imports in intermediate input costs, δ_g, is computed as the share of imported intermediates in total intermediate consumption by domestic producers of product g. Finally, ψ_{gj} is given by the share of expenditure on product j in domestic intermediate expenditure by domestic producers of product g from the Domestic Use Table. Similarly, μ_{gj} is the share of expenditure on product j in imported intermediate expenditure by domestic producers of product g from the Imports Use Table. All these parameters are calculated using data at basic prices.

To measure λ_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, the expenditure on distribution services, H_{Sg}, cannot be inferred from the input-output tables. Instead, we calculate H_{Sg} as:

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

where D_g is given by Distributors' trading margins for product group g and T_g by Taxes less subsidies on products. Both D_g and T_g are taken from the Supply of products table in the Supply and Use Tables. Given H_{Sg}, we then calculate λ_g as:

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

A.2 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:

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

where $\hat{p}^M_{Oil,t}$ 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.

Table A1: Import shares by COICOP class

Table A1 — *Continued on next page*

	COICOP class	(1) Direct	(2) Indirect	(3) Total	(4) Distribution services share λ_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
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

Table A1 — *Continued from previous page*

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
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

Table A1 — *Continued from previous page*

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 their sum, i.e., the total import share. Column (4) reports the share of distribution services in expenditure, λ_g, in percent.