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How Do Exchange Rate Depreciations Affect Trade and Prices? A Survey and Lessons about UK Experience after June 2016 *

Yohannes Ayele[†] **L Alan Winters**[‡]

Abstract

The sterling depreciation following the Brexit referendum was expected to boost the export sector of the UK economy. But the boom never arrived. This paper first reviews a selection of empirical research on the effects of exchange rate changes on import prices, consumer prices, export prices and trade quantities over the recent decades and then specifically discusses the effects of the recent sterling depreciation. It asks specifically whether the absence of an export boom should be considered a surprise or not. We find that the weakness of the export boom after the sterling depreciation was not wildly out of line with what the literature suggests. But we also argue, however, that the poor performance was also at least partly due to the huge increase in uncertainty about UK trade policy that accompanied the depreciation. .

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1 Introduction

On June 23, Britain voted to leave the European Union. The immediate effect of the result of the Brexit referendum was the depreciation of sterling relative to all major currencies, a change that has proved to be persistent. The sterling depreciation was expected to boost the export sector of the UK economy because it should have given UK firms a competitive advantage in foreign markets in terms of lower prices in foreign currency. But the export boom never arrived (e.g. De Lyon and Dhingra, 2019; Economist, 2017). In fact, depreciations have never reversed the secular decline in the UK share of world trade, but they can temporarily stem it. Not in 2016, though.

Figure 1 plots the volume of UK exports (goods and services) relative to the volume of world trade since 1961Q1, setting that quarter equal to 1. (Thanks to the NIESR for providing data). In addition, it shows, as dots, the six major depreciations of sterling since then. It shows a precipitous decline in relative trade until around 1967, followed by a more gentle decline punctuated by periods of stability. The average quarter-on-quarter change in relative trade over the whole period is -0.27%; if we treat the eight quarters after a depreciation as affected by that depreciation, the average change for non-depreciation quarters is -0.39%, while the depreciation quarters average 0.31% before 2000 and -0.25% after 2000.

This paper reviews a selection of empirical research on the effects of exchange rate changes on import prices, consumer prices, export prices and trade quantities over the recent decades. Having reviewed the general literature, we then specifically discuss the effects of the recent sterling depreciation on UK prices and export volumes, and consider specifically whether the absence of an export boom should be considered a surprise or not. In the latter discussion, we consider, the role of global value chains, the nature of UK exports, issues surrounding the currency of invoice and finally whether, uniquely to the UK following the referendum, the effects of the depreciation were merely eclipsed by a large increase in uncertainty about trade policy.

There is a significant recent literature about the effects of exchange rate depreciations, encompassing both macroeconomic approaches such as Bussière et al. (2020) and microeconomic studies like Berman et al. (2012), Amiti et al. (2014) and Fontagné et al. (2018), with earlier contributions admirably surveyed by Burstein and Gopinath (2014). We seek to update the latter and focus particularly on what the literature should have led us to expect in 2016.

In nutshell, although there is a good deal of variation between countries, the general literature suggests that:

- in the long run, depreciations generate rather small changes in a country's export prices measured in foreign currency terms, although short-run changes are observed;

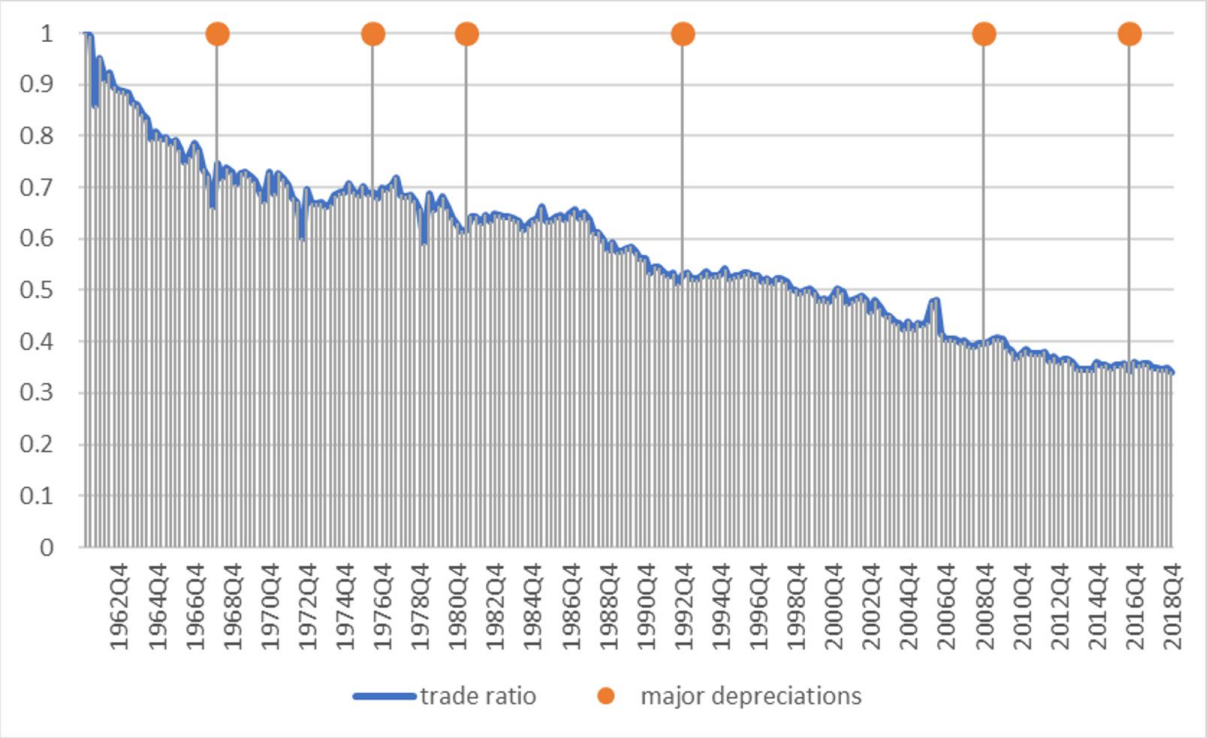


Figure 1: UK exports relative to world trade

- the prices of imported goods tend to rise after a depreciation, but less that proportionately than the depreciation;
- consumer prices rise a good deal less than import prices;
- trade quantities are rather unresponsive to exchange rate changes, proportionately much less so than they are to equivalent changes in tariffs or costs of production.

Turning to the UK experience after June 2016, we do not find much evidence that it was out of line with what the literature suggests, but we do argue that the weak response of exports to the depreciation was at least partly due to the huge increase in uncertainty about UK trade policy that accompanied the depreciation. The shock referendum result that the UK should leave the European Union that precipitated the depreciation also, at a stroke, put in severe doubt the unfettered access to the EU market that businesses had taken for granted. Recent scholarship has demonstrated that the uncertainty associated with prospective adverse changes in trade policy is antithetical to trade (e.g. Handley and Limao, 2015; Pierce and Schott, 2016; Handley and Limao, 2017) and recent studies of the UK have confirmed this (e.g. Graziano et al., 2018; Crowley et al.,

2019).

The rest of the paper is structured as follows. In section 2, we present a simple theoretical framework for the effect of exchange rate changes on trade prices and quantities. Section 3 provides a brief description of recent UK trade history. In section 4, we review and discuss different studies on the effect of exchange rate changes on trade prices, consumer prices and trade quantities, and in section 5 the apparent effect of the recent sterling depreciation on UK trade and price behaviour. Section 6 concludes

2 Theoretical framework

To interpret the empirical literature on the effect of exchange rate change on prices and quantities, we start with a simple general theoretical framework based on Burstein and Gopinath (2014). Assuming firms can segment their markets by country, the optimal log FOB price for a profit-maximizing firm, i, selling in market n, can be expressed as the sum of the logs marginal cost and gross markup:

$$p_{in} = \mu_{in} + mc_{in} \tag{1}$$

Let us assume that the markup p_{in} of exporting firm i depends on its price relative to the aggregate industry price level in the destination country n i.e.$\mu_{in} = \mu_{in}(p_{in} - p_n)$. This specification is perfectly general, but there are various models (with both CES and non-CES demand functions) which give exact and reduced form relationships between markup and relative prices. For instance, Corsetti and Dedola (2005) derived a variable markup equation as a function of the firm's relative price with CES demand and addictive distribution costs. Let us also assume that the marginal cost of exporting firm i depends on the total quantity sold in destination n, q_{in}, that all the variables that impact the cost of production are local to the exporting country, such as wages and total factor productivity (which we include in a single term (w_i)), and that the bilateral exchange rate is e_{in}. Thus $mc_{in} = mc_{in}(q_{in}, w_i, e_{in})$.

If we differentiate (1),

$$\Delta p_{in} = -\Gamma_{in}(\Delta p_{in} - \Delta p_n) + mc_q \Delta q_{in} + \Delta w_i + \alpha_{in} \Delta e_{in} \tag{2}$$

where $\Gamma_{in} = \frac{\partial \mu_{in}(.)}{\partial (p_{in} - p_n)}$ is the elasticity of the markup with respect to relative price and $mc_q = \frac{\partial mc_{in}(.)}{\partial q}$ is the elasticity of marginal cost with respect to output. We assume symmetry such that output is the same for firm. $\alpha_{in} = \frac{\partial mc_{in}(.)}{\partial e_{in}}$ is the partial-elasticity of marginal cost to exchange rate (expressed in the destination's currency). $\frac{\partial mc_{in}(.)}{\partial w_i} = 1$ is assumed. Let the log demand for exporting firm i's product be given as a function of its price relative to the aggregate in the

importing country.

$$q_{in} = q(p_{in} - p_n) + q_n \tag{3}$$

where q_n denotes the log of aggregate quantities/demand in the destination country n. Differentiating (3) we get,

$$\Delta p_{in} = -\epsilon_{in}(\Delta p_{in} - \Delta p_n) + \Delta q_n \tag{4}$$

where $\epsilon_{in} = -\frac{\partial q(.)}{\partial p_{in}} > 0$ is the price elasticity of demand, holding other prices constant. Then collecting terms from (2) and (4) we obtain the following equation

$$\Delta p_{in} = \frac{1}{1 + \Gamma_{in} + \Phi_{in}}[\Delta w_i + \alpha_{in}\Delta e_{in} + (\Gamma_{in} + \Phi_{in})\Delta p_n + mc_q \Delta q_n] \tag{5}$$

From equation (5) the effect of a change in bilateral exchange rate on price change can be decomposed into direct and indirect effect, as specified below. The direct exchange rate pass-through is given as (assuming $\Delta w_i = 0$, which is reasonable in the short run).

$$\frac{\Delta p_{in}}{\Delta e_{in}} = \underbrace{\frac{\alpha_{in}}{1 + \Gamma_{in} + \Phi_{in}}}_{\text{Direct Effect}} \tag{6}$$

The direct effect applies alone if we assume the change in exchange rate does not change the destination country's aggregate price and quantity ($p_n = \Delta q_n = 0$). We would get estimates of the direct effect if we estimated ERPT from a regression including marginal cost, aggregate quantities and aggregate prices. However, a change in exchange rate may result in a change in the importing country's aggregate prices and quantities. Thus, the total exchange rate pass-through including both direct and indirect effects is given as follow (again assuming $\Delta w_i = 0$).

$$\frac{\Delta p_{in}}{\Delta e_{in}} = \underbrace{\frac{\alpha_{in}}{1 + \Gamma_{in} + \Phi_{in}}}_{\text{Direct Effect}} + \underbrace{\frac{\Gamma_{in} + \Phi_{in}}{1 + \Gamma_{in} + \Phi_{in}} \frac{\Delta p_n}{\Delta e_{in}} + \frac{mc_q}{1 + \Gamma_{in} + \Phi_{in}} \frac{q_n}{\Delta e_{in}}}_{\text{Indirect Effect}} \tag{7}$$

The indirect effect captures the change in the exporter price if aggregate prices and quantities in the importing country adjust as a result of the movement in the bilateral exchange rate (i.e. $\Delta p_n > 0$, $\Delta q_n > 0$). For example, considering UK imports, an increase in UK aggregate quantities ($\Delta q_n > 0$), increases the foreign exporter's demand in the UK, and thus its marginal cost and eventually its price.

Assuming the exporting firm does not affect the destination's aggregate prices and output, let us focus on equation (6), the direct effect. If we assumed a constant markup ($\Gamma_{in} = 0$), that all producer costs are set in the currency of the producer (i.e. $\alpha_{in} = 1$) and that the marginal cost of

production is constant (i.e. $mc_q = 0$), then the exchange rate pass through would be 1. Incomplete exchange rate pass-through is thus just a reflection of the failure of one of these conditions. There are a number of models that derive the exact negative relationship between markups and relative price ($\mu_{in} = \mu_{in}(p_{in} - p_n)$), resulting $\Gamma_{in} > 0$. For example, with CES demand and additive distribution costs, Corsetti and Dedola (2005) derive the optimal markup for the monopolistic price-setter as a function of relative price ($p_{in} - p_n$) as $\mu_{in} = log[\frac{\theta}{\theta - 1 - \eta_{in} exp(-(p_{in} - p_n)}]$ where θ is the elasticity of substitution and η_{in} is the fixed distribution cost per good , so that the elasticity of the markup with respect to relative price is given by $\Gamma_{in} = log[\frac{1}{\frac{\theta-1}{\eta_{in} exp(-(p_{in} - p_n}) - 1}]$ (see Corsetti and Dedola (2005); Burstein and Gopinath (2014)). This shows that markup elasticities vary across firms, with more productive firms having higher expenditure shares and higher markup elasticities. Thus, as per equation (7), more productive firms have lower exchange rate pass-through, assuming exporting firms are too small to influence the destination country aggregate price level, p_n (Burstein and Gopinath, 2014).

3 What Happened? Descriptive Statistics

This section briefly presents the recent history of the UK economy so far as exchange rates are concerned. That is, the phenomena that we are trying to explain. Essentially, we take the depreciation of 24th June 2016 as an exogenous shock and ask what happened to related series following that. At this stage we are describing, not explaining.

Figure 2 shows the monthly effective exchange rate for sterling and also inflation. Focusing on the former (in black), the figure shows the immediate and large depreciation of sterling, and that unlike the stock market, it never recovered. Depreciations are generally expected to increase consumer prices and this, indeed, proved true. The figure also plots the annual rate of inflation (the change in the consumer price index relative to the same month a year previously). The exchange rate started to dip at the end of 2015 (after the UK election) and fell precipitously in June 2016. Inflation picked up from the latter date. The increases in prices were not spread evenly across commodities and services, but concentrated on those commodities that were most exposed to imports through having high exposure to imports via both direct consumer expenditure on imported final goods and indirect expenditure on imports that are used as intermediate inputs in domestic production – see Figure 3. As noted above, we expect a depreciation to affect the quantities traded. Figure 4 looks at the evolution of the quantities (volumes) of UK exports and imports since 2015 along with the effective exchange rate. There is a hint of an export increase in the latter half of 2016, but the underlying trend resumes from 2017 Q1 until 2019 Q3 and Q4,

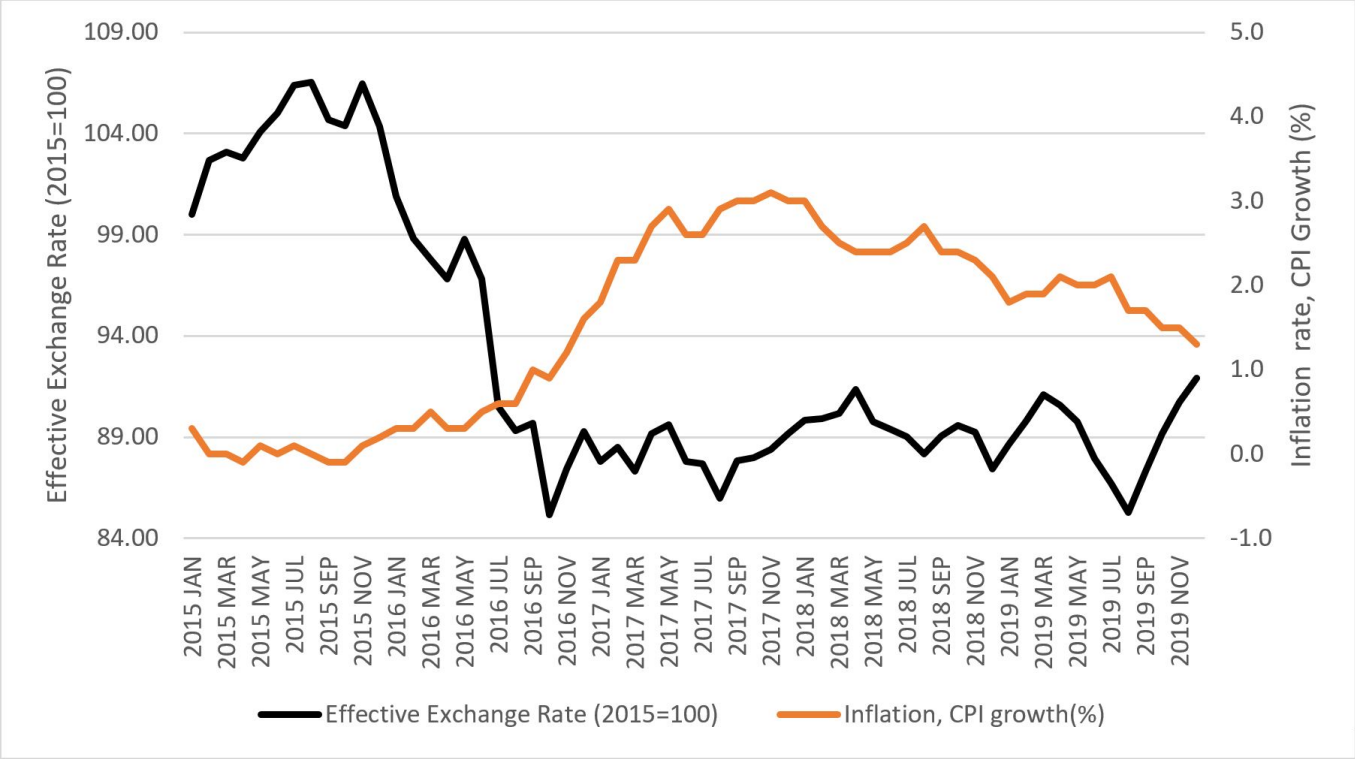


Figure 2: The real effective exchange rate and inflation

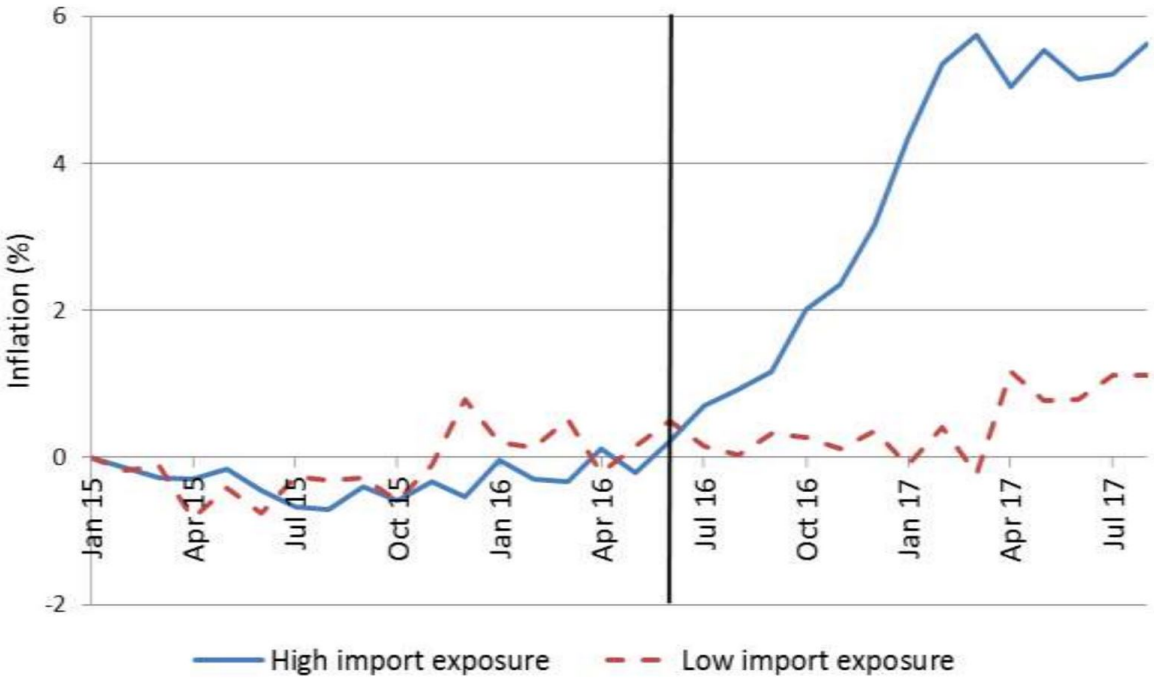


Figure 3: Import exposure and inflation, 2015-2017
Source: Adopted from Breinlich et al, 2019

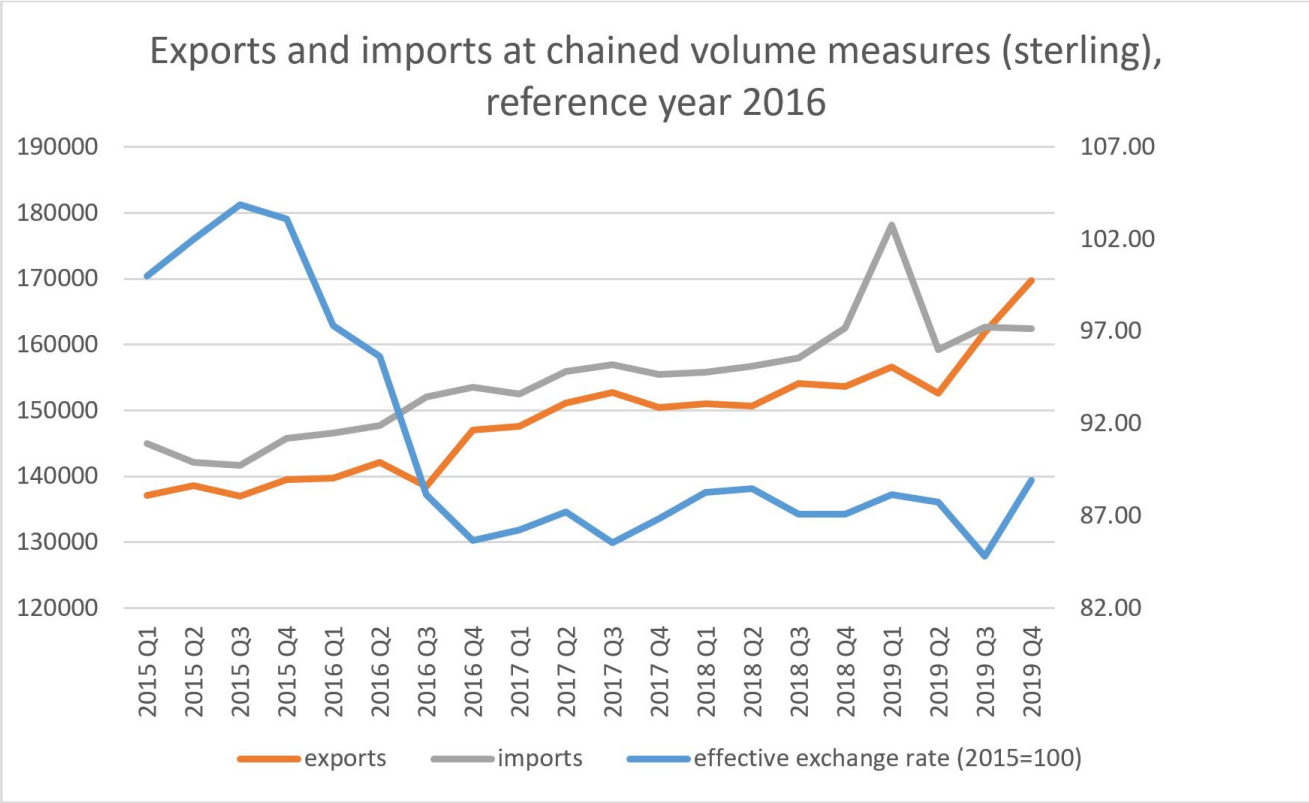


Figure 4: UK exports and imports of goods and services (seasonally adjusted) and the exchange rate

Source: ONS, 2020

when an upturn appears.[1] For imports, it appears that the depreciation has had no effect on the underlying trends, the peak in 2019 Q1 probably just being a timing anomaly.

Of course, simple outcome measures like figure 4 do not allow us to isolate the effects of the exchange rate change because other factors influence trade flows. Among the most important for exports is the growth of world trade, which was fairly buoyant between 2016 Q3 and 2018 Q1, so one would have expected reasonable UK export growth even without depreciation. Given that, the surprise that exports did not pick up after the depreciation is all the greater.[2]

[1]The increase in exports in the third quarter, is mainly driven by rising exports of machinery and transport equipment to non-EU countries. That in the fourth quarter is due to a large increase in exports of precious metals, which includes non-monetary gold

[2]There is one formal investigation in 2018 that suggests that export performance was surprisingly poor, but it has been subsequently withdrawn, so we will not rely on it here.

4 Effect of Exchange Rates on Prices and Trade Quantities

This section reviews a selection of the more important pieces of evidence on the effect of exchange rate changes on trade prices, trade quantities, and consumer prices. In keeping with the bulk of the literature surveyed, we measure the exchange rate as units of local currency per unit of foreign currency – the opposite of the usual practice in the UK – so that a depreciation corresponds to an increase in the exchange rate.

4.1 The Exchange Rate Elasticities of Prices

There are two approaches in the estimation of exchange rate elasticities on prices and quantities; the macro approach—that estimates the effect of the change in exchange rate on aggregate trade prices and flows (Bussière et al., 2014, 2020; Leigh et al., 2017), and the micro approach—that estimates the impact of exchange rate change on trade prices and flow at highly disaggregated level, usually at firm level (Berman et al., 2012; Amiti et al., 2014; Fernandes and Winters, 2018). We first review results from the macro approach.

The standard macro approach in exchange rates pass-through estimation is to regress the change in a measure of prices in an importing country (i.e. import prices, consumer prices) in local currency on the change in exchange rate and some additional controls as follow:

$$\Delta P_{in,t} = \alpha + \sum_{k=0}^{T} \beta_{in,k} \Delta e_{in,t-i} + \gamma X_{in,t} + \phi Z_{in,t} + \epsilon_{in,t} \tag{8}$$

where the dependent variable Δp_t is the change in a price measure expressed in the importing country currency, $\Delta e_{in,t-i}$ is the change in bilateral exchange rate. $X_{in,t}$ is a vector of factors that affect the exporter country costs, typically including things such as the cost of production in the country of exporter, and $Z_{in,t}$ is a vector of controls in the destination country demand condition, usually proxied with local GDP, and competitors prices in the importing country. $k > 0$ allows for lags in pass-through of exchange rate to prices, and T refers to time, it could be months, quarters or years. The variable of interest is the pass-through elasticity: $\beta_{in,0}$ captures the short-run effect of exchange rate pass-through to prices, while the sum of the estimated β_{in} coefficients $\sum_{k=0}^{T} \beta_{in,k}$ captures the long-run effect of exchange rate change on prices, where T is usually set at 2 years. If $\beta_{in,0} = 1$, exchange rate pass-through is complete i.e. the proportional change in exchange rates will pass completely through to the price measure. This would be the case with Producer Currency Pricing (PCP). If $\beta_{in,0} = 1$, exporters set prices in local currency and pass-through is zero, usually known as Local Currency Pricing (LCP). However, if pass-through is incomplete, $\beta_{in,0}$ is bounded between zero and one. In the estimation of the above pass-through

regression, the coefficient of exchange rate pass-through ($\beta_{in,0}$) will be biased if exchange rates are correlated with exporting firms' markups and marginal costs but we fail to control it (Campa and Goldberg, 2005). For instance, the marginal costs of firms could be affected by the exchange rate if for example exporting firms use imported intermediate goods from abroad.[3]

Most of the empirical results from the macro-approach show that exchange rate pass-through to import prices is incomplete. Using quarterly data on import prices indices from 23 OECD countries for 1975 through 2003, Campa and Goldberg (2005) find that the average elasticities of exchange rate pass-through into aggregate import prices in importer currency is approximately 0.46 in the short-run and 0.64 in longer-term. However, they find substantial cross-country variations, with the Netherlands registering relatively higher short-run pass-through elasticity at 0.79 and the US relatively low pass-through (0.23). For the United Kingdom, the short-run import price pass through elasticity is estimated at 0.36. The exchange rate pass-through to import prices is also incomplete at sector level, albeit with some heterogeneity across sectors such that energy and raw materials register import pass-through closer to unity while manufacturing and food sectors come in lower.[4]

Confirmation comes from Campa and Mínguez (2006), who estimated the exchange rate pass-through elasticity to import prices for the 11 Euro area countries at 0.62 in the short-run and 0.78 in the long-run, and from Cheikh and Rault (2016), who updated the results and found estimates of 0.43 for the short run and 0.54 for the long run. In addition, Ihrig et al. (2006) finds incomplete pass-through to import and consumer prices using the G-7 countries' data.

Bussière et al. (2020) provided the estimates of the elasticities of export and import prices with respect to the exchange rate using bilateral trade flow data from 25 advanced and 26 emerging countries, covering 1995-2012 with more than 160 trading partners. They regress bilateral trade flows at the HS-6 level (about 5,000 products) on bilateral exchange rates. They find that the unweighted average elasticity of export prices in producer currency is 0.35, which implies an elasticity of 0.65 for import prices in importer currency.[5] Using import data instead generates an unweighted average elasticity of import prices to exchange rate change in importer currency of around 0.48.[6] They also find heterogeneity in pass-through across countries. For instance,

[3]An alternative approach to estimate the ERPT to import and consumer prices is the structural Vector Autoregressive (SVAR) approach. Given that our main interest is in the trade quantities, we do not review this approach here. However, it does not suggest very different conclusions from the papers we do review.

[4]In comparing the elasticities of exchange rate pass-through into aggregate import prices it is important to note that, as unlike consumer prices, import prices are defined differently in different countries, and thus results based on import prices in cross-countries studies should be interpreted carefully (Burstein and Gopinath, 2014).

[5]By definition,$p_m = p_x/e$ where p_m is the import price in importer currency, px the exporter price in exporter currency and e units of exporter currency per unit of importer currency. Hence $\frac{\Delta ln(p_m)}{\Delta ln(e)}=\frac{\Delta ln(p_x)}{\Delta ln(e)-1}$. If we measure the exchange rate from the importer's perspective,e'(=1/e), we get $\frac{\Delta ln(p_m)}{\Delta ln(e')}$=1-$\frac{\Delta ln(p_x)}{\Delta ln(e)}$.

[6]Note that the data refer to each country's exports to 160 partners and imports from 160 sources, and so the differences in averages are not surprising. In addition, import prices include transportation costs (i.e. the cif price), whereas export

the elasticity of export prices in producer currency is zero for Switzerland, Norway, Chile, etc., implying complete pass-through to import prices (an elasticity of one in importer currency). On the other hand, for countries such as Ireland, Argentina and Costa Rica, the elasticity of export prices in producer currency with respect to exchange rate change is 1 (an elasticity of zero in importers currency), showing exporters do not change their export prices in terms of importer currency, i.e. they adopt complete pricing to market in import markets. Overall, Bussière et al. find that the average elasticity of export prices with respect to exchange rate change (in producer currency) for the advanced economies is lower than that for emerging countries, but that there is no significant difference in import price elasticities between the two groups of countries.

Reflecting the recent improvements in data availability, the recent literature on exchange rate pass through has focussed more on microeconomic analysis at firm or transaction levels. These studies reinforce the macro finding of incomplete exchange rate pass through, and in addition, have also been able to explore some of the reasons underlying the incompleteness.

Amiti et al. (2014) suggest that incomplete exchange rate pass-through is a result of a firm's import-intensity of export (i.e. the imported intermediate input channel) and its market share in the foreign market. Using Belgian manufacturing firm-level export data to OECD countries outside the euro area from 2000-2008,[7] Amiti et al. find that the annual average exchange rate pass-through elasticity to exporter prices in producer currency (the euro) is 0.2, implying a pass-through coefficient for Belgium firms' export prices in the destination country currency prices of 0.8.[8] However, the elasticities are heterogeneous across firm's import intensity. For instance, the elasticity of pass-through to Euro prices for a typical firm with zero import intensity—defined as the ratio of total non-euro import value to total variable cost—is 0.13 for a firm with 40 percent import intensity is 0.37.[9]

In a similar exercise but on French firm-level data from 1995-2005, Berman et al. (2012) emphasized the role of firm productivity and size on the incomplete exchange rate pass-through. They find that the elasticity of the average exporter's export prices in producer currency (euro) to the exchange rate is 0.08, giving the average export price pass-through in terms of the destination's currency is 0.92, but with significant variation by productivity. Firms that are more

prices do not (prices are fob).

[7]The non-euro zone OECD countries account for 58% of the Belgium's total non-euro exports and they performed robustness tests for the full set of non-euro destinations.

[8]The bilateral exchange is the rate of conversion from Euro to the destination currency. As noted, above, this can change either because the Euro changes (relative to SDR, say) or the destination currency does. In the latter case, if the destination is not an important market for Belgium, exporters may not bother to change their Euro prices because they can switch sales elsewhere.

[9]In estimating exchange rate pass-through to export prices, Amiti et al. (2014) interacted firm import intensity with the change in the exchange rate, finding a coefficient of 0.60. It implies that firms with high import intensity have lower pass-through in the destination currency. The interpretation is that for each 1-percentage point higher import intensity, the exchange rate pass-through to export prices in the producer currency is 0.6 percentage point higher, i.e. reduces the pass-through to the destination prices by 0.6 percentage points.

productive have lower pass-through to Euro prices, perhaps because they have larger mark-ups to squeeze or because they provide more sophisticated goods with lower price elasticities. Specifically, they find that the export price elasticity (producer currency) increases to 0.13 for one standard deviation increase in TFP and to 0.3 for one standard deviation increase in labour productivity. In addition, they also find that the elasticity is larger for consumer goods than for intermediate goods, with 0.2 for consumer goods, and 0.07 for intermediate goods, showing pricing to market arises in models with distribution costs and more pricing to market is observed for sectors with high distribution costs.

Closely related to productivity, is the notion of 'core' products – those most central to the firm's exporting effort. Fontagné et al. (2018), who also use French firm-level data, find average pass-through to the destination currency export prices of 0.97 but of 'only' 0.90 for firms' core products.[10] Berman et al. (2012), who consider pass-through in exporter currency, also find that pass-through for the core product–the highest export value–is 0.124, becomes 0.093 for product ranked 10th and is zero for the product ranked 36th in export size.[11] Using the Brazil data, Chatterjee et al. (2013) find that a firm's price response is lower for products that are further away from their core products.

Auer and Schoenle (2016) analyse market structure as a determinant of pass-through. They work on US import micro data to identify the effect of exporters' exchange rate changes relative to the dollar on US import prices in dollars. Their principal concern is to demonstrate the joint roles of marginal costs and of competitors' prices in the determination of any firm's delivered prices, the latter of which depends heavily on the firm's market share: larger market shares attenuate exchange rate pass-through. Using a variety of proxies for firms' shares of US imports of their commodities, their data suggest that whereas the pass-through elasticity for a near-monopolist firm is 0.07, that for a firm with a negligible market share is 0.19.

Using the Brazilian data from 1997-2006, Chatterjee et al. (2013) find that the export price elasticity with respect to the exchange rate (in producer currency) is 0.23, implying an exchange rate pass-through elasticity to import prices of 0.77 in the destination's currency. Similar to Berman et al. (2012) and Amiti et al. (2014), they also find that the exchange rate pass through varies with productivity, with more productive firms increasing their markups by more than less productive firms i.e. the former have lower pass-through.

Possibly related to productivity, pass-through may also vary with product-quality. Using Argentinian firm-level wine export data, Chen and Juvenal (2016) examined whether the exchange rate pass through varies across product qualities in multiproduct exporting firms, finding a vari-

[10] Multiproduct firms are more productive at their core product ((Arkolakis and Muendler, 2010; Mayer et al., 2014))

[11] For reference below, Berman et al. also find that the elasticity for export volume is 0.48 for the core product and becomes 0.619 for the tenth product.

ety of evidence that it decreases as quality increases. This is very possibly due to the fact (belief?) that higher quality products face lower price elasticities of demand, thus incentivizing sellers to absorb a larger proportion of any shock into their mark-ups. Auer et al (2016) also examined the role of quality and demand for quality (proxied by per capita income in the destination country) in incomplete pass-through, finding higher pass-through for low quality cars than for a top quality cars, with one standard deviation in quality associated with a 8.5 percentage points lower rate of pass-through.[12]

4.1.1 The Role of Currency Choice

Gopinath and Rigobon (2008) and Gopinath et al. (2010) explore the role of currency of invoicing. Firms involved in international trade set the prices of their exports in one of their own currency (producer currency invoicing), the currency of the destination country (local currency invoicing) or an unrelated currency (vehicle currency invoicing). Given the various frictions in economic life, this is likely to affect exchange rate pass-through, at least in the short-run. For instance, if exporters set prices in the importer's currency (local currency pricing), the immediate pass-through of a change in the bilateral exchange rate would be zero (i.e. no change in the price in importer currency), whereas if prices are set in the exporter's country prices (producer currency pricing), would see an immediate pass-through coefficient of unity. These purely mechanical effects would operate until the exporters reset their prices, but given that such adjustments take time they may persist in full or in part for some time.[13] This implies that the invoice-currency composition of a country's imports determines the short-run extent of exchange rate pass-through to import prices and consumer prices, as confirmed, for example, by Gopinath et al. (2010), Cravino (2017), Gopinath (2015), Boz et al. (2017), Auer et al. (2018), Chen et al. (2019). These are essentially short-run effects, however: in the long-run, given that we generally expect money-neutrality, we would expect such currency-invoicing effects to erode away to almost nothing.

4.1.2 On consumer prices

The basket of goods and services that consumers consume in any given country includes both goods and services that are imported for consumption and those that are produced domestically. The change in the exchange rate directly affects the prices of imports, but domestically produced goods prices (both traded and nontraded) are also affected if their production needs imported

[12] In addition to heterogeneity in firm productivity and size, Garetto (2016) suggests incomplete information about competitors in the foreign market as a contributing factor for incomplete exchange rate pass-through, finding that after controlling firm market share, new entrants operating under incomplete information have lower pass-through than firms operating under complete information.

[13] The adjustments may take considerable time if there are rigidities in certain nominal values such as debt or wage contracts.

intermediate inputs. In addition, the general price level of a country may increase if a change in its exchange rate boosts the economy via export growth and increases the cost of other inputs into production, for example, by increasing wages.

One empirical finding confirmed by multiple studies is that the extent of exchange rate pass-through to consumer prices is significantly less than the corresponding pass-through to import prices. First, pass-through to import prices is incomplete at the border. Second, distribution services such as local storage, transportation, wholesaling, insurance, retail, etc. increase the local value-added content of the imported good in the final consumer prices, which helps to dampen the effect of exchange rate change on consumer prices. Besides, distributors may also actively adjust their profit margin to absorb some of the currency fluctuations (Campa and Mínguez, 2006). Burstein and Gopinath (2014), using the standard pass-through estimation procedures, estimate the short-run and long-run exchange rate pass-through to the import price and tconsumer price indices of tradeable goods for various countries. For example, the short run pass-through to import prices for the UK is 0.37 (1985-2011) while the pass-through to traded CPI is 0.05 (1975-2011); for Canada the pass-through to the import price index is 0.75 while for the consumer price index it is 0.02.[14]

In the literature, there are two modeling approaches to explain the lower pass-through of exchange rate changes to consumer prices—the first emphasises the role of the distribution sector, and the second focuses on the role of imported intermediate goods in production for consumption.

Bacchetta and Van Wincoop (2003) presented a framework that shows the role of imported intermediate input and size of the non-tradable sector in explaining the differential exchange rate pass-through between consumer prices and import prices. A monopolistically competitive exporter sells intermediate input to monopolistically competitive final good producers, who use only imported intermediate inputs to assemble final goods for domestic consumers. Pricing decisions are made at two different levels, first at the level of the producer of the intermediate good (exporting firm) and second at the level of producer (assembly) of final consumer goods in the domestic economy. In this environment, they show that the optimal pricing strategy for the domestic final goods producers that assemble imported intermediates is to set prices in the local currency when the size of the non-tradable sector is larger, implying zero pass-through to consumer prices. At the same time, the exporters of the intermediate goods in a foreign country set prices in producer currency, resulting in a complete pass-through to import prices.[15] Thus,

[14]The estimation is on quarterly data and the short run pass through is at lag-0

[15]The final consumer goods producing sectors (assembly) faces stiffer competition including from the non-tradable sector while the intermediate good producing sector (i.e. foreign intermediate exporting firm) compete only with intermediate goods producers, making the size of the non-tradables sector important in the optimal pricing decision of the domestic final consumer goods producing sector.

Bacchetta and Van Wincoop's model shows a zero pass-through to consumer prices while pass-through is complete for import prices. This is obviously an extreme case but illustrates how consumer prices and import prices respond differently to exchange rate movement.

Goldberg and Campa (2010) emphasized and quantified the role of both distribution and imported input channels in transmitting exchange rate movements to consumer prices. First, working with data for 21 OECD countries, they documented the size of both distribution margins and imported inputs use in the production of tradable and non-tradable goods. Across the 21 OECD sample countries, between 30-50% of the prices of the final goods (purchasers' price) in household consumption are the distribution margins, with the highest levels registered in Finland and the Netherlands, closely followed by the UK at 48.7%.[16] Similarly, between 10% and 48% of the final prices of tradable goods are imported inputs, but the use of imported inputs for the production of non-tradable domestic goods production is smaller, ranging from 3% (US) to 22% (Hungary). Second, through simulation-based estimates, they show that the dominant channel for the transmission of exchange rate movements to consumer prices is the use of imported inputs in the production of domestic goods and services (both tradable and non-tradable) rather than through direct consumption of imported products. For instance, assuming non-zero distribution costs, the UK CPI elasticity wrt import prices is estimated at 0.2, and if decomposed by source 75% of it is due to imported inputs while just 25% is due to consumption of imports. Goldberg and Campa also suggest that the damping effect via distribution margins is substantial, although the contribution of distribution margins to pass-through into the consumption prices of imported goods has not increased in the past decade, unlike the role of imported inputs.

Practically, the extent of exchange rate pass-through to consumers depends first on how exporters pass the change into their export prices (the importer's import prices), and then, second, on how importers pass the prices to final consumers. In summary, as noted above, the exchange rate pass-through to import prices is incomplete, and its effect on consumer prices is further diluted because the consumer prices index (CPI) includes non-traded goods and services as well as domestically produced tradable goods which are not directly affected by exchange rate change except via imported intermediate goods. Besides, distributors' and retailers' margins (which account for between a third and half of the price that consumers pay) are likely to absorb some of the change in import prices, further cushioning the effect on consumers.

[16]The share of distribution margins is significantly lower for other components of final demand, i.e. fixed capital consumption and exports, than for household consumption.

4.1.3 Explaining cross-country differences

Understanding this phenomenon is important because the magnitude of the reaction of import prices to exchange rate change is important for the expected expenditure-switching effect of nominal exchange rate movements, and it has implications for the appropriate monetary policy response of the country to combat inflation. Several empirical studies show substantial variation across countries in terms of the response of both consumer and import prices to exchange rate changes. For instance, as discussed above Campa and Goldberg (2005) give the unweighted average import price elasticity with respect to the exchange rate for 23 OECD countries as 0.46, but it ranges from 0.23 in the US to 0.79 and 0.68 in Netherlands and Spain, respectively, and the differences are statistically significant.

Various arguments have been presented for these cross-country differences. For instance, Devereux and Engel (2002) and Devereux et al. (2004) emphasize the role of monetary policy stability and the currency choice of firms in setting their prices in equilibrium. They show that exporting firms are more likely to set prices in their markets' currencies (local currency pricing) where those countries have more stable monetary policy implying lower short-term exchange rate pass-through; they set prices in their own currencies (Producer Currency Pricing) when markets have less stable and credible monetary policy, implying higher pass-through to prices. Empirically, Campa and Goldberg (2005) find that exchange rate volatility and inflation variability have statistically significant effects on pass-through, suggesting that countries with higher rates of inflation and exchange rate volatility have higher exchange rate pass-through elasticities. On the contrary, other macroeconomic variables such as GDP do not seem to play a role in explaining cross-country variation in pass-through.

4.1.4 Declining Sensitivity of Prices to Exchange rate overtime?

More recently, many empirical studies argue that the sensitivity of import prices and consumer prices to exchange rate change is declining over time. The standard approach to testing whether exchange rate pass-through is declining is implemented by dividing the whole sample period into two sub-samples periods, estimating the pass-through equation for each, and comparing the resulting estimates.[17] Ihrig et al. (2006) find that the average long-run elasticity of import prices with respect to exchange rate change in G-7 countries decreased from 0.72 in the 1970s and 80s to 0.48 in 1990s and 2000s, while the elasticity of consumer prices declined from 0.13 to almost zero over 1990-2005, suggesting almost no impact on consumer prices.

[17]The break date can either be chosen exogenously (imposed) and checked using Chow tests of parameter stability or be chosen endogenously using methods such as Andrews and Ploberger (1994)' test. Others use the rolling regressions to map the development of import or consumer price sensitivity over time.

More recently, using data from 12 Euro area countries for 1979-2012, Cheikh and Rault (2016) find that the average short-run import price elasticity with respect to exchange rate change for the period 1979:2—1990:2 was 0.54 declining to 0.43 over 1990:3-2012:4. The long-run elasticity import prices declined from 0.77 in the 1980s to 0.54 for over 1990-2012. Gagnon and Ihrig (2004), using data for 20 industrialized countries between 1971-2000, find that the exchange rate pass-through to consumer prices declined between 1971 and 2003. Campa and Goldberg (2005) and Campa and Mínguez (2006), on the other hand, failed to find strong reductions in exchange rate pass-through over time. Campa and Goldberg (2005) divided their sample in two - 1975-1989 and 1990-2003 – and performed Chow tests, finding a mix of increases and decreases, only a few of which were significant; they did find declines more prevalent, however. Campa and Goldberg (2008) concluded "... the presumption that pass-through rates have systematically declined across countries, and across a wide spectrum of goods, is not supported. It is not yet appropriate to conclude that persistent change has occurred in the distribution of pass-through into the import prices of manufactured goods."

One explanation for the supposed decline in exchange rate pass-through is related to the previous discussion of cross-country variation. Taylor (2000) suggested low and stable inflation in many countries is one of the factors reasons for the low exchange rate pass-through observed recently. Gagnon and Ihrig (2004) argued that for 20 industrialized countries the decline in the elasticity of consumer prices with respect to exchange rate movement over 1990s is related to the inflation stabilization monetary policy followed by many central banks. Similarly, Cheikh and Rault (2016) find that the decline in exchange rate pass-through to import prices in euro area countries is related to the policy shift of those countries towards inflation targeting. On the other hand, Campa and Goldberg (2005) find that macroeconomic variables have little effect on the sensitivity of import prices to exchange rate. Instead, they appeal to the evolution of the composition of imports over time in their 23 OECD countries. They find that the elasticities of import prices to exchange rate change are heterogeneous across sectors with the energy and raw material import pass-through elasticities closer to unity and the manufacturing and food sectors elasticities lower and incomplete. These sectoral variations in elasticities of imports have implications for aggregate import price elasticities because over time the composition of OECD imports has shifted from raw materials to manufactured goods.[18]

[18]We should re-iterate, however, Burstein and Gopinath (2014) warning that import prices are calculated differently across countries, thus reducing comparability.

4.2 The Exchange Rate Elasticities of Trade Quantities

The reaction of export volumes to exchange rate change depends first on the extent to which exporters reflect the change in their export prices, second how importers pass the changes to consumers/users, and third how consumers react to the change in final goods prices, i.e. whether they switch consumption between foreign and domestic goods, which in turn depends on the availability of substitute goods in the market.

Fontagné et al. (2018) offer a similar disaggregation when considering the effect of exchange rate change on exports and argue that any estimation of the elasticity of firm export volumes with respect to tariff or exchange rate changes, will be biased unless it controls for the export price changes discussed above. They find, however, that while an exchange rate change is almost entirely passed-through to export prices in the destination country's currency, the elasticity of exports with respect to the exchange rate is only around -0.7, which is much lower than the response to tariff changes or changes in firms' non-import-related costs. This limited response may arise from the irreversibility of export decisions coupled with the volatile nature of exchange rate changes (Ruhl et al., 2008). Essentially, why make a costly adjustments to purchasing patterns when the exchange rate change is likely to be reversed?

Turing to direct estimates of the effect of exchange rate changes on export and import volumes, many factors may be at play. Bussière et al. (2020), who provide estimates of the elasticities of trade flows and prices wrt exchange rates using bilateral trade flow data from 25 advanced and 26 emerging countries, covering from 1995-2012 for more than 160 trading partners, find the elasticities of trade quantities between 0.2-0.4. Similarly small responses are also found in highly disaggregated firm-level studies. For instance, Fitzgerald and Haller (2014), using customs and product-level production microdata from Ireland for 1996 through 2009, find that the elasticity of export revenue in euro with respect to the real exchange rate is around 0.5 on impact (short-run) and between 0.6 and 0.8 in the long run, while the elasticity with respect to tariff revenue was significantly higher at between -1.5 and -3.5 for the short run. As they note, 'This is consistent with a story where real exchange rate movements are perceived by firms to be less persistent than trade liberalization shocks, and there are market-specific costs of adjustment for continuing exporters as well as sunk costs of export entry.'

Berman et al. (2012), using the French firm-level data from 1995-2005, similarly find that the average elasticity of export volume with respect to the exchange rate is 0.4. They go on to find that these elasticities decrease as firm TFP increases, with one standard deviation above the mean TFP resulting in an export volume elasticity of 0.28, while the elasticity of export prices increase from 0.08 to 0.13: that is, more productive firms respond to exchange rate change by adjusting their markups more and their export volumes less. Furthermore, they find similar results by

firm size; larger firms absorb more exchange rate variations in their markups, specifically the export elasticity is 0.25 for the highest decile. These findings have implications for aggregate exports (trade quantities). Given that a very large share of aggregate exports is made by a small number of large, high performance firms, responses to depreciations may be correspondingly attenuated.[19]

Global Value Chains: The production of many goods and services is fragmented across the world. Exporting firms import intermediate inputs and export inputs that will be re-exported to another country by third country. This integration – i.e. global value chains (GVCs) – seems very likely to affect the relationship between the exchange rate change and export prices and volumes. There are several reasons why GVCs might attenuate trade responses. The most obvious reason is that following a depreciation of its currency, the costs faced by an input-importing exporter rise, thus curtailing its ability to reduce its foreign currency export prices. In essence a local exchange rate change can only change the foreign-currency value of local value added (the local contribution) and if this is a relatively small part of the overall cost of a good, the scope for a depreciation, say, to increase competitiveness is correspondingly reduced.

However, global value chains also introduce further complications. First, prices may be determined by long-run contracts. Second, if an exporter is selling parts to another part of the chain, it probably accounts for only a small share of the final cost of a good and thus the effect of depreciating its currency has only a small effect on the final price and demand. Third, to the extent that GVCs entail co-ordination with up- and down-stream partners, for example of specifications or length of runs, it will be more difficult to change the direction or level of sales in response to local exchange rate changes. While it is true that GVCs may ultimately be even more assiduous than other firms in minimising costs, these frictions may very well delay or attenuate responses in the short run.

Ahmed et al. (2016), focusing on the manufacturing sector for 46 countries over 1996-2012 show that the more heavily a country is involved in the global production process, the smaller the response of its aggregate exports to exchange rate change. In their preferred specification, they find that the elasticity of manufacturing exports with respect to the real effective exchange rate with zero participation in the global value chains is 1.11, falling to 0.87 for countries with the average global value chain participation and 0.79 at the 80th percentile. Using sectoral data from 40 countries and 33 sectors between 1995 and 2009, De Soyres et al. (2018) examines the role of GVCs on the export volume elasticity for exchange rate depreciation. They examined three mechanisms. The first is the foreign value-added index (FV index), usually studied in the

[19]Engaging in international trade and exporting needs a fixed cost of entry, making it harder for smaller firms; Bernard et al. (2007) show that only 4% of the 5.5 million firms in the US that were exporters, and among these, the top tenth of exporters accounted for 96 percent of total US exports.

literature where an increase in the share of foreign value added in export decreases the change in export prices and then decreases the change in export volumes. The second mechanism is the return domestic value added (RDV index) and the third is the intermediate value added (IV index)—exports used in another country to produce and further re-export to a third country.[20] They find that higher shares of foreign value added content of export (FV) and return domestic value added (RDV) both decrease the elasticity of export volume to bilateral exchange rate change. In other words, the RDV result shows that the response of export volume to exchange rate change will be lower if the final demand driving the export is located at home. On the other hand, De Soyres et al. suggest that the intermediate vale added index (IV) does not affect the responsiveness of export volumes.

4.3 Exchange Rate Change and Firm Export Entry, Exit

Does a change in exchange rate fluctuation influence firms' entry into or exit from foreign markets? This question is important because there are (at least) two dimensions to the response of aggregate exports to an exchange rate shock: how many firms buy/sell abroad and how much, on average, each does so. Several models explain why the former might be important; most of them revolve around the sunk costs of entering foreign markets (e.g. (Baldwin and Krugman, 1989; Campa, 2004)). Sunk costs may involve researching demand, modifying products, setting up legal cover and distributor networks, etc. A firm will enter a foreign market if the expected discounted total gross profit from selling there exceeds the sunk costs of entry. If profits have to be accumulated over several years to cover if sunk costs, the permanence or otherwise of an exchange rate change becomes a critical factor. Observe also that sunk costs create asymmetries between entry and exit. Reversing an exchange rate change that was large enough to drive a firm out of a market, will not necessarily entice it back in. Similarly the reversal of a change large enough to encourage entry may not lead to exit (Krugman, 1986).

Evidence on the so-called extensive margin – the number of firms trading – is mixed. Using French firm-level data, Berman et al. (2012) estimate the effect of exchange rate depreciation on the probability of a firm exporting to a specific destination, finding that the probability of exporters entering an export market increases by 1.8 percentage points for a 10% depreciation of the exporter currency (euro).[21] On the contrary, Greenaway et al. (2007), using the UK manufacturing firm-level data from 1988 through 2004 find that the effect of exchange rate change on firm entry and exit is small. Fitzgerald and Haller (2018), on the other hand, using Irish customs

[20] The global value chain participation indices are constructed at bilateral country-sector-by-destination, based on currencies, not on countries

[21] Their sample comprises all French firms that export at least once over the sample period; because this omits 'never-exporting firms' the estimates could be an upper bound.

and product-level production microdata, estimated a significant effect of real exchange rates and tariffs on firm entry decisions. They find a statistically significant effect of exchange rate changes on firm entry but it that the exchange rate effect is only a third of that on tariff changes; they also find no significant effect on firm exit. Campa (2004), using Spanish manufacturing firm-level data, estimated the contribution of the intensive and extensive margins on aggregate export supply due to change in exchange rate. He finds that the majority of trade quantity adjustment occurs through existing exporters (intensive margin) rather than the extensive margin. Specifically, Campa (2004) estimates that the export elasticity to exchange rates is 0.77; with the intensive margins contributing 0.63 (82%) and the extensive margin 0.14. All these studies agree that the contribution of the extensive margin to the total trade effect is small, because new entrants are small and less productive than incumbent exporting firms.[22]

4.4 On the balance of trade:

Combining the estimates of the elasticities of exports and imports with respect to the exchange rate offers some insight into the responsiveness of the balance of trade—the difference between the monetary value of exports and imports over a specified time. In fact, doing so was the essence of more or less the first theory of the balance of trade – the so-called Marshall-Lerner condition which argued that the sum of the export and import elasticities had to exceed one for a depreciation to improve the balance of trade. Thus, for example, Bussière et al. (2014) provided the estimates of elasticities of the trade balance with respect to the exchange rate using highly disaggregated bilateral trade flow data from 25 advanced and 26 emerging countries, covering approximately 5000 HS6 products from 1995-2012. Overall, following depreciation they find improvement in the trade balance for all advanced and emerging countries in their sample, Similarly, for the aggregate data, Leigh et al. (2017) found that a 10 percent real effective depreciation in an economy's currency is associated with a rise in real net exports of, on average, 1.5 percent of GDP, with substantial cross-country variation around this average.

This approach to the balance of trade has fallen into disuse, however, superseded by Alexander (1952)'s Absorption Approach, which expresses the trade balance as the difference between a country's production and absorption of goods and services. This macroeconomic view has underlain virtually all subsequent discussion of depreciations and the trade balance and gave us the deep insight that a depreciation will improve the trade balance only if it can increase production and/or reduce absorption. We have not discussed this above, but it implies a connection between

[22] Although not directly related with the effect of exchange rate change on entry/exit, Crowley et al. (2019) estimated the effect of trade policy uncertainty on firm entry and exit, and its implication for total aggregate export volume. They find that in 2016 entry (exit) would have been 5% higher (6.1% lower) if firms exporting from the UK to EU had not faced increased trade policy uncertainty after the 2016 Brexit referendum.

the import and export elasticities that apply to any specific depreciation and hence the estimates of elasticities across many depreciations. Very loosely speaking, a strong export response to depreciation is likely to require the pre-existence of spare capacity in order that production can be easily increased.

Summary Table

Table 1 and Table 2 below reports summary of selected reviews result on exchange rate pass-through to both trade prices and quantities. Table 1 reports studies that use aggregate (macroeconomic studies)—that estimates the effect of the change in exchange rate on aggregate trade prices and flows. Table 2 reports summary of studies that use firm level and industry level studies—that estimates the impact of exchange rate change on trade prices and flow at highly disaggregated level, usually at firm level. The table presents results in terms of elasticity.

Table 1: Table 1 Macroeconomic studies

Authors	Data	Sample Period	Prices			Quantities	
			Import	Export	Consumer	Imports	Exports
Bussiere et al 2016	51 countries	Annual 1995-2012	0.48	0.65		0.245	0.347
Campa and Goldberg (2005)	23 OECD countries	Quarterly 1975-2003	0.46 (short run)				
Campa and Gonzalez (2006)	12 Euro Area Countries	Monthly 1981:1-2001:3	0.62 (short run) 0.78 (longrun)				
Cheikh and Rault (2016)	12 Euro-Area	Quarterly 1990-2012	0.43(short run) 0.55 (long run)				
Leigh et al (2015)	60 countries	1980-2014	0.58	0.455		0.258	0.26
Ihrig et al (2006)	G-7 Countries	Quarterly 1975:1-2004:4	1990-2004; U.S. (0.32), U.K (0.59)		1990-2004;U.S.(0.019) U.K (0.042)		
Marazzi et al (2005)	US	Quarterly 1980-2004	0.5 (For the 1980s0) 0.2 (For the 2000s)				

Table 2: Table 2 Microeconomic and industry studies

Authors	Data	Sample Period	Import Prices	Export Prices
Export Quantities				
Amiti et al (2014)	Belgium firm level	2000-2008		0.203
Auer and Schoenle (2016)	US import	1994-2005	0.1476	
Auer et al (2018)	European Car market	1970-1999		0.171
Berman et al (2012)	French Firm level	1995-2005		0.084
0.4				
Bernhofen and Xu (2000)	US petro chemical imports Germany and Japan	1982-1993	Germany 1.00	
			Japan 0.64	
Bloingen and Haynes (2002)	US imports of iron and steel from CA	1989-1995	0.349	
Chatterjee et al (2013)	Brazilian customs level	1997-2006		0.23
0.264				
Fitzgerald and Haller (2014)	Ireland firm level	1996-2009		
0.5				
Fontagne et al (2018)	French Firm level	1996-2010		0.03
0.659				
Goldberg and Verboven (2001)	European Car market	1980-1993		Average 0.46
Pollard and Coughlin (2005)	29 US manufacturing industries	1978: 200Q4	0.256 (2 digit)	
			0.381(3 digit)	

5 Understanding the UK Economy Response to Exchange Rate Changes

The immediate effect of the "leave" result of the Brexit referendum was the major depreciation of sterling relative to all major currencies, and the depreciation has persisted since then. The depreciation was widely expected to boost the UK export sector even if it also increased prices at home. In the event, the export boom never materialized (Corsetti and Dedola, 2005; Economist, 2017),[23] although the increase in import and consumer prices did. In this section we ask whether, in the light of the discussion above, these outcomes really should have been a surprise. Section 4 identified both the generally weak responses of trade quantities to exchange rate movements and also several specific factors that exacerbate that tendency. We consider whether these findings are sufficient to explain UK experience or whether we need to seek some additional factor. Thus, in this section, we revisit global value chains, the nature of UK exports and firms' currencies of invoicing from a UK perspective and then add in trade policy uncertainty as a possible additional factor. The general literature has been discussed, so here we focus exclusively on recent studies of the UK.[24]

5.1 Global Value Chains

Production of goods and services are increasingly fragmented across the world with firms specializing in a particular stages in the production of goods and services (IJtsma et al., 2018). The UK is no exception. OECD (2020) reports that, in 2016, the UK's average import content of gross exports was 15.4%.[25] Figure 5 shows the share of UK inputs from abroad by industry. The share is high in broad sectors such as manufacturing (30%), mining (26%) and health (25%), and higher still in particular industries - 50% in computers and electronics and nearly 40% in motor vehicles (IJtsma et al., 2018). Such integration into global value chains makes firm exporting less responsive for exchange rate change. The competitive advantage firms gained after sterling depreciation is partly offset by the rise in import costs. Costa et al. (2019) show that firms and sectors which are more involved in the global value chains experienced lower wage growth and greater reduc-

[23] Many commentators expect depreciation to take a long time to work through, as firms may need time to find new buyers or new markets to exploit their new competitive advantage. However, while this may be true for quantities, pass-through to prices is generally held to be a fairly rapid phenomenon. Moreover, we now have more than three years' data and there is still no boom.

[24] We should also note that Japan has also experienced a similar outcome with UK. The Japanese yen lost more than 20% of its value by the end of 2012, and yet it never got an export boom, export volumes actually falling by 1.5% in 2013 and by 0.4% between January and August 2014 (Economist, 2014).

[25] However, compared with other EU countries, the share of foreign value added in the total UK exports is lower, the share of domestic value added in the total UK export is one of the highest in Europe, and it has been growing overtime (IJtsma et al., 2018)

tions in training programs than did other firms, because, they infer, the depreciation of sterling increased the cost of imported intermediate inputs.

Some have argued, however, that the UK's share of foreign value added is low compared with other EU countries, and that, in fact, it has been falling recently (IJtsma et al., 2018). This is true, but it is not the comparison we require for understanding the depreciation of sterling. Most EU member states have very high integration with each other, and most intra-EU trade is denominated in Euros. Thus, while high shares of member states' inputs are imported from outside their borders, the shares denominated in foreign currencies are significantly lower. Thus among the larger European economies, on which much of the pass-through literature is based, the UK is among the most vulnerable to rising input costs following a depreciation.[26]

Figure 5 illustrates the point: figure 5A refers to the UK's shares of total inputs that are imported broken down in to EU and non-EU sources; Figure 5B gives the same for Germany. Germany is, indeed, more dependent on imported inputs but only 8.8% of them come from outside the EU and of the 15.4% that come from the EU, only 3.4% are not denominated in Euros. Thus, Germany has exchange rate exposure on around 12.2% of its inputs. For the UK, on the other hand, the entire import bundle is exposed – 18.6% in all.

This suggests that the relative failure of the depreciation to reduce UK foreign-currency prices and stimulate exports has some basis in in the UK's integration into non-sterling value chains, but that the effect does not seem likely to be much stronger than is observed in Europe.

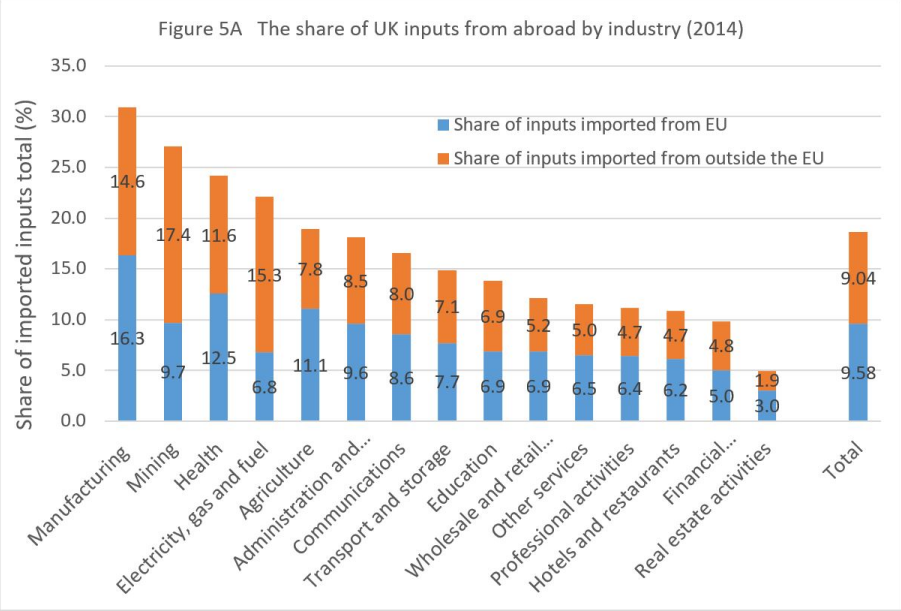
5.2 The UK Export Bundle

Atkeson and Burstein (2008) present some evidence that the pass-through of local exchange rate changes to export prices and exports will be lower for products with lower elasticities of demand. And, indeed, Fernandes and Winters (2018) find evidence of this for Portuguese exports to the UK after the referendum. Thus, the UK is concentrated on high value-added sectors such as professional services and pharmaceuticals, which typically have low elasticities of demand, it has been suggested that this could explain its lower than average low pass-through in the post-referendum period. However, at least looking at goods the UK actually includes a small share of high tech goods in total goods exports than either France or Germany (19% compared with 22% and 20% respectively).[27]

One piece of more direct evidence on price elasticities, is Broda et al. (2017), who estimate the price elasticity of substitution for exports for around fifty countries: the UK's is the lowest recorded. This is suggestive of somewhat weaker responses to depreciation among UK exporters,

[26] For example, in 2014, the shares of inputs imported from countries using a different currency are Italy 9.1%, France 11.1%, Germany 13.4%, and the UK 17.9%, data based on Timmer et al. (2015) (2015).

[27] Estimates from WITS based on Lall (2000) – an arguably rather dated set of definitions.



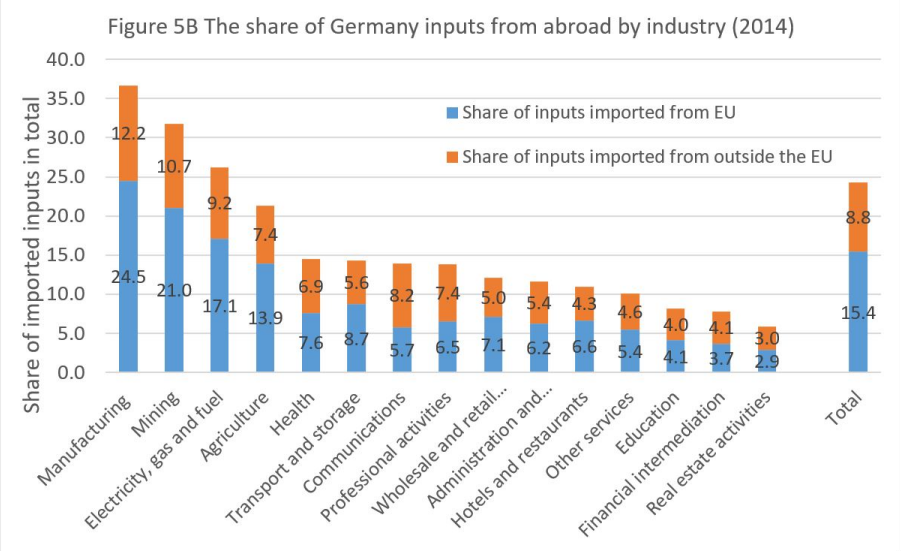


Figure 5: Share of imported inputs by broad industry

but Broda et al.'s exercise is completely different from a pass-through estimation, and so may not be perfectly applicable to our case.

5.3 Export Prices Adjustment and Trade Volume

One of the reasons why the sterling depreciation is expected to boost export volume arises from the price competitiveness advantage as the UK firms sell their products at cheaper prices in the foreign market. Using customs data on the universe of UK export and import transactions over the period 2010-2017, Corsetti and Dedola (2005) dispute this. They write '[b]y the end of the 2017, ... UK export prices in the currencies of the destination markets were essentially unaffected by the Brexit depreciation.' The authors do, however, find that different invoicing practices generated quite different patterns of price adjustment between June 2016 and December 2017.[28] Figure 6 illustrates with figures for exports invoiced in sterling (A), Local currency (B) and dollars (C). For all figures, the x-axis shows the number of weeks before and after the Brexit referendum, and the y-axis the percentage change in the UK export prices relative to June 2016 measured in sterling (blue) and foreign currency-sterling exchange rate (red), both normalized to zero in the weeks of the Brexit referendum. (The figures are adjusted to have the same vertical scale.)

The figures show that for the first few weeks (approximately a month), there is no change in the sterling export prices across any of the currencies of transaction, implying price in the importing country currency declined 1-to-1 with exchange rate. Corsetti et al. attribute this to having to submit customs forms in advance. Subsequently, however, the export price response becomes different across currencies of invoicing. For goods invoiced in sterling (Figure 6A), export prices in sterling increase gradually over the next 65 weeks, fully reflecting the depreciation only thereafter. The authors suggest that the gradual change in export prices for sterling-invoiced transactions is probably due to increases in marginal costs and in markups. Figure 6B shows the price response of goods invoiced in the local currency (destination country currency). Goods invoiced in importer currency adjusted fully after six weeks and after 36 weeks appeared to increase by more than the amount of the depreciation, probably reflecting increased input costs or increased mark-ups. Figure 6C shows the export price response of goods invoiced in vehicle currency (the dollar). The price response pattern is similar to that for local currency invoicing: full adjustment (i.e. no pass-through to importers) after about six weeks and staying aligned with sterling prices thereafter.

These results show that after a year and a half, UK export prices in destination currencies

[28] They find that while firms tend to invoice different transactions in different currencies, for a given (firm, product, destination) triple changes are fairly rare.

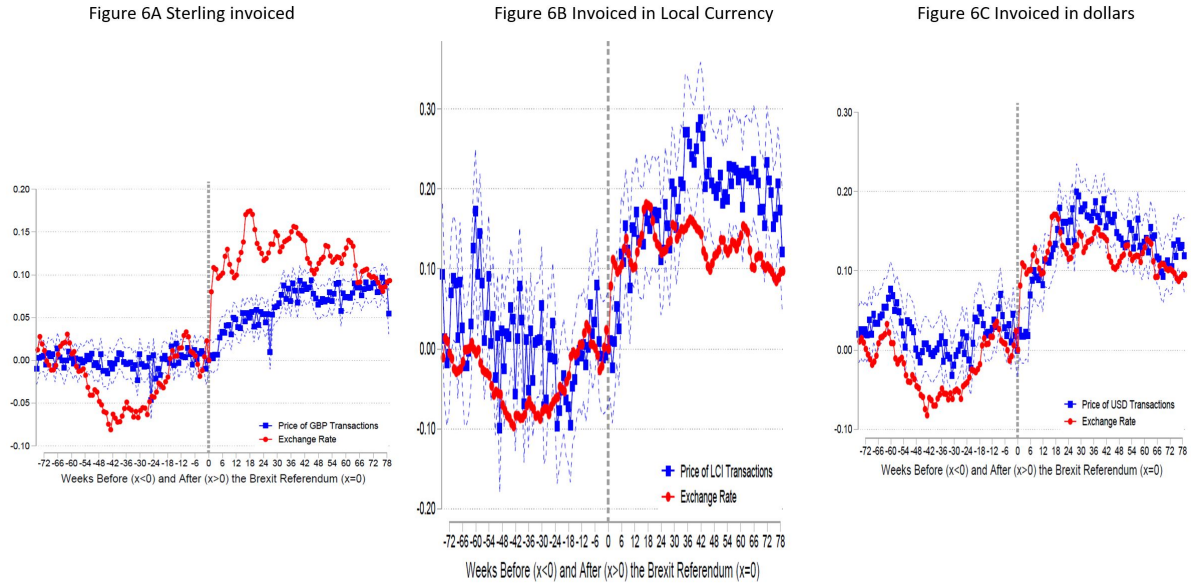


Figure 6: Price adjustments for UK exports following depreciation in June 2016, (week 0)
Source: Corsetti et al (2019)

were essentially unaffected by the Brexit depreciation. For very simple (commodity) goods one might expect exports to expand during the period of incomplete pass-through, but recognising that building up export markets requires extra costs and long-term commitment, one can see why the UK's relatively sophisticated export bundle did not show such behaviour. The studies above suggest that an exporting country's depreciation generally induces a nearly full pass-through to export prices in the purchaser's currency. Corsetti et al.'s results for the UK are at the top of this range, but not hugely out of line. They suggest that UK exporters possibly took slightly less advantage of the post-referendum depreciation than one might have expected.

Turning to import and consumer prices, Chen et al. (2019) examine the pass-through of the depreciation of sterling to UK import prices, also using highly disaggregated transaction-level customs data for the UK imports from non-EU countries over 2010-17. They find that the largest long-run pass-through elasticity (approx. 0.7) pertains to goods invoiced in producer currencies, while that for goods invoiced in vehicle currencies is about 0.6, provided that the estimates are corrected to take account of the depreciation relative to the vehicle currency and that for goods invoiced in sterling about 0.1. The short-run elasticities are similar: 0.62, 0.6 and 0 respectively. They argue, following Gopinath et al. (2010), that their results suggest that choice of currency of invoice is endogenous. Firms decide how much pass-through they are willing to offer in the

UK and then choose to invoice in sterling for low pass through and other currencies for high. Based on their estimates of pass-through, Chen et al. estimate that the 10 percent depreciation in 2016 should have raised average import prices by 2.9 percent by mid-2018. This is a lot less than would be suggested by the studies described above from other European countries, and it is also less than the actual change in import prices – 7.61% from July 2016 to June 2018.[29]

Breinlich et al. (2019) calculate the effects of the depreciation on UK consumer prices recognising both the direct consumption of imported goods and the use of imported inputs in domestic production.[30] Their empirical strategy exploits differences in product-level exposure to import costs. Two alternative specifications are estimated, the first being an event specification that regresses changes in consumer prices at product group levels over 2016-2018 on import shares—a measure of the cost of imports in consumer expenditure that accounts for both direct import consumption and indirect consumption of imports embodied in domestically produced goods and distribution services —interacted with a treatment dummy for the Brexit referendum. The second specification is to regress changes in consumer prices at product group levels on import shares interacted with the log difference of the exchange rate and its lags using quarterly data from 2011Q1 to 2018Q2. Their results are consistent with complete pass-through of import costs to consumer prices and imply an aggregate exchange rate pass-through of 0.29. Given the 10 percent depreciation, they estimate that the Brexit vote increased consumer prices by 2.9 percent, costing the average household £870 per year. This corresponds almost exactly to the growth in prices over the 18 months following the depreciation – see figure 4 above.

5.4 Trade Policy Uncertainty

The exchange rate shock was not the only consequence of the Brexit referendum; it also created severe uncertainty. It initiated a negotiation about the future trade relationship between the UK and the EU that is yet to be resolved, and thus created considerable uncertainty about the 47% of UK exports and 53% of UK imports that are to/from the EU. The lack of an export boom may reflect not only weak exchange rate responses, but also the uncertainty associated with the UK future trade and economic policy. As figure 7—the monthly economic policy uncertainty index of the UK—shows, the index spiked before and after the referendum, and then remained persistently above the 2015 level.

A recently emerging theoretical and empirical literature establishes that trade policy uncertainty has a significant impact on trade. Handley and Limao (2015) developed a model to examine the impact of trade policy uncertainty on a firm's decision to invest and export in a

[29]The import price index data is from the IMF's international financial statistics.

[30]This study does not test for pass-through to import prices, but assumes it and follows it though the economy to consumer prices.

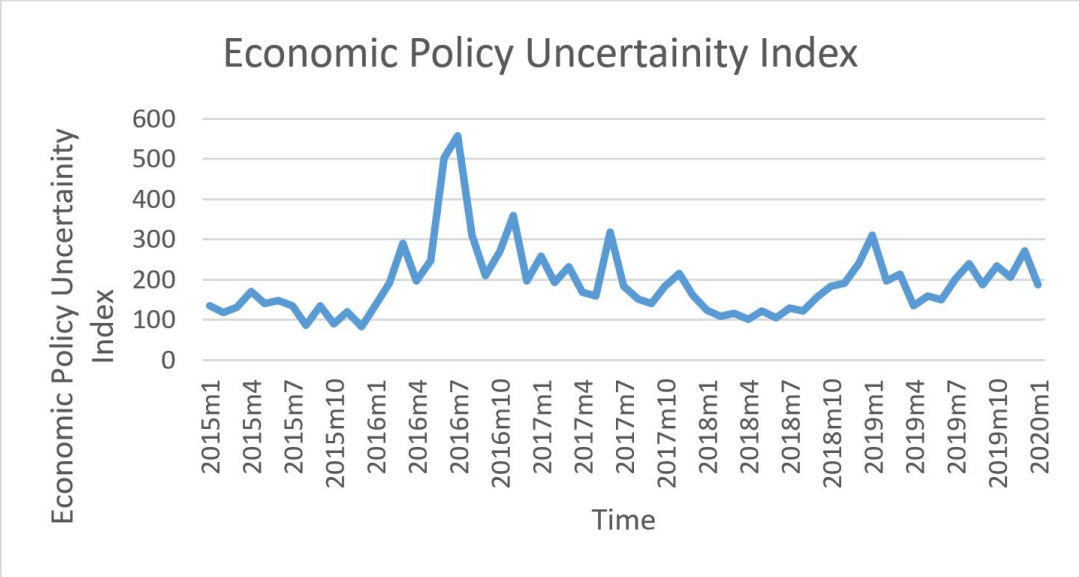


Figure 7: Economic Policy Uncertainty Index, UK (Monthly data)[31]

new market under trade policy uncertainty. They find that Portugal's accession to the European Community (EC) in 1986 increased the number of Portuguese firms' entry and sales in the EU market, mainly due to the removal of trade policy uncertainty.[32] Pierce and Schott (2016) showed the trade-increasing effects of the removal of US trade policy uncertainty for China, measured by the difference between the potential tariff rate if the US Congress had failed to renew annually China's access to MFN tariff rates (Non-Normal Trade Relations, non-NTR) and the MFN rates that were locked in by Permanent NTR in 2000. The latter were further reinforced by China's accession to the WTO in 2001. The accession did not change tariff rates at all but removed the uncertainties associated with its annual renewal by US Congress, thus increasing the incentives for the US and Chinese firms to incur the sunk cost associated either with shifting production to China or of investing in entering or expanding into the US market. Similarly, Handley and Limao (2017) find that 1/3 of the Chinese export boom from 2000-2005 is explained by the reduced threat of trade war from the US when they joined the WTO. Crowley et al. (2018), using the Chinese customs transaction data between 2000 and 2009, analysed the impact of an increase in uncertainty about future tariff rates on firms' decisions to enter into and exit from export markets. They find that firms are less likely to enter and more likely to exit foreign markets when their products are subject to increased trade policy uncertainty.

[32]They showed that around 61% of export entry growth and 87% of growth in export values is due to the elimination of trade policy uncertainty associated with the accession of Portugal to the European Community.

Two recent studies examine the effect of Brexit-related Trade Policy Uncertainty (TPU) on UK trade. First, in a post-Brexit analysis, using a generalized difference-in-difference strategy, Crowley et al. (2019) estimate the impact of trade policy uncertainty (i.e. trade agreement renegotiation) on UK firms' decisions to participate in the export market in 2016 relative to 2015. The empirical analysis is conducted using the universe of foreign transactions from HRMC oversea trade statistics. The unique feature of the UK trade renegotiation is that failure to reach agreement is not, as it usually is, the continuation of the status quo, but a significant increase in tariff rates. Crowley et al., measure the uncertainty by the level of the EU's MFN tariff which would apply if the renegotiation failed and trade reverted to the EU's World Trade Organization schedule of tariff commitments. They find that the uncertainty affected the extensive margin of UK exports to the EU. Specifically, they find that firms' entry (exit) in 2016 would have been 5% higher (6.1% lower) if firms exporting from the UK to EU had not faced increased trade policy uncertainty after 2016. They do note, however, that entry/exit has little effect on the total volume of exports because new entrants and exiters are generally small and less productive than incumbent firms.

Crowley et al show that their findings are not driven by the depreciation of sterling. They estimate the exchange rate pass-through to export prices at the 2-digit HS sectoral level and add this into the baseline tariff regression. Similarly, to confirm that the result is not driven by product-specific global demand shocks, they implemented a generalized triple difference comparing firm entry and exit to the EU in 2016 relative to 2015 across different products relative to non-EU countries. Specifically, they find that changes in entry into and exit from export markets reduced total exports by between £394 million and £3.0 billion in 2016.

Graziano et al. (2018) show that even before the Brexit referendum in June 2016, the uncertainty about the result of the referendum affected trade between the UK and EU. They find that an increase in the probability of Brexit (uncertainty about future trade policy), measured by the betting market's odds, decreased the UK-EU export and net export entry.[33] Specifically, the effect is stronger for products which could potentially face higher protection (above the median MFN tariff) if post-Brexit trade negotiations collapsed. They also find that the effect was stronger in industries with higher sunk costs. In summary, their analysis shows that the uncertainty associated with Brexit had already reduced the UK-EU bilateral trade flow even before the referendum. The data they used are bilateral monthly trade data between the UK and the EU at the 6 digit product level of HS between august 2015 to June 2016.

This section has asked whether the responses of prices and exports to the post-referendum depreciation of sterling should be viewed as disappointing given existing analyses of exchange rate pass-through and export performance. It is too early to say definitively. However, the UK's

[33] As a measure of Brexit uncertainty, they used the average daily price of a contract traded in PrecitIt.org, where it pays $1 if the majority voted for Brexit referendum and zero otherwise.

relatively heavy involvement in international value chains is one reason to expect significant pass-through to UK consumer prices and also attenuated export responses. Low elasticities of demand for UK exports would also suggest a weak export response, but currency of invoice of exports appears to have little role in the longer-run. Overall, however, we conjecture that these factors are not sufficient to explain recent UK export experience, and so would conclude that some part of the weakness in the growth of exports does reflects the dramatic increase in trade-policy uncertainty that the Brexit referendum result heralded.

6 Conclusion

On 23 June 2016, Britain voted to leave the European Union, resulting in an immediate and persisting depreciation of sterling relative to all major currencies. Although the sterling depreciation was expected to boost UK exports, the export boom never materialized. We ask whether this should have been a surprise?

We first review a selection of the literature encompassing both macroeconomic approaches and microeconomic studies on the effects of exchange rate changes on import prices, consumer prices, export prices and trade quantities over the recent decades. In nutshell the general findings are (1) in the long run, depreciations generate rather small changes in a country's export prices measured in foreign currency terms; (2) the prices of imported goods tend to rise after a depreciation, but a bit less than proportionately with the depreciation; (3) consumer prices rise a good deal less than import prices; (4) trade quantities are rather unresponsive to exchange rate changes, proportionately much less so than they are to equivalent changes in tariffs or costs of production.

In examining the UK experience after June 2016, we find that the weakness of the export boom after the sterling depreciation was not wildly out of line with what the literature suggests. We also argue, however, that it was also at least partly due to the huge increase in uncertainty about UK trade policy that accompanied the depreciation. The shock referendum result that precipitated the depreciation of sterling also, at a stroke, put in severe doubt the unfettered access to the EU market that UK businesses had taken for granted. Recent scholarship has demonstrated that the uncertainty associated with prospective adverse changes in trade policy is antithetical to trade. Thus, in general the failure of UK exports and export prices to respond to the depreciation of 2016 was partly due to certain structural features of the UK export sector but also significantly affected by the major increase in economic uncertainty.

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