The bilateral trade effects of announcement shocks

Citation for published version:
Douch, M & Edwads, TH 2021, 'The bilateral trade effects of announcement shocks: Brexit as a natural field experiment', *Journal of Applied Econometrics*. https://doi.org/10.1002/jae.2878

Digital Object Identifier (DOI):
10.1002/jae.2878

Published In:
Journal of Applied Econometrics

The Bilateral Trade Effects of Announcement Shocks: Brexit as a Natural Field Experiment

Mustapha Douch* T.Huw Edwards†

16th June 2021

Abstract

We analyze the effects of uncertainty and anticipation shocks associated with the 2016 Brexit vote as a treatment on trade between the UK and 14 EU and 14 non-EU trading partners, using the Synthetic Control Method (SCM). After controlling for exchange rate and GDP changes, UK exports to both groups of countries fell below those of the 'synthetic Britain', with much of the shortfall developing over the year prior to the referendum, following the 2015 Conservative general election win. The results indicate that UK exports to EU countries may have lost nearly 25% by early 2018, due to the Brexit shock, somewhat more than those to non-EU countries. Imports from the EU and non-EU countries also declined a little, although there is tentative evidence that UK consumers may have been avoiding countries with PTAs with the EU, and possibly turning towards the Commonwealth. Overall, the results confirm that policy uncertainty has a major effect upon trade, and that uncertainty about supply chain costs is a potential explanation for at least some of the shortfall.[1]

JEL Codes: F02, F13, F15

Keywords: Anticipation, policy uncertainty, Brexit, synthetic control method.

*The University of Edinburgh, Business School, UK

†Loughborough University, UK.

[1]The authors thank Christian Soegaard for work on early stages of this paper, as well as participants in the ETSG 2018 conference in Warsaw, the 2018 LSE conference on the Economic Performance of Brexit, the 2018 AMEF conference in Thessaloniki, the 2019 GPEN spring conference in London, the 2019 Africa meeting of the Econometric Society in Rabat, participants in workshops at Aston, Loughborough and Warwick, and Nuno Limão for advice. Also the editor and anonymous referees at this journal, who provided useful advice. Any errors are our own.

1 Introduction

In this paper, we focus upon the trade effects of the decisions by the United Kingdom in 2015-16 to hold a referendum, and subsequently to leave the European Union. In particular, we examine the changes in export and import flows between the UK and several EU and non-EU countries, using the synthetic control method (SCM) (Card 1990, Abadie & Gardeazabal 2003, Abadie et al. 2010, Saia 2017) to compare British trade flows, 'treated' by the Brexit shock, with a 'doppelganger' based upon trade flows elsewhere. We cover the period up to March 2018. Even though no formal trade barriers had been imposed, we already find considerable negative effects upon British exports: not just to the EU, but also to non-EU countries, possibly indicating fears about supply chain costs. In addition, in common with Graziano et al. (2018) and Douch & Edwards (2021), we find significant effects even in the months before the referendum, indicating that, despite the relatively low odds cited on a Leave win, trade was already being deterred, showing the importance of policy uncertainty in trade (Handley & Limão 2017).

The relative surprise of the 23 June 2016 referendum result is clear, from both the betting odds and the financial markets. In just seven hours, Sterling fell by 8.6% against the Euro and by 11.91% against the Dollar.[2] Politically, the referendum led to the immediate resignation of Prime Minister David Cameron, and a government commitment to leave the EU. New Prime Minister Theresa May invoked Article 50 on 29 March 2017, starting a two year negotiation/implementation period, which ended up being extended. Despite this, we argue that the Conservative general election victory in 2015, with the commitment to hold the referendum, provided at least as important a surprise to firms, in its impact on trading behaviour.

The rest of our paper is structured as follows. In section 2, we lay out some of the literature on trade agreements, disintegration and announcement shocks. We then consider potential mechanisms by which anticipation of trade barriers can affect various trade flows. Section 3 discusses our modelling approach, and the SCM analysis of the Brexit vote treatment effect, including testing for statistical significance. Section 4 lays out our our data sources. In Section 5 we focus in turn on the results for UK exports and imports to/from both EU and non-EU countries. We find clear evidence of a downward shift in Britain's exports. This fall is larger - in the order of 20-25% - for exports to the EU, but also 10-15% to non-EU countries. Much of the fall, particularly in exports to the EU, happened in the months prior to the

[2] Davies & Studnicka (2018) find significant stock market volatility immediately following the referendum, which is more marked among firms involved in supply chains with Europe.

referendum. This result is new compared to other SCM studies and is arguably consistent with analysis of the period by Graziano et al. (2018). UK imports showed a smaller fall. Section 6 carries out several further robustness checks: e.g. tests of the treatment date, allowing EU countries to be used in the donor pool, using a larger donor pool (by shortening the fitting window), extra confounding variables, the use of a difference-in-differences test and inclusion of dynamic exchange rate adjustment. Section 7 concludes.

2 Literature Review and Discussion of Hypothesized Mechanisms

There is a sizeable literature measuring the effects of preferential trade agreements (PTAs) upon trade, primarily in the form of structural gravity models (Head & Mayer 2014). Baier & Bergstrand (2009) pioneered the use of difference-in-differences gravity modelling techniques, showing that PTAs have larger effects than previously thought. There has been less work on dynamic anticipation effects of agreements, although Freund & McLaren (1999) show that trade flows change in anticipation of agreements.

The study of announcement and uncertainty effects has been formalized theoretically by Handley & Limão (2017), who focus on the real or quasi-option value of delaying market entry when policy changes have not been finalized. Other relevant studies include Osnago et al. (2015), who found that policy uncertainty has an average effect on trade equivalent to a tariff of 1.7 to 8.7%. Other studies find that trade agreements help reduce policy uncertainty (Limão & Maggi 2015 and Carballo et al. 2018).

Studies of divorces are less common, although Head et al. (2010)'s study of the trade effects of colonial breakup is well-known. Nevertheless, several macroeconomic studies of Brexit (Ebell & Warren 2016, Steinberg 2019, Dhingra et al. 2017), have stressed the risks to the UK economy of a 'hard' deal. Vandenbussche et al. (2017) also finds significant negative effects for remaining EU countries.

The inclusion of uncertainty and announcement effects in this literature is recent, and linked to the Brexit announcement shock. Key papers include studies of the goods market by Crowley et al. (2018), Graziano et al. (2018), Douch et al. (2020), Douch (2020), Graziano et al. (2020*b*), Crowley et al. (2020), Graziano et al. (2020*a*) and of services (Ahmad et al. (2020) and Douch & Edwards (2021)). While some of these papers look at firm-level entry decisions and others at product-level effects, all found evidence of a deterrence effect of the uncertainty and anticipated trade costs.

Yet more studies have found macroeconomic costs in anticipation of leaving, such as Born et al. (2019)'s study of GDP effects, or Breinlich et al. (2020)'s study of FDI, both using SCM.

2.1 Potential economic mechanisms for a Brexit announcement shock effect: effects of anticipated demand shocks upon supply

The papers above focus primarily upon the effects during a *renegotiation period* (Crowley et al. 2018) of *anticipated future barriers*. Subjective probabilities are attached to various tariff and non-tariff trade cost outcomes. In the case of Brexit, potential costs have included MFN tariffs, Technical Barriers to Trade, Sanitary and Phytosanitary Standards and border costs from checking delays and rules of origin.

Anticipated future costs will affect firm behaviour if there is an intertemporal aspect of firms' trading costs. While anticipated shifts in the demand side are a key driver, supply may start adjusting in advance (hence, we term it an 'anticipated demand shock effect upon supply'). This is classically the case with the extensive margin of trade, since a firm entering an export market will incur fixed costs (Melitz 2003), which may well be largely sunk. In the absence of any expected shock, a firm f, with efficiency ϕ_f, will enter if the present value of entry,

$$PV_f = \int_{t=0}^{\infty} e^{-rt} R_f\{\phi_f\} \partial t - I, \tag{1}$$

is positive, where revenue, $R_f\{\phi_f\}$ is increasing with respect to ϕ_f, while I is the sunk entry cost.[3]

Now, we introduce a renegotiation period, until a decision time $T > 0$. For simplicity, assume that, with probability (π) revenue will be reduced after T by proportion k, while otherwise there is no loss. Consequently, the present expected value of entry,

$$PV^E_{f,shock} = \int_{t=0}^{\infty} e^{-rt} R_f\{\phi_f\} \partial t - \pi k \int_{t=T}^{\infty} e^{-rt} R_f\{\phi_f\} \partial t - I, or \tag{2}$$

$$PV^E_{f,shock} = \left[1 - \pi k e^{-rT}\right] \int_{t=0}^{\infty} e^{-rt} R_f\{\phi_f\} \partial t - I. \tag{3}$$

The risk raises the threshold entry value of ϕ_f, reducing entry, and this effect increases with π and k, and decreases with respect to r and T.

[3] Note that with a constant expected growth path in the absence of a shock, we can subsume the growth rate and depreciation into the interest rate, r.

In many cases, firms may also be able to delay an entry decision. Assuming zero cost of delay, the quasi option value of delaying entry to T ,

$$V_{f,delay} = (1-\pi)e^{-rT}PV_f - PV^E_{f,shock}, \tag{4}$$

is the probability weighted discounted value of entry at T, minus the present value of entering now and taking the risk. Note that a firm for whom $PV_{f,shock}$ is very small will always prefer to delay entry, to avoid risk. Hence, the relevant threshold for entry is the value of ϕ_f which sets $V_{f,delay} = 0$, and a higher proportion of entry will be deterred than implied just by the effect of risk-weighted profitability. Differentiating equation 4 with respect to T also shows that deterrence increases sharply when T is close. We term this the 'looming deadline effect'.

Sunk costs may affect more than just firms' entry decision: exit may be affected, for example where sunk expenditures associated with interfirm trading relationships require renewal. The intensive margin (sales per firm) may also be affected: for example, firms already in a market may expand their sales by (sunk) marketing expenditure (as in Sedláček & Sterk (2017)), or by searching for new partners and building relationships. In either case, policy uncertainty may deter or delay expansion of the intensive margin of trade.

Policy uncertainty will affect both the UK's exports to and imports from the EU, since there are anticipated barriers in both directions. Moreover, Brexit potentially affects UK trade agreements with EEA members and the numerous non-EU countries which have PTAs with the EU or are negotiating them (Graziano et al. 2020*a*): obtaining rollover of such agreements has been a key UK trade objective.

We should also mention possible 'sentiment effects'. In the immediate aftermath of the Brexit vote, consumer spending in the UK actually rose, probably reflecting sentiment among Leave voters, raising the possibility of a sentiment shift in the UK towards non-EU (and particularly Anglosphere or Commonwealth) produce. We examine this in Section 5.6.

2.2 Indirect (supply side/supply chain cost) effects

Costs imposed upon imported inputs will potentially push up supply chain costs in the UK[4]. A good example is the motor industry (Bailey & De Propris 2017). Supply chains, which had been organized on a

[4]Costs in the EU27 are expected to rise by a lesser but significant degree, see Vandenbussche et al. (2017).

just-in-time basis, will be particularly vulnerable to border delays. Apart from individual industry studies, research on this has tended to utilize input-output analysis (Vandenbussche et al. 2017), or computable general equilibrium modelling (Dhingra et al. 2017): however, these have focused on longer-term effects, rather than anticipation and uncertainty effects before exit. A similar point applies to studies indicating lower long-run productivity in the UK from the loss of the dynamic gains from trade (Van Reenen 2016).

Another suggested mechanism affecting UK competitiveness is a fall in inward FDI. However, while Breinlich et al. (2020) find large falls in FDI in the UK following the referendum, these were concentrated in services, not the goods industries which we study here. Consequently, we might expect that this would not be a primary driver as yet for goods trade series.

2.3 Macroeconomic effects

As noted in the introduction, the June 2016 referendum led to an instantaneous downward adjustment in Sterling[5]. While expectations of UK monetary policy easing may have played a part, the fall seems consistent with an expectation of a long-term fall in the real return to UK factors of production, which would be expected with the introduction of significant costs on trade with Britain's main partner, the EU.

Indeed, general equilibrium theory would indicate a fall in UK factor returns in response to trade barriers, allowing trade to be redirected to new, non-EU markets. Note that this is not a rise in the demand schedule for UK exports to non-EU markets (at least in terms of non-UK currency). Consequently, if we are looking at changes in demand and supply for UK produce (other than the effects of a fall in real returns to UK factors), we need to correct for exchange rate effects.

A further macroeconomic effect is that most forecasters indicated that Brexit would cause a significant fall in GDP: this would be expected to reduce the UK's imports substantially from all sources and might well also reduce UK exports (as gravity models would indicate).

[5] In the $4\frac{1}{2}$ years since, there has been virtually no recovery of Sterling against the Euro, although some of the losses against the Dollar were recovered during the Trump presidency.

2.4 Summary of the various effects, and scope for contribution from an SCM study

The results of our SCM approach need to be taken with some caution, since flows are not disaggregated at the product or firm level. However, our data are monthly, broken down by country pairs and cover flows in both directions, which means we are able to draw at least some tentative inferences, both from the relative changes in trade flows in different directions, and from its timing. The conclusions on mechanisms are speculative but should help guide further research.

Table 1 summarizes the signs of the effects of hypothesized mechanisms by which the Brexit announcement may affect trade flows. We split these into the factors shifting the demand and supply curves (or supply shifting in response to anticipated demand), and those which we term the 'macroeconomic controls' (essentially changes in exchange rate and GDP), for which we control in our study.

While we expect UK trade with EU countries to be most adversely affected by the threat of both tariff and nontariff barriers, there may also be some effects upon trade with those non-EU countries with which the UK may need to negotiate replacement PTAs. Trade with the remaining non-EU countries will be expected to rise if there is substantial trade diversion but may indeed fall if UK-EU supply chain difficulties make the UK less competitive. We will therefore be able to draw at least some inferences from changes in the relative trade flows.

Table 1: Hypothesized effects of various mechanisms affecting trade flows. Sign of effect in the event of a no-deal Brexit, with no rollover of PTAs with other countries.

	Shifts in demand and supply curves				Macroeconomic controls	
Mechanism	Anticipated demand shock effect on supply	Supply chain costs	Sentiment	Total Total	Exchange rate	GDP
UK Exports to..						
EU	−−	−		−−−	+	−
Non-EU with EU PTA	−	−		−−	+	−
Non-EU No PTA	+	−		±	+	−
Non-EU Anglosphere	+	−	+	±	+	−
UK Imports from ..						
EU	−−	−	−	−−	−	−
Non-EU with EU PTA	−	−	?	−−	−	−
Non-EU No PTA	+	−	?	±	−	−
Non-EU Anglosphere	+	−	+	±	−	−

3 Empirical Strategy

We investigate the effects of the announcement shock upon the direction and volume of trade in the months before and after the Brexit referendum, but prior to any actual Brexit. Our modelling approach, which is based around aggregate trade flows between country pairs, is more aggregated in terms of products compared to some other studies (Crowley et al. 2018, Graziano et al. 2018), but disaggregated in terms of source/destination across a variety of both EU and non-EU partners.[6] We are also looking at effects on both exports and imports.

The SCM, which we use, has been applied successfully to date for a wide variety of case studies. This includes the modelling of EU membership effects by Campos & Coricelli (2017). We are looking at this in reverse. Saia (2017) analyzed the UK's foregone trade gains from not joining the Euro. In the case of Brexit announcement effects, we have already cited the study by Born et al. (2019) on GDP effects and Breinlich et al. (2020)'s work on FDI flows. Nevertheless, this is the first application of SCM to examining the trade announcement shock.

3.1 The Synthetic Control Method For Comparative Case Studies (SCM)

The SCM (Card 1990, Card & Krueger 1994, Abadie & Gardeazabal 2003, Abadie et al. 2010) is a variation of the difference-in-differences approach to estimating the effect of a clearly-defined treatment in a panel of data. The method is applied to a dependent variable $Y_{s,t}$ (in our case Y is exports) across a set of series s (country pairs), and a set of time periods, t (months). We split the country pair series s into two subsets: subset j of s is assumed to be treated (by Brexit)[7] and the treatment begins at a specific date, T, which lies somewhere well within the set t. We initially assume that this is the referendum date, although later we revise this assumption. Subset i of s comprises those country pairs which are never treated. For the treated pairs, $Y_{j,t}$, there is a treatment if and only if $t \geq T$. For the other, untreated series, i, there is no treatment at any time in our sample.

For a basic description of the SCM, we start, as in Abadie et al. (2010), by defining a treatment dummy $D_{j,t}$, which takes the value 1 where the series is treated by Brexit and 0 otherwise. Defining $Y_{j,t}$

[6] Graziano et al. (2018) use disaggregated monthly bilateral data by product and destination, from Eurostat, for EU countries only. Crowley et al. (2018) utilize disaggregated HMRC firm-product data for exports, but distinguish two destinations: EU and non-EU.

[7] Most previous studies work with just one treated series: we have several, which requires extra notation.

as the actual observed export series for treated country pair j, and $Y_{j,t}^N$ as the corresponding series as it would have been if untreated, then we can write

$$Y_{j,t} = Y_{j,t}^N + \alpha_{j,t} D_{j,t}. \tag{5}$$

As with any difference-in-differences technique, we aim to identify the treatment effect, $\alpha_{j,t}$, which affects the treated series only after time T and equals $Y_{j,t} - Y_{j,t}^N$ for the treated series j after T. The main issue is that $Y_{j,t}^N$ is not observable. Consequently, we therefore use the set of untreated series, i, to construct a fitted series, $\widehat{Y}_{j,t}^N$, using

$$\widehat{Y}_{j,t}^N = \theta_{j,t} Z_{j,t} + \sum_i w_i Y_{i,t}, \tag{6}$$

where Z_{jt} is a vector of observable confounding variables (for example, GDP or exchange rate variables) which may differ across country pairs and time, while the last term uses a series of weights, w_i, to weight the untreated series of $Y_{i,t}$, so as to provide the best fit for Y_{jt} during the period before it becomes subject to the treatment (i.e. $t < T$). In order to obtain a solution, the weights, w_i, are constrained to sum to 1, while, for tractability, the number of series out of i which are given non-zero weights is also restricted to a chosen maximum, n, which we set at 10 in our baseline.

The rationale for using a donor pool of untreated series to approximate $Y_{j,t}^N$ is that there is a vector of unobservable common shocks, μ_t, which affect all series, but potentially to different extents (which we proxy with a parameter λ_s), namely:

$$Y_{s,t} = \theta_{s,t} Z_{s,t} + \lambda_s \mu_t + \alpha_{s,t} D_{s,t} + \epsilon_{s,t}. \tag{7}$$

In these circumstances, Abadie et al. (2010) show in an appendix that creating a synthetic control from the observed, untreated series provides an unbiased estimator for $\alpha_{s,t}$. Intuitively, SCM utilizes an algorithm to weight more highly those series affected most similarly by the common shocks, μ_t, compared to the treated series, Y_{jt}. Note that, when the parameter, λ_s, for the impact of the unobservable shocks, is equal across all s, a set of equal weights $w_i = \overline{w}$ will work as well as any other, and the estimates of SCM become indistinguishable from a standard difference-in-differences model with time fixed effects.

There exists a variety of methods for selection of the vector W of weights, w_i, summing to 1. A number of recent studies, such as Abadie et al. (2010) and Born et al. (2019), follow Abadie & Gardeazabal (2003) in choosing the vector W to minimize the sum of squared differences between the actual series being modelled and the weighted (synthetic), over the period prior to treatment ($t \leq T$)[8]:

$$\hat{W} = \arg\min_{W} (Y_1 - Y_0 W)'(Y_1 - Y_0 W), \tag{8}$$

where vector Y_1 is the series being modelled and Y_0 is the matrix of donor series.[9] Breinlich et al. (2020) utilize a computationally simpler method derived by regressing the fitted series upon the donor series, although they compare it with the Abadie & Gardeazabal (2003) method as a robustness test.

By contrast, we use a slight modification of Politis & Romano (1994)'s subsampling methodology, as adapted by Saia (2017), which examines a wider set of potential weightings selected by an algorithm for good fit, in order to derive not just the deviation of the treated series from the synthetic, but its standard error. This is outlined in subsection 3.2 below.

3.2 Our estimation methodology

Our starting data set comprises monthly export flows between 812 pairs of countries,[10] over the period between January 1999 and March 2018. We assume in Section 5 that all trade flows involving the UK are treated by the Brexit anticipation shock. However, since it is important not to include treated pairs in the donor pool, and since Brexit potentially affects remaining EU countries through supply chains (Vandenbussche et al. 2017), we make the conservative assumption that the non-treated donor pool, i, should also exclude any flows involving EU members.

In Section 5, we divide the sample into pre- and post-treatment periods. In contrast to many studies, but in line with Graziano et al. (2018) and Douch & Edwards (2021), we apply a treatment date, $T =$

[8]For simplicity, we follow the literature here in presenting equations without the confounding variables, $Z_{j,t}$.

[9]Authors such as Abadie et al. (2010) create a synthetic series with multiple characteristics, and so include an extra weighting matrix, V, in equation 8 to reflect the modeller's preference in fitting.

[10]There are 29 countries including the UK, and we exclude a country's trade with itself.

$2015:7$, one year before the referendum (and just after the 2015 general election). This is justified by robustness checks in Section 6. Abadie et al. (2010) show that SCM is an unbiased estimator, as long as the number of observed periods before T is sufficient relative to the scale of transitory shocks (see also Castillo, Figal Garone, Maffioli & Salazar (2017)). This is an important reason for using data which are available on a monthly basis, and for starting our fitting period in 1999:1, even though this restricts our potential donor pool.

To outline how the method is applied, we start by considering the example of a single treated series, British exports to Germany, $j = (GBR - DEU)$ and a treatment date, T=2015:7, so that for $t \geq T$, the treatment dummy $D_{GBR-DEU,t} = 1$. In this case, we can derive our estimate of the treatment effect, $\hat{\alpha}_{GBR-DEU,t}$, by rearranging equation 5 above:

$$\hat{\alpha}_{GBR-DEU,t} = Y_{GBR-DEU,t} - \hat{Y}^N_{GBR-DEU,t}, \forall\, t \geq 2015:7,$$

where we have inserted an estimate, $\hat{Y}^N_{GBR-DEU,t}$, for the untreated counterfactual, constructed by SCM. Ignoring the confounding variables, for simplicity, we write

$$\hat{Y}^N_{GBR-DEU} = \sum_{i=1}^{n} \hat{w}_i Y^N_{i,t}, \tag{9}$$

where we have chosen to construct the counterfactual using n donor series from the untreated set i, for which the fitted weights are $\hat{w}_i$. In our main baseline, we set $n = 10$, although we carry out robustness checks with alternative sample sizes in sub-section 6.2.

In order to derive the average treatment effect over the whole period of our sample after the treatment date (i.e. 2015:7 to 2018:3), we use the formula

$$\hat{\alpha}_{GBR-DEU,2015:7-2018:3} = \frac{\sum_{t=2015:7}^{2018:3} \left(Y_{GBR-DEU,t} - \sum_{i=1}^{n} \hat{w}_i Y^N_{i,t} \right)}{\sum_{t=2015:7}^{2018:3} \sum_{i=1}^{n} \hat{w}_i Y^N_{i,t}} \tag{10}$$

In this case, $\sum_{i=1}^{n} \hat{w}_i Y_{i,t}^N$ is the synthetic counterfactual, $\hat{Y_j}^N$. In fact, we extend the method above, by splitting the post-treatment period into three: 2015:7-2016:6 (the referendum), 2016:7-2017:2 (roughly pre-Article 50) and 2017:3-2018:3.

As explained in subsection 3.1 above, rather than choosing a single, best-fitting set of weights, $\hat{w}$, as in Abadie et al. (2010), Born et al. (2019) or Breinlich et al. (2020), we follow the subsampling method of Politis & Romano (1994), which was also adopted by Saia (2017), to derive mean fit and variance across a sample of sets of weights which meet some predefined criteria for acceptable fit. We do this as follows. First, we randomly construct C different counterfactual groups of sample size n, which must each fit the criterion that its produced counterfactual, $Y_{GBR_DEU,t}^N$ is closer on average to the actual $Y_{GBR_DEU,t}$ than a chosen threshold, over the pre-treatment period $t < T$.[11]

Using this procedure we calculate a mean treatment effect across the subsamples:

$$\hat{\alpha}_{GBR-DEU,2015:7-2018:3} = \frac{1}{C}\sum\nolimits_{c=1}^{C} \left[\frac{\sum\limits_{t=2015:7}^{2018:3} \left(Y_{GBR-DEU,t} - \sum\limits_{i=1}^{n} w_{i,c} Y_{i,t}^N \right)}{\sum_{t=2015:7}^{2018:3} \sum_{i=1}^{n} {}_{i,c} Y_{i,t,c}^N} \right] \tag{11}$$

and a standard deviation,

$$\hat{\sigma}_{GBR-DEU,2015:7-2018:3} = \sqrt{\frac{1}{C}\sum\nolimits_{c=1}^{C} \left(\alpha_{GBR-DEU,2015:7-2018:3,c} - \hat{\alpha}_{GBR-DEU,1999:1-2018:3}\right)^2} \tag{12}$$

where $\alpha_{GBR-DEU,2016:7-2018:3,c}$ is the percentage difference between observed exports and the constructed counterfactual group (Y_c^N). We use a sample size equal to 500, e.g. $C = 500$. This allows us to create a distribution of parameter estimates, which can be tested for statistical significance. In sub-section 6.3 we examine alternative values of C.

To evaluate the aggregate effects, we can modify equation 11 by summing all treated pairs, to provide an estimate of the overall effect of the Brexit policy shock on UK exports and imports with EU and/or

[11] We add a second hurdle that no individual month exceeds a higher threshold.

non-EU partners, as follows:

$$\hat{A}_{2015:7-2018:3} = \frac{1}{500}\sum\nolimits_{c=1}^{500} \left[\frac{\sum\limits_{t=2015:7}^{2018:3} \left(\sum\limits_{j=1}^{J} Y_{j,t} - \sum\limits_{j=1}^{J} \sum\limits_{i=1}^{n} \hat{w}_{i,j,c} Y_{j,t,c}^{N} \right)}{\sum_{t=2015:7}^{2018:3} \left(\sum_{j=1}^{J} \sum_{j=1}^{J} {}_{i,j,c} Y_{i,t,c}^{N} \right)} \right], \tag{13}$$

where $\sum_{j=1}^{J} Y_{j,t}^{T}$ is the sum of export flows of the J treated country pairs, whereas $\sum_{j=1}^{J} \sum_{i=1}^{n} \hat{w}_{i,c} Y_{i,t,c}^{N}$, is the corresponding sum of counterfactual units.

In addition, we correct for the effects of observable confounding variables, $Z_{s,t}$ in equation 7: namely GDP of the reporting country, GDP of the partner, bilateral exchange rates and the volatility of exchange rates, and bilateral distance, as well as average values of the dependent variable across the fitting period.

4 Data

Our sample uses monthly data from IMF Direction of Trade Statistics for bilateral trade in goods for the period January 1999 to March 2018 inclusive. Sadly, data on bilateral services trade are not available on a monthly basis for any comparable period.[12] We supplement the data set with GDP and exchange rate data from the IMF. GDP is expressed into current US dollars. We calculate a set of bilateral exchange rates, as well as a measure of bilateral exchange rate volatility over a 5 year period.

SCM requires a balanced panel, with no missing values. Consequently, we had to drop data from a number of economically significant non-EU countries, such as Turkey and Indonesia, due to holes in the data. This left us with 14 non-EU countries: Australia, Brazil, Canada, China, Hong Kong, India, Israel, Japan, South Korea, Mexico, New Zealand, Russia, USA and South Africa, plus 14 EU countries, namely Germany, France, the Netherlands, Italy, Spain, Belgium, Luxembourg, Portugal, Austria, Finland, Denmark, Sweden, Ireland and Greece. Even with these countries, we had to fill in a small proportion of observations: 109 export observations and 55 import observations out of a total of nearly 400,000 - see Table B1 in the Online Appendix. Only two observations involving the UK were missing.

Data were seasonally adjusted, to reduce seasonal volatility before fitting for the synthetic doppel-

[12] Douch & Edwards (2021) use an SCM to model services exports, but in the aggregate only, while Ahmad et al. (2020) estimate a model for bilateral services trade by product, but only starting at the referendum date.

gangers. In addition, in a few circumstances, since GDP is reported on a monthly basis, we used linear interpolation when data were missing.

5 Baseline Specification

5.1 The timing of the treatment

SCM chooses weights such that a fitted synthetic trade flow moves closely with the actual series, up until treatment date T. Assuming the treatment is valid, the divergence should quickly become statistically significant after this (see Section 6.1).

In choosing T, we have already noted that the referendum result of 23 June, 2016, took the market by surprise. However, in Section 2.1 we note that, where firms can costlessly delay market entry or sales expansion, the quasi option value of delay may deter entry/expansion even when the perceived probability of an adverse outcome is low. We therefore need to consider the possibility of earlier treatment effects, especially after the unexpected Conservative general election win on 7 May 2015, which committed the government to holding a referendum. Graziano et al. (2018) provide evidence that, at least from about a year before the referendum, markets were already beginning to anticipate a risk of a Leave vote and show some impact on UK firms' participation in trade. We therefore choose the middle of 2015 as our treatment date. As equation 7 makes clear, the treatment effect can vary over time after T, which gives SCM the ability to handle a succession of treatment events, so long as they apply to the same subset of series. In Section 6.1 we explore still earlier treatments but find no evidence of any treatment in 2014.

By contrast, in the Online Appendix A, we include some estimations (Figures A1 to A4) using just after the referendum as the treatment date, $T = 2016:7$. The issue in this case is that fitting on the pre-referendum period can introduce bias if this period was already treated. In addition, we add a qualitative observation from these graphs, that constraining the treatment to $T = 2016:7$ leads to an implausible spike in the synthetic series just after the referendum. This spike is replaced by a more gradual divergence, if we do not constrain our synthetic doppelganger to fit the actual up to 2016:6.

For our baseline, we therefore split our data into a pre-treatment fitting period (before T = 2015:7) and a post-treatment period thereafter. The model is fitted using donor series for the fitting period, drawn from flows excluding the UK as a trading partner. As explained above, we also exclude flows involving

EU members from the donor pool, in case they are also treated. We then fit the series for the period from T to the end of our sample (2018:3), but focusing in particular on three periods: 2015:7-2016.6, the pre-referendum period, 2016:7-2017:2, the pre Article 50 period, and 2017:3-2018:3, the post Article 50 period. We model UK import and export flows with each of 14 EU and 14 non-EU countries, but aggregate these into four main categories: UK exports to EU and non-EU countries in Section 6.4, and UK imports from EU and non-EU countries in Section 5.6.

5.2 The estimation

The model is fitted over the period (1999:1-2015:6), following the sampling approach developed in Politis & Romano (1994) and applied in Saia (2017), as discussed in Section 3.2, estimating and projecting synthetic series for UK exports to and imports from each of 14 EU and 14 non-EU countries. These are then aggregated into export and import totals with EU and non-EU countries.

Because the number of estimations is huge, it is not possible for us to make available a complete set of sample weights. Nevertheless, in the Online Appendix, Table B2 we report the 20 most frequently chosen donor pairs. These include Austria-New Zealand, Korea-Japan, Brazil-China and Hong Kong-Japan, These share an average weight of 38%, 36%, 31% and 29%, respectively.

As we explain in Equation 7 in 3.2, we include a number of confounding variables. Again, due to the huge number of estimations, we can only provide average values, which we attach for UK-EU trade in the Online Appendix tables B4 and B5.

5.3 Baseline: Modelling and Results for UK exports to the EU and discussion

In order to focus on the effects of Brexit, and the mechanisms underlying them, as discussed in Section 2, we choose to review the results of our SCM analysis for the UK's exports first, in this sub-section and the next, and then discuss them, before moving on to reviewing results for imports in Section 5.6.

An important issue in a SCM (or any difference-in-differences model) is that the treated series should be clearly differentiated from those which are untreated. Tests on the exogeneity of various EU countries showed that trade flows involving EU countries have also been affected by the treatment, in line with other simulations (Vandenbussche et al. 2017), due to the presence of complex supply chains linking all

European economies.[13] Consequently, we use only non-EU country pairs to form the donor pool, even when modelling UK trade with EU countries.

Given the dissimilarity of some of the non-EU countries to the UK, our approach is first to pre-select an appropriate pool of relatively less dissimilar countries, using an index of Revealed Comparative Advantage (RCA) (Redding & Weinstein 2018, Balassa 1965).[14] To this end, we use 2015 values of the RCA index from WITS for all trading partners in our sample at country-product level.[15] In Online Appendix Table B7, we report correlation coefficients for RCA for a number of different countries with that of UK exports, calculated across 30 export products for 2015. Based on these, we choose the donor pool. Note that we use trade in both directions in our donor pool, because the direction of trade flow matters, and also to improve fit.

Our fitting and simulation of the synthetic counterfactual follows Saia (2017), as was explained in Section 2, showing the mean and standard error of a Monte Carlo sampling of donor weightings which satisfied our selection thresholds for the fitting period. The relatively low standard error reflects the fact that the various sample synthetic series cluster quite closely in the post-treatment period.[16]

Table 2: Percentage difference in exports from the UK to individual EU partners vs counterfactual

% difference actual minus synth.	AUT	BEL	DEU	DNK	ESP	FIN	FRA	GRC	IRL	ITA	LUX	NLD	PRT	— SWE—	TOTAL EU 14
1999:1-2015:6	0.447	-0.323	0.231	-0.035	-0.242	0.148	-0.125	0.075	-0.404	0.250	-0.412	-0.060	0.368	0.281 —	-0.0160
	(0.083)	(0.057)	(0.050)	(0.072)	(0.053)	(0.082)	(0.054)	(0.086)	(0.047)	(0.055)	(0.207)	(0.050)	(0.074)	(0.066) —	(0.053)
2015:7-2016:6	16.910	-17.090	-8.345	-9.023	-15.466	-17.639	-24.898	-27.476	-17.069	-8.123	-43.037	-20.187	-9.104	-14.894 —	-20.833
	(1.723)	(1.267)	(1.765)	(1.444)	(1.103)	(1.558)	(1.247)	(1.728)	(1.347)	(1.140)	(2.269)	(1.293)	(2.501)	(0.978) —	(1.554)
2016:7-2017:2	-2.109	-25.691	-12.568	-19.272	-17.583	-31.592	-27.540	-38.111	-26.882	-13.073	-49.906	-22.865	-21.595	-24.260 —	-24.888
	(1.909)	(1.237)	(1.563)	(1.308)	(1.205)	(1.270)	(1.204)	(1.263)	(1.182)	(1.224)	(1.579)	(1.246)	(1.774)	(0.970) —	(1.444)
2017:3-2018:3	-1.895	-21.309	-12.697	-18.059	-22.084	-31.018	-15.077	-31.719	-19.971	-14.286	-57.004	-17.388	-17.609	-18.840—	-20.377
	(2.164)	(1.277)	(1.612)	(1.458)	(1.159)	(1.432)	(1.509)	(1.558)	(1.305)	(1.251)	(1.811)	(1.342)	(2.053)	(1.082) —	(1.512)

Notes: The table reports the percentage difference between actual and synthetic for trade flows between the UK and EU members. Synthetic counterfactuals are a weighted average of non-EU country pairs, randomly drawn from the pool of potential donors, where weights are chosen to best resemble the actual treated unit. Standard errors are reported in parentheses.

Table 2 shows that aggregate UK export values to the EU (right hand column) declined by between 20% and 25% compared to the synthetic. See also Figure 1. The divergence is larger than the decline in

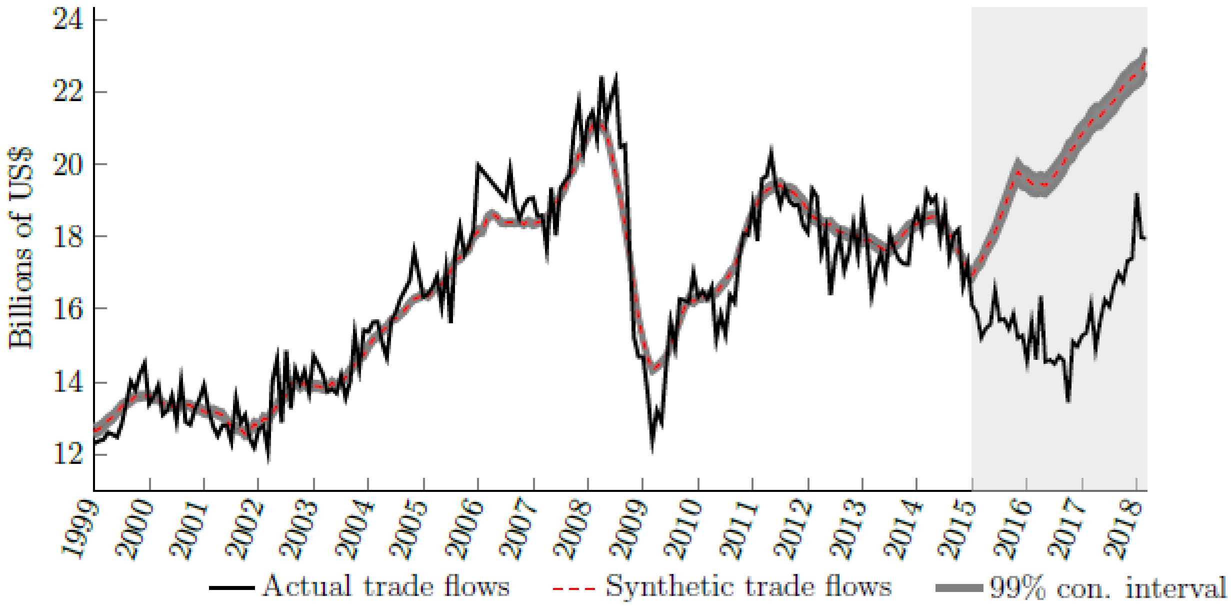
[13]SCM fittings including EU countries in the donor pool are shown in subsection 6.4. These produced smaller estimates of the effects of the anticipation shock upon UK exports to EU partners (around 15 %), but we conclude that this is because the donor series themselves were shocked.

[14] We are grateful to an anonymous referee for the suggestion of this alternative specification.

[15]https://wits.worldbank.org/CountryProfile/en/Country/ALL/StartYear/1988/EndYear/2017/TradeFlow/Export/Indicator/RCA/Partner/WLD/Product/Total

[16]Saia (2017)'s study also produces quite a narrow confidence interval.

Figure 1: Aggregate exports from UK to EU, baseline with 2015 treatment and no EU countries in the donor pool



Notes: This figure is for our main baseline specification for a treatment in 2015, on trade with 14 EU countries. We control for revealed comparative advantage in selecting the donor pool. We use non-EU country pairs.

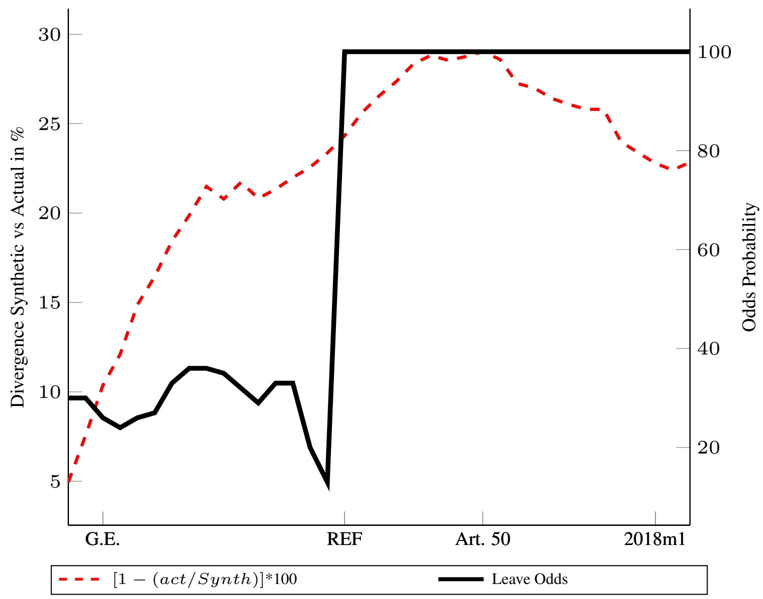
UK exports to non-EU countries, which we show in Figure 3 in subsection 5.4, below. Results are very significant.

It is useful to look at the divergence of the actual and synthetic series during the treatment period in more detail: to do this, we make use in Figure 2 of a gap diagram, plotting the divergence of the synthetic from the actual after the treatment. As in Graziano et al. (2018) and Douch & Edwards (2021), a series of betting odds on Leave winning are included for comparison, during the period prior to the referendum.[17] Note that we have chosen to plot the divergence of synthetic minus actual, which rises as the treatment reduces the latter. What is clear from the diagram is that there is steady rise in the divergence during 2015 after the general election, continuing at a slightly slower pace throughout 2016. By the time of the referendum, most of the adverse effect upon exports to the EU had already been reached, although there continued to be an increase after the referendum, peaking at around 29% at the time Article 50 was invoked in March 2017. If anything, since that point, the shortfall fell back slightly, possibly reflecting

[17]These are derived from data cited in Fry & Brint (2017), although some approximation had to be used in converting daily to monthly data.

the stated desire of Theresa May's government to achieve a softer Brexit deal than some feared, or at least the fact that actual barriers would be delayed.

Figure 2: UK-EU exports – Synthetic comparison with Leave Odds



Notes: This figures reports the deviation of actual aggregate flows vs synthetic Britain. This is for the main baseline specification using 14 EU countries. We compare this with the odds on Brexit derived from Fry & Brint (2017).

Tentatively, we would suggest that this pattern of reaction to anticipation of a shock is consistent with the quasi-option value model of delayable trade participation in Section 2. In particular, the sharp fall in exports in the 6 months prior to the referendum suggests that the vote was seen as a looming deadline, which was sufficiently risky to frighten traders, even when the betting odds on a Leave win were about 30% and, if anything, falling. Conceivably, traders' fear at this stage may have been fueled by a lack of knowledge of the Article 50 process, so that many may have assumed that exit from the Single Market would be swift following a Leave win. That interpretation would seem to be confirmed by the levelling off - almost a sense of relief - once it became apparent that the UK government, while proceeding with Brexit, was going to apply Article 50, with its implementation period, so delaying the potential imposition of barriers by at least two years.

In the Online Appendix Figures B5 and B6, we apply, as an alternative, an economic complexity index (ECI) (Hausmann et al. 2014), with broadly similar results to those using RCA.[18]

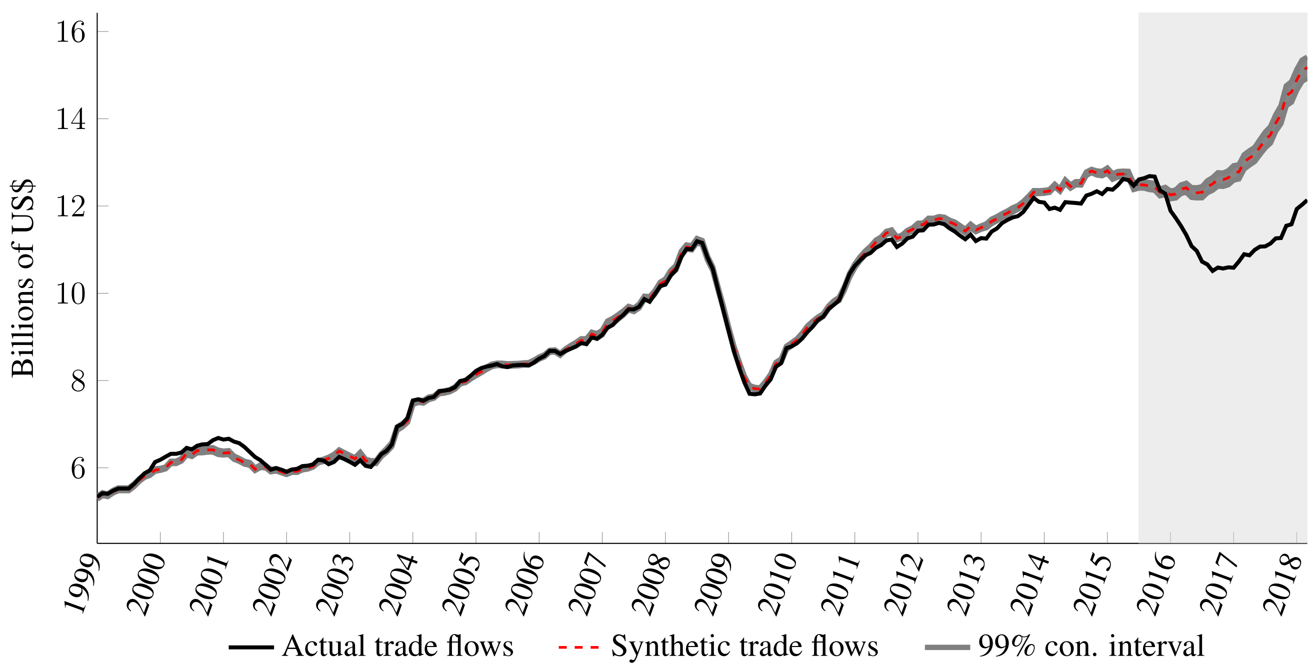
[18] Using a donor pool selected by ECA, the estimated percentage difference between actual and the counterfactual for the extra-EU export flows is about -15% (standard errors 1.427). In terms of imports the EU flows were about -13.8% down

Exports to individual EU countries, in Table 2 above, show considerable heterogeneity, with exports to some of the smaller countries performing particularly badly.

5.4 Results for UK exports to non-EU countries

We now turn to UK exports to our pool of 14 non-EU countries. The fitting period and the average synthetic/actual divergence across the 14 countries are shown quite clearly in Figure 3, again using mid 2015 as the initial treatment date (but with a time-varying treatment, which can incorporate later treatments). What is perhaps remarkable is the overall similarity with the pattern of UK exports to the EU. Again, there is a substantial divergence after our initial treatment, but starting before the referendum, and also taking the form of a fall in actual export values, while synthetic values stay flatter.

Figure 3: Aggregate exports from UK to non-EU, 2015 treatment main baseline model



Note: This figure is for our main baseline specification for a treatment in 2015:6, on trade with 14 non-EU countries.

Table 3 again breaks down the average divergence between actual and synthetic by period. In Figure 4, we show a gap diagram, which emphasizes a steady increase in the shortfall of exports below the doppelganger, both before and after the referendum, albeit starting a little later than that for exports to

(standard errors 1.573) and -6.32% for extra-EU imports (standard errors 1.486). These results are in line with our previous estimates about the worsened position of the UK's trade pattern due to the overall increase in uncertainty.

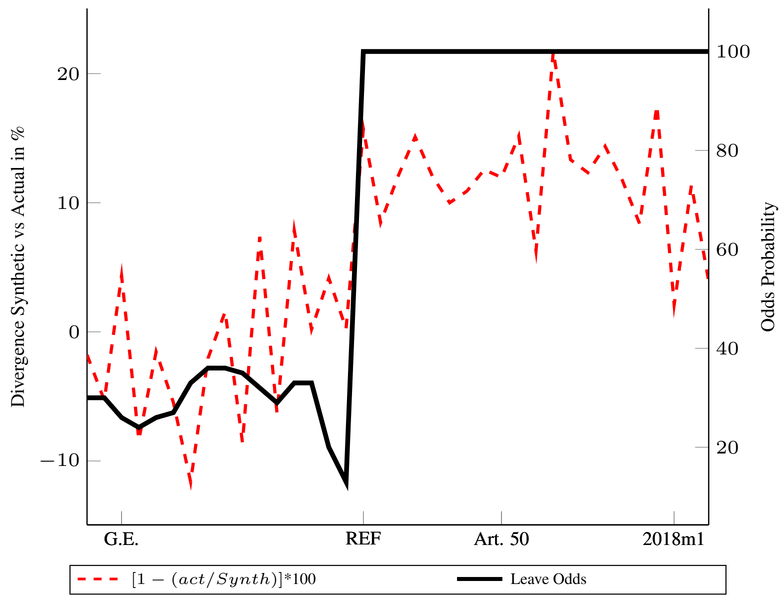
Table 3: Percentage difference in aggregate UK exports to non-EU partners vs counterfactual

	Pre-referendum	Post-General Elec.		Post-Refer.	Post-Art. 50
	1999:1-2015:6	2015:7-2018:3	2015:7-2016:6	2016:7-2017:2	2017:3-2018:3
% difference actual	.070	-10.711	-3.615	-13.462	-15.184
vs synthetic	(0.098)	(1.918)	(1.513)	(2.004)	(2.175)

Notes: The table reports the percentage difference between actual and synthetic aggregate trade flows between the UK and non-EU members over different periods. Synthetic counterfactuals are obtained as a weighted average of non-EU country pairs. Our treatment period starts just after the general election in 2015, rather than on the referendum date of June 2016. Standard errors are reported in parentheses.

the EU in Figure 2.

Figure 4: UK- Non-EU exports – Synthetic comparison with Leave Odds



Notes: This figure reports the deviation of actual aggregate flows vs synthetic Britain. This is for the main baseline specification. We compare this with the odds on Brexit derived from Fry & Brint (2017).

5.5 Export trends and discussion of the mechanisms

An important question is why UK exports towards non-EU countries fell by 15% compared to the doppelganger. We know from the discussion in Section 2 that there are a number of possible explanations here. First of all, a large part of UK manufacturing is tied closely to supply chains with the EU and other EEA countries. For example, 23% of the UK's imports are intermediate products from the EU, and 24% are intermediate products from the rest of the World (much of which may be in countries with PTAs with the EU) (McKinsey & Company 2019). Difficulties in accessing these inputs may, in turn negatively affect Britain's exports to all destinations. This may include increasing complications in rules of origin after Brexit.

A second issue is that many non-EU countries in our sample have PTAs with the EU, which would have been seen as under threat for the UK given Brexit. These include Israel, Korea, Mexico and South Africa by 2016, followed by Canada in 2017 and Japan in 2019 (see Table B6 in the Online Appendix). However, in Table 4, below, last two columns, we find little difference in terms of export performance between countries with and without PTAs with the EU (if anything, the former suffer less fall).

In Table 4, below, we look for other patterns in the differences between actual and synthetic exports by country. Despite the very weak performance overall, there is a wide variability in performance: exports to China (CHN), Korea (KOR) and New Zealand (NZL) seem to have performed very well since the referendum, while those to Mexico also grew. By contrast, exports to Israel (ISR), Russia (RUS) and Brazil (BRA) performed very badly compared to their synthetic counterparts. We have divided the countries in this sample into a Commonwealth grouping (including Hong Kong, which strictly left the Commonwealth in 1997) and a non-Commonwealth grouping, with the English-speaking USA as an intermediate case. It is worth noting that Brexit-supporting ministers have made a number of bullish statements about trade with former Commonwealth countries. However, there is virtually no difference between these groups with respect to British exports. See also Online Appendix Figure B2 for trade with individual countries.

Table 4: Percentage difference in UK exports to individual non-EU partners vs counterfactual

% diff. actual	Commonwealth + HK						USA	Rest of World							PTA with EU	
vs synth.	AUS	CAN*	HKG	IND	NZL	ZAF*	USA	BRA	CHN	ISR*	JPN*	KOR*	MEX*	RUS	no PTA	PTA
1999:1-2015:5	0.109	0.114	0.626	0.183	0.433	-0.076	0.346	0.333	1.243	0.180	0.327	0.577	0.491	-0.710	0.0487	0.0261
	(0.069)	(0.069)	(0.078)	(0.074)	(0.123)	(0.074)	(0.044)	(0.099)	(0.277)	(0.073)	(0.070)	(0.087)	(0.118)	(0.100)	(0.044)	(0.047)
2015:6-2016:6	7.684	5.025	26.746	-16.388	6.267	-14.371	3.486	5.990	34.761	-20.747	6.648	6.692	29.253	-22.960	2.135	0.608
	(1.092)	(1.120)	(1.255)	(0.860)	(1.631)	(0.862)	(2.671)	(1.117)	(2.491)	(1.923)	(1.215)	(1.085)	(1.447)	(1.026)	(1.375)	(0.707)
2016:7-2017:2	-6.574	1.580	-3.799	-34.624	23.728	-34.947	-6.939	-30.550	9.591	-31.724	-1.867	0.930	6.627	-34.972	-11.684	-9.749
	(0.928)	(1.154)	(1.115)	(0.711)	(1.671)	(1.146)	(2.216)	(0.740)	(2.330)	(1.938)	(1.361)	(1.280)	(1.525)	(1.010)	(1.157)	(1.164)
2017:3-2018:3	2.353	1.209	1.974	-13.969	34.080	-33.063	-10.369	-29.121	5.935	-30.227	7.038	14.154	20.319	-32.648	-11.434	-3.438
	(0.943)	(1.170)	(1.110)	(0.850)	(1.882)	(1.319)	(2.213)	(0.659)	(2.254)	(2.161)	(1.348)	(1.619)	(1.842)	(0.786)	(1.197)	(1.419)
	Aggregate Commonwealth + HK							Aggregate Rest of World								
1999:1-2015:5			0.225								0.345					
			(0.043)								(0.060)					
2015:6-2018:3			-4.894								-4.888					
			(0.830)								(2.073)					

Notes: The table reports the percentage difference between actual and synthetic for each non-EU trade flows between the UK and non-EU members over different periods. Each synthetic counterfactual is obtained as a weighted average of non-EU country pairs, randomly drawn from the pool of potential donors, where weights are chosen to best resemble the actual treated unit. Standard errors are reported in parentheses. *An asterisk indicates that the country has a PTA with the EU.

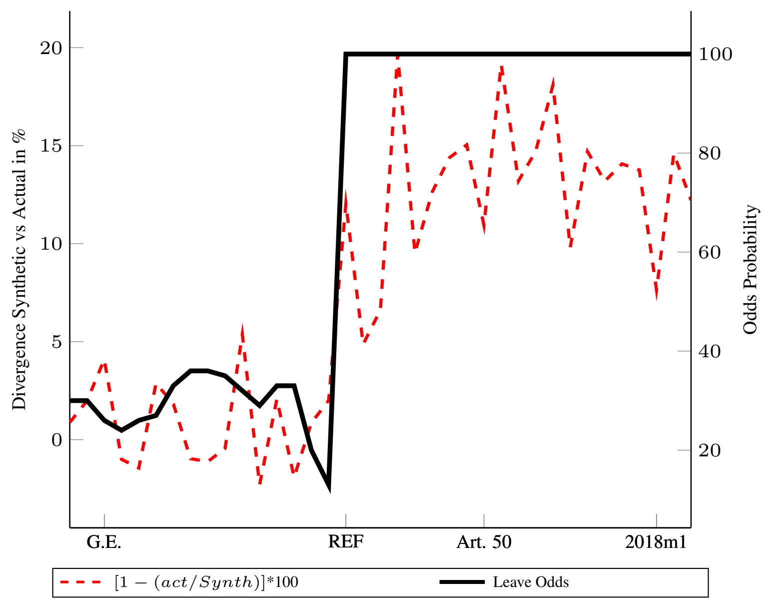
A tentative conclusion from the above discussion is that the poor performance of UK exports to non-

EU countries seems to be primarily driven by a loss of confidence in the UK economy, and to supply chains in particular.

5.6 Results for UK imports and discussion

For imports, as with exports, we assume a treatment date T=2015:7 and exclude from the donor pool pairs including EU countries. For aggregate UK exports to our 14 EU countries, we plot the divergence of actual imports from our synthetic doppelganger as a gap diagram in Figure 5. The treatment effect is a little over half that for UK exports, and there is no significant treatment until the election, after which the import shortfall increases rapidly.

Figure 5: UK- EU Imports – Synthetic comparison with Leave Odds



Notes: This figure reports the deviation of actual aggregate flows vs synthetic Britain. This is for the main baseline specification. We compare this with the odds on Brexit derived from Fry & Brint (2017).

Results for individual countries are presented in Table 5, above. The main comment is that individual country series show considerable heterogeneity, and that it is not easy to pick out a pattern, although imports from France seem to have been among the worst hit.

In Figure 6, below, we plot the divergence of actual from synthetic aggregate UK imports from non-EU countries, again in the form of a gap diagram, compared with the odds of a Leave win. The series shows considerable volatility over time, although there does seem to be quite a large divergence.

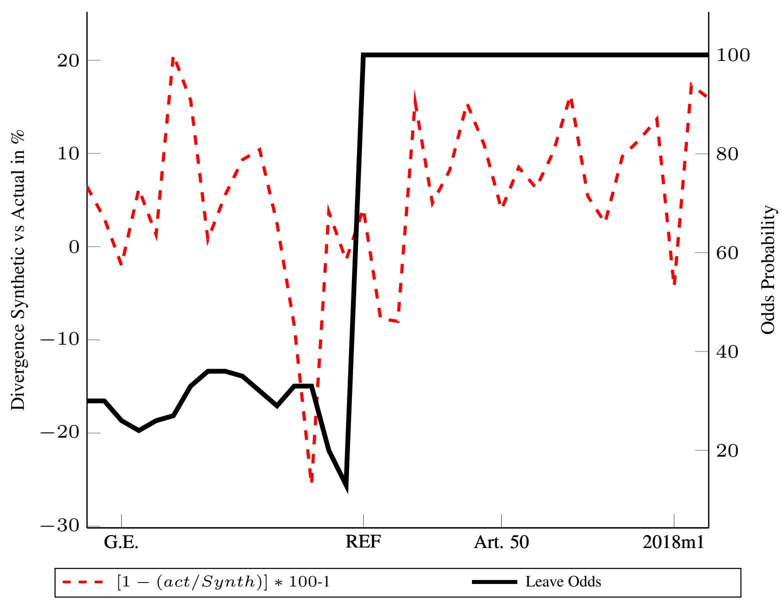
Table 5: Percentage difference in UK imports from individual EU partners vs counterfactual

% diff. actual vs synth.	AUT	BEL	DEU	DNK	ESP	FIN	FRA	GRC	IRL	ITA	LUX	NLD	PRT	SWE
1999:1-2015:5	0.034	-0.037	-0.019	-0.060	0.009	-0.092	-0.009	0.019	0.053	0.069	-0.068	-0.029	0.124	0.098
	(0.044)	(0.041)	(0.041)	(0.037)	(0.041)	(0.036)	(0.041)	(0.047)	(0.039)	(0.036)	(0.167)	(0.042)	(0.085)	(0.044)
2015:6-2016:6	7.894	-0.448	-5.225	-17.517	13.112	-23.538	-19.548	4.933	-7.307	-5.900	-45.392	-9.500	19.228	-11.895
	(2.039)	(1.515)	(2.046)	(1.359)	(1.765)	(1.021)	(1.576)	(2.085)	(1.577)	(1.616)	(8.578)	(1.475)	(4.003)	(1.467)
2016:7-2017:2	-7.891	-4.371	-14.128	-21.549	1.899	-33.294	-30.313	-3.562	-17.972	-14.932	-60.702	-10.286	10.958	-25.247
	(1.783)	(1.766)	(1.854)	(1.298)	(1.892)	(0.879)	(1.558)	(2.444)	(1.407)	(1.726)	(3.894)	(1.778)	(4.521)	(1.444)
2017:3-2018:3	0.703	-7.485	-14.217	-7.297	-10.446	-23.539	-26.157	-1.735	-13.048	-11.709	-61.814	-5.317	16.142	-24.038
	(2.228)	(1.801)	(1.958)	(2.295)	(1.796)	(1.355)	(1.779)	(2.430)	(1.801)	(1.991)	(5.135)	(2.004)	(3.776)	(1.550)

Notes: The table reports the percentage difference between actual and synthetic for each EU trade flows between the UK and EU members. Synthetic counterfactuals are a weighted average of EU country pairs, randomly drawn from the pool of potential donors, where weights are chosen to best resemble the actual treated unit. Standard errors are reported in parentheses.

Comparison with the other trade series suggests that UK imports from non-EU countries performed relatively less badly, which one might well expect from the discussion in Section 2 above.

Figure 6: UK- Non-EU imports – Synthetic comparison with Leave Odds



Notes: These figures report the deviation of actual aggregate flows vs synthetic Britain. This is for the main baseline specification using 14 non-EU countries. We compare this with the odds on Brexit derived from Fry & Brint (2017).

We examine the changes by individual countries in Table 6, below. The table sorts countries to into Commonwealth countries (plus Hong Kong), the United States and the rest - and hence is looking for sentimental pro-Commonwealth or pro-Anglosphere effects (as discussed in Section 2[19]). Overall, the USA and Commonwealth countries performed much less badly than those from the Rest of the World, although there is variability: Australian imports performed well, but New Zealand badly. Hong Kong may

[19]https://www.newstatesman.com/politics/2015/02/rise-anglosphere-how-right-dreamed-new-conservative-world-order

have been affected by growing tensions with China. Of the Rest of the World countries most performed badly, except Mexico.

Table 6: Percentage difference in UK imports from individual non EU partners vs counterfactual

% diff. actual	Commonwealth + HK						USA	Rest of World							PTA with EU	
vs synth.	AUS	CAN*	HKG	IND	NZL	ZAF*	USA	BRA	CHN	ISR*	JPN*	KOR*	MEX*	RUS	no PTA	PTA
1999:1-2015:5	-0.248	0.054	0.035	-0.055	0.058	-0.107	0.291	-0.022	-0.161	-0.060	-0.003	0.092	-0.133	-0.139	0.0107	-0.0125
	(0.129)	(0.037)	(0.122)	(0.041)	(0.079)	(0.137)	(0.032)	(0.053)	(0.038)	(0.042)	(0.038)	(0.098)	(0.066)	(0.055)	(0.068)	(0.043)
2015:6-2016:6	12.563	-11.638	-3.251	-3.052	3.376	-5.518	-1.817	-10.976	14.214	-26.779	-26.934	20.955	17.249	-45.231	0.859	-12.270
	(3.988)	(1.067)	(5.502)	(0.964)	(2.356)	(1.743)	(2.733)	(1.815)	(1.909)	(1.082)	(0.910)	(2.704)	(2.849)	(0.989)	(1.159)	(0.657)
2016:7-2017:2	19.031	-3.195	54.259	-10.716	-16.282	1.345	-0.458	-16.725	-0.268	-29.586	-19.645	3.467	5.548	-40.290	-2.445	-9.542
	(5.044)	(1.426)	(8.088)	(1.435)	(1.944)	(4.908)	(3.175)	(2.119)	(1.847)	(0.953)	(1.144)	(2.382)	(2.971)	(1.113)	(1.008)	(0.771)
2017:3-2018:3	8.878	-5.961	-13.025	-7.858	-16.343	-0.600	-1.916	-27.969	-4.764	-23.633	-24.858	-1.364	11.753	-27.831	-6.356	-12.411
	(3.964)	(1.323)	(4.776)	(1.531)	(2.290)	(6.312)	(3.110)	(2.236)	(1.866)	(2.354)	(1.227)	(2.432)	(3.436)	(1.319)	(1.003)	(0.807)
	Aggregate Commonwealth + HK							Aggregate Rest of World								
1999:1-2015:5	0.240							0.330								
	(0.044)							(0.039)								
2015:6-2018:3	-2.481							-9.643								
	(0.711)							(0.849)								

Notes: The table reports the percentage difference between actual and synthetic for each non-EU trade flows between the UK and non-EU members over different periods. Each synthetic counterfactual is obtained as a weighted average of non-EU country pairs, randomly drawn from the pool of potential donors, where weights are chosen to best resemble the actual treated unit. Standard errors are reported in parentheses. *An asterisk indicates that the country has a PTA with the EU.

The second question which we investigate with respect to imports is the influence of the various PTAs which the EU had. Taking Israel, Korea, Mexico, South Africa, Canada and Japan as the non-EU countries with PTAs or imminent PTAs with the EU, we can see that, unlike with UK exports, UK imports from these countries performed much worse than from the other non-EU countries. This is in line with Graziano et al. (2020*a*). Douch et al. (2020) suggest that UK firms have responded to Brexit by redirecting supply chains. This is despite the UK's stated preference of negotiating successor/rollover agreements in all of these cases.

6 Robustness checks of the synthetic control application

6.1 Tests of the treatment date

In section 5.1 we explain that our baseline treatment was chosen for the month 2015:7, just after the Conservatives won an unexpected majority in the general election. Prior to this, we had investigated a treatment associated with the 2016 referendum (as consistent with Crowley et al. (2018), Graziano et al. (2020*a*) among other studies). Graphs of this treatment are available in the Appendix figures A1, A2, A3 and A4. However, the first three of these figures show a sudden jump in the synthetic series just after treatment, which we do not regard as plausible.

In order to select for the most plausible treatment date, in the case of UK exports to the EU and to non-EU countries, we examined a series of alternative treatment dates. A treatment at the start of 2014 suggested no difference between actual and synthetic series for exports to the EU in the early months - in other words, this was a true placebo.[20] We then examined treatment dates for each month in 2015, shown in Table 7. Fitting dates for UK exports to the EU in early 2015 did indicate a significant, if small, treatment in the early months, but the discrepancy between actual and synthetic began to rise sharply and steadily in June 2015. For exports to non-EU countries, the actual exceeded the synthetic in early 2015, and they only crossed in August. In the Online Appendix, Figures B7 and B8 report the underlying trend.

Table 7: Earlier treatment effect in 2015, EU and non-EU Exports

Column	1	2	3	4	5	6	7	8
Treatment	UK exports to EU				UK exports to non-EU			
	Up to Referendum		First 3 months		Up to Referendum		First 3 months	
year: month	Mean	Std. Err.	Mean	Std. Err	Mean	Std. Err.	Mean	Std. Err
2015:1	-4.631	0.0184	-2.121	0.043	-3.256	0.075	-0.764	0.176
2015:2	-4.770	0.0186	-1.745	0.042	-2.147	0.076	4.806	0.174
2015:3	-4.625	0.020	-0.165	0.052	-2.088	0.078	6.465	0.139
2015:4	-4.499	0.021	-0.873	0.056	-2.364	0.078	3.583	0.127
2015:5	-4.825	0.0223	-0.519	0.051	-2.822	0.086	5.450	0.141
2015:6	-5.131	0.024	-1.620	0.057	-3.636	0.087	4.802	0.165
2015:7	-5.387	0.023	-1.283	0.0023	-4.149	0.089	3.813	0.145
2015:8	-6.069	0.0254	-0.892	0.0559	-5.910	0.089	-1.170	0.151
2015:9	-6.325	0.025	-2.758	0.046	-6.916	0.099	-1.478	0.145
2015:10	-6.965	0.027	-4.607	0.040	-7.112	0.112	-1.588	0.167
2015:11	-7.495	0.029	-5.256	0.039	-7.014	0.121	-.278	0.156
2015:12	-7.838	0.033	-6.948	0.046	-8.319	0.138	-5.728	0.163
EARLIER TREATMENT			First 6 months				First 6 months	
			Mean	Std. Err			Mean	Std. Err
2014:1			-0.134	0.233			-0.288	0.109

Notes: The table reports the percentage differences between actual and synthetic trade over different months of 2015, for exports, calculated over the period up to the referendum, or alternatively for the first 3 months. The final rows show the effects for the first 6 months of an earlier treatment in January 2014.

What emerges from this analysis is that the effect of policy uncertainty may indeed have started around a year earlier than the actual Brexit referendum, or even a little earlier. This is in line with Handley & Limão (2017) and Graziano et al. (2018)'s findings of potential anticipatory effects. Furthermore, the

[20] We found a small divergence for exports to non-EU countries, but much less than at later dates.

gap has significantly increased since the early part of 2016, potentially highlighting the increasing climate of policy uncertainty among businesses about future trade arrangements. The results are symmetric both when we look at exports as well as imports with both the EU and non-EU countries.

6.2 Sample size in terms of donor pairs

In equation 9 in subsection 3.2, we draw $n = 10$ country pairs. Potentially, one could argue that drawing just 10 pairs may result in a lot of noise due to small sample size. To investigate this, we examine alternative random sample sizes of 50 and 80 (we also consider also other sizes) - and analyze the overall fit of the algorithm. The result of this alternative specification is reported in the Online Appendix Table B8. The overall results remain relatively robust to the sub-sample approach.

6.3 Alternative C size

We also investigate how the change in our distribution size may affect the underlying results. In Tables B9, B10, B11 and B12 we report the underlying exercise for both exports and imports. Using this alternative specification the results remain consistent.

6.4 Including EU countries in the donor pool for UK exports to the EU

In Section 5.3 above we have made a cautious decision to exclude trade flows between EU countries from the donor pool, given the likelihood that these will also be treated by Brexit uncertainty. We report here, as a sensitivity, alternative results where trade between EU country pairs are used in the donor pool for modelling UK exports to the EU. In this case, the shortfall in UK exports to the EU is less compared to the counterfactual than in the sub-section 5.3.

Because there is a huge number of estimations, it is not possible for us to make available a complete set of sample weights. However, to better understand which potential country pairs contribute most to the doppelganger we provide an example in the Online Appendix, Table B3, when we include EU countries in the pool. What emerges from this is that the EU country pairs which contribute most often to this analysis involve France, Italy, Germany, Ireland, Luxembourg and Portugal. In particular, the top 3 bilateral flows are France-Italy, France-Luxembourg and France-Portugal with an average weight of about 24%, 21% and 19%, respectively. Similarly, in the case of non-EU flows, France-Israel, Germany-Israel, and France-New Zealand are those mostly used with an average weight of 34%, 31% and 24%. This shows that there is substantial heterogeneity in the analysis.

Table 8: Percentage difference in aggregate UK exports to EU partners vs counterfactual, with EU countries included in the pool.

	Pre-referendum	Post-General Elec.		Post-Refer.	Post-Art. 50
	1999:1-2015:6	2015:7-2018:3	2015:7-2016:6	2016:7-2017:2	2017:3-2018:3
% difference actual - synth	-.711	-8.652	-5.420	-9.860	-10.974
Standard error	(0.049)	(0.443)	(0.506)	(.436)	(0.463)

Notes: The table reports the percentage difference between actual and synthetic aggregate trade flows between the UK and EU members over different periods. Synthetic counterfactuals are obtained as a weighted average of EU country pairs. We consider the start of the uncertainties around general election in 2015, rather than on the referendum date of June 2016. Standard errors are reported in parentheses.

Table 8 shows the estimated effect of the treatment on UK exports to the EU, splitting the treatment period into subperiods defined by the referendum and the triggering of Article 50.

The fit of the model is shown in Appendix Figure A5, and a gap diagram is Appendix Figure A6. Over the whole period, there is a decline in actual trade values of about 9% compared to the doppelganger. This rises in successive periods, averaging around 10% after the referendum and 11% after the triggering of Article 50. The treatment averaged around 5% in the year before the referendum. Hence these results show a more modest shortfall than in the sub-section 5.3. Our tentative view is that trade flows including EU countries were also negatively treated by the Brexit shock, and so a synthetic based upon them falls short of a true counterfactual.

6.5 A larger pool of countries and alternative matching window

In order to make use of data for a long pre-treatment period, we restricted our sample to 14 of the 27 EU countries for which monthly bilateral data was available since 1999. However, a possible issue is that these 14 EU member countries may not represent the EU as a whole. To address this concern, we limit our analysis only to the period 2012-2018 where we have all 27 EU country pairs in our sample. This allows us to consider all available countries to construct our counterfactual as well as restrict the analysis to only post financial crisis. We report the results of this in Table B13. The results highlight a consistent negative impact of the Brexit referendum shock, albeit of somewhat reduced magnitude.

6.6 Leave-out-Test

We also analyze whether dropping a particular trade flow will affect the overall results. In other words, if the effect is coming from one specific bilateral trade flow that will drastically affect the aggregate result. To test this, we report in the online Appendix, Table B14 the resulting percentage difference between the actual flows and the doppelganger when we exclude one trade flow at the time. The results indicate a consistent decline in aggregate export value to the EU of about 24%. These are not generally affected by single trade flow. Similar results also hold for other flows.[21]

6.7 Additional explanatory variables

Following Saia (2017), we perform an extra robustness check, in which we add extra input variables in our model ($Z_{s,t}$ in equation 7). In particular we an index of Revealed Comparative Advantage (as used in Section 5.3 above), as well as data on common legal origins and the stock of migrants.[22] The results are presented in the Online Appendix Table B15, for both imports and exports to/from EU and non-EU countries. In particular, columns (1) and (4) consider only the overall effect of selecting countries based on RCA index, which account for the type of product specialization. To this we add a further input variable consisting of common legal origins between the two trading partners, in columns (2) and (5). Finally, in columns (3) and (6) we add to this specification also the migration stock. The results remain consistent across the various specifications.

6.8 SCM and Differences-in-Differences

Castillo, Garone, Maffioli & Salazar (2017) apply a differences-in-differences approach to subtract the average pre-treatment difference from post-event. We follow their procedure, computing:

$$DID_{i,t,c} = \left(Y_{i,t,c} - \sum_{j=1}^{J} \sum_{i=1}^{n} \hat{w}_{i,c} Y_{i,t,c}^{N} \right) - \frac{1}{T_0} \left(Y_{i,t_0,c} - (\sum_{j=1}^{J} \sum_{i=1}^{n} \hat{w}_{i,c} Y_{i,t_0,c}^{N}) \right); t\varepsilon\{T0+1, \ldots, T\}. \tag{14}$$

[21]The results are available from the authors upon request.

[22]Migration stock is derived from the UN database. https://www.un.org/en/development/desa/population/migration/data/estimates2/estimates19.asp

The first term represents the difference between actual and synthetic flows post treatment, while the second term averages the same difference across the entire pre-treatment period -i.e. (Castillo, Garone, Maffioli & Salazar 2017). This eliminates any remaining differences between synthetic and actual flows. This second term approximates to zero if there is a good fit between the actual and the doppelganger. Inclusion of this result, in Online Appendix Table B16, supports our overall conclusions.

6.9 Exchange Rate considerations

We need to give a little more consideration to the possible role of exchange rates in this analysis, especially given the very large exchange rate movements directly following the referendum (see Appendix Figure B9). Our analysis has been carried out in dollars: this makes sense in any panel-type comparison of bilateral trade between multiple pairs of countries, since it would not make sense to compare trade denominated in multiple exchange rates. Of course, given the scale of the exchange rate depreciation, a flat export performance in dollar terms may appear as a sharp rise in exports in sterling terms.

There is also a potential issue of dynamics. While our SCM contains the bilateral exchange rate of each trading pair (i.e. Sterling to Euro, for UK-German trade, for example), and both countries' GDPs in Dollars (which will change rapidly if the Dollar exchange rate changes) as confounding variables, they are there in current levels, with the dynamics of the Synthetic Control Method (SCM) provided by the weighted matching of the other bilateral trade flows in the synthetic doppelganger. We need to consider the possibility that traded volumes may take time to react to a large fall in the exchange rate, and hence that dollar values of UK exports may initially fall simply because UK export costs are falling.[23]

To test for this, we repeat our SCM exercise for UK exports to EU countries, but adding lagged, as well as current, export values and exporters' nominal GDP, which incorporates the dollar exchange rate. Results are reported in the Online Appendix Table B17 below. We find that including these rather simple dynamics does not greatly change our finding of a significant fall in UK export demand.

In addition, to investigate whether exchange rate may drive our results, we consider running our baseline model in logs, then calculate the percentage difference between the doppelganger and synthetic. The results of this exercise using non-EU countries as the donor pool is reported in Table 9. The results remain broadly consistent to our baseline model, especially for exports to the EU. The export gap to

[23] Against this, of course, many studies suggest that traded prices are sticky in terms of the importer currency, with limited exchange rate pass-through.

non-EU countries is somewhat reduced, but more volatile, than in the linear model.

Table 9: Percentage difference in aggregate UK exports vs counterfactual, using logs

	Pre-referendum	Post-General Elec.		Post-Refer.	Post-Art. 50
	EU				
	1999:1-2015:6	2015:7-2018:3	2015:7-2016:6	2016:7-2017:2	2017:3-2018:3
% difference actual - synth	-.720	-18.355	-15.257	-21.18	-19.400
Standard error	(0.273)	(1.207)	(1.193)	(1.106)	(1.287)
	Non-EU				
	1999:1-2015:6	2015:7-2018:3	2015:7-2016:6	2016:7-2017:2	2017:3-2018:3
% difference actual - synth	.253	-7.055	-1.800	-13.482	-7.534
Standard error	(0.208)	(0.892)	(0.937)	(0.847)	(0.923)

Notes: The table reports the percentage difference between actual and synthetic aggregate trade flows between the UK and EU and non-EU members over different periods. Synthetic counterfactuals are obtained as a weighted average of non-EU country pairs. We consider the start of the uncertainties around the general election in 2015, rather than on the referendum date of June 2016. All variables were included in logs, but exponentials of the actual and synthetic flows were taken before summing across countries. Standard errors are reported in parentheses.

7 Conclusions

In this paper, we have examined the effects upon trade of the Brexit policy shock, associated with the referendum of 23 June 2016. This can be seen as a classic case of anticipation and policy uncertainty, since no formal trade barriers were in fact put in place for a further $4\frac{1}{2}$ years.

Despite the lack of formal barriers, our work confirms very clearly that policy uncertainty can have strong economic effects. These started roughly a year before the referendum - probably about the time of the unexpected Conservative general election victory in May 2015. Even though the odds on a Leave win were around $\frac{1}{3}$ prior to the referendum, this appears to have been sufficient to put much trade engagement on hold, and maybe suggesting that people feared a rapid exit should Leave win.

The discussion in Sections 6.4 and 5.3 shows that UK export demand, measured in dollar terms, started to fall well below what would be expected, from the trends of other countries' trade and GDP, and from exchange rate movements to both EU and non-EU destinations, particularly from early 2016, and this shortfall increased until after the referendum. Exports performed badly to both EU and non-EU countries. The most seriously affected were exports to EU countries, shown in Section 5.3, with a shortfall of 20-25% compared to the doppelganger. We argue that this reflects, in part, an inward shift in supply in anticipation of a risk of demand decline in the event of Brexit.

However, UK exports to exports to non-EU countries also performed poorly - some 15% below trend.

This decline does not seem to be particularly affected by whether a country has a PTA with the EU, or whether or not it is in the Commonwealth. Hence, our conclusion is that this poor performance probably indicates worries about UK competitiveness, likely from supply chain costs.

To summarize: we find tentative evidence of both an inward shift in supply in anticipation of a decline in the demand curve, as well as signs that demand from all destinations has been deterred by fear of post-Brexit supply interruptions and/or cost increases. Further robustness checks confirm that this does not seem to be simply a case of a delayed response of exports to devaluation.

Regarding imports, Section 5.6 shows that those from the EU fall modestly below the doppelganger. Imports from many non-EU countries also perform badly, but there is a possible distinction between Commonwealth countries, whose sales to the UK have risen, and non-Commonwealth countries. We argue that this may be consistent with the Brexit campaign reinforcing pro-Commonwealth sentiment among Leave voters, whose consumer confidence also rose following the result. There is also some evidence that UK importers were wary of supplies from those non-EU countries which had existing PTAs with the EU - indicating the importance to the UK of reaching rollover trade agreements with these.

A few extra points are in order. We do not investigate services exports in this paper, due to the lack of a comparable long string of bilateral services trade data. However, Douch & Edwards (2021), using aggregate services export data and Ahmad et al. (2020), using a shorter run of bilateral services export data, confirm that policy uncertainty has had similar effects in services.

It is worth noting that the poor export performance picked out by our analysis is mostly in comparison with what one should have expected, given an upturn in many other economies, and the stimulus from a fall in sterling. This would be less evident in data published in sterling terms. The poor performance is that the UK is now having to sell its exports at a lower price, with little gain in volume terms.[24]

Overall, however, there seems to be an important message. Even before actual policy changes have been finalized uncertainty and anticipation have sizeable and measurable effects upon trade.

As regards Brexit: substantial parts of the British electorate may have chosen 'the wide open sea'[25], but there is little evidence of the World outside Europe switching towards British exports – in fact, rather the reverse.

[24] In this regard, the Department of International Trade's announcement in its export strategy briefing of 21 August 2018 that UK exports were 'at record levels' was both true and quite misleading in terms of the UK's ability to purchase imported goods and services with what it exports.

[25] In Winston Churchill's famous phrase.

References

Abadie, A., Diamond, A. & Hainmueller, J. (2010), 'Synthetic control methods for comparative case studies: Estimating the effect of California's tobacco control program', *Journal of the American Statistical Association* **105**(490), 493–505.

Abadie, A. & Gardeazabal, J. (2003), 'The economic costs of conflict: A case study of the Basque Country', *American Economic Review* **93**(1), 113–132.

Ahmad, S., Limao, N., Oliver, S. & Shikher, S. (2020), 'Brexit Uncertainty and its (Dis)Service Effects', *NBER Working Papers* (28053).

Baier, S. L. & Bergstrand, J. H. (2009), 'Estimating the effects of free trade agreements on international trade flows using matching econometrics', *Journal of International Economics* **77**(1), 63–76.

Bailey, D. & De Propris, L. (2017), 'Brexit and the UK Automotive Industry', *National Institute Economic Review* .

Balassa, B. (1965), 'Trade liberalisation and "revealed" comparative advantage 1', *The Manchester School* **33**(2), 99–123.

Born, B., Müller, G., Schularick, M. & Sedlacek, P. (2019), 'The Costs of Economic Nationalism: Evidence from the Brexit vote.', *Economic Journal* **129**.

Breinlich, H., Leromain, E., Novy, D. & Sampson, T. (2020), 'Voting with their money: Brexit and outward investment by UK firms', *European Economic Review* **124**, 103400.

Campos, N. F. & Coricelli, F. (2017), 'EU Membership, Mrs Thatcher's Reforms and Britain's Economic Decline', *Comparative Economic Studies* **59**(2), 169–193.

Carballo, J., Handley, K. & Limão, N. (2018), Economic and policy uncertainty: Export dynamics and the value of agreements, Technical report, National Bureau of Economic Research working paper 24368.

Card, D. (1990), 'The impact of the Mariel boatlift on the Miami labor market', *ILR Review* **43**(2), 245–257.

Card, D. & Krueger, A. B. (1994), 'Minimum Wages and Employment: A Case Study of the Fast-Food Industry in New Jersey and Pennsylvania', *American Economic Review* **84**(4), 772–793.
URL: *https://ideas.repec.org/a/aea/aecrev/v84y1994i4p772-93.html*

Castillo, V., Figal Garone, L., Maffioli, A. & Salazar, L. (2017), 'The causal effects of regional industrial policies on employment: A synthetic control approach', *Regional Science and Urban Economics* **67**(August), 25–41.

Castillo, V., Garone, L. F., Maffioli, A. & Salazar, L. (2017), 'The causal effects of regional industrial policies on employment: A synthetic control approach', *Regional Science and Urban Economics* **67**, 25–41.

Crowley, M. A., Exton, O. & Han, L. (2020), 'The looming threat of tariff hikes: Entry into exporting under trade agreement renegotiation', *AEA Papers and Proceedings* **110**, 547–51.

Crowley, M., Exton, O. & Han, L. (2018), Renegotiation of trade agreements and firm exporting decisions: Evidence from the impact of Brexit on UK exports, Technical report, University of Cambridge Working Papers in Economics, 1839.

Davies, R. B. & Studnicka, Z. (2018), 'The heterogeneous impact of Brexit: Early indications from the FTSE', *European Economic Review* **110**(C), 1–17.

Dhingra, S., Huang, H., Ottaviano, G., Paulo Pessoa, J., Sampson, T. & Van Reenen, J. (2017), 'The costs and benefits of leaving the EU: trade effects', *Economic Policy* **32**(92), 651–705.

Douch, M. (2020), *The effect of policy uncertainty on South Africa, SADC, and beyond*, United Nations University World Institute for Development Economics Research.

Douch, M., Du, J. & Vanino, E. (2020), Defying Gravity? Policy Uncertainty and Trade Diversion, Technical report, Working Paper. Birmingham: Aston University.

Douch, M. & Edwards, T. (2021), 'The Brexit Policy Shock: Were UK services exports affected, and when?', *Journal of Economic Behavior and Organization* **182**, 248–63.

Ebell, M. & Warren, J. (2016), 'The long-term economic impact of leaving the EU', *National Institute Economic Review* **236**(1), 121–138.

Freund, C. L. & McLaren, J. (1999), 'On the dynamics of trade diversion: evidence from four trade blocs', *International Finance Discussion Papers no 637, Board of Governors of the Federal Reserve System (U.S.)* .

Fry, J. & Brint, A. (2017), 'Bubbles, Blind Spots and Brexit', *Risk* **37**(5).

Graziano, A. G., Handley, K. & Limão, N. (2020*a*), 'Brexit Uncertainty and Trade Disintegration*', *The Economic Journal* .

Graziano, A. G., Handley, K. & Limão, N. (2020*b*), 'Brexit Uncertainty: Trade Externalities beyond Europe', *AEA Papers and Proceedings* **110**, 552–556.

Graziano, A., Handley, K. & Limao, N. (2018), 'Brexit Uncertainty and Trade Disintegration', *NBER Working Paper 25334* .

Handley, K. & Limão, N. (2017), 'Policy Uncertainty, Trade, and Welfare: Theory and Evidence for China and the United States', *American Economic Review* **107**(9), 2731–2783.

Hausmann, R., Hidalgo, C. A., Bustos, S., Coscia, M., Simoes, A. & Yildirim, M. A. (2014), *The Atlas of Economic Complexity: Mapping paths to prosperity*, MIT Press.

Head, K. & Mayer, T. (2014), *Gravity Equations: Workhorse, Toolkit, and Cookbook*, Vol. 4 of *Handbook of International Economics*, Elsevier, chapter 3, pp. 131–195.

Head, K., Mayer, T. & Ries, J. (2010), 'The erosion of colonial trade linkages after independence', *Journal of International Economics* **81**(1), 1–14.

Limão, N. & Maggi, G. (2015), 'Uncertainty and trade agreements', *American Economic Journal: Microeconomics* **7**(4), 1–42.

McKinsey & Company (2019), Brexit: The bigger picture—rethinking supply chains in a time of uncertainty, Technical report, May7, 2019.

Melitz, M. J. (2003), 'The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity', *Econometrica* **71**(6), 1695–1725.

Osnago, A., Piermartini, R. & Rocha, N. (2015), Trade policy uncertainty as barrier to trade, Technical report, WTO Staff Working Paper ERSD-2015-05.

Politis, D. N. & Romano, J. P. (1994), 'The stationary bootstrap', *Journal of the American Statistical Association* **89**(428), 1303–1313.

Redding, S. & Weinstein, D. E. (2018), 'Accounting for trade patterns', *Princeton University, mimeograph* .

Saia, A. (2017), 'Choosing the Open Sea: The cost to the UK of staying out of the Euro', *Journal of International Economics* **108**, 82–98.

Sedláček, P. & Sterk, V. (2017), 'The Growth Potential of Startups over the Business Cycle', *American Economic Review* **107**(10), 3182–3210.

Steinberg, J. B. (2019), 'Brexit and the macroeconomic impact of trade policy uncertainty', *Journal of International Economics* **117**(C), 175–195.
URL: *https://ideas.repec.org/a/eee/inecon/v117y2019icp175-195.html*

Van Reenen, J. (2016), 'Brexit's long-run effects on the U.K. economy', *Brookings Papers on Economic Activity* pp. 367–83.

Vandenbussche, H., Connell Garcia, W. & Simons, W. (2017), 'Global Value Chains, Trade Shocks and Jobs: An application to Brexit', *CESifo Working Papers* .

A ONLINE APPENDIX

The Bilateral Trade Effects of Announcement Shocks: Brexit as a Natural Field Experiment

This Appendix reports the analysis of exports and imports for both UK-EU and UK-non-EU, using just after the referendum date, July 2016 as the start of treatment, instead of 2015 as in our baseline specification.

Figure A1: Aggregate exports from UK to EU (Treatment date of the referendum, 2016:6).

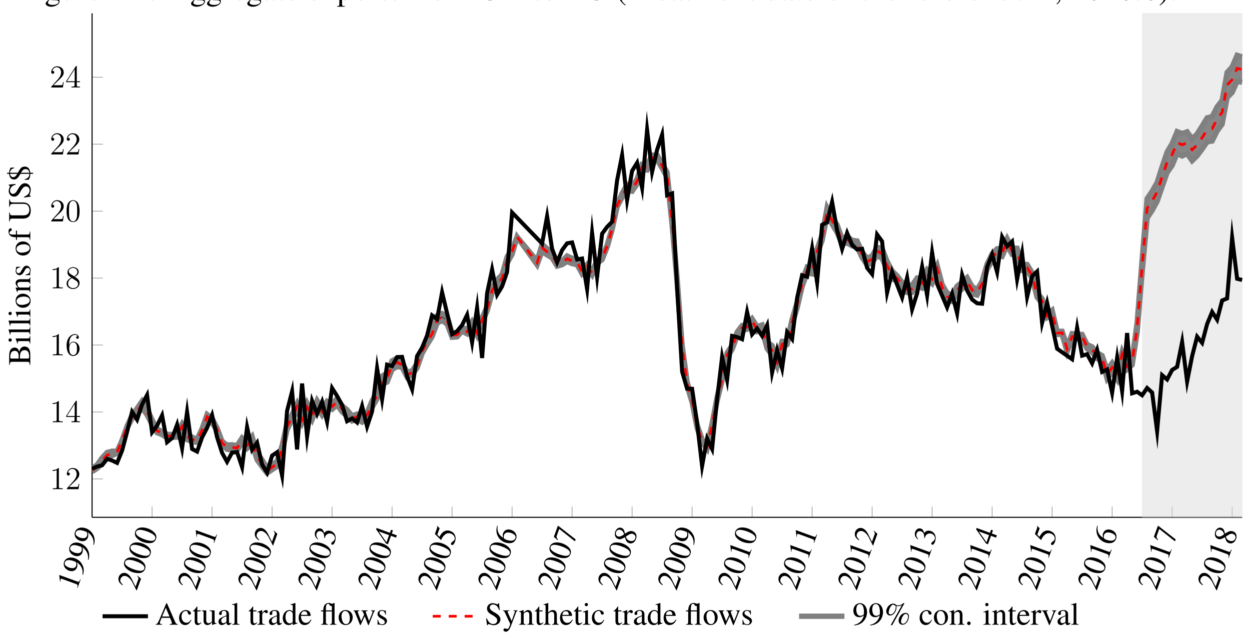


Table A1: Percentage difference in aggregate UK exports to EU partners vs counterfactual. (Treatment date of the referendum, 2016:6).

	Pre-referendum	Post-referendum		
	1999:1-2016:6	2016:7-2018:3	2016:7-2017:2	2017:3-2018:3
% difference actual	-0.227	-15.643	-16.480	-15.477
vs synthetic	(0.033)	(0.321)	(0.317)	(0.349)

Notes: The table reports the percentage difference between actual and synthetic aggregate trade flows between the UK and EU members over different periods. Synthetic counterfactuals are obtained as a weighted average of EU country pairs. Standard errors are reported in parentheses.

We summarize the results in Table A3, below. Over the whole post-Brexit period, actual exports are 13.3 % lower than their synthetic counterparts. Inspecting the last two columns of the table we note that the shortfall in actual exports relative to the doppelganger was slightly larger in our second post-Brexit period (2017-early 2018).

Table A2: Percentage difference in exports from the UK to individual EU partners vs counterfactual. (Treatment date of the referendum, 2016:6).

	AUT	BEL	DEU	DNK	ESP	FIN	FRA	GRC	IRL	ITA	LUX	NLD	PRT	SWE
% difference actual minus synth														
1999:1-2016:5.	-0.422	0.040	-0.099	-0.305	-0.156	-0.349	-0.155	-0.224	0.144	-0.243	0.160	0.071	-0.322	-0.112
	(0.036)	(0.014)	(0.025)	(0.025)	(0.021)	(0.036)	(0.030)	(0.050)	(0.022)	(0.020)	(0.168)	(0.019)	(0.043)	(0.017)
% 2016:6-2018:3.	-3.604	-22.465	-4.276	-24.769	-22.783	-37.361	-15.950	-44.691	-18.582	-18.080	-50.553	-14.723	-31.564	-24.748
	(1.116)	(0.366)	(0.377)	(0.677)	(0.349)	(0.705)	(0.401)	(0.726)	(0.391)	(0.366)	(2.925)	(0.357)	(0.879)	(0.387)

Notes: The table reports the percentage difference between actual and synthetic aggregate trade flows between the UK and EU members over different periods. Synthetic counterfactuals are obtained as a weighted average of EU country pairs. Standard errors are reported in parentheses.

Figure A2: Aggregate exports from UK to non-EU. (Treatment date of the referendum, 2016:6).

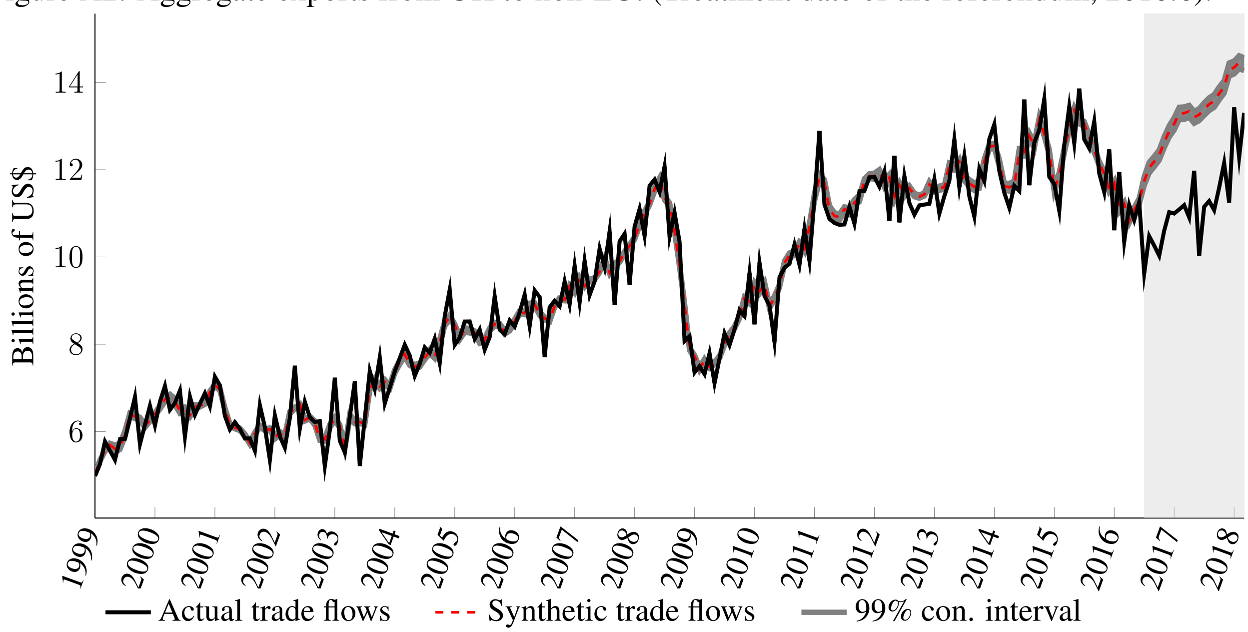


Table A3: Percentage difference in aggregate exports from UK to Non-EU partners vs counterfactual. (Treatment date of the referendum, 2016:6).

	Pre-referendum	Post-referendum		
	1999:1-2016:6	2016:7-2018:3	2016:7-2017:2	2017:3-2018:3
% difference actual	-0.605	-13.326	-12.529	-13.565
vs synthetic	(0.098)	(1.171)	(1.250)	(1.585)

Notes: The table reports the percentage difference between actual and synthetic aggregate trade flows between the UK and non-EU members over different periods. Synthetic counterfactuals are obtained as a weighted average of non-EU country pairs. Standard errors are reported in parentheses.

Table A4: Percentage difference in UK exports to individual non EU partners vs counterfactual. (Treatment date of the referendum, 2016:6).

	Commonwealth + HK						USA	Rest of World						
	AUS	CAN	HKG	IND	NZL	ZAF	USA	BRA	CHN	ISR	JPN	KOR	MEX	RUS
% diff. actual vs synth.														
1999:1-2016:5	0.002	-0.092	0.045	-0.047	-0.097	-0.103	-0.346	-0.147	0.020	-0.107	-0.138	-0.145	-0.327	-0.099
	(0.035)	(0.029)	(0.029)	(0.028)	(0.080)	(0.038)	(0.087)	(0.034)	(0.036)	(0.049)	(0.032)	(0.035)	(0.044)	(0.031)
2016:6-2018:3	-19.753	-19.351	-4.269	-23.196	24.396	-42.431	-17.281	-28.804	43.615	-40.552	-18.663	30.762	0.236	-31.563
	(0.902)	(0.834)	(1.190)	(0.756)	(3.177)	(0.750)	(0.188)	(0.987)	(2.592)	(1.025)	(0.919)	(1.464)	(1.745)	(0.851)

Notes: The table reports the percentage difference between actual and synthetic aggregate trade flows between the UK and non-EU members over different periods. Synthetic counterfactuals are obtained as a weighted average of EU country pairs. Standard errors are reported in parentheses.

Figure A3: Aggregate imports from EU. (Treatment date of the referendum, 2016:6).

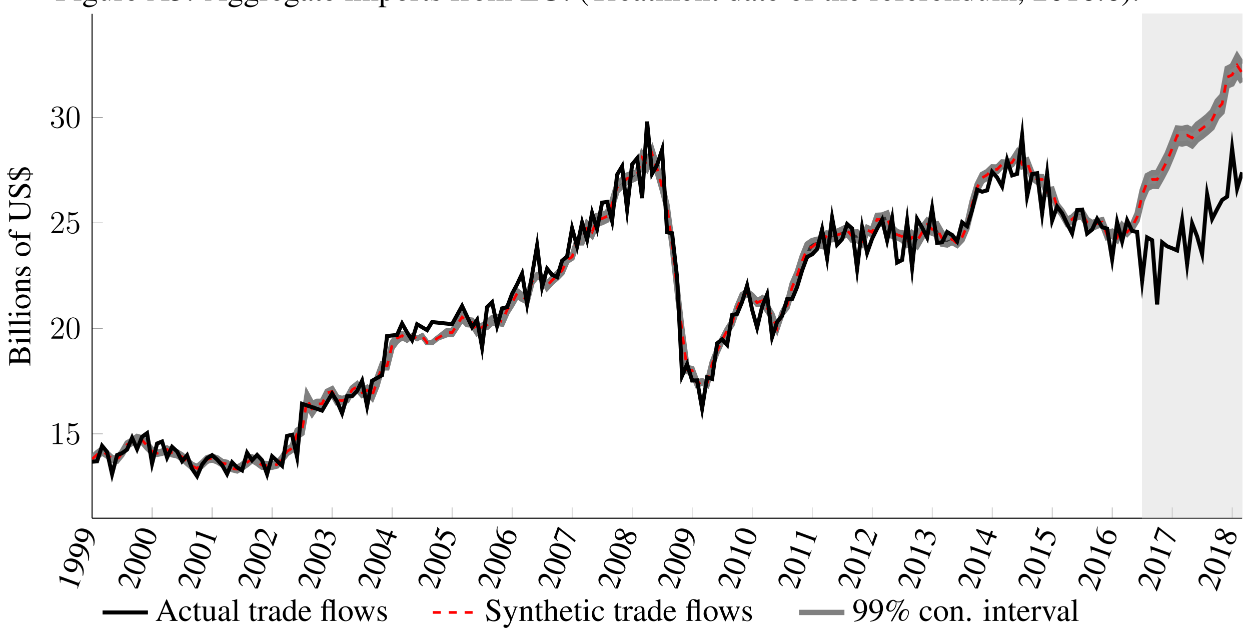


Table A5: Percentage difference in aggregate UK imports from EU partners vs counterfactual. (Treatment date of the referendum, 2016:6).

	Pre-referendum	Post-referendum		
	1999:1-2016:5	2016:6-2018:3	2016:6-2016:12	2017:1-2018:3
% difference actual	-0.339	-3.084	-1.191	-3.643
vs synthetic	(0.027)	(0.955)	(0.684)	(1.045)

Notes: The table reports the percentage difference between actual and synthetic aggregate trade flows between the UK and EU members over different periods. Synthetic counterfactuals are obtained as a weighted average of EU country pairs. Standard errors are reported in parentheses.

Figure A4: Aggregate imports from non-EU countries. (Treatment date of the referendum, 2016:6).

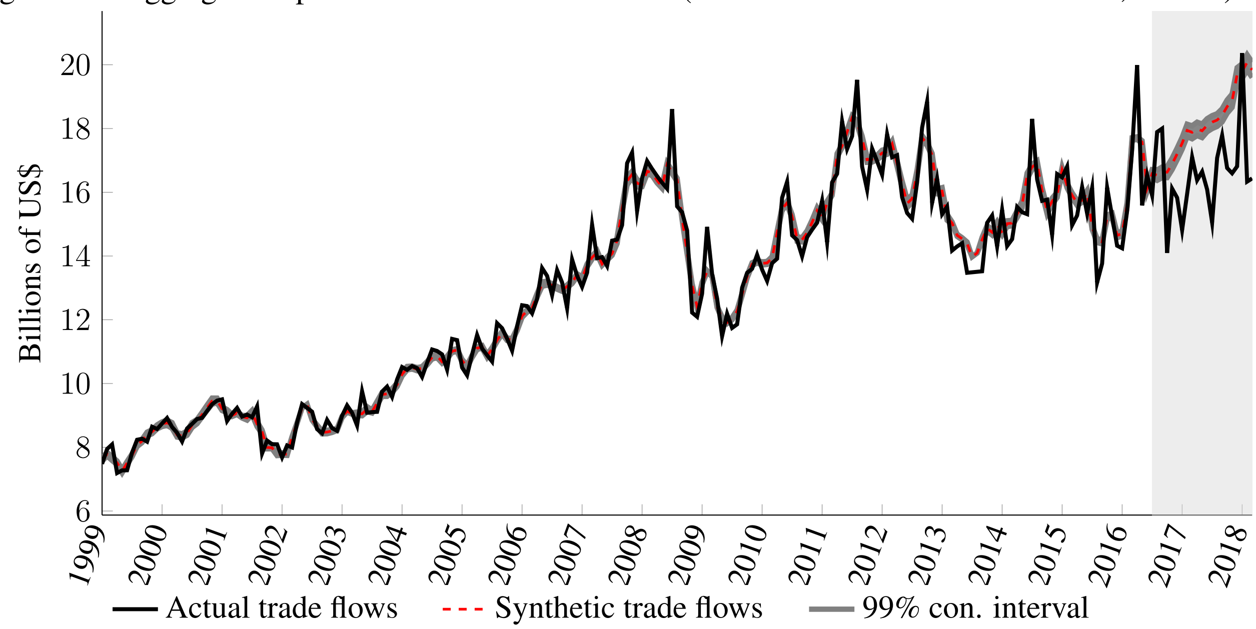


Table A6: Percentage difference in aggregate UK imports from non-EU partners vs counterfactual. (Treatment date of the referendum, 2016:6).

	Pre-referendum	Post-referendum		
	1999:1-2016:6	2016:7-2018:3	2016:7-2016:12	2017:1-2018:3
% difference actual	0.291	-8.283	-1.323	-9.937
vs synthetic	(0.103)	(1.346)	(1.279)	(1.307)

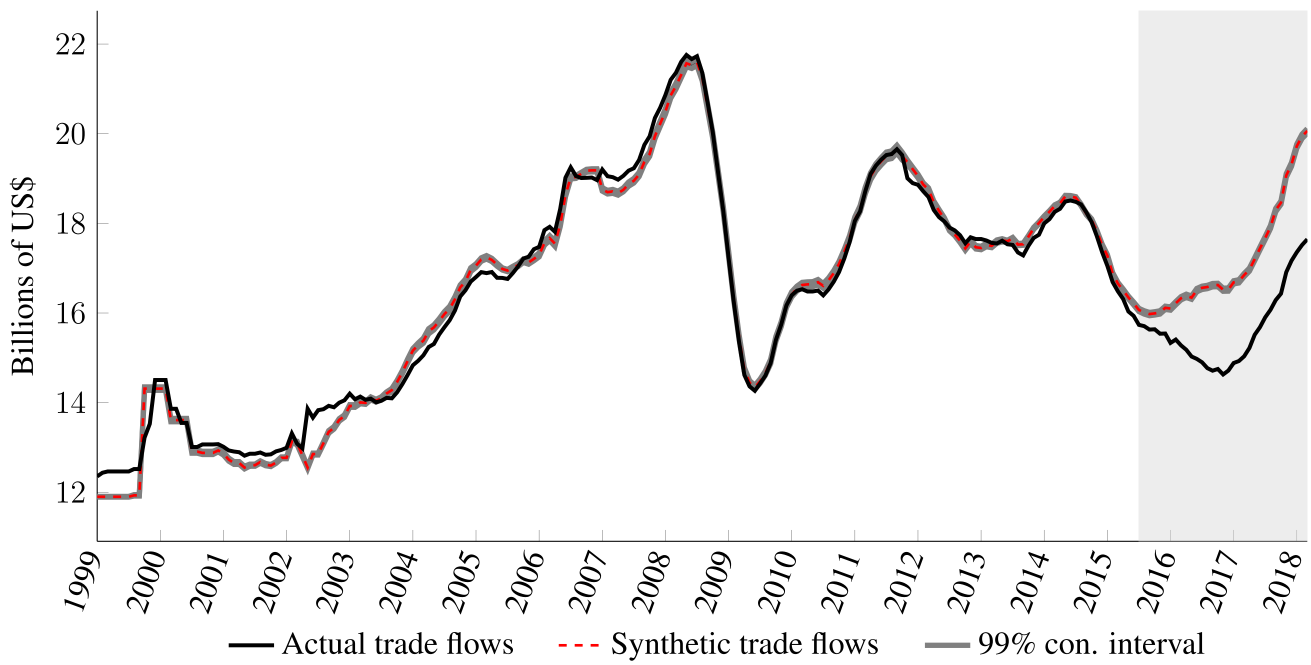
Notes: The table reports the percentage difference between actual and synthetic aggregate trade flows between the UK and non-EU partners over different periods. Synthetic counterfactuals are obtained as a weighted average of non-EU country pairs. Standard errors are reported in parentheses.

Table A7: Percentage difference in UK imports from individual non-EU partners vs counterfactual. (Treatment date of the referendum, 2016:6).

	Commonwealth + HK						USA	Rest of World						
	AUS	CAN	HKG	IND	NZL	ZAF	USA	BRA	CHN	ISR	JPN	KOR	MEX	RUS
% diff. actual vs synth.														
1999:1-2016:5	0.107	0.125	0.107	0.055	0.095	0.163	-0.060	0.020	0.112	-0.095	0.027	0.091	-0.220	0.063
	(0.036)	(0.031)	(0.032)	(0.026)	(0.045)	(0.030)	(0.110)	(0.023)	(0.044)	(0.038)	(0.042)	(0.028)	(0.032)	(0.033)
2016:6-2018:3	1.887	12.604	12.509	29.827	-5.608	4.423	-11.701	-18.361	-6.689	-27.059	-25.524	-1.591	23.314	-20.666
	(2.122)	(2.020)	(2.129)	(2.175)	(1.883)	(1.922)	(0.139)	(1.238)	(1.964)	(1.469)	(1.328)	(1.652)	(2.298)	(1.454)

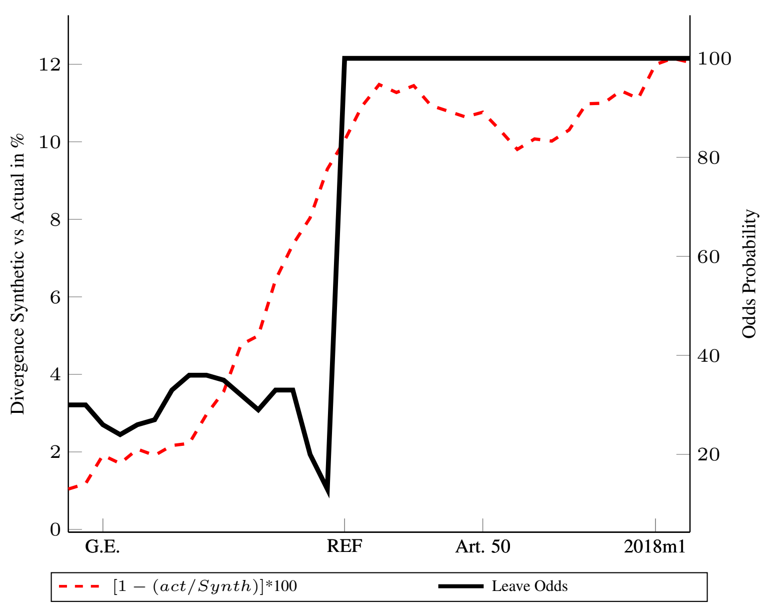
Notes: The table reports the percentage difference between actual and synthetic for each non-EU trade flows between the UK and non-EU members. Each synthetic counterfactual is a weighted average of non-EU country pairs, randomly drawn from the pool of potential donors, where weights are chosen to best resemble the actual treated unit. Standard errors are reported in parentheses.

Figure A5: Alternative aggregate exports from UK to EU, including EU country pool



Notes: This figure assumes a treatment in 2015:6, on trade with 14 EU countries. The donor pool includes trade involving EU countries.

Figure A6: UK-EU exports – Synthetic comparison with Leave Odds



Notes: This figure assumes a treatment in 2015:6, on trade with 14 EU countries. The donor pool includes trade involving EU countries. We compare the shortfall of actual compared to synthetic with the odds on Brexit derived from Fry & Brint (2017).

B ONLINE APPENDIX

The Bilateral Trade Effects of Announcement Shocks: Brexit as a Natural Field Experiment

B.1 Data

In this appendix we report some data harmonization that we undertook. In particular, Table B1 shows that 164 export or import series had missing values, out of about 400,000 (2 x 28 x 29 x 241), or 0.04%. In fact, only 66 out of 812 country pairs had either an export or an import value missing, and only 6 of these had more than a single value missing. In addition, since traded goods appear in the statistics twice (as exports from A to B and imports by B from A), we were able to fill in all the small number of holes between our chosen sample of countries. In the few cases where there is not a direct month-on-month comparison, partly because trade often takes time, we were able to fill in missing values using regressions on lagged (or leading) trade reported in the other direction.

Note that only two monthly observations for UK trade were affected: one month for imports to Sweden from the UK and one month for imports to South Africa from the UK. In both cases, the corresponding flow was reported from the other end.

Table B1: Bilateral trade: number of missing observations (out of 241) by country pairs.

Reporter	Partner	Exports	Imports	Reporter	Partner	Exports	Imports
AUS	BEL		1	AUS	CAN		1
AUS	LUX	2	1	AUS	RUS	1	1
AUS	ZAF		6	BEL	NLD		1
BRA	AUT		1	BRA	IND		1
BRA	IRL	1		BRA	LUX	12	1
BRA	NZL	1		BRA	SWE	1	
BRA	ZAF		1	CHN	SWE		1
DNK	SWE	1		FIN	ESP		1
FIN	NLD		1	GRC	LUX	5	
HKG	LUX	2		IND	CAN		2
IND	RUS		1	IND	SWE	1	
ITA	ESP		1	KOR	SWE	1	
MEX	SWE	1		NZL	BRA	4	
NZL	LUX	64		RUS	KOR	3	
RUS	ZAF		1	SWE	AUS		1
SWE	AUT		1	SWE	BEL		1
SWE	BRA		1	SWE	CAN		1
SWE	DEU		1	SWE	DNK		1
SWE	ESP		2	SWE	FIN		1
SWE	FRA		1	SWE	GBR		1
SWE	GRC		1	SWE	HKG		1
SWE	IND		1	SWE	IRL		1
SWE	ISR		1	SWE	ITA		1
SWE	JPN		1	SWE	KOR		1
SWE	LUX		1	SWE	MEX		1
SWE	NLD		1	SWE	NZL		1
SWE	PRT		1	SWE	USA		1
SWE	ZAF		1	ZAF	CHN		2
ZAF	ESP		1	ZAF	GBR		1
ZAF	HKG	1		ZAF	ISR	1	
ZAF	ITA	1		ZAF	KOR	1	
ZAF	LUX	1		ZAF	NLD	2	
ZAF	PRT	1	1	ZAF	RUS	1	
Total		109	55				

Note: This table reports the number of missing values (out of 241 months) ONLY for those country pairs for which some values are missing. The total number of country pairs is 812, of which only 66 have any values missing at all. The total number of trade observations (exports or imports) is nearly 400,000.

B.2 Graphs

Figure B1: UK exports to individual EU countries. (Treatment date of the referendum, 2016:6).

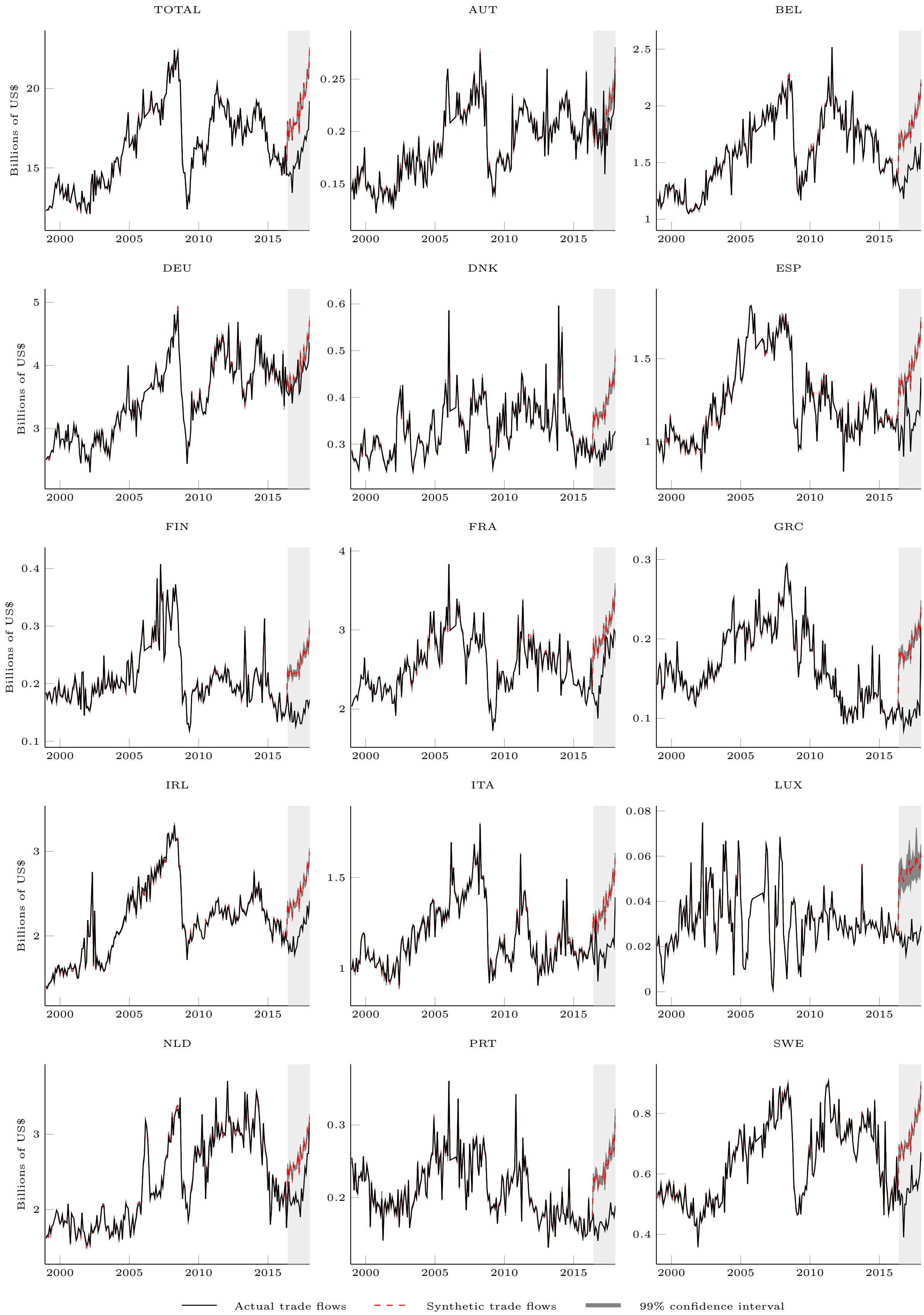


Figure B2: UK exports to individual non-EU countries. (Treatment date of the referendum, 2016:6).

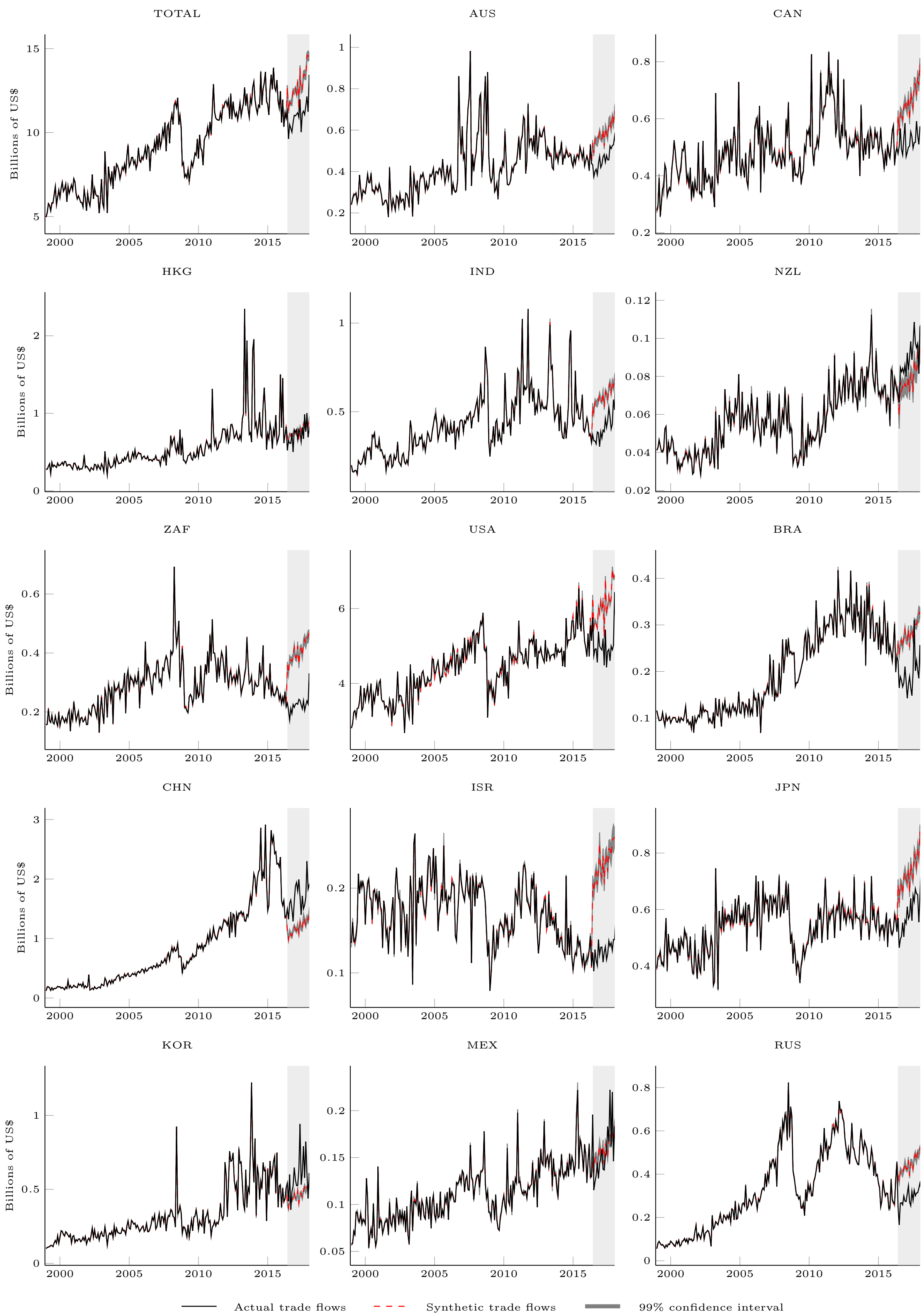


Figure B3: UK imports from individual EU countries. (Treatment date of the referendum, 2016:6).

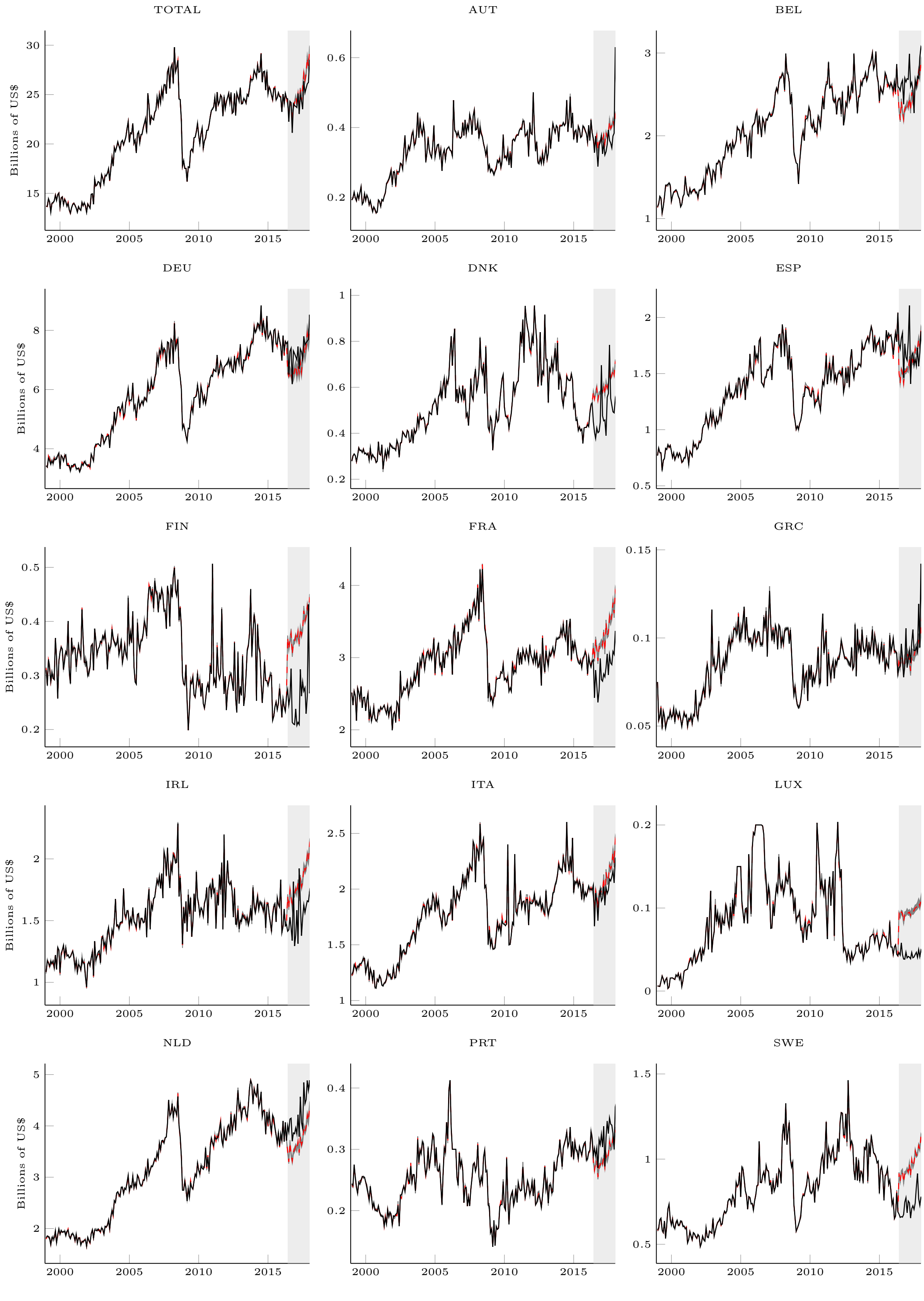
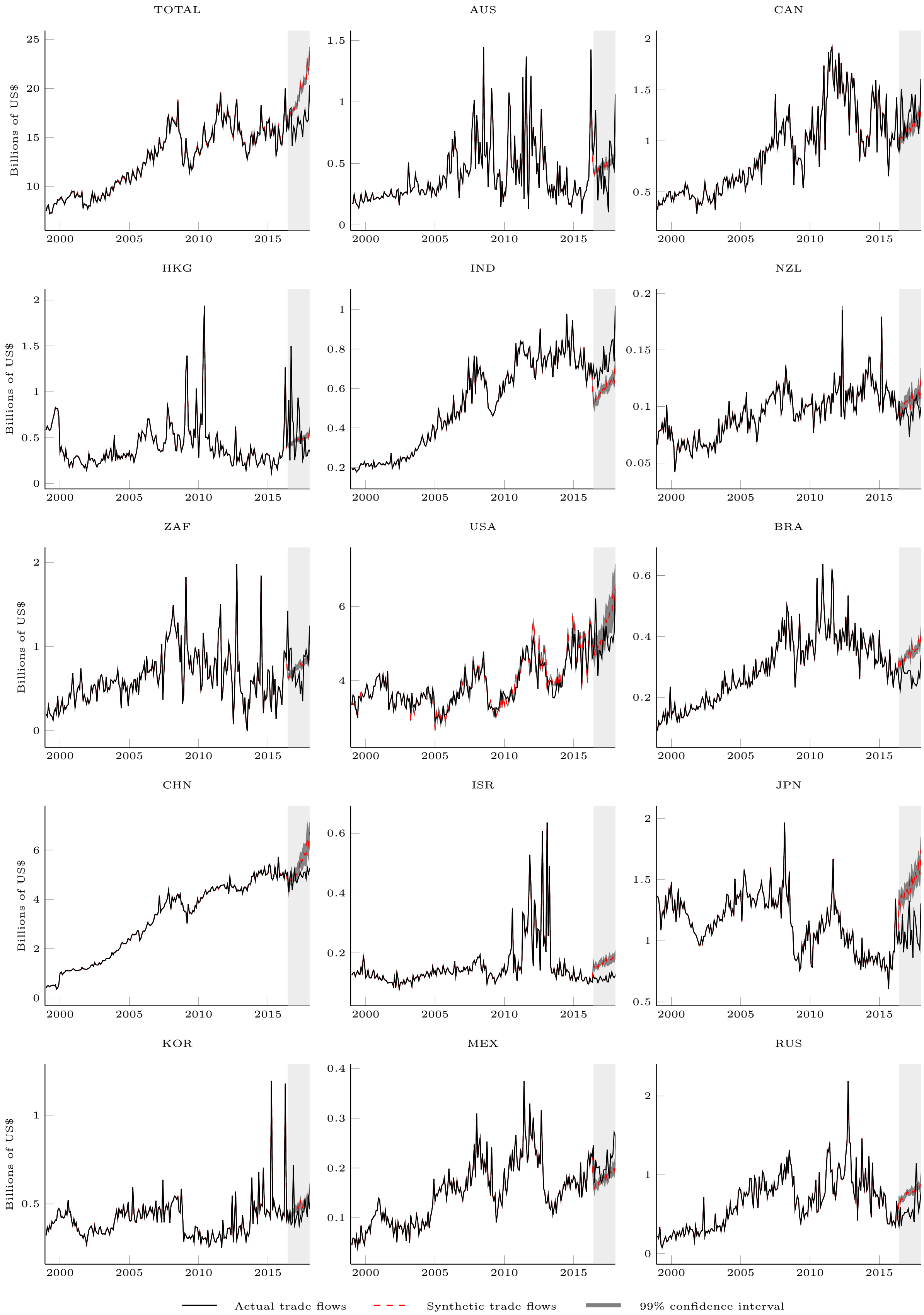


Figure B4: UK imports from individual non-EU countries. (Treatment date of the referendum, 2016:6).



B.3 Doppelganger Sample Weights

Table B2: Top 20 ranked country pairs used in the doppelgangers for UK exports to the EU using non-EU countries pool.

EU exports							
Av. Weight	sd	Country Pairs	rank	Av. Weight	sd	Country Pairs	rank
0.3782	0.3135	AUS-NZL	1	0.2291	0.3018	RUS-ISL	11
0.3552	0.3828	KOR-JPN	2	0.2283	0.3617	ISR-USA	12
0.3142	0.4226	BRA-CHN	3	0.2219	0.3021	ISR-RUS	13
0.2871	0.3202	HKG-JPN	4	0.2211	0.3495	AUS-JPN	14
0.2764	0.3255	AUS-HKG	5	0.2198	0.2883	ARG-CHL	15
0.264	0.3216	ARG-BRA	6	0.199	0.3064	BRA-USA	16
0.2509	0.3229	IDN-JPN	7	0.1899	0.2612	JPN-HKG	17
0.2496	0.3122	TUR-ISL	8	0.1885	0.3005	ISR-NOR	18
0.2394	0.3414	HKG-CAN	9	0.1877	0.2916	ARG-USA	19
0.2374	0.2551	HKG-USA	10	0.1867	0.3158	AUS-CHN	20

Note: This table reports an example of the average weights of those country pairs most frequently used to construct the doppelganger.

Table B3: Top ranked country pairs used in the doppelgangers for UK exports to the EU and to non-EU countries: alternative donor pool including EU members.

	EU exports				Non-EU exports		
Country Pairs	Av. Weight	sd	rank	Country Pairs	Av. Weight	sd	rank
FRA-ITA	0.2444	0.2705	1	FRA-ISR	0.3415	0.3695	1
FRA-LUX	0.215	0.3591	2	DEU-ISR	0.3114	0.2519	2
FRA-PRT	0.1938	0.2822	3	FRA-NZL	0.2718	0.3574	3
ITA-LUX	0.1875	0.2768	4	DEU-NZL	0.2517	0.2412	4
FRA-NLD	0.184	0.3051	5	DEU-HKG	0.2169	0.2426	5
FRA-GRC	0.1532	0.2593	6	FRA-ZAF	0.2056	0.333	6
DEU-LUX	0.1296	0.1844	7	FRA-CAN	0.1832	0.2722	7
DEU-GRC	0.1196	0.1578	8	FRA-IND	0.1449	0.3001	8
FRA-IRL	0.1188	0.289	9	FRA-AUS	0.1449	0.2863	9
DEU-ITA	0.0783	0.1473	10	FRA-MEX	0.1438	0.2989	10
DEU-IRL	0.066	0.1468	11	FRA-JPN	0.1127	0.2167	11
DEU-PRT	0.0414	0.0814	12	DEU-IND	0.1015	0.1987	12
DEU-ESP	0.0213	0.0942	13	DEU-KOR	0.0922	0.205	13
DEU-FIN	0.016	0.0508	14	DEU-BRA	0.0917	0.1568	14
DEU-FRA	0.0126	0.0491	15	ITA-NZL	0.072	0.1866	15

Note: This table reports an example of the average weights of those country pairs most frequently used to construct the doppelganger. We report this for both EU and non-EU exports. This is based on 14 EU countries in the main analysis.

B.4 Confounding Variables

Table B4: UK-EU Exports: Mean Values of Confounding variables (example).

	Treated	Synthetic
Average of lagged Exports	5.35e+08	5.29e+08
Average Exports	5.40e+08	5.46e+08
Bilateral Exchange Rate	.0059139	1.299067
Reporter GDP	623308.1	620428.7
Partner GDP	4945512	4868784
lag Reporter GDP	605283.5	596869
Revealed Comparative Advantage	.4130296	.2697205
Weighted Distance	9436.248	10848.68
Bilateral Exchange Rate Standard Dev.	.0001777	.0268902

Notes: The table reports an example of the resulting confounding variables for the treated and doppelganger. These are included as averaged over the period of pre-treatment.

Table B5: UK-EU Imports: Mean Values of Confounding variables (example).

	Treated	Synthetic
Average of lagged Imports	1.47e+08	1.52e+08
Average Imports	1.56e+08	1.61e+08
Bilateral Exchange Rate	.0525894	2.048361
Reporter GDP	623308.1	624464
Partner GDP	990560.9	989623.2
lag Reporter GDP	605283.5	606305.6
Revealed Comparative Advantage	.1827371	.1823376
Weighted Distance	8734.489	8734.352
Bilateral Exchange Rate Standard Dev.	.0020252	.06744

Notes: The table reports an example of the resulting confounding variables for the treated and doppelganger. These are included as averaged over the period of pre-treatment.

Table B6: Non-EU states: status of trade agreements with EU and dates of agreements.

Country	FTA by 2016	FTA by 2020	Negotiations started	On hold	
AUS				Launched 2018	
BRA			Negotiations completed 2019		
CAN		Since 2017			
CHN				Launched 2013	
HKG				?	
IND					On Hold
ISR	Since 2000				
JPN		Since 2019			
KOR	In force since 2015				
MEX	In force since 2000				
NZL				Launched 2018	
RUS					
ZAF	Since 2016				
USA					On hold

Source: https://ec.europa.eu/trade/policy/countries-and-regions/negotiations-and-agreements/.

B.5 Robustness

B.5.1 Exogeneity of the synthetic series: economic complexity index (ECI)

This appendix relates closely to Section 5.3 in the main paper, in which we seek to exclude from the donor pool country pairs involving EU14 members.

However, not all of the non-EU countries in our sample will necessarily be good proxies for UK trade, since some countries are at quite different levels of skill-intensity, and hence specialized in production of very different goods to the UK, whose global demand may follow quite different trends and cycles. In Section 5.3 we use an index of Revealed Comparative Advantage for this. However, here, as an alternative, we utilise the economic complexity index (ECI) developed by Hausmann et al. (2014). This ranks countries based upon the variety of goods which are exported, which, it is argued, is closely related to the similarity of the knowledge embodied in their exports. We concentrate on non-EU countries which are in the same quartile as the UK in terms of economic complexity.[26]

Appendix Figure B5 reports the corresponding estimates for UK exports (/imports) to (/from) both the EU and non-EU countries, based upon synthetic doppelgangers constructed only with non-EU flows with countries of sufficiently close ECI to the UK.

When we compare these results with those in the baseline, there is a clear consistency, although the estimated shock to UK trade is, if anything, slightly larger. The estimated percentage difference between actual and synthetic flows is about -21% for the case of aggregate UK exports to the EU (-23% for imports) and for exports to non-EU countries, it is about -16% (-14% for imports). The most significant change is that UK imports from the EU14 appear to have taken a worse hit than in our previous estimate: this may be because the negative supply chain shocks are sufficiently widespread across Europe - c.f. Vandenbussche et al. (2017) - that series from the EU14 are not sufficiently exogenous to be good for constructing this particular counterfactual.

We then examine the effects of also excluding flows to the EU from the pool of countries identified using ECI, when constructing our doppelganger. This means that we consider only bilateral flows between countries that export similar products but to the rest of the world. The results of this alternative specification are reported in Appendix Figure B6, and show similar patterns compared to Appendix Fig-

[26] Namely China, Belarus, Hong Kong, Israel, Japan, Korea, Mexico, Malysia, Singapore, Thailand and USA. However, only 7 countries are in our database, namely China, Hong Kong, Israel, Japan, Korea, Mexico and USA. This enables us to have about 277 monthly BTF to draw from each month.

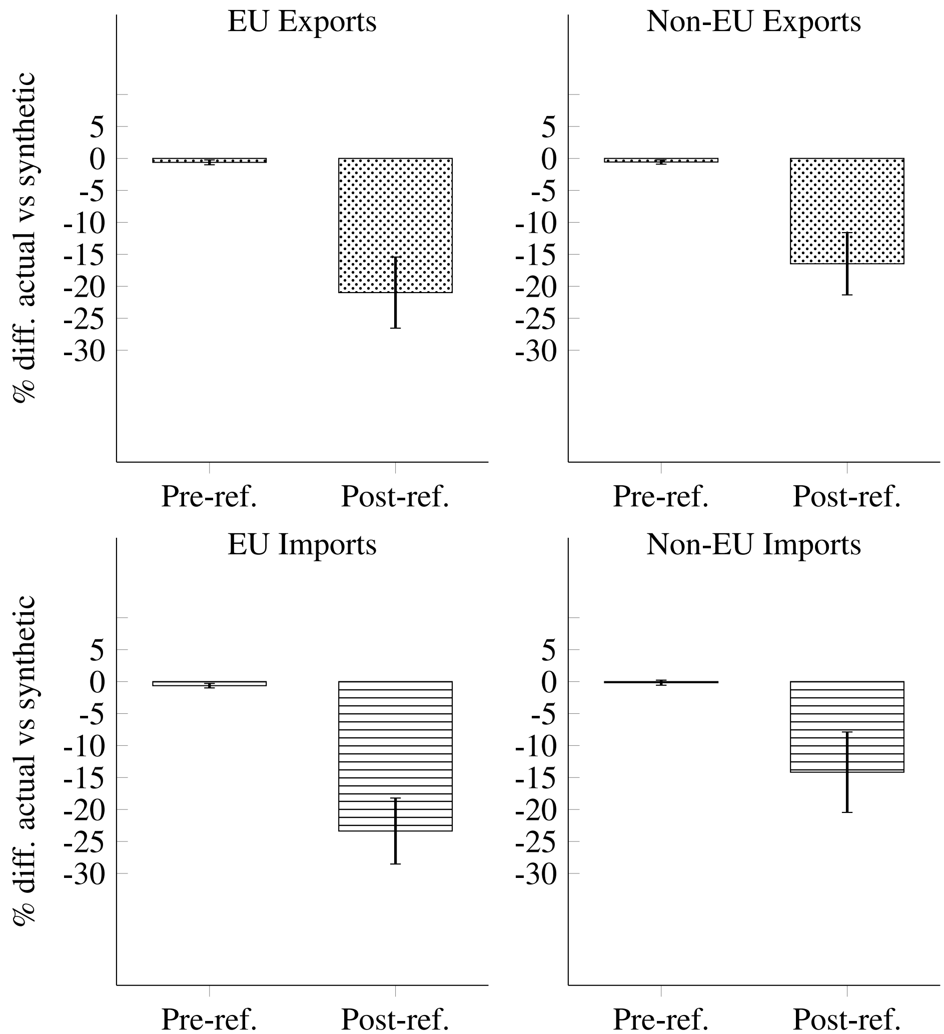
ure B5, namely a drop in export value of about 25% for EU exports (19% for non-EU) and about 20% for EU imports (13% for non-EU). This suggests that policy uncertainty has had stronger effect on risk aversion of the UK firms trading with the EU than for those trading with the rest of the world.

Table B7: Revealed Comparative Advantage: correlation coefficient with GBR for each country in the sample.

Country	Correlation	non-EU country	Correlation
GBR	1.0000		
AUT	0.2071	AUS	-0.3200
BEL	0.6758	CAN	-0.0042
DEU	0.5300	HKG	0.4727
DNK	-0.0222	IND	0.0829
ESP	0.0514	NZL	-0.1125
FIN	-0.0478	ZAF	0.2620
FRA	0.4403	USA	0.4124
GRC	-0.2485	BRA	-0.4100
IRL	0.4295	CHN	-0.2446
ITA	-0.0570	ISR	0.7587
LUX	0.1610	JPN	0.4138
NLD	-0.0010	KOR	0.2120
PRT	-0.2577	MEX	0.1844
SWE	0.0004	RUS	-0.1663

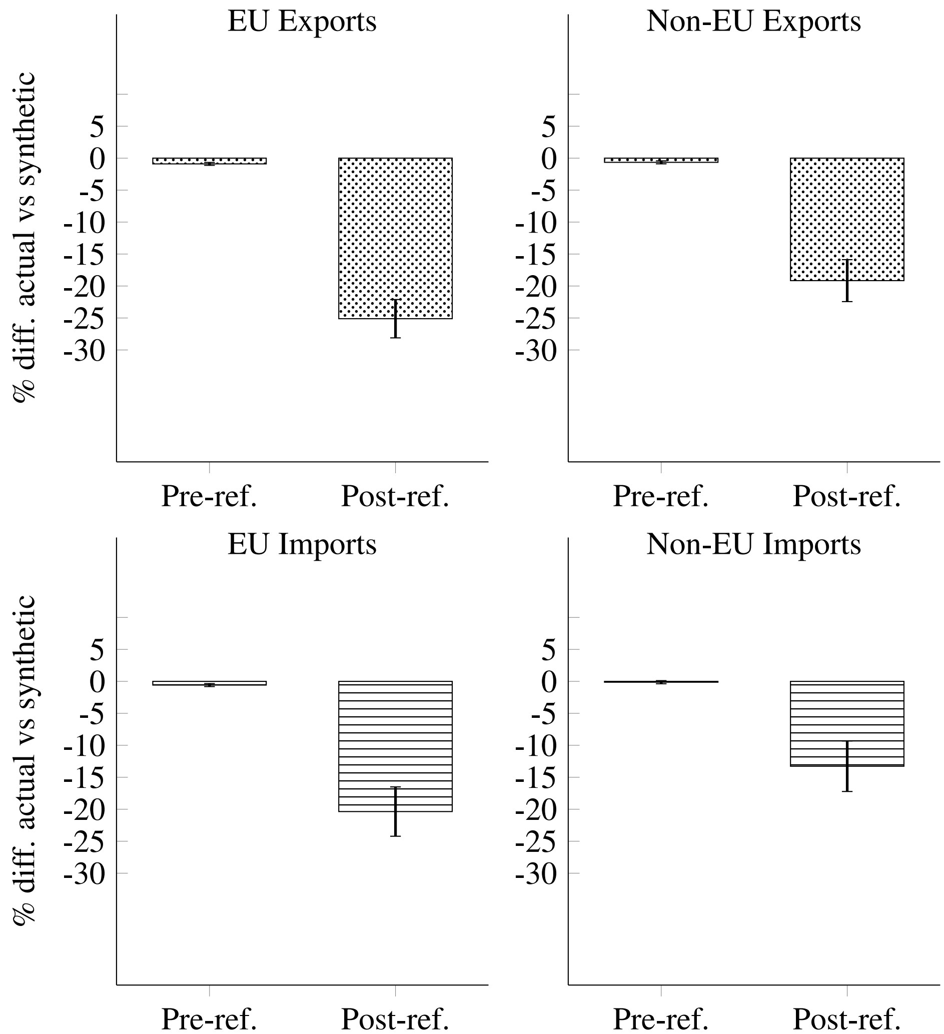
Note: WITS has data for revealed comparative advantage (RCA) for 28 classes of product, for a series of years. This table looks at 2015 values, and calculates the correlation coefficient for each country's RCA with that for the United Kingdom.

Figure B5: Counterfactuals Using Economic Complexity Index (Haussman) to construct a doppelganger from non-EU countries



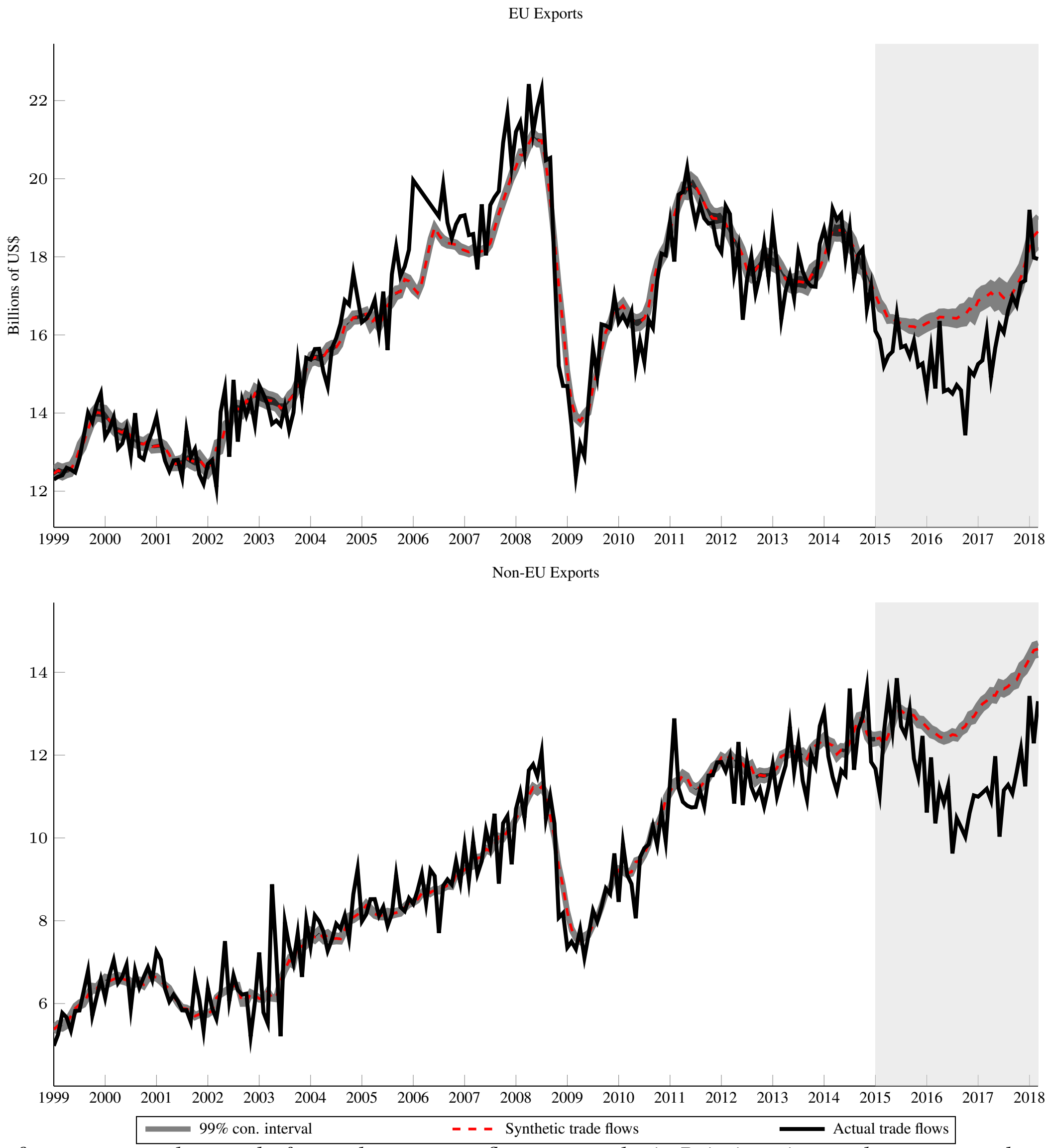
Notes: These figures report the % difference between actual aggregate flows vs synthetic Britain. We built a SCM using as counterfactual a pool of countries with similar export complexity index to the UK, namely China, Hong Kong, Israel, Japan, Korea, Mexico and USA (we have 277 bilateral flows each month to draw from). Furthermore, in this exercise we control for bilateral import or export complexity index. This allows us to find a best match in terms of flows with similar characteristics.

Figure B6: Counterfactuals Using Economic Complexity Index Without EU flows



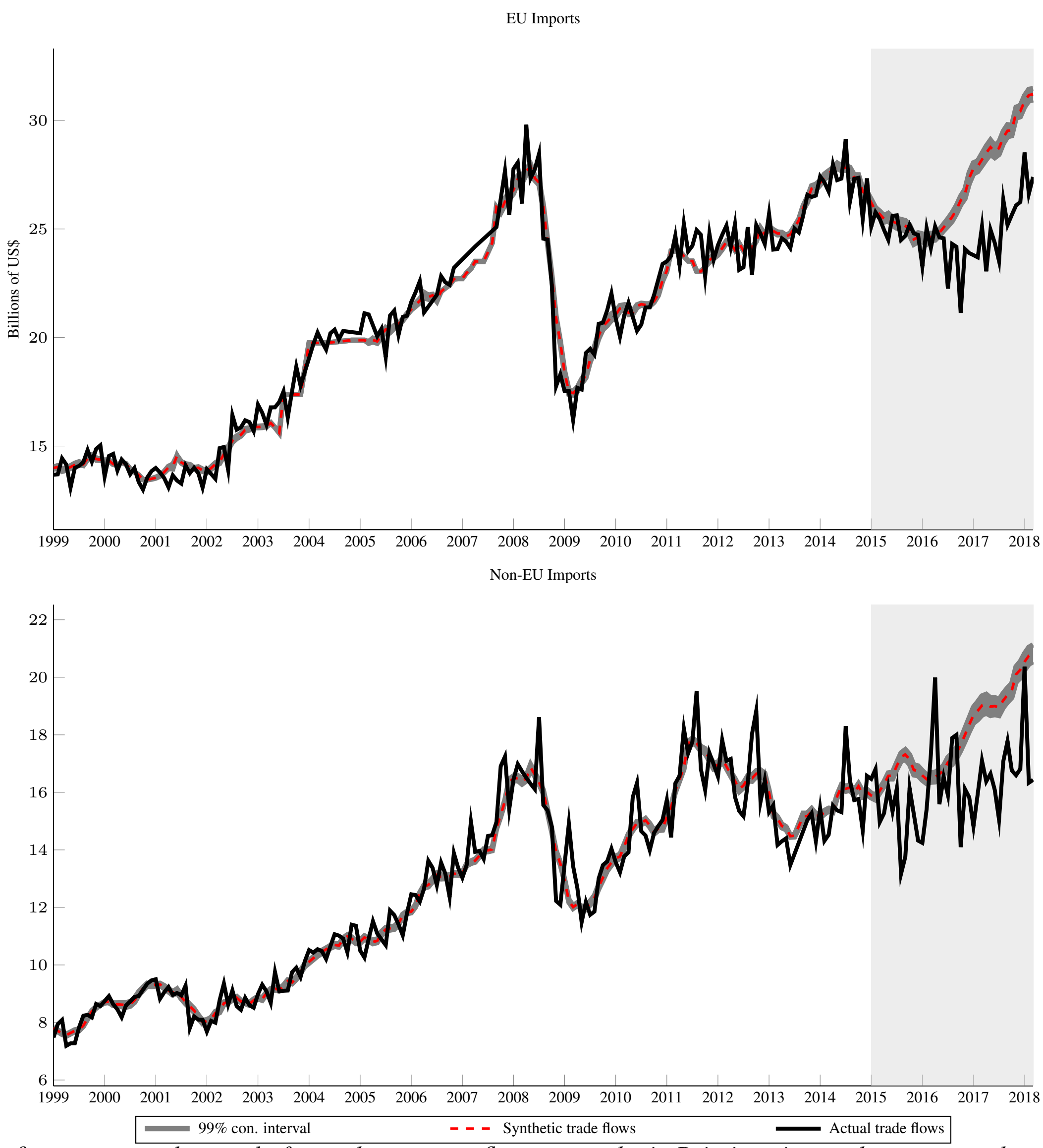
Notes: These figures report the % difference between actual aggregate flows vs synthetic Britain. We built a SCM using as counterfactual a pool of countries with similar export complexity index to the UK, namely China, Hong Kong, Israel, Japan, Korea, Mexico and USA. Furthermore, in this exercise we control for bilateral import or export complexity index. This allows us to find a best match in terms of flows with similar characteristics. Here we exclude flows to the EU.

Figure B7: UK –Exports Flows 2015 treatment



Notes: These figures report the trend of actual aggregate flows vs synthetic Britain using early treatment date (e.g. 2015/6, however results do not quantitatively change using an alternative month). We built a SCM using as counterfactual a pool of countries with similar export complexity index to the UK, namely China, Hong Kong, Israel, Japan, Korea, Mexico and USA. Furthermore, in this exercise we control for bilateral import or export complexity index. This allows us to find a best match in terms of flows with similar characteristics.

Figure B8: UK –Imports Flows 2015 treatment



Notes: These figures report the trend of actual aggregate flows vs synthetic Britain using early treatment date (e.g. 2015/6, however results do not quantitatively change using an alternative month). We built a SCM using as counterfactual a pool of countries with similar export complexity index to the UK, namely China, Hong Kong, Israel, Japan, Korea, Mexico and USA. Furthermore, in this exercise we control for bilateral import or export complexity index. This allows us to find a best match in terms of flows with similar characteristics.

Table B8: Alternative Subsampling Size

	Pre-Referendum	Post-Referendum
Subsample 50		
	EU Exports	
% difference actual	-0.141	-15.457
vs synthetic	(. 005)	(. 140)
	Non-EU Exports	
% difference actual	-0.194	-11.745
vs synthetic	(. 018)	(. 343)
Subsample 80		
	EU Exports	
% difference actual	-0.0975	-15.436
vs synthetic	(. 002)	(. 838)
	Non-EU Exports	
% difference actual	-0.0826	-11.621
vs synthetic	(. 089)	(. 227)

Note: This table reports the overall effect of the Brexit policy shock by employing alternative sub-sampling procedure. In the main specification we used a sub-sample of 10 randomly selected country pairs, whereas here we report a sub-sampling group of 50 and 80 out of 91 pairs available. The overall results remain robust to this specification. Note: the referendum was used as treatment date in this exercise.

Table B9: Percentage difference in aggregate UK exports to EU partners vs counterfactual with different C samples

	Pre-referendum	Post-referendum		
	1999:1-2016:5	2016:6-2018:3	2016:6-2016:12	2017:1-2018:3
C==250				
% difference actual	-0.2310	-14.5554	-15.4780	-14.4989
vs synthetic	(.0407)	(.3875)	(.3799)	(.3963)
C==500				
% difference actual	-0.169	-14.359	-15.103	-14.440
vs synthetic	(0.029)	(0.294)	(0.293)	(0.295)
C==750				
% difference actual	-0.1760	-14.1340	-14.8609	-14.2430
vs synthetic	(.0241)	(.2429)	(.2433)	(.2461)
C==1000				
% difference actual	-0.1873	-14.0440	-14.7719	-14.1409
vs synthetic	(.0210)	(.2115)	(.2103)	(.2125)

Notes: The table reports the percentage difference between actual and synthetic aggregate trade flows between the UK and EU members over different periods. Synthetic counterfactuals are obtained as a weighted average of EU country pairs. We report alternative sample size for robustness check. Standard errors are reported in parentheses. Note: the referendum was used as treatment date in this exercise.

Figure B9: Sterling vs Dollar and Euro – Jan 2016-June 2018

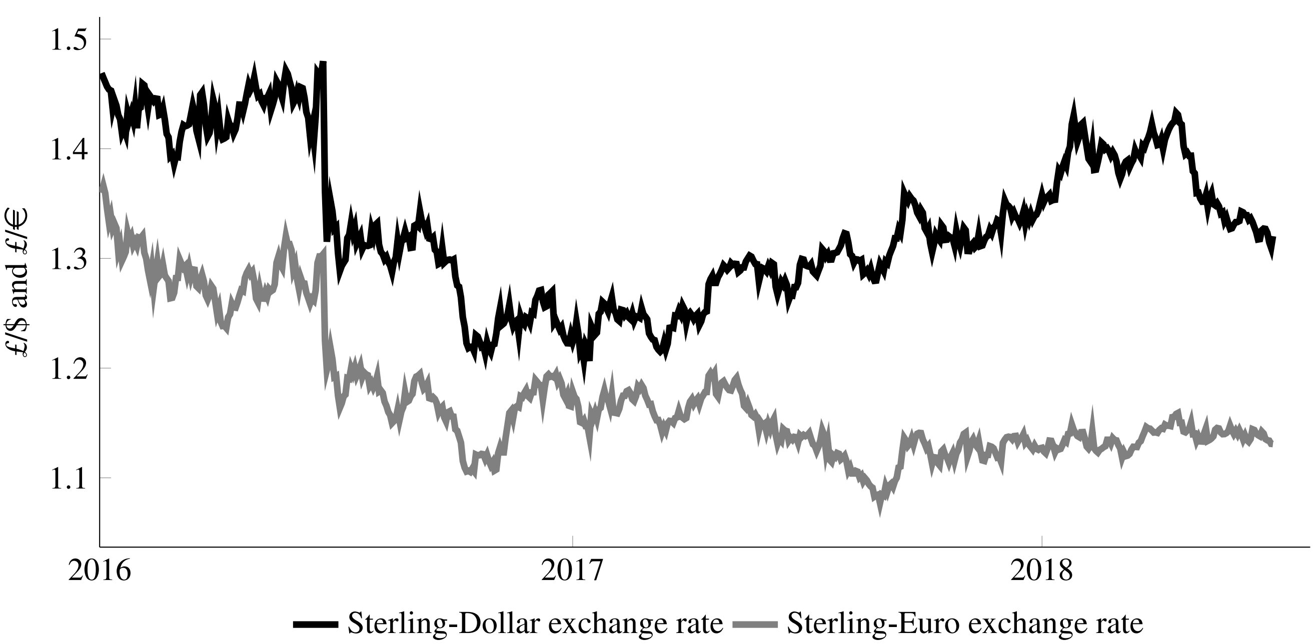


Table B10: Percentage difference in aggregate UK exports to non-EU partners vs counterfactual with different C samples

	Pre-referendum	Post-referendum		
	1999:1-2016:6	2016:7-2018:1	2016:7-2016:12	2017:1-2018:1
C==250				
% difference actual	-0.4942	-16.3865	15.0513	-16.7997
vs synthetic	(.1484)	(1.0607)	(.9795)	(1.1088)
C==500				
% difference actual	-0.476	-16.518	-15.090	-16.955
vs synthetic	(0.096)	(0.649)	(0.635)	(0.644)
C==750				
% difference actual	-0.4930	-16.2062	-15.0634	-16.5655
vs synthetic	(.0714)	(.7636)	(.7423)	(.7562)
C==1000				
% difference actual	-0.4820	-16.0659	-14.8597	-16.4785
vs synthetic	(.0639)	(.6667)	(.6464)	(.6667)

Notes: The table reports the percentage difference between actual and synthetic aggregate trade flows between the UK and non-EU members over different periods. Synthetic counterfactuals are obtained as a weighted average of non-EU country pairs. We report alternative sample size for robustness check. Standard errors are reported in parentheses. Note: the referendum was used as treatment date in this exercise.

Table B11: Percentage difference in aggregate UK imports from EU partners vs counterfactual with different C samples

	Pre-referendum	Post-referendum		
	1999:1-2016:6	2016:7-2018:3	2016:7-2016:12	2017:1-2018:3
C==250				
% difference actual	-0.2834	-2.055	-.332	-2.470
vs synthetic	(.0424)	(1.386)	(.036)	(1.505)
C==500				
% difference actual	-0.316	-3.083	-2.564	-3.643
vs synthetic	(0.029)	(0.954)	(0.647)	(1.045)
C==750				
% difference actual	-0.3108	-2.844	-3.0909	-3.482
vs synthetic	(.0243)	(.754)	(.5201)	(.829)
C==1000				
% difference actual	-0.3048	-2.089	-3.7101	-2.657
vs synthetic	(.0207)	(.664)	(.4539)	(.731)

Notes: The table reports the percentage difference between actual and synthetic aggregate trade flows between the UK and EU members over different periods. Synthetic counterfactuals are obtained as a weighted average of EU country pairs. We report alternative sample size for robustness check. Standard errors are reported in parentheses. Note: the referendum was used as treatment date in this exercise.

Table B12: Percentage difference in aggregate UK imports from non-EU partners vs counterfactual with different C samples

	Pre-referendum	Post-referendum		
	1999:1-2016:6	2016:7-2018:1	2016:7-2016:12	2017:1-2018:1
C==250				
% difference actual	-0.1391	-5.8324	-20.2381	-0.0670
vs synthetic	(.0591)	(1.7967)	(2.2446)	(1.6135)
C==500				
% difference actual	-0.141	-7.635	-25.628	-4.435
vs synthetic	(0.042)	(1.304)	(1.424)	(0.977)
C==750				
% difference actual	-0.1072	-7.8340	-22.3069	-1.7740
vs synthetic	(.0361)	(1.1339)	(1.4049)	(1.0281)
C==1000				
% difference actual	- 0.1380	-7.7948	-22.9111	-1.7140
vs synthetic	(.0321)	(1.0278)	(1.2658)	(.9407)

Notes: The table reports the percentage difference between actual and synthetic aggregate trade flows between the UK and non-EU members over different periods. Synthetic counterfactuals are obtained as a weighted average of non-EU country pairs. We report alternative sample size for robustness check. Standard errors are reported in parentheses. Note: the referendum was used as treatment date in this exercise.

Table B13: Percentage difference in aggregate UK exports to EU partners vs counterfactual with 27 EU countries

	Pre-referendum	Post-referendum		
	2012:1-2016:5	2016:6-2018:3	2016:6-2016:12	2017:1-2018:3
% difference actual	-0.0413	-11.043	-8.859	-11.803
vs synthetic	(.218)	(1.167)	(1.146)	(1.196)

Note: This table reports the overall effect of Brexit referendum by using all 27 countries to build our counterfactual since 2012. In the main specification we used 14 out 27 due to data availability. The overall results remain robust to this specification. Note: the referendum was used as treatment date in this exercise.

Table B14: Leave-out-Test: EU exports Aggregate Effect

Pre-Ref.	Post-Ref.	Pre-Ref.	Post-Ref.
1		8	
-0.02143	-24.5135	-0.03724	-24.2963
(0.055)	(1.650)	(0.053)	(1.695)
2		9	
-0.05392	-27.544	-0.06571	-25.2351
(0.057)	(1.538)	(0.057)	(1.616)
3		10	
-0.02674	-24.6615	-0.01186	-24.5829
(0.060)	(1.624)	(0.059)	(1.614)
4		11	
-0.01668	-24.8193	0.005788	-24.5313
(0.057)	(1.624)	(0.057)	(1.607)
5		12	
-0.01775	-24.5272	-0.04399	-24.8712
(0.059)	(1.622)	(0.058)	(1.625)
6		13	
-0.00365	-24.5805	-0.01732	-24.6038
(0.057)	(1.569)	(0.059)	(1.626)
7		14	
-0.01437	-24.503	-0.03002	-24.8201
(0.051)	(1.621)	(0.059)	(1.617)

Notes: The table reports the aggregate percentage differences between actual and synthetic EU export trade flows. In particular, we use non EU trade flows to construct the doppelganger and RCA. We exclude each of the 14 UK-EU trade flow at the time to perform a leave-out test.

Table B15: Alternative inputs for the synthetic algorithm: UK trade flows

	EU			non-EU		
	Exports					
	(1)	(2)	(3)	(4)	(5)	(6)
% difference actual vs synthetic	-0.01778	-0.07335	-0.07287	0.528881	0.40935	0.506978
Pre-Ref.	(0.059)	(0.050)	(0.050)	(0.051)	(0.041)	(0.044)
% difference actual vs synthetic	-24.6897	-23.5977	-24.6931	-14.9863	-13.442	-14.1025
Post-Ref.	(1.607)	(1.358)	(1.373)	(1.428)	(1.306)	(1.209)
RCA	Y	Y	Y	Y	Y	Y
Common legal origins	N	Y	Y	N	Y	Y
Migration stock	N	N	Y	N	N	Y
	Imports					
% difference actual vs synthetic	0.589667	0.44486	0.534343	0.467298	0.306784	0.320582
Pre-Ref.	(0.092)	(0.083)	(0.092)	(0.068)	(0.061)	(0.068)
% difference actual vs synthetic	-13.8295	-13.1486	-13.835	-6.32105	-6.68717	-7.76765
Post-Ref.	(1.574)	(1.333)	(1.376)	(1.487)	(1.318)	(1.361)
RCA	Y	Y	Y	Y	Y	Y
Common legal origins	N	Y	Y	N	Y	Y
Migration stock	N	N	Y	N	N	Y

Notes: The table reports the percentage difference between actual and synthetic aggregate trade flows between the UK and EU and extra-EU countries. Synthetic counterfactuals are obtained as a weighted average of non-EU country pairs. This additional exercises in column (1)-(3) and equivalently (4)-(6) add extra input variables compared to the baseline specification, where distance, GDP, exchange rate and exchange rate standard deviation, we add revealed compared advantage in column (1), then common legal origins column (2) and finally adding to this also migration stock column (3) as additional input. Standard errors are reported in parentheses.

Table B16: SCM and Diff-in-Diff

	Pre-referendum	Post-General Elec.		Post-Refer.	Post-Art. 50
	EU Exports				
	1999:1-2015:6	2015:7-2018:3	2015:7-2016:6	2016:7-2017:2	2017:3-2018:3
% difference actual	-.009	-16.814	-15.609	-19.371	-16.429
vs synthetic	(.007)	(.510)	(.579)	(.635)	(.576)
	non-EU Exports				
% difference actual	-.016	-11.248	-1.117	-8.084	-3.391
vs synthetic	(.08)	(.679)	(1.002)	(1.015)	(1.008)

Notes: The table reports the percentage difference between actual and synthetic aggregate trade flows using diff-in-diff approach between the UK and EU members over different periods. Synthetic counterfactuals are obtained as a weighted average of non-EU country pairs. We consider a treatment starting around the general election in 2015. Standard errors are reported in parentheses.

Table B17: Percentage difference in aggregate exports from UK to EU partners vs counterfactual: lagged values included as confounding variables

	Pre-referendum	Post-referendum		
	1999:1-2016:6	2016:7-2018:3	2016:7-2017:2	2017:3-2018:3
% difference actual	-0.206	-12.733	-13.758	-13.385
vs synthetic	(0.131)	(1.145)	(1.097)	(1.088)

Notes: The table reports the percentage difference between actual and synthetic aggregate trade flows between the UK and EU members over different periods. Synthetic counterfactuals are obtained as a weighted average of EU country pairs. Standard errors are reported in parentheses. Note: the referendum was used as treatment date in this exercise.