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JEL Classification: F15, F21, F23

Keywords: Brexit, Foreign direct investment, synthetic control method

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Holger Breinlich† Elsa Leromain‡ Dennis Novy§ Thomas Sampson¶

July 8, 2019

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1 Introduction

The Leave vote in the Brexit referendum on 23 June 2016 is likely to lead to the most important changes in UK economic policy for decades. Most analyses carried out before the referendum came to the conclusion that leaving the European Union would have negative short and long-run consequences for a range of economic indicators, including inflation, foreign direct investment and per capita income (see for example, Dhingra et al. 2016/2017; HM Treasury, 2016a/b; OECD, 2016; NIESR, 2016). While Brexit has been repeatedly postponed, most recently to 31 October 2019, and no actual changes to the UK-EU economic relationship have taken place so far, a growing number of papers have shown that the referendum outcome has already had a detrimental impact on UK living standards (see, for example, Born et al., 2019, on GDP; and Breinlich et al., 2017, on inflation).

In this paper, we contribute to the literature on the short-run effects of the Brexit vote by examining changes in foreign direct investment (FDI) patterns between the UK and the remaining member states of the European Union (henceforth, EU27) since the referendum. Our analysis is motivated by substantial anecdotal evidence that the threat of reduced access to the EU market after Brexit has pushed UK firms into setting up subsidiaries or acquiring companies in the remaining EU member states. For example, the UK Attractiveness Survey, which is published annually by professional services firm EY, reports evidence of an increase in UK outbound investment in both 2017 and 2018, with Germany and France being the main recipients (EY, 2019). Media reports have also documented that both large UK companies such as Barclays, HSBC and EasyJet, and smaller companies such as Crust & Crumb, a Northern Irish pizza maker, have invested in the EU in response to Brexit (The Guardian, 2017; France24, 2018; The Telegraph, 2018; The Journal.ie, 2018).

We study whether the anecdotal evidence of increased EU investment by UK firms is representative of a systematic change in outward FDI. To do so, we use the synthetic control method (Abadie and Gardeazabal, 2003; Abadie, Diamond and Hainmueller, 2010 and 2015) to construct an appropriate counterfactual for what would have happened to UK-EU investment flows in case of a Remain victory in the 2016 referendum. We find that compared to this counterfactual, the number of new greenfield investments and mergers and acquisitions (M&A) by UK firms in the EU27 increased by approximately 17% between the Brexit vote and March 2019, the last month for which data are available. Essentially all of this increase was accounted for by the UK services sector, with manufacturing outward FDI evolving similarly to the synthetic control. Using data on average transaction values, we estimate that the value of the additional investments was around £21.2 billion until March 2019. While we cannot be sure if these funds would otherwise have been invested in the UK, the anecdotal evidence mentioned above suggests that the additional investment often occurred at the expense of UK operations.

One potential concern with our analysis is that the findings could reflect a broader realignment of UK trade and investment, consistent with the view that Brexit has led UK firms to become more globally oriented. However, we find no support for this hypothesis in the data. We show that the number of UK investments in non-EU OECD countries did not evolve differentially from a control group constructed using the synthetic control method.

Finally, one might expect that the threat of reduced market access after Brexit works both ways. That is, European firms might also increase FDI in the UK to guarantee continued access to the UK market. But we find the opposite: new FDI projects in the UK by EU firms have actually declined as a result of the referendum, leading to a reduction in new EU27 investment by 9% or around £13.1 billion. This asymmetry illustrates that being a smaller economy than the EU27 leaves the UK more exposed to the costs of economic disintegration.

Our paper contributes to two strands of the literature. First, we add to the research on the short-run economic effects of the Brexit vote. This body of work has studied a range of economic outcomes including GDP (Born et al., 2019), inflation (Breinlich et al., 2017), stock market reactions (Breinlich et al., 2018; Davies and Studnicka, 2018), trade flows (Crowley et al., 2019) and wages and worker training (Costa et al., 2019). Most similar to the present paper is a recent study by Serwicka and Tamberi (2018) who look at the evolution of inward UK FDI and show that the referendum reduced the number of foreign greenfield investments in the UK by around 16-20% between mid-2016 and July 2018. By contrast, we mainly focus on UK outward FDI and examine the separate hypothesis that the threat of higher market access barriers has led UK firms to increase investment in the remaining EU member states. We also apply a broader definition of FDI, looking at both greenfield and M&A transactions, and make use of more recent data that includes the run-up to the original UK exit date in March 2019. As we show, the first quarter of 2019 has seen an acceleration of FDI outflows from the UK.

Second, our results provide new evidence on the determinants of foreign direct investment flows and, in particular, on tariff-jumping FDI. The tariff-jumping literature starts from the observation that multinational firms face a proximity-concentration trade-off (see Brainard 1997, Helpman, Melitz and Yeaple 2004). On the one hand, increasing returns to scale push firms towards concentrating production in one location; on the other hand, locating production close to customers generates savings through the avoidance of transport cost and other trade barriers such as tariffs. Consequently, changes in trade barriers affect firms' location decisions by affecting the proximity-concentration trade-off. For example, there is strong evidence that higher protection cause firms in developed countries to substitute affiliate production for exports to avoid increased market access costs (Belderbos 1997, Blonigen 2002). Using Japanese FDI flows into the US for 4-digit SIC industries between 1981 and 1988, Bloningen and Feenstra (1997) show that not only actual increases, but also the threat of higher trade barriers led to an increase in the number of inward FDI investments.

All of these studies proxy changes in trade policy by anti-dumping cases. Our analysis adds to this literature by studying the effects of an unexpected and major shock to an existing economic integration agreement, which is likely to ultimately lead to substantial increases in trade barriers. We also make a methodological contribution by showing how the synthetic control method can be used to study the effects of trade policy on FDI when a differences-in-differences strategy is not appropriate because there is only one treated unit (the UK).

Interestingly, our results are consistent with the idea that firm-level responses result from the interaction of two different forces. On the one hand, higher expected future trade barriers increase the incentive to establish a foothold in the foreign market. On the other hand, higher barriers also mean that the foreign location is potentially less attractive, either because of expected lower future economic growth or because it is less well suited as an export platform FDI destination. Our results on the differential impact of the Brexit referendum on inward and outward investment between the UK and the EU suggest that relative market size is a key determinant of which force dominates. In our case, the Leave vote increased investment by the UK in the larger EU27 market, while reducing flows in the opposite direction.

The rest of this paper is structured as follows. Section 2 describes our data and the synthetic control method in more detail. Section 3 shows results for the impact of the Brexit referendum on UK FDI flows and carries out a number of robustness checks. Section 4 concludes. The appendix provides further details about our data and how we compute the overall value of the FDI flows caused by the referendum.

2 Methodology and Data

2.1 Data Sources

We measure FDI activity through a count of greenfield and M&A transactions. Greenfield activity is taken from the Financial Times' fDi Markets database and refers to investments that create new establishments or production facilities from scratch, for example, setting up a new factory. M&A transactions, by contrast, refer to the acquisition of existing companies or divisions and come from Bureau van Dijk's Zephyr database. We describe these two data sources in more detail in the appendix to this paper. In both databases, we observe when a new FDI transaction is announced. This helps in identifying the timing of any changes in FDI behaviour.

Our analysis mostly focuses on the period from the first quarter of 2010 (2010Q1) to the first quarter of 2019 (2019Q1), during which we observe around 100,000 transactions in total.[1] We do not use data on the value of FDI (as opposed to counts) since this information is only available in a minority of cases and tends to be dominated by a small number of very large transactions, rendering it less informative.[2] But we do use the available data on transaction values to compute an estimate of the changes in aggregate FDI investment caused by the referendum result, as we explain in more detail below and in Appendix B.

Table 1 provides basic descriptive statistics on the greenfield and M&A transactions in our data. Over our sample period 2010-2019, there were around 300 M&A and 300 greenfield investments by UK companies in the EU27 every year. The value of the average M&A transaction is substantially larger than that of the average greenfield investment. In part, this reflects the fact that M&As are mostly acquisitions of entire companies whereas greenfield investments include expansions of existing production facilities. The table also shows that the majority of transaction values are missing in the original data. Moreover, using information from similar transactions to impute missing values, it seems that there is a clear selection pattern, with larger transaction values more likely to be reported. As discussed above, these facts motivate our focus on counts rather than overall values.

To provide some initial evidence on a potential link between the referendum and outward UK FDI activity, we plot two key series in our dataset. Figure 1 compares the count of quarterly FDI transactions from the UK to the EU27 with the count of transactions from non-EU OECD countries to the EU27 from 2010Q1 to 2019Q1.[3] As the figure shows, the

[1]Zephyr and fdiMarkets are updated continuously, with a lag of up to three months between the announcement of a transaction and when it first appears in the data. At the time of writing, the latest available quarter was 2019Q1.

[2]Unfortunately, other sources for the value of bilateral FDI transactions, such as data reported by the UK's Office for National Statistic (ONS) or the United Nations Conference on Trade and Development (UNCTAD) are only available with a substantial time lag. This makes them unsuitable for tracing the impact of the referendum which requires very recent data, ideally up to and including the UK's original exit date in March 2019.

[3]Throughout this paper 'non-EU OECD' refers to all OECD countries apart from the UK and other EU member states. These are Australia, Canada, Switzerland, Chile, Israel, Iceland, Norway, Japan, Mexico, New Zealand, South Korea, Turkey and the United States. In Figure 1 and all subsequent figures, we show moving averages over the two preceding and the two subsequent quarters to smooth out volatility.

Table 1: Descriptive Statistics: M&A and Greenfield Investments from the UK to the EU27 from 2010Q1 to 2019Q1

	M&A	Greenfield
Average number of transactions per year	302	315
Average value per transaction, million GBP (not imputed)	198.5	42.1
Average value per transaction, million GBP (all)	112.1	26
Share of non-imputed values	36%	17%

Notes: We use transaction values from the fDi Markets and Zephyr databases. 'Value' signifies the value of the transaction for M&As and the incurred capital expenditure for greenfield investments. fDi Markets imputes value information for transactions where capital expenditure is not reported, using information from similar transactions. Likewise, we manually impute value information in Zephyr by using the mean value of other M&A transactions from the same country pair, year and 2-digit NACE industry code. Values in fDi Markets are reported in dollars, while values in Zephyr are reported in euros. We convert these values into pounds using average exchange rates over 2010-2019 from the IMF IFS database (pounds per dollar = 0.67; pounds per euro = 0.83).

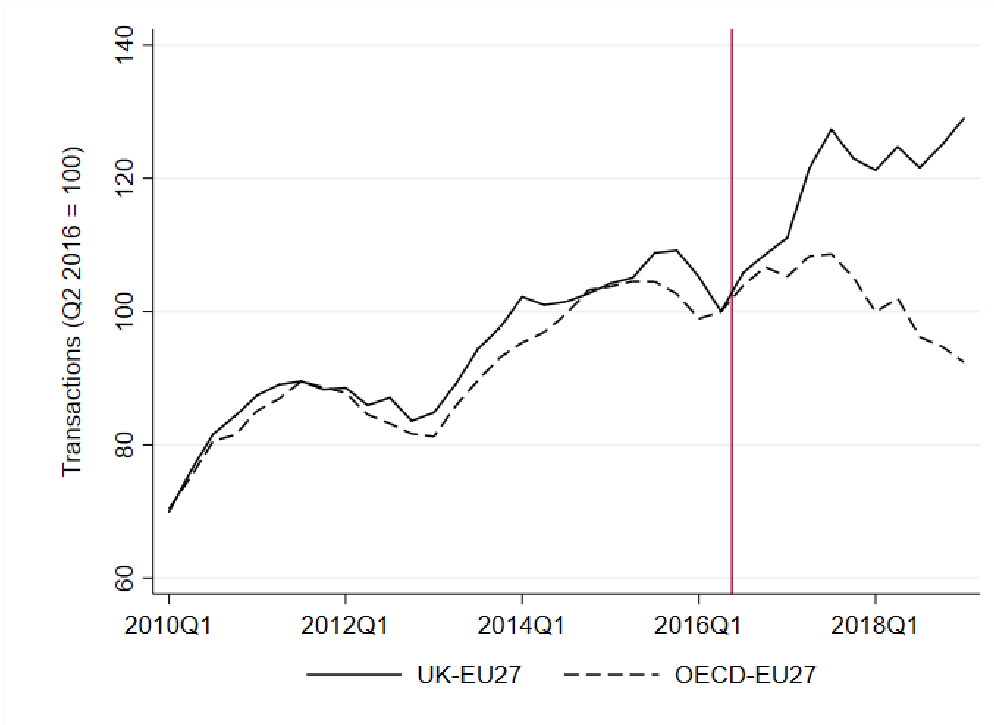
evolution of FDI into the EU27 prior to the referendum was similar for the UK and the OECD, with both series showing an upward trend until 2016. From early 2017 onwards, however, UK-EU transactions increased sharply while FDI from the non-EU OECD first stagnated and then fell, opening up a substantial gap between the two series. This simple plot suggests the referendum was followed by an increase in UK outward FDI to the EU27, both in absolute terms and relative to a group of comparable countries.

2.2 The Synthetic Control Method

Overview. To analyse the impact of the Brexit vote more formally we employ the 'synthetic control method' (SCM, see Abadie and Gardeazabal, 2003; Abadie, Diamond and Hainmueller, 2010 and 2015). The SCM provides a systematic way to choose comparison units in comparative case studies. In our case, we are interested in constructing a counterfactual outcome for the UK-EU27 FDI flows that would have taken place in the absence of a Leave vote in the Brexit referendum of 2016. The difficulty is that we cannot simply assume that some other bilateral FDI flow, or a simple average of other flows, would provide a good approximation to the counterfactual UK-EU27 flows.

The SCM proposes instead using a weighted average of other FDI flows, with the weights chosen such that the resulting synthetic control resembles UK-EU27 FDI flows in the pre-referendum period as closely as possible, in a sense to be defined more precisely below. If a number of potentially suitable control group flows are available, as is the case in our setting, the SCM has the additional advantage that researchers do not have to make ad hoc decisions

Figure 1: UK-EU27 FDI counts vs. Non-EU OECD-EU27 counts



Notes: This figure plots the count of FDI transactions from the UK to the EU27 (solid line) and the count of transactions from non-EU OECD countries to the EU27 excluding the UK (dashed line). The series are normalized to 100 in 2016Q2. The vertical line after 2016Q2 indicates the beginning of the post-referendum period. Source: fDi Markets and Zephyr. See the text for details.

which of these flows to use; instead, the SCM provides a procedure that reduces discretion in the choice of control group by 'letting the data speak'.

Computation of Weights. We now provide a technical description of the SCM, following the exposition in Abadie, Diamond and Hainmueller (2010) and Ferman, Pinto and Possebom (2018). Assume that we observe data for $J+1$ units (here: country pairs) for T time periods (here: quarters). Unit 1 (here: UK-EU27 FDI) will be affected by an intervention (here: the outcome of the Brexit referendum) that is in force from period T_0+1 until period T. The remaining flows $j = 2, ..., J+1$ are not affected by the intervention and form the so-called donor pool from which the synthetic control will be constructed.

Let Y_{1t}^N be the outcome (here: the count of FDI transactions) that would be observed for unit 1 in the absence of the intervention and Y_{1t}^I the outcome in its presence. The effect of the intervention in period t is then measured by $\alpha_{1t} = Y_{1t}^I - Y_{1t}^N$. Of course, for the post-intervention period, $t \geq T_0+1$, we observe $Y_{1t}^I = Y_{1t}$ but not the counterfactual non-intervention outcome (Y_{1t}^N). The goal of the synthetic control method is to construct an estimate for this counterfactual outcome as a weighted average of the outcomes (Y_{jt}) of the non-treated units:

$$\hat{Y}_{1t}^{N} = \sum_{j=2}^{J+1} \hat{w}_j Y_{jt},$$

where $\hat{w}_j \geq 0$ for $j = 2, ..., J+1$ and $\sum_{j=2}^{J+1} \hat{w}_j = 1$. The weights $\hat{w}_j$ are obtained as the solution to the following minimisation problem:

$$\hat{\mathbf{W}}\left(\hat{\mathbf{V}}\right) = \arg\min_{\mathbf{W}\in\mathcal{W}} \left(\mathbf{X}_1 - \mathbf{X}_0\mathbf{W}\right)' \hat{\mathbf{V}} \left(\mathbf{X}_1 - \mathbf{X}_0\mathbf{W}\right), \tag{1}$$

where $\mathcal{W}$ is the set of all possible combinations of weights $\mathbf{W} = (w_2, ..., w_{J+1})'$, $\mathbf{X}_1$ is an $F \times 1$ vector of pre-treatment observations of the treated unit and $\mathbf{X}_0$ is an $F \times J$ matrix of the corresponding observations for the donor pool. Note that $\mathbf{X}_0$ and $\mathbf{X}_1$ can include pre-intervention outcomes of the variable of interest (i.e., Y_{jt} for $t \leq T_0$) as well as other predictors of Y_{jt}. Thus, the approach underlying the SCM is to choose weights to minimise pre-intervention differences (in terms of FDI counts and additional determinants of these counts) between the treated unit and the synthetic control. Abadie, Diamond and Hainmueller (2010) show that if the synthetic control can match $\mathbf{X}_1$, it provides a valid counterfactual for Y_{jt}^{N} in the sense that $\hat{Y}_{1,t}^{N} - Y_{jt}^{N}$ will be close to 0 for all $t \geq T_0 + 1$.[4]

The weighting matrix $\hat{\mathbf{V}}$ in (1) is determined by minimising the distance between pre-treatment outcomes of unit 1 and the synthetic control:

$$\hat{\mathbf{V}}\left(\hat{\mathbf{W}}\right) = \arg\min_{\mathbf{V}\in\mathcal{V}} \left(\mathbf{Y}_1 - \mathbf{Y}_0\hat{\mathbf{W}}\left(\mathbf{V}\right)\right)' \left(\mathbf{Y}_1 - \mathbf{Y}_0\hat{\mathbf{W}}\left(\mathbf{V}\right)\right), \tag{2}$$

where $\mathcal{V}$ is the set of diagonal positive semidefinite matrices of dimension $F \times F$. The SCM algorithm iterates between (1) and (2) until convergence is achieved.

In practice, however, a simpler and faster method of choosing $\hat{\mathbf{V}}$ often yields essentially identical results (see Kaul et al., 2018). For every period $t \leq T_0$, this method regresses Y_{jt} ($j = 1, ..., J+1$) on all predictors contained in X_t, yielding regression coefficients $\hat{\beta}_{1t}$,...,

[4]See Abadie et al. (2010, p.495) for details. This result is derived under the assumption that Y_{it}^{N} is given by a factor model, $Y_{it}^{N} = \delta_t + \theta_t Z_i + \lambda_t \mu_i + \varepsilon_{it}$, where Z_i is a vector of observed covariates, μ_i are time-invariant unobserved determinants of Y_{it}^{N} and ε_{it} are unobserved transitory shocks with mean zero. Intuitively, if the number of pre-intervention periods is large relative to the scale of the transitory shocks, the only way the synthetic control can match pre-intervention outcomes as well as the additional covariates is by fitting Z_i and μ_i exactly which in turn guarantees that $Y_{it}^{N} - \hat{Y}_{it}^{N}$ is close to zero. Note that the above data generating process generalises the traditional difference-in-difference model by allowing the effect of the unobserved confounders μ_i to vary with time.

$\hat{\beta}_{Ft}$. The diagonal elements of $\hat{\mathbf{V}}$ corresponding to each predictor are then simply given by

$$\hat{v}_f = \frac{\sum_t \left(\hat{\beta}_{ft}\right)^2}{\sum_{k=1}^{F} \sum_t \left(\hat{\beta}_{kt}\right)^2}.$$

Intuitively, both approaches give more weight to variables with greater predictive power for the outcome of interest, Y_t. For computational reasons, we use the faster regression-based method to obtain most of our results, although we have checked that using the full nested procedure yields essentially identical estimates for control group weights.[5]

Statistical Significance. Abadie, Diamond and Hainmueller (2010) also propose a way of evaluating the statistical significance of the estimated treatment effect, $\hat{\alpha}_{1t} = Y_{1t}^I - \hat{Y}_{1t}^N$, based on the classic framework for permutation inference (see Abadie and Cattaneo, 2018). The idea is to sequentially reassign treatment to all units j in the donor pool and construct a new synthetic control in each case using all remaining units in that pool as well as the originally treated unit. For all $j = 2, ..., J+1$, we can then compute the corresponding treatment effects, $\hat{\alpha}_{jt} = Y_{jt}^I - \hat{Y}_{jt}^N$. Intuitively, this exercise allows us to examine whether or not the estimated effect of the Brexit referendum is large relative to the distribution of the effects estimated for the FDI flows not affected by the vote.

Given our estimates of all $\hat{\alpha}_{jt}$, we can evaluate statistical significance by computing a p-value associated with the Brexit referendum effect, $\hat{\alpha}_{1t}$. For this, we first compute the ratio of mean squared prediction errors in the post-intervention period relative to the pre-intervention period for each of the $J+1$ units:

$$R_j = \frac{RMSPE_{j,post}}{RMSPE_{j,pre}} = \frac{\sum_{t=T_0+1}^{T} \left(Y_{jt} - \hat{Y}_{jt}^N\right)^2 / (T - T_0)}{\sum_{t=1}^{T_0} \left(Y_{jt} - \hat{Y}_{jt}^N\right)^2 / T_0}.$$

We can then calculate a p-value by comparing the value of this statistic for unit 1 (R_1) to that of all other units:

$$p_1 = \frac{\sum_{j=1}^{J+1} 1\left(RMSPE_j \geq RMSPE_1\right)}{J+1},$$

[5] Computational concerns only play a role for the computation of significance levels using permutation methods (see below). It is here that we exclusively use the regression-based method. The estimated weights for the original treated flow (UK-EU27) are essentially identical for all our results, irrespective of whether we use the nested or the regression-based approach.

where 1 (.) denotes the indicator function.[6] Using this procedure, we compute p-values for all SCM figures in this paper and report them in the notes to the corresponding figures.

Implementation. In our baseline specification, we choose the synthetic control weights to match all quarterly UK-EU27 pre-referendum FDI counts since 2010. We start in 2010 because the global financial crisis of 2008/2009 was associated with substantial fluctuations in FDI activity so that it is doubtful whether the data generating process for Y_{jt}^N remained stable over that time period.[7]

Given that we attempt to match the entire path of pre-intervention outcomes, both algorithms outlined above will give zero weight to additional co-variates and we do not include any in our baseline specification.[8] As discussed by Ferman, Pinto and Possebom (2018), this reduces issues with specification searching among a large set of potential co-variates. Using pre-intervention outcomes only may also improve the SCM's ability to capture unobserved determinants of FDI flows, albeit at the cost of potentially omitting relevant co-variates (Kaul et al., 2018). Even if such co-variates are omitted, however, Botosaru and Ferman (forthcoming) show that the synthetic control estimator will not necessarily be biased.[9] Indeed, we show in our robustness checks that using a less-than-complete series of pre-intervention outcomes together with standard gravity predictors of FDI flows (bilateral distance and GDPs of the origin and destination countries) yields very similar results.

For our baseline analysis of UK outward FDI transactions in the EU27, we include all bilateral FDI series between OECD and EU countries in the donor pool, aggregating all EU countries other than the UK into one group (EU27). We exclude all pairs that involve the UK from the donor pool since those series are potentially directly affected by the EU referendum and, therefore, would not be suitable for constructing the synthetic control. Finally, we drop all country pairs with five or fewer transactions over the entire period. This is because including too many units in the donor pool can lead to overfitting by matching the treated

[6] As Abadie, Diamond and Hainmueller (2010) discuss, this approach produces classical randomisation inference if the intervention is indeed randomly allocated across units. If this is not the case, the approach is best interpreted as a series of placebo checks that examine whether the estimated treatment effect is large compared to the placebo effects for other flows that we would not expect to be affected by the referendum.

[7] In principle, our data allows us to go back to 2003. In practice, using the period 2003Q1-2019Q1 instead of 2010Q1-2018Q1 only leads to minor differences in the estimated treatment effects and significance levels (see Figure 6 below).

[8] See Kaul et al. (2018) for a formal proof. Intuitively, weights are chosen to match the pre-intervention path of the outcome variable of interest and the outcome at time t is of course fully explained by the outcome itself. So if the full set of pre-intervention outcomes is included in $\mathbf{X}_0$, all additional co-variates will be assigned zero weight.

[9] Unbiasedness in this case requires an extension of the regularity conditions in Abadie, Diamond and Hainmueller (2010) from the unobserved to the observed determinants of Y_{it}^N.

unit to idiosyncratic variation of a large number of control units (see Abadie, Diamond and Hainmueller, 2015). However, we show below that our results are not affected by including such pairs. With these restrictions, we end up with 124 country pairs in the donor pool. As discussed above, we focus on the period 2010Q1-2019Q1 for our main analysis although we show below that extending our sample to 2003Q1-2019Q1 does not affect our conclusions.

3 Empirical Results

3.1 Baseline Results

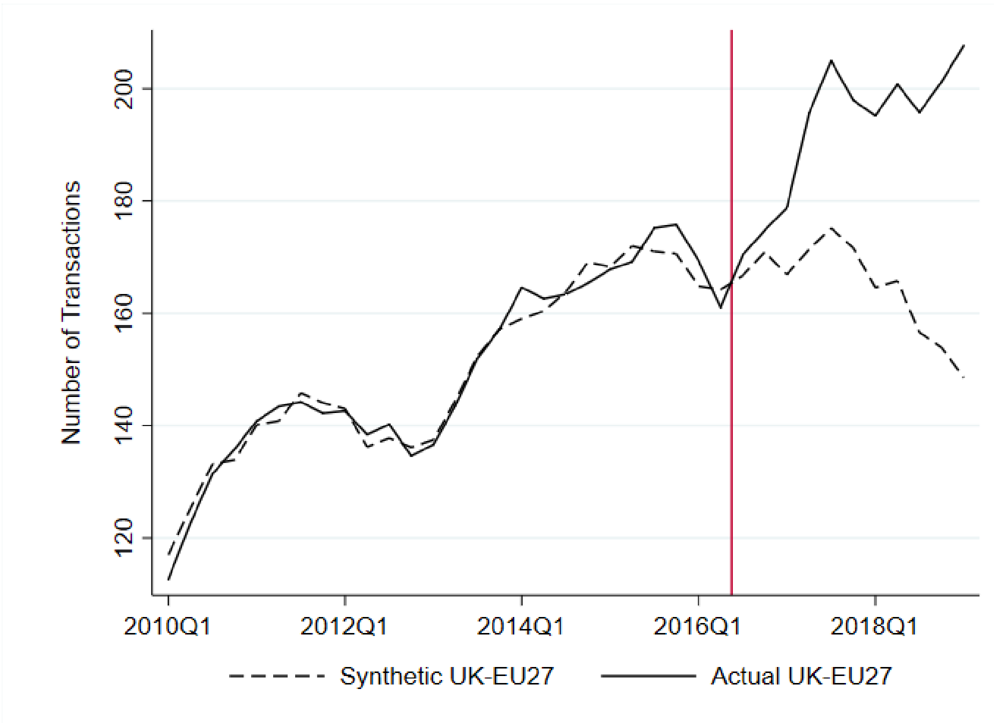
We now present results for the baseline SCM specification described in the previous section. The algorithm chooses the following bilateral series to construct the synthetic control for UK-EU27 FDI transactions (weights in parentheses): Switzerland-EU27 (52.4%), US-EU27 (37.5%), Japan-Mexico (8.6%), EU27-Switzerland (1.4%) and EU27-EU27 (0.1%), with all other country pairs receiving a weight of zero. Thus, the most important series used to construct the synthetic control are bilateral FDI from Switzerland into the EU27, followed by FDI from the US into the EU27. We believe that this is intuitive as both Switzerland and the US – similar to the UK – have a close economic relationship with the EU and are important origin countries for FDI into the EU27.

Figure 2 shows the evolution of UK-EU27 FDI flows compared to our control group series. Prior to the referendum, the two series track each other closely, demonstrating the suitability of the synthetic control. After 2016Q2, however, the number of FDI transactions from the UK into the EU27 goes up compared with the control series, which remains at 2014 and 2015 levels. The gap between the two series appears almost immediately but widens substantially in 2017 and then again towards the end of our sample period (2018Q4 and 2019Q1). This is consistent with heightened concerns of investors about the possibility of a 'No-Deal Brexit' at the end of March 2019, the UK's original exit date from the EU. While this date has since been postponed twice, most recently to 31 October 2019, it was uncertain in early 2019 whether or not the UK would leave the EU in March 2019 without a transition agreement in place.

To visualise the impact of the referendum further, in Figure 3 we plot the cumulative difference between the actual and synthetic FDI series. The figure shows that by 2019Q1, 311 greenfield and M&A transactions from the UK into the EU27 had taken place that would not have occurred in the absence of Brexit. For comparison, this increase is almost twice as high as the average number of quarterly FDI transactions prior to the referendum (see

Figure 2) and represents a 17% increase over the level of the synthetic control. Note that at the current (2019Q1) level of actual and control group FDI counts, this cumulative difference will continue to grow at a rate of over 50 transactions per quarter.

Figure 2: UK-EU27 FDI counts (actual vs. synthetic control)



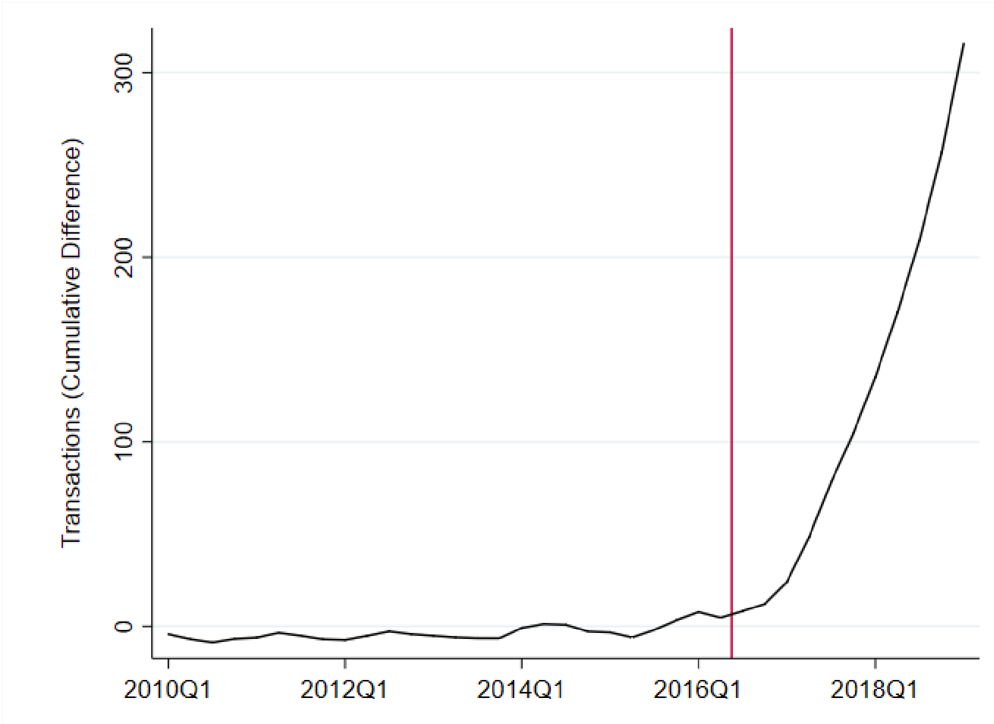
Notes: This figure plots the actual count of FDI transactions from the UK to the EU27 (solid line) and the corresponding synthetic control series (dashed line). The vertical line after 2016Q2 indicates the beginning of the post-referendum period. The p-value for the null hypothesis that the cumulative Brexit referendum effect on FDI transactions is zero equals 0.024. Source: fDi Markets, Zephyr and authors' calculations. See Sections 2.2 and 3.1 for details.

While our data do not provide sufficient information to perform a similar analysis for aggregate deal values (see Section 2.1 and Appendix A), we can carry out a back-of-the-envelope calculation to obtain an approximate value for the additional UK-EU27 investment caused by the referendum result. Specifically, using the minority of observations for which such data is available, we infer mean transaction values over the period 2017-2018. We then multiply the mean value by the increase in the number of transactions due the referendum.[10] This gives an estimate of the value of additional FDI outflows of approximately £21.2 billion by 2019Q1.

As a note of caution, we stress that the £21.2 billion outflow can only be interpreted as 'lost investment' for the UK under the assumption that the investment transactions would

[10]See Appendix B for details of these calculations.

Figure 3: Cumulative difference between the actual and synthetic UK-EU27 FDI transaction counts



This figure shows the cumulative difference between the actual count of FDI transactions from the UK to the EU27 and the synthetic control series (both are taken from Figure 2). The vertical line after 2016Q2 indicates the beginning of the post-referendum period. Source: Authors' calculations.

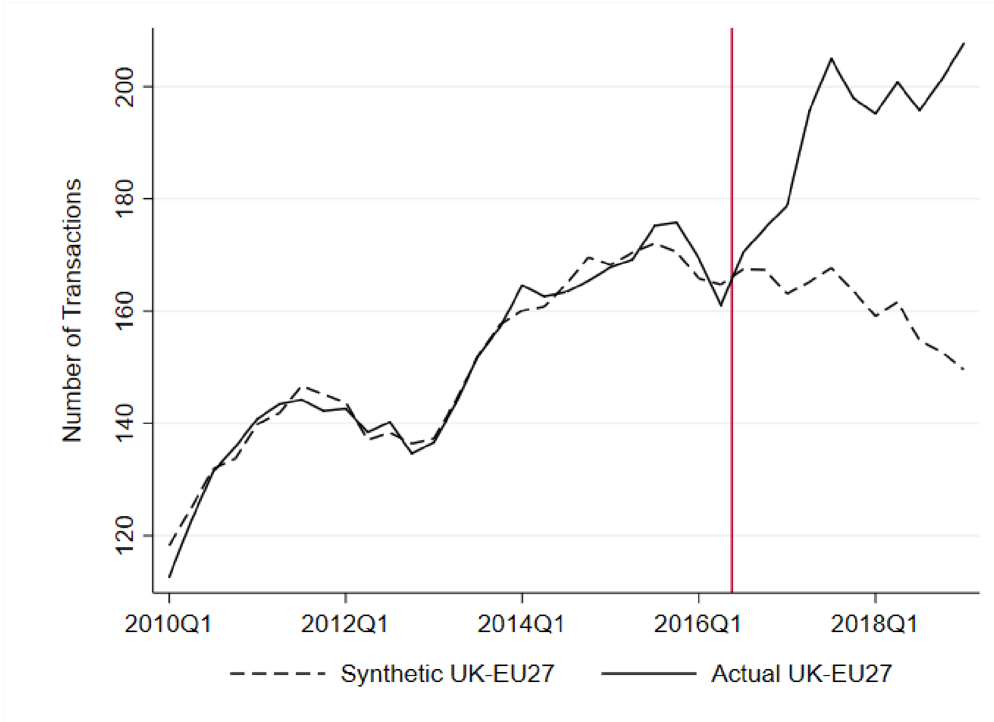
have taken place in the UK, instead of the EU27, were it not for the Leave vote. While the anecdotal evidence discussed in the introduction suggests this was indeed often the case, it could also be that the referendum outcome simply triggered additional investment by UK firms in the EU. We therefore regard £21.2 billion as an upper bound on lost investment.

3.2 Robustness Checks

We now carry out a number of robustness checks on our baseline results.

Extended Donor Pool. As our first set of robustness checks, we add to the donor pool bilateral pairs that involve the UK (Figure 4) or pairs with five or fewer transactions (Figure 5). As discussed in Section 2.2, we initially excluded all UK-related series since they were potentially directly affected by the EU referendum, while country pairs with five or fewer transactions over the entire period were dropped to avoid problems of overfitting. In practice, however, including both types of pairs yields results that are very similar to the baseline estimates from Figure 2.

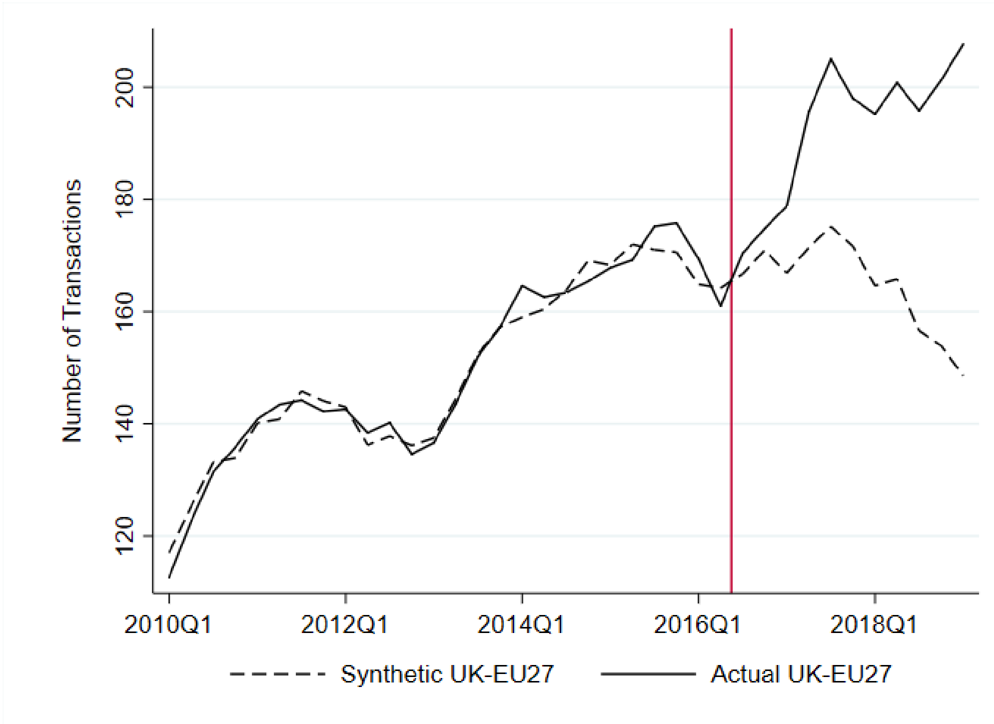
Figure 4: UK-EU27 FDI counts (actual vs synthetic control), full set of pairs



Notes: This figure plots the actual count of FDI transactions from the UK to the EU27 (solid line) and the corresponding synthetic control series (dashed line). The synthetic control series was computed using the full set of pairs in the donor group. The p-value for the null hypothesis that the Brexit referendum effect on FDI transactions is zero equals 0.020. See Sections 2.2 and 3.2 for details. Source: fDi Markets, Zephyr and authors' calculations.

Extended Pre-Referendum Period. Figure 6 extends our sample period to include all quarters from 2003Q1 to 2019Q1. As previously mentioned, we prefer the shorter 2010Q1 to 2019Q1 time window because the global financial crisis of 2008/2009 was associated with very substantial fluctuations in FDI activity. These changes are clearly visible in Figure 6, suggesting that the data generating process underlying our time series may not have been stable over the entire period since 2003. In practical terms, the strong fluctuations during the financial crisis and in its run-up mean that the fit of the synthetic control to the UK-EU27 series is not quite as good as for the post-2010 period. However, this issue also affects other units when applying the permutation methods from Section 2.1, so the resulting p-value for the estimated referendum effect is actually slightly lower than for the baseline and the magnitude of the effect is essentially identical.

Figure 5: UK-EU27 FDI counts (actual vs synthetic control), including all transactions

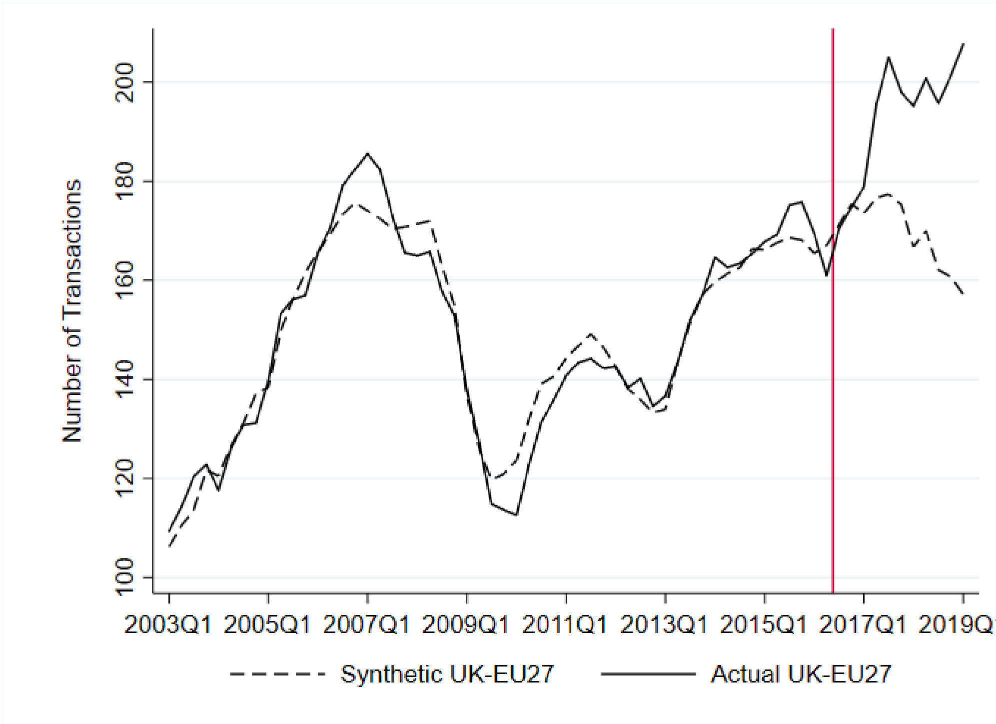


Notes: This figure plots the actual count of FDI transactions from the UK to the EU27 (solid line) and the corresponding synthetic control series (dashed line). Pairs with five or fewer transactions were included in the donor group. The p-value for the null hypothesis that the cumulative Brexit referendum effect on FDI transactions is zero equals 0.033. See Sections 2.2 and 3.2 for details. Source: fDi Markets, Zephyr and authors' calculations.

Additional Covariates. In Figure 7, we evaluate the robustness of the baseline results to using additional covariates to calculate the synthetic control. Specifically, we now include bilateral distance and the GDPs of the origin and destination countries as additional predictors for FDI flows.[11] As discussed, for these additional co-variates to be given positive weights by the SCM algorithm, we have to exclude some pre-intervention outcomes. Figure 7 plots a number of synthetic controls based on using only every second, fourth, eighth and sixteenth pre-intervention outcome, respectively. As seen, the trajectories of these additional synthetic controls look similar to before, yielding estimated treatment effects similar to, or slightly larger than, our baseline from Figure 2.

[11] A simple regression of $\ln(FDIcounts)$ on the logs of these variables yields an R-squared of 71%, demonstrating their potential for explaining bilateral FDI counts.

Figure 6: UK-EU27 FDI counts (actual vs synthetic control), 2003Q1-2019Q1



Notes: This figure plots the actual count of FDI transactions from the UK to the EU27 (solid line) and the corresponding synthetic control series (dashed line) for the period 2003Q1-2019Q1. The p-value for the null hypothesis that the cumulative Brexit referendum effect on FDI transactions is zero equals 0.016. See Sections 2.2 and 3.2 for details. Source: fDi Markets, Zephyr and authors' calculations.

3.3 Additional Results

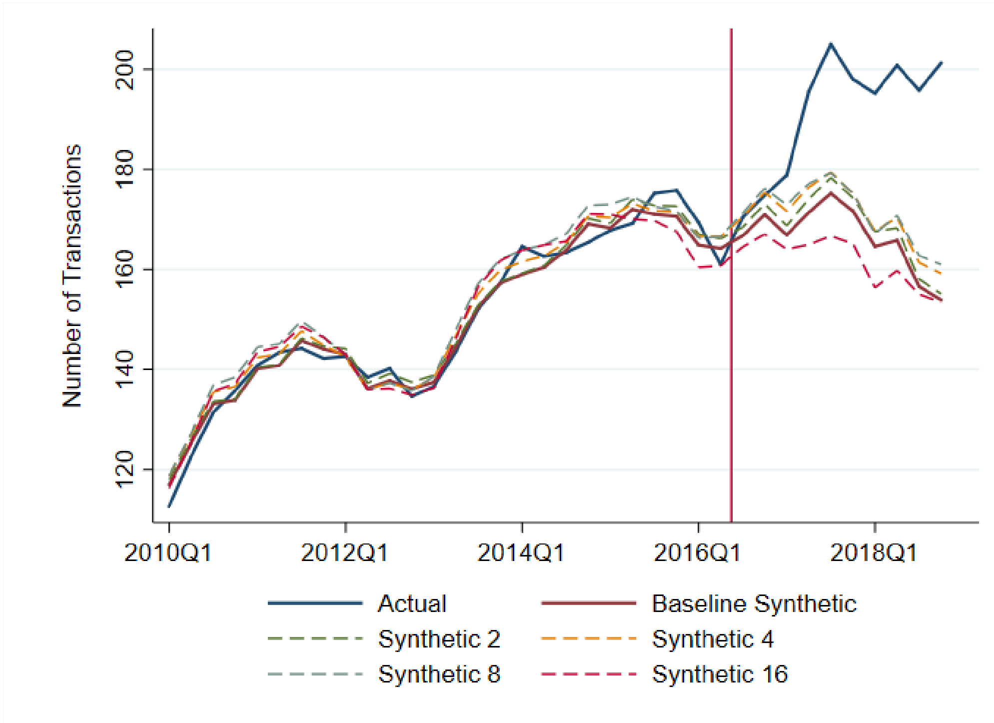
Having shown that our baseline results are robust to a number of different specifications, we now present a few additional results that shed further light on the effect of the referendum on UK FDI activity.

UK Investment outside the EU. One concern with our focus on UK-EU27 flows is that our results might be indicative of a general increase in the outward orientation of UK firms since the referendum. This would cast doubt on our conjecture that UK firms have been increasing FDI activity in the EU to hedge against potentially higher trade barriers after Brexit.

To evaluate this possibility, we construct a synthetic control for UK investment into non-EU OECD countries.[12] We present the results in Figure 8. Compared with the synthetic

[12]The donor pool in this case consists of flows between EU27 countries, between non-EU OECD countries, and between EU27 and non-EU OECD countries.

Figure 7: UK-EU27 FDI counts (actual vs synthetic control), including additional covariates



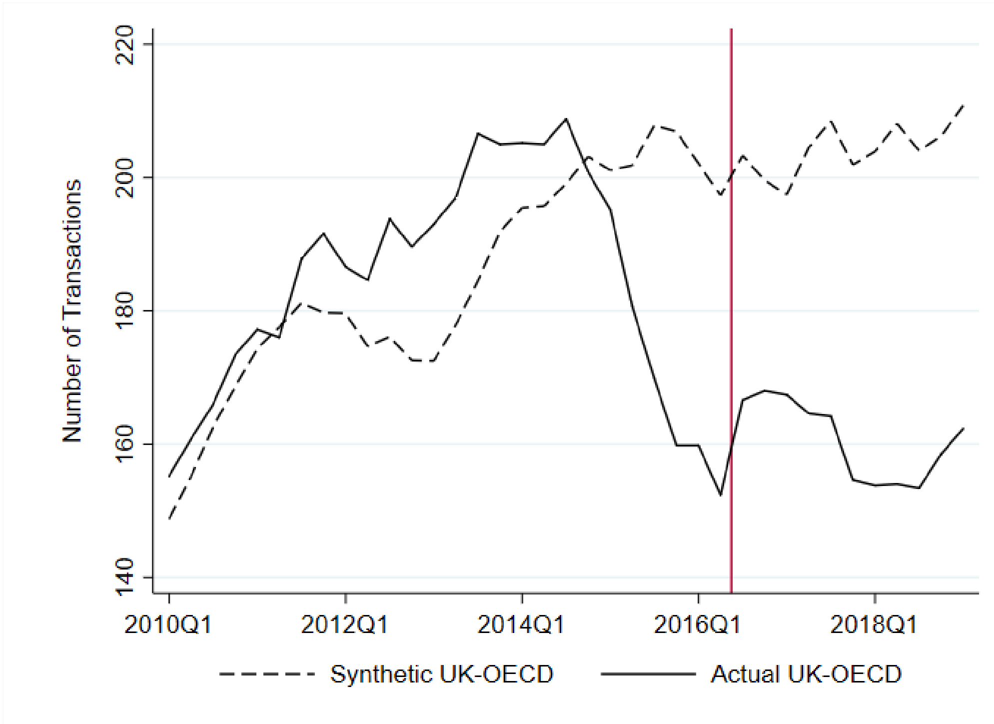
Notes: This figure plots the actual count of FDI transactions from the UK to the EU27 (solid line) and the corresponding synthetic control series (dashed lines). The dashed lines are based on using only every second, fourth, eighth or sixteenth pre-intervention outcome, respectively, to calculate the synthetic control. The additional covariates are bilateral distance and origin and destination GDP levels. The p-value for the null hypothesis that the cumulative Brexit referendum effect on FDI transactions is zero equals 0.024, 0.024, 0.016, 0.024, and 0.010 for the baseline, second, fourth, eighth and sixteenth pre-intervention outcome estimations, respectively. See Sections 2.2 and 3.2 for details. Source: fDi Markets, Zephyr and authors' calculations.

control, UK investment activity into non-EU OECD countries after the referendum has, if anything, decreased. But as the figure shows, the fit of the synthetic control series prior to the referendum is poor, implying it is not a good control for UK-OECD FDI. We are therefore reluctant to interpret this figure other than concluding that there is no sign of a 'Global Britain' effect. That is, UK investment in advanced economies outside of the EU has not experienced a post-referendum surge.

EU Investment in the UK. So far, we have analysed how Brexit has affected outward FDI decisions by UK firms. But the threat of a loss of market access after Brexit could also have led to more investment by European firms in the UK. To see whether this has happened, we construct a synthetic control for FDI from the EU27 to the UK.[13]

[13]Here, the donor pool consists of flows between and among the EU27 and non-EU OECD countries in our data.

Figure 8: UK to Non-EU OECD FDI counts (actual vs. synthetic control)



Notes: This figure plots the actual count of FDI transactions from the UK to non-EU OECD countries (solid line) and the corresponding synthetic control series (dashed line). The vertical line after 2016Q2 indicates the beginning of the post-referendum period. The p-value for the null hypothesis that the cumulative Brexit referendum effect on FDI transactions is zero equals 0.75. See Sections 2.2 and 3.3 for details. Source: fDi Markets, Zephyr and authors' calculations.

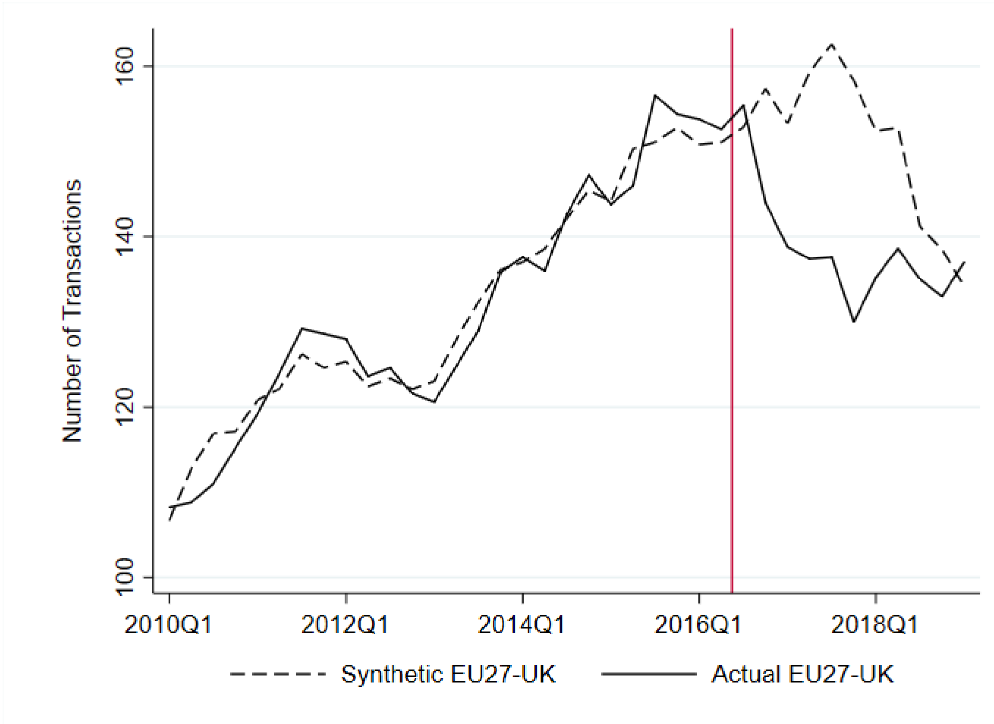
The results are displayed in Figure 9. Relative to the synthetic control, the number of new investments from the EU27 to the UK went down by around 9% after the referendum, amounting to £13.1 billion of lost investment.[14] This finding is consistent with Serwicka and Tamberi (2018) who present evidence that the referendum led to a decline in the total number of UK inward greenfield FDI transactions.

Our analysis shows that in contrast to the rise in UK investment flows to the EU27, there was a decrease in FDI activity in the opposite direction. This asymmetry suggests that the UK and the EU might be differentially exposed to the effects of Brexit. Put simply, because the EU is a much bigger market than the UK, access to the EU27 is more important than access to the UK.[15]

[14]See Appendix B for details on this calculation.

[15]Note, however, that the size of the estimated referendum effect is only half as large as for our baseline – 9% compared to 17% – and that the two series have converged again by 2019Q1, possibly reflecting the fact that keeping access to the UK market became more of a priority for EU27 firms in the run-up to the original exit date in March 2019.

Figure 9: EU27-UK FDI counts (actual vs. synthetic control)



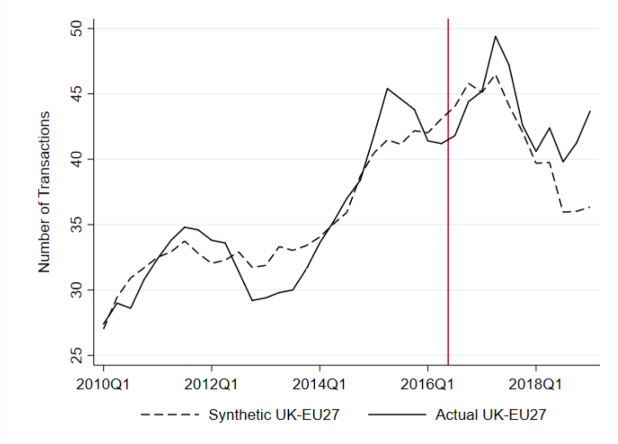
Notes: This figure plots the actual count of FDI transactions from the EU27 to the UK (solid line) and the corresponding synthetic control series (dashed line). The vertical line after 2016Q2 indicates the beginning of the post-referendum period. The p-value for the null hypothesis that the cumulative Brexit referendum effect on FDI transactions is zero equals 0.097. See Sections 2.2 and 3.3 for details. Source: fDi Markets, Zephyr and authors' calculations.

Services versus Manufacturing. We now return to considering FDI from the UK to the EU27 and ask whether the increase in outward FDI shown in Figure 2 occurred in all sectors. We split the sample between transactions occurring in the manufacturing and services sectors, and construct a separate synthetic control series for each sector.

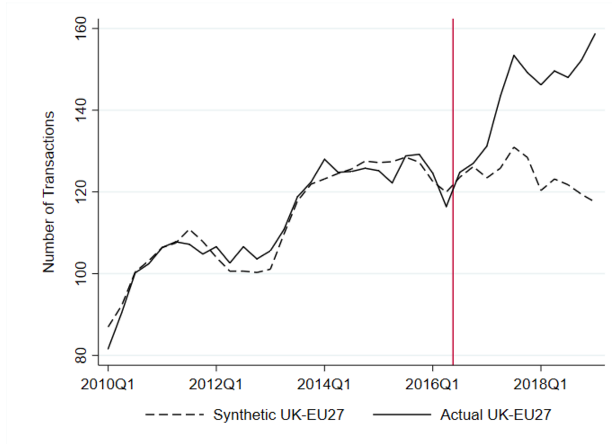
We present the results in Figure 10. While we observe no difference between actual FDI and the synthetic control for the manufacturing sector, we find a sizeable increase in outward FDI for the services sector. These results show that the aggregate effect in Figure 2 is entirely driven by services.[16] This is consistent with the notion that the fixed costs of setting up new foreign affiliates are lower in services industries than in manufacturing. Alternatively, it could be that firms expect Brexit to increase trade barriers by more for services than for manufacturing, perhaps because the UK government has prioritised the

[16] We have experimented with further disaggregating our data by looking at subsectors within the services sector. Unfortunately, the smaller number of underlying transactions made the disaggregated series too volatile, preventing us from obtaining a good fit prior to the referendum as is required for reliable inference with the synthetic control method. However, we were able to verify that the aggregate service sector effect is not entirely driven by financial services – we obtain a similarly sized effect when excluding that subsector.

interests of manufacturing over services in the Brexit negotiations by focusing on reducing customs frictions, while ruling out membership of the EU's single market.



(a) Manufacturing



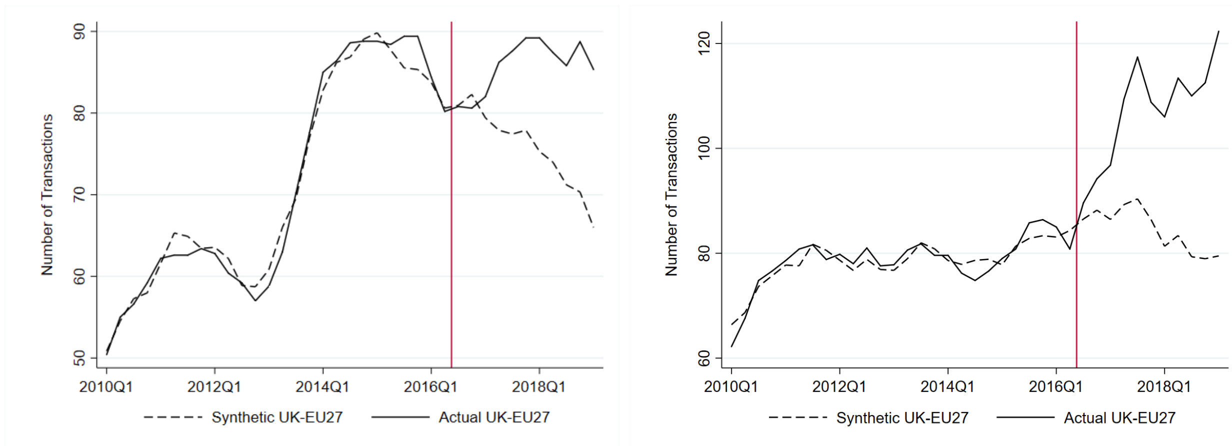
(b) Services

Figure 10: UK-EU27 FDI counts per sector (actual vs. synthetic control)

Notes: These figures plot the actual count of FDI transactions in from the UK to the EU27 (solid line) and the corresponding synthetic control series (dashed line). The left panel restricts to FDI transactions in the manufacturing sector, while the right panel restricts to FDI transactions in the services sector. The vertical line after 2016Q2 indicates the beginning of the post-referendum period. The p-value for the null hypothesis that the cumulative Brexit referendum effect on FDI transactions is zero equals 0.775 for manufacturing and 0.045 for services. See Sections 2.2 and 3.3 for details. Source: fDi Markets, Zephyr and authors' calculations.

Separate Results for M&A and Greenfield. Finally, we estimate our baseline specification separately for M&A and greenfield transactions. As shown in Figure 11, we find a significant effect for both types of FDI flows although the impact on greenfield flows is more pronounced (a 27% increase compared to 13% for M&As). A potential explanation for this asymmetry is that many UK services sector firms, who account for the entirety of the referendum effect we estimate, might require specific capabilities in Europe which are easier to create from scratch than by buying other firms. For example, in order to continue serving clients in the EU27 after Brexit, many banks only require a limited local presence rather than the full range of banking operations that the acquisition of a local firm would bring.

Figure 11: UK-EU27 FDI counts per transaction type (actual vs. synthetic control)



(a) M&A (b) Greenfield

Notes: These figures plot the actual count of FDI transactions in from the UK to the EU27 (solid line) and the corresponding synthetic control series (dashed line). The left panel restricts the underlying sample to M&A FDI transactions, while the right panel restricts the sample to greenfield FDI transactions. The vertical line after 2016Q2 indicates the beginning of the post-referendum period. The p-value for the null hypothesis that the cumulative Brexit referendum effect on FDI transactions is zero equals 0.039 for M&A transactions and 0.010 for greenfield transactions. See Sections 2.2 and 3.3 for details. Source: fDi Markets, Zephyr and authors' calculations.

4 Conclusions

This paper shows that the Brexit referendum has led to a substantial increase in the number of foreign direct investment transactions undertaken by UK firms in EU27 countries. The increase is entirely concentrated in the services sector, with no discernible effect for manufacturing. Higher UK FDI to the EU has not been accompanied by increased UK FDI outside of the EU, nor by an increase in EU firms' investing in the UK.

Our data do not allow us to make definitive statements about why UK firms have increased FDI in the EU or how this change has affected domestic jobs and investment. But our findings are consistent with the idea that firms expect Brexit to make the UK a less attractive location to do business and that this is causing some British firms to offshore production to EU countries, and EU firms to reduce their investment in the UK.

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A Data Appendix

This appendix provides additional information on the two main data sources we use in this paper.

A.1 fDi Markets

The fDi Markets database has been tracking cross-border greenfield investment since 2003, covering all sectors and countries worldwide. Our baseline specification using data from Q1-2010 to Q1-2019 contains around 63,200 greenfield investments between EU and non-EU OECD countries (99,400 for the full period 2003Q1 to 2019Q1).

fDi Markets obtains data on new greenfield transactions by searching over 8,000 information sources (newspapers, magazines, industry associations, company websites) in 23 languages on a daily basis. Each news article is then checked on the investing company's website, which also allows fDi Markets to gather additional information on the company and further details of the FDI project in question.

Whenever possible, fDi Markets also collects information on the capital investment and jobs associated with FDI projects based on announcements by the investing company. In practice, however, this information is only available for around a fifth of projects and has to be estimated by fDi Markets based on similar projects for the remaining cases. Even if data on jobs and capital expenditure are released, they are usually based on plans rather than realised outcomes. These are the principal reasons why we use count data throughout our analysis. In addition, job and capital investment data can be dominated by a small number of very large transactions, leading to much noisier time series than for counts. We do, however, make use of the available information about transaction values to compute a rough estimate of the changes in aggregate FDI investment caused by the referendum result.

A.2 BvD Zephyr

Bureau van Dijk's Zephyr is a database of deal information containing data on M&A, IPO, private equity and venture capital deals. It contains information on over 1,600,000 deals with up to 100,000 additional deals being added each year. Data on new transactions are obtained by searching a wide range of news publications, company press releases, stock exchange announcements, advisor submissions and websites in over 30 languages.

For our analysis, we focus on cross-border mergers and acquisitions between EU and non-EU OECD countries, yielding approximately 43,000 transactions for the period 2010Q1-

2019Q1 (73,000 for the full period 2003Q1-2019Q1). For comparison with the greenfield investment data, we associate each transaction with its announcement date, although using completion dates yields very similar results.

Zephyr also provides information on deal values although this information is only available for around 40% of transactions in our sample. Similar to the greenfield data, aggregate bilateral M&A deal values are often dominated by a small number of large deals, so we again prefer to focus on counts of the number of deals.

B Calculation of the Value of Additional FDI Outflows

To estimate the value of the additional outward FDI flows from the UK to the EU27 caused by the referendum, we use data on transaction values from the fDi Markets and Zephyr databases. From fDi Markets, we calculate that the mean capital investment value of UK-EU27 greenfield transactions in 2017/2018 was $24.5 million. This corresponds to £18.9 million based on the average 2017/2018 exchange rate of 0.76 £/$. From Zephyr, we obtain a mean value of €169.8 million for UK-EU27 M&A transactions in 2017/2018, or £149.5 million based on the average 2017/2018 exchange rate of 0.88 £/€.[17]

To use this information on mean values per transaction, we apply the synthetic control method to estimate the effect of the referendum on UK outward FDI to the EU27 separately for greenfield and M&A transactions. We find that the leave vote resulted in 254 additional greenfield transactions and 110 additional M&A transactions (cumulatively by 2019Q1).[18] We then multiply these additional transactions by their respective mean values. This yields a total increase in FDI outflows from the UK to the EU27 due to the referendum of £21.2 billion by 2019Q1. As shown in Figure 10, the aggregate effect is entirely driven by services. If we only use transaction values for services to calculate means as described above, we estimate the total increase in FDI outflows from the UK to the EU27 due to the referendum to be £20.7 billion by 2019Q1.

[17]fDi Markets imputes value information for transactions where investment expenditure is not reported, using information from similar transactions. Likewise, we manually impute missing value information in Zephyr by using the mean value of other M&A transactions from the same country pair, year and 2-digit NACE industry code. If no such transactions are available, we successively widen the imputation comparison group to i) the same country pair and industry, ii) the same country pair, and iii) the same industry only. The effect of this imputation is to lower the mean transaction value compared to our raw data (see Table 1). We believe that this approach is superior to only using directly observable data. This is because value information tends to be more readily available for larger projects, implying the directly observable data is likely to overestimate average project value.

[18]See Figure 11 in Section 3.3. We note that the estimated treatment effects for the M&A and greenfield sub-samples are statistically significant at the 5% and 1% level, respectively.

We can use a similar procedure to compute "lost investment" due to the reduction in FDI flows into the UK from the EU27 (see Figure 9). We need data on the average capital investment of greenfield EU27-UK transactions and on the average value of M&A transactions in 2017/2018. We calculate a mean capital investment value for greenfield transactions of £25 million. The mean value of an M&A transaction is £235.8 million. Similar to UK-EU27 flows, we compute the referendum effect separately for greenfield and M&A transactions and obtain an estimate of 145 fewer greenfield transactions and 40 fewer M&A transactions.[19] This yields an estimated reduction in aggregate EU27-UK FDI flows of £13.1 billion by 2019Q1. The estimated reduction in aggregate EU27-UK FDI flows is £9.2 billion by 2019Q1 when only using transaction values in services to compute means.

[19] Details on these two additional SCM estimations are not shown here but are available from the authors on request.