Technical Appendix to 'The Impact of Brexit on Foreign Investment in the UK'

Gravitating Towards Europe: An Econometric Analysis of the FDI Effects of EU Membership

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How much additional foreign direct investment (FDI) does a country receive as a consequence of being a member of the European Union (EU)? The objective of this paper is to offer novel estimates of the effect of EU membership on FDI inflows using bilateral FDI data from 34 OECD countries 1985-2013. We find that EU membership robustly increases FDI inflows by 14% to 38% depending on the choice of econometric techniques. Should the UK leave the EU, we predict about a 22% fall in FDI inflows. Our results are robust to the use of more sophisticated econometric estimators. In light of the recent debates on Brexit, we also try to understand the reasons for foreign investors choosing the UK vis-à-vis other European countries, emphasising the potential effects of European integration on FDI inflows to the UK.

* We would like to thank, without implicating, Swati Dhingra, John Van Reenen and seminar participants at NIESR and LSE for valuable comments on previous versions.

1 Introduction

The gravity model has been a staple of international economics. It explains bilateral cross-border flows (trade, migration, investment, etc.) based on the relative size and distance between countries or regions (see Head and Mayer, 2014, for an authoritative review). A country's economic size is expected to have a positive effect on bilateral flows while distance is expected to have a negative effect (distance is often taken to reflect a whole range of trade costs including language, bureaucracy, culture, etc.).

The last two decades have witnessed enormous progress in this area. Among many influential pieces, Anderson and van Wincoop (2003) and Santos Silva and Tenreyro (2006) are the crucial ones for our present purposes. This new Structural Gravity approach (Fally, 2015) provides needed theoretical underpinnings as well as strong support for the econometric estimation of gravity models.

This paper offers novel estimates of the effect of membership of the European Union (EU) on inflows of foreign direct investment (FDI). As such, it is motivated by two concerns. The first motivation is that although the benefits of FDI are well established in the economic literature,[1] there is a dearth of analysis of its impact within the European integration experience. Inward FDI is a major contributor to the diffusion of managerial best practices (Bloom et al, 2012). It increases competition and shores up technological innovation; and it is believed to do so in a more resilient and sustainable fashion than other international capital flows. Despite the obvious importance of the subject, the literature focusing on potential reasons for foreign investors to choose the UK vis-à-vis say Germany, Poland or Switzerland remains scarce. We try to address this gap. European integration may have played a significant role and we need a good understanding of these potential effects.

The second motivation refers to the potential value of an indirect comparison between the trade effects of the EU and the FDI effects of currency unions like the euro. For example, Glick and Rose (2016) find that their earlier estimates (Glick and Rose, 2002) on the impact of currency unions were statistically fragile when subject to a wide range of modern econometric techniques. Most of these new techniques were developed and used in the estimation of gravity models after they published their original paper.

We therefore ask whether the use of modern econometric techniques eliminates the effects of the EU on FDI. *We find that it does not*. EU membership significantly increases FDI inflows

[1] For example, see Alfaro et al (2004) on international macro data or Haskel et al (2007) on UK micro-data.

by around 28% depending on the precise choice of econometric technique. We show that this finding is consistent with alternative methodologies that look specifically at the UK experience of FDI compared to other countries (Campos and Coricelli, 2015).

This Appendix is structured as follows. Section 2 introduces the gravity model, Section 3 the synthetic cohort approach and Section 4 the data. Section 5 presents the main new empirical findings of the positive effects of being in the EU from a gravity model of bilateral FDI flows. Section 6 concludes.

2 The gravity model

Gravity has gravitas. The original gravity study was authored by Jan Tinbergen, the first winner of the Nobel Prize in Economics. These original estimations used pooled OLS methods without time or country fixed effects. The inclusion of fixed effects has (justifiably) become a standard estimation feature, usually by adding 'dyadic effects' (that is, a dummy variable for each pair of countries involved in a bilateral flow). These control for any time-invariant characteristic common to every pair of trading partners. A number of important issues fall into this category, particularly distance between countries and whether they share a common culture, language or border. The subsequent step in the evolution of gravity modelling was the use of time-varying country and dyadic fixed effects. The current stage in the evolution of modelling gravity is the Poisson estimator (Santos Silva and Tenreyro, 2006).

Baldwin (2006) and Baldwin and Taglioni (2007) provide important insights for the application of the gravity model in the empirical analysis. They derive the basic gravity equation for trade that we use for FDI:

$$ln(\text{Bilateral Inflow of } FDI_{o,d,t}) = \alpha_0 + \alpha_1 lnX_{o,t} + \alpha_2 lnX_{d,t} + \alpha_3 Z_{o,d,t} + \square_{o,d} + u_{o,d,t}$$

where *ln(.)* stands for a natural logarithm and the $X_{o,t}$ is a vector of characteristics of the origin country, *o*, in year *t*. This will include measures of the size (GDP) and wealth (GDP per capita) of the country. Similarly $X_{d,t}$ is a vector of destination nations' characteristics. The $Z_{o,d,t}$ is a vector of characteristics specific to a country pair and will include things like geographical distance (a proxy for trade costs) and cultural distance (colonial history, common language, etc.). Being a member of the EU will be one of the time-varying observable characteristics of a country that enter the $X_{o,t}$ and $X_{d,t.}$ vector. Many FDI-relevant characteristics will be hard to control for with observables, which is why including a dyadic fixed effect ($\square_{o,d}$) is so important (a dummy variable for each pair of countries – around 630 fixed effects). Since culture and

geography do not change much over time, the fixed effects will control for them, so the coefficients of interest are identified from the impact of changes in trading relationships (and other economic variables) over time on the change in FDI flows over time. The $u_{o,d,t}$ is an error term that includes a full set of time dummies to control for global macroeconomic shocks. The standard errors are clustered by dyadic pair to allow for serial correlation of the errors.

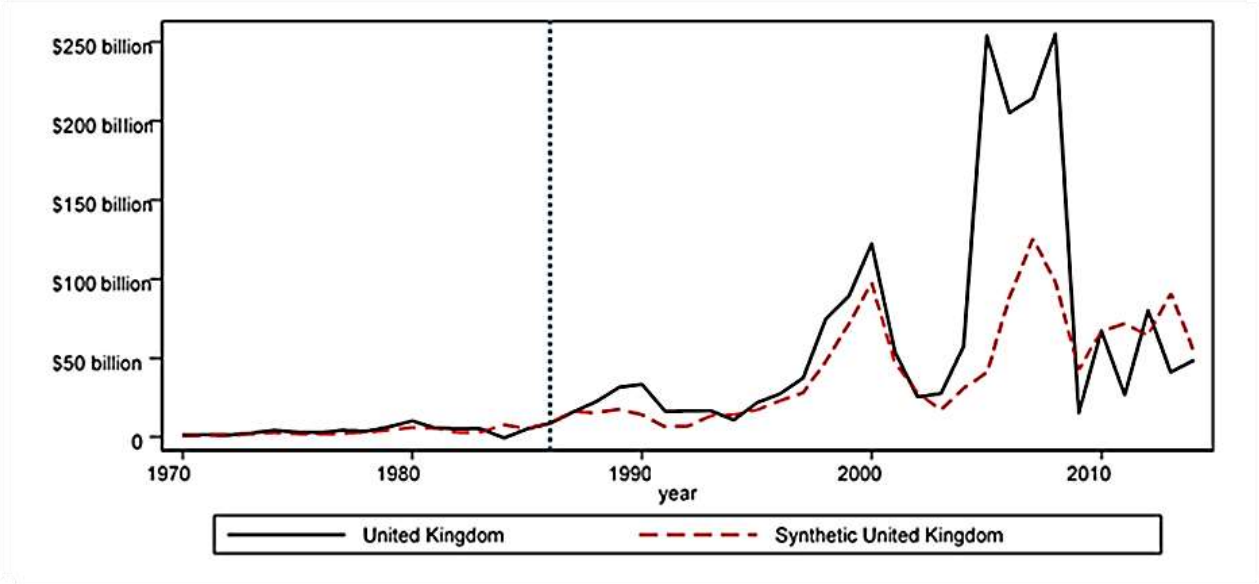
3 FDI in the UK after 1970: a synthetic cohort approach

The UK is one of the main FDI recipients in Europe. Net FDI inflows to the UK were small in absolute terms until the mid-1990s, but afterwards they exhibit two periods of rapid expansion, one in the second half of the 1990s and the other before the financial crisis. The 2008 financial crisis generated a substantial 'sudden stop' in FDI inflows (see Figure 1).

Campos and Coricelli (2015) use these data to provide some estimates of the effects of the Single Market on UK FDI net inflows. In Figure 1, the dashed red line shows their 'synthetic counterfactual' estimates, showing what would have been FDI net inflows after 1986 if the UK had decided not to join the Single Market.[2] The results suggest that the Single Market played a key role in mobilising FDI to and from the UK. Interestingly, they show that the bulk of these benefits (in terms of additional UK FDI, had the UK chosen to opt out instead) occurred post-euro, between the dot-com bubble and the financial crisis. In other words, these results suggest that for the whole period of 1986 to 2014, the UK would have received on average about 25% to 30% less FDI had it not been in the EU, but that this average conceals large variations over time that deserve further study.

[2] These results use the Synthetic Control Method pioneered by Abadie and Gardeazabal (2003) and originally reported in Campos and Coricelli (2015). They are based on a simple model focusing on market size, per capita GDP and trade openness as key determinants of location choice. The following estimated weights were obtained: the United States (20%), Canada (44%) and New Zealand (36%). Data source is World Bank's World Development Indicators.

Figure 1:
What would UK FDI net inflows be if the UK had not been in the EU Single Market?



Source: Campos and Coricelli (2015).
Notes: FDI is measured in nominal US$. The actual FDI flows for the UK (solid black line) are compared to a counterfactual (dashed line) of a 'synthetic UK' made up of a weighted basket of three other countries (the United States, Canada and New Zealand). Vertical line is when the EU Single Market Programme set up.

4 Data and modelling strategy

To estimate the impact of EU membership on FDI, we collected the most recently available data on bilateral FDI flows, GDP and GDP per capita (sender and target), bilateral distance and the shares of manufacturing output, exports and imports in total GDP. Table 1 reports definitions and sources, while Table 2 reports basic descriptive statistics.

Our data set covers 34 OECD countries between 1985 and 2013.[3] Our data represent more than 70% of global FDI inflows and, because the countries are all OECD members, they are collected in a homogenous manner and are of relatively high quality. The main disadvantage of our data is the exclusion of most developing countries including China and India. Notice that a by-product of this drawback is that we are limited in the currency unions we can study (for example, vis-à-vis Glick and Rose, 2016).

[3] The maximum theoretical number of observations is 34*33*29=32,538. For many countries, especially before the 1980s, bilateral FDI flows are in fact zero. The missing values for FDI in the data reflect these zeros (and a few near zero). Missing observations are assigned zeros (which explains the different number of observations in Tables 2 and 3). We used the Heckman selection model to try to deal with whether we should treat zero FDI in a special way.

Table 1: List of variables

	Definition	Unit	Source
Bilateral FDI flow	Inward FDI flows (sender to target)	USD, Millions	OECD database
Bilateral FDI stocks	Inward FDI Stocks (sender to target)	USD, Millions	OECD database
GDP (sender)	Total GDP of FDI sender	USD, millions	World Bank
GDP (target)	Total GDP of FDI target	USD, millions	World Bank
GDP per capita (sender)	GDP per capita of FDI sender	USD, PPP	World Bank
GDP per capita (target)	GDP per capita of FDI target	USD, PPP	World Bank
EU member (sender)	Sender country is EU member	0,1	EU website
EU member (target)	Target country is EU member	0,1	EU website
Manufacturing share (target)	Share of manufacturing output as percentage of total GDP	%	World Bank
Export share (target)	Share of export as percentage of total GDP	%	World Bank
Import share (target)	Share of import as percentage of total GDP	%	World Bank

Notes: 'Target' indicates the country that is the recipient of the FDI and 'sender' indicates the country that is the sender of the FDI.

Table 2: Summary statistics

	Obs.	Mean	CV (SD/mean)	p25	p50	p75
Bilateral FDI inward flow	19,241	680	6.23	0	6.5	190.2
Bilateral FDI inward stock	16,880	7371	3.53	0	289.6	3154.8
GDP (sender)	19,834	1,056,215	2.04	150,218.9	310,006.2	1,121,872.0
GDP (target)	19,776	1,088,197	1.97	169,867.0	368,753.4	1,162,375.0
GDP per capita (sender)	19,682	27,324	0.47	18,224.8	25,859.9	344,41.4
GDP per capita (target)	19,776	26,764	0.49	17,298.7	25,221.5	340,82.7
EU member (sender)	20,268	1	0.97	0.0	1.0	1.0
EU member (target)	19,788	1	0.85	0.0	1.0	1.0
Manufacturing share of GDP(target)	16,283	18	0.29	13.8	17.8	21.6
Export/GDP (target)	19,776	40	0.66	24.1	31.6	49.0
Import/GDP (target)	19,776	38	0.58	25.1	31.4	44.7

Notes: 'Target' indicates the country that is the recipient of the FDI and 'sender' indicates the country that is the sender of the FDI. SD = Standard Deviation; p25=25th percentile; p50=median and p75=75th percentile.

Our modelling strategy follows the standard structural gravity approach. For example, a similar specification is used by Baier and Bergstrand (2007, their equations (9) and (10)). First, we estimate a baseline model using the natural logarithm of bilateral FDI flows; second, we estimate a Poisson model; and finally, we estimate a Heckman model that takes into account the zero flows bilateral trade and as such has a larger number of observations. In all cases, we control for dyadic fixed effects and time dummies.

Dyadic fixed effects and time dummies matter. The inclusion of bilateral fixed effects helps to minimise the effects of the exclusion of many of the usual suspects in explaining FDI flows. They control for country pair unobserved heterogeneity and implicitly for factors such as cultural distance, bilateral regulatory agreements, etc. The usual concern regarding 'omitted variable bias' is mitigated in this way in these types of models. Year fixed effects are also important. They reflect the macro phenomena that are common across all country-pairs.

Finally, we also address a selection problem. Suppose that the OLS and Poisson regression are biased by the inclusion of 'positive only' data of bilateral FDI flows. 41% of the observations are zero and the OLS model deals with this by giving a value of $1 of FDI to the missing value so we can take logarithms. But this is rather arbitrary and the fact that there are no bilateral trade flows between two countries may be telling us more about the sunk costs of doing business between the pair of countries.

We try to address this issue *via* a Heckman selection model in which we first estimate a selection equation (column (4)). The likelihood of non-zero flows is modelled as a function of manufacturing, exports and import shares as well as the per capita GDP of the destination country. The selection equation generates some interesting lessons: a higher likelihood of positive FDI flows is related to lower per capita GDP in the destination country (FDI goes to countries where the return to capital is higher), higher industry shares (better integration in the value chain), lower export shares (substitution effect) and higher import shares of the target.[4]

[4] The lambda term is significant and negative, suggesting that the error terms in the selection and primary equations are negatively correlated and the selection equation is needed.

5 Econometric results

Table 3 shows our main results with the dependent variable being the bilateral FDI flows. The regressors in all specifications (OLS, Poisson and Heckman) carry the expected signs. The size of the two countries (measured by GDP) has a coefficient close to one and the level of development (GDP per capita) of the sender exerts a positive effect on FDI flows.

The main variable of interest for this study is that capturing the effect of EU membership on FDI inflows. Focusing on the estimated coefficients for the EU target dummy for the host economy is between 14% and 38% depending on the statistical technique. This coefficient is always statistically significant. On the baseline OLS estimate of column (1) the effect is 33% (= $e^{0.285}$-1). In the Poisson model of column (2) it is 38% (= $e^{0.32}$ - 1). In column (3), which tries to control for selection on the zeros, the effect is 14% (= $e^{0.13}$- 1). A simple average of these three estimates would be 28% and we consider this as the 'baseline case'.

In terms of considering Brexit, we are running the experiment in reverse so the proportionate effect is smaller, as a country's new FDI level is higher thanks to being in the EU. For example, if joining the EU increases FDI by 28%, we would predict leaving the EU would reduce FDI by 22% (= 0.22/(1+0.22)). Similarly, the three estimates of 14%, 33% and 38% translate to Brexit-induced falls of FDI of 12%, 25% and 28% respectively.

Is it reasonable to use these estimates of the past effects of the EU on FDI as a guide to the future? One view is that although EU membership benefited FDI flows in the past, leaving the EU would not generate a significant penalty because 'times have changed'. It is hard to understand why this would be the case. It is true that the effects going forward of EU membership could be smaller than in the past. But it is equally possible that they may be larger.

To us, it seems that the most reasonable approach for a baseline case is to assume that things will be similar to what has happened in the past, unless there is a strong reason to think otherwise.[5]

[5] PWC (2016) find that Brexit will induce a fall of UK FDI by 25% by 2020, a very similar quantity to what we have here.

Table 3: Panel estimates of the effects of EU membership on FDI inflows

Dependent variable:	(1) Ln(1 + FDI)	(2) FDI	(3) Ln(FDI)	(4) Dummy 1(FDI>0)
EU member (target)	0.285***	0.320*	0.132***	
	(0.077)	(0.163)	(0.050)	
EU member (sender)	-0.010	0.828***	0.199***	
	(0.079)	(0.191)	(0.050)	
Ln(GDP, target)	0.473***	3.799***	0.686***	
	(0.056)	(1.432)	(0.226)	
Ln(GDP, sender)	0.500***	3.903***	0.766***	
	(0.154)	(1.462)	(0.226)	
Ln(GDP per capita, target)	0.180	-1.489	-0.010	0.230***
	(0.158)	(1.513)	(0.255)	(0.017)
Ln(GDP per capita, sender)	1.450***	-1.125	1.655***	
	(0.154)	(1.623)	(0.254)	
Manufacturing value added/GDP (target)				0.005***
				(0.002)
Exports/GDP (target)				-0.013***
				(0.001)
Imports/GDP (target)				0.011***
				(0.002)
Mills' Ratio			1.043***	
			(0.164)	
Observations	33,524	33,147	33,524	33,524

Notes: *** indicates significance at the 1% level, ** at the 5% level and * at the 10% level. Coefficients with standard errors (clustered by 630 bilateral country pair in first two columns) in brackets. All regressions include fixed effects for years and dyadic pair. Column (1) is estimated by OLS. Column (2) is estimated by Poisson PML. Columns (3) and (4) are a two-part Heckman selection equation. The dependent variable in column (4) is a dummy equal to 1 if there are any FDI inflows and zero otherwise. The Mills' ratio is constructed from this column and included in column (3). The 34 OECD countries included are Austria, Australia, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, Norway, New Zealand, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, UK and the US. 'Target' indicates the country which is the recipient of the FDI and 'sender' indicates the country is the sender of the FDI.

We have subjected our estimates to a wide range of robustness checks. First, we are implicitly treating the counterfactual to EU membership as simply being a standard member of the World Trade Organization (WTO), whereas we may believe being in the European Free Trade Association (EFTA) or the European Economic Area (EEA) is a more optimistic alternative for the UK after leaving the EU – so-called 'Brexit' (Dhingra et al, 2016). If we add two dummy variables for being an EFTA sender or receiver to column (1) both coefficients are statistically insignificant and the EU recipient dummy remains positive and significant (0.211 with a standard error of 0.100). This suggests that it is being in the EU that matters. Further, the point estimate on being an EFTA recipient is actually negative (-0.206 with a standard error of 0.144). This implies that there may be some trade diversion from EFTA members like Switzerland to EU members (for example, because Switzerland is not in the Single Market for financial services).

Second, we have focused on modelling flows, but an alternative would be to use FDI stocks. This gives qualitatively similar results. The EU recipient dummy always attracts a positive coefficient in the three alternative estimators in the equivalent columns to Table 3.

Third, we examine some of the dynamic impacts of EU membership. We find that the big effects came quite quickly following membership rather than taking a long time to feed through.

How do these results compare with other estimates in the literature? As noted in Section 2, the synthetic cohort approach generates effects of 25% to 30% for the UK, which are very much in the same ballpark.

Straathof et al (2008) also use a gravity model to look at bilateral FDI stocks. One of their specifications uses dyadic fixed effects but a somewhat different set of controls and on earlier data (1981-2005). They find that if a country is in the EU, it enjoys a 28% increase in its inward FDI stocks from other EU countries and a 14% increase from non-EU countries (their Table 5.1, column (2)).

We can also look at the bilateral trade flows literature for a comparison, but we need to bear in mind that we focus on bilateral FDI in our model. Baier and Bergstrand (2007) find that free trade areas (FTAs) increase trade by about 100% after 10 years. We find instead that EU membership increase FDI inflows by about 28% in a country that is a member of the EU, which may be because trade is easier to adjust than FDI flows.

6 Conclusions

How much additional FDI does a country receive as a consequence of being a member of the EU? This is an obviously important question for which, surprisingly, one still finds very few answers. The objective of this note was to try to redress this gap.

Does the use of modern econometric techniques wipe out the EU effect on FDI? We find it surely does not. EU membership robustly increases FDI inflows. Our three main estimates range between 14% and 38% depending on the choice of econometric technique. The average of these is 28%, which implies that leaving the EU would reduce FDI inflows by around 22%. Our magnitudes are comparable with alternative methodologies. Whichever way the data are cut, Brexit is likely to have the effect of significantly lowering FDI coming to the UK.

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