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BREXIT and FDI: Key Issues and New Empirical Findings

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Summary

This contribution takes a new look at the gravity equation model in relation to foreign direct investment of leading industrialized countries which presents a useful basis for assessing certain potential impacts arising from BREXIT. The gravity equation estimated allows considering the case of BREXIT and the broader role of EU membership and other variables. Looking at the period from 1985 to 2012 for a dataset which contains 34 OECD countries: The PPML dyadic fixed estimations take into account a broad set of approaches and variables, respectively. Besides the traditional variables of the EU/EU single market membership of the source country and of the host country, we further consider the role of trade openness as well as corporate tax rates and the ratio of inward FDI stock to total capital stock. The analysis shows that trade openness is a variable which can be largely replaced by the inward FDI stock/capital stock ratio so that gravity FDI modeling with a strong emphasis on trade openness is likely to overstate the role of trade and to understate the role of relative FDI accumulation effects. The implication for BREXIT analysis is that the UK will face three impulses for FDI inflows: (1) leaving the EU single market will strongly reduce FDI inflows; (2) if foreign ownership in the UK capital stock should strongly increase in the run-up to the BREXIT year 2019, part of the dampening effects of leaving the EU will be mitigated by the increase of the FDI stock/capital stock ratio which in turn is likely to reflect a Froot-Stein effect related to a real Pound deprecation 2016-2018; (3) to the extent that the UK government will want to reinforce output growth through higher FDI inflows, a reduction of corporate taxation could generate high effects – but could also stimulate a downward international corporate tax reduction game.

Zusammenfassung

Dieser Artikel leistet einen neuen Beitrag zur Analyso von Direktinvestitionsflüssen führender Industrieländer mithilfe des Gravitationsmodells, was eine nützliche Grundlage für die Bewertung bestimmter potenzieller Auswirkungen von BREXIT darstellt. Die Gravitationsgleichung ermöglicht die Berücksichtigung des BREXIT-Falles, der umfassenderen Rolle der EU-Mitgliedschaft und anderer Variablen. Betrachtet wird der Zeitraum von 1985 bis 2012 für einen Datensatz, der 34 OECD-Länder enthält: Der dyadische PPML-Fixed-Effects Schätzer berücksichtigt eine breite Palette von Ansätzen bzw. Variablen. Neben den traditionellen Variablen der Mitgliedschaft der EU bzw. des EU-Binnenmarktes im Herkunfts- und im Empfängerland, betrachten wir die Rolle der Handelsoffenheit sowie der Körperschaftssteuersätze und des Verhältnisses der FDI-Bestände zum gesamten Kapitalbestand. Die Analyse zeigt, dass die Handelsoffenheit eine Variable ist, die weitgehend durch die FDI-Aktien- / Kapitalstock-Quote ersetzt werden kann, so dass die FDI-Modellierung mit Schwerpunkt auf Handelsoffenheit die Rolle des Handels überbewerten und die Rolle der relativen kummulierten FDI-Effekte unterbewerten. Die Analyse zeigt, dass der BREXIT für das Vereinigte Königreich drei Effekte für die FDI-Zuflüsse haben wird: (1) wenn der EU-Binnenmarkt verlassen wird, werden die FDI-Zuflüsse stark sinken; (2) Sollte die ausländische Beteiligung am britischen Kapitalstock im Vorfeld des BREXIT-Jahres 2019 stark ansteigen, wird ein Teil

der dämpfenden Auswirkungen des EU-Austritts durch die Erhöhung der FDI-Aktien-/Kapitalstockquote gemildert, dies reflektiert einen Froot-Stein-Effekt, der sich auf eine reale Pfund-Abwertung 2016-2018 bezieht; (3) In dem Maße, in dem die britische Regierung das Produktionswachstum durch höhere FDI-Zuflüsse verstärken will, könnte eine Senkung der Unternehmensbesteuerung hohe Auswirkungen haben – könnte aber auch eine Senkungsspirale des internationalen Steuersatzes stimulieren.

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1. Introduction

Brexit will have considerable effects in OECD financial markets; this will concern capital flows, including foreign direct investment (FDI) dynamics. FDI, in addition to trade dynamics, is a key element of the economic linkages in Europe, North American and Asia. Since multinational companies – in the manufacturing industry – stand for firms with ownership-specific advantages (Dunning 1998), one may expect that FDI inflows also bring international technology transfers; in the case of greenfield investment, inflows also have a positive effect on capital accumulation unless there are monopolization effects in the host country. Such effects could discourage investment by other firms and could also reduce the sales volume of intermediate suppliers in the host country since the monopoly equilibrium output is below that under competition; an effect which should, however, not be relevant outside of the non-tradables sector in the EU28 single market established at the end of 1992; and a fortiori in the European Economic Area (EEA:EU plus Norway, Iceland and Liechtenstein: EEA countries apply the rules of the EU single market with its basic freedoms, namely free trade, free capital flows and free migration). With BREXIT – the envisaged leaving of the EU by the United Kingdom – the economic links between the United Kingdom and the EU/EEA will be weakened (HM Government, 2016; Welfens, 2017a) as reduced future British access to the EU single market will be part of a new regime for the UK and the EU27. Depending on sectoral free trade agreements yet to be negotiated, there could be at least partial free trade between the UK and the EU27 after 2019, the actual exit year, which raises a question about the role of trade openness. In addition, there is the question of the impact of the EU membership/EU single market membership; if the EU-UK negotiations would lead to a soft BREXIT, namely continued membership of the UK in the EU Customs Union or a set of wider sectoral agreements on trade and FDI liberalization, the negative effects of BREXIT on British inward FDI after 2019 – the expected year of the UK leaving the EU – would be mitigated. There is also the question of how important the transition effects between 2016-2019 could be, particularly effects related to enhanced FDI inflows (greenfield or international M&As) which in turn could be related to strong real exchange rate depreciations. Froot/Stein (1991) have shown for the case of the US that inward FDI inflows – relative to GDP – are a positive function of the real exchange rate; the theoretical background is an imperfect capital market model that should also be relevant in a broader OECD context.

The relevance of FDI inflows for BREXIT dynamics is rather strong because a key part of the debate about the referendum refers to the question of GDP losses (e.g. HM Government, 2016; Rabobank, 2017) or real GNI losses (Welfens, 2017b). The forecast revisions of the Office for Budget Responsibility already suggest, comparing the November 2017 forecast up to 2020 with the figures of the November 2015 forecast, that overall investment in 2016-2020 is reduced by about 30% and output for 2020 by almost 5%. Since the share of foreign ownership in the UK in 2016 was 17%, part of the reduced investment and output dynamics will be related to foreign investors. It is noteworthy that, for example, the US subsidiaries in the UK alone stood for about 7% of UK output in 2014. Recent FDI gravity modelling (Bruno et al., 2016) can be used to understand both the effects of BREXIT on British inward FDI dynamics and British outward FDI

dynamics. This then will naturally lead to refined gravity equation modeling that allows to derive some results with respect to the BREXIT dynamics.

In a macroeconomic perspective, in the macroeconomic production function – with capital K, labor L and knowledge A being key input factors – FDI inflows are linked to K and A, respectively. The development of A over time t and dA/dt, respectively, can be explained in the context of a knowledge production function (KPF). According to the knowledge production function (Machlup, 1979; Griliches 1979), FDI dynamics are particularly important for output growth since the increase of knowledge, namely dA/dt (t is the time index) is dependent on the number of researchers, the ratio of the inward stock of FDI to GDP and other inputs as shown empirically for the case of EU countries by Jungmittag/Welfens (2016). The knowledge production function considered by Jungmittag/Welfens (2016) for 20 EU countries has shown that the number of researchers, per capita income and the stock of inward FDI relative to GDP are three key variables that explain the creation of new knowledge/new patent applications in EU countries. The fixed country effects show that this argument is more crucial for the UK than the average effect found for the sample of countries.

The particular relevance of FDI dynamics for long-term technology transfer, capital accumulation and output development can be considered in the context of an FDI gravity equation for industrialized countries so that anticipating BREXIT effects will become possible. In the subsequent analysis we look at the relevant literature, add a few variables to the traditional setup and discuss the implications for BREXIT analysis and policy conclusions.

It should be emphasized that the role of the EU single market on the FDI outflow dynamics of countries such as Germany and the United Kingdom has been studied early on, namely only a few years after the creation of the EU single market where Barrel/Pain (1997) have presented empirical evidence for both countries on the basis of time series analysis.

New FDI gravity modeling has been presented, namely based on various scenarios with, for example, post-BREXIT inward barriers to FDI in the UK or with new inward FDI barriers imposed by the EU27 in the context of BREXIT (McGrattan/Waddle, 2017). Searching for an understanding of the effects of BREXIT on FDI one could also consider the findings on UK or German FDI in the context of EU single market creation as derived by Barrell/Pain (1997): One may argue that understanding BREXIT effects in the context of reduced British access to the EU single market should largely be the negative mirror effect of the UK joining – with the EU partner countries – the EU single market. The emphasis in the subsequent modeling, however, is on FDI gravity modeling where the relevant time period examined, 1985-2012, allows to focus on a period of general FDI liberalization in OECD countries after 1984, often along broad programs of privatization which enhanced the international M&A menu considerably (in some EU countries with a delay, in fixed line telecommunications, for example, general EU opening up of the sector and subsequent privatization took place only after 1998). The EU single market program was implemented by the end of 1992; with certain delays such as in insurance. There is no doubt that the EU single market dynamics should be largely reflected in companies' adjustment dynamics after 1992 – in many cases also a few years earlier since firms' anticipation of new investment opportunities will matter.

1.1 Selected BREXIT Aspects

It is useful to emphasize that the Treasury's study (HM Gov., 2016) on the long run benefits of British EU membership – or, in a mirror perspective, the cost of BREXIT – has suggested that the UK could witness a 10 percent real income loss in the long run, namely a 6 percent loss from reduced future British access to the EU single market and another 4 percent loss from the non-implementation of the results of EU-UK negotiations on deepening the EU single market, i.e. the results from Prime Minister Cameron's negotiations in Brussels in early 2016. The analytical focus of the Treasury reports is primarily on trade and only partly on FDI when modeling the key economic effects of reduced future British access to the EU single market. It is not fully clear what higher FDI barriers imposed on the UK by the EU27 after March 2019 could mean, but clearly there would be serious economic effects that could already be gauged by referring to the study of Francois et al. (2012) on the economic effects of a Transatlantic Trade and Investment Partnership (TTIP) on the EU28. Basically, in chapter 6 of that study, the authors presented some FDI gravity modeling and consider the scenario that the transatlantic barriers to trade would be reduced to the same level as the intra-EU FDI barriers which are assumed to be a quarter lower than transatlantic FDI barriers.

The result of a hypothetical elimination of the extra transatlantic barrier is more transatlantic FDI and an 11 percent employment increase in US subsidiaries in the EU28. One may add that BEA statistics show that the US cumulated FDI in the EU28 accounts for about 3 percent of gross domestic product and based on the derived employment effects one would naturally then assume that the induced output expansion effects from reduced FDI barriers would be 0.33 percent of GDP. In a mirror perspective, one may ask the question of how strongly EU27 barriers faced by UK firms would increase after March 2019 and how serious therefore real output reduction effects in the UK could be in the context of British FDI reduction in the EU – or, if there should be arguments for an expansion of British FDI in the EU, how large output and employment effects would be for the EU27.

Barrell/Pain (1997) have presented a multi-sector panel data analysis for UK outward FDI and German outward FDI which shows, as key drivers of FDI, the output of the host country *j*, the technological strength – knowledge based assets – in the form of the stock of patents registered in the US by domestic firms, the relative unit costs in the respective home country and country-specific and industry-specific indicators for labor relations, namely the number of strikes in host countries, the exchange rate stability (e_{ij}), an industry indicator for the EU single market as well as a services sector indicator for the EU single market plus a financial indicator for firms – the ratio of interest payments relative to the cash-flows in the case of UK firms. While the German model showed significant results for business sector profitability and the growth of real equity prices; a tighter financial situation reduces outward FDI. As regards the single market variables, both the industrial sector variable and the services sector variable showed a significant impact. The implications from the Barrell/Pain approach with respect to BREXIT thus are threefold for UK industrial outward FDI if one considers it rather likely that the UK's leaving of the EU will reduce profitability of UK firms, lead to higher exchange rate instability and to reduced British access to the EU single market:

- British FDI outflows will reduce in the EU and this should dampen knowledge accumulation in EU27 countries;
- Taking additionally into account the arguments of Froot/Stein (1991), British FDI outflows – with an emphasis on international M&As – will particularly reduce to those EU27 countries where the real appreciation (a mirror of Pound depreciation) is rather high. One may assume that the Eurozone's appreciation rate will be higher than that of other EU countries to the extent that BREXIT itself will create nervous markets for some time and thus could reinforce the role of Germany, France, the Netherlands and Luxembourg as typical safe-haven countries in the Eurozone. Thus one should consider real exchange rate effects.

As regards the McGrattan/Waddle (2017) analysis, their approach differs in terms of simulation analyses and cases considered for EU FDI and UK FDI. The authors present simulations of a multi-country neoclassical growth model that includes MNCs investing in research and development and other intangible capital to be used as non-rival assets by their respective subsidiaries at home and abroad. The scenarios covered consists at first of a situation of a unilateral tightening of British FDI inward barriers vis-à-vis EU27 countries. As a consequence, there is less EU technology available in the UK and thus British firms would have to undertake additional R&D investment of their own; this is costly and imposes negative welfare effects on British citizens. If, in this setting, the EU27 remains as open as before, EU27 citizens will enjoy continuous FDI inflows from the UK and thus EU27 citizens will face modest welfare gains. Instead, one could consider – following the authors – the case that the EU27 imposes FDI restrictions as well. The impact is lower British FDI outflows to the EU27, thus EU27 firms will have to invest more in R&D and there will be a welfare loss for the people in the EU27. By contrast, the UK could increase international lending and those funds could be used for financing the production of firms both domestically and abroad – the British inward FDI inflows are raised, UK consumption falls and leisure is going up so that there is a negligible impact on the welfare of British citizens. As regards the EU27, there will be a modest welfare loss. If the UK reduced FDI inward barriers for non-EU countries, the UK will attract higher FDI inflows and experience welfare gains. A counterargument to some of the UK scenarios considered is that the UK's government pushes for a hard BREXIT meaning that skilled foreign workers and managers from abroad could find it more difficult to enter and live in the UK so that relative skill gaps in the UK will increase which, in turn, will reduce inward FDI dynamics from EU27 countries as well as other countries.

One may also argue that the real depreciation of the Pound observed in 2016/2017 – about 14 percent in the year after the British EU referendum of June 23, 2016 – will, in line with the Froot/Stein (1991) argument, reinforce international mergers & acquisitions in the UK; at the same time, greenfield investment will slow down in the context of slower output growth. It should be emphasized that higher shares of foreign capital ownership in the UK – reflecting international M&As in the BREXIT context – imply that consumption growth will reduce since consumption is proportionate to gross national product, not to GDP; with a higher share of foreign capital ownership in the UK, dividend payments transferred abroad, as a share of British GDP, will increase and hence GNP growth will be smaller than GDP growth until a new steady state is reached (Welfens, 2017a, 2017b).

As regards FDI gravity modeling by (Bruno et al. 2016) the results suggest that the British inward FDI could reduce by 22 percent in the long run. Clearly, the scenarios to be

considered in a BREXIT context will differ depending on the results of the EU-UK negotiations about future British access to the EU single market. In any case it will be useful to focus carefully on advanced FDI gravity modeling in order to better understand the potential implications of BREXIT on FDI and output dynamics in both the EU and in the UK. One may emphasize that part of the problem likely to be faced by Britain is a slowdown of industrial innovation dynamics – in an economy whose industrial sector is already rather modest in comparison with leading EU27 countries. From this perspective, it is obvious that further gravity analysis should shed light on the BREXIT FDI issues.

The key finding presented subsequently is that FDI gravity modeling for industrialized countries shows not only the logic of traditional explanatory variables such as host country GDP, source country GDP and EU membership, but also the role of the corporate tax rate and the ratio of inward FDI stock to the overall capital stock. We emphasize that the role of trade openness on the one hand is significant but if we control additionally for the ratio of inward FDI stock to the overall capital stock trade, openness is no longer significant which so far has not been considered in the literature. We show that EU membership plays a very considerable role – judged by the heights of the relevant coefficient – however, one should add a word of caution in order not to lump, for example. the role of broad privatization in infrastructure sectors (e.g. telecommunications, railways, energy) and in more traditional sectors with state-owned enterprises in with the EU single market dynamics which partly have an overlap with international privatization waves in which EU countries have played a strong role.

The following analysis highlights the relevant literature in section 2 and presents the empirical findings in section 3. The final section looks into policy conclusions and prospects for future research.

2. FDI Dynamics: Theoretical Aspects

As regards EU countries, FDI should be expected to be affected by major institutional changes, such as the creation of the EU itself in 1957, major enlargement rounds (e.g. UK, Denmark and Ireland joining the EU in 1973; and the EU's eastern enlargement in 2004) and the establishment of the EU single market. Free trade and foreign direct investment as well as free portfolio capital flows plus free migration are the four pillars of the EU single market created in 1993 – with free trade in goods already having been established in the period between 1957 and July 1968. To some extent, foreign direct investment and trade in goods and services could be substitutes, namely in the context of tariff jumping where foreign investors create subsidiaries abroad in order to bypass import tariffs. After 1993 this could be a relevant case only for investors from third countries, at the same time one should not overlook that the elimination of FDI barriers in the EU single market gave incentives to create European production networks – a perspective that was reinforced by the two-stage EU eastern enlargement in 2004 and 2007.

In a single market, foreign direct investment and trade should be substitutes or complements for macroeconomic and structural reasons:

- To the extent that trade reinforces specialization and that in turn specialization gains raise factor productivity, there will be enhanced investment opportunities; particularly in those countries where technology-intensive Schumpeterian sector production has increased. Jungmittag (2006) has shown in an empirical analysis for the EU15 that output in those EU countries which have achieved more high-technology specialization is raised through trade. According to the theory of asset-seeking foreign direct investment (e.g. Makino et al., 2002; Ivarsson/Jonsson, 2003) such a specialization pattern will attract higher FDI inflows as foreign investors seek to acquire firms with technological advantages that are complementary to the respective foreign firm's core research and production activities.
- The combination of regional free trade and free capital flows implies that there are particular opportunities for regional production networks in the EU. As offshoring (i.e. imports of intermediate products as intra-MNC trade) and international/interregional (intra-EU) and regional outsourcing is reinforcing the international competitiveness of multinational firms, such firms, following the OLI approach of Dunning, should increase production abroad. In the case of EU countries this implies that FDI outflows to third countries (e.g. to the US) should increase.
- As trade-related specialization gains raise per capita income, demand for differentiated products will increase and those products in turn stand for technology-intensive and knowledge-intensive goods that are typically produced by multinational companies; and if the economic logic of production suggests that producers should have production in geographic proximity to markets (e.g. Raff/Ruhr, 2001) it is obvious that multinational production would expand in a way that enhances FDI. This points to a positive reciprocal link between trade and FDI.
- The single market enhances trade in intermediate products which will raise the productivity of internationalized firms in a way that will contribute to more exports as more productive firms can benefit through higher export shares (Melitz, 2003). Hence there is a reciprocal link between FDI and trade in this respect.
- Another reciprocal link between trade and FDI comes from the fact that FDI inflows go along with international technology transfer for the host country – and in the case of greenfield investment with a higher capital stock in the host country – so that output and gross national income, respectively, are raised; and therefore imports will be raised (and, following the logic of the trade gravity model, both imports and exports would increase). Hence trade will be raised as well so that there is a positive reciprocal link between FDI and trade.

Oligopolistic interdependence could also play a role (Knickerbocker, 1973). If there is an oligopoly, there will be an interdependence reaction of leading firms. For example, if multinational companies from the US invest in the EU in certain sectors – say in the pharmaceutical sector – EU firms could fight back and try to take over US pharmaceutical firms. If the relevant market is the EU, there could also be an intra-EU FDI intensification where, for example, German firms take over some firms in France, the UK and Italy which would induce counterattacks in the form of foreign FDI inflows from French, British and Italian investors willing to invest in Germany. The implication of such EU interdependency would be that the EU single market is a strong driver of foreign direct investment inflows in the US. Tariff jumping could also play a role in the context of BREXIT – however, EU import tariffs outside agriculture are only about 3% (Lawless and

Morgenroth, 2016). A more serious aspect would have to be considered in the case of sectoral EU-UK FTAs since this brings rules of origin into play: A typical requirement would be – judging by the international FTAs of many OECD countries – that there is a 60% local content requirement imposed on the UK. British firms with established European production networks thus would have to close down some of the production facilities in EU27 countries; or British subsidiaries on the continent and in Ireland would be sold. UK firms might, however, also consider whether additional FDI outflows to EU countries could be useful in order to avoid costly regulatory costs – for example, in the case of pharmaceuticals.

Membership in currency and policy unions and their effect on trade and FDI attractiveness historically find broad interest amongst researchers and policy makers with the literature comprising of thousands of studies. Therefore, we focus especially on FDI flows and stocks and the effect an EU membership can potentially have in order to anticipate the 'worth' of a membership concerning FDIs. While it is important to look at this area as new data becomes available and variables of interest change over time[1], we take the forthcoming BREXIT as a reason to accurately analyze this topic further. In this regard, we use various methods and data and compare our results amongst each other as well as with previous studies, in an attempt to discern a clear-cut picture in the so far partly contradicting pattern.

The first important study using a modern EU FDI gravity model comes from Straathof et al. (2008), who analyze the internal market effect, more specific EU membership, on trade and FDI. Deviating from previous FDI studies which suggest flow and stock depend on variables such as country size (GDP, population) and the distance between partners (see Straathof et al. 2008, pp. 51-52), they more specifically point at the gravity studies of Brenton et al. (1999) and Egger and Pfaffermayer (2004); whilst the former authors create a single model for each country instead of a combined study, Egger and Pfaffermayer split EU integration into three separate phase models. The aim of Straathof et al. (2008) therefore was to close this gap and show the EU's effect on FDI in a combined model. They follow those two previous studies in using OECD FDI stock data instead of flow data, as they see those as presenting a "better proxy for the sales activities of foreign affiliates as a measure of the capital stock", (Straathof et al. 2008, p. 53). They use bilateral data of 30 OECD countries from 1981 to 2005 for their country-year fixed effect model, covering the 1986, 1995 and 2004 EU enlargements, noting that they struggle with data availability and bad data quality, particularly relating to the 1980s.[2] Their findings show that bilateral FDI within EU countries are 28% higher than between non-EU countries, and that EU countries attract 14% more FDI from EU-outsiders than non-EU countries.

Next, we take a closer look at the study by Fournier et al. (2015), who examine the EU single market effect with a gravity fixed effect (on country level) Pseudo Poisson Maximum Likelihood (PPML) model on trade and inward FDI. Their contribution to previous studies is to include product market regulation, employment protection as well as trade intensity (i.e. the ratio of trade to GDP) to the analysis. They use OECD flow data. Their findings for the linear regression OLS method are a surplus of 57% if the target

[1] Some variables, such as distance, might lose importance with falling transport costs, others such as digitalization and innovation gain due to globalization.

[2] Therefore they ran two models, 1981-2005 and 1994-2004; they did not find significant differences.

country is an EU member and a surplus of 48% if the origin country is an EU member. Findings for the favored PPML methodology are a surplus of 48% if the target country is an EU member and a surplus of 58% if origin country is an EU member. If both countries are EU members, no significant effect is found.

The study by Bruno et al. (2016) is the most advanced and precise study so far and therefore a good reference point for our study. They use bilateral FDI flow data of all 35 OECD countries from 1985 to 2012, and test it with dyadic fixed and time fixed OLS and PPML methodology. They use classical gravity variables, GDP and GDP per capita of both, the target and origin countries, while for all pairs the country-pair-specific characteristics such as distance, common language, cultural past etc. are controlled for via dummies for each possible pair. If the target country is an EU member, the OLS methodology predicts a surplus of 33%, and the PPML estimator predicts a surplus of 38% in terms of FDI inflows. An EU FDI origin country will send 129% (PPML) more FDI than a non-EU origin country, which exaggerates previous studies by far.

A recently published working paper by Barrell et al. (2017) also examines EU membership, exchange rate volatility and common currencies. They use FDI outward stocks (divided by a GDP deflator) as the dependent variable for selected OECD countries in the years from 1995 to 2012. Their findings show that bilateral FDI stocks are at least 50 percent higher if both countries are members of the EU,[3] however this effect is mainly due to the EU single market. Furthermore, a decline in exchange rate volatility leads to increasing FDI. Common currencies seem to have little to no effect. Further general FDI gravity variables such as GDP, distance and trade openness are shown to be significant.

Folfas (2011) and Wojciechovski (2013) use Hausman-Taylor gravity estimators to determine FDI flows between EU countries. Their reason not to utilize PPML models is that time invariant variables such as distance represent critical variables in their research question. The exclusion of fixed effects leads to different results concerning the variable "EU membership", which has to be taken into account when comparing their findings with Fournier et al. (2015) and Bruno et al. (2016). Folfas (2011) focuses especially on the corporate tax rates of countries as a driver of FDI (low tax rates attract FDI, tax haven effect) and controls for offshore financial centers, naming Cyprus, Luxembourg and Malta in particular, via a dummy variable. He finds no significant effect of EU membership on FDI flows, however he does find a significant tax haven effect and significant variables representing cultural similarity. Wojciechovski, however, finds a significant effect if both countries are in the European Economic and Monetary Union.

One clear drawback of using OLS is that zero flow (or stock) observations mislead the results, especially if this is combined with too many missing values, as is the case especially in the earlier years. Even though bilateral OECD FDI flow data quality is superior to UNCTAD data, this has to be strongly considered. In general, UNCTAD data has the advantage of being globally available (2001-2012), but as it is collected by national statistical authorities, the data collection methods are not uniform – contrary to the OECD. With UNCTAD, bilateral inflow data can deviate by up to a multiple of the counterparts reported outflow. Missing values are very often also problematic, especially for Asian and Latin American countries. Researchers working with UNCTAD data prefer using stocks

[3] They use a two-step system Generalized Method of Moments (GMM) estimator for their gravity model.

instead of flows, as due to the large stock figure, annual deviations will not present a significant problem. Also it is easier to "fix" data holes by averaging previous and subsequent annual stocks. For our purpose, OECD flow data prove more consistent than stock and UNCTAD flow/stock data, however we also control for stock. Due to data structure and quality, PPML dyadic fixed panel estimation is the clear model of choice (for a review of eight of the most popular estimation methods for gravity models see Kareem et al., 2016). It shall be noted that the conclusion that Whyman and Petrescu (2017) draw in their literature review on BREXIT gravity FDI modeling by interpreting the results of different models as being either optimistic or pessimistic is somewhat misleading, as PPML is superior. It is therefore emphasized that the results of the model with the best fit is noted as "central".

Table 1: EU-membership and their effect on FDI; gravity studies

Study	Data	Model	OLS results	PPML results
Straathof et al. (2008)	OECD stock (1981-2005)	OLS dyadic fixed	+14% (from EU outsiders), +28% (from EU insiders)	
Fournier et al. (2015)	OECD flow (mid-1990s-2011)	OLS country fixed, ppml country fixed	+57% (if target is EU), +48% (if origin is EU)	+48% (if target is EU), +58% (if origin is EU)
Bruno et al. (2016)	OECD flow (1985-2012)	OLS dyadic fixed, ppml dyadic fixed, Heckmann Sample Selection	+33% (if target is EU)	+38% (if target is EU), +129% (if origin is EU)

As we evaluate the methodology used by Bruno et al. (2016) as being the most suitable for the available data (Santos Silva and Tenreyro, 2011; Head and Mayer, 2014; Kareem et al., 2016), we base our study on their work. However, we pick up open questions from previous literature and additionally control for corporate income tax and tax havens (Folfas, 2011), the (relative) size of foreign owned capital stock and real exchange rates (Barrell et al., 2017). Trade will be included in the model by constructing the classical openness-indicator of relative exports and imports to GDP. Additionally, we want to check whether the properties of an EU membership is the driving force of FDI flows, or if we can reduce the explanatory power to the characteristics of being member in the single market, as suggested by Barrell et al. (2017). This leads us to the formulation of the following hypotheses:

1. EU (EU single market) membership of target and origin country will increase FDI flows
2. Trade openness will increase FDI flows
3. Corporate tax level constrains FDI flows
4. A higher relative FDI stock will attract more FDI flows – *the FDI stock variable is considered relative to the total capital stock that may be assumed to implicitly reflect some path dependency as well as reinvestment of profitable subsidiaries abroad (as we*

want to explain FDI inflows endogeneity might be a potential problem; lagging this variable by one period could be considered).

5. A low real exchange rate (to USD) will attract more FDI flows – *depreciation of the home currency stimulates higher FDI inflows.*

3. Econometric Specification and Data

3.1 Theoretical Foundation of the gravity model

Newton's law of gravitation serves as an eponym for the gravity model of trade, where the countries GDPs serve as pull factors stimulating trade and the distance between them as a push factor constraining it.[4] Anderson and Van Wincoop (2003) provide the sound econometric basis for a broad range of models utilized in empirical research. Shepherd (2016) refers to the traditional models as "intuitive", contrary to the "structural" gravity models as they underlie microeconomic foundation by bringing the consumer side, production side and trade cost together. In its simplest form, exports from country i to country j depend on their economic size Y and trade cost t. However, more recently gravity models have also been used to predict FDI flows and stocks from origin to target country and find a broad empirical fit. In order to capture multilateral resistance terms[5] in structural models, the fixed effects panel data estimation method established itself as useful, see Anderson (2011) and Head and Mayer (2014). In panel-structured data, time varying country- and dyadic fixed effects control for national characteristics as well as characteristic relationships which would probably be largely unobservable otherwise. However, all time invariant variables such as the distance between the countries or trade agreements (if constant over panel) are captured by those fixed effects which makes it hard to interpret them. Country-specific variables can overcome this by constructing them bilaterally.[6]

For our estimation, we derive the model in log-linearized form under consideration of common econometric misspecifications in modern gravity modelling, especially panel data implications, as unveiled by Baldwin and Taglioni (2007). The dependent variable FDI flow from origin country o to target country (destination country) d in time period t is defined as follows:

$$(1)\quad \ln FDIflow_{odt} = \alpha_0 + \alpha_1 \ln X_{\alpha} + \alpha_2 \ln X_{dt} + \alpha_3 Z_{od} + \delta_{odt} + \tau_t + e_{odt} ,$$

with the following notation:

α_0 – regression constant,

[4] Utilization of the model in economic research is described by De Benedictis and Taglioni (2011).

[5] Outward and inward resistance: Exports from country i to country j depend on trade costs of all possible export markets (outward resistance); imports into country i from j depend on trade costs of all possible import markets.

[6] Controlling for EU membership in an era without entries or exits in a country fixed effects setting will not work (due to omitted variable bias); bilateral dummies are constructed: (1) member exports to member, (2) non-member exports to member, (3) member exports to non-member; the non-non case acts as a baseline for interpretation.

$X\alpha$ – characteristics of the origin country (GDP, GDP/capita, EU membership),

X_{dt} – characteristics of the target country (GDP, GDP/capita, EU membership, openness, R&D investment, ICT investment, corporate tax level, relative FDI stock),

Z_{odt} – characteristics of the relationship between country pairs (distance, cultural and historical differences, etc.),

δ_{od} – dyadic fixed effects, i.e. one dummy variable for each possible set of partner countries, controls for all unobservables and satisfies the multilateral resistance requirement),

τ_t – time fixed effects, i.e. one dummy variable for each year,

e_{odt} – error term.

As most components of Z_odt are not time-varying, they coincide with dyadic fixed effects. It is assumed that common culture and history does not change significantly over the relatively short period of about 30 years.

3.2 Data

3.2.1 Definition and Sources

Data for FDI flows (in current USD) is obtained from the OECD due to higher data quality compared to UNCTAD, as mentioned above. An additional benefit is the longer time series available (1985–2013), even though there is almost no data available for 2013. As missing values are a problem, 2013 was left out completely. One drawback, however, is that important relevant newcomers to FDI such as Russia or China are not included; OECD countries account for roughly 70% of global FDI flows (UNCTAD).

GDP and GDP per capita (in current USD) is obtained from the World Bank, as is data for openness (import + export/GDP). Corporate tax on a country level from 1985 – 2007 is obtained from Mintz, J. and Weichenrieder, A. (2010) and from KPMG (data available 2003 – 2017). Relative FDI stock is obtained by dividing FDI in-stock (the total FDI inward position of the target country in current USD; data source: OECD) by total inward capital stock (capital stock at constant 2011 national prices; converted into current USD via the price level of capital stock, price level of USD in 2011 = 1; data source: Feenstra et al., 2015). Therefore, we use FDI stock in current USD over total capital stock in current USD; the variable describes a relative index and we do not have to deflate numbers. Index is lagged by one year, to minimize the endogeneity problem annual FDI flow can have on FDI stock index. Real exchange rates are calculated as follows: Nominal exchange rates to USD multiplied by the US consumer price index, divided by the home consumer price index (data source: OECD). Taking logs is necessary as statistical outliers are by definition very large for a big fraction of the data. Finally, when controlling for the EU single market, we introduce a dummy variable representing whether the European Economic Area agreement is ratified, including EU28, Iceland and Norway. Switzerland is additionally included as bilateral treaties with the EU mirror a very similar relationship. We decided not

to include Turkey, as we find heavy institutional deviance (especially migration and legislation).

Table 2: List of Variables

Variables	Definition	Source
inflow	Inward FDI flows (origin to target), in current USD	OECD database
target_gdp	GDP of FDI target country, in current USD	World Bank
origin_gdp	GDP of FDI origin country, in current USD	World Bank
target_gdp_per_capita	GDP per capita of FDI target country, in current USD	World Bank
origin_gdp_per_capita	GDP per capita of FDI origin country, in current USD	World Bank
target_openness	Total imports plus total exports of FDI target country, divided by its GDP	World Bank
foreign_capstock_share_lagged	Total FDI inward stock in the target country (in current USD) by total inward capital stock (converted from constant 2011 national prices into current USD); lagged by one year	OECD database; Feenstra et al. (2015) for conversion methodology
target_corporate_taxrate	General corporate tax rates, including average/typical local taxes	Mintz, J. and A. Weichenrieder (2010); KPMG
target_rer	Nominal exchange rates (target country to USD) multiplied by US consumer price index, divided by home consumer price index	OECD database
target_ict_investment	Acquisition of equipment and computer software that is used in production for more than one year; indicator is measured as a percentage of total non-residential gross fixed capital formation	OECD database
target_r&d_to_gdp	Total expenditure (current and capital) on R&D as percentage of GDP	OECD database

3.2.2. Treating missing values:

For the period from 1985 to 2012 our dataset contains 34 OECD countries (without Latvia which joined the OECD only in 2016) and 29,262 possible bilateral FDI flows. Dropping 13,903 observations due to missing values (listwise deletion) leaves the dataset with 15,359 observations, of which 5,278 are negatives or zeroes, characterizing the problems with regard to OLS estimations (see Kareem et al., 2016). While Bruno et al. (2016) address this issue by assigning very small values to non-observed or zero flows, we do not want to follow this quite strong assumption, especially due to well-known weakness regarding the inaccuracy of FDI data. We will concentrate solely on the explanatory power of the PPML model, which fits the data quite well, and use OLS only as robustness check. Utilizing listwise deletion seems an adequate solution, as more than 15,000 observations are fully sufficient for gravity modelling. That way we additionally avoid extensive matrix calculations which commonly occur in two-way fixed effects estimations involving large datasets as described by Stammann (2017). The econometric solution they offer for handling large amounts of data is not applicable so far with PPML models. As a drawback, a possible selection bias must be noted; however we assess this bias to be smaller than the bias which would occur by assuming missing data equals zero flow.

3.2.2 Treating negative values:

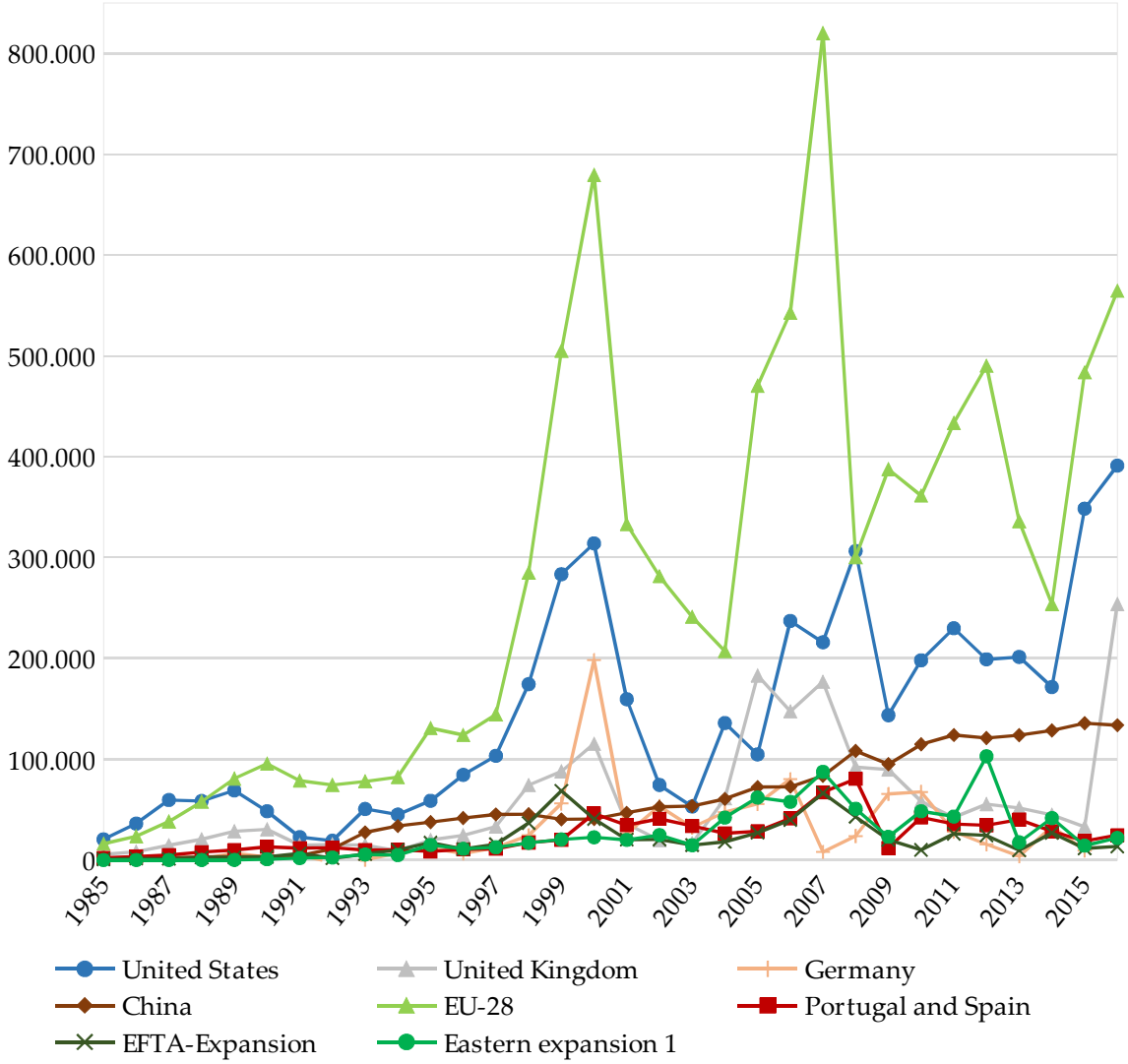
As neither PPML nor OLS estimators work with negative values, this leaves us with three options: Re-scaling flows,[7] dropping flows or setting flows equal to zero. While the first are not straightforward to interpret, dropping flows would result in a larger bias than when setting negatives to zero. In previous literature, this problem was not addressed in detail, however Fournier et al. (2015) and Bruno et al. (2016) seemed to have assigned zeroes (which then convert to one, in order to be able to also utilize OLS) to negatives instead of dropping them.[8] While this is indeed a strong assumption, as pointed out by Folfas (2011), we will follow their approach in order to be able to use PPML estimators, leaving us with 15,359 observations, of which 5,278 represent a flow of one USD. To distinguish between "real" and "negative" one-dollar-flow (zero flow), a dummy is inserted.

Figure 1 shows the total FDI inflow of selected countries and regions using UNCTAD data.[9] Before 1985, the total amount of FDI flows was relatively low, gaining importance in the 1990s and speeding up from 1997 especially within the EU and USA. Portugal and Spain joined the EU in 1986, Austria, Sweden and Finland in 1995 and Estonia, Latvia, Lithuania, Poland, the Czech Republic, Slovakia, Hungary, Slovenia, Malta and Cyprus in 2004. Whilst small increases for new member states can be observed in 1995 and 2004, the graph for the EU28 shows large amplitudes beginning in 1996 and 2004. The EU single market came into effect in 1993; aligning with rising FDI flows shortly after, this might indicate that the single market has indeed had a significant impact. The UK and Germany are among the leading FDI attractors, with Germany experiencing a peak in 2000 and the

[7] Setting the smallest equal to zero and adding up.
[8] Comparing their datasets and non-dropped observations lead to this conclusion.
[9] While good quality aggregated FDI data can be obtained quite easily, bilateral data has to be requested from the UNCTAD bilateral FDI statistics publication (2014) and is collected on a national level, contrary to the OECD where uniform bilateral data collection is implemented.

UK a peak between 2004 and 2008 (i.e. pre-financial crisis). FDI flows into China rise constantly from the 1990s and it can be said that China is the second biggest FDI attractor after the USA today.

Figure 1: Annual FDI Inflows in USD (mio.)

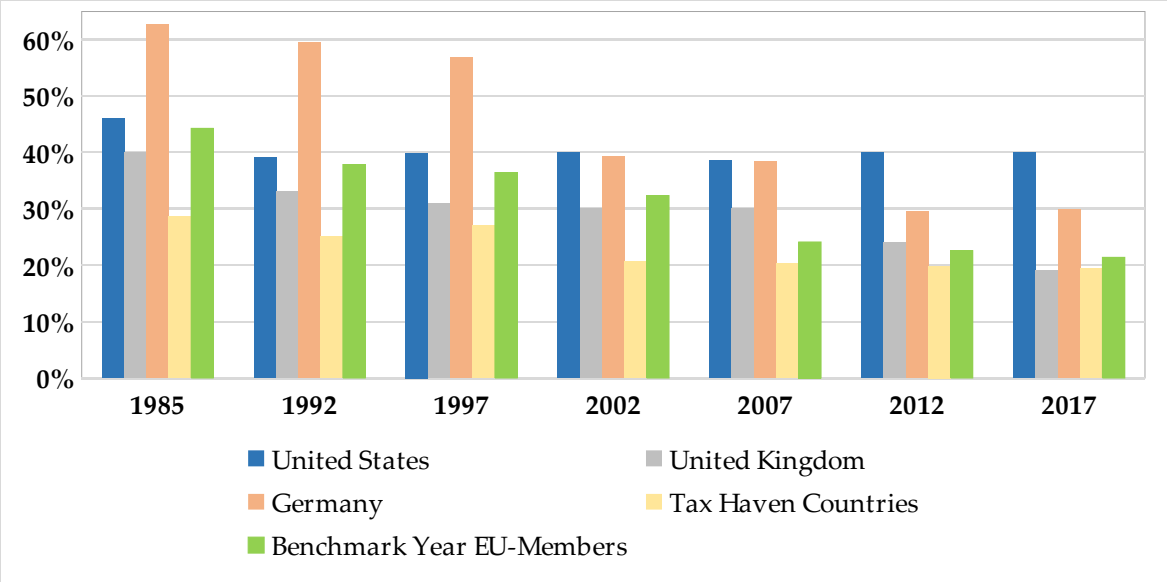


Source: UNCTAD.

The corporate tax levels of FDI target countries are expected to have an impact on FDI inflows, as described by Folfas (2011). Figure 2 shows the corporate tax level on commercial profit for selected countries. Within our dataset of 34 OECD countries, we label Iceland, Ireland, Luxembourg and Switzerland as "tax havens", attracting firms with relatively good business conditions; corporate taxes are part of firm-friendly conditions, but do not define tax havens per se.[10] As we see, Germany and the US, the latter overtaking the former, represent countries with relatively high corporate tax levels, while our 'tax havens' have relatively low levels. In recent years, the UK converges to the group of tax havens in terms of the corporate tax level.

[10] Countries with the lowest corporate tax levels include Ireland, Switzerland, Slovenia, Chile, the Czech Republic, Poland and Hungary.

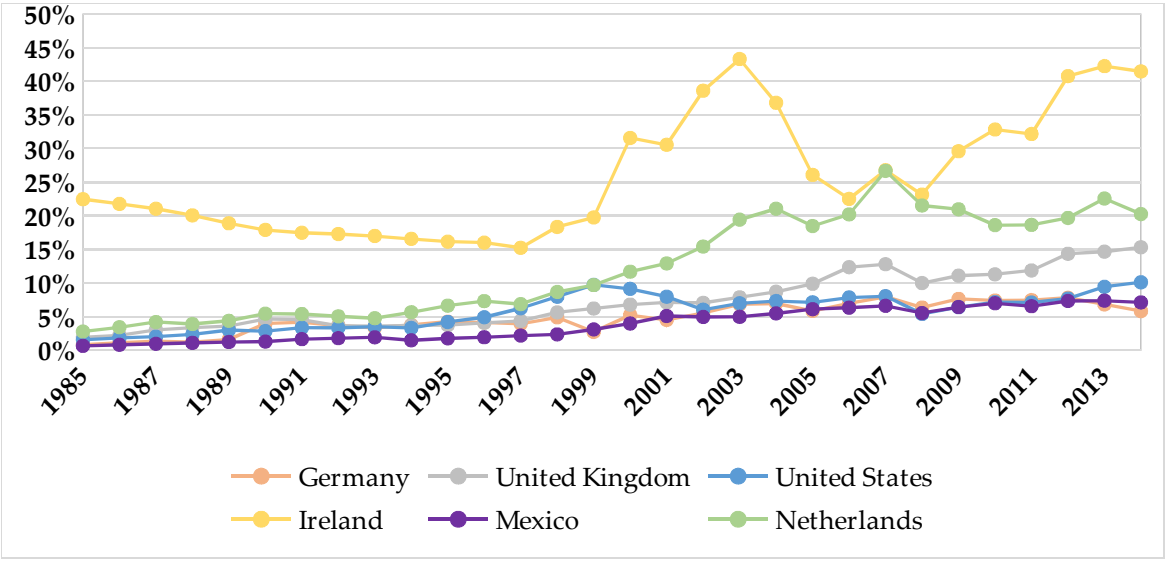
Figure 2: Corporate Tax Levels of Selected Countries



Source: Mintz, J. and Weichenrieder, A. (2010) (timeframe 1985-2008) and from KPMG (timeframe 2003 – 2017).

Another critical explanatory variable in our analysis is the relative FDI stock size of the various countries. For the regressions we use OECD data for reasons referred to above, even though UNCTAD stock data is to some degree more reliable. However, it is helpful to consider UNCTAD stock data for descriptive analysis, as consistent data is available up to 2014. Figure 3 shows the relative FDI stock development among selected countries. Ireland, as an example of a tax haven country, has relatively high values, similar to the Netherlands. The USA, Germany and Mexico are on similar levels below 10%, while 16% of the UK capital stock is comprised of foreign owned facilitates.

Figure 3: FDI Inward Stock as Percentage of National Capital Stock



Source: UNCTAD.

4. Empirical Findings

4.1 PPML dyadic fixed estimations

Findings from the preferred PPML estimator are presented in Table 4. Several models are developed, all including country pair-fixed effects ("dyadic fixed effects"), i.e. one dummy variable for each FDI origin to target direction. It should be noted that not only country-relationship (as, for example, the classical gravity variable "distance") but also direction matters.[11] We cluster the regression by country pairs in order to avoid problematic variance matrix calculations (singular or non-symmetric variance matrices occur with large numbers of fixed effects dummies and missing data). Furthermore, we treat panel data via time dummies for each year.

Initially, one can see that the methodology fits the data well, as about 66% of FDI flows are explained by the model.[12] Model (1) results are presented in the first column, showing the classical gravity variables of "size" via GDP and also GDP per capita, representing "wealth". Distance, including all time non-varying trading costs and time non-varying country- and country pair-specific characteristics, is captured via fixed effects. This also explains the relatively high R-squared values. EU membership is also included in model (1) as a time-variant dummy variable, as is the real exchange rate. In columns (2), (3) and (4) the corporate tax rate on firms' profits of the target country, trade openness indicating import/export activities and the share of the capital stock which is owned by foreign countries are added.

Overall, the four models show a clear-cut picture without changes in the signs of significant coefficients and quite even results across models, with the exception of trade openness of a country. It loses explanatory power as soon as we control for FDI inward stock, suggesting that trade is closely linked with FDI.[13]

11 For example, one dummy for Australia-Austria, but also one dummy for Austria-Australia.
12 For R-squared interpretation in PPML models we follow Shepherd (2016).
13 The variables target_openness and foreign_capstock_share_lagged show a correlation coefficient of 0.75, indicating that the capital stock variable swallows the explanatory power of trade openness; see table 3 in the appendix.

Table 3: Results for dyadic fixed panel-data estimation using PPML estimators for FDI inflow

	(1)	(2)	(3)	(4)
VARIABLES	**inflow**	**inflow**	**inflow**	**inflow**
target_eu	0.235	0.135	0.0378	0.124
	(0.152)	(0.151)	(0.157)	(0.161)
origin_eu	0.589***	0.504***	0.511***	0.480***
	(0.205)	(0.184)	(0.184)	(0.181)
ln_target_gdp	1.346	3.958**	3.859**	3.204*
	(1.519)	(1.966)	(1.907)	(1.700)
ln_origin_gdp	1.766*	1.269	1.302	1.178
	(1.073)	(1.083)	(1.068)	(1.017)
ln_target_gdp_per_capita	0.185	-2.233	-2.216	-1.972
	(1.642)	(1.880)	(1.829)	(1.684)
ln_origin_gdp_per_capita	-1.104	-0.529	-0.580	-0.431
	(1.132)	(1.156)	(1.135)	(1.097)
ln_target_rer	0.819	1.305*	1.177*	1.004
	(0.629)	(0.716)	(0.709)	(0.674)
target_corporate_taxrate		-4.077***	-3.775***	-3.804***
		(1.165)	(1.136)	(1.096)
target_openness			0.634**	0.161
			(0.290)	(0.324)
foreign_capstock_share_lagged				2.092***
				(0.795)
Observations	15,359	15,359	15,359	15,359
R-squared	0.639	0.648	0.655	0.657

Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

The effect of EU membership on FDI attractiveness and FDI outflows is mixed; while FDI attractiveness is not influenced by EU membership, countries send significantly more FDI abroad if they are a member of the EU. Specifically, FDI outflow is increased by 62% (origin_eu 0.480***, standard error 0.181). Origin country membership findings are in line with Fournier et al. (2014) and Bruno et al. (2016), while the effect of target country membership lost significance when negative flows are checked for via a dummy. We therefore suggest considering multiple econometric approaches for negative dependent variables in gravity model settings.

Before going deeper into an analysis of the explanatory variables, we check whether it is EU membership or rather participation in the EEA, i.e. access to the European single market, which has a significant impact on FDI flows. Table 5 shows the results as above, but the EU membership variables for both origin and target countries are dropped in exchange for variables indicating access to the European single market, yielding cumulative models (6), (7), (8) and (9).

We notice a shift in GDP and GDP per capita compared to the table above, which makes sense as EU countries' and other countries' access to the single market correlate unequally to those. All other variables remain similar, confirming the robustness of the results. In both model (3) and model (7) trade openness of the target country has a significant (and similar) impact on FDI flows. However this effect vanishes in model (4) and (8), indicating a correlation between trade and FDI stock. Both the corporate tax rate and the foreign owned share of the target country's capital stock (flow-independent) have strong significant impacts in all models, as do the variables indicating participation in the EU single market.

Table 4: Results for dyadic fixed panel-data PPML estimation for FDI inflow, single market access as explanatory variable

	(5)	(6)	(7)	(8)
VARIABLES	**inflow**	**inflow**	**inflow**	**inflow**
target_eu_singlemarket	0.545**	0.468**	0.408**	0.349*
	(0.215)	(0.196)	(0.204)	(0.190)
origin_eu_singlemarket	0.634***	0.618***	0.626***	0.602***
	(0.216)	(0.204)	(0.199)	(0.198)
ln_target_gdp	2.958	5.280**	5.078**	4.276**
	(1.854)	(2.201)	(2.165)	(1.954)
ln_origin_gdp	2.562**	2.096*	2.152**	2.000*
	(1.079)	(1.097)	(1.088)	(1.048)
ln_target_gdp_per_capita	-1.704	-3.841*	-3.703*	-3.203
	(1.996)	(2.194)	(2.157)	(1.986)
ln_origin_gdp_per_capita	-2.003*	-1.463	-1.539	-1.359
	(1.163)	(1.195)	(1.180)	(1.154)
ln_target_rer	0.558	1.022	0.920	0.834
	(0.562)	(0.642)	(0.639)	(0.612)
target_corporate_taxrate		-3.936***	-3.653***	-3.720***
		(1.080)	(1.076)	(1.040)
target_openness			0.576*	0.157
			(0.304)	(0.329)
foreign_capstock_share_lagged				1.945**
				(0.780)
Observations	15,359	15,359	15,359	15,359
R-squared	0.645	0.654	0.659	0.661

Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

4.2 Results

1. The EU membership of the origin country has a significant impact on FDI flows, namely +62% if the origin country is an EU member. No significant impact on FDI flow concerning the target country and EU membership is found. This contradicts previous studies, especially Bruno et al. (2016) as they also use OECD flow data. We

ascribe the different results to not controlling for negative flows, as we get similar results to Bruno et al. (2016) when we do not control for them. FDI origin country and EU membership findings mirror those in literature. When controlling for single market instead of pure membership, we find a highly significant impact of both origin and target country having access to it. Interpreting model (8) which includes the total set of variables of interest, a country attracts +42% FDI inflows and sends +83% FDI outflows if it has access to the EU single market. While this number seems very high, it mirrors previous findings (see table 1).

- Hypothesis 1 is therefore accepted, indicating that access to the single market results in considerably higher FDI in- and outflows.

2. Trade openness has a significant impact on FDI flows: a 1% increase in openness will lead to a 0.6% Increase in FDI flows (model 7); when controlling for the share of foreign ownership of a country's capital stock, the effect vanishes, as both variables correlate strongly (see table 3 in the appendix).
   - Hypothesis 2 is neither accepted nor rejected; while many studies prove the significant impact of the classical openness indicator, we show that it is important to focus attention on other variables, especially the share of already existing foreign capital within a country. Further research concerning trade and FDI is needed (keywords: production to market, supply chain analysis etc.), and will be discussed to some extent in the conclusion.
3. The corporate tax level has a negative impact on FDI flows; a 1% increase in the statutory corporate tax level will lead to an almost 4% decrease in FDI flows, and therefore results are in line with Folfas (2011). This will have different implications on greenfield and brownfield investments, mainly impacting decisions on where to construct new production plants. In addition, this should be considered in the context of tax havens.
   - Hypothesis 3 is accepted, high corporate tax levels in home countries constrain FDI inflows.
4. If the foreign-owned share of a country's capital stock (namely inward stock over capital stock, lagged by one year to control for annual inflow) increases by 1%, the FDI inflow will increase by 1.9%. On one hand, an annually rising FDI stock by aggregated inflow, depreciated and growth-considered, the stock-flow relationship is straightforward. On the other hand, we are interested in cluster and spillover effects which pre-existing investment has on further investment. By lagging stocks we neutralize the direct inflow effect, leaving only the cluster effect.

   These findings are assessed to have strong implications, especially when considering policy changes such as an exit from the EU. To mirror this effect more clearly, an intertemporal gravity model could be altered, which we suggest for future research in the field of FDI flows, but especially stocks.
   - Hypothesis 4 that the relative foreign share of the capital stock of a country attracts increasing FDI is accepted.
5. According to Barrell (2017), we would suspect that a low real exchange rate vis-à-vis USD will attract a higher FDI inward flow. However, the real exchange rate of home

country to USD does not significantly impact FDI inward flows. However, this variable may not be compiled in an optimal way, and further research will be done.

- Hypothesis 5 is rejected.

5. Policy Implications and Future Research

We evaluated recent FDI literature and selected those variables which had the biggest impact on FDI flows and stocks between countries. FDI gravity models and the two common data banks for bilateral FDI, UNCTAD and OECD, were analyzed. Bilateral FDI data is assessed to be a bit disappointing, as the latest data we could get was for 2012 and for OECD countries only (due to large discrepancies in UNCTAD data), therefore only the PPML estimator in a dyadic fixed panel setting for gravity models seems to be adequate for an FDI analysis.14 EU membership and participation in the European single market are the critical variables of interest in our study, also due to the forthcoming BREXIT as well as the broader anti-European sentiments which could be witnessed in other countries in 2016/2017. We control for the size of the relative foreign capital stock within the target country, the statutory corporate tax rate of the target country as well as real effective exchange rates between partners. Our findings are in line with previous studies, however we suggest to analyze access to EU single market instead of pure EU membership (also due to higher R-squared in respective models).

This indicates that in the case of BREXIT, it will be important for the UK to remain in the EEA and to have similar bilateral treaties with the EU as Norway, for example, which they could reach when achieving a "soft Brexit". Considering the "hard Brexit" case, the UK would lose almost half their FDI inflows from other European countries in the long run (20 years plus), especially from the Netherlands, Belgium and Luxemburg, but also Germany and France, amongst others. That a "hard Brexit" would have no impact on FDI inflows from EU outsiders shall be doubted, as discussed in detail below. UK FDI outflows, i.e. UK investments abroad, will also decrease in the long run. A solution to counteract decreasing FDI flows could be to decrease the statutory corporate tax rate, as a 1% decrease leads to 3-4% increase in flows. However the statutory corporate tax rate of the UK has already reached a very low level, competing with other OECD tax haven countries. We would be careful in giving the policy advice to further decrease the tax rate. The relatively large FDI stock in the UK will however absorb the BREXIT effect to a small degree, or at least slow down the process of reducing FDI inflows. Considering the exchange rate of the British Pound to USD, it can be suspected that a cheaper Pound stimulates FDI activities, especially brownfield investments. However we do not find a significant effect of real exchange rates against USD.

The following table shows hypothetical combinations of changes in the statutory corporate tax rate which would be necessary to neutralize the combined effects of a "hard Brexit" (no EU single market membership) and the various cases of an assumed increase in the foreign share of the target capital stock (for example, due to increasing M&A activities 2015-

[14] Barrell et al. (2017) were the first to take on a different modelling approach. Their findings are quite similar to ours, however they did not use fixed effects and as well FDI stocks rather than FDI flows.

2020). We have highlighted in red the required policy action in the sense of reducing the UK statutory corporate tax rate. As can be seen from the table, a given foreign share in the UK capital stock would require a reduction of a corporate tax rate by 11% to offset the BREXIT decision (interpreted here as losing access to the EU single market). If, for instance, the increase in the foreign share of the UK capital stock – driven by a real Pound devaluation – would be 5%, the corporate tax rate would have to decrease by 8 percentage points in order to neutralize BREXIT in the long run.

Table 5: Scenario-matrix for Corporate Tax and FDI Inward Stock Changes on FDI Inflows

Increase in foreign share of target capital stock, lagged (UK)	Decrease in Corporate Tax Rate										
	0%	**-1%**	**-2%**	**-3%**	**-4%**	**-5%**	**-6%**	**-7%**	**-8%**	**-9%**	**-10%**
0%	0.0%	3.7%	7.4%	11.1%	14.8%	18.5%	22.2%	25.9%	29.6%	33.3%	37.0%
1%	1.9%	5.6%	9.3%	13.0%	16.7%	20.4%	24.1%	27.8%	31.5%	35.2%	**38.9%**
2%	3.8%	7.5%	11.2%	14.9%	18.6%	22.3%	26.0%	29.7%	33.4%	37.1%	**40.8%**
3%	5.7%	9.4%	13.1%	16.8%	20.5%	24.2%	27.9%	31.6%	35.3%	**39.0%**	**42.7%**
4%	7.6%	11.3%	15.0%	18.7%	22.4%	26.1%	29.8%	33.5%	37.2%	**40.9%**	**44.6%**
5%	9.5%	13.2%	16.9%	20.6%	24.3%	28.0%	31.7%	35.4%	**39.1%**	**42.8%**	46.5%
6%	11.4%	15.1%	18.8%	22.5%	26.2%	29.9%	33.6%	37.3%	**41.0%**	**44.7%**	48.4%
7%	13.3%	17.0%	20.7%	24.4%	28.1%	31.8%	35.5%	**39.2%**	**42.9%**	46.6%	50.3%
8%	15.2%	18.9%	22.6%	26.3%	30.0%	33.7%	37.4%	**41.1%**	**44.8%**	48.5%	52.2%
9%	17.1%	20.8%	24.5%	28.2%	31.9%	35.6%	**39.3%**	**43.0%**	46.7%	50.4%	54.1%
10%	19.0%	22.7%	26.4%	30.1%	33.8%	**37.5%**	**41.2%**	**44.9%**	48.6%	52.3%	56.0%

Source: own calculations.

Taking into account that the total amount of FDI inflows of the countries considered has amounted to $0.735 trillion in 2012 and to $1.121 trillion in 2016 one gets a clear idea of just how important FDI inflows are. The reduction of the statutory corporate tax rate in the UK by 1 percentage point in 2017 and the US reduction of the statutory corporate tax rate by 15 percentage points should have a strong impact on the country breakdown of FDI flows in OECD countries; taking into account the particular role of China, one could also include China into future enhanced FDI gravity modeling – once sufficient data for this country are available.

As regards BREXIT, the implication is that the UK would not only face a negative income effect related to reduced trade dynamics but also lower FDI inflows will be relevant. As the UK government wants a hard BREXIT, it is clear that the full effect of the single market variable should be relevant – unless some "quasi EU membership" could be achieved in the form of a broad treaty on UK access to the EU single market. The approach presented here could also be applied to an FDI gravity equation with a specific sectoral analysis where financial services FDI are of particular interest in the case of the UK and BREXIT, respectively. ICT FDI dynamics should also be of special interest since information &

communication technology is a major driver of innovation and growth in most OECD countries; the ICT sector might also be more footloose in the context of the relevant technologies so that the relevant parameter estimates should differ from the broader analysis presented here. For policy makers interested in targeting ICT sector inflows, additional insights from modified gravity modeling indeed could be quite important.

In particular, the approach presented could be applied to financial sector FDI flows and BREXIT analysis. As is well known from statistics (see appendix) about 30% of the British inward FDI stock consists of FDI in the financial services sector; and future UK-EU27 relations will most likely not reflect a continuation of the banks' single passport which has allowed them to cover all banking services for clients in EU27 countries from the City of London as the UK's global financial center. The European Central Bank, as well as the national prudential supervisors of EU countries, will require that banks offering financial services in the EU27 will have to get a separate banking license and to provide additional (separate) equity capital in order to be able to serve the EU single market post-BREXIT. The implication is that many British banks, US banks in London, Japanese banking subsidiaries in London et cetera will move banking activities – assets and staff – to EU27 countries, mostly Ireland, Germany, France, Luxembourg and the Netherlands, so that one may anticipate a real Euro appreciation effect in the context of a structural adjustment in the British and Eurozone banking sectors. It is noteworthy that a study by Oliver Wyman (2017) has estimated the necessary additional capitalization needs of "London banks" going to do business in EU27 could amount to close to €50 billion in a post-BREXIT situation. The implication then is that the overall supply of financial services in the EU27 should not change much compared to 2018 (the last full year of EU28 activities), but that there will indeed be a one-off FDI inflow effect in the EU27 financial services sector.

From a theoretical perspective, one may argue that FDI outflow/inflow patterns should differ by sectors if one considers technology-intensity on the one hand and industrial versus financial sectors/firms on the other hand. As regards the future access of British industrial firms to the EU27 single market, one may also point out that sectoral free trade agreements will typically require a minimum of 50-60% in value-added in the UK for British exports to qualify for duty free/preferred access to the EU single market. This implies that British firms will have to give up part of their existing EU28 production networks in order to raise the British value-added share from the current often rather low share of 30-40 percent in order to achieve the higher future minimum value-added shares. This implies a one-off disinvestment in EU27 countries by British firms on the one hand, on the other hand it implies that the relative unit cost of many UK sectors which reduce their European supply chain production will increase. From the Barrell/Pain (1997) study it is known for German multinational firms that relative unit costs are a significant FDI outward variable – and Germany's outward FDI to the UK is about one quarter of all EU27 FDI in Great Britain. Thus the UK should face lower inward FDI flows from Germany (and other EU27 countries) in the future.

This, however, does not rule out that a massive real depreciation of the British Pound would trigger larger international M&As in the UK. This would clearly have a negative impact on the growth of real national income (Z). If one considers a case of asymmetric cumulated FDI inflows only, we can write $Z= Y(1-\alpha^*ß)$ – with α^* denoting the share of foreign ownership in the capital stock and ß representing the share of profits in GDP under

competition in goods and factor markets and a Cobb-Douglas production function $Y=K^{ß}(AL)^{1-ß}$. The implication is that as an approximation (assuming $\alpha*ß$ to be close to zero) we can write $\ln Z = \ln Y - \alpha*ß$ and therefore $d\ln Z/dt = d\ln Y/dt - ßd\alpha*/dt$. If BREXIT raises the share of foreign ownership in the UK capital stock by 10% and we take the standard assumption that $ß= 0.33$ the growth rate of real income will be reduced by 3.3% through BREXIT. If the Treasury analysis of -10% of GDP due to BREXIT were correct, the total effect would be -13.3%. This is still an underestimation since UK-EU27 is a case of interdependency: Trade links, FDI links and innovation links – with cumulated FDI capital accumulation contributing to Schumpeterian innovation dynamics – have to be considered simultaneously and only in such a broader perspective can lead to an understanding of output development over time.

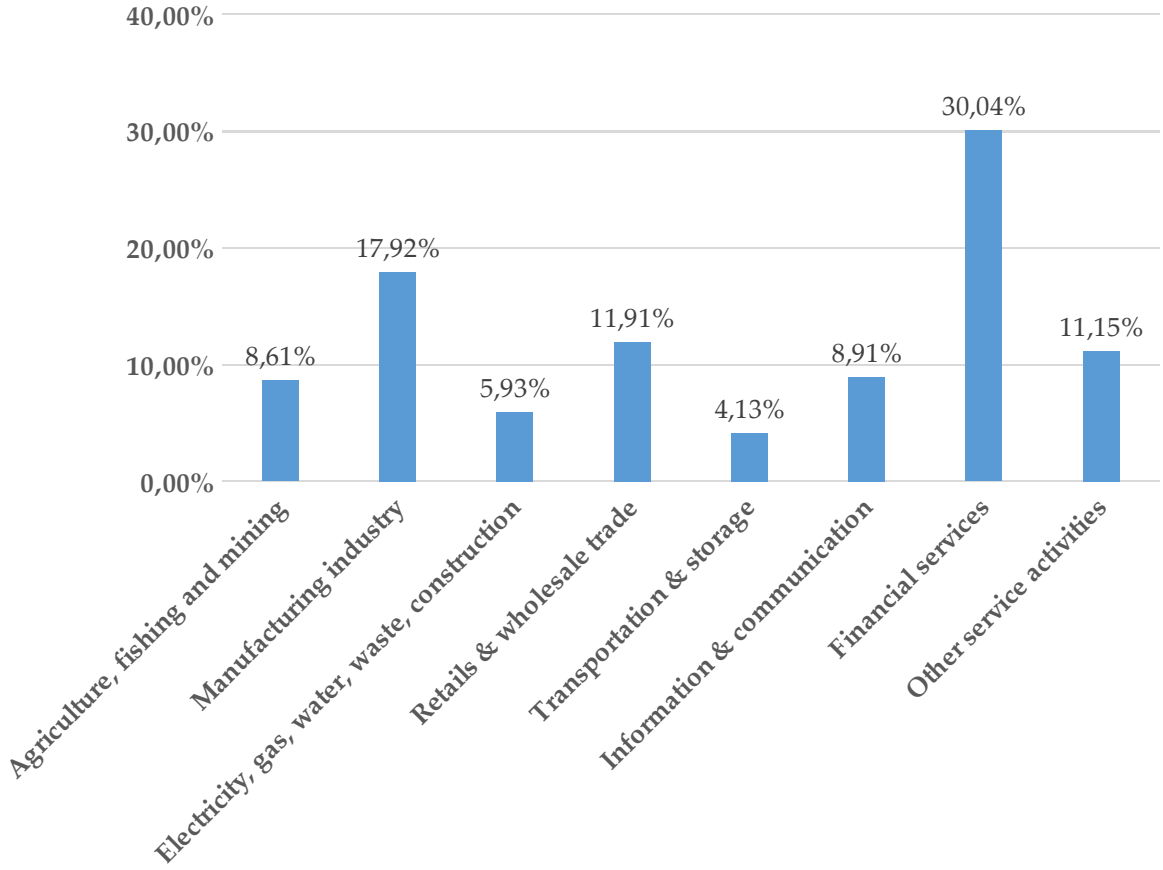
One potentially important aspect that could be considered in future research is the changing geographical composition of UK FDI inflows post-BREXIT and the impact on sectoral FDI inflows and outflows in banking and finance in particular; for example, a higher inflow of US FDI in manufacturing and non-financial services is likely to go along with more US FDI inflows in banking and finance where the US is a relatively strong source country in a global perspective. Manufacturing FDI inflows from advanced OECD countries are likely to bring a positive international technology transfer that could affect both economic growth and the long run current account position of host countries. To the extent that higher US FDI outflows would overcompensate lower EU27 FDI outflows to the post-BREXIT UK, the overall FDI position of the UK is not weakened. However, a similar FDI result for the UK could have been expected under an EU-US TTIP agreement which had been envisaged under the Obama Administration but which was no longer a priority under President Trump.

Appendix

Table 6: Correlation matrix for selected explanatory variables to FDI flow

var_list	ln_target_rer	target_corporate_ taxrate	target_ openness	foreign_capstock_ share_lagged
ln_target_rer	1			
target_corporate_ taxrate	-0.2153	1		
target_openness	-0.057	-0.4553	1	
foreign_capstock _share_lagged	-0.1741	-0.3248	0.7546	1

Figure 4: FDI inward stock UK, by industry, 2015



Source: Office for National Statistics, UK 2017

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