Challenges in estimating the economic impact of Brexit: A comparative analysis of the short and long run effects using gravity and CGEs.

Submitted Abstract

This paper provides a thorough assessment of the impact of Brexit. Most of the previous studies on Brexit have analysed its impact on trade. Others have included elements such as migration, uncertainty, exchange rate effects, budget savings and changes in the unemployment rate (for more details see the reviews of Busch and Matthes, 2016; Fernández-Pacheco et al., 2018; Latorre et al., 2019a; 2019b). However, only a few have analysed in detail the impact of Foreign Direct Investment (FDI) and have disentangled its effects from the ones caused by other forces. Modelling FDI is much more difficult than modelling some aspects of trade (tariffs and non-tariffs barriers). Investment is volatile and to a great extent, its performance is more difficult to be grasped than trade (Fernández-Pacheco et al., 2018). However, the potential emergence of restrictions on cross-border investment due to Brexit suggests that the total cost of leaving the EU is likely to be larger than what previous estimations based only on trade suggest. Therefore, this paper provides an impact assessment of Brexit considering not only barriers to trade but also the role of FDI in the UK.

Hence, in this paper we extend our previous work on Brexit (omitted for the sake of anonymity), with three main objectives: the first one is to provide a thorough analysis of Brexit, including many macroeconomic and microeconomic results in the short and long-run. To do that, we use both a static and a dynamic multi-region and multi-sector Computable General Equilibrium (CGE) model. These two models are the static Global Trade Analysis Project (GTAP) model (Corong et al., 2017) and the GTAP Recursive Dynamic (GTAP-RD) model (Aguiar et al., 2019a). Both models allow integrating several economic dimensions to provide a complete description of an economy, thus providing detailed macroeconomic and sectoral results. Our second objective is to offer a complementary estimation for the trade effects. Thus, we also use a gravity model to offer an econometric approach and compare the results from different methods. To this aim, we use the multiplicative Poisson pseudo-maximum likelihood (PPML) estimator, which is widely used in the international trade literature to estimate the gravity equation. Thus, the paper also presents the differences between the estimations using an ex-ante (CGE) approach and an ex-post analysis using the gravity model.

The third objective is to shed light on the role of FDI in the context of Brexit. Therefore, we proceed in a step-by-step manner to understand the contributions of trade and FDI in the overall impact of Brexit. We present a comparison between the results obtained in the static framework with the impacts derived in the dynamic setting. The latter reflects the simultaneous impact of trade and capital accumulation, while the former allows to disentangle the impact of trade from the one of capital accumulation. Thus, the static model helps us to decompose the dynamic results in order to understand them better. A comment by Dhingra et al. (2017, p. 679) may help to express some common difficulties involved in the analysis of the results of dynamic models: "The dynamic gains from trade are less well understood than the static gains captured by our model. More empirical work is needed to

establish the relative importance of the different channels studied in the theoretical literature and to allow for the development of a workhorse quantitative trade model that incorporates dynamic technology effects. However, the existing literature suggests that dynamic effects are quantitatively important and that static models substantially underestimate the gains from trade. This implies that by using a static trade model we underestimate the costs of Brexit". We believe the interpretation of the results and the decomposition we propose can shed light for policy analysis.

Our fourth objective is to offer an estimation of the impact of the new Trade and Cooperation Agreement (TCA) struck by the EU and the UK last December 2020, which was applied provisionally as of 1 January 2021 and entered into force on 1 May 2021.

Finally, we offer a broad set of macroeconomic results (GDP, skilled and unskilled wages, capital remuneration and accumulation, aggregate exports and imports) for both the UK and the rest of the EU (i.e., EU28 excluding the UK). At the sectoral level we cover the impact on production, exports and imports for 21 sectors in the UK under the static and dynamic setting. Our results isolate the sole impact of Brexit from the ones of Covid-19, which have so far overshadowed Brexit effects.

Paper Proposal (Under revision of Journal Economic Modelling)

Challenges in estimating the economic impact of Brexit: A comparative analysis of the short and long run effects using gravity and CGEs.

Abstract

We provide a thorough assessment of the impact of Brexit through trade combining both a static and a dynamic Computable General Equilibrium (CGE) model and a structural gravity model. Our analysis allows us to shed light not only on the role of trade, but also on the potential effects of Foreign Direct Investment (FDI), which has received less attention in the context of Brexit. We simulate a hard Brexit and the new Trade and Cooperation Agreement (TCA) negotiated by Boris Johnson. We analyse several reductions in the United Kingdom's capital stock, which are consistent with the empirical evidence on potential reductions in the FDI capital stock after Brexit. This allows us to disentangle the effects of the static (short-term) impact of trade from its dynamic (long-term) impact. We focus on the impact for the UK but offer macroeconomic results for the European Union (including its individual countries), the US, China and the Rest of the world. The gravity model estimates considerably larger contractions in UK's GDP, but a smaller role for FDI than the CGE. UK services sectors are affected more negatively than what previous analyses of Brexit focusing on trade suggest.

Keywords: Foreign Direct Investment, Multinationals, Non-tariff Barriers, United Kingdom, Recursive Dynamics.

JEL codes: C68, F15, F21, F61, F62

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1. Introduction

Most of the previous studies on Brexit have analysed its impact on trade. Others have included elements such as migration, uncertainty, exchange rate effects, budget savings and changes in the unemployment rate (for more details see the reviews of Busch and Matthes, 2016; Fernández-Pacheco et al., 2018; Latorre et al., 2019a; 2019b). However, only a few have analysed in detail the impact of Foreign Direct Investment (FDI) and have disentangled its effects from the ones caused by other forces. Modelling FDI is much more difficult than modelling some aspects of trade (tariffs and non-tariffs barriers). Investment is volatile and to a great extent, its performance is more difficult to be grasped than trade (Fernández-Pacheco et al., 2018). However, the potential emergence of restrictions on cross-border investment due to Brexit suggests that the total cost of leaving the EU is likely to be larger than what previous estimations based only on trade suggest. Therefore, this paper analyses the impact of Brexit considering not only barriers to trade but also the role of FDI. Our general equilibrium results suggest that the inclusion of FDI considerably worsens the negative effects of trade caused by Brexit.

In this paper we extend our previous work on Brexit (omitted for the sake of anonymity), with four main objectives: the first one is to provide a thorough analysis of Brexit, including many macroeconomic and microeconomic results in the short and long-run. To do that, we use both a static and a dynamic multi-region and multi-sector Computable General Equilibrium (CGE) model. These two models are the static Global Trade Analysis Project (GTAP) model (Corong et al., 2017) and the GTAP Recursive Dynamic (GTAP-RD) model (Aguiar et al., 2019a). Both models allow integrating several economic dimensions to provide a complete description of an economy, thus providing detailed macroeconomic and sectoral results. Hence, our trade-related effects combine numerous economic interdependencies, which contrasts with the "reduced form" approach that others have derived to proxy the dynamic effects of Brexit (e.g., Dhingra et al, 2017; Aichele et al., 2015).

These methodologies allow us to derive the results for the 21 sectors in which the UK economy has been split. We pay particular attention to the impact of Brexit on services sectors. The UK economy is particularly specialized in services. Should we, then, expect that because foreign trade is not that important for services sectors as for manufactures, Brexit will not harm the UK economy to an important extent? Our data for the UK show that business services account for 12.3% on UK's production and that finance and insurance account for 5.1% and 1.9%, respectively. These shares tend to be larger than in other economies and could potentially dampen the impact of Brexit. However, the results of the dynamic model allow us to identify, that services will probably lose with Brexit, despite their limited export orientation. We believe these results may be of interest for the policy makers and cannot be easily identified by looking at trade impacts alone in a static setting.

The second objective is to shed light on the role of FDI in the context of Brexit. Therefore, we proceed in a step-by-step manner to understand the contributions of trade and FDI in the overall impact of Brexit. We present a comparison between the results obtained in the static

framework with the impacts derived in the dynamic setting. The latter reflects the simultaneous impact of trade and capital accumulation, while the former allows to disentangle the impact of trade from the one of capital accumulation. Thus, the static model helps us to decompose the dynamic results in order to understand them better. A comment by Dhingra et al. (2017, p. 679) may help us in this regard: "The dynamic gains from trade are less well understood than the static gains captured by our model. More empirical work is needed to establish the relative importance of the different channels studied in the theoretical literature and to allow for the development of a workhorse quantitative trade model that incorporates dynamic technology effects. However, the existing literature suggests that dynamic effects are quantitatively important and that static models substantially underestimate the gains from trade. This implies that by using a static trade model we underestimate the costs of Brexit".

Our third objective is to offer an estimation of the impact of the new Trade and Cooperation Agreement (TCA) struck by the EU and the UK in December 2020, which was applied provisionally as of 1 January 2021 and entered into force on 1 May 2021. To the best of our knowledge, there are not many assessments of this new agreement, apart from the one of UK in a changing Europe (2019), Cubells and Latorre (2021) and Freeman et al. (2022).

Based on our CGE models, we offer a broad set of macroeconomic results (GDP, skilled and unskilled wages, capital remuneration and accumulation, aggregate exports and imports) for both the UK and the EU (i.e., EU28 excluding the UK). At the sectoral level we cover the impact on production, capital demand, exports and imports for 21 sectors in the UK under the static and dynamic setting. These estimates of the impact of FDI are absent in the previous literature analysing the impact of FDI (e.g., Pain and Young, 2014; OECD, 2016; UK Government, 2016; and Dhingra et al., 2017, Aichele et al., 2015, PWC, 2016). In addition, our structural gravity approach allows us to cover the impact individually for all the EU countries for GDP, aggregate imports and aggregate exports.

Fourth, we conduct a structural gravity analysis using the same trade data as our CGE models in order to analyse a meaningful comparison. We demonstrate that trade moves in parallel with the FDI stocks which, when diminished, reinforce the reduction in trade. By contrast, our gravity model estimates a considerably larger contraction in GDP for the UK than the one derived with our CGEs, in accordance with the studies comparing both methodologies and with the long run interpretation of the gravity results.

The paper is organized as follows. Section 2 describes the new agreement negotiated by Boris Johnson and its potential implications for the UK. Section 3 presents a review of the empirical literature related to the potential evolution of FDI inflows in the UK after Brexit and how other CGE models have implemented FDI. We also explain the differences between our CGE approach and the previous ones. Section 4 describes our CGE approach including the data, simulations and its micro and macroeconomic results. Section 5 turns into the gravity approach, presenting the methodology, data and results obtained using it. A final section offers provides the main conclusions.

2. The New Brexit Agreement

In December 2020, the EU and the UK agreed on a Trade and Cooperation Agreement (TCA) which implies zero tariffs or quotas on trade between the UK and the EU. However, to benefit from the absence of tariffs and quotas firms now need to comply with rules of origin, which did not happen before. This implies new paperwork for the steps that used to be routine, and it is causing border delays, uncertainty and difficulties (New York Times, 2021). Interestingly, the agreement also contemplates that the EU may introduce tariffs, if changes in environment, labour, taxation or state laws put at risk the level playing field.

What is more, according to Financial Times (2021) "The TCA struck by the EU and the UK was short on detail in many areas, but it was particularly threadbare in services". The newspaper also points that "the main text of the EU-UK agreement appears to commit the trading partners to mutual guarantees on services. But the annexes contain multiple detailed reservations, which were raised by individual member states and are dotted through the document". The 'Trade Specialised Committee on Technical Barriers to Trade' has been created to consider areas of cooperation in the mutual interest of both parties. Indeed, in some of them, such as financial services or sanitary and phytosanitary measures, the final relationship still has to be defined. "The new UK-EU trade deal only covers goods and not Britain's biggest exports services. The two sides have just begun negotiating on what kind of access Britain's banking and financial sector might get to the bloc" (Wall Street Journal, 2021a).

This agreement was presented to voters as a triumph because it got rid of the Northern Irish backstop negotiated by Theresa May. In fact, Northern Ireland has in effect remained in the single market and customs union to avoid a hard border on the island of Ireland. However, The New York Times (2021) emphasizes that "some British companies have suspended sales to continental Europe and even to Northern Ireland, which is part of the UK although it now has a special customs status because of its land border with Ireland, a European Union member state". The Nordern Ireland protocol is giving so many problems that "politicians are arguing over whether to rewrite the deal with the EU or tear it up entirely" (The Economist, 2022, p. 19).

It is true that the agreement avoids a worse non-deal scenario. "Although the UK has avoided a more severe operational disruption threatened by a no-deal departure, the procedures spelled out in the trade agreement may, in many cases, increase the amount of red tape involved in cross-border probes compared with when Britain was part of the EU" (Wall Street Journal, 2021b). It seems that this Trade and Cooperation Agreement would be between the soft (i.e., a Norway-EU type of agreement) and hard Brexit (i.e., no deal).
For all these reasons, the new post-Brexit relationship can certainly limit the trade and FDI operations in the other EU member states of foreign multinationals located in the UK. Therefore, the loss of the UK' appeal for the entry of FDI does not affect only the flows coming from the EU investors but also from the rest of partners that are interested in accessing to the European single market.

3. A review of the literature on FDI

There are several studies which have assessed the impact of regional integration in the flows or stocks of FDI. Overall, they find that regional integration affects FDI entry positively. Levy, Stein and Daude (2003) find evidence that a regional integration agreement (such as the EU membership) would increase the stock of FDI by around 27%. Fournier (2015) estimates that a reduction of 20% in regulatory differences increases FDI inflows by 15% and suggests that belonging to the EU single market can have an additional positive impact on FDI flows beyond the effects of traditional Free Trade Agreements (FTAs). This makes sense given the fact that the EU is the economic area which is most integrated (i.e., with the lowest regulatory barriers across different countries) in the world.

In addition, there are other studies that focus on the impact of the EU membership on FDI flows. Clausing and Dorobantu (2005) examine the impact of EU membership on the Central and Eastern European economies. They find that key announcements around EU accession resulted in increased FDI inflows going to the applicant countries. Bajo-Rubio and Torres (2001) found that FDI going to Spain expanded due to its EU accession and played an important role in promoting productivity growth. Bajo-Rubio and Sosvilla-Rivero (1994) and Barrell and Pain (1998) found that the inward FDI in Spain and Portugal increased significantly after their accession into the EU in 1986. Similar results were found for the UK, Ireland, Spain and Sweden too (Barrell and Pain, 1998). Baldwin et al. (1996) also confirm the increase in FDI inflows for the accession of Austria, Finland and Sweden. It seems, that FDI inflows rise when a country forms part of the EU. Brouwer et al. (2008) estimate the impact of a potential enlargement of the European Monetary Union (EMU) to the ten countries that obtained EU membership in 2004. They estimate that the FDI inflow would rise around 21%.

On the other hand, UK Government (2016), Clausing and Dorobantu (2005) and Bruno et al. (2016) have estimated the potential impact on FDI of leaving the EU. UK Government (2016) estimates comprise different ranges of FDI reductions. According to its three alternative scenarios, the UK would face a fall in FDI flows by 10% under the European Economic Area (EEA) membership, between -15% and -20% under an FTA with the EU or a reduction between 18% and 26% in the "no deal" case. These results have been latter used as inputs into modelling the overall macroeconomic impact of leaving the EU. Clausing and Dorobantu (2005) calculate that the FDI stock would decrease by 34%. On the other hand, Bruno et al. (2016) predict a 22% decrease in FDI inflows in the UK after leaving the EU.

All in all, the empirical studies analysing economic integration and FDI find a positive relationship. This is common in economic integration processes, in general, but seems to be even more pronounced in the case of EU integration and is also confirmed by the studies focusing on Brexit. Most of the studies cited above focus on estimating the size of the reduction in FDI stock or flows but do not evaluate its resulting impact. This is precisely what we do in this paper.

Among the few papers which estimate the impact of a reduction on FDI in the UK after Brexit, we can find the analysis of Dhingra et al. (2017), OECD (2016), UK Government (2016), Latorre et al. (2020a, 2020b), Ciuriak et al. (2015) and Pain and Young (2004).

Dhingra et al. (2017) and OECD (2016) evaluate the impact of FDI flow reductions in the UK. The former uses the average of the estimations of the impact of EU membership on FDI in the UK calculated by several authors (Bruno et al., 2016; Campos and Coricelli, 2015; Straathof et al., 2008), while OECD (2016) use the estimations of Fournier (2015).

Dhingra et al. (2017) estimate that an average reduction of 26% fall in the inflow of FDI would lead to lower real income in the UK by 3.4%. In this paper we aim at broadening the number of variables for which we offer the impact of FDI, compared to the analysis of Dhingra et al. (2017). The OECD (2016) runs a decline on FDI stock between 10 and 45%. Unlike, Dhingra et al. (2017), the OECD and UK Government (2016) approaches do not show the effects of FDI reductions in the real incomes separately from the rest of channels considered in the study (e.g., migration, tariffs and non-tariff barriers on trade, uncertainty, among others). The latter is precisely one of the objectives of this paper, by which we want to disentangle the effects of FDI from those of trade in the dynamic impact of Brexit.

To the best of our knowledge only Latorre et al. (2020a, 2020b), Ciuriak et al. (2015), Pain and Young (2004) include FDI and the operations of multinationals. Latorre et al. (2019a, 2019b) and Ciuriak et al. (2015) derive the impact of Brexit as an increase of the barriers that multinationals would face to operate in the Brexit partners. Latorre et al. (2020a, 2020b) find that one third of the overall negative impact of Brexit is because multinationals would face costs increases (i.e., 0.8 of the overall 2.6% GDP falls in the UK under hard Brexit scenario). However, Latorre et al. (2020a, 2020b) only cover the impact of Brexit on service multinationals (and not on multinationals operating in manufactures and agriculture), while this paper covers FDI throughout all sectors of the economy. On the other hand, Ciuriak et al. (2015) estimate that the impact of FDI reductions on the GDP in the UK is close to zero (-0.002%). This result is surprising since multinationals play a very important role in the UK. Finally, Pain and Young (2004) estimate a very significant effect from FDI in the UK´s GDP (2.25% reduction). However, the mechanisms of FDI are different from the ones in the two previous studies because lower FDI inflows result in a reduction of productive efficiency. Note that, Pain and Young (2004) and Dhingra et al. (2017), OECD (2016) and UK Government (2016) do not provide estimates of the impact of FDI fall on sectoral production and trade across sectors, as we do in this paper.

There have been other attempts, not necessarily in the context of Brexit, of modelling multinationals and FDI flows in CGE models. However, due to the complex specifications of the CGE dynamic models, a lot of challenges arise to estimate the impact of FDI, or even of the changes in the capital stock in isolation. In a dynamic model using GEMPACK software it is not possible to separate the impact of capital accumulation alone from the one of trade barriers. As we have just noted, Ciuriak et al. (2015, 2016, 2017) do not derive any significant impact from FDI (or multinationals) using GEMPACK software when they evaluate the impact of the TPP and Brexit, although they extend the model specifically to

account for the presence of foreign affiliates. On the other hand, another study by USITC (2019) combines econometric estimations and a CGE model formulated in GEMPACK that includes foreign affiliate sales to derive more sizeable impacts from multinationals. Adjustments in the Investor State Dispute Settlements of the USMCA could result in a 4.8% reduction in FDI stocks within affected industries in Mexico.

Using GAMS software, some authors (e.g., Hosoe, 2014; Latorre and Hosoe, 2016) have derived the direct impact of FDI in isolation in different contexts. However, they evaluate the overall impact from FDI, and the effects for the operations of foreign multinationals and national firms, with a very comprehensive modelling strategy, but they do not combine those FDI and multinationals effects with other trade effects derived from NTBs. These previous studies suggest that dynamic modelling is difficult. Our analysis allows to get a proxy of the impact of capital accumulation itself, which has received very little attention in CGE models.

On the other hand, few studies have looked at the dynamic effects of Brexit (Dhingra et al., 2017; Aichele et al., 2015 and PwC, 2016). To incorporate the dynamic impact of Brexit in the UK, both Dhingra et al. (2017) and Aichele et al. (2015) used a reduced form approach that "uses existing empirical estimates of the effects of EU membership to infer the impact of leaving the EU on UK income per capita" (Dhingra et al., 2017 p. 679). Dhingra et al. (2017) derive reductions in GDP per capita in the UK in a range of 6.3%–9.4%. Aichele et al. (2015) report that GDP per capita could fall between 6% and 26% in the UK. However, "we must warn readers here not to take the results too seriously because they always apply the average effect of openness (determined for many countries) to the specific case of a Brexit" (Aichele et al., 2015, p. 50). The reduced form approach has received some criticisms. Gancía suggests that "this approach suffers from well-known identification issues. For example, since EU countries are not randomly selected, it is difficult to predict what their volume of trade would be, had they not joined the EU. Second, the elasticity of income to trade is estimated using a clever strategy exploiting the fact that air travel changed the cost of the distance between country pairs. However, this raises the question of whether this elasticity is applicable to other countries, to different time periods and whether it applies to trade policy barriers as well" (Dhingra et al., 2017 p. 691).

Regarding PwC (2016), for a hard Brexit they predict a contraction in GDP per capita in the UK of 2.7% in 2030. Because population growth cannot expected to be very high in the UK in the coming decade, these results are close to the ones we obtain with a 2.43% contraction of GDP in 2030 after a hard Brexit.

As noted above, to the best of our knowledge, the latter dynamic models do not deliver or, at least, the authors have not reported the impact at the sector level that Brexit would imply. In addition, the results at the macroeconomic level are confined to a few variables. In this paper we provide a detailed sectoral analysis of production, exports and imports after Brexit and a broader set of macroeconomic results.

4. The Computable General Equilibrium (CGE) approach

Our simulations are conducted by means of two well-known CGE models, namely, the static (Corong et al., 2017) and dynamic (Aguiar et al., 2019a) versions of the GTAP model, extended to include Non-Tariff Barriers. Online Appendix 1 provides their technical description, while online Appendix 2 shows the computational codes.

4.1 The static CGE model

We use version 7 of the GTAP model (Corong et al., 2017), which is a publicly available and widely used comparative-static general equilibrium model of the global economy. As a CGE model, the static GTAP model rests on the circular flow of the income and spending in the economy. Therefore, incomes from production are returned to a regional household, who allocates regional income to three sources of aggregate final demand: private expenditure, government spending and saving-investment spending. The behavioural adjustments to shocks introduced in the model are derived from the efficiency-maximizing behaviour of firms and the utility-maximizing behaviour of consumers. These microeconomic optimization decisions are then comprised in a framework representing national accounts identities, which also define the equilibrium in the economy. Regarding firm's behaviour, the production structure in GTAP model is based on a sequence of nested Constant Elasticity of Substitution (CES) functions, which allow to re-produce the substitution possibilities across the full set of inputs.

In the static GTAP model, unchanged aggregate endowments of population, labour, and capital are assumed so that the economy's factors of production are in fixed supply, unless they are modified as a model experiment. Mathematically, ensuring that a model is "closed" amounts to ensuring that we have enough independent equations to explain the endogenous variables. Thus, we must make a choice as to what is to be determined within the model (the endogenous variables) and what is to be considered external to the model (the exogenous variables). This is done through the closure rules. For the labour market, we have included the most common closure, which is that the wage rates for skilled and unskilled labour are assumed to vary to ensure full employment of both types of labour (neoclassical closure). On the other hand, changes in the capital market closure are usually used to represent different adjustment time frames. When capital is sector-specific the stock of capital in each industry is exogenous, and the price of capital in each sector is endogenous. This closure choice does not attempt to explain the allocation of capital. By contrast, when capital is fully mobile, capital moves across sectors and its price is equalized. The specific factors case is thought of as "short run" adjustment and the fully mobile as "long run". Capital is assumed to be fully mobile in this paper.

For macroeconomic closures, there is a savings-driven closure at the national level, in which the savings rate (the percentage of income that is saved) is assumed to be exogenous, constant and based on the empirical value in the GTAP dataset. This implies that a nation's savings rate remains the same as the rate observed in the base year. If the nation's income falls, as happens with Brexit, the fixed savings' rate in the UK and the EU translate into a smaller

value saved in these regions. Savings of each regional household are aggregated across all regions and given to a global investor known as the "global bank", which distributes global savings across regions according to their rates of return, till capital returns converge across regions. To be more precise, investment is allocated across regions such that percentage changes in regional expected rates of return are equalized across regions. This latter mechanism is known as the rental rates of return closure. Note that although, many CGE modelers consider fixed trade balance a suitable closure in the short run, Bekkers and Orlov (2020) recommend that for large trade policy experiments, the rate of return closure would be more appropriate. Because large trade policy experiments would involve investment and savings decisions, which consequently result in macroeconomic decisions, therefore, fixed trade balance closure would imply a significant loss of the action. In addition, in a framework in which we aim at studying capital accumulation processes, this closure rule seems more appropriate.

4.2 The recursive dynamic CGE model

We also apply the Recursive Dynamic GTAP model (GTAP-RD) in our analysis. The core code in GTAP-RD is derived from the static GTAP model version 7 explained in Corong et al., (2017), that we have briefly described above. Compared to the static version of GTAP, the GTAP-RD (Aguiar et al., 2019a) updates the exogenous endowments of population and labour force, technology, preferences and policies between periods. In this type of model, growth in the capital stock is derived from endogenous capital accumulation, i.e., there is a stock-flow relation between investment and capital stock, with a 1-year gestation lag. Therefore, this model reflects a sequence of time-based comparative static equilibria, which allows to estimate the long run impacts of Brexit. In our analysis, Brexit will unfold from 2020 till 2030.

Arguably, the reductions in the capital stock could be considered the dynamic effects of trade and not necessarily the impact of FDI reductions. We understand that the frontiers between trade dynamic effects and FDI inflows may be blurred. In any case, what we try to understand is which part of the dynamic adjustment corresponds to trade barriers and which part is due to reductions in the capital stock, even if the latter are also related to the dynamic impacts of trade. To disentangle both effects, we use the static model which introduces them in a step-by-step manner, as will be explained below.

As in the static model in GTAP-RD we assume that the allocation of global savings to investment across different regions is driven by the expected rates of return. Therefore, a global investor is sensitive to changes in relative rates of return. This would imply net flows of capital to countries with an above-average rate of return. Hence, the use of rate of return closure, in both the static and dynamic framework seems to be suitable to analyse and capture the impact of large trade policy experiments, such as Brexit.

To estimate the potential impact of Brexit in the long-term, each scenario is modelled against a baseline scenario in which Brexit is not in force. The difference between the two scenarios quantifies the impact of Brexit in the UK (Aguiar et al., 2019a). The baseline projection is

developed simulating the model forward from the 2014 base year of the dataset (GTAP10) to 2030, using the tools of a dynamic database. In our model, the baseline includes updates in GDP, GDP per capita, population and labour force (skilled and unskilled). Different values for these variables and parameters are assumed depending on the year and region.

4.3 Data and CGE simulations

The database for micro and macroeconomic variables and the model's input-output framework come from the latest version of the GTAP10 dataset (Aguiar et al., 2019b), released in August 2019. We disaggregate the world economy in 21 sectors, 5 economies (UK, EU, USA, China, and ROW), and 4 factors of production (skilled and unskilled labour, land, and capital). We use this new database to simulate our scenarios with the static and dynamic model. As mentioned before, with the dynamic model, scenarios are modelled against a baseline scenario or Business as Usual (BaU) simulation in which the UK remains in the European Union. The baseline is developed by simulating the model forward from the 2014 base year of the dataset to 2020. In this latter year we simulate the shock of Brexit and then run the dynamic model results till 2030.

Table 1 provides the industry share in total production, exports and imports (columns 1, 2 and 3), as well as the import and export share on total production by sector (columns 4 and 5). As we can see, data in Table 1 reflect a worldwide trend, in which trade in manufacturing goods prevail on total trade. In the UK, the weight of manufacturing goods in total exports and total imports is beyond 60%, while services account for 36.9% and 23.9%, respectively. The sectors that devote an important share of their production to exports or rely heavily on imports (e.g., motor vehicles, chemicals, other primary, textiles, and metals), would be expected to experience an important transmission of trade shocks into production shocks.

The share of exports and imports in total production in services is considerably smaller than in manufactures (columns 4 and 5), except for air transport. This suggests that the bulk of production in services is sold in the domestic market and that we would expect services to be less vulnerable to trade shocks. However, as we shall see services will be harmed by the Brexit shock. The UK economy is a services economy. Overall manufactures account for 29.3% of its production, while services account for 69.9%.

On the other hand, Table 2 shows the bilateral trade flows of the UK with the EU, the US, China and the ROW. The most important destinations of UK's exports are the EU and ROW, which account for 44.6% and 36.8%, respectively. Regarding UK's imports, 48.1% come from the EU and 31.1% from ROW. Foreign trade is expected to be more intensively affected by Brexit in the sectors that have an important share of the bilateral trade with the EU, particularly in exports. This is true for most British sectors.

Sector	Industry share in:			Import share in total production	Export share in total production
	Total production	Total exports	Total imports		
Agriculture	0.8	0.8	2.1	39.9	10.4
Other primary	0.8	2.2	5.3	104.4	29.2
Food	3.0	4.1	6.3	33.2	14.4
Textiles	0.5	1.5	6.3	192.3	31.5
Wood and Paper	1.3	1.4	2.5	32.0	11.7
Chemicals	4.5	14.6	13.4	46.7	34.1
Metals	2.8	11.2	7.0	39.0	41.9
Motor vehicles	1.9	9.7	9.5	78.3	53.7
Other transport	0.9	4.2	2.1	39.0	51.0
Electronics	1.0	4.1	7.8	119.4	42.3
Other machinery	2.1	6.6	8.8	64.5	32.5
Other manufactures	1.6	2.4	4.5	44.5	15.6
Construction	8.9	0.4	0.3	0.6	0.4
Water transport	0.8	0.7	0.6	11.1	8.5
Air transport	0.8	2.3	2.4	46.3	30.5
Communications	6.3	3.4	2.1	5.3	5.6
Finance	5.1	8.1	2.9	9.1	16.9
Insurance	1.9	2.2	0.4	3.2	12.2
Business services	12.3	12.9	6.6	8.4	11.0
Personal services	3.1	1.7	1.6	7.9	5.9
Other services	39.5	5.7	7.3	2.9	1.5
Agriculture	**0.8**	**0.8**	**2.1**	**39.9**	**10.4**
Manufatures	**29.3**	**62.3**	**74.1**	**39.6**	**22.4**
Services	**69.9**	**36.9**	**23.9**	**5.4**	**5.6**
Total	**100.0**	**100.0**	**100.0**		

Source: based on GTAP 10 baseline.

Table 1. Initial data: Industry share in total production, exports and imports (percentage shares reference year, 2020).

Finally, Table 3 provides the exact values of the barriers that we run in our model. Column 1 shows the NTBs for every sector in the UK and in the EU with the Johnson's Brexit, while columns 2, 3 and 4 reflect the values of the Most Favoured Nation (MFN) tariffs and NTBs that the UK and the EU would face under a hard Brexit. The Johnson's Brexit scenario reflects the main characteristics of the TCA struck by the EU and the UK. The TCA implies a 100% tariff liberalisation. This means there will be no tariffs or quotas on trade goods between both nations. However, the arrangements should take account of the fact that the parties will form separate markets and distinct legal orders. This implies customs checks, new product standards and regulations, and other costs of cross-border trade. For example, in terms of Sanitary and Phytosanitary Measures (SPS), parties should treat one another as single entities, so, it implies extra regulatory checks on borders.

The larger size of the NTBs compared to the tariffs suggest that they would guide the bulk of Brexit's impact on trade. NTBs are especially high in agriculture, other primary, food, and motor vehicles, and to a lesser extent, in textiles, chemicals, metals, and other transport. The sectors that would experience the emergence of the largest barriers would also be the candidates to have their trade most affected by Brexit.

In principle, three important characteristics that make sectors more vulnerable to Brexit are the following ones: 1) How much of the production in each sector is related to trade (last two columns in Table 1), in particular how much of the production is devoted to exports; 2) How important is the EU as a trade partner, specially, as a destination for each sector's exports (first column in Table 2); and 3) How large are trade barriers expected to be for each particular sector (Table 3). Increases (decreases) in exports are expected to be followed by a rise (contractions) in production. If these three characteristics jointly unleash forces that push to a reduction in production after Brexit, the sector will likely decrease its production. If not all of them are pushing production downwards, then they may compensate one another, leaving production nearly unchanged or experiencing a small increase.

Sector	UK Exports to					UK Imports from				
	EU	US	China	ROW	TOTAL	EU	US	China	ROW	TOTAL
Agriculture	64.7	4.6	9.5	21.2	100.0	53.9	4.2	1.9	40.1	100.0
Other primary	86.9	1.2	2.8	9.0	100.0	8.5	2.4	0.1	89.0	100.0
Food	58.7	9.3	1.8	30.3	100.0	74.2	2.8	2.1	21.0	100.0
Textiles	70.4	4.0	3.1	22.5	100.0	27.0	1.0	39.0	32.9	100.0
Wood and Paper	56.4	5.7	8.7	29.2	100.0	61.9	9.4	15.2	13.5	100.0
Chemicals	55.8	13.3	3.9	27.0	100.0	62.1	8.3	5.8	23.7	100.0
Metals	20.4	4.4	10.8	64.3	100.0	37.1	10.6	9.2	43.1	100.0
Motor vehicles	43.1	11.2	20.0	25.6	100.0	83.0	1.6	1.9	13.5	100.0
Other transport	29.7	19.9	4.9	45.5	100.0	49.7	9.7	6.3	34.3	100.0
Electronics	53.9	9.3	8.1	28.7	100.0	33.9	7.0	41.1	18.1	100.0
Other machinery	42.7	12.0	5.4	39.9	100.0	49.6	7.6	24.5	18.3	100.0
Other manufactures	43.5	13.3	2.8	40.5	100.0	42.3	9.9	26.5	21.3	100.0
Construction	37.5	2.1	6.8	53.5	100.0	40.4	4.0	13.8	41.9	100.0
Water transport	39.7	5.3	3.0	52.0	100.0	45.3	2.1	1.5	51.2	100.0
Air transport	29.5	20.9	4.8	44.8	100.0	43.6	13.3	1.6	41.4	100.0
Communications	52.6	10.7	5.6	31.1	100.0	46.5	13.4	3.2	37.0	100.0
Finance	48.7	20.2	2.5	28.6	100.0	35.2	29.6	0.8	34.3	100.0
Insurance	20.4	31.6	9.5	38.5	100.0	48.5	17.7	3.3	30.5	100.0
Business services	47.5	6.1	6.0	40.5	100.0	40.3	12.2	5.0	42.5	100.0
Personal services	39.8	8.5	5.2	46.5	100.0	39.5	23.9	5.2	31.5	100.0
Other services	33.8	16.7	7.9	41.6	100.0	39.1	16.8	4.8	39.3	100.0
Agriculture	**64.7**	**4.6**	**9.5**	**21.2**	100.0	**53.9**	**4.2**	**1.9**	**40.1**	100.0
Manufacturing	**45.3**	**10.3**	**8.0**	**36.4**	100.0	**50.5**	**6.1**	**15.2**	**28.2**	100.0
Services	**42.9**	**13.8**	**5.5**	**37.8**	100.0	**40.4**	**16.6**	**3.8**	**39.2**	100.0
Total	**44.6**	**11.5**	**7.1**	**36.8**	100.0	**48.1**	**8.6**	**12.2**	**31.1**	100.0

Source: Authors' estimations based on GTAP 10 baseline.

Table 2. Initial data: Bilateral trade by sector (2020).

It is less clear, a priori, the relationship between imports and production. Imports may be of intermediates and, therefore, would move in the same direction of production (i.e., if production goes up (down), then imports of intermediates would also go up (down). By contrast, imports may be final goods which will compete with (or compensate for the fall of) domestic goods.

However, we cannot assume that the bulk of the adjustment in total production in these sectors would be related to the evolution of trade flows. This is because, as we will see in the next sections, all sectors will face a negative impact from the reduction in the stock of capital (that we interpret as FDI shock), too. In addition, private consumption will be negatively

affected with Brexit. This will constitute an extra force leading to the contraction of production in some sectors whose output is mostly devoted to the satisfaction of private consumption.

Sectors	Johnson's Brexit	Hard Brexit				
	NTBs to trade	NTBs to trade	MFN tariffs		Total	
	In EU and UK	In EU and UK	In EU	In UK	In EU	In UK
Agriculture	21.3	28.4	10.2	10.8	38.6	38.6
Other primary	21.3	28.4	0.0	0.1	28.4	28.4
Food	21.3	28.4	19.8	22.0	48.2	48.2
Textiles	7.2	9.6	10.0	9.5	19.6	19.6
Wood and Paper	4.3	5.8	0.5	1.0	6.3	6.3
Chemicals	5.1	6.8	2.8	2.7	9.6	9.6
Metals	4.5	6.0	1.9	2.0	7.9	7.9
Motor vehicles	9.6	12.8	8.0	8.8	20.8	20.8
Other transport	7.1	9.4	1.7	1.6	11.1	11.1
Electronics	4.8	6.4	0.9	1.5	7.3	7.3
Other machinery	7.7	10.3	1.7	1.8	12.0	12.0
Other manufactures	4.3	5.8	2.6	2.2	8.4	8.4
Construction	1.7	2.4			2.4	2.4
Water transport	3.5	4.0			4.0	4.0
Air transport	0.9	1.0			1.0	1.0
Communications	5.2	6.0			6.0	6.0
Finance	5.1	5.8			5.8	5.8
Insurance	4.7	5.4			5.4	5.4
Business services	6.9	8.0			8.0	8.0
Personal services	1.9	2.2			2.2	2.2
Other services	1.9	2.2			2.2	2.2

Source: Ecorys (2009), Cadot et al. (2018) and Latorre et al. (2019a, 2019b).

Table 3. Non-tariff barriers and MFN tariffs under Brexit.

Regarding our simulations, as shown in Table 3, we estimate the effects of two broad post-Brexit scenarios: the Boris Johnson's and the hard Brexit. In the Boris Johnson's scenario, we run zero tariffs. But, in terms of NTBs, these would be slightly higher than those that the UK would face under a potential soft Brexit and slightly lower than the hard Brexit. We simulate an increase of NTBs, whose level is 38% of the ones in goods and 44% of the ones in services estimated for Europe by Ecorys (2009) and Latorre and Yonezawa (2018)[1]. The hard Brexit scenario represents the "no deal" case between the UK and the EU. It involves

[1] For machinery we introduce a 20.5 non-tariff measure that is different than the one equal to zero from Ecorys (2009) and Latorre and Yonezawa (2015). Since these measures include at least customs clearance we believe it is not possible that they are zero. For Europe Cadot et al. (2018) provide this value of 20.5. This means, that under Hard and Johnson's Brexit scenarios the NTBs to trade in this sector amount to 10.3 and 7.7, respectively.

two simultaneous shocks. First, we assume that import tariffs between the UK and the EU would increase to the MFN level. This means, that the UK and the EU would trade under the WTO conditions. Second, the no deal is also composed of a shock in which we simulate the increase of NTBs, whose level is 50% of the ones estimated for Europe by Ecorys (2009), again following the literature. The TCA and the hard Brexit scenarios are simulated with the static and dynamic models.

We also simulate potential reductions in the inflow of FDI coming to the UK, proxied by reductions in the UK's capital stock. We assume decreases in FDI stocks by 6.8%, 12.11%, 19.53% and 30% only in the UK. This allows us to cover a broad range of impacts, which are consistent with the evidence discussed in section 3. To simulate the impact in the stock of FDI, we consider the share of the gross capital stock in the UK, which is controlled by multinationals. According to OECD (2018), it is 15%. If we apply this 15% to the information in the GTAP database, we obtain that, multinationals control i.e., US$ 114,810.42 billion of capital stock in the UK. Then, we calculate the corresponding absolute values of 6.8%, 12.11%, 19.53% and 30% decreases in total UK FDI stocks which correspond to 1.05%, 1.89%, 2.83% and 4.64% reductions in the overall capital stock in this country. These contractions in the capital stock in the UK are lost and not reallocated to the rest of regions. This is because once we split it across regions the impact on them would be negligible.

4.4 CGE Results

4.4.1 CGE Aggregate results

Table 4 offers a rich set of macroeconomic impacts arising from the emergence of trade restrictions and the reduction in the stock of FDI in the UK. It is important to note that CGE models isolate the impact of the particular shock analysed with them, Brexit in our case, *Ceteris paribus*, i.e., assuming the rest is held constant. Therefore, our results should not be interpreted as forecasts. In the real world the impact of Brexit is interacting with other forces, among which Covid-19 effects stand out. Table 4 shows two sets of columns. In the first set we present the results with the static model, while the second set displays the results using the dynamic model. Columns 1 and 2 display the impact of trade restrictions considering the two scenarios of Johnson's Brexit and hard Brexit. Columns 3, 4, 5 and 6 provide the impact of a fall in the stock of FDI in the UK, also using the static model. Columns 7 and 8 show the simultaneous impact of the emergence of barriers to trade and the reduction in the stock of FDI with the static model. Finally, the last two columns display the impact in 2030 of trade barriers using the dynamic model.

The impact on GDP appears at the top of the table. The effect of Brexit seems to be confined to the two regions directly involved in it, while for the rest the impact would be again negligible. That is why we focus on the results for the rest of macroeconomic variables in the UK and in the EU in the middle and bottom parts of Table 4. For the rest of regions, the impact would be very close to zero.

As we can see, the impact of Brexit would be more harmful to the UK than to the EU. The increase of barriers to trade (columns 1-2) would imply a reduction in GDP in the UK between 0.78% and 1.22%, while the EU would face a fall between 0.10% and 0.15%. In addition, the UK would face a more intense fall in GDP than the EU, when we analyse the simultaneous impact of a reduction in the stock of FDI and the rise of barriers to trade (columns 7 and 8). Do note however, that for the simulations in columns 7 and 8, we only run the reduction in FDI stock in the UK, while for the EU we only run the trade barriers.

	Static CGE								Recursive Dynamic CGE	
									Bariers to Trade	
									Difference with respect to the BAU in 2030	
	Barriers to Trade		Reduction in FDI stock				Johnson's Brexit + FDI 12.11%	Hard Brexit + FDI 19.53%	Johnson's Brexit	Hard Brexit
	Johnson's Brexit	Hard Brexit	6,77%	12,11%	19,53%	30,00%				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
GDP										
United Kingdom	-0,78	-1,22	-0,46	-0,83	-1,25	-2,06	-1,60	-2,45	-1,65	-2,43
European Union	-0,10	-0,15	0,00	0,00	0,00	-0,01	-0,10	-0,15	-0,15	-0,23
United States	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,03	0,05
China	0,01	0,02	0,00	0,00	0,00	-0,01	0,01	0,01	0,06	0,09
Rest of the World	0,01	0,01	0,00	0,00	0,00	0,00	0,01	0,01	0,09	0,13
United Kingdom										
Wages										
Skilled	-2,9	-5,34	0,03	0,05	0,08	0,13	-2,83	-5,22	-3,21	-4,48
Unskilled	-3,17	-5,83	0,10	0,19	0,28	0,46	-2,97	-5,51	-3,32	-4,62
Capital Rents	-2,78	-5,15	0,72	1,31	1,98	3,30	-1,48	-3,18	-2,00	-2,62
Capital Stock			-1,05	-1,89	-2,83	-4,64	-1,89	-2,83	-1,89	-2,83
Welfare	-1,21	-2,07	-0,23	-0,42	-0,62	-1,03	-1,61	-2,67	-2,14	-2,98
Aggregate exports	-1,78	-5,38	-1,36	-2,44	-3,65	-5,95	-4,25	-9,06	-7,39	-11,99
Aggregate imports	-6,17	-13,40	0,05	0,08	0,13	0,20	-6,03	-13,12	-6,81	-10,51
European Union										
Wages										
Skilled	-0,25	-0,56	-0,01	-0,03	-0,04	-0,06	-0,28	-0,59	-0,39	-0,68
Unskilled	-0,26	-0,60	-0,02	-0,03	-0,05	-0,09	-0,30	-0,65	-0,43	-0,75
Capital Rents	-0,22	-0,53	-0,01	-0,02	-0,03	-0,06	-0,25	-0,56	-0,31	-0,55
Capital Stock									-0,11	-0,18
Welfare	-0,12	-0,18	-0,01	-0,01	-0,02	-0,03	-0,13	-0,20	-0,19	-0,32
Aggregate exports	-0,11	-0,39	0,02	0,03	0,04	0,07	-0,08	-0,35	-0,45	-0,80
Aggregate imports	-0,23	-0,64	-0,03	-0,05	-0,07	-0,11	-0,27	-0,70	-0,47	-0,84

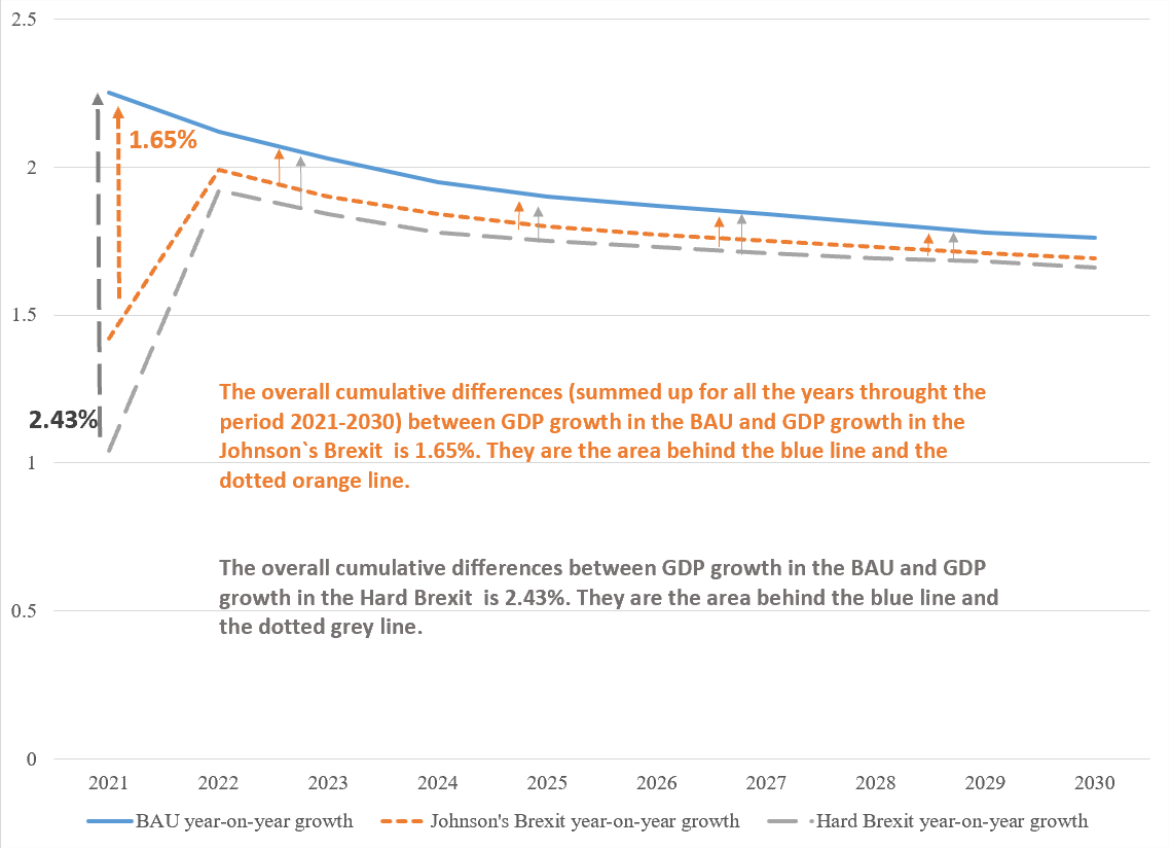
Source: Authors' estimations.

Table 4. Macroeconomic results.

The dynamic results in Table 4 and in subsequent tables are presented as "differences with respect to the BAU in 2030". To better understand what we mean by differences with the BAU (i.e., the evolution of economic variables if no policy simulation takes place), Figure 1 presents how would be the year-on-year growth of the GDP in the BAU, Johnson's Brexit and Hard Brexit scenarios between 2021 and 2030. We can see that the initial GDP growth in 2021 in the BAU is above 2%, while for the Hard and Johnson's Brexit it is between 1% and 1.5%. We have simulated that all Brexit barriers arise in the first year of implementation of the TCA (2020), therefore the biggest negative shock for the UK arises in that year.[2] UK's GDP in the Brexit simulations recovers strongly after that (in 2022) due to a rebound effect. However, it will always be below the GDP growth experienced in the BAU throughout 2022-2030, although the distance diminishes as time passes by. If we calculate the percentage points (p.p.) differences between the GDP growth under the Brexit impact and the one of the

[2] We have also analysed the results in case the barriers arise later. If they are spread in the first four years of implementation of the TCA or of a Hard Brexit the difference with the BAU is not very different from the results in Table 4 (columns 9 and 10) with values for GDP of -1.53% and -2.31%, respectively. Interestingly, if barriers arise later the fall in GDP is delayed in time and this dampens the overall negative impact of Brexit, compared to the case in which the shock occurs in the first year.

BAU for each year and add up all those p.p. differences for the years 2021-2030, we obtain the final numbers displayed as results of our dynamic simulations (i.e., a 1.65% and 2.43% overall difference for GDP in the Johnson's and Hard Brexit, respectively, from columns 9 and 10 in Table 4). The exact details of these calculations for GDP that underlie Figure 1 are provided in Table A1 of the Appendix.



Source: Authors' estimations.

Figure 1. GDP calculations behind the estimations of the "difference with respect to BAU in 2030"

Regarding trade restrictions (columns 1 and 2), the decline in UK's GDP seems to be explained by the reduction of total production due to the fall in output of industries such as motor vehicles, other primary, construction, communications and other services. This will be seen in the sectoral results below. Table 4 shows that barriers to trade constrain trade flows. That is why both aggregate exports and imports go down (see rows of aggregate exports and imports for the UK and the EU in columns 1 and 2). The contraction in production explains the fall in factors remuneration in both regions. Wages of skilled and unskilled workers go down, as capital remuneration does. Additionally, there would be a reduction in welfare. The fall in factors remunerations and the introduction of barriers to trade lead to a reduction in imports and competition from other firms. This would allow local firms to supply these goods at higher prices. Therefore, the variety of goods supplied in the local market would shrink and they would be more expensive than before the emergence of trade restrictions.

In terms of FDI stock reductions (columns 3-6), we can see that, losses from FDI in the UK after Brexit would not have a significant impact on the rest of regions considered in the model, whose capital stock remains unchanged. For example, the maximum reduction of 30% in the stock of FDI in the UK would imply a negligible effect on the GDP (-0.01%) in the EU. Focusing on the UK (columns 3-6) we obtain that, of course, with less productive capital GDP falls. We also find that there is an increase in capital rents. This is consistent with economic theory which points out that less capital combined with the same amount of labour makes capital become more productive, thus, resulting in an increase of its remuneration. However, wages should decrease since the marginal product of labour would fall when there is less capital available for workers. Our results contradict "a priori" this latter expected outcome, since wages go up slightly after the capital stock reductions. Nevertheless, these wage increases are relatively small, particularly compared to the much larger increases in the capital rents. So, in relative terms, when looking at the ratio: wages/capital rent, which is the relevant ratio to explain capital and labour movements across sectors, capital remuneration goes up in relative terms while wages go down in relative terms.[3]

Recall that both NTBs and tariffs are run simultaneously in the joint impact of barriers to trade. If we compare the impact of these barriers to trade under the static and dynamic CGE models, i.e., columns 1 and 2 versus columns 9 and 10, respectively, we can see that the contractionary patterns for all macro variables are common with both models, but that the losses in GDP are more pronounced in the dynamic framework, as expected. Note that the impact on the UK's GDP would be almost double if we simulate the shock with the dynamic model. In the static CGE model, the GDP would drop by 0.78% and 1.22% in the UK under the Johnson's and hard Brexit, respectively, while it would decrease by 1.65% and 2.43% in the dynamic model. This is because in a dynamic setting the capital stock is no longer pre-determined and fixed, but depends on the endogenous level of investment, which will go down after Brexit. Therefore, in this contractionary shock, the capital stock shrinks. However, as discussed in the literature review, in the complex framework of a dynamic CGE model, it is difficult to disentangle the effect of the reduction of the capital stock from other forces interacting in the model. To address this gap in the dynamic CGE model, we use the static CGE model to try to disentangle the potential impact of a reduction in the stock of FDI from the trade effects of Brexit. First, we simulate the impact of both shocks separately in the static model (in columns 1-6) and then we combine both in order to estimate the simultaneous impact of a reduction in the stock of FDI and the rise of barriers to trade also using the static model (columns 7 and 8). Second, we compare these latter results obtained with the static model (columns 7 and 8), with those from the dynamic model (Columns 9 and 10).

Note that the impact of a reduction in the stock of FDI by 12.11% and 19.53%, would lead to falls in the capital stock by 1.89% and 2.83%, respectively (see row "capital stock" in columns 4 and 5). These results for the capital stock are the same as those obtained with the dynamic model (row "capital stock", columns 9 and 10). For example, the impact of a

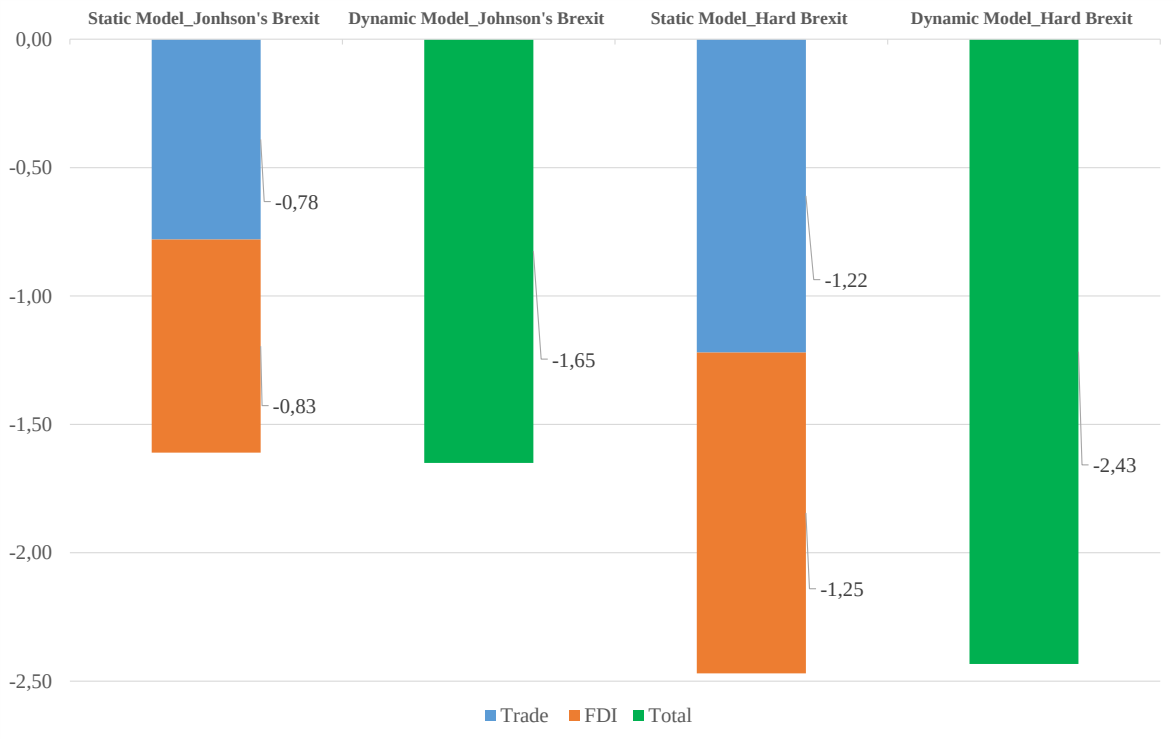
[3] For a more thorough analysis of the effects of the ratio wage/capital rent in a CGE context see Latorre (2013).

reduction by 12.11% in the stock of FDI in the UK (column 4), would imply a fall in the capital stock by 1.89% (row "capital stock" in column 4). This result for the capital stock of -1.89% is the same under the Johnson's Brexit in the dynamic setting (row "capital stock" and column 9). The same applies when we compare the impact of a decline in FDI stock by 19.53% (column 5), which yield 2.83% decreases in the capital stock, which are the same as the ones derived after the impact of hard Brexit in the dynamic setting (column 10). That is why for the combination of trade and FDI results in the static model (columns 7 and 8), we assume that under Jonson's Brexit, the UK would face a reduction of FDI stock by 12.11%, while under the hard Brexit this reduction would be 19.53%.

The simultaneous trade and FDI impacts in the UK derived with the static model (columns 7 and 8) are very close to those obtained with the dynamic model (columns 9 and 10), at least in terms of GDP. What is more, using the static model we can decompose the contribution of the trade barriers (columns 1 and 2) and FDI components (columns 3-6) to the total results (columns 7 and 8). Thus, under the Johnson's Brexit, the two static shocks together, barriers to trade (column 1) and FDI reduction (column 4) (-0.78% + -0.83% = -1.60%) yield a very similar impact on GDP (column 7) than the one that combines both shocks in the dynamic setting, which yields a 1.65% loss in UK's GDP (column 9). Figure 2 provides a graphical representation of the impact of Brexit on the UK´s GDP under both scenarios in the static and dynamic settings.

This decomposition of the impact of trade and FDI using the static model works very well to proxy the GDP results of the dynamic model in the UK. It also provides an approximation for the evolution of capital rents, aggregate exports, aggregate imports, wages and welfare. The FDI shock raises factors' remunerations and aggregate imports, contrasting with their contractionary trend after the trade barriers. As a consequence, welfare is less damaged in the FDI simulations because factors remunerations go up. Despite the somewhat more marked differences between the static and dynamic results for these latter variables, it seems that this decomposition approach can be helpful to get an idea about the impact of FDI. We would have no clue for the role of FDI after Brexit, relying only on the results of the dynamic model alone.

Going back to the impact of FDI stock reductions with the static model, column 6 allow us to expand the results for FDI to match some of the estimations of the literature. We can see this reduction of 30% in the FDI stock (in isolation), would bring about GDP a loss of 2.06%. These are important losses which would have to be added to the ones derived from trade losses alone, if FDI stocks reductions end up being larger than the ones derived in the dynamic setting. Let us go to deeper into this analysis by looking at the sectoral results in the next section.



Source: Authors' estimations.

Figure 2. Impact on GDP in the UK under the Johnson´s Brexit and Hard Brexit Scenario (percentage change)

4.4.2 CGE Sectoral results

Table 5 displays the estimates obtained for the Boris Johnson's scenario. We concentrate on the analysis of this scenario because it reflects the main characteristics of the TCA struck by the EU and the UK. As we can see in Table A2 of the appendix, the results follow a very similar pattern for the hard Brexit, mainly differing in magnitude.

The first set of columns in Table 5 shows the results with the static model, which involves the shock of barriers to trade and the reduction of FDI stock by 12.11%. As already noted, the fall of FDI stock by 12.11% implies a reduction in the capital stock of 1.89% (Table 4, row capital stock), which is equivalent to the drop in the capital stock obtained for the Johnson's Brexit with the dynamic model. The second set of columns in Table 5 provides the results with the dynamic model.

The static model shows that sectoral adjustments after trade barriers clearly contrast with the one experienced with a reduction in the stock of FDI. Focusing on the static joint effects of NTBs and tariffs (i.e., the simultaneous effects of barriers to trade), we find a negative impact on the flow of exports in *several* sectors and a contraction in imports *across* all sectors in the UK (columns 2 and 3 in Table 5). The increase of barriers to trade will reduce exports in agriculture, other primary, food, textiles, other machinery and motor vehicles to a larger extent than exports in chemicals and electronics. This is because, although all these sectors

have an important share of the bilateral trade with the EU (Table 2), agriculture, other primary, food, textiles, motor vehicles and other machinery are the ones that will face the largest barriers to trade once Brexit comes into force (Table 3). In particular, food, agriculture and other primary, exhibit by far the largest trade barriers among sectors and this is reflected in the most sizeable contractions of their exports. On the other hand, as we increase the barriers to trade from a scenario of Johnson's Brexit to the hard Brexit. Trade contractions become larger than with smaller barriers, when we compare Table 5 with Table A2 in the appendix.

Sector	Static CGE						Recursive Dynamic CGE		
	Barriers to Trade			Reduction in FDI stock (12.11%)			Barriers to Trade Difference with respect to the BAU in 2030		
	Production	Exports	Imports	Production	Exports	Imports	Production	Exports	Imports
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Agriculture	1.94	-30.53	-12.23	-0.95	-1.38	-0.06	2.89	-33.48	-11.05
Other Primary	-4.16	-56.72	-9.54	-3.08	-4.44	-0.72	-7.65	-59.50	-10.99
Food	0.53	-26.44	-20.56	-1.06	-2.11	0.23	0.95	-34.32	-18.82
Textiles	0.70	-9.80	-5.91	-2.08	-3.01	0.16	-0.78	-18.82	-4.32
Wood and Paper	2.46	0.80	-8.22	-1.38	-2.94	0.34	1.79	-3.12	-7.22
Chemicals	2.00	-1.76	-6.36	-1.81	-2.40	-0.25	0.64	-5.55	-6.23
Metals	4.59	4.83	-2.68	-1.87	-2.16	-0.92	3.57	3.84	-2.96
Motor Vehicles	-2.75	-10.62	-10.06	-1.33	-1.69	-0.01	-4.31	-16.43	-7.54
Other Transport	2.43	1.07	-11.82	-1.72	-2.68	0.91	1.88	-2.45	-9.25
Electronics	3.40	-1.72	-4.86	-2.30	-2.72	-0.27	2.89	-5.14	-3.11
Other Machinery	2.22	-5.01	-10.80	-1.87	-2.90	0.45	1.35	-11.13	-6.61
Other Manufactures	1.84	3.10	-7.84	-1.33	-3.25	0.70	0.86	-1.19	-6.26
Construction	-3.26	9.70	-9.46	0.38	-3.44	2.24	-2.87	5.47	-7.14
Water Transport	1.75	2.32	-4.78	-0.77	-0.73	0.07	1.26	1.78	-4.46
Air Transport	1.24	3.79	-2.95	-1.12	-1.59	0.01	0.14	2.46	-3.12
Communications	-0.38	3.72	-8.41	-0.71	-3.02	0.98	-1.24	-0.65	-7.41
Finance	1.11	3.72	-6.51	-1.20	-2.27	0.33	-0.04	1.10	-6.33
Insurance	0.74	6.86	-7.58	-1.20	-3.20	0.81	-0.34	4.71	-6.94
Businness Services	0.34	2.32	-8.08	-0.99	-2.68	0.61	-0.68	-1.42	-7.21
Personal Services	0.28	8.14	-5.84	-0.94	-3.15	0.81	-0.63	5.80	-5.49
Other Services	-0.33	7.71	-5.65	-0.71	-2.57	0.55	-1.14	5.28	-5.34

Source: Authors' estimations.

Table 5. Impact on production, exports and imports in the UK under the Johnson's Brexit scenario (percentage change).

As mentioned before, decreases in exports will tend to push down production. However, we cannot assume that this channel of adjustment applies to all sectors. Reductions in exports could explain declines in production in other primary and motor vehicles but not in agriculture, food, textiles, wood and paper, chemicals, metals, other transport, electronics, and other machinery. Regarding agriculture, food and wood and paper, they would experience a slight increase in total production. The fact that these sectors sell abroad less than 15% of their total production (as can be seen in Table 1) could explain why their production does not fall with the export decreases. These sectors mainly supply the local market.

Concerning electronics and chemicals, they experience rather small contractions in total exports, which are not big enough so as to contract overall production. Communications and other services would experience reductions in total production. However, the fall in total production in these sectors responds more to the contraction of aggregate investment and private consumption in the UK. Do note that production in most services sectors seems to be unaffected by trade barriers, with the exception of other services and communications. On the other hand, the UK will import less products and services to satisfy the decreasing production and consumption.

We turn now to the sectoral adjustment process due to a reduction in the stock of FDI in isolation (columns 4-6) in Table 5. We can see that reductions in the capital stock bring about a fall in production across the board, with the only exception of construction. This contracting trend in output is due to the reduction in the capital available for production in each sector. In addition, the drop in production and the rise in factor remunerations (Table 4) reduce exports, which also contract across the board. Contrasting with the decrease in exports, imports go up very slightly because domestic prices are pushed up by higher factors' remunerations, while the absence of barriers to trade makes imports comparatively cheaper than domestic products.

The negative outcomes for services in the dynamic framework are more related to the capital stock reductions (or FDI outflows), as can be seen in the second block of columns of Table 5, than to trade impact themselves. Our decomposition analysis allows us to shed light on the origin of these contractions of output in services sectors that are nearly absent in the static simulations and arise either in a dynamic setting or in a stating setting considering contractions in the capital stock as a result of Brexit. As a consequence, putting both effects together (i.e., the increase of barriers to trade and the reduction of the FDI stock) in the static model, we obtain results that are similar to the ones of the dynamic model that, somehow, combines these two shocks in a dynamic setting (columns 3, 4 and 5 in Table 6).

Thus, note that Table 6 again provides estimates from the static and dynamic CGE models. For the static model we focus now on the simultaneous impact of barriers to trade and reductions in the capital stock (i.e., we do not show these results in isolation as in Table 5, but jointly). The table presents the results for capital demand, as well as for production, exports, and imports across sectors under Johnson's Brexit scenario.

Even though the percentages changes of production differ slightly in intensity in the dynamic and static setting, in general overall patterns of production are similar with both models. In particular, the sectors that tend to contract or increase production tend to be the same with both models.

On the other hand, Table 6 also shows that Motor vehicles would be the second most severely hurt sector in the UK after the Other Primary good sector. Note, however, that even though Other primary goods accounts for an important share in aggregate imports (since it includes oil imports), Motor vehicles is much bigger with more relevant shares in UK's imports, exports and production (Table 1). It is precisely the smaller size of the Other Primary goods sector, which helps to somehow overvalue changes when they are measured in percentage change. Production in Motor vehicles would decline more than the one of the rest of sectors in the economy. In the long-term production in motor vehicles would decrease by 4.31% under the Johnson's Brexit scenario, experiencing a drop in exports and imports flows by 16.43% and 7.54%, respectively. The fall in production in the dynamic setting is very similar to the one we derive after combining the trade and FDI effects in the static setting (4.05%). In addition, our decomposition approach with the static model shows that trade effects would

account for the largest share with a 2.75% reduction while FDI effects would explain the remaining 1.33%, as displayed in Table 5.

Sector	Capital Demand		Static CGE (Barriers to trade + FDI fall)			Recursive Dynamic CGE		
						Barriers to Trade		
						Difference with respect to the BAU in 2030		
	Static CGE	Dynamic CGE	Production	Exports	Imports	Production	Exports	Imports
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Agriculture	-1.89	-0.61	-1.89	-31.56	-12.21	2.89	-33.48	-11.05
Other Primary	-1.89	0.52	1.01	-58.99	-9.99	-7.65	-59.50	-10.99
Food	-1.89	-0.86	-7.03	-28.08	-20.31	0.95	-34.32	-18.82
Textiles	-1.89	-0.40	-0.47	-12.63	-5.71	-0.78	-18.82	-4.32
Wood and Paper	-1.89	-0.16	-1.39	-2.26	-7.84	1.79	-3.12	-7.22
Chemicals	-1.89	-0.10	1.05	-4.24	-6.55	0.64	-5.55	-6.23
Metals	-1.89	0.29	0.11	2.48	-3.57	3.57	3.84	-2.96
Motor Vehicles	-1.89	-0.30	2.58	-12.21	-10.02	-4.31	-16.43	-7.54
Other Transport	-1.89	0.00	-4.05	-1.77	-10.88	1.88	-2.45	-9.25
Electronics	-1.89	-0.01	0.66	-4.50	-5.06	2.89	-5.14	-3.11
Other Machinery	-1.89	0.13	0.98	-7.90	-10.26	1.35	-11.13	-6.61
Other Manufactures	-1.89	-0.05	0.34	-0.37	-7.11	0.86	-1.19	-6.26
Construction	-1.89	-0.22	0.49	5.80	-7.26	-2.87	5.47	-7.14
Water Transport	-1.89	0.14	-2.79	1.55	-4.68	1.26	1.78	-4.46
Air Transport	-1.89	-0.09	0.95	2.09	-2.92	0.14	2.46	-3.12
Communications	-1.89	-0.09	0.07	0.52	-7.46	-1.24	-0.65	-7.41
Finance	-1.89	0.00	-1.08	1.32	-6.17	-0.04	1.10	-6.33
Insurance	-1.89	0.02	-0.11	3.40	-6.81	-0.34	4.71	-6.94
Businness Services	-1.89	0.00	-0.49	-0.49	-7.47	-0.68	-1.42	-7.21
Personal Services	-1.89	-0.07	-0.65	4.68	-5.05	-0.63	5.80	-5.49
Other Services	-1.89	-0.13	-0.67	4.87	-5.09	-1.14	5.28	-5.34

Source: Authors' estimations.

Table 6. Impact on demand of capital, production, exports and imports in the UK under Johnson's Brexit scenario (percentage change).

Motor vehicle's trade with the EU is very intense, accounting for 43.1% and 83.0% of its total exports and imports, respectively (Table 2). In addition, Motor vehicles exhibits one of the highest trade barriers (Table 3). These two forces push down exports in this sector. Moreover, it is a sector whose production relies heavily on trade, i.e., its export and import shares account for 53.7% and 78.3% of its total production (Table 1). This implies that the reduction in exports in this sector, will in turn, heavily affect its production. In fact, there are other sectors, which would experience larger contractions in exports and imports than Motor vehicles. Those sectors would have even more sizeable barriers after Brexit or their trade would be more related to the EU, than in the case of motor vehicles. However, trade contractions are not transmitted as severely to production as in motor vehicles since foreign trade is not so important for their production. For example, because UK's agriculture or food exhibit rather small shares of production devoted to exports in the context of manufactures, their production is not so harmed as the one of motor vehicles, despite the large contractions in exports they experience.

All in all, it seems that our static simulations give us hints to understand and proxy the different channels through which Brexit can affect the evolution of sectors in the UK. The sectoral analysis confirms that with the static model we can decompose the dynamic effects of a trade shock into a proxy for the impact of FDI and another one for the effects of trade barriers. Only when trade shocks are combined with capital stock effects, either by implementing a reduction in the capital stock in the static setting or by running a dynamic

model, the full effects for services sectors unfold. It is noteworthy, that some previous attempts of modelling Brexit have overlooked these sectoral impacts, because their methodologies do not offer much sectoral details if any, as happens in macroeconometric approaches and New Quantitative Trade Models (see Latorre et al., 2019a; 2019b for details).

5. Gravity model

A different approach widely used by economists to understand the international trade is the structural gravity model. This model was first presented in 1962 by Jan Tinbergen, who proposed that the size of bilateral trade flows between any two countries can be assimilated to Newton's theory of gravitation. In 2003, Anderson and vanWincoop derived the structural gravitational equation from the demand side.

Newtons Law:	Anderson and vanWincoop's structural gravity:
$F_{ij} = G\frac{M_i M_j}{{D_{ij}}^2}$	$X_{ij} = \tilde{G}\frac{Y_i Y_j}{{T_{ij}}^{\theta}} = \frac{Y_i Y_j}{Y_w}\left(\frac{t_{ij}}{P_i P_j}\right)^{1-\sigma}$
F_{ij}: gravitational force between i and j	X_{ij}: exports from country i to country j
G: gravitational constant	$\tilde{G}$: inverse of world production ($\tilde{G} = \frac{1}{Y_w}$)
M_i and M_j: object i and j's mass	Y_i and Y_j: country i and j's production
${D_{ij}}^2$: distance between objects i and j	${T_{ij}}^{\theta}$: total trade cost between countries i and j ($T_{ij}^{\theta} = \left(\frac{t_{ij}}{P_i P_j}\right)^{\sigma-1}$)

Source: Authors' estimations.

Figure 3. Comparison between Newton's Law and Anderson and vanWincoop's structural gravity.

When we log-linearize the gravity equation, and add an error term, we get its most popular form that been used routinely in the trade literature to study the effects of various determinants of bilateral trade:

$$\ln(X_{ij}) = \ln(Y_i) + \ln(\mathrm{Y_j}) - \ln(\mathrm{Y_w}) + (1-\sigma)\ln(\mathrm{t_{ij}}) - (1-\sigma)\ln(P_i) - (1-\sigma)\ln(\mathrm{P_j}) + \varepsilon_{\mathrm{ij}}$$

In order to consistently compare results with our CGE analyses, we use the same trade data, leading us to do a cross-section analysis. We follow the best practices in literature to solve this equation. Multilateral resistance terms (P_i *and* P_j) are unobservable, and we use exporter and importer fixed effects to control for unobserved country-specific factors that affect the trade flows and deal with heterogeneity in cross-section models.

The elasticities of substitution are also provided by the GTAP 10 database (Aguiar et al., 2019). Information about FDI stocks comes from a database provided by the Financial Times (2022) and the additional data are supplied by the CEPII databases. By using FDI

accumulated stocks over the years instead of FDI flows, we control for time-variant effects in cross-section estimations and allows us to deal with possible endogeneity that may arise in the FDI and trade relationship[4]. We proxy for the bilateral trade costs (t_{ij}) using the distance between countries, whether they have a common language or if importer and exporter share a common border. In order to cope with zero trade values and heteroscedasticity, we use the multiplicative Poisson pseudo-maximum likelihood (PPML) estimator as well as robust estimations for the standard errors.

The results for the regressions are presented in Table 7. We can see that the FDI stock has a positive impact on both exports and imports. In both cases we control by standard variables as well as by a dummy representing the existence of any regional trade agreement between importer and exporter. $DIST_{ij}$ is the population-weighted distance between most populated cities (km) in countries i and j. $CONTIG_{ij}$ is equal to 1 when exporter and importer share a common border and $LANG_{ij}$ is equal to 1 when exporter and importer speak a common language and RTA_{ij} that is equal to 1 when the trade between exporter and importer is under any regional trade agreement. And the FDI_{ij} variable represents the accumulated Foreign Direct Investment stock from country i in country j. We also include in our regression dummies for importer-exporter fixed effects, which are not included in the table below for simplicity. The results suggest that, when the FDI stock goes down, trade follows suit. When the inward FDI stock falls by -1%, exports drop by -0.11% and imports by -0.09%. This equation allows us to estimate the relationships between FDI, exports and imports, which we find is in line with our CGE simulations and with other estimations from the FDI literature mentioned above. The rest of parameters show the expected results, assuming that talking a common language is irrelevant when we include the existence of a regional trade agreement in the regression.

[4] Correlation (Trade, FDI) = 0.01

	Exports	Imports
LN_DIST	-0.634***	-0.651***
	(0.0277)	(0.0291)
CONTIG	0.385***	0.384***
	(0.0655)	(0.0688)
LANG	-0.0542	-0.042
	(0.0582)	(0.0612)
RTA	0.114**	0.119**
	(0.0518)	(0.0529)
LN_FDI	0.112***	0.0905***
	(0.0136)	(0.0105)
Observations	14,525	14,524
R-squared	0.905	0.896

Source: Authors' estimations.

Table 7. Gravity equations for exports and imports (importer-exporter fixed effects variables are removed for the sake of clarity). Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1)

Taking in consideration the positive effects of the FDI stock in trade (i.e., the sum of exports and imports), we extend the structural gravity equation defined by Anderson and vanWincoop to implement our regression of interest.

$$T_{ij} = \exp[\beta_1 \ln DIST_{ij} + \beta_2 CONTIG_{ij} + \beta_3 LANG_{ij} + \beta_4 EU_{ij} + \beta_5 CU_{ij} + \beta_6 RTA_{ij} + \beta_7 INT_{ij} + \beta_8 lnFDI_{ij} + \pi_i + \tau_j] * \varepsilon_{ij}$$

Where T_{ij} represents trade between countries i and j (when i=j, T_{ij} denotes internal consumption or intra-national trade) DIST, CONTIG, LANG, RTA and FDI have the same meaning than in table 7.We also include EU_{ij}, which equals to 1 for trade within the EU and CU_{ij} that is equal to 1 if there is a customs union agreement between exporter and importer. The dummy INT_{ij} is equal to 0 for intra-national trade and 1 for international trade and, finally, π_i and τ_j are the exporter and importer fixed effects, which also capture the effect of importer and exporter's GDP (Y_i *and* Y_j) and world GDP (Y_w).

Table 8 shows the results of the baseline regression, where fixed effects have been removed for simplicity.

	Trade
LN_DIST	-0.336***
	(0.0354)
CONTIG	0.507***
	(0.0891)
LANG	0.0345
	(0.0689)
EU	0.455***
	(0.0918)
CU	0.149**
	(0.0694)
RTA	0.182***
	(0.0557)
INT	-6.419***
	(0.142)
LN_FDI	0.204***
	(0.0095)
Observations	14,646
R-squared	1

Source: Authors' estimations.

Table 8. Effects on Trade. Robust standard errors in parentheses (*** p<0.01, ** p<0.05, * p<0.1)

We observe that DIST and CONTIG are significant and their effects are in line with the economic theory. The speak of a common language (LANG) has a small and non-significant effect when we include the FDI stocks and trade agreements in the equation. These results suggest that in a world full of commercial trade agreements, where de facto language is English, the local official language does not really affect the trade volume.

In line with Camarero et al. (2018) who analyse the effects of FDI in the European Monetary Union (EMU), the effect of being part of the EU (as well as of a customs union or having a regional trade agreement) on trade is positive and significant. FDI stocks have also a positive and significant effect, promoting trade and showing a complementary relationship between both variables. International trade (INT) presents a negative and significant effect due to the restrictions provided by the border effects.

We want to analyse the effects of our counterfactual scenario, where the UK leaves the EU (and also include that fact that also leaves the customs union with Turkey). We run three different simulations. In the first one the UK leaves the EU, but the inward FDI stock remains without changes. In simulations 2 and 3, we assume that the inward FDI stocks in the UK are

dropped by -12.11% and by -19.53%, in line with the estimations of the literature summarized above and with the capital stock reduction derived in our dynamic CGE[5]. Now, to analyse these effects, we follow Yotov et al. (2016), (1) solving the baseline scenario, (2) obtaining the partial equilibrium effects, (3) attaining the conditional general equilibrium effects and, finally, (4) deriving the full endowment equilibrium effects. As we allow for asymmetric trade costs and unbalanced trade, we have to normalize the multilateral resistance terms. We normalize by the value of the inward multilateral resistance term for a country which should hardly be affected by our counterfactual exercise. We choose China for our normalization.

Table 9 shows the joint effects on GDP, exports and imports in the UK, EU27 countries and USA, for the three counterfactual scenarios. With gravity models it is straightforward to provide these estimations per country because they are designed to explain bilateral trade flows between pairs of countries, providing a detailed picture of the global trade network.

Country	UK leaves the EU			UK leaves the EU and 12.11%			UK leaves the EU and 19.53%		
	Δ GDP (%)	Δ Exports (%)	Δ Imports (%)	Δ GDP (%)	Δ Exports (%)	Δ Imports (%)	Δ GDP (%)	Δ Exports (%)	Δ Imports (%)
UK	-7,23	-7,62	-2,94	-7,26	-8,61	-3,97	-7,28	-9,29	-4,67
Austria	-0,06	-1,27	-1,36	-0,06	-1,3	-1,39	-0,06	-1,32	-1,41
Belgium	-0,07	-2,18	-1,91	-0,07	-2,24	-1,95	-0,07	-2,27	-1,97
Bulgaria	-0,11	-1,84	-1,65	-0,11	-1,88	-1,69	-0,11	-1,92	-1,71
Croatia	-0,08	-1,29	-1,27	-0,08	-1,32	-1,28	-0,09	-1,33	-1,3
Cyprus	-0,11	-1,48	-1,38	-0,11	-1,52	-1,41	-0,12	-1,54	-1,42
CzechRepubl	-0,07	-1,39	-1,6	-0,07	-1,42	-1,64	-0,07	-1,45	-1,66
Denmark	-0,1	-2,28	-2,29	-0,1	-2,34	-2,34	-0,1	-2,38	-2,37
Estonia	-0,12	-1,46	-1,4	-0,12	-1,49	-1,43	-0,12	-1,52	-1,44
Finland	-0,07	-1,45	-1,63	-0,07	-1,49	-1,66	-0,07	-1,51	-1,68
France	-0,06	-2,19	-2,09	-0,07	-2,25	-2,13	-0,07	-2,29	-2,16
Germany	-0,05	-1,8	-2,15	-0,05	-1,85	-2,2	-0,05	-1,88	-2,23
Greece	-0,07	-1,81	-1,58	-0,07	-1,86	-1,61	-0,07	-1,89	-1,63
Hungary	-0,08	-1,55	-1,75	-0,08	-1,59	-1,78	-0,08	-1,62	-1,81
Ireland	-0,28	-5,29	-8,13	-0,29	-5,42	-8,32	-0,29	-5,51	-8,45
Italy	-0,04	-1,63	-1,89	-0,05	-1,67	-1,93	-0,05	-1,7	-1,95
Latvia	-0,13	-1,61	-1,39	-0,13	-1,65	-1,42	-0,13	-1,68	-1,43
Lithuania	-0,1	-1,76	-1,54	-0,11	-1,81	-1,57	-0,11	-1,84	-1,59
Luxembourg	-0,08	-1,79	-1,53	-0,09	-1,84	-1,55	-0,09	-1,87	-1,57
Malta	-0,12	-2,43	-1,62	-0,13	-2,5	-1,64	-0,13	-2,54	-1,66
Netherlands	-0,08	-2,22	-2,68	-0,08	-2,27	-2,73	-0,09	-2,31	-2,77
Poland	-0,05	-1,41	-1,48	-0,06	-1,45	-1,5	-0,06	-1,47	-1,52
Portugal	-0,09	-1,84	-1,85	-0,09	-1,88	-1,89	-0,09	-1,91	-1,91
Romania	-0,07	-1,49	-1,49	-0,07	-1,53	-1,52	-0,07	-1,56	-1,53
Slovakia	-0,05	-0,92	-1,1	-0,05	-0,91	-1,08	-0,05	-0,9	-1,07
Slovenia	-0,06	-0,95	-1,02	-0,06	-0,97	-1,03	-0,06	-0,98	-1,03
Spain	-0,07	-2,06	-2,19	-0,07	-2,11	-2,23	-0,07	-2,15	-2,26
Sweden	-0,08	-1,96	-2,16	-0,08	-2,01	-2,21	-0,08	-2,05	-2,24
USA	0,01	1,04	0,59	0,01	0,98	0,56	0,01	0,94	0,53

Source: Authors' estimations.

Table 9. Full-endowment effects.

[5] These same reductions have also been introduced in our static CGE to estimate the contribution of capital stock reductions, as a proxy for FDI, to the overall dynamic effects of Brexit.

As we can see, Brexit harms all EU countries, but the negative effect is much deeper in the UK than in the rest of the EU countries. These results are logical, since once the UK leaves the EU, there is trade creation effect among the remaining countries within the EU, which will divert their exports/imports to/from the UK to the rest EU members.

Analysing the three scenarios, we can conclude that the gravity approach derives that leaving the EU is the main cause of the negative impact and aggregated inward FDI stock reduction brings little additional effects. This contrasts with our CGE simulations, which suggest a much greater importance of FDI effects. Maybe one explanation for this is that while the dynamic CGE derives a reduction in the capital stock available for production after Brexit, a reduction in FDI stocks do not necessarily reflect less real capital available for production. This is because FDI data are often based on asset/liability criteria only when they materialise into a balance of payment movement and can also be related to mergers and acquisitions or intracompany loans.

On the other hand, GDP in the UK is predicted to fall much more than with our CGE simulations, no matter whether the latter are for Johnson's Brexit or for the hard Brexit. In terms of trade, the results for the UK are more similar, although the dynamic CGE derives stronger import reductions than the gravity approach. By contrast, for the countries of the EU27 and the USA, the GDP impact derived with gravity is more in line with the one from the dynamic CGE. However, trade impacts for the latter countries are considerably more intense with the gravity than with the dynamic CGE. These results go in line with the theory, since gravity model estimates of the trade-creation/diversion effect substantially exceed the estimations of computable general equilibrium (CGE) models (DeRosa and Gilbert, 2005).

Conclusions

Despite the importance of FDI in the UK, its effects after Brexit have received little attention in the literature. Modelling FDI is a challenging issue. In this paper we proxy its impact by implementing reductions in the UK's capital stock, that are consistent with empirical estimations on potential reductions in FDI after Brexit using computable general equilibrium (CGE) modelling.

The analysis of this paper again confirms what we had seen in previous studies, namely, that the impact of Brexit would be more harmful to the UK than to the EU. In our new dynamic CGE setting we obtain that for the year 2030 UK's GDP would fall by 1.65% under Johnson's Brexit (i.e., the Trade and Cooperation Agreement that entered into force in 2021), while the EU's GDP would face a reduction of 0.15%, compared to the business as usual (BAU) scenario.

The dynamic model allows estimating the impact of Brexit in the long run. Several methodologies are not able to provide the effects of a reduction in the capital stock in

isolation, because investment adjusts endogenously leaving no trace of its impact. Endogenous capital movements appear together with trade shock effects and previous attempts to model FDI explicitly have failed to obtain its impact, which they derive as being nearly zero in the context of Brexit (e.g., Ciuriak et al., 2015; 2017) or simply providing no effects for capital accumulation itself (Dhingra et al., 2017; Aichele et al., 2015). Therefore, in order to disentangle the effects of an increase of barriers to trade from the impact of a fall in the capital stock, we use the static CGE model. This helps us to proxy and understand the role of FDI in Brexit and the adjustments that underlie the dynamic setting.

Our CGE results point out that the joint impact of a fall in the stock of FDI (i.e., capital stock reductions) and barriers to trade with the static model are quite close to the results obtained with the dynamic model, for GDP. We show that once we combine the impact of the resulting fall in the stock of FDI (i.e., capital stock reductions) in the dynamic setting with the ones of the barriers to trade, we can reproduce the dynamic results for GDP in our static setting. What is more, our step-by-step procedure with the static model allows us to disentangle the trade effects from the FDI effects underlying the dynamic results. Thus, in Johnson's Brexit scenario, the drop in GDP by 1.65% involves a fall of approximately 0.78% and 0.83% related to barriers to trade and FDI, respectively. This estimation for the role of FDI is larger than one of the few previous existing ones by Latorre et al. (2020a; 2020b), who estimated they accounted for around one third of the total overall impact of Brexit including trade and FDI in a static setting. The contrasting results are understandable since Latorre et al. (2020a; 2020b) only consider services multinationals in their analysis, while here we consider FDI in all sectors of the economy.

Our CGE analysis expands the number of macroeconomic variables considered in the few studies analysing the impact of Brexit in a dynamic setting (e.g., Dhingra et al., 2017; Aichele et al., 2015). We provide results not only for GDP, but also for welfare, factors' remunerations (including skilled and unskilled wages), capital stock variations, as well as aggregate exports and imports for the year 2030. Our dynamic results suggest that remunerations of skilled (unskilled) workers and capital rents would decrease under Johnson's Brexit. Reductions in factors' remunerations and the increase in barriers to trade would imply contractions of aggregate imports. Hence, competition from foreign firms would decrease, leading to less variety of goods in the local market which would be more expensive than before the emergence of trade restrictions. Therefore, the UK would face a loss of welfare between 2.14% and 2.98%.

We find that motor vehicles would be one of the most harmed sectors in the UK. In the long-term production in motor vehicles would decrease by 4.31% under the Johnson's Brexit scenario in 2030, experiencing a decrease in exports and imports flows by 16.43 and 7.54%, respectively. The contraction in production that we derive in the dynamic setting is very similar to the one we derive by combining the trade and FDI effects in the static setting. The fall in this static setting in motor vehicles would be of (4.05%), trade effects would explain (2.75%) while FDI effects would explain (1.33%).

Another important finding is that using the static CGE model including only the trade shock (with no FDI shock) derives a rosy future for services sectors, in general. However, once we introduce either the trade shock in the static CGE model combined with the FDI stock reduction or a trade shock in a dynamic CGE model, we obtain that services sectors suffer considerably after Brexit. This is an important contribution of the sectoral analysis of this paper, which carries important policy implications. Britain's large services sector—including its vast financial, legal and accounting centres—will no longer have seamless access to EU clients after Brexit. This will have important consequences. However, some quantitative models, particularly static trade models, will miss these effects even if they consider non-tariff barriers in services sectors.

Our structural gravity approach demonstrates that trade moves in parallel with FDI stocks, which when diminished, reinforce the reduction in trade. In addition, it suggests considerably larger reductions in UK's GDP, stemming mainly from trade impacts, than our CGE simulations. This is in the line with previous results in the literature for which gravity estimations tend to be more intense than the ones derived from CGEs.

Finally, in this paper we offer estimations for the effects of Brexit alone, isolating it from other sources that are simultaneously impacting the economies. Although the effects of the pandemic Covid-19 have overshadowed Brexit so far, Brexit is still causing some negative impacts in the short run.

Appendices

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
BAU year-on-year growth	2,25	2,12	2,03	1,95	1,9	1,87	1,84	1,81	1,78	1,76
Johnson's Brexit year-on-year growth	1,42	1,99	1,9	1,84	1,8	1,77	1,75	1,73	1,71	1,69
Hard Brexit year-on-year growth	1,04	1,92	1,84	1,78	1,75	1,73	1,71	1,69	1,68	1,66
P.P. difference between Hard Brexit and BAU	-0,83	-0,13	-0,13	-0,11	-0,1	-0,1	-0,09	-0,08	-0,07	-0,07
P.P. difference between Johnson`s Brexit and BAU	-1,21	-0,20	-0,19	-0,17	-0,15	-0,14	-0,13	-0,12	-0,10	-0,10
Cumulative p.p. differences of Johnson`s Brexit	-0,81	-0,94	-1,06	-1,17	-1,27	-1,36	-1,44	-1,52	-1,59	**-1,65**
Cumulative p.p. differences of Hard Brexit	-1,18	-1,38	-1,56	-1,72	-1,87	-2,01	-2,13	-2,24	-2,34	**-2,43**

Source: Authors' estimations based on dynamic CGE simulations.

Note: The highlighted results for 2030 of the "Cumulative p.p. difference of the GDP results after Brexit (compared to the BAU)" is what is reported in Table 4 as difference with respect to BAU in 2030 in the Recursive Dynamic CGE (columns 9 and 10) and indicates the approach of all the CGE results displayed. Because the volume of GDP from which the year-on-year percentage growth is calculated is also dynamic, our p.p. difference do not exactly but only approximately grasp the real cumulative differences provided as "Differences with respect to the BAU in 2030". The latter are internally calculated by our GEMPACK software used for dynamic simulations.

Table A1. GDP calculations behind the estimations of the "difference with respect to BAU in 2030"

Sector	Static CGE						Recursive Dynamic CGE		
							Barriers to Trade		
	Barriers to Trade			Reduction in FDI stock (19.53%)			Difference with respect to the BAU in 2030		
	Production	Exports	Imports	Production	Exports	Imports	Production	Exports	Imports
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Agriculture	4,26	-53,92	-20,76	-1,44	-2,09	-0,09	4,96	-46,84	-15,44
Other Primary	-3,53	-68,34	-13,31	-4,59	-6,60	-1,08	-8,23	-62,83	-13,52
Food	2,55	-50,38	-39,92	-1,59	-3,15	0,35	2,93	-50,77	-30,92
Textiles	-3,52	-37,46	-12,72	-3,10	-4,49	0,24	-5,36	-45,19	-6,29
Wood and Paper	4,35	-0,34	-15,56	-2,07	-4,39	0,51	2,27	-5,83	-10,36
Chemicals	1,42	-10,32	-13,76	-2,72	-3,59	-0,38	-1,29	-14,29	-10,41
Metals	6,97	6,11	-6,50	-2,80	-3,23	-1,37	3,42	2,48	-5,26
Motor Vehicles	-7,42	-29,18	-23,62	-1,99	-2,54	-0,02	-7,51	-31,32	-15,09
Other Transport	3,80	1,06	-21,34	-2,57	-4,01	1,35	1,79	-4,67	-12,94
Electronics	5,54	-5,34	-9,52	-3,44	-4,06	-0,41	3,23	-8,99	-4,50
Other Machinery	3,36	-10,33	-19,86	-2,80	-4,33	0,67	0,91	-16,83	-9,26
Other Manufactures	2,40	-0,71	-15,20	-1,99	-4,85	1,05	0,30	-8,20	-8,98
Construction	-6,20	18,01	-16,99	0,55	-5,12	3,36	-4,23	7,04	-9,80
Water Transport	3,34	4,42	-7,75	-1,16	-1,10	0,11	1,73	2,53	-5,53
Air Transport	2,11	6,53	-4,89	-1,68	-2,38	0,01	-0,29	2,54	-3,90
Communications	-0,64	7,89	-13,96	-1,07	-4,50	1,47	-1,76	0,71	-9,45
Finance	2,21	7,69	-10,90	-1,79	-3,39	0,49	0,07	2,91	-8,18
Insurance	1,61	13,10	-12,33	-1,79	-4,77	1,23	-0,37	6,95	-8,67
Businness Services	0,70	5,34	-13,30	-1,48	-4,00	0,92	-0,94	-0,21	-9,19
Personal Services	0,74	15,45	-9,87	-1,42	-4,70	1,22	-0,82	8,32	-7,10
Other Services	-0,45	14,44	-9,58	-1,07	-3,84	0,83	-1,58	7,23	-6,88

Source: Authors' estimations.

Table A2. Impact on production, exports and imports in the UK under a hard Brexit scenario (percentage change).

References

Aguiar, A. Corong, E. & van der Mensbrugghe, D. (2019a). The GTAP Recursive Dynamic (GTAP-RD) Model: Version 1.0. West Lafayette, Indiana: Center for Global Trade Analysis, Department of Agricultural Economics, Purdue University.

Aguiar, A. Chepeliev, M. Corong, E. McDougall, R. & van der Mensbrugghe, D. (2019b). The GTAP Data Base: Version 10. West Lafayette, Indiana: Center for Global Trade Analysis, Department of Agricultural Economics, Purdue University.

Aichele, R. Felbermayr, G. Petersen, T. & Schoof, U. (2015). Brexit- potential economic consequences if the UK exits the EU. *Policy Brief #2015/05*. Germany: Future Social Market Economy, Bertelsmann Stiftung. Available at: https://www.bertelsmann-stiftung.de/en/publications/publication/did/policy-brief-201505-brexit-potential-economic-consequences-if-the-uk-exits-the-eu/

Anderson, J. E. and van Wincoop, E. (2003). Gravity With Gravitas: a Solution to the Border Puzzle. *American Economic Review* 93(1), 170-192.

Bajo-Rubio, O. & Torres, A. (2001). The impact of Spain´s integration with the EC on trade and foreign investment. Wydawnictwo Akademii Ekonomicznej im. Oskara Langego we Wroclawiu, Wroclaw.

Bajo-Rubio, O. & Sosvilla-Rivero, S. (1994). An econometric analysis of foreign direct investment in Spain, 1964-89. Southern Economic Journal, 61(1), 104-120. doi: 10.2307/1060133

Baldwin, R.E. Forslid, R. & Haaland, J.I. (1996). Investment creation and diversion in Europe. *The World Economy*. 19(6), 635-659. doi: https://doi.org/10.1111/j.1467-9701.1996.tb00704.x

Barrel, R. & Pain, N. (1998). Real exchange rates, agglomerations and irreversibilities: macroeconomic policy and FDI in EMU. *Oxford Review of Economic Policy*. 14(3), 152-167. doi: https://doi.org/10.1093/oxrep/14.3.152

Bekkers, E. & Orlov, D. (2020). The impact of macroeconomic closures on long run trade projections and trade policy experiments. Paper presented at the 23rd Annual Conference on Global Economic Analysis, Virtual Meeting, June 2020. Available at: https://www.gtap.agecon.purdue.edu/resources/download/9705.pdf

Brouwer, J. Paap, R. & Viaene, J.M. (2008). The Trade and FDI Effects of EMU Enlargement. *Journal of International Money and Finance*. 27(2), 188-208. doi: https://doi.org/10.1016/j.jimonfin.2007.12.005

Bruno, R. Campos, N. Estrin, S. & Tain, M. (2016). Gravitating Towards Europe: An Econometric Analysis of the FDI Effects of EU Membership. *Technical Appendix to The Impact of Brexit on Foreign Investment in the UK*. Available at:

Busch, B. & Matthes, J. (2016). Brexit- The Economic Impact A Meta-Analysis. *IW Report 10/2016*. Germany: Cologne Institute for Economic Research. Available at: https://www.econstor.eu/bitstream/10419/157171/1/IW-Report-2016-10.pdf

Cadot, O., Asprilla, A., Gourdon, J., Knebel, C. and Peters, R. (2015). Deep Regional Integration And Non-Tariff Measures: A Methodology For Data Analysis, Policy Issues in International Trade and Commodities, Research Study Series No. 69, United Nations, New York and Geneva.

Camarero, M., Gómez-Herrera, E. and Tamarit, C. (2018). New Evidence on Trade and FDI: how Large is the Euro Effect?. *Open Econ Rev 29*, 451–467

Campos, N. & Coricelli, F. (2015). Some unpleasant Brexit econometrics. Available at: https://voxeu.org/article/some-unpleasant-brexit-econometrics

Ciuriak, D. Dadkhah, A. & Xiao, J. (2016). Taking the Measure of the TPP as Negotiated. *Working Paper*. Canada: Ciuriak Consulting INC. Available at SSRN: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2743009

Ciuriak, D. Dadkhah, A. & Xiao, J. (2017). Brexit Trade Impacts: Alternative Scenarios. *Working paper*. Canada: Ciuriak Consulting INC. Available at SSRN: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2981314

Ciuriak, D. Xiao, J. Ciuriak, N. Dadkhah, A. Lysenko, D. & Narayanan G. B. (2015). The trade-related impact of a UK exit from the EU single market. Canada: Ciuriak Consulting INC. Available at SSRN: https://ssrn.com/abstract=2620718 or http://dx.doi.org/10.2139/ssrn.2620718

Clausing, K.A. & Dorobantu, C.L. (2005). Re-entering Europe: Does European Union candidacy boost foreign direct investment?. *The Economics of Transition*. 13(1)77-103. doi: https://doi.org/10.1111/j.1468-0351.2005.00208.x

Corong, E. Hertel, T. McDougall, R. Tsigas, M. & van del Mensbrugghe, D. (2017). The Standard GTAP model, version 7. *Journal of Global Economic Analysis*. 2(1), 1-119. *doi: 10.21642/JGEA.020101AF*

Cubells, J.F. & Latorre, M.C. (2021). Brexit deal done! A detailed micro- and macroeconomic analysis of its fallout. *Economic Systems Research*. 33(2), 171-196. doi: 10.1080/09535314/2021.1887089

DeRosa, D. & Gilbert, J. (2005). Predicting Trade Expansion under FTAs and Multilateral Agreements. No WP05-13. *Working Paper Series*. Peterson Institute for International Economics

Dhingra, S. Huang, H. Ottaviano, G. Pessoa, J.P. Sampson, T. & Van Reenen, J. (2017). The Costs and Benefits of Leaving the EU: Trade Effects. *Economic Policy*. 32(92), 651-705. doi: https://doi.org/10.1093/epolic/eix015

Ecorys (2009). Non-Tariff Measures in EU-US Trade and Investment- An Economic Analysis. *Final report OJ 2007/S 180-219493.* European Commission, Directorate-General Trade. Available at: http://www.i4ide.org/content/wpaper/ntm_book_final.pdf

Fernández-Pacheco Theurer, C. López, J.L. & Latorre, M.C. (2018). Multinationals' effects: A nearly unexplored aspect of Brexit. *Journal of International Trade Law and Policy.* 17(1/2), 2-18. doi: https://doi.org/10.1108/JITLP-12-2017-0053

Financial Times (2021). UK's services sector starts to count the real cost of Brexit. Available at: https://www.ft.com/content/d0c10195-0e2e-4913-af74-3b7057163e3f

Financial Times (2022). FDI Markets. Available in: https://www.ft.com/capital-markets

Fournier, J. (2015). The negative effect of regulatory divergence on foreign direct investment. *OECD Economics Department Working Papers, No 1268*. OECD Publishing, Paris. Available at: https://www.oecd-ilibrary.org/economics/the-negative-effect-of-regulatory-divergence-on-foreign-direct-investment_5jrqgvg0dw27-en

Freeman, R., Manova, K., Prayer, T. and Sampson, T. (2022) "Unravelling deep integration: UK trade in the wake of Brexit", Center for Economic Performance, Discussion paper No.1847, April.

GOV.UK (2020) UK-EU Trade and Cooperation Agreement Summary. Available at: https://www.gov.uk/government/publications/agreements-reached-between-the-united-kingdom-of-great-britain-and-northern-ireland-and-the-european-union

Hosoe, N. (2014). Japanese manufacturing facing post-Fukushima power crisis: ad dynamic computable general equilibrium analysis with foreign direct investment. *Applied Economics.* 46 (17), 2010-2020. doi: https://doi.org/10.1080/00036846.2014.892198

Latorre, M.C. (2013). On the differential behaviour of national and multinational firms: A within and across sectors approach. The World Economy, vol. 36, pp. 1245-1372.

Latorre, M.C. & Hosoe, N. (2016). The role of Japanese FDI in China. *Journal of Policy Modelling*. 38(2), 226-241. doi: http://dx.doi.org/10.1016/j.jpolmod.2016.02.003

Latorre, M. C. & Yonezawa, H. (2018). Stopped TTIP? Its potential impact on the world and the role of neglected FDI. *Economic Modelling*. 71, 99–120. doi: https://doi.org/10.1016/j.econmod.2017.12.006

Latorre, M. C. Olekseyuk, Z. Yonezawa, H. & Robinson, S. (2019a). Brexit: Everyone loses, but Britain loses the most. Peterson Institute for International Economics. Available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3345244

Latorre, M.C. Olekseyuk, Z. Yonezawa, H. & Robinson. S. (2019b). Making sense of Brexit losses: An in-depth review of macroeconomic studies. *Economic Modelling*. doi: https://doi.org/10.1016/j.econmod.2019.10.009

Latorre, M.C. Oleksekyuk, Z. &Yonezawa, H. (2020a). Trade and Foreign Direct Investment-related impacts of Brexit. *World Economy*. 43 (1), 2-32. doi: https://doi.org/10.1111/twec.12859

Latorre, M.C. Oleksekyuk, Z. &Yonezawa, H. (2020b). Foreign multinationals in service sectors: A general equilibrium analysis of Brexit. *World Economy*. 43 (11), 2830-2859. doi: https://onlinelibrary.wiley.com/doi/epdf/10.1111/twec.13034

Levy, E. Stein, E & Daude, C. (2003). Regional Integration and the Location of FDI. *Working Paper No.492*. Research Department of Inter-American Development Bank. Available at SSRN: https://ssrn.com/abstract=532464

New York Times (2021). A Week into Full Brexit, the pain for UK Businesses Has Arrived. Available at: https://www.nytimes.com/2021/01/09/business/Brexit-British-economy.html

OECD. (2016). The Economic Consequences of Brexit: A Taxing Decision. *Economic Policy Paper No.16*. Available at: https://www.oecd.org/eco/the-economic-consequences-of-brexit-a-taxing-decision.htm

OECD (2018). OECD database: Globalization, Activity of Multinationals. Available at: https://stats.oecd.org/

Pain, N. & Young, G. (2004). The macroeconomic impact of UK withdrawal from the EU. *Economic Modelling.* 21(3), 387-408. doi: https://doi.org/10.1016/S0264-9993(02)00068-8

Pricewaterhouse Coopers PwC. (2016). Leaving the EU: Implications for the UK economy. *Report commissioned by The Confederation of British Industry (CBI)*. Available at: https://www.pwc.co.uk/financial-services/assets/Leaving-the-EU-implications-for-the-UK-FS-sector.pdf

Straathof, B. G.J, Linders. Lejour, A. & Möhlmann, J. (2008). The internal market and the Dutch economy: implications for trade and economic growth. *CPB Document 168.* CPB Netherlands Bureau for Economic Policy Analysis. Available at:

https://www.cpb.nl/sites/default/files/publicaties/download/internal-market-and-dutch-economy-implications-trade-and-economic-growth.pdf

The Economist (2021). The cost of Brexit becomes apparent. Filling the GDP gap that Brexit has created will be hard. Available at: https://www.economist.com/britain/2021/03/13/the-cost-of-brexit-becomes-apparent

The Economist (2022). How a year outside the EU's legal and trading arrangements has changed Britain. Available at: https://www.economist.com/britain/2022/01/01/how-a-year-outside-the-eus-legal-and-trading-arrangements-has-changed-britain

UK in a changing Europe. (2019) The economic impact of Boris Johnson's Brexit proposals. *Report*, London, UK: The UK in a Changing Europe. Available at: https://ukandeu.ac.uk/wp-content/uploads/2019/10/The-economic-impact-of-Boris-Johnsons-Brexit-proposals.pdf

UK Government (2016). HM Treasury analysis: the long-term economic impact of EU membership and the alternatives. *Discussion paper*. London, UK: HM Treasury. Available at: https://www.gov.uk/government/publications/hm-treasury-analysis-the-long-term-economic-impact-of-eu-membership-and-the-alternatives

USITC. (2019). U.S. -Mexico – Canada trade agreement: likely impact on the U.S. Economy and on Specific Industry Sectors. Publication Number: 4889 Investigation Number: TPA 105-003. Available at: https://www.usitc.gov/publications/332/pub4889.pdf

Wall Street Journal (2021a) Investors bet UK stocks can banish Brexit Blues. Available at: https://www.wsj.com/articles/investors-bet-u-k-stocks-can-banish-brexit-blues-11610533556

Wall Street Journal (2021b). Joint Probes to Continue Post-Brexit- With More Red Tape. Available at: https://www.wsj.com/articles/joint-probes-to-continue-post-brexitwith-more-red-tape-11610377200

Yotov, Y. V., Piermartini R., Monteiro J., and Larch M. (2016). An Advanced Guide to Trade Policy Analysis: The Structural Gravity Model. *World Trade Organization*, 10.30875/abc0167e-en.