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A short- and long-term general equilibrium analysis of the impact of Brexit.

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Abstract

This paper provides an impact assessment of Brexit and the role of foreign direct investment (FDI) in the United Kingdom (UK). We use both, a static and a dynamic Computable General Equilibrium (CGE) model, which are the Standard Global Trade Analysis Project (GTAP) and the Recursive Dynamic GTAP model, respectively.

We offer a comparative analysis, which identifies the role of FDI and barriers to trade in the overall impact of Brexit. Regarding barriers to trade, we study three potential scenarios: soft Brexit, Johnson's Brexit and hard Brexit. We extend our previous research including the simulation of the new agreement negotiated by Boris Johnson, which would introduce more barriers to trade and FDI than the one struck by Theresa May. To the best of our knowledge there are not many assessments which simulate the new agreement. With respect to FDI, we simulate several levels of FDI reductions.

This CGE approach allows to estimate the impact on GDP, welfare, wages, and capital remuneration, together with the evolution of aggregate and sectoral output, exports and imports, for 21 sectors and five regions: UK, European Union (EU), the United States of America (USA), China, and the Rest of the World (ROW).

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

JEL codes: C68, F15, F23, F62

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 Busch and Matthes, 2016; Fernandez-Pacheco et al., 2018; Latorre and Yonezawa, 2018; Latorre et al., 2019). Only a few have analysed in detail the impact of Foreign Direct Investment (FDI) and have disentangled its effects from the ones of 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).

According to the World Investment Report (UNCTAD, 2018), FDI inflows to the United Kingdom (UK) declined by 92 percent in 2017. This contraction is explained by the return to prior levels of FDI inflows in the UK after the large cross-border mergers and acquisitions (M&As) that it experienced in 2016. However, this negative evolution may also be related to the uncertainty generated by Brexit.

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 and migration suggest. Therefore, this paper provides an impact assessment of Brexit considering not only barriers to trade but also the role of FDI in United Kingdom.

We have three main objectives: the first one is to provide a thorough analysis of Brexit, including many macroeconomic and microeconomic results. 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 standard Global Trade Analysis Project (GTAP) model (Corong et al., 2017) and the GTAP Recursive Dynamic model (Aguiar et al., 2019a), respectively. Both models allow integrating several economic dimensions to provide a complete description of an economy to further with detailed macroeconomic and sectoral results. Hence, our trade-related effects are based on a very detailed approach, which contrasts with the "reduced form" approach that others have derived to proxy the dynamic effects of Brexit (Dhingra et al, 2017; Aichele and Felbermayr, 2015).

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 simulations under 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.

Our third objective is to offer an estimation of the impact of the new Brexit agreement struck by Boris Johnson in Brussels last November 2019. With the exception of Menon (2019), to the best of our knowledge, there are not many assessments of this new agreement, which would introduce more barriers to trade and FDI than the one struck by Theresa May in November 2018.

Regarding the database, we use the latest version of the GTAP 10 dataset for 2014 (Aguiar et al., 2019b), which we disaggregate in 21 sectors, 4 factors (skilled and unskilled labour, land and capital) and 5 economies (UK, EU, USA, China, and ROW).

We offer a broad set of macroeconomic results (GDP, wages, 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 all sectors in the UK.

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 and 5, describe the models, data and simulations used in the study. Finally, we offer a detailed analysis of the macroeconomic and sectoral results in section 6, while section 7 provides the main concluding remarks.

2. The New Brexit Agreement of Boris Johnson.

The Withdrawal Agreement (WA) negotiated by Theresa May and approved by the 27 EU leaders last 25 November 2018, intended to set the main terms of the UK's exit from the EU, e.g., the divorce bill, citizens' rights, and the problematic Northern Ireland 'backstop'.

After several failed attempts to ratify the WA and its Political Declaration (PD), Prime Minister Theresa May presented her resignation on May 24, 2019. She was eventually substituted by Boris Johnson, who was elected the new UK's PM on July 24, 2019. With Boris Johnson, a new WA proposal born. This proposal seeks to remove the 'backstop' provision from the deal.

The revised WA and its PD were considered and agreed at the European Council on 17 October 2019. The former was ratified by the Members of the European Parliament with 621 votes to 49 against, and it entered in force on 31 January 2020 at midnight CET.

According to HM Treasury (2019), the new PD states that the future relationships between the UK and the EU must be based on a Free trade agreement (FTA) that ensures no tariffs, no fees, charges or quantitative restrictions across all sectors. In this agreement disciplines on Technical Barriers to Trade, Sanitary and Phyto-sanitary control and service liberalization must be based on and go beyond the WTO agreements. Therefore, it seems that this new proposal would be between the soft and hard Brexit, although the PD is not politically binding.

Under the new Brexit agreement negotiated by Boris Johnson, if the UK and EU do not agree on a new future relationship deal at the end of the transition period, an open border between Northern Ireland and Ireland will be maintained. Northern Ireland will be part of the EU customs union, while the rest of the UK will not. However, Northern Ireland will apply many EU customs rules and there will be a customs border between the UK and the Northern Ireland in the Irish Sea. Also, trade in goods between the rest of the UK and the EU will fall back to WTO rules (Curtis et al., 2019).

Leaving the EU without a deal would imply new checks on both sides of the border, introducing delays in supply chains, which means higher cross-border costs. In addition, the flow of exports and imports conducted by foreign affiliates would also be affected and consequently could negatively impact their further investment decisions, which could be delayed or even cancelled.

Moreover, if the UK is no longer represented by the EU in the WTO, some amendments to the current lists of concessions and schedules commitments will be required. Hence, the UK will need to record its own list of concessions and commitments. This would imply that trade partners could ask for renegotiating the conditions of those agreements that would remain in force after Brexit.

According to Molinuevo (2017) and Sacerdoti (2017), after Brexit, those Preferential Trade Agreements (PTAs) that are focused only on goods and the Generalized System of Preferences (GSP) will no longer apply to the UK. However, the applicability of those agreements that include services, investment and intellectual property (mixed agreements) remains uncertain. This is because these agreements include provisions that go well beyond the competences of the EU and require the acceptance by the states that form part of the EU. On the other hand, WTO membership and Bilateral Investment Treaties (BITs) with third countries will remain in force.

Regarding BITs, until the 2009 Lisbon treaty, Member States in the EU made their network of Bilateral Investment Treaties and national regulation to attract FDI. This is because, before the 2009 Lisbon Treaty, the EU did not have formally competence over the negotiations of FDI agreements of its Member States. According to Meunier (2014, p.4) "by the time of the Lisbon Treaty, member states had about 1,200 extra-EU BITs with 148 countries, accounting for almost half of the investment agreements in the world". For example, UK had concluded over 100 BITs since 1975, the last one with Colombia in March 2010 (Molinuevo, 2017).

Although, the investment treaties concluded by the UK with third countries will remain valid after Brexit, some of these third countries may want to renegotiate some terms of the treaty or reject the deal, if they consider that Brexit could have a potential impact on their economic relationship with the UK or in their business with other EU member states. As Molinuevo (2017, p.16) suggests "Third countries may consider that the original rights and obligations set out in the BITs are not proportionate to the new conditions and could wish to revise the terms of the investment treaty that links them to the UK". For example, Fernández-Pacheco et al. (2018) found in their study that the USA, France, Germany, Japan and China were the most important investment partners for the UK in 2014. Hence, companies located in the UK could consider that Brexit could limit their operations in the other EU member states and their government could ask to revise the current BITs with the UK or could seek the cancelation of the agreements.

The exit of the UK from the EU without a deal and even with a deal would imply an increase in the cross-border cost and potential retards, which would negatively affect the just-in-time delivery that most companies apply. According to Anastassia Beliakova, head of trade policy at the British Chambers of Commerce, the uncertainty of Brexit negotiations "has forced companies to look at their supply chains". In the case of a no deal things would be more

complicated than with a deal. For example; the aerospace giant Airbus S.E., based in Toulouse, France argues that delays produced by a withdrawal from EU without a trade deal "would be so costly that it could likely close its British operations" and "even a negotiated exit would likely throw grit into the gears of the sensitive supply chains built up over decades" (Wall Street Journal, 2018).

As we noted above, 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 short 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. Daude et al. (2003) find evidence that a regional integration agreement (such as the EU membership) would increase the stock of FDI by around 27 percent. Fournier (2015) estimates that a reduction of 20 percent in regulatory differences increases FDI inflows by 15 percent 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. Both studies use a gravity model. The former uses a dataset that covers FDI from 20 source countries, all of them from the OECD, while the latter uses a baseline country sample that includes OECD countries in which the share of FDI assets owned by Special Purpose Entities (SPEs) does not exceed 80 percent. The little or no physical presence of this type of company in the country implies that they are less likely to be affected by regulations of the country. Hence, it seems to be suitable to control the share of this type of company in the sample when the researcher wants to analyse the impact of a potential reduction in the inflow of FDI due to restrictions imposed by the host country.

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 percent.

On the other hand, HM Treasury (2016b), Clausing and Dorobantu (2005) and Bruno et al. (2016) have estimated the potential impact on FDI of leaving the EU. HM Treasury Analysis

(2016b) estimates comprise different ranges of FDI reductions. It estimates the impact on total FDI inflows into the UK from EU and non-EU countries under different counterfactuals using a panel dataset constructed with FDI data for 40 countries over the period 2000 to 2012. According to its three alternative scenarios, the UK would face a fall in FDI flows by -10 percent under the European Economic Area (EEA) membership, between -15 and -20 percent under an FTA with the EU or a reduction between -18 and -26 percent 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 percent. On the other hand, Bruno et al. (2016) estimate the effect of EU membership on FDI inflows using bilateral FDI data from 34 OECD countries between 1985 and 2013. They predict a 22 percent 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), HM Treasury (2016b), Latorre et al. (2019a, 2019b), 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; and Straathof et al., 2008), while OECD (2016) use the estimations of Fournier (2015).

Dhingra et al. (2017) estimate that an average reduction of 26 percent fall in the inflow of FDI would lead to lower real income in the UK by 3.4 percent, while, OECD (2016) runs a decline on FDI between -10 and -45 percent. Unlike, Dhingra et al. (2017), the OECD and HM Treasury (2016b) approaches do not show the effects of FDI reduction 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).

To the best of our knowledge only Latorre et al. (2019a, 2019b), Ciuriak et al. (2015) and 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. (2019a, 2019b) find that one third of the overall negative impact of Brexit (e.g., -0.88 of the overall -2.64 percent GDP fall in the UK under hard Brexit scenario) is because multinationals would face costs increases. However, Latorre et al. (2019) 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 percent). This result is surprising since multinationals play a very important role in

the UK, as was shown above[1]. Finally, Pain and Young (2014) estimate a very significant effect from FDI in the UK´s GDP (2.25 percent 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 (2014) and Dhingra et al. (2017), OECD (2016) and HM Treasury (2016b) do not provide estimates of the impact of FDI fall on production and trade across sectors, as we do in this paper.

On the other hand, few studies have looked at the dynamic effects of Brexit (Dhingra et al., 2017; Aichele and Felbermayr, 2015)[2]. To incorporate the dynamic impact of Brexit in the UK, both Dhingra et al (2017) and Aichele and Felbermayr (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).

However, this 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). He revisado nuevamente el documento de Gancía y no indica ninguna crítica respecto a como se estima el impacto de FDI. Se concentra aspectos relacionados con comercio.

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 this paper, we provide a very detailed sectoral analysis of production, exports and imports after Brexit.

4. Model and simulations

A CGE model includes both the supply and demand side of the economy in order to capture the interactions of households, firms and the government. These connections are presented as a system of equations, which are derived from microeconomic optimization theory.

With respect to the demand side of the economy, four categories are explicitly modelled, private consumption, investment, public consumption and exports. Regarding the supply side, a representative firm in each sector decides the optimal combination of intermediates inputs and factors of production to produce goods or services.

All economic agents are in contact with one another through the markets of factors and commodities. There are a representative household and a government, both consume goods

[1] Similarly, in a paper analysing the impact of the agreement between the EU and Canada (CETA), Ciuriak et al. (2017) also obtain that the impact of FDI is close to zero.

[2] Dhingra et al. (2017) use a New Quantitative Trade Model (NQTM) based on Ottaviano (2015). Aichele and Felbermayr (2015) base their analysis on a static model, the IFO NQTM but to estimate the dynamic effects, they draw on the results of the empirical ad hoc models.

and services offered by producers in the goods and services markets. The income that producers receive is used to employ factors of production and to buy imported or domestic intermediates in order to produce goods and services. Therefore, producers are related to one another through the demand of intermediates and are related to households through the demand of factors of production (labour and capital). In turn, the representative household receives a remuneration (through wages and rents) that is used to buy goods and services, in order to maximize its utility. These microeconomic optimization decisions are then comprised in a framework representing national accounts identities, which also define the equilibrium in the economy.

In the standard static GTAP model[3], 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[4]. As a consequence, the results that a static model grasps are derived from a reallocation of resources throughout the economy (i.e., efficiency effects). After a shock, the static CGE moves from one equilibrium point to another (i.e., the impact is a before and after comparison of the economy) due to efficiency effects. We consider that it is a suitable framework to analyse the impact of a short run reduction in the stock of FDI in the UK after Brexit.

By contrast, a recursive dynamic model updates the exogenous endowments of population and labour force, technology, preferences and policies between periods[5]. 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, typically with a 1-year gestation lag. Therefore, this model reflects a sequence of time-based comparative static equilibria.

Regarding our simulations, we estimate the effects of three broad potential post-Brexit scenarios: a soft, the Boris Johnson's and the hard Brexit and simulate a potential reduction in the inflow of FDI in the UK. In the soft Brexit we assume that the UK and the EU continue to enjoy a free trade agreement, which implies that tariffs between both remain at zero. In this scenario we simulate the emergence of NTBs with a level of 0.25 of the ones that exist between the EU and the USA (Table 1), following the approach of Dhingra et al. (2017), Latorre et al. (2019a, 2019b) and Ortiz and Latorre (2019).

Johnson's Brexit scenario reflects the main characteristics of Boris Johnson's Brexit political declaration. As we have noted, he proposes that the UK applies its own regulatory and trade policy based on and going beyond the WTO agreements. It also envisages the creation of a

[3] A detailed explanation of the models is available in the book of Hertel (1997) and has been updated in McDougall (2000), Corong et al. (2017) and in Aguiar et al. (2019a).

[4] In addition, in our static model we assume that national capital and land are specific. This means that these two factors can be used only in the production in which they are used in the initial data. Thus, increases in total production using specific capital can be achieved only through the employment of more units of labour or more capital coming from FDI inflows. Hence, producers are related with one another not only by the demand of intermediates but also through competition in attracting labour. This type of model is appropriate to simulate short-run estimations.

[5] In this study, the baseline projection includes updates in GDP, GDP per capita, population and labour force (skilled and unskilled).

free trade area between the UK and the EU that combines deep regulatory and customs cooperation between both parties. However, the arrangements should take account of the fact that the parties will form separate markets and distinct legal orders. This could imply customs checks, product standards, 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 could imply extra regulatory checks on borders. Hence, following the approach of Menon (2019) we assume zero tariffs as in the soft Brexit. But, in terms of NTBs, these would be slightly higher than those that the UK would face under the soft Brexit and slightly lower than the hard Brexit. Therefore, we simulate an increase of NTBs, whose level is 0.38 of the ones in goods and 0.44 of the ones in services that exist between the EU and the USA.

The hard Brexit scenario represents the "no deal" case between the UK and the EU. It involves two shocks. First, we assume that import tariffs between the UK and the EU would increase to the Most Favoured Nation (MFN) level. This means, that the UK and the EU would trade under the World Trade Organization (WTO) conditions. Second, the no deal is also composed of a shock in which we simulate the increase of NTBs, whose level is 0.50 of the ones that exist between the EU and the USA, again following the literature.

These three types of Brexit are simulated with the static and dynamic models. Additionally, with the latter we simulate trade restrictions considering two different techniques. In one of them, we assume the whole value of trade restrictions appear in the first year once the UK leaves the EU. In the other one, we adopt a gradual increase in barriers to trade over 4 years, i.e., we apply one-third of the total shock in the first year while the rest of NTBs emerge gradually along 3 years, finally reaching the same barriers as in the previous scenario.

Table 1 provides the exact values of the barriers that we run in our model. Columns 2 and 3 show the NTBs for every sector in the UK and in the EU with the soft and Johnson's Brexit, while columns 4, 5, and 6 reflect the values of MFN tariffs and NTBs that the UK and the EU would face under a hard Brexit. The larger size of the NTBs compared to the tariffs suggest that they would guide the bulk of Brexit's impact on trade. They are especially high in agriculture, other primary, food, and motor vehicles, and to a lesser extent, textiles, chemicals, metals, and other transport.

Table 1. Non-tariff barriers and MFN tariffs under Brexit

Sectors	Soft Brexit	Boris Johnson's Brexit	Hard Brexit				
	NTBs to trade	NTBs to trade	NTBs to trade	MFN tariffs		Total	
	In EU and UK	In EU and UK	In EU and UK	In EU	In UK	In EU	In UK
Agriculture	14.20	21.30	28.40	10.20	10.80	38.60	39.20
Other primary	14.20	21.30	28.40	0.00	0.10	28.40	28.50
Food	14.20	21.30	28.40	19.80	22.00	48.20	50.40
Textiles	4.80	7.20	9.60	10.00	9.50	19.60	19.10
Wood and Paper	2.80	4.20	5.70	0.50	1.00	6.20	6.70
Chemicals	3.40	5.10	6.80	2.80	2.70	9.60	9.50
Metals	3.00	4.50	6.00	1.90	2.00	7.90	8.00
Motor vehicles	6.40	9.60	12.80	8.00	8.80	20.80	21.60
Other transport	4.70	7.05	9.40	1.70	1.60	11.10	11.00
Electronics	3.20	4.80	6.40	0.90	1.50	7.30	7.90
Other machinery	0.00	0.00	0.00	1.70	1.80	1.70	1.80
Other manufactures	2.80	4.20	5.70	2.60	2.20	8.30	7.90
Construction	1.20	1.80	2.30			2.30	2.30
Water transport	2.00	3.50	4.00			4.00	4.00
Air transport	0.50	0.88	1.00			1.00	1.00
Communications	2.90	5.08	5.90			5.90	5.90
Finance	2.80	4.90	5.70			5.70	5.70
Insurance	2.70	4.73	5.40			5.40	5.40
Business services	3.70	6.48	7.50			7.50	7.50
Personal services	1.10	1.93	2.20			2.20	2.20
Other services	1.10	1.93	2.20			2.20	2.20

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

Concerning the FDI reduction, we assume decreases in FDI stocks by 6.77, 10, 16.77, 20 and 30 percent to cover a broad range of impacts which are consistent with the evidence discussed in section 3. In order 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 percent. If we apply this 15 percent to the GTAP database, we obtain that multinationals control US$ 114,810.42 billion of capital stock in the UK. Then, we calculate the corresponding absolute values of 6.77, 10, 16.77, 20 and 30 percent decreases in total UK FDI stocks which correspond to 1.05, 1.55, 2.43, 3.10 and 4.64 percent reductions in the overall capital stock in this country.

5. Data

The database for micro and macroeconomic variables and the model's input-output framework come from the latest version of the GTAP 10 dataset (Aguiar et al., 2019b), which we disaggregate in 21 sectors, 5 economies (UK, EU, USA, China, and ROW), and 4 factors

(skilled and unskilled labour, land, and capital). We use this database to simulate our scenarios with the static and dynamic model. 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 2030, using GTAP dynamic database tools. The projections draw on available macroeconomic data of the Shared Socio-Economic Pathways (SSPs) projections on GDP per capita, population and employment growth developed by the International Institute for Applied Systems Analysis (IIASA).[6] GTAP has prepared a friendly version of the SPPs which includes the UN's population projections and that can be used with the GTAP recursive dynamic model. Compared to the projections of GDP and GDP per capita from other sources such as OECD, IMF and World Bank, which usually provide short and medium term projections, the SSPs version from GTAP include more countries in order to match the UN's population dimensionality and offers annualized projections that were initially available in 5-year steps (Aguiar et al., 2019a).

The baseline simulation allows projecting the economic conditions of the UK before Brexit comes into force. Table 2 and 3 provides a detailed sectoral picture of the UK economy for 2020.

On the one hand, Table 2 provides the industry share in total production, exports and imports (columns 2, 3 and 4), as well as the import and export share on total production by sector (columns 5 and 6).

[6] SSPs offer five pathways that the world could take; SSP1 (Sustainability, taking the green road), SSP2 (middle of the road), SSP3 (regional rivalry, a rocky road), SSP4 (inequality, a road divided) and SSP5 (fossil-fuelled development taking the highway). Differences between them come from assumptions on global population growth, access to education, urbanization, economic growth, resource availability, technological development and other factors.

Table 2. Initial data: Industry share in total production, exports and imports (percentage shares reference year, 2020).

Sector	Industry share in:			Import share in total production	Export share in total production
	Total production	Total exports	Total imports		
Agriculture	0.81	0.80	2.07	39.92	10.38
Other primary	0.80	2.21	5.31	104.45	29.21
Food	2.99	4.06	6.31	33.16	14.36
Textiles	0.51	1.54	6.30	192.34	31.52
Wood and Paper	1.25	1.38	2.55	31.95	11.68
Chemicals	4.51	14.57	13.43	46.75	34.12
Metals	2.82	11.18	7.01	39.03	41.86
Motor vehicles	1.91	9.71	9.52	78.32	53.74
Other transport	0.86	4.17	2.15	39.00	50.97
Electronics	1.02	4.10	7.78	119.38	42.31
Other machinery	2.14	6.61	8.81	64.50	32.54
Other manufactures	1.60	2.37	4.55	44.48	15.58
Construction	8.90	0.36	0.34	0.59	0.43
Water transport	0.81	0.65	0.57	11.11	8.51
Air transport	0.80	2.32	2.37	46.31	30.47
Communications	6.33	3.36	2.14	5.29	5.61
Finance	5.05	8.07	2.94	9.13	16.86
Insurance	1.94	2.23	0.39	3.19	12.16
Business services	12.32	12.87	6.60	8.41	11.03
Personal services	3.10	1.74	1.57	7.95	5.92
Other services	39.53	5.69	7.27	2.89	1.52
Manufatures	**30.12**	**63.06**	**76.14**	**39.64**	**22.09**
Services	**69.88**	**36.94**	**23.86**	**5.36**	**5.58**
Total	**100.00**	**100.00**	**100.00**		

Source: based on GTAP 10 baseline.

As we can see, data in Table 2 reflect a worldwide trend, in which manufacturing goods prevail on total trade. In the UK, the weight of manufacturing goods in total exports and total imports is beyond 60 percent, while services account for 36.94 and 23.86 percent, respectively. The sectors with the largest share in total exports and imports are chemicals, metals, motor vehicles, other machinery, business services, and other services.

Regarding the share of exports and imports in total production, it is smaller in services than in manufactures (columns 5 and 6), with the exception of air transport. This suggests that the bulk of production in services is sold in the domestic market.

On the other hand, Table 3 shows the bilateral trade flows of the UK with the EU, the US, China and the ROW. As we can see, the most important destinations of UK's exports are the EU and ROW, which account for 44.54 and 36.64 percent, respectively. Regarding UK's

imports, 44.34 percent come from the EU and 36.68 percent from ROW. On the one hand, agriculture, other primary, food, textiles, wood and paper and chemicals are those sectors in which more than 55 percent of total exports are sold in the EU. On the other hand, agriculture, food, wood and paper, chemicals and motor vehicles are those sectors in which more than 55 percent of total imports come from the EU.

Table 3. Initial data: Bilateral trade by sector (2020)

Sector	UK Exports to					UK Imports from				
	EU27	US	China	ROW	TOTAL	EU27	US	China	ROW	TOTAL
Agriculture	64.73	4.63	9.48	21.17	100.00	53.87	4.16	1.91	40.06	100.00
Other primary	86.95	1.18	2.83	9.05	100.00	8.49	2.39	0.08	89.05	100.00
Food	58.66	9.31	1.77	30.26	100.00	74.21	2.76	2.06	20.97	100.00
Textiles	70.44	4.02	3.06	22.48	100.00	26.99	1.04	39.02	32.94	100.00
Wood and Paper	56.41	5.73	8.66	29.20	100.00	61.86	9.43	15.20	13.51	100.00
Chemicals	55.81	13.29	3.92	26.98	100.00	62.14	8.34	5.81	23.71	100.00
Metals	20.42	4.40	10.84	64.34	100.00	37.08	10.61	9.16	43.14	100.00
Motor vehicles	43.15	11.25	19.98	25.62	100.00	82.97	1.62	1.93	13.48	100.00
Other transport	29.69	19.93	4.86	45.53	100.00	49.70	9.73	6.28	34.29	100.00
Electronics	53.89	9.27	8.10	28.74	100.00	33.87	6.98	41.06	18.09	100.00
Other machinery	42.65	12.00	5.42	39.92	100.00	49.58	7.62	24.48	18.32	100.00
Other manufactures	43.46	13.26	2.81	40.47	100.00	42.25	9.95	26.53	21.27	100.00
Construction	37.55	2.06	6.85	53.55	100.00	40.38	3.99	13.75	41.87	100.00
Water transport	39.67	5.33	3.03	51.97	100.00	45.27	2.10	1.46	51.18	100.00
Air transport	29.50	20.87	4.80	44.83	100.00	43.63	13.32	1.62	41.43	100.00
Communications	52.65	10.68	5.59	31.08	100.00	46.48	13.38	3.15	36.99	100.00
Finance	48.73	20.19	2.48	28.60	100.00	35.25	29.61	0.81	34.32	100.00
Insurance	20.43	31.57	9.51	38.49	100.00	48.45	17.73	3.29	30.53	100.00
Business services	47.46	6.06	6.03	40.45	100.00	40.33	12.23	4.96	42.49	100.00
Personal services	39.77	8.46	5.23	46.55	100.00	39.46	23.86	5.17	31.51	100.00
Other services	33.81	16.74	7.89	41.56	100.00	39.10	16.78	4.77	39.34	100.00
Manufacturing	**44.58**	**11.52**	**7.13**	**36.77**	100.00	**48.13**	**8.60**	**12.20**	**31.07**	100.00
Services	**42.85**	**13.78**	**5.54**	**37.82**	100.00	**40.40**	**16.59**	**3.80**	**39.21**	100.00
Total	**44.54**	**11.23**	**7.60**	**36.64**	100.00	**44.34**	**11.36**	**7.62**	**36.68**	100.00

Source: Authors' estimations based on GTAP 10 baseline.

As already noted, sectors that account for an important share in total exports and imports in the UK (e.g., chemicals, motor vehicles and business services), and those that have an important share on the bilateral trade with the EU (e.g., agriculture, other primary, food, textiles, chemicals and motor vehicles) would also be the most protected sectors once Brexit comes into force (Table 1). Therefore, the increase of barriers to trade between the UK and the EU would negatively affect trade flows in these sectors to a higher extent than in the rest of sectors. However, we cannot assume that the bulk of the adjustment in total production in these sectors would be related to the fit on trade flows. That is because, as we will note in the next sections, these sectors would face a negative impact from the reduction in the stock of FDI, too.

6. Empirical Results

6.1 Macroeconomic results

Table 4 offers a rich set of macroeconomic impacts arising from the emergence of trade restrictions and the reduction of FDI in the UK. In the case of barriers to trade, we provide a comparison of the results obtained with the static and dynamic GTAP CGE models. 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 2, 3 and 4 display the impact of trade restrictions in the UK considering the three scenarios of soft Brexit, Johnson's Brexit and hard Brexit. Columns 5, 6, 7, 8 and 9 provide the impact of a fall in the stock of FDI in the UK, also using the static model. Columns 10, 11 and 12 show the simultaneous impact of the emergence of barriers to trade and the reduction in the stock of FDI. Finally, the last three columns display the impact of trade barriers using the dynamic model in 2030.

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 middle and bottom parts of Table 4 on the results for the UK and the EU.

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 would imply a reduction in GDP in the UK between -0.49 and -1.02 percent, while the EU would face a fall between -0.06 and -0.14 percent. In addition, the UK would face a higher fall on 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.

Regarding trade restrictions, the decline in UK's GDP seems to be explained by the reduction of total production due to the fall in total output of industries such as motor vehicles, other primary, textiles, food, construction, communications and other services[7], which would face a reduction in exports. Barriers to trade constraint trade flows that is why both aggregate exports and imports go down. This contraction in production explains the fall in factors remuneration. Wages of skilled and unskilled workers go down, as capital remuneration does. Also, there would be a reduction in welfare. That is because of the fall in factors remuneration and due to the introduction of barriers to trade, which lead to a reduction in imports and competition from other firms. It would allow local firms to supply these goods at higher prices. Therefore, the variety of goods supplied in the local market would be more expensive than before the emergence of trade restrictions.

In terms of FDI stock reductions, 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. For example, the maximum reduction of 30 percent in the stock of FDI in the UK would imply a negligible effect on the GDP (-0.01 percent) in the Rest of the European Union.[8]

We obtain that with less capital GDP fall. So, we also find that there is an increase in capital rents, this is consistent with the economic theory by which less capital combined with the same amount of labour makes capital become more productive, thus, resulting in an increase

[7] This drop will be analysed in the microeconomic results, that are discussed below.

[8] Recall that we simulate the shock of reductions of the FDI stock in the UK alone, with no FDI shock whatsoever in the rest of the EU.

of its remuneration. To compensate the reduction in capital some sectors increase labour demand, which push up wages.

As mentioned above, less capital involves a reduction in GDP. That fall in GDP is explained by the drop in total production, which leads to a decline in aggregate exports. It also implies an increase in aggregate imports that would supply the local market.

Comparing the impact of NTBs and tariffs under the static and dynamic CGE models. We can see that the pattern of adjustment of the different variables would be the same, but the losses on GDP are more pronounced in the dynamic framework. Note that the impact on the UK's GDP would be almost double if we simulate the shock with the dynamic model. For example, in the static CGE model, the GDP would drop by -0.49, -0.73, and -1.09 percent in the UK under the soft, Johnson's and hard Brexit, respectively, while it would decrease by -0,96, -1.43, and -2.15 percent in the dynamic model. This is because in a dynamic setting the capital stock is no longer pre-determined but depends on the endogenous level of investment. Therefore, in this contractionary shock, the capital stock would contract.[9] However, due to the specifications of the model, it is not possible to simulate the effect of a potential reduction in FDI in isolation. Therefore, in a dynamic setting it is not possible to approximate how much of the impact of Brexit corresponds to a reduction in the stock of FDI.[10]

Therefore, to address this gap in the dynamic model, we use the static 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 and them we estimate the simultaneous impact of a reduction in the stock of FDI and the rise of barriers to trade using the static model (columns 10, 11 and 12). Second, we compare the results obtained with the static model with those from the dynamic model.

Note that the impact of a reduction in the stock of FDI by 6.77, 10 and 16.77percent, would lead to potential falls in the capital stock by -1.05, -1.55 and -2.43 percent, respectively (columns 5 to 7 and columns 10 to 12). These results are similar to those obtained under the dynamic model (row "capital stock", columns 13 to 15). For example: the impact of a reduction by -6.77 percent in the stock of FDI in the UK would imply a fall in the capital stock by -1.05 percent (row "capital stock"). This result is very close to the impact on capital stock under a soft Brexit in the dynamic setting (row "capital stock" and column 13). This pattern is similar when we compare the impact of a decline in FDI stock by -10 and -16.77 percent in the capital stock (i.e., -1.55 and -2.43 percent) to the impact of Johnson's and hard Brexit in the dynamic setting (columns 14 and 15). Due to that, we assume that under soft Brexit, the UK would face a reduction of FDI stock by -6.77 percent, while under the Johnson's and hard Brexit this reduction would be -10 and -16.77% percent (columns 10, 11 and 12).

[9] By contrast, the static setting focuses only on trade impacts without allowing the capital stock to adjust. In the static model, changes in the investment level only affect the composition of demand but have no impact on the capital stock.

[10] Despite this, the dynamic model allows for estimating the impact of Brexit in the long run.

We find that results from the static model are very close to those with the dynamic model, at least in terms of GDP.

With soft Brexit, the two static shocks together, barriers to trade and FDI reduction (-0.49% + -0.46% = -0.95%) yield a very similar impact on GDP to soft Brexit that combines both shocks in the dynamic setting, which implies a -0.95 percent adjustment in the GDP (columns 10 and 13).

For Johnson's Brexit, the static model yields a fall in GDP by -1.41 percent which comprises the impact of -0.73 percent due to barriers to trade and the effect of -0.68 percent because of the fall of 10 percent in the stock of FDI (i.e., a decline on the capital stock by -1.55 percent). The impact with the static model is very close to the one with the dynamic model (a reduction of -1.43 percent on GDP).

Finally, with hard Brexit, the static model yields a -1.09 percent fall in GDP due to trade barriers and a reduction of -1.07 percent GDP after the fall of -6.77 percent in FDI (i.e., a reduction of -2.43 percent in the capital stock). Note that the static shock yields a total impact of -2.15 percent in the GDP, which is the same as the -2.15 percent GDP impact in the dynamic hard scenario.

The capacity from the static model to decompose the impact of trade and FDI seems to proxy well the GDP results. It also seems to provide an approximation for the evolution of capital rents, wages, aggregate exports, and aggregate imports. This can be seen by comparing the sum of the impact of FDI reduction and the static trade restrictions with the impact of the dynamic model. However, in the case of welfare, the decomposition approach does not offer a good approximation to the impact derived in the dynamic setting. The differentiated impact of FDI, which raises factors' remunerations and aggregate imports with respect to the effects of barriers to trade that are contractionary for all micro variables, becomes clearer in the evolution of welfare. In addition, while FDI effects are more intense for GDP than in the case of trade, for welfare the opposite trend holds.

Despite the fact that for welfare the decomposition does not work so well, these results shed light to better understand the impact of a dynamic CGE model. They allow us to decompose the impact obtained with the dynamic model between trade barriers themselves and capital stock reductions. They reflect that the combined results of an increase of NTBs and the reduction of capital stock due to the potential fall in the stock of FDI would be close to the results obtained in the dynamic shock. Let us go to deeper into this analysis by looking at the sectoral results in the next section.

Table 4. Macroeconomic results

	Static CGE											Recursive Dynamic CGE		
												Cumulative results for the UK (2030)		
	Barriers to Trade			Reduction in FDI stock										
	Soft Brexit	Johnson's Brexit	Hard Brexit	6.77%	10.00%	16.77%	20.00%	30.00%	Soft Brexit + FDI 6.77%	Johnson's Brexit + FDI 10%	Hard Brexit + FDI 16.77%	Soft Brexit	Johnson's Brexit	Hard Brexit
GDP														
United Kingdom	-0.49	-0.73	-1.09	-0.46	-0.68	-1.02	-1.33	-2.06	-0.93	-1.41	-2.15	-0.96	-1.43	-2.13
Rest of the European Union	-0.06	-0.1	-0.14	0.00	0.00	0.00	0.00	-0.01	-0.07	-0.10	-0.13	-0.09	-0.13	-0.21
United States	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.03	0.04
China	0.01	0.01	0.02	0.00	0.00	0.00	-0.01	-0.01	0.00	0.01	0.01	0.03	0.04	0.07
Rest of the World	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.08	0.12
United Kingdom														
Wages														
Skilled	-2.31	-3.14	-4.59	0.05	0.08	0.13	0.16	0.25	-2.06	-3.06	-4.45	-1.92	-2.82	-4.06
Unskilled	-2.35	-3.46	-5.09	0.14	0.21	0.34	0.43	0.65	-2.2	-3.25	-4.74	-1.99	-2.9	-4.18
Capital Rents	-2.31	-2.90	-4.31	0.77	1.14	1.81	2.32	3.53	-1.35	-1.77	-2.51	-1.27	-1.85	-2.49
Capital Stock				-1.05	-1.55	-2.43	-3.10	-4.64	-1.05	-1.55	-2.43	-1.05	-1.56	-2.43
Welfare	-0.86	-1.28	-1.82	-0.23	-0.34	-0.53	-0.67	-1.02	-1.09	-1.61	-2.33	-1.47	-2.16	-3.03
Aggregate exports	-2.40	-3.33	-6.24	-1.28	-1.89	-2.96	-3.78	-5.64	-3.68	-5.20	-8.14	-4.32	-6.74	-11.27
Aggregate imports	-5.19	-7.41	-11.39	0.04	0.05	0.09	0.11	0.16	-6.24	-8.92	-13.73	-4.29	-6.11	-9.72
Rest of the European Union														
Wages														
Skilled	-0.20	-0.30	-0.53	-0.01	-0.02	-0.05	-0.04	-0.07	-0.21	-0.32	-0.59	-0.23	-0.35	-0.58
Unskilled	-0.22	-0.33	-0.61	-0.02	-0.03	-0.05	-0.06	-0.09	-0.24	-0.36	-0.66	-0.24	-0.36	-0.65
Capital Rents	-0.22	-0.32	-0.56	-0.02	-0.03	-0.04	-0.05	-0.08	-0.23	-0.35	-0.63	-0.18	-0.27	-0.49
Capital Stock												-0.06	-0.09	-0.16
Welfare	-0.07	-0.11	-0.18	-0.01	-0.01	-0.01	-0.02	-0.03	-0.08	-0.12	-0.19	-0.12	-0.18	-0.3
Aggregate exports	-0.14	-0.20	-0.31	0.01	0.02	0.03	0.04	0.06	-0.12	-0.18	-0.28	-0.27	-0.39	-0.72
Aggregate imports	-0.24	-0.33	-0.62	-0.02	-0.04	-0.06	-0.07	-0.11	-0.36	-0.56	-0.92	-0.26	-0.4	-0.76

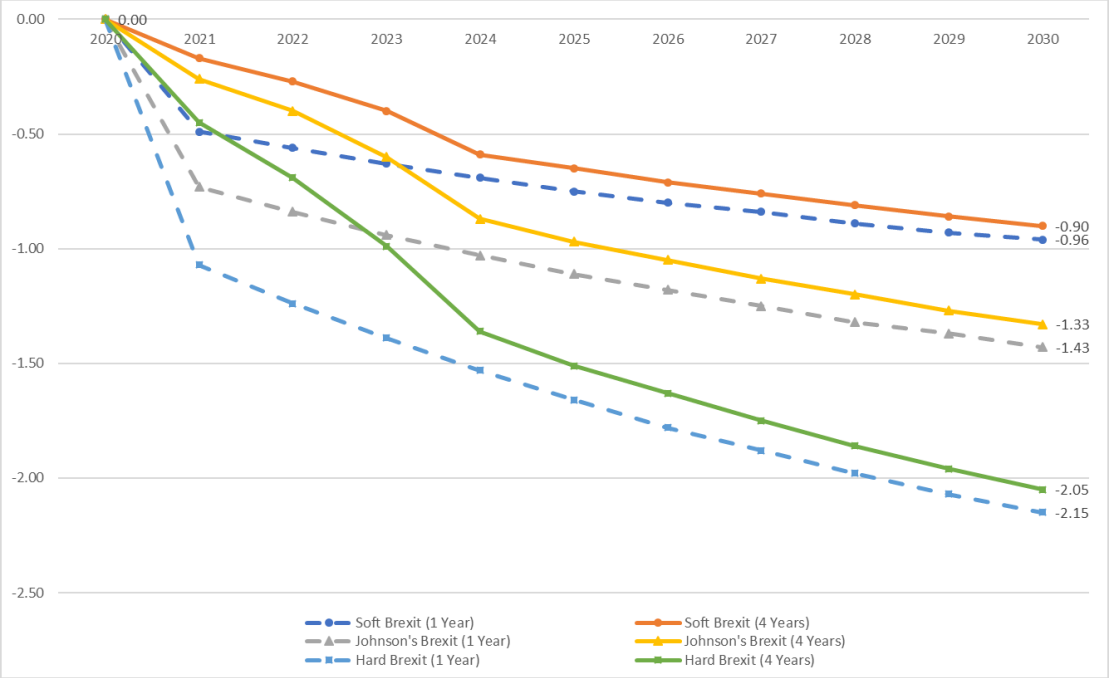
Source: Authors' estimations.

To identify how it can affect the way non-tariff barriers are simulated along time. We also apply two different techniques to simulate the emergence of barriers to trade using the dynamic model. First, we assume that all barriers to trade appear once the UK leaves the EU. We assume that the increase of NTBs and tariffs take place in 2021, due to the transition period ends on 31 December 2020. With the second technique, we assume a gradual increase in barriers to trade along 4 years. We apply one-third of the total shock in 2021, while the rest of the NTBs emerge gradually over the next 3 years (2022-2024).

Figure 1 shows the GDP cumulative percent deviation in the UK from 2020 to 2030. Results correspond to the three scenarios considered in the model, soft, Johnson's and hard Brexit. Dotted lines reflect the evolution of GDP when we apply the whole increase of barriers to trade in the first year, while solid lines indicate a gradual shock.

As we can see, both techniques provide similar results and tend to converge along time. The time it takes the economy to adjust once the complete shock is applied explains differences at the beginning of the period.

Figure 1. The UK's GDP cumulative percent deviation (2020-2030)



Source: Authors' estimations.

6.2 Microeconomic results

This section presents the main microeconomic results to the UK, obtained with the static and the dynamic model. We provide three tables that reflect how production, exports, and imports across sectors adjust once Brexit comes into force.

Table 5 displays the estimates obtained for soft Brexit. The first set of columns shows the results with the static model, which involves the shock of barriers to trade and the reduction of FDI stock by -6.77 percent. As noted, the fall of FDI stock by -6.77 percent implies a reduction in the capital stock of -1.05 percent (Table 4, row capital stock), which is equivalent to the drop in capital stock obtained for soft Brexit with the dynamic model. The second set of columns provides the results with the dynamic model.

Table 6 provides estimates for Johnson's Brexit. It shows the results with the static and the dynamic model, too. In the static model, we assume a reduction in the FDI stock by -10 percent, which leads to a drop in the capital stock by -1.55 percent (Table 4, row capital stock). This fall in the capital stock is the same that the UK would face under Johnson's Brexit with the dynamic model.

Finally, table 7 offers the results obtained for hard Brexit, in which we assume a reduction in the capital stock of -2.43 percent due to the fall in the stock of FDI by -16.77 percent. Similar to soft and Johnson scenarios, in hard Brexit, the reduction in the capital stock in the static model is equivalent to the fall of it in the dynamic model (Table 4, row capital stock, columns 12 and 15).

Note that sectoral adjustments after trade barriers clearly contrast with the one experienced with a reduction in the stock of FDI.

The rise of NTBs and tariffs would imply a negative impact on the flow of exports and imports in most sectors in the UK (columns 3 and 4 in Tables 5, 6, and 7). The increase of trade barriers would reduce exports in agriculture, other primary, food, textiles, wood and paper, chemicals, motor vehicles, other transport, and electronics; and would decrease imports in all sectors. Note that most of these sectors would be the most protected once Brexit comes into force, and they also have an important share in the bilateral trade between the EU and the UK (Tables 1 and 3). The adjustment on exports and imports lead to a fall in total production in other primary, textiles, motor vehicles, construction, communications, and other services.

Regarding the sectoral adjustment process due to a reduction in the stock of FDI. We can see that reductions in the capital stock bring a fall in production across the board, with the only exception of construction. That is because of the capital available in each sector. The drop in production and the rise in factor remunerations (Table 4) reduce exports, which also contract across the board. By contrast, imports go up slightly to compensate for the reduction in local production with foreign varieties and also because, with the increases in factor remunerations, domestic varieties have become relatively more expensive than imports.

By observing the results from the static model, we can assume that contractions in manufacturing goods production would be related to reductions in the stock of FDI and the fall in exports and imports, due to the increase of cross border costs to trade. While in services sectors, production declines would be explained to a higher extent by the reduction in FDI.

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 quite similar to the ones of the dynamic model that somehow combines these two shocks in a dynamic setting (columns 8, 9 and 10 in Tables 5, 6 and 7).

However, there are some differences between the results obtained under the static model and those under the dynamic framework.

Our results with the static model (in which we combine the effects of barriers to trade and FDI reductions) suggest that other primary, textiles, motor vehicles, and construction would face the largest decrease in total production. By contrast, food, electronics, chemicals, communications, finance, insurance, business services, personal services, and other services would be harmed to a lesser extent. Comparing to results in the dynamic model, food, electronics, and finance would face a positive impact. It means, that with the dynamic model, the number of sectors that will be negatively affected declines. In addition, the size of the impact differs across sectors between both, the static and the dynamic model.

These differences would be related to how we simulate the shock in FDI. In the static model, we run a homogeneous reduction in the capital stock in each sector. This means we apply a fall of -1.55 percent in the stock of capital to every sector under soft Brexit. By contrast, in the dynamic model, sectors would adjust their demand for capital in response to changes in the endogenous level of investment.

Table 8 provides estimates with the static and the dynamic model, it shows the simultaneous effect of barriers to trade and reductions in the stock of FDI in the demand of capital, production, exports, and imports across sectors under Johnson's Brexit scenario. We focus on the analysis of Johnson's Brexit, due to it seems to be the most likely scenario. Results seem to provide light on the impact of the adjustments in the demand for capital in production, exports, and imports across sectors.

First, we find that those sectors in which the increase (decrease) in production is greater with the dynamic model than with the static model face a rise (higher reduction) in the capital stock. Also, they experience higher growth (higher decline) in exports or a less reduction (less increase) in exports than in the static framework. On the other hand, those sectors which present a less reduction in total production with the dynamic model than with the static one, they also face a less decline in the stock of capital and a higher increase in their exports in the dynamic setting than in the static model.

Second, there are three sectors whose behaviour differs from the described above. Textiles, motor vehicles, and construction would face a less reduction in total production with the dynamic model than with the static one. However, they also would face a higher decrease in the demand for capital and a higher fall or less increase in exports.

Despite this, we consider our analysis is suitable to approximate the impact of FDI and trade barriers in the UK after Brexit.

Table 5. Impact on production, exports and imports under a soft Brexit scenario (percentage change)

Sector	Static CGE						Recursive Dynamic CGE		
	Barriers to Trade			Reduction in FDI stock (6.77%)			Cummulative Results for the UK (2030)		
	Production	Exports	Imports	Production	Exports	Imports	Production	Exports	Imports
Agriculture	0.71	-30.22	-10.93	-0.62	-1.21	0.13	1.66	-25.65	-7.90
Other Primary	-0.25	-46.51	-11.42	-1.05	-1.15	-0.52	-6.82	-49.74	-8.91
Food	-0.11	-26.57	-17.92	-0.60	-1.21	0.15	0.32	-26.54	-13.19
Textiles	-0.46	-11.03	-4.75	-0.97	-1.40	0.08	-1.10	-14.27	-2.69
Wood and Paper	1.41	-2.36	-6.31	-0.75	-1.53	0.14	1.15	-2.67	-4.54
Chemicals	0.85	-3.37	-5.49	-0.87	-1.12	-0.17	0.37	-4.03	-4.13
Metals	2.78	2.12	-2.53	-0.97	-1.12	-0.48	2.26	2.01	-1.81
Motor Vehicles	-2.76	-10.44	-8.65	-0.72	-0.92	-0.01	-3.04	-11.61	-4.97
Other Transport	0.99	-1.52	-9.52	-0.93	-1.42	0.43	1.19	-2.38	-6.09
Electronics	1.06	-4.51	-3.39	-1.11	-1.28	-0.18	1.37	-4.71	-1.77
Other Machinery	2.72	6.10	-2.50	-0.94	-1.41	0.17	2.76	7.44	-2.72
Other Manufactures	1.09	0.00	-5.37	-0.71	-1.71	0.34	0.61	-1.24	-3.91
Construction	-1.91	8.01	-7.40	0.12	-2.49	1.45	-1.63	3.29	-4.44
Water Transport	1.17	1.50	-3.41	-0.43	-0.42	0.09	0.75	1.08	-2.76
Air Transport	0.67	2.25	-2.05	-0.59	-0.84	0.01	0.08	1.46	-1.86
Communications	-0.19	2.11	-6.15	-0.45	-1.39	0.61	-0.66	0.01	-4.42
Finance	0.58	1.75	-4.61	-0.65	-1.23	0.17	0.05	1.00	-3.81
Insurance	0.32	3.92	-5.44	-0.70	-1.93	0.51	-0.15	2.97	-4.20
Businness Services	0.19	0.90	-5.75	-0.57	-1.52	0.34	-0.31	-0.26	-4.26
Personal Services	0.18	5.27	-4.11	-0.56	-1.92	0.51	-0.33	3.63	-3.83
Other Services	-0.20	5.26	-4.13	-0.40	-1.55	0.37	-0.67	3.19	-3.22

Source: Authors' estimations.

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

Sector	Static CGE						Recursive Dynamic CGE		
	Barriers to Trade			Reduction in FDI stock (10%)			Cummulative Results for the UK (2030)		
	Production	Exports	Imports	Production	Exports	Imports	Production	Exports	Imports
Agriculture	1.22	-40.63	-14.80	-0.92	-1.79	0.19	2.72	-34.10	-10.71
Other Primary	-0.28	-58.26	-14.06	-1.55	-1.70	-0.77	-7.94	-59.72	-10.99
Food	0.28	-35.23	-24.87	-0.88	-1.79	0.22	0.87	-34.97	-18.42
Textiles	-0.53	-15.67	-6.88	-1.43	-2.06	0.12	-1.47	-20.18	-3.88
Wood and Paper	2.12	-3.41	-9.22	-1.11	-2.26	0.21	1.66	-4.03	-6.58
Chemicals	1.16	-5.18	-7.98	-1.29	-1.65	-0.24	0.34	-6.31	-5.94
Metals	4.12	3.07	-3.58	-1.44	-1.65	-0.71	3.22	2.74	-2.55
Motor Vehicles	-3.65	-14.77	-12.57	-1.07	-1.36	-0.02	-4.06	-16.40	-7.20
Other Transport	1.76	-1.60	-13.60	-1.38	-2.10	0.63	1.85	-2.99	-8.71
Electronics	1.73	-6.35	-5.65	-1.64	-1.88	-0.26	2.06	-6.74	-2.58
Other Machinery	4.12	9.15	-3.77	-1.38	-2.08	0.25	4.06	10.96	-3.93
Other Manufactures	1.60	0.04	-8.52	-1.06	-2.52	0.51	0.83	-2.02	-5.62
Construction	-2.81	11.64	-10.96	0.18	-3.66	2.14	-2.42	4.37	-6.56
Water Transport	1.72	2.15	-5.36	-0.64	-0.62	0.13	1.08	1.48	-4.12
Air Transport	0.96	3.22	-3.11	-0.88	-1.24	0.01	0.03	1.92	-2.73
Communications	-0.33	2.11	-9.61	-0.66	-2.78	0.90	-1.05	-1.23	-6.75
Finance	0.76	1.84	-7.25	-0.96	-1.82	0.26	-0.07	0.44	-5.74
Insurance	0.46	5.58	-8.59	-1.04	-2.84	0.75	-0.28	3.90	-6.43
Businness Services	0.20	0.27	-9.08	-0.84	-2.25	0.50	-0.56	-1.68	-6.51
Personal Services	0.26	7.59	-6.27	-0.82	-2.82	0.75	-0.52	4.93	-4.95
Other Services	-0.29	7.62	-6.29	-0.59	-2.28	0.55	-0.98	4.38	-4.79

Source: Authors' estimations.

Table 7. Impact on production, exports and imports under a hard Brexit scenario (percentage change)

Sector	Static CGE						Recursive Dynamic CGE		
	Barriers to Trade			Reduction in FDI stock (16.77%)			Cummulative Results for the UK (2030)		
	Production	Exports	Imports	Production	Exports	Imports	Production	Exports	Imports
Agriculture	2.24	-56.40	-20.02	-1.46	-1.82	0.30	4.65	-47.53	-15.10
Other Primary	-0.25	-63.11	-15.85	-1.44	-1.66	-1.20	-6.46	-68.12	-15.43
Food	1.75	-52.38	-38.89	-1.38	-1.81	0.34	2.62	-53.73	-39.14
Textiles	-3.58	-37.70	-12.01	-2.24	-3.23	0.19	-5.70	-45.42	-13.81
Wood and Paper	3.10	-5.26	-13.62	-1.74	-3.54	0.33	1.86	-7.91	-9.39
Chemicals	0.48	-11.99	-13.32	-2.03	-2.59	-0.38	-1.43	-14.80	-10.16
Metals	4.92	2.60	-6.41	-1.26	-1.58	-1.12	3.07	1.38	-4.87
Motor Vehicles	-6.97	-29.16	-23.91	-1.68	-2.13	-0.03	-7.64	-33.55	-14.45
Other Transport	2.31	-2.32	-19.31	-2.16	-3.29	0.99	2.02	-4.91	-12.41
Electronics	2.52	-9.48	-8.52	-2.57	-2.95	-0.41	1.70	-12.07	-8.97
Other Machinery	4.66	7.57	-6.04	-2.17	-3.26	0.40	3.68	7.17	-6.58
Other Manufactures	1.68	-4.63	-13.29	-1.66	-3.94	0.80	0.54	-8.12	-8.47
Construction	-4.31	18.54	-13.31	0.27	-5.68	3.37	-3.70	6.59	-8.99
Water Transport	2.68	3.46	-6.83	-1.00	-0.97	0.20	1.54	2.22	-5.19
Air Transport	1.35	4.61	-4.10	-1.37	-1.95	0.01	-0.38	1.98	-3.48
Communications	-0.37	5.32	-12.40	-1.04	-4.34	1.41	-1.52	0.08	-6.80
Finance	1.38	4.36	-9.38	-1.50	-2.85	0.41	0.05	2.18	-7.61
Insurance	0.81	8.77	-10.73	-1.62	-4.45	1.19	-0.28	6.16	-8.16
Businness Services	0.48	2.75	-11.52	-1.32	-3.52	0.78	-0.78	-0.38	-8.47
Personal Services	0.51	11.72	-8.32	-1.29	-4.41	1.19	-0.67	7.47	-6.56
Other Services	-0.34	11.60	-8.38	-0.93	-3.56	0.87	-1.39	6.36	-6.33

Source: Authors' estimations.

Table 8. Impact on demand of capital, production, exports and imports under Boris Johnson's Brexit scenario (percentage change)

Sector	Capital		Static CGE (Barriers to trade + FDI fall)			Recursive Dynamic CGE Cummulative Results for the UK (2030)		
	Static CGE	Dynamic CGE	Production	Exports	Imports	Production	Exports	Imports
Agriculture	-1.55	2.78	0.32	-41.85	-14.51	2.72	-34.10	-10.71
Other Primary	-1.55	-8.37	-1.83	-59.06	-14.53	-7.94	-59.72	-10.99
Food	-1.55	0.09	-0.55	-36.48	-24.54	0.87	-34.97	-18.42
Textiles	-1.55	-2.23	-1.93	-17.50	-6.74	-1.47	-20.18	-3.88
Wood and Paper	-1.55	0.86	1.01	-5.65	-8.97	1.66	-4.03	-6.58
Chemicals	-1.55	-0.25	-0.15	-6.80	-8.17	0.34	-6.81	-5.94
Metals	-1.55	2.18	2.61	1.35	-4.26	3.22	2.74	-2.55
Motor Vehicles	-1.55	-5.01	-4.65	-15.96	-12.55	-4.06	-16.40	-7.20
Other Transport	-1.55	0.76	0.40	-3.72	-12.96	1.85	-2.99	-8.71
Electronics	-1.55	1.14	0.07	-8.17	-5.36	2.06	-6.74	-2.58
Other Machinery	-1.55	3.16	2.67	6.86	-3.48	4.06	10.96	-3.93
Other Manufactures	-1.55	0.04	0.54	-2.54	-8.00	0.83	-2.02	-5.52
Construction	-1.55	-3.12	-2.58	7.44	-8.94	-2.42	4.87	-6.56
Water Transport	-1.55	-0.19	1.07	1.52	-5.23	1.08	1.48	-4.32
Air Transport	-1.55	-0.87	0.06	1.92	-3.10	0.03	1.92	-2.73
Communications	-1.55	-1.65	-0.99	-0.77	-8.77	-1.05	-1.23	-6.75
Finance	-1.55	-0.77	-0.20	-0.03	-7.00	-0.07	0.44	-5.74
Insurance	-1.55	-0.67	-0.59	2.59	-7.90	-0.28	3.90	-6.43
Businness Services	-1.55	-1.20	-0.63	-2.01	-8.61	-0.56	-1.68	-6.51
Personal Services	-1.55	-1.10	-0.57	4.55	-5.55	-0.52	4.93	-4.95
Other Services	-1.55	-1.76	-0.88	5.14	-5.77	-0.98	4.88	-4.79

Source: Authors' estimations.

7. Conclusions

According to UNCTAD (2018) reductions in FDI inflows have already taken place in the UK in 2017. Despite the importance of FDI in the UK, the effects of the impact of FDI after Brexit have received little attention in the literature.

This study extends the analysis of Brexit by including the impact of a reduction in the inflow of FDI with respect to previous estimates about the increase of barriers to trade or migration. To this aim, this research implements two models, a static and a dynamic one.

The dynamic model allows for estimating the impact of Brexit in the long run. However, it is not possible to simulate in isolation the impact of a potential reduction in the stock of FDI, due to investment adjusts endogenously in a dynamic model. Therefore, to disentangle the effects of Brexit due to an increase of barriers to trade from the impact by a fall in the stock of FDI, we use the static model.

The joint results with the static model (the fall in the stock of FDI and barriers to trade) are quite close to the results obtained with the dynamic model. Therefore, our analysis sheds light to approximate the impact of a reduction in FDI in the UK after Brexit and disentangle trade and FDI effects in the dynamic model.

We find that the impact of Brexit would be more harmful to the UK than to the EU. With the static model, the simultaneous impact of barriers to trade and reductions in the stock of FDI imply a fall between -0.45 and -2.15 percent in the UK's GDP. While the EU would face a reduction between -0.07 and -0.14 percent.

In general, we find that results from the static model are very close to those with the dynamic model. At the macroeconomic level results are similar at least in terms of GDP. For example, with the static model, the GDP in the UK would drop by -0.95, -1.41, and -2.15 percent, under soft, Johnson's and hard Brexit, respectively, while it would decrease by -0.96, -1.43, and -2.15 percent in the dynamic model.

At the microeconomic level, the sectoral adjustments due to trade barriers clearly contrast with the one from a reduction in the stock of FDI. The emergence of barriers to trade would imply a negative impact on the flow of exports and imports in most sectors in the UK leading to a reduction in total production in motor vehicles, other primary, textiles, food, construction, communications, and other services. On the other hand, the decrease in the stock of FDI would produce a drop in production across the board leading to a reduction in exports too.

We also find that results and patterns of adjustment in the static model (in which we combine both, barriers to trade and reductions in the stock of FDI) are quite similar to the ones of the dynamic model. Differences in results would be related to how the demand for capital across sectors is adjusted. For example, those sectors in which the increase (decrease) in production is greater in the dynamic model than in the static model, face a rise (higher reduction) in the capital stock. Note that the stock of capital in the dynamic model adjusts endogenously. Hence estimates from the static model do not exactly fit the ones from the dynamic model.

With the dynamic model, we also apply to two different techniques to simulate the impact of barriers to trade (first all barriers to trade appear once Brexit comes into force and second the gradual increase of trade barriers along 4 years). We find both techniques provide similar results and these results tend to converge along time.

Finally, Boris Johnson's proposal is not as favorable as a soft Brexit but would better conditions than leaving the EU without a deal. Losses under a hard Brexit imply a reduction of GDP by -2.15 percent by 2030, while under the Boris Johnson's proposal the UK would face a GDP loss of -1.43 percent.

Sensitivity Analysis

To evaluate the robustness of our model, we employ an unconditional systematic sensitivity analysis. This consists of re-running all the scenarios included in this paper but changing the values of three crucial elasticities: the elasticity of substitution between labour and capital, the Armington substitution between imports and domestic goods and the Armington substitution among imports by origin. To do that, each elasticity has been varied, one by one, while keeping the rest fixed at their initial value. This approach follows the sensitivity analysis developed in Harrison et al. (1993), Latorre and Hosoe (2016) and Ortiz and Latorre (2019), among others.

We perform the sensitivity analysis of the results obtained across our six simulations under the static model (i.e., soft, Johnson's, and hard Brexit, and FDI reductions of 6.77, 10 and 16.77 percent) and across our three simulation under the dynamic setting (i.e., soft, Johnson's and hard Brexit). To simplify, this analysis focuses on the effects for GDP. The results are displayed in Table 9.

Note that in those scenarios, in which we assume the increase of barriers to trade under the static framework, results are robust to changes in the value of the elasticity of substitution between factors. On the other hand, larger values in the Armington substitution between imported varieties and domestic goods, and in the Armington substitution among imports by origin, lead to slightly lower GDP losses in the UK than with smaller values of these elasticities. That is because, if consumers and producers can more flexibly substitute goods, the GDP losses due to barriers to trade would be lower. Larger values of these elasticities imply that the UK can more easily substitute the trade lost with the EU with imports from other regions or with domestic production. These reductions in losses when there is more flexibility becomes more marked in the dynamic setting. Overall, the results suggest that our previous results are robust to different elasticities' specifications, even though in the long run slight deviations from the short run are accumulated and the trend becomes somewhat more intense.

In those scenarios in which we only assume FDI reductions, results are quite robust to the different values of the three elasticities.

Table 9. Sensitivity Analysis.

			GDP								
			Static Model						Dynamic Model		
			Soft Brexit	Johnson's Brexit	Hard Brexit	FDI 6.77%	FDI 10%	FDI 16.77%	Soft Brexit	Johnson's Brexit	Hard Brexit
Value		EU27	-0.06	-0.10	-0.14	0.00	0.00	0.00	-0.09	-0.13	-0.21
		UK	-0.49	-0.73	-1.09	-0.46	-0.68	-1.07	-0.96	-1.43	-2.15
		USA	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.03	0.04
		CHN	0.01	0.01	0.02	0.00	0.00	0.00	0.03	0.04	0.07
		ROW	0.01	0.01	0.01	0.00	0.00	0.00	0.01	0.08	0.12
A) Elasticity of substitution between labor and capital	Double	EU27	-0.06	-0.10	-0.14	0.00	0.00	0.00	-0.10	-0.15	-0.24
		UK	-0.49	-0.73	-1.10	-0.47	-0.69	-1.09	-1.01	-1.49	-2.27
		USA	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.03	0.05
		CHN	0.01	0.01	0.02	0.00	0.00	0.00	0.03	0.05	0.08
		ROW	0.01	0.01	0.01	0.00	0.00	0.00	0.06	0.08	0.13
	Half	EU27	-0.07	-0.10	-0.14	0.00	0.00	0.00	-0.07	-0.11	-0.17
		UK	-0.49	-0.74	-1.09	-0.45	-0.66	-1.04	-0.85	-1.26	-1.88
		USA	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.03
		CHN	0.01	0.01	0.02	0.00	0.00	-0.01	0.02	0.03	0.05
		ROW	0.01	0.01	0.01	0.00	0.00	0.00	0.05	0.07	0.10
B) Elasticity of substitution between imports and domestic production (Armington)	Double	EU27	-0.06	-0.10	-0.14	0.00	0.00	0.00	-0.10	-0.15	-0.23
		UK	-0.45	-0.68	-1.01	-0.47	-0.69	-1.08	-0.79	-1.16	-1.74
		USA	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.03
		CHN	0.01	0.01	0.01	0.00	0.00	0.00	0.02	0.03	0.05
		ROW	0.01	0.01	0.01	0.00	0.00	0.00	0.04	0.05	0.08
	Half	EU27	-0.06	-0.10	-0.14	0.00	0.00	0.00	-0.07	-0.11	-0.18
		UK	-0.52	-0.79	-1.18	-0.46	-0.68	-1.06	-1.15	-1.70	-2.58
		USA	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.04	0.06
		CHN	0.01	0.01	0.01	0.00	0.00	0.00	0.04	0.05	0.09
		ROW	0.01	0.01	0.01	0.00	0.00	0.00	0.07	0.10	0.15
C) Elasticity of subtitution between regional allocation of imports	Double	EU27	-0.06	-0.10	-0.14	0.00	0.00	0.00	-0.08	-0.11	-0.17
		UK	-0.39	-0.57	-1.03	-0.47	-0.69	-1.09	-0.86	-1.24	-1.79
		USA	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.03	0.04
		CHN	0.01	0.01	0.02	0.00	0.00	0.00	0.03	0.04	0.06
		ROW	0.01	0.00	0.01	0.00	0.00	0.00	0.05	0.07	0.10
	Half	EU27	-0.07	-0.11	-0.16	0.00	0.00	0.00	-0.10	-0.16	-0.27
		UK	-0.52	-0.80	-1.20	-0.45	-0.66	-1.04	-0.93	-1.40	-2.10
		USA	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.03	0.04
		CHN	0.01	0.01	0.02	0.00	0.00	-0.01	0.03	0.04	0.07
		ROW	0.00	0.01	0.01	0.00	0.00	0.00	0.05	0.08	0.12

Source: Authors' estimations.

Notes: EU27 stand for the Rest of the European Union.

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