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BREXIT AN ANALYSIS OF UK TRADE FLOWS

Borja García Izu

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Antonio Gómez Gómez-Plana
Análisis Económico

**ABSTRACT**

This paper analyses the current situation of Brexit focusing on the UK trade. The aim is to evaluate how important the EU membership for the UK is because Free Trade and European Integration are beneficial for the UK. The Gravity Model of International Trade augmented with dummy variables is applied following two different approaches. First, 2016 Cross-sectional data and second, 1995-2016 Panel data for United Kingdom. With this methodology it is demonstrated that the Gravity Model holds for the UK trade flows. Besides, the EU membership does enhance UK trade being more important for imports than for exports. The EU membership overcomes non-tariff barriers and has created more trade for the UK than diverted. Therefore, Brexit would shrink welfare mainly in the UK and unevenly in EU member states.

**KEYWORDS**

**0. Index**

## 1. Introduction

The aim of this paper is to analyse how British trade is enhanced thanks to European Union (EU, hereinafter) membership. The upcoming exit of the United Kingdom (UK) from the EU is an issue of big concern within the European framework. The pace of Europe is going to be shaped by this event not only in the short-run but also in the long-run because the post-Brexit relationship that the EU is going to have with the UK is going to define the future of trade flows. There are many fields that are going to change, and one of them is trade. Both the UK and EU members will be affected after Brexit.

The Gravity Model developed by Tinbergen (1962) is a relationship where trade flows are explained by the GDP of each trading country and distance, that acts as trade barrier between countries. It has been chosen as the empirical tool for the analysis because of its robustness and consistent relationship in international trade, as Bergeijk and Brakman (2010) show. Besides, it can be implemented with economic and non-economic variables that are useful for the explanation of tariff and non-tariff barriers hindering trade. Hence, the model will be applied with two different approaches. First, on 2016 UK trade flows with a cross-sectional data, and second, on 1995 to 2016 for UK trade flows with panel data.

The structure of the paper is as follows. First, the background of Brexit is going to be explained in Section 2. Section 3 shows how important the static and dynamic gains coming from trade are, as well as the gains from European integration. Section 4 will contrast studies from contradictory points of view: Europeanism vs. Euroscepticism. Section 5 makes an analysis of UK trade and how they are linked to the EU. Section 6 applies two gravity models on UK trade flows: one using 2016 cross-sectional data and the other one, 1995-2016 panel data. Then, the options that UK has outside the EU and its outcomes are reviewed. Finally, some conclusions are provided.

## 2. What is Brexit?

Brexit stands for "BR" of Britain and "Exit" from the EU. This word first appeared in 2013 when David Cameron promised to hold a referendum about the EU membership in case the conservative political party were going to win the next general elections. Brexit supporters argued that having some powers from Brussels back were going to be beneficial making UK stronger, and, on the other hand, EU supporters argued that staying at the EU significantly

reduces risk of conflict and makes Britain more powerful by boosting trade and investment between UK and the rest of Europe. Since the very first moment this idea came up, there has been an intense debate about which option is more advantageous for the UK country. Therefore, UK having to leave the EU is facing a trade-off, which is to negotiate the access to the Single Market in exchange of continuing following rules or reduce the ease of access in return of gaining regulatory sovereignty (Springford and Tilford, 2014).

After 43 years of United Kingdom being part of the European Union, when they applied for the second time in 1973 for joining to the EU, the UK decided to leave with a referendum which took place in June 2016. This implied the application of the Article 50 of The Lisbon Treaty, which was triggered on 23 March 2017 after UK notified its intention to leave to the EU.

The Article 50 of The Lisbon Treaty states:

*"1. Any Member State may decide to withdraw from the Union in accordance with its own constitutional requirements.*

*2. A Member State which decides to withdraw shall notify the European Council of its intention. In the light of the guidelines provided by the European Council, the Union shall negotiate and conclude an agreement with that State, setting out the arrangements for its withdrawal, taking account of the framework for its future relationship with the Union. (…)*

*3. The Treaties shall cease to apply to the State in question from the date of entry into force of the withdrawal agreement or, failing that, two years after the notification referred to in paragraph 2."*

*(…)*

The application of this article grants two years for negotiating the exit before UK had totally left. By 23 March 2019, Brexit will officially take place. Until then, the UK has the same rights and obligations with the European Union partners.

Fortunately, the door does not close for ever. According to the fifth point of the Article 50, the UK country might decide to re-join the EU if they wanted to and trigger the Article 49.

## 3. Welfare gains from trade and European integration

Having access to the biggest single market on Earth with few barriers of entry and the inexistence of tariffs makes participants, as the UK is, enjoy higher living standards and an increase on welfare thanks to free trade and integration. Then, in this section it will be briefly

overviewed what economic principles, based on international economics and trade, say about trade liberalization and integration of countries.

## 3.1    Gains from trade

Firstly, it is needed to know the benefits and costs implied from being a part of the European Union, which means enhancing trade thanks to the four freedoms (free movement of goods, services, people and capital) as stated in the Maastricht Treaty (1993) and the abolition of tariffs on goods and the standardization of rules that firms need to follow to be able to sell in 27 different countries and several trade agreements and associations with countries worldwide.

Generally, the economic literature mainstream shows and prove that free trade is good for countries´ welfare. However, sometimes countries prefer to impose barrier in their own markets in order to control market imperfections (second-best) and protect strategic home sectors by using tariffs, subsidies, quotas or voluntary export restraints. The gains of trade can be split up into static (short-run) and dynamic effects (long-run).

### 3.1.1    Static trade effects

When countries trade between each other, as the Ricardian model predicts, they will specialize in which they have a comparative advantage. Eaton and Kortum (2002) apply the Ricardian model considering artificial and natural barriers, showing that trade liberalization and its promotion through comparative advantage, increases welfare by benefiting any country with a bigger availability of goods and services without no one being worse off, a Pareto improvement. They also show that natural barriers such as distance, and artificial barriers such as transport costs, tariffs and quotas reduce the trade between and countries and, therefore, they inhibit welfare.

By empowering and increasing trade, not only there are cheaper goods available, but also countries enjoy from a diverse and higher variety of goods and services because as long as countries trade more with each other, the market diversity or width that a consumer can enjoy is higher than either country alone, and furthermore, each country exploits the good or service their markets are made for because of the possibility of taking advantage from economies of scale (Krugman, 1980).

### 3.1.2    Dynamic trade effects

In the long-run, dynamic gains can be found. Trade increases the GDP growth rate, R&D&I

investment and thus, the technology transmission as well as the diffusion of learning effects which shortens learning curves across countries. Trade induces a reorganization of production that raises domestic productivity so welfare gains from trade can become arbitrarily large (Melitz and Redding, 2014).

Trade fosters technological change and improvement of technology since it strengthens competition among firms, and therefore, they are forced to seek new ways of improving in a regular-basis by rethinking and reorganizing production, which results in an increased productivity and undoubtedly an increase in a country´s welfare (Melitz, 2003).

## 3.2 Gains from European integration

Apart from the general gains coming from trade, the case aimed to be analysed in this paper also needs from some economic theory about the consequences of economic integration, in other words, the economic benefits and costs of the European integration process in economic magnitudes and the four freedoms, whose final long-term target is the political integration of member states.

The process of economic integration is defined as the arrangement between physical regions, which aim to increase trade and coordinate monetary and fiscal policies. There exist four frames to act with, Free Trade Area, Custom Union, Common Market and Economic and Monetary Union. The EU already controls trade policy and most of the countries (19, not the UK) have already outsourced their monetary policy to the European Central Bank who issues the euro currency.

Within the European framework two different effects on trade can be identified in the stage of customs union, trade creation and trade diversion. These two effects rely on the idea that within a Free Trade Area creation with a Customs Union, members can be worse off or better off, trade diversion and trade creation respectively.

Trade creation exists when a country A is not buying a particular good from abroad because their own production results in the best alternative for them because the price of goods from other countries are more expensive when a tariff is imposed. If this country A is going to form a customs union with country B, whose good´s price without tariff is cheaper than the own production, the country will enjoy more quantity of goods at a cheaper price coming from B imports, and trade has been created. This is a gain because the consumer surplus gains outweigh the producer surplus loss.

On the other hand, think of the same country A whose best choice is importing goods from a country C because their price of that good plus the tariff imposed is better than own production or than any other country. Now, a customs union between country A and B is created and the tariff to country C is maintained. If it is supposed that once the customs union has been made, the best alternative for A is importing from B rather than C because there is not a tariff on that B´s good anymore. It is true that now country A will enjoy more quantity of that good at a cheaper price, that is a consumer surplus increase, however the revenue coming from the tariff imposed to C is lost. Then, this is known as trade diversion and it would make a country worse off whenever the loss of a previous tariff revenue is higher than the gains (consumer surplus) coming from enjoying a good cheaper.

The magnitude of trade creation and diversion depends on several factors. It is important to bear in mind that the more similar the economies of the union partners, the higher the probability that trade creation offsets trade diversion. When the price spread between the union partners is higher, the higher the trade creation, and when the price spread between a union country that is going to be the new partner and the external country, the higher the trade diversion effect. Besides, trade creation is positively related to the ex-ante tariff with the union partner whereas the trade diversion is positively related to the ex-post common tariff applied after the custom union. Finally, the bigger the size of the new customs union, the higher the probability of trade creation against trade diversion.[1]

According to Gandoy and Diaz (2000), it can be confirmed that the European integration process has contributed to trade creation, primarily on manufactured goods, fostering productivity, competitiveness and welfare. On the other hand, it is known that in agriculture goods, trade diversion has been governing due to the Common Agriculture Policy exerted by the EU.

### 3.3   EU challenges on trade and outcomes of integration

In case of trade within the EU, it is true that thanks to free trade, there does not exists huge obstacles to trade with EU partners and trade in goods is the most mature and developed market. Services market has followed a slower growth and more hindrances, and it is one of the highest challenges for the EU since approximately 70% of EU GDP is based on services[2].

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[1] See "Economia de la Union Europea" Gandoy and Diaz (2000), Chaper 5.
[2] See "Economía de la Unión Europea" Gandoy and Diaz (2000), Chapter 6.

This is of consideration for the UK, since part of its comparative advantage are services.

Currently there exists non-tariff barriers on goods and services such as technical barriers, access to public contest, differentiated fiscal systems or sanitary and quality requirements. The market for services should be freer and for that it is needed more cooperation until the achievement of a full customs union. EU complexity is challenging for a full integration especially for modern technologies, energies and infrastructure.

Although some periods of economic recession have affected the EU there has been a sustained growth in most of the member states. Through integrating policies in education, capital investment and R&D&I, there are evidence of improvements in productivity based on technological innovation and higher efficiency of public bodies as well as more labour mobility in spite of language barriers, a field where there still exists a lot of work to do.[3]

In summary, economic integration in the EU and its free trade in the four markets, breaks tariff barriers and tries to overcome non-tariff barriers, improves terms of trade[4], fosters product differentiation as well as economies of scale and enhances savings and investment to be used in technical progress. All these effects head to convergence among EU countries. In fact, poorer EU countries have grown faster than the richest thanks to integration. Consequently, the UK, when leaving, would begin to lose a part of the benefits from trade liberalization and, primarily from integration with the European Union that they had gained.

## 4. Brexit welfare estimations: Europeanist vs. Eurosceptic

Unfortunately, some estimations on welfare analysis are not free from political ideology. Thus, in this section it will be discussed the position of each party. Despite of their differences, both parties agree that free trade is good, and they value it, however, they disagree on whether this free trade should be done with a higher priority for the EU rather than the rest of the world (Springford and Tilford, 2014).

### 4.1 Brexit supporters: Euroscepticism

In general, the shared belief among Eurosceptic people is that the loss coming from Brexit would be totally outweighed by the benefits. For them, since the monetary union was carried out, UK is far from the main integration proposition that the EU promotes, and that

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[3] See "Economía de la Unión Europea" Gandoy and Diaz (2000), Chapter 4.

[4] Terms of trade is Price of the exports (EU) relative to Price of the imports (Rest of the World) and it is heavily related to welfare and states wellbeing. An improvement of terms of trade usually leads an increase on welfare.

proposes differ significantly with the ones of UK. Besides, the UK country will enjoy from higher bureaucratic and decision-making independence in addition to not paying the fee for being part of the EU. When it comes to trade, they claim that UK would be able to trade more with non-EU countries through new trade deals without facing the constraint of European rules and interests (Dhingra *el al.* 2016).

Minford (2016), who belongs to the economic mainstream "Economists for Brexit", supports by following the standard trade model that exiting the EU and substitute the customs union for unilateral free trade, the UK will make gains thanks to trade agreements with other small countries that will divert UK trade flows to these markets without affecting overall trade or output levels. In fact, he also points out that UK´s welfare would increase by 4% as a result of increased trade by abolishing unilaterally all its import tariffs. However, on the other hand, taking this position in the world market would increase wage inequality and a downturn of the manufacturing industry. These two last drawbacks seem to be hard to sell them to citizens when persuading them to leave, despite of that, Brexit won. This policy is known as "Britain Alone". After Brexit, UK will not be tied to tariff barriers to exporters in accessing the Single Market of the EU anymore.

## 4.2  Brexit critics: Europeanism

As expected, there exists a vast amount of criticism against these claims partially led by the Centre of Economic Performance (CEP) of the London School of Economics and Political Science (LSE).[5] They clustered several papers in unique report about Brexit Dhingra and Sampson (2016), Dhingra *et. al* (2016) and Dhingra *et. al* (2017), where they use state-of-the-art static models and calculate structural estimations based on calibrated quantitative trade models. In fact, these economists find that the "Britain Alone" scenario after Brexit results in a decrease between 1% and 2,3% in UK incomes. Bhagwati (2002) argues that unilateral freeing is generally less beneficial than reciprocity, although it can trigger sequential reciprocity. Most of them point out that Minford´s results ignore most of the empirical evidence on trade, such as the existence of gravity in trade patterns and the fact that joining the EU has created new trade supported by evidence. He just assumes that the only reason for importing a product is the price, so any decision in buying a product will lead to the cheapest offer, while quality is not considered at all. Nowadays, ignoring the gravity

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[5] Note that the academic literature is limited since Brexit is a recent event.

relationship between economic size and distance, implies being a step back when statically working with modern trade models and current patterns.

Although the EU does have restrictive rules about product safety and quality which might become products a bit more expensive, he assumes that the price differences when buying goods from the EU compared to low-cost countries are only based on the trade barriers that the EU has. Besides, for Minford, it seems that goods and services can effortlessly sold regardless of their natural or artificial barriers. Then, since it is widely known that trade satisfies the gravity equation and that EU has certainly created trade creation and not trade diversion, it can be concluded that Minford´s model is inconsistent with international trade. Sampson *et. al* (2016).

Lastly, it should be discussed an argument appropriated by some Eurosceptic people regarding immigration. They argued that immigration was a threat for the UK´s economy. However, some studies findings Kierzenkowski *et. al* (2016) and Dhingra *et. al* (2016) show that this kind of statements are misleading, since immigrants coming to UK are skilled, they increase productivity, real wages and eventually aggregate demand because they also consume goods and services which helps in the creation of national employment. Changes in wages and unemployment has little correlation with changes in EU immigration.

Now, the estimated economic and trade losses incurred from Brexit will be overview. For UK leaving the EU will make them poorer, mainly due to reduced trade since they are losing free access to the largest Single Market on the planet. Additionally, uncertainty coming from negotiations and how future relationships between UK and EU will be, are also potential factors which would affect both UK and EU.

The only foreseeable gain coming from Brexit is that would not have to pay the fee that is only 0,4 % of national income and it is never higher than the estimated losses of national income, which ranges between 6% and 9%. In fact, if UK hypothetically agrees in the European Free Trade Agreement (EFTA), like Norway does, the UK country should continue paying a fee and, additionally they would lose the right to vote.

When it comes to trade, the EU is currently the largest UK trade partner and it will continue being so. Crafts (2016) states that thanks to the EU, the British GDP per capita increased between 8.6% and 10.6%. The UK is just 18% of the EU´s Single Market and approximately half of its trade is made with the EU and being a part of it makes goods cheaper for UK consumers and transactions easier for businesses. However, the UK country leaving would

mean decreased trade due to higher barriers and, also the opportunity cost of losing some future benefits from further market integration and trade deals with USA and Japan if UK would remain the EU, which is estimated to improve real incomes by 0,6%. The effect of trade on income would result in a decrease between 1,3% to 2,6% in average UK incomes. Besides, it is thought that if leaving, 1% trade decrease worsen income per capita by 0.5% and 0.75% Feyrer (2009). In the long-run, the reduction of trade would worsen productivity, which would cause a loss between 6,3% and 9,5% of the GDP. The dynamic losses are also related to less investment on R&D, decreases in productivity and a technology development slowdown Dhingra *et. al* (2017).

By making smaller the amount of trade with EU countries, the estimated loss on GDP is between 26 and 55 billion pounds, which is twice bigger than the loss from Brexit of all EU members together, and yes, the overall world welfare will be reduced because of Brexit. Furthermore, UK will have to deal with a loss of bargaining power when arranging trade deals, since it is not going to be a member of the Single Market anymore.

Finally, Foreign Direct Investment (FDI), which is an important factor in trade (but, since this paper has its constraints it is not going to be analysed), raises productivity and thus, wages and output. Pain and Young (2004) claim that EU membership has increased GDP by 2.25% through FDI flows. Half of FDI inflows in the UK are coming from the EU and most of it is also coming because of the attractiveness that the UK has in accessing the Single Market. With Brexit, FDI investment is forecasted to fall by 22% in the next decade with a higher impact on key sectors such as car industry and financial services. It is widely known that FDI investment brings enhanced productivity thanks to new technologies and management practices which are shared in form of spill-overs to British firms Bloom *et. al* (2012) and Haskel *et. al* (2007).

## 5.  UK trade with the EU: Analysis and current state

Before going forth, it is important to take into account which effects the EU has had on UK´s trade. At first sight, it can be said that there exists little evidence supporting the EU-membership has pulled down trade with non-EU-countries and that, in spite of the fact that trade importance between UK and EU decreased because of the past financial crisis and current stagnation of the European economy. This is not a significant reason to leave because the only reason that the UK country would benefit from exiting the EU is that it had created more trade diversion rather than trade creation, which it is not the case because membership

has boosted trade in goods by approximately 30% (Springford and Tilford, 2014).

## 5.1    UK trade

The UK country has been dealing these last years with a negative trade balance as seen in Figure 1. However, free trade plays a very important role for its economy since it is a crucial source of income and moves forward the economy. Except for major shocks such as the Great Depression and World wars, both exports and imports have been accounted for over 20% of UK´s GDP, and reaching the 30% of it nowadays, which accentuates the upcoming drawbacks from Brexit.

**Figure 1** *Importance of Trade to the UK Economy as a percentage of GDP*
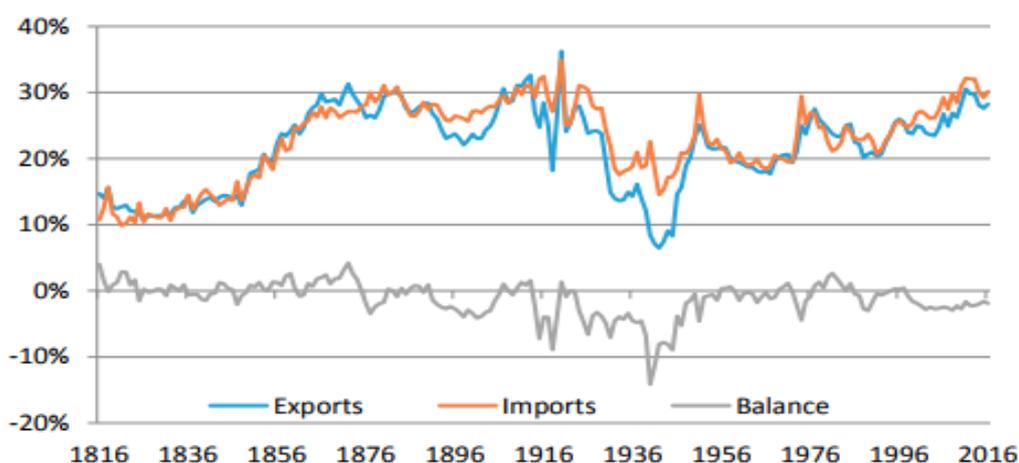


Source: Fox (2017) UK Department for International Trade

Historically, these increases in UK trade have been led primarily by the growth of intra-industry trade, which has played a key role in UK manufacturing industry with 80% of trade, and by the development of cross-border supply chains, mainly intermediate goods[6].

When it comes to UK exports, the most important partner by far it is the United States (US), that is 15% of 2016 UK exports. During the stagnation because of the 2008 financial crisis (2011-2016) of the EU economy, exports to US have increased by 26%, meanwhile the UK exports to the EU have decreased. On the other hand, UK imports are led by a EU partner, that is Germany. German imports count for approximately 14% of 2016 UK imports.[7]

The UK has a strong comparative advantage in services related to financial and business services. The UK country exports in services has grown more than twice the EU GDP since

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[6] Source: Fox (2017) UK Department for International Trade
[7] ONS Digital (2018) who does the UK trade with?

1998 and 1.5 times with the US, but that increase is explained due to the US economy expands faster than the EU economy (Springford and Tilford, 2014). This also shows the importance of the EU market when exporting UK´s comparative advantage.

Despite of that, manufacturing industry persists as crucial part of UK trade being higher than services. Goods are 55% of total exports and 75% of total imports in 2016. It is important to consider that 47% of UK goods exports go to the EU. Besides, the EU is a source of many intermediate goods that UK needs for producing final goods, for example the car industry. [8]

## 5.2  UK-EU trade composition

The fact that the EU lets UK to freely trade with other 27 countries, makes the EU the most important market and trade partner for the UK country. According to data provided by the Office for National Statistics (ONS[9]) from UK, membership and access to the Single Market allows that 48% of total exports from the UK are done within the EU meanwhile imports coming from the EU are almost 54% of total UK imports. These data show that the trade for UK is not only crucial for its economy, but also its partnership with the EU since it is the biggest area that the UK trade with. Furthermore, the UK economy runs a trade deficit with the biggest economies in the EU, which has been used as an argument for Eurosceptic for voting to leave as they claimed that they were going to take advantage from leaving and stop running these trade deficits, that as it has previously seen, it is not a proper argument.

In fact, the biggest trade deficit that the UK runs with a EU country is with Germany, because it is the largest source of imports, however it is the second country when it comes to the destination of exports. Furthermore, the trade deficit that UK also runs with France and the Netherlands, they are the third and fourth destination of exports. Trade reduction with these countries will harm the UK economy.

Figure 2 shows total merchandise trade (exports and imports) of the UK country relative to UK GDP from year 1960 to 2016 and the total merchandise trade with the EU relative to UK GDP from year 1993 to 2016[10]. When UK joined the European Economic Community (EEC) in 1973, there was a big rise of its trade relative to GDP within a short period of time,

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[8] ONS Digital (2018) UK goods trade with EU partners.
[9] Office for National statistics that is the UK's largest independent producer of official statistics and the recognised national statistical institute of the UK
[10] Note that data for EU merchandise trade before 1993 is unavailable.

from 30.38% in 1972 up to 44.81% in 1975. Since then, this indicator has not been lower than the maximum value before they joined, 33.37% in 1969. The shock of joining the EEC for the UK, which later became the EU and the biggest single market in the world, is remarkable and it gives a clue about the importance for the UK to continue as a part of the EU. Unfortunately, it cannot be compared with EU trade data to see the quantitative change of UK trade composition with the current EU countries.

**Figure 2** *Total UK merchandise trade as % of UK GDP*
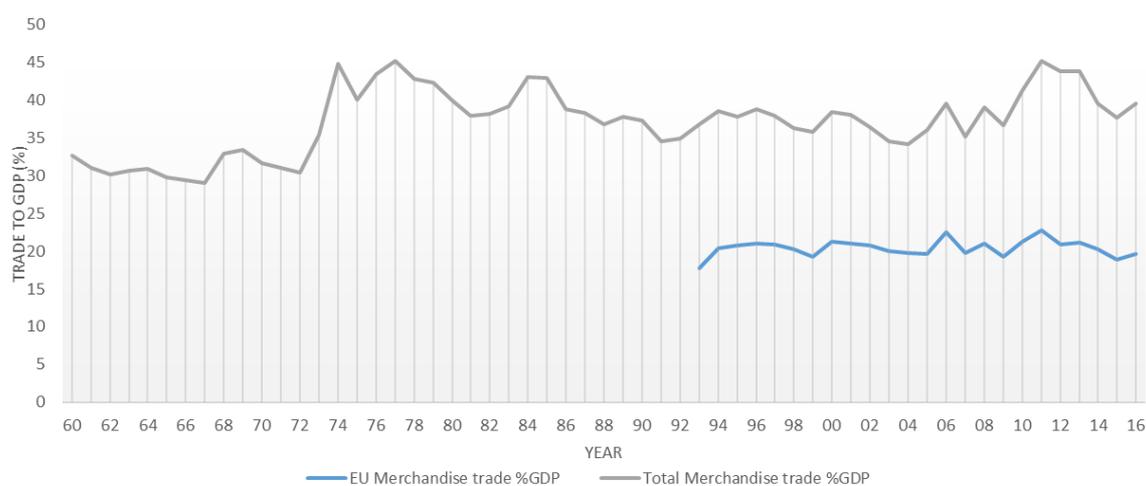


Source: Own elaboration. Data source: World Bank and WITS

However, it can be observed that the blue line that corresponds to EU merchandise trade counts approximately half of the UK trade. Moreover, it follows approximately the same trend as the total merchandise trade does, except for years after the 2008 financial crisis. This demonstrate a previous statement, that during the economic downturn, UK tended to trade more with USA, who lasted less time in recovering, than with the EU. That is why the gap between UK total trade and the EU total trade becomes bigger from 2009 to 2014. In spite of this fact, EU total UK trade counts for 19.63% against total UK trade 39.51%, so it is still a big stake.

Most importantly, it should be considered, how the trade of UK is like with the EU members. Although it would sound obvious, it must be recalled that UK is entirely an island which may make trade a bit more complicated with neighbours. The existence of sea and the adjacency are important factors when it comes to the ease of trade.

Figure 3 shows an important relationship that consists of how the size, that is GDP 2016 of any EU member state (blue dots) relative to the total size of the EU somehow shapes the

weight of each country on the UK 2016 total trade[11] with member states of the EU. Thus, the weight of a EU country that has on UK trade it would be higher whenever the weight of this country is high in terms of GDP relative to the EU GDP. As a reference, the steeped line is 45º line. Whenever a country is on the right-hand of the 45º line, it trades less with the UK than it should trade according to its GDP weight. A country lying on the left-hand side, trades more than it should trade.

**Figure 3** *UK trade with EU and EU GDP size 2016*
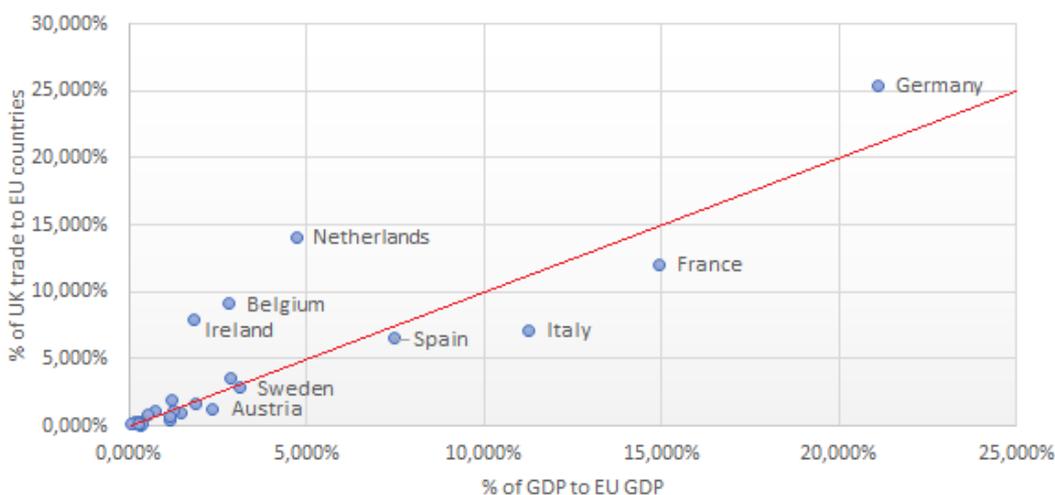


Source: Own Elaboration. Data Source: Eurostat and WITS

This relationship is important to the extent which gives a first approach to what it is going to be applied later, the gravity model. The gravity model tries to predict something similar. From this figure it can be easily concluded, that the positive relationship holds for the UK country and the EU. Germany is the biggest country member of the EU and therefore, it is also the most important ally for UK in terms of trade relationships within the EU. Approximately 25% of total UK trade with EU member states is arranged with Germany. Note that in terms of total trade, exports plus imports, Germany is the most important trade partner, being the second destination of UK exports and the first country supplying goods and services to the UK.

The next three biggest countries are France, Italy and Spain. According to their economic GDP size, their importance in the UK trade share is lower than it is for Germany. The reason is because these three economies do not bear too much on their trade as a basis of their

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[11] Exports + Imports

economy as Germany does. Nevertheless, the relationship still applies.

There are two particular cases when looking at the figure. First, Belgium and The Netherlands are two countries with low share in the total EU GDP that clearly show a big share in UK trade relative to their size in the EU. There might be two main reasons behind this phenomenon. The first reason has to do with the fact that these two countries are small rich countries whose economies has been based mainly on exporting manufactured goods. Furthermore, it is important to take into account that both countries have access to overseas, which opens a wide range of opportunities. Their commercial ports are worldwide known due to their concurrence, the Antwerp port for Belgium and the Rotterdam port for The Netherlands. In fact, the latter is the biggest one in Europe. The second reason is trivial. The distance separating these two countries with the UK country makes trade easier than with any other countries in spite of sea land between them.

Ireland is the second case that, as The Netherlands and Belgium do, shows more share in UK trade than it should show according to its EU share in terms of size. The causes behind this are that, Ireland shares border with the UK, North Ireland precisely, both countries speak English, which makes trade easier and that of course, Ireland is closer to the UK than many other countries belonging to the EU are.

Then, it can be assumed that if more countries are added to the figure, the dispersion between the right-hand and left-hand would be similar if it is follow the same methodology. Unfortunately for the British that statement is wrong. Figure 4 has been computed with the same approach but with new non-EU big countries (red dots), China, Russia, USA, Japan, Turkey, Brazil and Argentina. These countries have been chosen because the EU is currently negotiating deals with them and because of their importance in the world economy. All of them, except for Turkey, lie on the right-hand side of the 45º line, which means that they do not trade with the UK as much as they should do according to their GDP.

Besides, in Figure 4, every EU member state is on the left-hand side of the 45º line. From this, it can be concluded that the EU membership is very important in shaping UK trade flows and the fact that Turkey is on the left-hand side is due to its membership to the Customs Union, which also fosters trade. Finally, an important conclusion, which is going to be analysed, is that also distance is an important non-tariff barrier on trade.

**Figure 4** *2016 UK trade with EU, USA, China, Turkey, Brazil, Argentina, Russia and Japan*
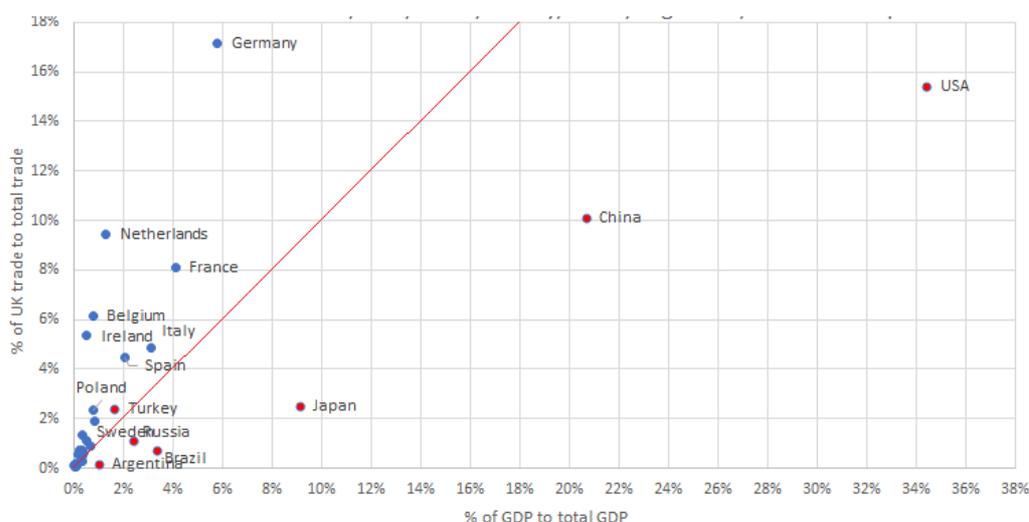


Source: Own Elaboration Data source: Eurostat, World Bank and WITS

## 5.3    Potential impact of Brexit on EU member states

Of course, there exists an important nuance that should not be forgotten. The impact of Brexit on the EU economy is going to differ among countries. The bigger effect on EU economy is going to be provided by the biggest member countries. That is why in Figure 5, the EU top 11 biggest countries in 2016 GDP terms have been arranged in order to show how important trade with the UK country is for them. The share of 2016 exports and imports for the UK to each country has been added to contrast some data graphically. Countries are ordered according to their export share to the UK, from left to right.

**Figure 5** *2016 Exports and Imports share of top 11 EU countries and the UK*



| | Ireland | Netherlands | Belgium | Spain | France | Germany | Poland | Denmark | Sweden | Italy | Austria |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ■ Share of Exports to UK | 12,79% | 8,99% | 8,90% | 7,52% | 7,05% | 7,02% | 6,61% | 5,99% | 5,86% | 5,39% | 3,05% |
| ■ Share of Imports from UK | 23,84% | 5,35% | 4,77% | 4,09% | 3,84% | 3,72% | 2,55% | 4,13% | 5,17% | 3,01% | 1,76% |
| ■ Share of Exports for UK | 5,57% | 6,19% | 3,82% | 3,17% | 6,43% | 10,64% | 1,38% | 0,82% | 1,51% | 3,19% | 0,59% |
| ■ Share of Imports for UK | 2,85% | 7,45% | 4,95% | 3,34% | 5,65% | 13,84% | 1,97% | 0,84% | 1,33% | 3,80% | 6,19% |
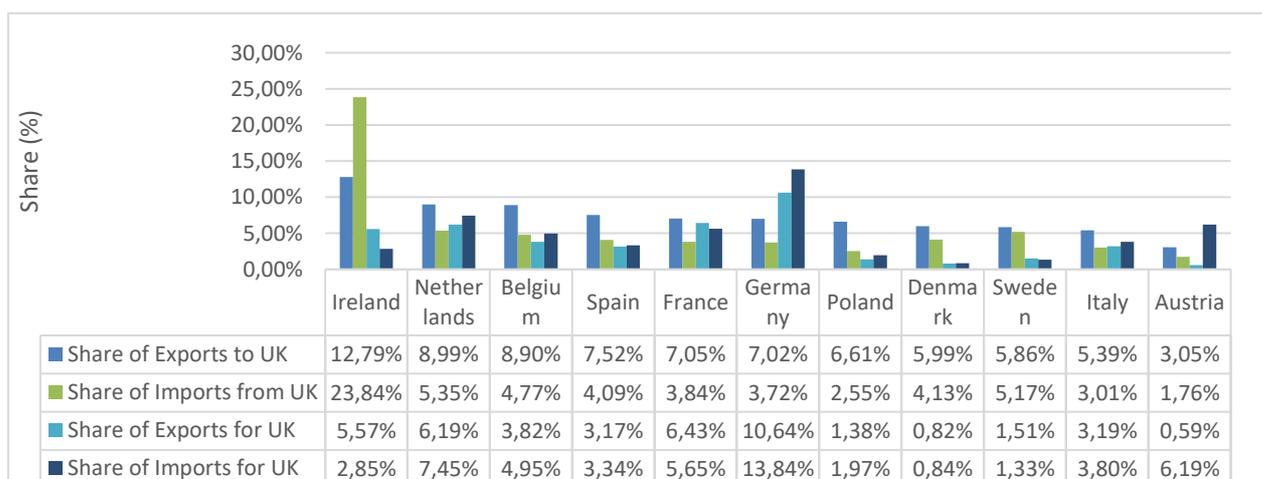
Source: Own Elaboration. Data source: WITS

Ireland has the highest dependence on the UK economy with 23.84% of imports coming from the UK and 12.79% of Irish exports going to British territory. For Ireland, Brexit is an issue of big concern. The reason is that although the UK matters to Ireland, for the UK the share of Irish exports (share of UK imports from Ireland) is just 2.85% which is not too much for them. Something similar happens with Irish imports from UK, for the British they are just 5.57 % of total UK exports. In this case, the UK gains a bit of negotiation power. Ireland is followed by Netherlands, Belgium, Spain, France and Germany. Except for Belgium, they are in the top 5 EU biggest economies, so this also supports the idea that Brexit will also affect greatly EU top Economies

In contrast, Germany exports and imports share to UK are of less importance than the other way around, that is British exports and imports share to Germany. Germany exports to the UK is 7.02% which represent a British share of 13.84%. On the other hand, Germany imports from the UK are 3.72%, counting for 10.64%. In this case Germany would count with more negotiation power for the EU.

In conclusion, the top 11 economies account for 43.31% of total UK exports and 52.21% of total UK imports, that means that the UK is in a disadvantageous position in negotiating a trade deal with the EU. They are going to be much more affected by Brexit although the EU members are not free from burden and need of consideration.

## 6. The Gravity Model and empirical analysis

This section analyses the UK trade flows taking into account several variables by using the gravity model. Then, it could be foreseen which are the effects on UK trade and the consequences of exiting within the EU frame.

### 6.1 The gravity model

The gravity model is an econometric formulation that was inspired by the Newton´s "law of universal gravity", by which the attraction of two objects depends on the masses, and this is proportional to the distance multiplied by gravitational constant. Hence, Tinbergen in 1962 developed a model by which this gravity law could be applied to predict the trade flows of a country $j$ with a country $i$.

The model consists of the following formula:

$$(1) \quad T_{ij} = R_j \frac{GDP_i^{\varphi} GDP_j^{\beta}}{D_{ij}^{\gamma}}$$

Where $T_{ij}$ is the trade flow between country of origin $i$ and destination $j$, this trade could be whether exports, imports or total volume of trade, GDP is the Gross Domestic Product of a country $i$ and $j$ with an exponent of $\varphi$ and $\beta$ that sets the impact of these two GDPs in trade flows, and D is the distance between country $i$ and $j$, with also an exponent $\gamma$ setting the impact of distance on trade flows.

The variable R is called remoteness or gravity factor, which can be interpreted and calculated by several methods. The existence of this variable is explained by the fact that a country that is isolated would trade more with the closest partners than with the rest of the world because its partners will deal with less competition and a narrower set of choices. The example given by Head (2003) shows that the gravity model would predict that given the distance and GDPs of countries, say Portugal-United Kingdom and Australia-New Zealand, which are approximately at the same distance from each other, the prediction of trade flows between them would say that trade between United Kingdom and Portugal is larger than trade between Australia and New Zealand. This is a false statement because the trade between the two isolated countries, Australia and New Zealand is nine times larger than the other. In a sense, it can be seen that the fact that a country is isolated or is remote, this country would have higher dependence from the closest neighbours. The case of United Kingdom and Portugal shows that these two countries are surrounded by many other countries and therefore, have access to more markets, diversifying their trade flows.

Remoteness it is hard to measure as well as to apply, and it has been assumed many times to be constant across countries and it is going to be set apart from this research by using a constant $k$, because the UK country does not have the unique geographical features that an isolated country has, so it does not have many sense to estimate this variable in this case study.

This might sound very simplistic; however, it is actually one of the most robust relationships found in economics and it is able to predict pretty well the patterns of trade across countries Bergeijk and Brakman (2010). What it basically tells, it is that the amount of trade flowing between two countries depends positively on the economic mass of both them and negatively on the distance between them. Distance in this model is used as a proxy of trade barriers and costs such as transport costs, time length of shipments, risk, cultural distance…, mainly non-

tariff barriers, and thus, the higher the distance, the lower the ease to trade.

This model has been further developed and many variables can be added to it as well as variation over time as it is going to be seen forth with panel data.

Previous studies of Brexit with panel data Belke *et. al* (2017), Brakman *et. al* (2017) and Oberhofer and Pfaffermayr (2017) show that Brexit lead to a significant fall of UK-EU trade, there is no trade enhacement alternative except to the one similar to the current situation and trade diversion effects caused by EU membership are lower than the gains.

## 6.2    Cross-sectional data 2016

In this section the gravity model is tested for total UK trade, exports and imports for UK data of 2016. Then, it shows the importance for the UK to belong to the EU, especially for its imports. Having arranged the data with a final N of 181, the parameters can be calculated with a regression ran by the econometric software Gretl. The estimators will be found using Ordinary Least Squared (OLS) when cross-sectional data is analysed.

### 6.2.1    Data source

The exports and imports data has been gathered from the WITS (World Integrated Trade Solution), which is a simple yet powerful tool that gives access to merchandise trade and tariff related statistical information, for the trade flows of UK with the rest of countries of the year 2016 in current thousand dollars. The 2016 GDP[12] in current dollars has been taken from the World Bank database, (that it is consistent with WITS, since the latter is linked with the world bank) and has been converted into thousand dollars. Both WITS and World Bank are trustful sources for this data analysis and gather most of the data available worldwide. Distance between the UK and the rest of countries has been calculated with the Haversine[13] formula by using longitude and latitude data found at CEPII Mayer and Zignago (2011), which provides the geographical coordinates of capital cities of each country in the world. CEPII is a French research centre in international economics which produces studies, research, databases and analyses on the world economy and its evolution. Although there

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[12] Some minor countries have been removed from the analysis due to the lack of updated data or availability: Aruba, Bermuda, Cayman Islands, Cuba, Djibouti, Eritrea, Feroe Islands, French Polynesia, Gibraltar, Greenland, Isle of Man, North Korea, Libya, Liechtenstein, Monaco, Myanmar, New Caledonia, Puerto Rico, Syria, Turks and Caicos Islands, Venezuela, Virgin Islands and British Virgin Islands.

[13] The Haversine formula allows computing the distance between two points that are found in a curved surface from two coordinates. See Robusto (1957).

exist other data sources, these ones have been found to fulfil the needs of this paper.

### 6.2.2  2016 Total trade analysis

The first model to analyse is a very simple one, and later new variables will be added to it:

$$(2) \quad T_{ij} = k \frac{GDP_j^{\beta}}{D_{ij}^{\gamma}}$$

It is the same model as (1) but without Remoteness, that there is a constant instead and without the UK GDP. Since this first estimation of parameters are with cross-sectional data, this implies that the UK GDP is constant, that is the 2016 UK GDP. Therefore, it should be removed from the model due to exact collinearity and it takes the value of 1 in the model because its exponent parameter $\varphi$ is 0.

In order to rightly estimate the parameters, the equation is converted into logarithms as it follows. This is **Model 1**:

$$(3) \quad ln\,T_{ij} = ln\,k + \beta\,ln\,GDP_j + \gamma\,ln\,D_{ij} + u_i$$

What is expected from this first estimation is that $\beta$ would be positive and provide the *ceteris paribus* percentage mean increase in total trade flows between the UK and a country j, when the GDP of a given country increases 1%. Besides, the $\gamma$ parameter is expected to affect negatively the total trade flows. Then, it would estimate the *ceteris paribus* percentage mean decrease of total trade flows between the UK and country j, when distance between the UK and a given country is increased by 1%.

The $u_i$ term is all other variables affecting trade flows that are omitted in this model, that is the residual. In order to be an unbiased model, it should be assumed that the expected value of $u_i$ given other independent variables in the log formulation to be 0:

$$(4) \quad E\big(u_i\big|D_{ij}, GDP_j\big) = 0$$

However, since the model is logged and as Arvis and Shepherd (2011) state ( $ln\,E(u_i) \leq E(ln\,u_i)$ ), it usually shows a pattern of heteroskedasticity with the variance depending on the other dependent variables ant therefore, and hence, the parameters would not be BLUE (Best Linear Unbiased Estimators) any more:

$$(5) \qquad Var(u_i) = \sigma_{ij}^2 = f(D_{ij}, GDP_j)$$

This means that the variance is not constant among individuals and therefore, when the model is run in Gretl it must be corrected for heteroskedasticity. That is why every model in this paper needs of this kind of correction.

For now, the model will be kept that way and it is going to focus on how the gravity model behaves in predicting and explaining the UK trade flows. Then, the model can be expanded.

The regression of Model 1 in Gretl tells that both parameters $\beta$ and $\gamma$ are significant enough to say that they are different from 0, with 99% of confidence interval. Residuals have been checked for normality and the $R^2$ is big, with 88,32% of changes of the dependent variable, total trade flows, are explained by changes in the regressors, basically, distance in km and GDP. Table 1 contains the results of the models regressed in this subsection. Modelling and results interpretations follow these data:

**Table 1: 2016 UK Trade Flows: Cross-Sectional Data Analysis (OLS and heteroskedasticity-corrected)**

| Dependent variable: Regressor | Total Trade Flows | | Imports | | | Exports |
|---|---|---|---|---|---|---|
| | **Model 1** | **Model 2** | **Model 3** | **Model 4** | **Model 5** | **Model 6** |
| **const $k$** | -0.74 | -3.47** | -4.80*** | -10.63*** | -10.59*** | -1.01 |
| | (1.01) | (1.37) | (1.51) | (2.03) | (0.96) | (1.31) |
| **$GDP_j\ \beta$** | 1.06*** | 1.05*** | 1.25*** | 1.22*** | 1.24*** | 0.97*** |
| | (0.03) | (0.03) | (0.05) | (0.05) | (0.05) | (0.03) |
| **$D_{UKj}\ \gamma$** | -0.61*** | -0.29** | -0.66*** | 0.05 | - | -0.49*** |
| | (0.08) | (0.13) | (0.11) | (0.18) | - | (0.13) |
| **$EU_j\ \delta$** | - | 1.00*** | - | 1.95*** | 1.88*** | 0.57** |
| | - | (0.25) | - | (0.37) | (0.22) | (0.23) |
| $R_2$ | 0.88 | 0.88 | 0.80 | 0.82 | 0.82 | 0.88 |
| $F\ test$ | 673.56 | 450.59 | 370.85 | 279.55 | 408.27 | 451.58 |
| | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |

Notes: N=181. Parameters are percentage change since they have been calculated as logs. Note that for the dummy $EU_j$ the percentage change is computed as it states: $(e^\delta - 1)x100$ when the dummy is 1, otherwise there is no percentage change $(e^{\delta*0} - 1)x100 = 0\%$. The robust standard deviations are found in parenthesis. For the F-test, the p-value is found also in parenthesis. Individual parameters are 1%, 5% or 10% significant depending on ***, ** and * respectively. Gretl outputs are located in Annexes section.

Source: Own Elaboration. Data come from Gretl outputs.

From the regression it can be confirmed that the total UK trade flows (exports plus imports) with the rest of the is working as it has predicted when explaining the model. Then, when the distance separating a country from the UK increases by 1%, the effect on total trade flows is a mean reduction of 0,6227% other things equal. Keeping other variables constant and when the GDP of a trade partner are increased by 1%, the total trade flows increase in mean by 1,0668% if other variables are kept constant.

In this first regression of the model, it is interesting to analyse two figures that clearly show the positive or negative relationship coming from the parameters that first regression has estimated. This is also interesting in order to show a graphical view of how good the model is behaving.

Figure 6 graphically shows how the model behaves, that are the blue dots and how data actually is, that are the red dots. The closer the blue dots with the red dots, the better because the error term $u_i$ is lower for that country and the model better explains this relationship. What it can be appreciated at the figure is one of the two important relationships of the gravity model. It explains how distance, lnDistancekm is negatively related with lnTotaltradeflows. As it can be seen, the total trade flows of UK with a given country becomes smaller as long as distance is increased.

**Figure 6** *Actual and fitted relationship between Total Trade Flows and Distance*
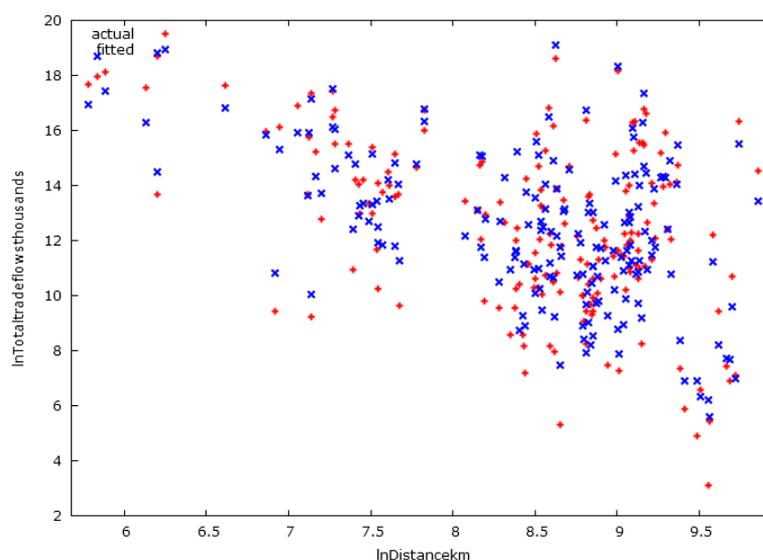


Source: Own Elaboration, Gretl output.

Likewise, Figure 7 relates Total trade flows, (lnTotaltradeflows) of UK with each country's GDP, (lnGDP). Similarly, the closer these dots, the better the model. The second figure may show a stronger relationship than the first one. That is why, GDP explains more changes in total trade flows than distance does. As it can be observed, as long as the GDP of the country trading with the UK, the total trade flows become higher.
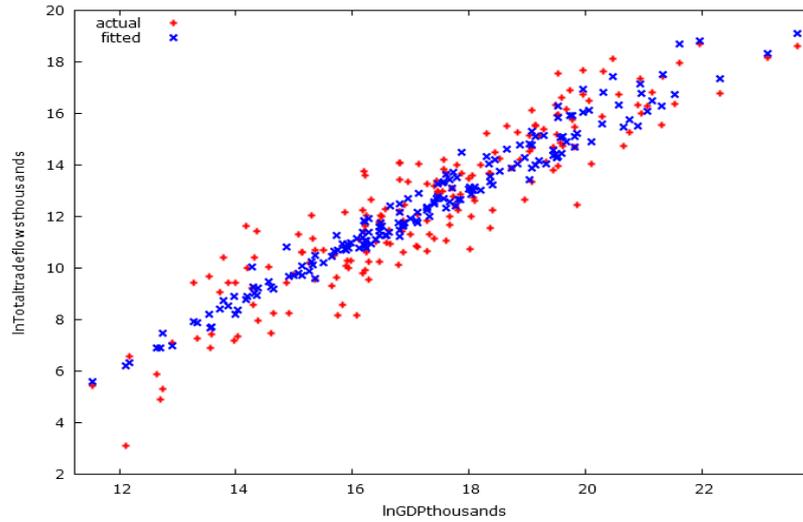
**Figure 7** *Actual and fitted relationship between Total Trade Flows and GDP*



Source: Own Elaboration, Gretl output.

The first regression is important in order to see that the model works well with the trade of UK. However, this paper aims to see how important the trade of the UK with the EU is.

Then, the first regression may be too naïve if the target is to analyse the membership of UK to the EU, and, in order to estimate the effect of being part of the EU, the model must be modified in the following way:

$$(6) \qquad T_{ij} = k \frac{GDP_j^{\beta}}{D_{ij}^{\gamma}} \cdot e^{\delta EU_j}$$

Which can be expressed as the following regression model shows. This is **Model 2**:

$$(7) \qquad \ln T_{ij} = \ln k + \beta \ln GDP_j + \gamma \ln D_{ij} + \delta\, EU_j + u_i$$

A new variable has been added to the model, which is EU. It is a dummy variable that takes the value 0 if the country is not a EU member and 1 if the country does belong to the EU. The main propose of this new variable is an attempt to capture the effect and importance on UK trade because of being part of the EU. Its parameter $\delta$ will serve as a proxy to know how much the EU membership affects UK trade. Notice that this parameter will not show the loss of UK trade when they will leave the EU, this parameter just shows the importance of the EU for UK in trade issues. The reason is that when the UK finally leaves, they will not stop trading with the EU in any case, UK will still trade but with more tariff and non-tariff barriers instead. Of course, the higher this importance, the worse for the British citizens, but the reduction in trade is difficult to assess.

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When the dummy variable EU, is included into the model, its parameter $\delta$ shows that when the country trading with the UK is part of the EU (value of 1), total trade flows are 173.31% higher in mean than if the country does not belong to the EU (value of 0).[14] Besides, the parameter estimating the effect of GDP on total trade flows remains similar as the first regression were the dummy variable had not been introduced. A 1% increase in GDP, increases total trade flows by 1.05461% in mean other things equal. In contrast, distance effect on total trade flows changes in comparison with the first model. This effect is now much smaller than it was, decreasing total trade flows in mean by 0.29% when distance between UK and a given country increases 1% other things equal.

This result shows how distance effect in total trade flows is decreased when membership to the EU is considered. Then, distance plays a less significant role than before when explaining total trade flows of UK with other countries and belonging to the EU becomes a very important factor. This is a big concern for the UK country because EU membership makes trade easier with other members and also, with other non-EU-members.

### 6.2.3    Splitting up imports and exports

For a further research on how the gravity model behaves with the dummy variable as a friction proxy on the gravity equation, let´s show what happens if the model is split up in Exports and Imports instead of analysing both together. If UK trade is analysed by trade flow, splitting up exports and imports, a fascinating effect is obtained when 2016 imports are used as dependent variable instead of total trade flows. With the introduction of the dummy variable EU in the Imports regression, the variable Distance is not a hindrance for trade anymore, and it only happens with Imports. When Exports or Imports are analysed individually as dependent variable, notice the constant $k$ has a much bigger negative effect than total trade flows as a dependent variable, because Exports and Imports flows are approximately half of total trade flows. Starting by the Imports side. This is **Model 3**:

$$(8) \quad IMP_{ij} = k \frac{GDP_j^{\beta}}{D_{ij}^{\gamma}}$$

$$(9) \quad \ln IMP_{ij} = \ln k + \beta \ln GDP_j + \gamma \ln D_{ij} + u_i$$

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[14] Recall that: in order to come up with this value note that: $e^{1.00546} = 2.7331$, which mean that trade is increased by $(2.7331 - 1) = 1.7331$ times, that is a 173.31% increase if EU is 1. When EU is 0: $e^0 = 1$, so 1-1=0 times.

In Model 3, $R^2$ is very high, with approximately the 80% of variability in imports is explained by changes in the regressors. Additionally, both parameters $\beta$ and $\gamma$ are significant and state the relationship as expected. This shows that the gravity model also works as expected for the Imports side, so it can be compared with the modified model to see how EU membership affects UK Imports.

However, if Imports flows are estimated in order to try to find the importance of being a member of the EU on Imports, the model to be estimated is the following. This is **Model 4**:

$$(10) \quad IMP_{ij} = k \frac{GDP_j^{\beta}}{D_{ij}^{\gamma}} \cdot e^{\delta EU_j}$$

$$(11) \quad \ln IMP_{ij} = \ln k + \beta \ln GDP_j + \gamma \ln D_{ij} + \delta\, EU_j + u_i$$

The main conclusion extracted from Model 4 is that the introduction of the dummy variable EU sorts totally out the effect of distance when explaining UK imports. That means that the parameter $\gamma$ is not significant anymore and distance does not impede the UK from trading with other countries belonging to the EU and the parameter is assumed to take the value of 0. Thus, before doing a quantitative and qualitative analysis distance must be removed from the regression as it follows. This is **Model 5**:

$$(12) \quad IMP_{ij} = kGDP_j^{\beta} \cdot e^{\delta EU_j}$$

$$(13) \quad \ln IMP_{ij} = \ln k + \beta \ln GDP_j + \delta\, EU_j + u_i$$

Model 5, then shows the gravity model in UK Imports 2016 once distance has been removed from the model. The dummy variable $EU_i$, it can be observed that when a state is a member of the EU, import flows increase in mean by 560.44% other things equal.

To see that this conclusion differs between Imports and Exports, the Exports are also estimated using the same approach. This is **Model 6**[15]:

$$(14) \quad EXP_{ij} = k \frac{GDP_j^{\beta}}{D_{ij}^{\gamma}} \cdot e^{\delta EU_j}$$

$$(15) \quad \ln EXP_{ij} = \ln k + \beta \ln GDP_j + \gamma \ln D_{ij} + \delta\, EU_j + u_i$$

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[15] Note that Exports also works initially with no dummy. However, it is omitted due to the limitations of this paper.

Model 6, shows that for Exports, Distance variable is significant and its parameter $\gamma$ is negative as expected and more importantly, significant. What is important from this regression is that the EU membership in Exports increases in mean only by 77.16% other things equal.

Then, being part of the EU increases much more imports than exports for the UK (see model 5 and 6), 560.44% and 77.16% respectively. And yes, this was a statement used by Eurosceptic UK citizens when they voted to leave the EU, claiming that the EU does not let the UK to buy more goods from other non-EU countries that would result cheaper. However, the fact that the EU fosters much more imports than exports does not mean that being out of this market will fix this effect. As it has been discussed, UK citizens will not totally substitute their imports by the cheapest good or service available, because British firms and citizens also consider quality in addition to price.

Therefore, the effects of leaving the EU in the UK economy differ in case of Imports and Exports. When the UK leaves, its imports from the EU are going to be affected as long as they impose import tariffs, which would create inflation and increase the final prices of UK manufactured good, increasing prices of goods that use imported intermediate goods, and therefore, making them harder to sell abroad, since it would cause terms of trade to worse off. Fortunately, import tariffs are up to the UK to be imposed, and therefore the case of "Going Alone" or becoming a European Free Trade Area member must be seriously considered.

In case of Britain Alone, it should be analysed how important is the customs union that there exist with the EU for the UK, and to which extent it protects the UK home production or "forces" the UK to purchase goods from the EU. As it has been discussed before, this would only have sense in case of agriculture goods, because for the rest of imported goods, quality is an important factor that really matters.

If the UK does impede Imports to the UK, exports can be affected twice. The first effect is when other countries impose barriers to the UK goods, mainly in the EU and the second effect is if the final goods the UK is exporting are affected by a higher price of imported intermediate goods.

Finally, the UK country must consider that the treatment that other countries are going to provide to their exports is crucial, since they also represent an important source of welfare.

Besides, the UK trade balance is negative (that it is not likely to improve with Brexit), and if they do not improve their balance and if it repeatedly remains negative over next years, the UK will be exposed to a huge financial and economic risk because they need to be financed by the rest of the world.

## 6.3    Panel data 1995-2016

Working with cross-sectional data is useful to understand UK trade flows. However, the data just takes into account a single time period, that is year 2016. Over time, trade is affected by more things such as trade policy, exchange rates, changes in competitiveness… whose impact on trade cannot be observed in a single period. That is why, in this paper, data from year 1995 to 2016 is going to be analysed with the gravity model. This period of time has been selected because it captures times of economic prosperity as well as economic recession (i.e. the 2008 financial crisis), and an important event on the European integration that is the introduction of the euro as well as its consolidation in the eurozone. Moreover, more countries are joining the EU in this time period.

### 6.3.1    Data source and estimation selection procedure

The data currently presented is going to be treated as stacked time series panel data because it mixes cross-sectional advantages with time series advantages. It counts with 22 years and 165 countries[16], that is an N of 3630 observations for each variable. One of the advantages regarding the econometric regression using panel data is that UK GDP can be maintained in the model since it does not represent a problem of exact collinearity any more.

The data has been taken from CEPII, as the dataset for cross-sectional data was. UK trade flows from year 1995 to year 2016 have been also taken from the WITS database and have been deflated to constant 2010 prices from the World Bank database. The GDP data have been taken from the World Bank database at constant 2010 prices. Both total trade flows and GDP are expressed in thousand dollars. The reasoning followed in the choice of this

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[16] Note that the following countries had to be removed due to lack of data: Aruba, America Samoa, Antarticta, Bonaire, Botswana, Bouvet Island, Bunkers, Christmas Island, Cocos, Curaçao, East Timor, French Guiana, Sudan, Guadalupe, Guam, Heard Islands, Holy See, Lesotho, Martinique, Moyotte, Monaco, Montenegro, Namibia, Norfolk Island, Nive, Reunion, Saint Barthelemy, Saint Marteen, San Marino, South Sudan, South George, Swazilandia, Tokelau, Dutch Antiles, Wallis and Futura Islands, Anguila, Bermuda, British Virgin Islands, Cayman Islands, Cook Islands, Cuba, Djibouti, Eritrea, Feroe Islands, Falkland Islands, French Polynesia, Gibraltar, Greenland, North Korea, Lybia, Montserrat, Myanmar, New Caledonia, Pitcairn, Saint Helena, Saint Pierre, Syria, Turks and Cacao Islands, Tuvalu, Venezuela, Afghanistan, Bahrain, Haiti, Maldives, Nauru, Northern Marian Islands, Oman, Qatar, Somalia and Sao Tome and Principe.

sources are the same as cross-sectional data sources.

Dealing with a panel dataset of 22 periods is more difficult to analyse than only with one year and cross-sectional data. Hence, the approach used for the regression of panel data varies from the cross-sectional methodology. With panel data, it can be used a pooled regression or either Random Effects (RE hereinafter) or Fixed Effects (FE hereinafter). Each methodology has its advantages and disadvantages and the use of RE or FE is governed by the nature of the individual effects, that can be correlated with the explanatory variables or not. The best alternative to be used can be found out with a test in Gretl clustered in Table 2.

**Table 2: Diagnostics: assuming a balanced panel with 165 cross-sectional units observed over 22 periods:**

| | | |
|---|---|---|
| **Joint significance** of differing group means: A low p-value counts against the null hypothesis that the pooled OLS model is adequate, in favour of the fixed effects alternative. | $F(164, 3462)$ | 86.2207 |
| | **p-value** | 0.00 |
| **Breusch-Pagan test** statistic: A low p-value counts against the null hypothesis that the pooled OLS model is adequate, in favour of the random effects alternative. | **LM** | 23971.3 |
| | **p-value**: prob(chi-square(1)>23971.3) | 0 |
| **Hausman test** statistic: (A low p-value counts against the null hypothesis that the random effects model is consistent, in favour of the fixed effects model.) | **H** | 10.2226 |
| | **p-value**: prob(chi-square(3)> 0.2226) | 0.0167656 |

Source: Own Elaboration. Data from Gretl.

The panel diagnosis, supports the use of either FE and RE over a pooled OLS model, meanwhile the Hausman test supports the use of a FE effect model. However, our regression needs from a RE model, so the individual effects are going to be assumed as random since the FE model cannot estimate the effect of a time-invariant variable, that is distance on the regressor $T_{UKjt}$ due to exact multicollinearity.

With a RE model the parameters are estimated with Generalised Least Squares (GLS) rather than OLS. If RE model is used instead of FE there is a problem when it is suspected that

the individual effects are correlated with endogenous variables, that is endogeneity and leads to inconsistent GLS estimators, but fortunately, this is not the case. Besides, as Harris and Matyas (1998) state, the use of RE, the coefficients of the explanatory variables are likely to be estimated with greater precision, which is much better for the accuracy of the results.

### 6.3.2 Empirical analysis

The model to be regressed states as follows. This is **Model 7**:

$$(16) \quad T_{ijt} = k \frac{GDP_{UKt}^{\varphi} GDP_{jt}^{\beta}}{D_{ij}^{\gamma}}$$

$$(17) \quad \ln T_{UKjt} = \ln k + \varphi \ln GDP_{UKt} + \beta \ln GDP_{jt} + \gamma \ln D_{UKj} + \alpha_j + u_{ijt}$$

The model changes because time series data has been included. $T_{UKjt}$ is the dependent variable total trade flows, exports and imports between the UK and country j in year t. $GDP_{UKt}$ is the UK GDP for year t. $GDP_{jt}$ is the GDP of country j in year t. $D_{ij}$ is the distance between the UK country and country j. It is important to notice that distance is time-invariant, its value is maintained over time. Since this is a panel model, $\alpha_j$ is known as the individual effects of each country, it captures all unobserved time constant factors that affect $T_{UKjt}$ that are specific for each country Wooldridge (2013). Note that the model must be also corrected for heteroskedasticity as it was explained when analysing cross-sectional data.

The results obtained from Model 7 are more useful in capturing the behaviour of the gravity model on UK trade flows than Model 1, because this Model takes into account 22 years instead of only year 2016. The regression shows that a 1% *ceteris paribus* increase in UK GDP, has a mean increase of 0.86% in UK total trade flows, when the GDP of country j increases by 1% other things equal, the total trade flows increase 1.088% in mean and when distance between the UK and a given country is increased by 1% other things equal, total trade flows decrease in mean 0.35%.

These results show that for data ranged from year 1995 to year 2016, a fraction of time where many important events have taken place, the gravity model is still working.

Model 8 is performed so it can be finally known the effect of membership to the EU using panel data. The variable EU is a dummy variable that stands for 1 when a country belongs to the EU and 0 when it does not. Note that some countries take some periods between

1995-2016 the value of 0 and from year of entry, the value of 1. This is **Model 8**:

$$(18) \quad \ln T_{UKjt} = \ln k + \varphi \ln GDP_{UKt} + \beta \ln GDP_{jt} + \gamma \ln D_{UKj} + \delta\ EU_{jt} + \alpha_j + u_{ijt}$$

Fortunately, when doing the regression GLS estimates are consistent, that is shown by the Husman test, so the RE estimation of the parameters is consistent.

The qualitative analysis of this regression is very similar to cross-sectional data. From Model 7 to Model 8, the effect of distance lose significance from 1% to 10% when the dummy EU has been introduced. Again, this clearly demonstrates how the EU membership helps in enhancing trade between members and the EU and breaks somehow non-tariff barriers as distance is. Moreover, the effect of the variable Distance also lose power, now a 1% increase in distance, other things equal, decreases in mean total trade flows 0.22%, against the previous result of -0.35%. GDP of country j and UK GDP variables also lose power, although UK GDP does it more importantly.

The variable of concern of this regression is EU. When the country that is trading with the UK is part of the EU (EU takes value of 1), trade between them is in mean 78.33% higher than if that country does not belong to the EU.

Finally, to the last model has been added a new variable, $AGR_{jt}^{EU}$ that tries to capture the effect on UK trade due to the existence of trade agreements and associations of the EU with other countries j. It is a dummy variable that takes the value of 1 from year that an agreement comes into force and 0 if there is no agreement or association with a country j in year t. This data has been taken from the Negotiations and Agreements[17] section of the European Commission webpage. Hence, **Model 9** is:

$$(19) \quad T_{ijt} = k \frac{GDP_{UKt}^{\varphi} GDP_{jt}^{\beta}}{D_{ij}^{\gamma}} \cdot e^{\delta\ EU_{jt} + \omega\ AGR_{jt}^{EU}}$$

---

[17] Customs Union: Andorra (1991), Turkey (1995), San Marino (1991), Monaco (1963)
Stabilisation and Association Agreement: Albania (2009), Bosnia and Herzegovina (2015), Macedonia (2004), Montenegro (2010), Serbia (2013)
Association Agreement: Algeria (2005), Egypt (2004), Georgia (2016), Israel (2000), Lebanon (2006), Moldova (2016), Morocco (2000), Tunisia (1998)
Partnership and Cooperation Agreement: Armenia (1999), Azerbaijan (1999), Jordan (2002) Kazakhstan (1999)
Association Agreement and Additional Protocol: Chile (2005)
Economic Area Agreement (EFTA): Iceland (1994), Norway (1994), Switzerland (1973), Liechtenstein (1991)
Free Trade Agreement: South Korea (2016)
Interim Association Agreement
Partnership and Cooperation Agreement: Russia (1997)
Global Agreement: Mexico (2004)

$$（20）\quad \ln T_{UKjt} = \ln k + \varphi \ln GDP_{UKt} + \beta \ln GDP_{jt} + \gamma \ln D_{UKj} + \delta\, EU_{jt} +$$
$$\omega\, AGR_{jt}^{EU} + \alpha_j + u_{ijt}$$

The introduction of this new variable is important because when the UK leaves, they will also lose these trade agreements with countries named in the footnote. This is also needed in order to know how big the effect of Brexit might be for the UK country.

Before analysing, note that the GLS estimators are consistent when using the RE model.

Once again, the results are consistent with the ones obtained in this paper before. As long as more things are taken into account, distance becomes insignificant and its effect decreases significantly. Likewise, both GDP of country j and UK GDP lose power in comparison with previous models (Model 7 and 8).

Model 9 reinforces the importance of membership for the UK. In this model, being part of the EU has two advantages. First, when there is trade with a EU member (other things equal), trade increases in mean by 83.11%. Second, it is demonstrated that the EU also eases trade with other countries that need not to be members, that is the variable $AGR^{EU}$. This makes trade 42.00% higher in mean when a country j has a trade agreement with the EU.

Then, this last model states two potential sources of trade loss, enhanced trade within the EU and enhanced trade outside the EU thanks to EU agreements and associations. It could be said that the UK country could maintain these agreements after Brexit, however UK is considered a small country if compared to the EU and its negotiation power is much smaller than if they are part of the EU and negotiate as whole.

Table 3 contains the results of the models regressed in this subsection. Modelling and results interpretation follow these data.

**Table 3: 1995-2016 UK Trade Flows: Panel Data Analysis (Assuming Random Effects, GLS estimation and Robust (HAC) Standard Errors)**

| Dependent Variable: | Total Trade Flows | | |
|---|---|---|---|
| Regressor: | **Model 7** | **Model 8** | **Model 9** |
| $const\ k$ | -21.75*** | -19.82*** | -18.03*** |
| | (4.10) | (3.69) | (3.73) |
| $GDP_{jt}\ \beta$ | 1.08*** | 1.08*** | 1.07*** |
| | (0.06) | (0.06) | (0.06) |
| $GDP_{UKt}\ \varphi$ | 0.86*** | 0.71*** | 0.62*** |
| | (0.20) | (0.18) | (0.18) |
| $D_{UKj}\ \gamma$ | -0.35*** | -0.21* | -0.18 |
| | (0.11) | (0.11) | (0.11) |
| $EU_{jt}\ \delta$ | - | 0.57*** | 0.60*** |
| | - | (0.11) | (0.11) |
| $AGR_{jt}^{EU}\ \omega$ | - | - | 0.35*** |
| | - | - | (0.12) |
| *Joint test* | 625.09 | 692.22 | 691.18 |
| | (0.00) | (0.00) | (0.00) |
| *Hausman test* | NA | 2.60 | 5.02 |
| | (failed) | (0.62) | (0.41) |

Notes: 22-time periods and 165 cross-sectional units N=3630. Parameters are percentage change since they have been calculated as logs. Note that for the dummies $EU_j$ and $AGR_{jt}^{EU}$ the percentage change is computed as it states: $(e^{\delta\ or\ \omega} - 1)x100$ when the dummy is 1, otherwise there is no percentage change $(e^{\delta\ or\ \omega*0} - 1)x100 = 0\%$. The robust standard deviations are found in parenthesis. For the Joint-test, the p-value is found also in parenthesis. Individual parameters are 1%, 5% or 10% significant depending on ***, ** and * respectively. The Hausman test supports that the Generalised Least Squares (GLS) are consistent and the Random Effects estimation works. Gretl outputs are located in Annexes section.

Source: Own Elaboration. Data come from Gretl outputs.

## 6.4  Summary of results

As a summary, Table 4 shows the effect that each variable analysed has in the regressions run by Gretl, both with Cross-sectional and Panel data. Recall that the effect of the dummy

EU, does not mean that after Brexit the UK will lose that percentage trade. It means that UK trade with the EU is very important instead, and the higher the variable the bigger the negative effect of Brexit. The outcome of Cross-sectional models may be seen as short-term influence of the EU on UK trade flows, whereas the Panel data may be seen as a long-term effect that the EU shapes UK trade because it takes a wider range of years where more shocks have happened, and it is seen as a mean effect of both time and cross-sectional.

**Table 4: Summary of results**

| Variable | Cross-sectional data 2016 on Total Trade | | Panel data 1995-2016 on Total Trade | | |
|---|---|---|---|---|---|
| | No EU dummy | EU dummy | No EU dummy | EU dummy | EU and AGR$^{EU}$ dummies |
| $GDP_j$ | 1.06% | 1.05% | 1.08% | 1.08% | 1.07% |
| $D_{UKj}$ | -0.62% | -0.29% | -0.35% | -0.21% | -0.18% |
| $GDP_{UK}$ | - | - | 0.86% | 0.71% | 0.62% |
| $EU_j$ | - | 173.31% | - | 78.33% | 83.11% |
| $AGR_j^{EU}$ | - | - | - | - | 42.00% |
| **Cross-sectional data 2016 by flow direction with EU dummy** | | | | | |
| Variable | Exports | | Imports | | |
| $EU_j$ | 77.16% | | 560.44% | | |
| $D_{UKj}$ | -0.49%*** | | Not significant | | |

Source: Own Elaboration.

## 7. Life after Brexit

The exhaustive analysis done before with the application of the gravity model has strongly supported the fact that EU-membership is very important for the UK. Then, finally, it is going to be briefly seen how life after Brexit could be like.

**Figure 8** *European Agreements Framework*
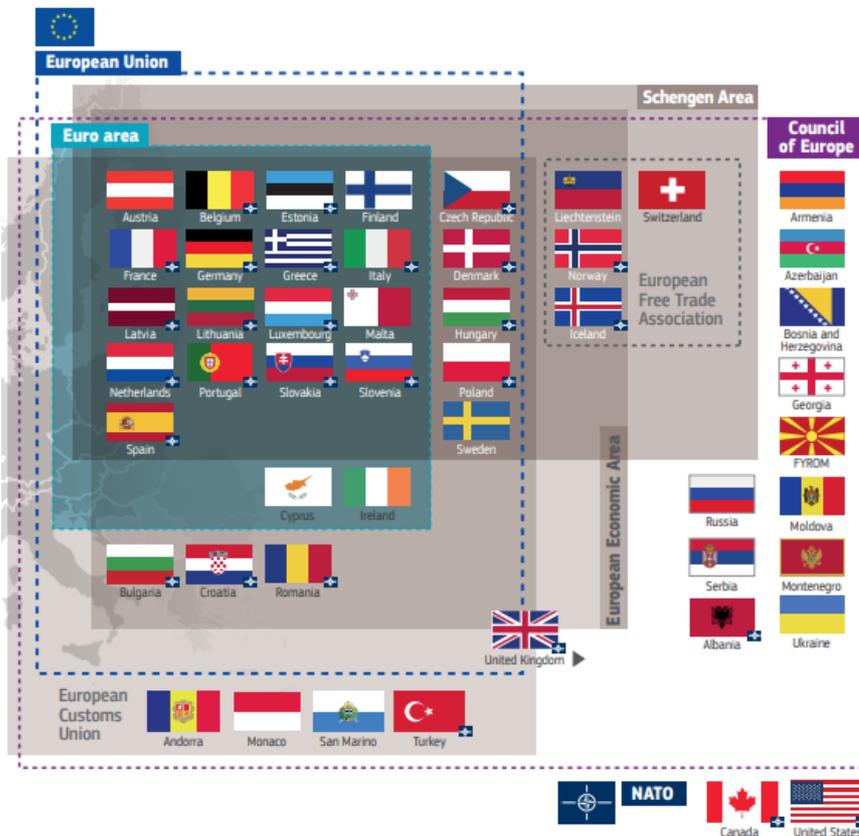


Source: White Paper on the Future of Europe (2017)

When the UK country finally leaves, it must be seen where they are going to be positioned with the EU because they are forced to reach a post-Brexit agreement. Figure 8 is a good way to show the options that the UK has. UK can be alone just as a member of the World Trade Organization, join the EFTA, join the European Economic Area, join the Customs Union or maybe agreeing a unique association with the EU. Undoubtedly, the state of the UK and EU relationship is going to be an issue of concern in current negotiations because, as it has been seen is not only a big burden in terms of trade for the UK to cope with, but also affects EU members.

Baier *et. al* (2008) estimated, using a gravity model of bilateral trade augmented with dummy variables, before Brexit referendum took place that leaving the EU and joining EFTA would reduce the UK's trade with EU members by 25%. Currently, it is the most likely outcome.

British citizens also lose the opportunity to establish new agreements with trade partners. Currently, the EU is negotiating deals with MERCOSUR (Argentina, Brazil, Paraguay and

Uruguay), Canada (CETA)[18], Japan and USA (TTIP). These agreements have big potentials to enhance trade and welfare because they are big economies. To the UK the agreement that might be made in the future United States has a bigger weight because it is the first exporting country for the UK. The UK should consider reaching a final agreement in the deal with USA and other countries out of the EU.

There was a secret research undertaken by the UK government about Brexit that was leaked[19] in January 2018. It analyses three different scenarios (EEA, EFTA and Britain alone in WTO) after Brexit and it claims that the UK will be worse off in every scenario. Any tariffs imposed on goods between UK and the EU will have significant negative economic consequences in every sector analysed (also financial services, a field where the EU has already rejected a deal with the UK). According to this leaked report, the softest option is to be part of the European Economic Area, which would still lower 15-year long-term growth (status-quo) by 2%. Joining EFTA, would decrease 15-year long-term growth by 4.8% and Britain alone in the WTO would decrease it by 7.7%.

## 8. Conclusion

This paper demonstrates how important the EU membership is for the UK because EU membership fosters UK trade. The Gravity Model holds for UK trade flows and demonstrates that the EU overcomes non-tariff barriers and makes trade less dependent on the economic size of each country. It also has been proved that the UK has a strong dependence on the EU for its imports, which are going to suffer more than exports after Brexit. In fact, imports are 560.44% in mean higher when the trading county belongs to the EU and exports just 77.16% higher. Dissimilar to exports, imports are not affected by distance within the EU.

Moreover, the main conclusion extracted from the models regressed and the analysis is that EU membership has increased welfare in the UK, because in general, it has created more trade than diverted. Therefore, the trade creation caused by the EU is going to be partially disrupted by Brexit. If UK were to remain, they could benefit even more from European integration, since the more integrated, the better, and thus, higher welfare. This is demonstrated by the higher effect on trade, 173.31% of the variable EU in cross-sectional

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[18] CETA is in trial since 2017
[19] EU-Exit-Analysis-Cross-Whitehall-Briefing. (2018)

data than in panel data because since it only takes year 2016, the process of European integration is more advanced than the mean of years 1995 to 2016, with an increase on trade of 78.33% when a country is a EU member. It has also been demonstrated the significant increase on trade due to deals of other countries with the EU, which are going to be lost for the UK as well as future agreements. In fact, current EU agreements increase in mean trade by 42%.

However, this paper faces some limitations. The methodology used has been constrained by the estimation of Random Effects instead of Fixed Effect due to the existence of time invariant variables in panel data. However, Random Effect estimation was consistent and is adequately selected if there exists interest in estimating distance parameters Egger (2002) and Brun *et. al* (2005). Besides, several countries have been removed from both data analysis, which despite they are less significant it makes results slightly less accurate because the econometric treatment of zero trade or missing data for the gravity model is a hard burden to deal with. Within theoretical interpretation of the gravity model, remoteness still is a variable barely estimated and the existence of a constant instead usually suffers from lack of interpretation. Finally, due to the growth of services rendered from abroad thanks to the internet, if this trade is added to the model, distance becomes less significant because it is hardly a non-tariff barrier.

The post-Brexit agreement between the UK and the EU is going to be a long process of hard negotiations where each party will try to get as much as possible. Although there is no better post-Brexit agreement than remain, it seems that the most likely option is to become a member of the European Economic Area or of the European Free Trade Association in order to minimize British losses at any economic and social field. A Customs Union would be less harmful for both parties and it reduces the problems with the Irish border.

Therefore, this project has been useful to analyse how UK trade is and how important the EU membership for the UK are. Although there is a lot of issues to be deeply discussed, this project has followed a general trade flows approach and encourages further researches that analyse more concrete issues such as FDI, labour mobility, forecasting of Brexit and long-run effects dynamic effects or even potential solutions to Brexit losses.

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## 10. Annexes

**Model 1**: Heteroskedasticity-corrected, using observations 1-181
Dependent variable: lnTotaltradeflowsthousands

|               | *Coefficient* | *Std. Error* | *t-ratio* | *p-value* |     |
|---------------|-----------|-----------|-----------|-----------|-----|
| const         | −0.742885 | 1.01787   | −0.7298   | 0.4664    |     |
| lnDistancekm  | −0.622708 | 0.0854868 | −7.2843   | <0.0001   | *** |
| lnGDPthousands | 1.06686  | 0.0315861 | 33.7762   | <0.0001   | *** |

Statistics based on the weighted data:

| | | | |
|---|---|---|---|
| Sum squared resid | 505.7735  | S.E. of regression | 1.685652 |
| R-squared         | 0.883289  | Adjusted R-squared | 0.881977 |
| F(2, 178)         | 673.5656  | P-value(F)         | 9.40e-84 |
| Log-likelihood    | −349.8249 | Akaike criterion   | 705.6499 |
| Schwarz criterion | 715.2454  | Hannan-Quinn       | 709.5401 |

Statistics based on the original data:

| | | | |
|---|---|---|---|
| Mean dependent var | 12.41980 | S.D. dependent var | 3.024349 |
| Sum squared resid  | 227.5155 | S.E. of regression | 1.130565 |

Test for normality of residual -
 Null hypothesis: error is normally distributed
 Test statistic: Chi-square(2) = 1.598
 with p-value = 0.449777

**Model 2**: Heteroskedasticity-corrected, using observations 1-181
Dependent variable: lnTotaltradeflowsthousands

|               | *Coefficient* | *Std. Error* | *t-ratio* | *p-value* |     |
|---------------|-----------|-----------|-----------|-----------|-----|
| const         | −3.47256  | 1.37702   | −2.5218   | 0.0126    | **  |
| lnDistancekm  | −0.295074 | 0.133213  | −2.2151   | 0.0280    | **  |
| lnGDPthousands | 1.05461  | 0.0336733 | 31.3189   | <0.0001   | *** |
| EU            | 1.00546   | 0.255832  | 3.9301    | 0.0001    | *** |

Statistics based on the weighted data:

| | | | |
|---|---|---|---|
| Sum squared resid | 546.1101  | S.E. of regression | 1.756521 |
| R-squared         | 0.884222  | Adjusted R-squared | 0.882259 |
| F(3, 177)         | 450.5941  | P-value(F)         | 1.36e-82 |
| Log-likelihood    | −356.7692 | Akaike criterion   | 721.5383 |
| Schwarz criterion | 734.3323  | Hannan-Quinn       | 726.7253 |

Statistics based on the original data:

| | | | |
|---|---|---|---|
| Mean dependent var | 12.41980 | S.D. dependent var | 3.024349 |
| Sum squared resid  | 216.5571 | S.E. of regression | 1.106113 |

Test for normality of residual -

Null hypothesis: error is normally distributed
Test statistic: Chi-square(2) = 0.851192
with p-value = 0.65338

**Model 3**: Heteroskedasticity-corrected, using observations 1-181
Dependent variable: lnImports

|  | Coefficient | Std. Error | t-ratio | p-value |  |
|---|---|---|---|---|---|
| const | −4.8069 | 1.51156 | −3.1801 | 0.0017 | *** |
| lnGDPthousands | 1.25291 | 0.0506926 | 24.7158 | <0.0001 | *** |
| lnDistancekm | −0.666307 | 0.118005 | −5.6464 | <0.0001 | *** |

Statistics based on the weighted data:

| | | | |
|---|---|---|---|
| Sum squared resid | 595.0648 | S.E. of regression | 1.828404 |
| R-squared | 0.806461 | Adjusted R-squared | 0.804286 |
| F(2, 178) | 370.8552 | P-value(F) | 3.33e-64 |
| Log-likelihood | −364.5386 | Akaike criterion | 735.0771 |
| Schwarz criterion | 744.6726 | Hannan-Quinn | 738.9673 |

Statistics based on the original data:

| | | | |
|---|---|---|---|
| Mean dependent var | 11.15792 | S.D. dependent var | 3.772391 |
| Sum squared resid | 595.5852 | S.E. of regression | 1.829203 |

Test for normality of residual -
Null hypothesis: error is normally distributed
Test statistic: Chi-square(2) = 16.9093
with p-value = 0.000212905

**Model 4**: Heteroskedasticity-corrected, using observations 1-181
Dependent variable: lnImports

|  | Coefficient | Std. Error | t-ratio | p-value |  |
|---|---|---|---|---|---|
| const | −10.6375 | 2.03397 | −5.2299 | <0.0001 | *** |
| lnGDPthousands | 1.22202 | 0.0511324 | 23.8991 | <0.0001 | *** |
| lnDistancekm | 0.052602 | 0.187848 | 0.2800 | 0.7798 |  |
| EU | 1.95456 | 0.377119 | 5.1829 | <0.0001 | *** |

Statistics based on the weighted data:

| | | | |
|---|---|---|---|
| Sum squared resid | 586.4419 | S.E. of regression | 1.820228 |
| R-squared | 0.825731 | Adjusted R-squared | 0.822777 |
| F(3, 177) | 279.5569 | P-value(F) | 6.83e-67 |
| Log-likelihood | −363.2176 | Akaike criterion | 734.4351 |
| Schwarz criterion | 747.2291 | Hannan-Quinn | 739.6221 |

Statistics based on the original data:

| | | | |
|---|---|---|---|
| Mean dependent var | 11.15792 | S.D. dependent var | 3.772391 |
| Sum squared resid | 549.1882 | S.E. of regression | 1.761465 |

**Model 5**: Heteroskedasticity-corrected, using observations 1-181

Dependent variable: lnImports

| | Coefficient | Std. Error | t-ratio | p-value | |
|---|---|---|---|---|---|
| const | −10.5977 | 0.966935 | −10.9601 | <0.0001 | *** |
| lnGDPthousands | 1.24474 | 0.0529167 | 23.5227 | <0.0001 | *** |
| EU | 1.88775 | 0.224655 | 8.4029 | <0.0001 | *** |

Statistics based on the weighted data:

| | | | |
|---|---|---|---|
| Sum squared resid | 674.6919 | S.E. of regression | 1.946896 |
| R-squared | 0.821026 | Adjusted R-squared | 0.819015 |
| F(2, 178) | 408.2780 | P-value(F) | 3.15e-67 |
| Log-likelihood | −375.9041 | Akaike criterion | 757.8081 |
| Schwarz criterion | 767.4036 | Hannan-Quinn | 761.6984 |

Statistics based on the original data:

| | | | |
|---|---|---|---|
| Mean dependent var | 11.15792 | S.D. dependent var | 3.772391 |
| Sum squared resid | 545.1310 | S.E. of regression | 1.750010 |

Test for normality of residual -
Null hypothesis: error is normally distributed
Test statistic: Chi-square(2) = 14.4173
with p-value = 0.000740153


**Model 6**: Heteroskedasticity-corrected, using observations 1-181
Dependent variable: lnExports

| | Coefficient | Std. Error | t-ratio | p-value | |
|---|---|---|---|---|---|
| const | −1.0124 | 1.31353 | −0.7707 | 0.4419 | |
| lnDistancekm | −0.491721 | 0.130006 | −3.7823 | 0.0002 | *** |
| lnGDPthousands | 0.972039 | 0.0303451 | 32.0328 | <0.0001 | *** |
| EU | 0.571925 | 0.232179 | 2.4633 | 0.0147 | ** |

Statistics based on the weighted data:

| | | | |
|---|---|---|---|
| Sum squared resid | 612.7026 | S.E. of regression | 1.860537 |
| R-squared | 0.884446 | Adjusted R-squared | 0.882487 |
| F(3, 177) | 451.5826 | P-value(F) | 1.14e-82 |
| Log-likelihood | −367.1820 | Akaike criterion | 742.3640 |
| Schwarz criterion | 755.1580 | Hannan-Quinn | 747.5510 |

Statistics based on the original data:

| | | | |
|---|---|---|---|
| Mean dependent var | 11.68382 | S.D. dependent var | 2.877995 |
| Sum squared resid | 210.0530 | S.E. of regression | 1.089376 |

Test for normality of residual -
Null hypothesis: error is normally distributed
Test statistic: Chi-square(2) = 0.371983
with p-value = 0.830281


**Model 7**: Random-effects (GLS), using 3630 observations

Included 165 cross-sectional units
Time-series length = 22
Dependent variable: lnTradeFlow
Robust (HAC) standard errors

|  | Coefficient | Std. Error | z | p-value | |
|---|---|---|---|---|---|
| const | −21.7589 | 4.10821 | −5.2964 | <0.0001 | *** |
| lnDistance | −0.351385 | 0.110217 | −3.1881 | 0.0014 | *** |
| lnUKGDP | 0.860084 | 0.202961 | 4.2377 | <0.0001 | *** |
| lnGDP | 1.08897 | 0.0659749 | 16.5058 | <0.0001 | *** |

| Mean dependent var | 12.44694 | S.D. dependent var | 2.868766 |
|---|---|---|---|
| Sum squared resid | 5336.913 | S.E. of regression | 1.213029 |
| Log-likelihood | −5850.275 | Akaike criterion | 11708.55 |
| Schwarz criterion | 11733.34 | Hannan-Quinn | 11717.38 |

'Between' variance = 1.16838
'Within' variance = 0.298229
theta used for quasi-demeaning = 0.892906
Joint test on named regressors -
 Asymptotic test statistic: Chi-square(3) = 625.096
 with p-value = 3.65452e-135

Breusch-Pagan test -
 Null hypothesis: Variance of the unit-specific error = 0
 Asymptotic test statistic: Chi-square(1) = 23971.3
 with p-value = 0

Hausman test -
 Null hypothesis: GLS estimates are consistent
 Asymptotic test statistic: Chi-square(3) = NA (failed)

**Model 8**: Random-effects (GLS), using 3629 observations
Included 165 cross-sectional units
Time-series length: minimum 21, maximum 22
Dependent variable: lnTradeFlow
Robust (HAC) standard errors

|  | Coefficient | Std. Error | z | p-value | |
|---|---|---|---|---|---|
| const | −19.8219 | 3.69896 | −5.3588 | <0.0001 | *** |
| lnDistance | −0.219569 | 0.113572 | −1.9333 | 0.0532 | * |
| lnUKGDP | 0.717322 | 0.183871 | 3.9012 | <0.0001 | *** |
| lnGDP | 1.08642 | 0.064507 | 16.8419 | <0.0001 | *** |
| EU | 0.578456 | 0.112411 | 5.1459 | <0.0001 | *** |

| Mean dependent var | 12.44558 | S.D. dependent var | 2.868004 |
|---|---|---|---|
| Sum squared resid | 5203.527 | S.E. of regression | 1.198105 |
| Log-likelihood | −5803.237 | Akaike criterion | 11616.47 |
| Schwarz criterion | 11647.46 | Hannan-Quinn | 11627.51 |

'Between' variance = 1.13732
'Within' variance = 0.292285
mean theta = 0.892529
Joint test on named regressors -
 Asymptotic test statistic: Chi-square(4) = 692.223
with p-value = 1.68307e-148

Breusch-Pagan test -
 Null hypothesis: Variance of the unit-specific error = 0
 Asymptotic test statistic: Chi-square(1) = 23734.3
with p-value = 0

Hausman test -
 Null hypothesis: GLS estimates are consistent
 Asymptotic test statistic: Chi-square(4) = 2.60811
with p-value = 0.625387

**Model 9**: Random-effects (GLS), using 3629 observations
Included 165 cross-sectional units
Time-series length: minimum 21, maximum 22
Dependent variable: lnTradeFlow
Robust (HAC) standard errors

|  | Coefficient | Std. Error | $z$ | p-value | |
|---|---|---|---|---|---|
| const | −18.034 | 3.73186 | −4.8324 | <0.0001 | *** |
| lnUKGDP | 0.626536 | 0.18563 | 3.3752 | 0.0007 | *** |
| lnGDP | 1.07888 | 0.0663568 | 16.2588 | <0.0001 | *** |
| lnDistance | −0.188892 | 0.116826 | −1.6169 | 0.1059 | |
| EU | 0.604939 | 0.11266 | 5.3696 | <0.0001 | *** |
| EUexternalAgreem ents | 0.350684 | 0.125347 | 2.7977 | 0.0051 | *** |

| | | | |
|---|---|---|---|
| Mean dependent var | 12.44558 | S.D. dependent var | 2.868004 |
| Sum squared resid | 5224.797 | S.E. of regression | 1.200717 |
| Log-likelihood | −5810.638 | Akaike criterion | 11633.28 |
| Schwarz criterion | 11670.46 | Hannan-Quinn | 11646.52 |

'Between' variance = 1.14459
'Within' variance = 0.289898
mean theta = 0.893301
Joint test on named regressors -
 Asymptotic test statistic: Chi-square(5) = 691.188
with p-value = 3.95013e-147

Breusch-Pagan test -
 Null hypothesis: Variance of the unit-specific error = 0
 Asymptotic test statistic: Chi-square(1) = 23765.5
with p-value = 0

Hausman test -
 Null hypothesis: GLS estimates are consistent
 Asymptotic test statistic: Chi-square(5) = 5.02805
 with p-value = 0.412466