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Unraveling Brexit: Assessing the impact on UK trade using the gravity model

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Acknowledgment

Following the story of Brexit and seeing the effects of a political decision on something as complex as international trade patterns have been very interesting. By working on this thesis, I have gained important knowledge of global economics and how exports and imports of the UK have changed over the last two decades. The story of Brexit has just begun, and it will be interesting to follow the development and to see how Brexit will affect international trade in the following years.

I want to thank my supervisor, Roberto J. Garcia, for helping me with this study. I sincerely appreciate the feedback and motivation I have received from you during my time at NMBU, and especially during this last semester. Your comprehensive knowledge of international economics and the Brexit situation has been invaluable. I also thank Olvar Bergland for answering my last-minute econometrics questions. Your thorough feedback in econometrics class has given me the knowledge to fully understand the econometrics behind this study.

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Abstract

The European Union (EU) is the largest trading partner of the United Kingdom (UK). When the decision of leaving the EU was taken in June 2016, it created uncertainty for the future of the UK. This uncertainty could have led to some changes in trade patterns that need to be explored. Since different groups of trade can have different responses to political shocks, the aim of this study has been to explore the effects on total exports and imports, and exports and imports of food and live animals. The gravity model is the most common way to explore trade patterns between countries. By implementing panel data methodology to the gravity model, the study explores the UK exports and imports patterns for selected groups of countries for the period 2000 – 2021. The study finds that gross domestic product (GDP) and distance are the main factors in determining the value of UK exports and imports. GDP has a positive influence on a country's import demand, while distance has a negative effect on trade. Historical ties can also influence trade patterns, and being a member of the Commonwealth has a proven positive effect on UK imports in this study. However, UK exports does not seem to be affected by a membership of the Commonwealth.

Through the implementation of the correlated random effects model, this study finds that Brexit has had a significantly negative effect on total exports and imports, with imports being more affected than exports. The random effects estimations of food and live animals do, however, not find a significant effect of Brexit. To explore the possibility of redistribution, EU sub-groups of each of the samples were created. This resulted in Brexit becoming significantly negative for all four samples, concluding that food and live animals have experienced a redistribution of trade from EU to non-EU. In contrast, total trade has experienced an overall decrease in trade from 2016.

Keywords: *Brexit, gravity model, panel data, fixed effects, random, effects, correlated random effects, trade, United Kingdom, European Union*

Sammendrag

Den europeiske union (EU) er Storbritannias største handelspartner. Når avgjørelsen om å forlate EU ble tatt i juni 2016, skaptes en usikkerhet for framtiden til Storbritannia. Denne usikkerheten kan ha ført til endringer i handelsmønsteret som burde undersøkes nærmere. Siden ulike handelsgrupper har ulike reaksjoner til politiske sjokk i markedet, er målet for denne studien å undersøke effekten på total eksport og import, og på eksport og import av mat og levende dyr. Gravitasjonsmodellen er den mest brukte måten å utforske handelsmønster mellom land på. Ved å ta i bruk panel data metodologi i kombinasjon med gravitasjonsmodellen, undersøker denne studien Storbritannias eksport og import mønster for en utvalgt gruppe land i perioden 2000-2021. Studien finner at bruttonasjonalprodukt og avstand er avgjørende faktorer for verdien av Storbritannias import og eksport. Bruttonasjonalprodukt har en positiv effekt på etterspørselen etter import i et land, mens avstand har en negativ effekt på handel. Historiske bånd kan også ha en innvirkning på handelsmønster, og et medlemskap i Commonwealth viser en positiv effekt på import til Storbritannia. Commonwealth viser imidlertid ingen effekt på eksport fra Storbritannia.

Gjennom å ta i bruk modellen for «correlated random effects» finner analysen at Brexit har hatt en signifikant negativ effekt på total eksport og import, hvor import er hardest rammet. Gjennom å bruke modellen «random effects» på gruppene for mat og levende dyr, oppdages ingen signifikant effekt av Brexit. For å utforske muligheten for redistribusjon ble dataene delt for å danne grupper som kun inkluderte EU land. Dette resulterte i at Brexit ble signifikant for alle fire gruppene, og det kan konkluderes med at mat og levende dyr har opplevd en redistribusjon av handel fra EU til ikke-EU. Total handel har imidlertid opplevd et generelt fall etter 2016 for EU og ikke-EU land.

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List of acronyms and abbreviations

CM	Common market
CRE	Correlated random effects
CU	Customs union
EMU	Economic and Monetary Union
EU	European Union
F&A	Food and live animals
FE	Fixed effects
FTA	Free trade agreement
HS	Harmonized system
IPS	Im-Pesaran-Shin
LLC	Levin-Lin-Chu
OLS	Ordinary Least Squares
RE	Random effects
ROEU	Rest of EU
ROO	Rules of origin
ROW	Rest of world
RTA	Regional trade agreements
SCM	Synthetic Control Model
SITC	Standard international trade classification
TCA	Trade and Cooperation Agreement
UK	United Kingdom
UKIP	United Kingdom Independence Party
WTO	World Trade Organization

1 Introduction

This thesis aims to analyze the trade patterns of the UK during 2000 - 2021. The goal is to determine whether there have been any distinct changes in import and export patterns since the United Kingdom (UK) decided to leave the European Union (EU) in 2016 (Dhingra et al., 2021). This study explores how the political shock of a country choosing to "de-integrate" its economy, i.e., disjoining from the European Union, affects trade patterns with countries with which it was once relative to the rest of the world. Exploring the effects of political decisions on trade is an important part of international economics because it furthers our understanding of the factors that affect trade patterns. The trade patterns we see today are also subjects of history, and important historical events need to be determined to see how history might play into today's trade patterns.

Four years before the Covid-19 pandemic, the UK made the political decision to leave the EU. The decision was made through a referendum in June 2016, and the leaving side won by a slim majority. The relationship between the UK and the EU was a topic of discussion long before the referendum, with the first mention of the phrase Brexit dating back to 2012. Between the 2016 referendum and the end of the transition period in December 2020, several studies have tried to determine the effects of Brexit and discussed the different options on how the UK could leave the EU. These studies (Armstrong & Portes, 2016; Chadha et al., 2016; Dhingra et al., 2021; Sampson, 2017; Springford, 2021) have predicted that Brexit will have, and have had, an effect on the UK's trade. While most forecasts point to negative trade effects of Brexit, the extent of the effects vary based on what scenario the researchers have predicted. What all these studies have in common is that they focus on the sum of exports and imports from and to the UK, as opposed to looking at potential changes in the individual countries or sectors. Analyzing total imports and exports masks important sectoral differences. While this thesis will contain analyses of total exports and imports, it will also look at the sector of food and live animals (F&A).

The sector of food and live animals made up to 10% of UK trade in 2021. While it is not the largest sector, it is an important sector, as the UK is dependent on food imports. In 2021, 31% of all imports came from the sector food and live animals (UN Statistics Division, n.d.). Since goods in the sector are considered necessities, it is interesting to see how a political shock such as Brexit affects this specific sector. Live animals are a group of goods that can be more troublesome to move across long distances and that require more border control than other

goods. The de-integration of the EU single market could therefore show a different outcome for this sector than for other sectors of less necessary goods.

While the type of good may matter for how a political shock affects trade, other factors are also used to determine why countries trade the way they do. The membership in the EU has been a determining factor for UK trade and the decision to leave could therefore implement some interesting changes. Through the study period, the EU has been the UK's largest trading partner (Douch et al., 2018), and almost 50% of all trade in 2021 happened with the twenty-seven members of the European Union. The short distance and connection through the single market has made trade with the EU more accessible. While trade of goods in the group food and live animals has mainly been conducted with non-EU countries, petroleum and road vehicles has been the largest traded goods with the EU. The value of trade with the EU has increased between 2000 – 2021, but the share of EU trade relative to non-EU trade has experienced decreasing importance (Ward, 2022).

History and written agreements are also factors that must be considered when investigating trade patterns. The British Empire has given the UK a unique connection to a group of countries rooted in shared history. After the colonies regained independence, some have chosen to keep the connection with the UK by becoming a member of the Commonwealth. The English language has also remained the official language in several countries, and some have chosen to keep the British king as head of state (Ward, 2023). Agreements is another way to create a bond between two countries that would not naturally form a connection. While the term trade agreements were initially reserved for adjoining countries, the definition has expanded to also allow trade agreements between more distant countries. These types of connections could challenge the effects distance have on trade today and must be consider when analyzing trade patterns.

1.1 Research questions

This study sets out to explore the effects of Brexit on imports and exports to and from the UK.

The research questions to answer are as followed:

1. What affects the UK trade pattern, and how?
2. Have Brexit had an effect on UK trade? If so,
    a. Has Brexit affected total trade and sectoral trade similarly?
    b. Has Brexit affected EU trade more than non-EU trade?

3. Has the share of trade with EU countries changed, vis-à-vis non-EU countries?
4. Does being a member of the Commonwealth have an effect on UK trade?

To analyze the UK's trade pattern a gravity model has been constructed. The model is based on standardized gravity theory and explores the connection between economic size, distance and trade. The gravity model has been a cornerstone for explaining trade patterns across the world since the introduction of it in 1962 (Tinbergen, 1962). For this study, there has been added six variables to the basic model, in addition to the variables that explain distance and economic size, to capture the effects of political decisions and economic shocks. The variables are added to explore the trade effects of regional trade agreements, membership of the Commonwealth, the global financial crisis, the Covid-19 pandemic, as well as the effects of the exchange rate and Brexit.

The UN Comtrade database has been used to create a data set including yearly trade data between 2000 – 2021. A subset of the UK's trading partners, both EU and non-EU countries, make up the samples used in the analyses. With a total of four separate samples, total exports and imports, and imports and exports of food and live animals, the number of countries included vary between 47 and 66 and makes up at least 70% of trade for each sample. The analyses will be conducted by the use of panel data methodology, to allow for both time effects and entity effects. The specific models included in this study is the pooled OLS, fixed effects, random effects and the correlated random effects models. Each of the samples will be put through a number of tests to determine the most appropriate model. The estimations will not only evaluate the question of Brexit but will also help determine how and to what extent the other factors influence trade.

1.2 Organization of the thesis

Chapter 2 provides background information on how Brexit came about, and the UK's trade patterns since 2000. This will include the political process of Brexit, complications and economic concerns following Brexit, and how trade have developed. In chapter 3 I present the theory behind the analysis, as well as the literature review. The theory section will focus on the different types of trade agreements, as well as the concept of trade creation and trade diversion. The literature review will contain previous studies conducted on the topic of Brexit, using both the gravity model and other analyzing tools. Chapter 4 presents the data and methods used in the analysis, before results are reported in chapter 5. Chapter 6 provides concluding remarks and offer recommendations for future work.

2 Background

2.1 Brexit

The road towards Brexit started in January 2013, when the UK's prime minister David Cameron held a speech addressing the challenges facing Europe. In his speech, Mr. Cameron raised three main challenges:

> First, the problems in the Eurozone are driving fundamental change in Europe. Second, there is a crisis of European competitiveness as other nations across the world soar ahead. And third, there is a gap between the EU and its citizens which has grown dramatically in recent years (Cameron, 2013).

The intention of the Bloomberg speech was not to encourage a departure from the EU. Mr. Cameron stated in the speech that Britain was too dependent on the EU to sever all ties and that leaving the EU would only reduce the UK's influence on European politics. Mr. Cameron's solution to the challenges was to renegotiate the EU treaty in a way that strengthened the UK's position within the union. Only after a renegotiation and seeing the effects of a new treaty, the people were to vote on whether or not Britain should remain a member of the EU. The support for the EU was low at the time of the speech. According to Mr. Cameron, this was caused by misunderstandings and false promises of a referendum. At the end of his speech, Mr. Cameron expressed his support for remaining in a renegotiated EU and stated that the time had come to decide how Europe should impact British politics (Cameron, 2013; Daddow, 2015). This speech started the EU-UK debate, where Leavers and Remainers took opposing positions (Walker, 2021).

In February 2016, Mr. Cameron announced that the referendum of Brexit would take place in June. Despite the slim majority of 51,9% to 48,1% voting to leave, and that the referendum was only "indicative", the government announced that the UK was heading for Brexit. The initial date of leaving was set to be on 29 March 2019 but due to the difficulty of negotiating a deal (Dhingra et al., 2021), it ended up being postponed three times before prime minister Boris Johnsen announced during a speech in January 2020 that he would "get Brexit done". This became the official date of Brexit, and after a transition period of 11 months, the UK left the EU single market and customs union on 31 December 2020 (Walker, 2021).

2.1.1 Political and economic objectives of the debate

In this part of the paper, I summarize the two sides of the Brexit campaign, to help the understanding on how the Leave side ended up winning the 2016 referendum. This win came despite a substantial amount of pessimistic economic forecasts for the leaving scenario (Chadha et al., 2016; Dhingra et al., 2017; Emmerson et al., 2016; Portes, 2022).

The Remainers main focus during the campaign period was the economic loss the UK would face in leaving the EU, and how staying a member would allow the UK to have a bigger influence in the world (Swales, 2016). Economic and financial experts argued that the EU was the UK's largest trading partner, both in exports and imports, and that leaving the EU single market would cause the prices to increase as they no longer would be able to trade freely with the EU. This increase in price would lead to a decrease in national welfare for UK citizens. The Remainers also argued that companies located in the UK and which had duty-free access to the EU market would move out, taking away valuable jobs (Chang, 2018).

What the Remain side did not consider was the distrust in "experts" present among the British people. Research has shown that there has been a decreasing trust in banks and economic experts after the financial crisis in 2008, which weakened the economic arguments to remain in the EU (Curtice, 2016). Forecasts are educated guesses with multiple uncertain factors, which means that the Remainers could never give an accurate number to what it would cost the British people to leave the EU (Chadha et al., 2016). The economic arguments also tended to focus on what the country would profit by staying a member, but seeing that the government had run a tight austerity since 2011, there was little reason for people to assume this loss in profit would make their situation worse (Fetzer, 2019).

There were three main arguments used throughout the campaigns: economy, immigration and sovereignty. While the Remainers attracted voters that were concerned about the economic future of the UK, the Leavers attracted people concerned about the amount of control the EU had over British borders and law-making (Swales, 2016).

Fetzer (2019) argues that the win for Leave can be seen in context with the rise in support for the United Kingdom Independence Party (UKIP). Figure 2.1 shows that when austerity accelerated between 2010 and 2011, there was a sharp decrease in spending on both education, healthcare, and welfare and protection, while government spending on pension continued to increase.

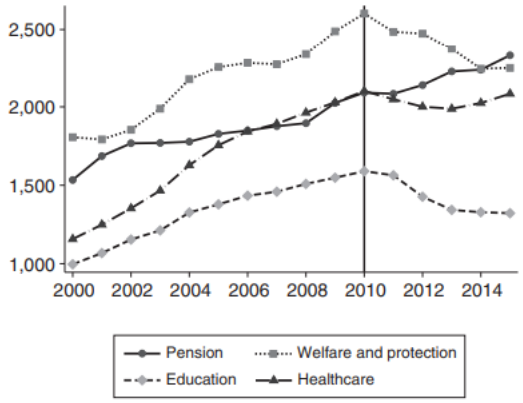

Figure 2.1: Real spending per capita (£) (Fetzer, 2019).

At the same time there was a freeze in public salaries, causing public employment to become less attractive. This created staffing problems in essential sectors, such as the National Health Services (NHS). People started to lean towards UKIP, not purely because of Euroscepticism or the belief that being a member of the EU was the reason for austerity, but because they wanted to protest what they believed to be misleading promises from other political parties (Fetzer, 2019).

In addition to the rise in support for the UKIP, the argument of controlling immigration was important during the campaign. Staying in the EU would mean open borders for anyone that wanted to come from the EU to work. Arguments used against this was that EU workers took away jobs from the British people, and thereby increased unemployment (Swales, 2016). Most of the elderly demographic also supported the Leave. The Euroscepticism has been large amongst the elderly demographic since the UK joined the EU in 1992, and controlling immigration has been one of the leading reasons for this skepticism (Fetzer, 2019).

The main arguments for the Leavers side on the subject of trade was that the EU had caused the UK's decrease in trade. After the global financial crisis in 2008, the EU experienced slow growth rates. To increase trade's contribution to UK's GDP it would be necessary to increase trade outside of the EU as well. The Leavers argued that the UK's economic agreement with the EU and the single market made this impossible (Chang, 2018).

While the Remainers focused more on economy than the Leavers, it is not unlikely that the economy was the reason behind the Leavers victory in 2016. The austerity made many people worse off, especially in struggling areas, which increased distrust in the government for the period leading up to the referendum. The Leavers campaign was also more relatable, as it was

easier for most people to see how Brexit would change the government's policy response to challenges such as immigration, rather than how leaving would affect the economy. Especially given the level of uncertainty associated with economic forecasts.

2.2 UK trade trends

To better understand how Brexit could affect UK trade, it is necessary to look at the historical trade patterns. The trade statistics in this section is divided between intra-EU and extra-EU trade, for total trade and the groups food and live animals. I will also comment on the trade pattern between the UK and the Commonwealth countries with regards to total trade. Except for the section on the Commonwealth, all numbers are collected from The Pink Book 2022, released by the Office of National Statistics each year to view UK Balance of Payments (Office for National Statistics, 2022)

Figure 2.2 starts with showing the total value of traded goods between 2000 - 2021. The stacked bars represent the three largest trading partners of the UK: the EU, USA and China. The graph shows an overall increase in trade for the study period. The value of trade in 2021 equaled £800 billion, an increase of 94% from 2000. There are two significant drops in value during the period, which lines up with the global financial crisis in 2008/2009, and the Covid-19 pandemic in 2019/2020.

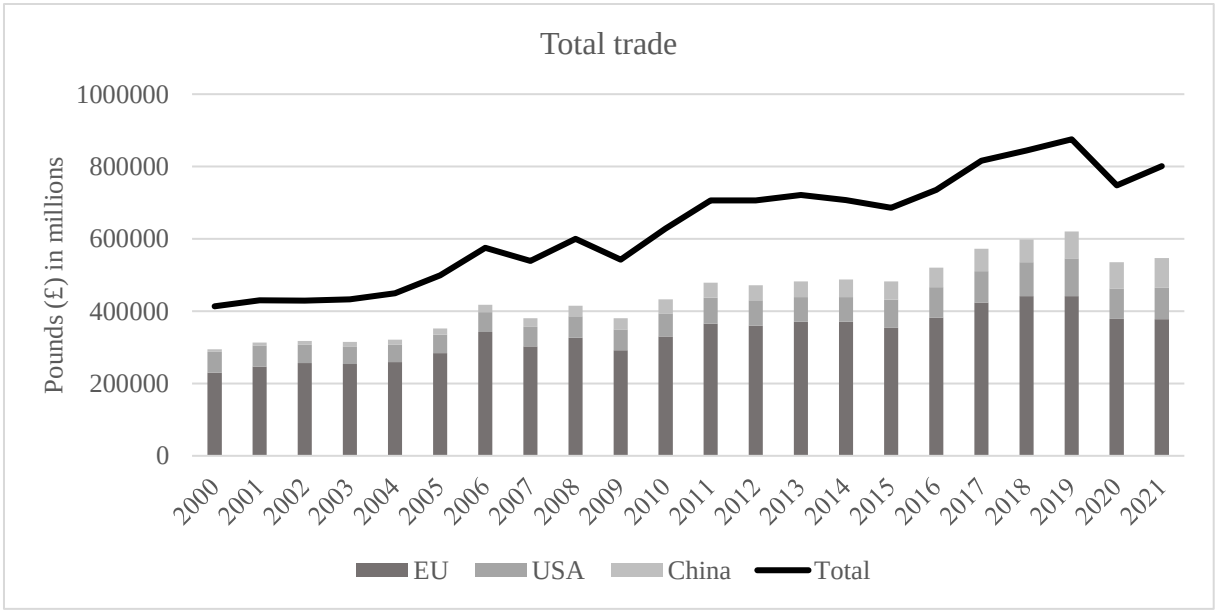

Figure 2.2: Aggregated UK trade from 2000-2021 (Office for National Statistics, 2022).

The sum of the top three trading partners made up 68% of all UK trade in 2021. With a 47% share, EU was the UK's largest trading partner. USA came in second with 11%, and China

accounted for 10% of total trade in 2021. While the EU is the largest trading partner, China has experienced the largest increase in share of total trade. Between 2000 and 2021, China's share of total trade has increased with 5%.

When disaggregating trade between exports and imports, the trends are similar. Figure 2.3 display a steady increase in both exports and imports from 2000 - 2019, with the exception of a drop in 2009 due to the global financial crisis. Both exports and imports experienced the largest drop in value during the period of the Covid-19 pandemic. In the same period the UK was also transitioning out of the EU. The graph shows that both imports and exports started to grow between 2020 and 2021 but did not catch up to 2019 values (Ward, 2021). While the exports and imports follow the same pattern, exports have experienced a larger growth than imports. In 2000, exports represented 55% of total UK trade and in 2021 it had risen to 60%.

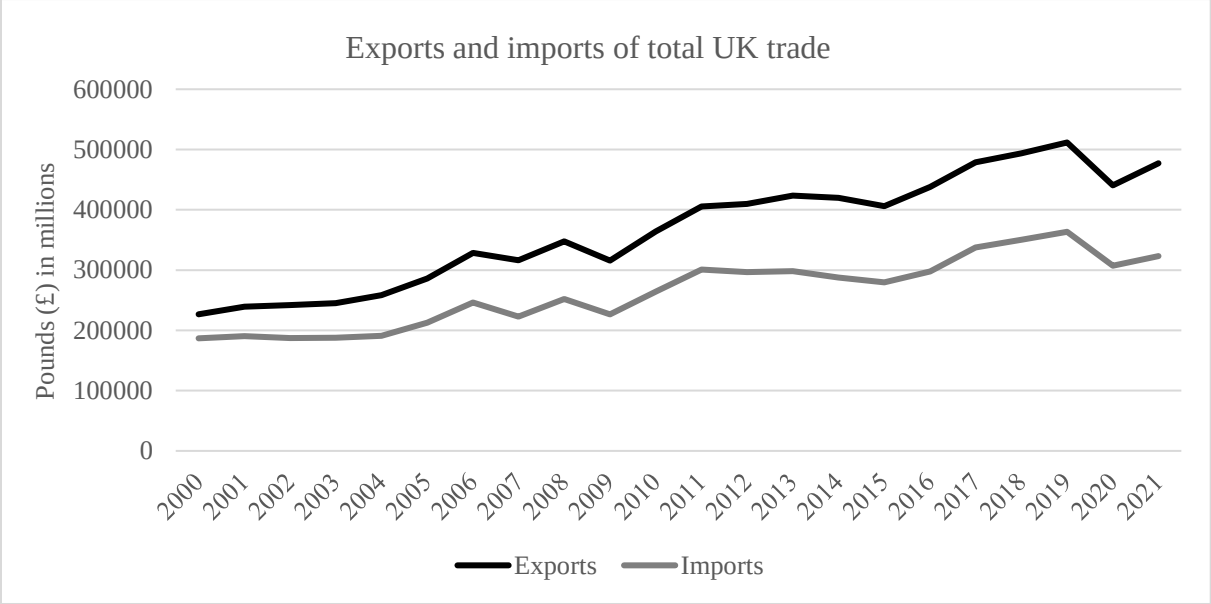

Figure 2.3: Total UK trade disaggregated between exports and imports (Office for National Statistics, 2022).

There seem to be little change in the value of imports and exports around the time of the referendum. In 2016, both exports and imports started to grow, before dropping in 2019. As trade started to develop in 2021, the transition period was over. There are some indications that imports did not experience the same recovery as exports did. By looking at intra-EU and extra-EU trade, I will be able to look for asymmetry between EU and non-EU.

2.2.1 Intra-EU trade

Trade with the EU has always been important to the UK. As seen in the previous section, trade with the EU made up almost half of total UK trade in 2021. Figure 2.4 shows the disaggregated intra-EU trade. Overall, there has been an increase in value traded for both exports and imports

during 2000-2021, with imports starting to increase faster than exports from 2011. In 2000 imports represented half of total trade with the EU, while in 2021 the share had increased to 59%.

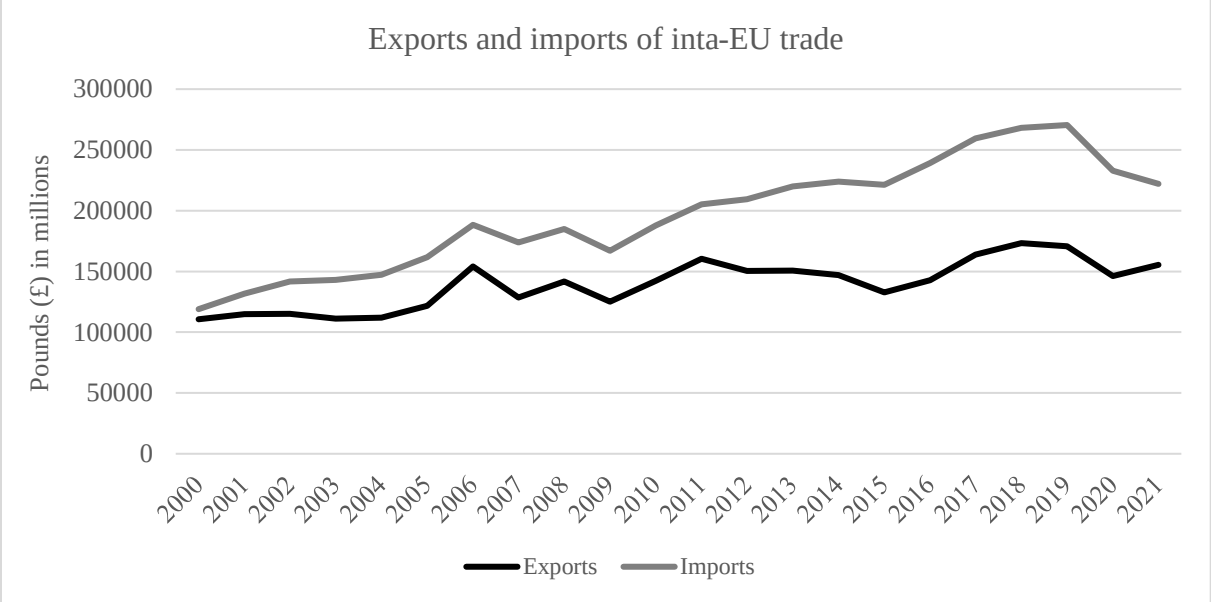

Figure 2.4: Value of UK exports and UK imports with the EU (Office for National Statistics, 2022).

A decrease in value of exports and imports can be seen for intra-EU trade for the period of the Covid-19 pandemic, with both imports and exports falling 14% from 2019 to 2020. Signs of Brexit cannot be spotted before the transition period in 2020. Since both Brexit and Covid-19 happened over a short time span it is difficult to separate the events without thorough research. What the numbers show is a drop in imports and exports with the EU after the first lockdown on 23 March 2020 (Ward, 2022). When exports started to increase in the third quarter of 2020, imports from the EU continued to fall, but at a slower pace. Exports showed a 5% increase from 2020 - 2021, which is less than total trade with an 8% increase in the same period.

While the value of trade with the EU has increased, the EU's proportion of UK's total trade has not. The share of EU in total trade has decreased from 56% in 2000 to 47% in 2021. This shows that while the EU is still an important trading partner, the UK has increased trade with countries outside of the EU more than they have with countries inside (Office for National Statistics, 2022).

Since members of the single market trade without border control, the EU is often referred to as one trading partner, while it in reality consists of 27 individual countries that all influence UK trade to a different degree (Ward, 2022). Figure 2.5 displays the distribution of UK trade between major intra-EU trading partners. The five largest countries are shown separately, while

the rest is represented in the ROEU (rest of EU). The sum of the five largest trading partners represents about 70% of all EU trade through the entire study period.

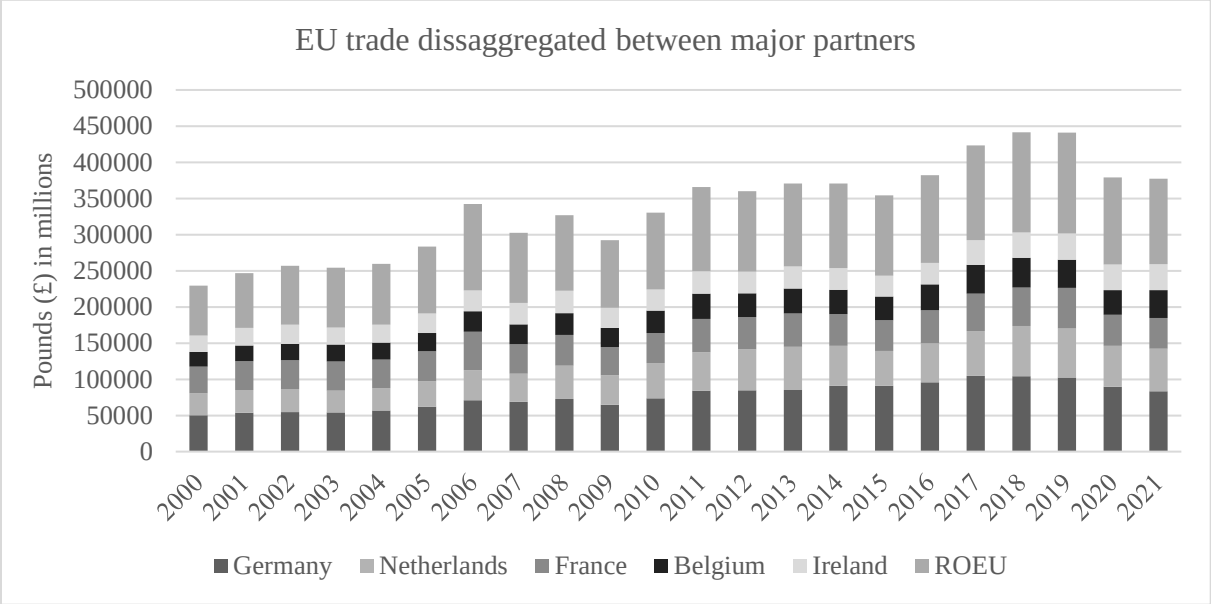

Figure 2.5: UK exports to the EU disaggregated between major trading partners(Office for National Statistics, 2022).

While the UK trade with all members of the EU, the most important trading partners are Germany, Netherlands, Ireland, France, and Belgium. In 2021 Germany was the largest trading partner, representing 21% of all UK trade with the EU. This made Germany the, overall, second largest trading partner with the UK in 2021 (Office for National Statistics, 2022). Besides Germany, the Netherlands and France are the two most important. Up until 2007 France was the second largest, trading 3-4% more than the Netherlands. From 2007 the Netherlands moved passed France, and in 2021 the Netherlands accounted for 5% more trade than France. When looking at the shares of trade, all countries react very similar to the fluctuations in trade. This indicates that the decreases and increases of trade with the EU during the study period is not caused by a major change in trade from one country but is a result of external shocks.

When only looking at exports from the UK, Germany remains the number one trading partner in the EU, with France, Netherlands and Ireland take turns being the second largest. For the Covid-19 period, all EU partners, except for Ireland, experienced a decrease in exports from the UK. Ireland experienced a small growth in value of exports from the referendum in 2016 until 2021. From 2021, ROEU and Germany keeps the downwards trend in exports, while the other major trading partners started to increase trade. Exports to the Netherlands grew rapidly in 2020-2021 and the UK exported the largest value to the Netherlands in 2021 (Office for National Statistics, 2022).

For imports, the distribution between the countries is a lot more similar to the aggregated EU trade. The difference between the biggest partner, Germany, and the second largest, the Netherlands, were significantly larger for imports than for exports. From 2010, Germany grew faster than all other EU trading partners, and in 2021 they accounted for 24% of all EU imports. All countries experience a decrease in the period 2019-2020. But, unlike exports, where countries started to see an increase in 2021, the value of imports kept falling for all EU countries.

2.2.2 Extra-EU trade

While the EU is an important trading partner for the UK, the share of EU trade has decreased for the study period. The UK is also one of the countries that traded the most outside the single market as a member state (Ward, 2022). The value of trade with non-EU countries has increased since 2000, and Figure 2.6 shows exports and imports between 2000-2021. What the graphs show is large differences in value for exports and imports. While the UK count on the EU for imports of goods, non-EU is the most important for UK exports.

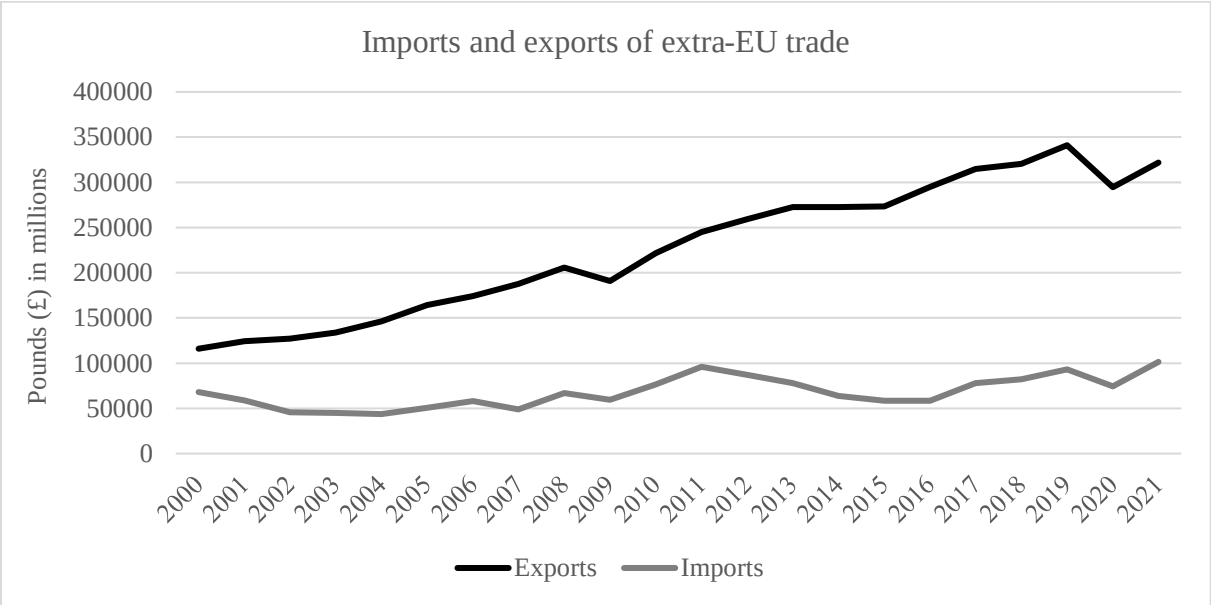

Figure 2.6: Value of UK exports and UK imports with non-EU (Office for National Statistics, 2022).

Exports has increased with £205 billion in the study period, which equals a percentage increase of 178%, while imports have had an increase of £3 billion, equaling a 50% increase. When looking at share of total trade, exports represented 76% of all trade between non-EU and the UK in 2021.

The graph shows that non-EU trade was affected by the global financial crisis and Covid-19 as well. Looking at the numbers, export fell by 14% and imports by 20% between 2019 and 2020.

Unlike the EU, which experienced a decline in value of imports after 2020, the imports with non-EU started to increase. By 2021, the imports from non-EU countries had passed the 2019 value by 2%. Exports also started to increase from 2020, but not as fast as imports.

To explore the non-EU trade further, Figure 2.7 shows non-EU trade disaggregated between the continents. The graph shows that America and Asia are the two largest continents, and together they accounted for 59% of all non-EU trade in 2021. Australasia and Oceania are the smallest, and accounts for only 10% of trade with the UK. While America has kept the same share of the trade market through the entire study period, Asia has experienced a 6% increase in market share from 2000 – 2021.

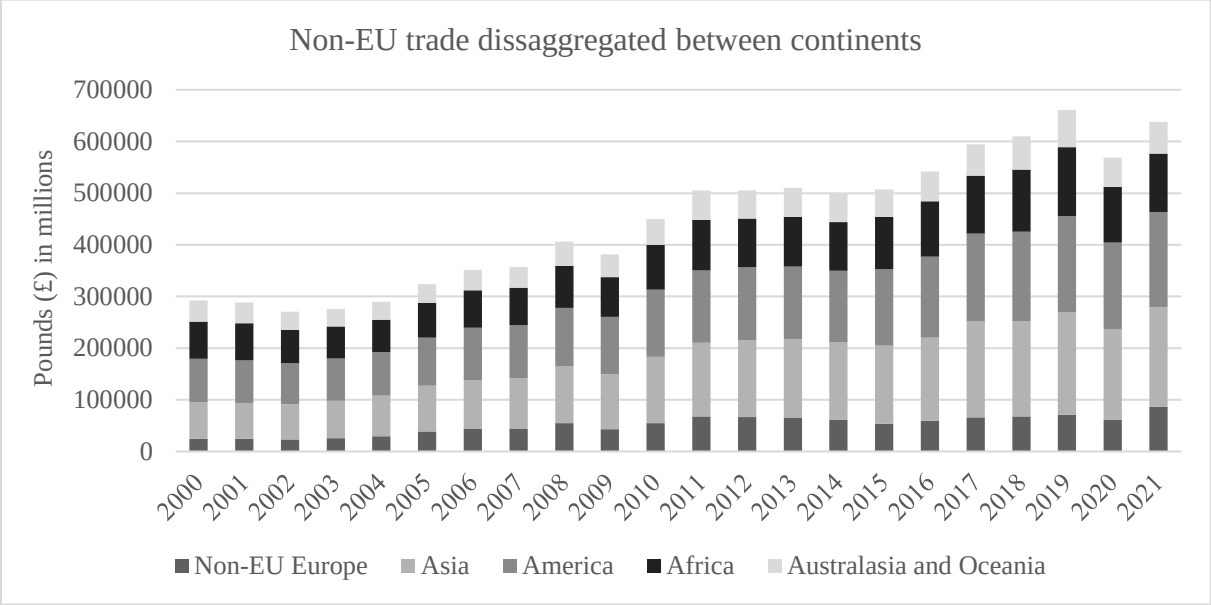

Figure 2.7: Non-EU trade disaggregated between continents (Office for National Statistics, 2022).

One reason for the development in non-EU trade is the increased importance of China. In 2021, 42% of all Asian trade was with China, compared to 10% in 2021 (Office for National Statistics, 2022). Exports from Asia has increased by 190% during the study period, making Asia the most important non-EU region for both imports and exports. While the UK also shows a significant increase in value exported to America, trade with America has always been a large share of UK trade. The most important American country is US. Covering 13% of all exports and 12% of all imports with the UK in 2021, the US is the largest individual trading partner of the UK (HM Revenue & Customs, 2022).

Figure 2.7 can also shed some light on the increase in trade after 2020. The non-EU Europe experienced a large increase in trade with the UK. The main reason for this fast increase was

Norway, which increased their market share in UK imports by 144% between 2020 and 2021 (HM Revenue & Customs, 2022).

2.2.3 Trade with the Commonwealth

The Commonwealth was historically connected to the British Empire, and while it is not a requirement today, most members of the Commonwealth have a joint history with the UK. It is therefore beneficial to comment on the trade pattern between the Commonwealth and the UK (Ward, 2023). The Commonwealth consists of 56 member states, which vary in size, population and date of joining. The Commonwealth countries made up 9% of UK's imports and 10% of their exports in 2021 (Ward, 2023). As a comparison, Germany, the second largest individual trading partner of the UK made up 11% of UK's imports and 9% of exports in 2021 (HM Revenue & Customs, 2022).

Similar to countries that trade with the UK, the Commonwealth has also experienced growth in value traded. Comparing 2000 and 2021, imports increased by £40 billion and exports by £35 billion. If we look at their share of imports and exports in the market, the Commonwealth's market share in imports has been between 8 and 10% in the entire period, and exports has been between 8 and 11%. While imports seemed to be affected by Covid-19, a fall of 12% in import value from the Commonwealth, exports did not change notably, and imports were also almost back to 2019 numbers in 2021 (Ward, 2023).

The largest individual trading partner within the Commonwealth is India, which made up 1,5% of both total imports and exports with the UK in 2021. India equals 21% of UK's total trade with the Commonwealth, and together with Canada, Australia, Singapore and South Africa, they made up 73% of all UK trade with the Commonwealth in 2021, while the remaining 26% was divided between the 44 other members.

2.2.4 Trade of food and live animals

When investigating the trade pattern of food and live animals, the trade data was collected through UN Comtrade, by specifying exports or imports in the standard international trade classification (SITC) 0 (UN Statistics Division, n.d.).

In 2021, food and live animals accounted for 11% of UK's total export, with its main share coming from non-EU countries. Figure 2.8 shows the total value of food and live animals exported, as well as the aggregated value separated between EU and the rest of the world (ROW). When comparing total exports in Figure 2.3 with exports of food and live animals, the trade patterns vary. Food and live animals experienced a decrease in the start of the study period,

before increasing steadily. When total exports started to decrease in 2006, F&A started increasing more rapidly.

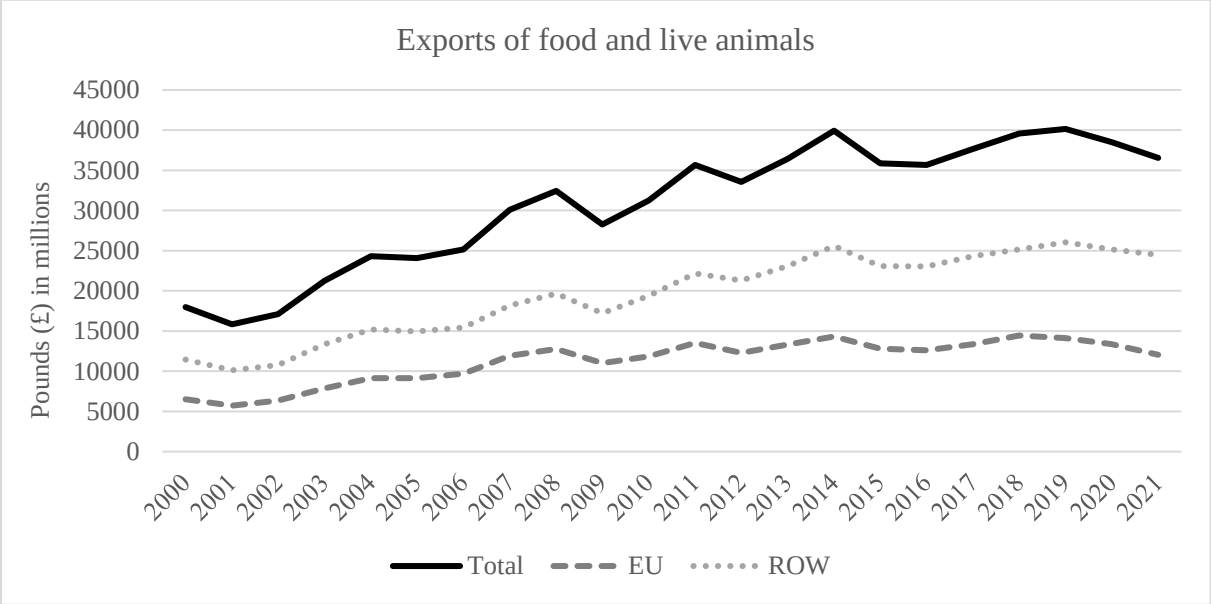

Figure 2.8: Exports of food and live animals as total trade, EU and ROW trade (UN Statistics Division, n.d.).

F&A also experience a drop in exports leading up to 2016, before increasing after the referendum. This increase is however much slower than for total exports. When it comes to the period of Covid-19, F&A experience a decrease in exports, but not to the same extent as total trade. From 2020 – 2021 exports of F&A fell by 4%, while total exports fell by 14%. When reaching 2020, the exports of total goods started to increase, while exports of F&A continued to decrease. When comparing 2019 to 2021, F&A had a 9% decrease in exports, whereas total exports only fell by 7% (Office for National Statistics, 2022).

Looking at the disaggregated exports, the same fluctuations can be seen in both EU and ROW, but from 2008, the gap between ROW exports and EU exports started to increase. In 2021, ROW accounted for 67% of total F&A exports, compared to 64% in 2000. From 2019, the patterns of the disaggregated exports started to differ. While the EU experience a drop in exports around 2019, there are much smaller changes in ROW. ROW also seems to flatten out throughout 2021, while EU continues to decrease. When looking at percentage change from 2019 – 2021, the EU exports fell by 15%, while ROW fell by 6% (UN Statistics Division, 2023).

Food and live animals are significantly more important for UK imports than for UK exports, and in 2021, imports of F&A equaled 32% of total imports. Figure 2.9 shows the total imports

of F&A, as well as the disaggregated value separated between EU and ROW. Similar to the situation of exports, the pattern between total imports and imports of F&A differ.

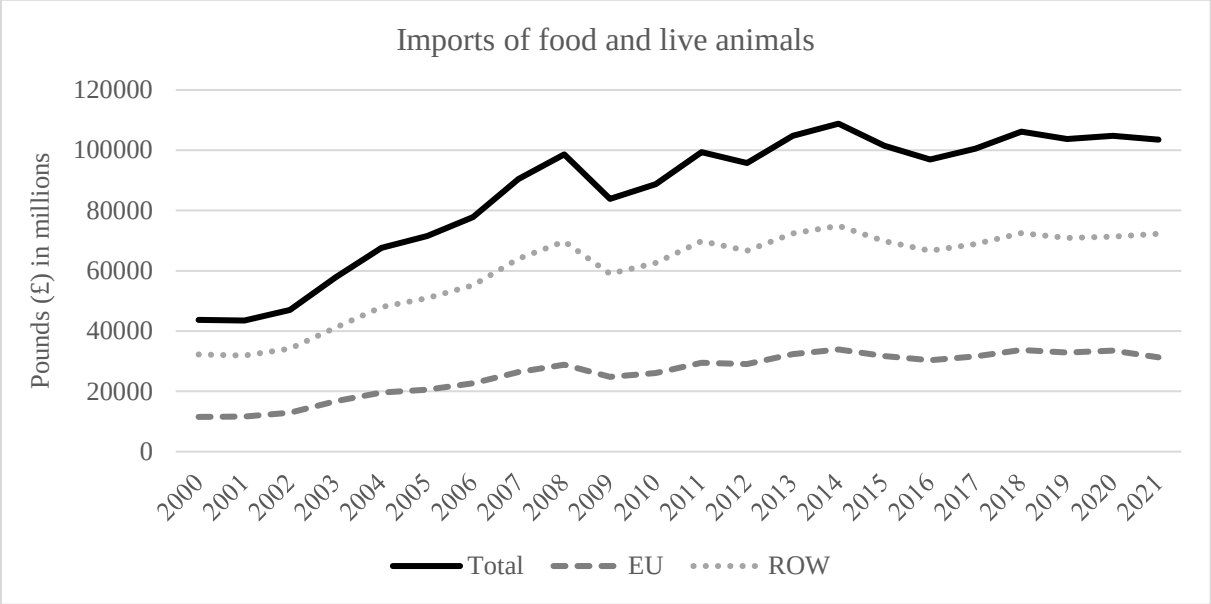

Figure 2.9: Imports of food and live animals as total trade, EU and ROW trade (UN Statistics Division, n.d.).

Where F&A experienced a steep increase in imports between 2000 - 2008, total imports increased slowly. Both experienced a decrease caused by the financial crisis, but as the value of total imports started to stagnate from 2011, imports of F&A continued to grow until 2014, with the exception of a small dip in 2012. The most interesting observation from food and live animals, is the lack of decrease in value around the Covid-19 pandemic. While total imports fell by 15% between 2019 – 2020, imports of F&A increased by 1% in the same period. The imports do, however, indicate a small decrease of 1% between 2020 and 2021 (UN Statistics Division, 2023).

Looking at disaggregated trade, EU and ROW show the same fluctuations as total imports of F&A. Overall, imports from the EU have very small fluctuations throughout the entire period. The graphs start to move in opposite directions from 2020, where ROW increases and EU decrease. From 2020 to 2021, EU imports fell by 7%, while ROW increased by 1%. While the EU has increased its share of total imports over the period, ROW is still the largest trading group accounting for 70% of UK imports in 2021 (UN Statistics Division, 2023).

2.3 Post-Brexit complications

When the UK left the EU single market on 31 December 2020, they carried out what is referred to as a hard Brexit (Walker, 2021). This meant that the UK left both the single market and the customs union, and would have to trade under the WTO agreements, while making individual

trade agreements with all trading partners (Chang, 2018). The negotiations on a trade agreement between the UK and the EU started just after the transition period began. After months of negotiations the EU-UK trade agreement was signed on 30 December 2020, avoiding a departure from the EU without an agreement on the future relationship between the two parties (Cabinet Office, 2021).

The new agreement between the EU and the UK changed the relationship between the two parties. The Trade and Cooperation Agreement (TCA) oversees a range of issues concerning trade in goods and services, the movement of people and capital and several other important issues (Fusacchia et al., 2022). The elements of the TCA are further explained in chapter 3.

Seeing the final outcome of Brexit on the British economy is not possible in such a short-time perspective, but there are several estimates that deal with the short-term effects and try to predict the long-term effects. Estimating these numbers increased in difficulty when Covid-19 hit at the same time as Brexit (Springford, 2022). The UK, highly dependent on imports of oil and gas to meet their energy needs, have also been affected by the Russian invasion of Ukraine through higher energy prices on the international market, which will cause more disturbance when trying to estimate the effects of Brexit in a longer perspective (OBR, 2022).

With regards to trade, the implementation of the TCA has had an effect on both imports and exports. The TCA states that goods can still be traded without quotas or tariffs, but the reinstating of a customs framework comes with a cost for importers or exporters, as well as increased transportation time due to customs (Bakker et al., 2022). The initial costs linked to trade are likely to fall upon the customers, increasing the price of goods even if the good itself enters duty-free and quota-free.

Despite the UK holding off on implementing the customs check, and the EU tightening restrictions immediately, UK imports have fallen by more than UK exports. There are debates as to how much of the decrease in trade that comes from the TCA, but that it changed the relationship between the EU and the UK is undebatable (Fusacchia et al., 2022). The drop in imported goods have created trouble for British firms, as most of the imported goods are intermediate products used in British production (Bakker et al., 2022).

Export with the EU has followed the same pattern as exports with non-EU countries, which implies that the UK has not been hesitant on continuing exports, despite the implementation of the EU customs check (Freeman et al., 2022). Looking at trade in goods outside of the EU, the relationship between the UK and third countries has not changed since Brexit. OBR (2022)

finds that the decrease in trade with the EU is not fully covered by trade with third parties, creating an overall drop in imports and exports to and from the UK.

The short-term estimates points to a negative economic outcome from Brexit in the longer run. Decreased trade with the EU has not been fully replaced by trade outside of the EU, with services taking a harder hit than goods. Researchers are however more positive towards the migration trend but are uncertain as to how the new system will affect wages in the different sectors.

3 Theory and literature review

3.1 Regional trade agreements

Regional trade agreements (RTAs) have experienced growing importance in international economy since the second world war, but the number of RTAs did not escalate before the World Trade Organization (WTO) was established in 1995. Since the UK left the EU, the UK has signed over 70 trade agreements, demonstrating the government's commitment to trade through RTAs (Department for International Trade, 2022). In line with the increasing number of trade agreements, the definition of an RTA has also changed. An RTA was initially an agreement between neighboring countries to promote economic integration, but has now expanded to also include agreements between two parties, which no longer need to be adjoined (Ravenhill, 2020). This allows the free trade agreement between the UK and Singapore to be categorized as an RTA.

Trade agreements are divided into different types based on the restriction they impose on the member states. The least restrictive is the free trade area (FTA). The intention of an FTA is to remove any trade barriers between countries to allow free movement of goods and services. By removing tariffs on goods and services, it becomes cheaper to import from member countries. The idea with an FTA is to remove tariffs on all sectors between members, but it is possible to keep some sectors outside of the agreement. This could be done to protect non-competitive sectors (Appleyard & Field, 2017). FTA agreements do not interfere with national decision making or control trade outside of the trading area. This allows countries to decide their own external tariffs, or to join as many FTAs as desired. Do to the simplicity of these agreements, FTAs are the most common form of RTAs (Ravenhill, 2020).

Both customs unions (CUs) and common markets (CMs) involves deeper integration between areas. Instead of only controlling barriers between the members of the agreement, a CU has a set of guidelines that explains how all members are to trade with third parties. These guidelines involve a common external tariff, and a common customs authority. The negotiation of a common external tariff makes the creation of CUs difficult, and only a handful of RTAs are CUs. The common market goes even further and combines a CU with the free movement of labor and capital. This requires that countries who joins a CM give up even more of their sovereignty, and a high level of collaboration between the parties is necessary (Ravenhill, 2020).

The most integrated RTA is an economic union. In addition to the CM, an economic union also unifies all economic institutions and have a shared economic policy for all members. The economic union could also become a monetary union if the countries choose to create a common currency. The degree of collaboration needed in an economic union requires the establishment of a supranational power to ensure equal treatment across countries (Appleyard & Field, 2017). Within the EU, there is a sub-union called the Economic and Monetary Union (EMU), which is an example such an agreement. Since it is a sub-organization, members of the EU can choose whether they want to join the EMU (Juncker et al., 2015).

When the UK was a member of the EU, they chose to opt-out of several such agreements within the EU, to preserve certain aspects of UK sovereignty (Miller, 2014). The most significant exemption was the EMU to allow the UK to keep the pound sterling as the official currency. They also chose not the sign the Schengen Agreement that allows for passport-free travels between member countries (European Commission, 2015). In 2014, the UK Parliament also voted on the exemption of the European Arrest Warrant, but the result favored to remain a member (Godec & Lipscombe, 2017).

3.1.1 The political and economic motivation behind RTAs

But why do countries choose to enter into RTAs? There are several economic and political motivations for countries to sign an RTA. Political motives are usually rooted in the creation of a closer relationship with other parties, while economic motives stem from a wish to increase domestic markets (Ravenhill, 2020).

Security is one of the main political reasons for countries to join a trade agreement. Countries that have few or no natural allies might join an RTA to increase the feeling of security. If countries are bound by a contract, even if it is not a contract regarding security, it is more likely that they would help in a conflict. There are also examples of countries using RTAs to reward security partners. Ravenhill (2020) uses the US as an example and explains how the US negotiated several new RTAs after the attack on 9/11, to reward and ensure support from important partners. Recently, RTAs has also been signed for less traditional security matters. Agreements between industrialized and less developed countries is used to prevent trafficking and environmental damage, for instance (Ravenhill, 2020).

The stronger the RTA is, the more likely it is to inflict some consequences on a country that chooses to leave. When the UK decided to leave the EU, they were exempted from commitments that followed being a member, but also lost several political benefits. When the

UK left, it was found necessary to sign an agreement on security cooperation, and part 3 in the Trade and Cooperation Agreement (TCA) between the EU and the UK concerns security measures. It states that the parties will continue to exchange information and data, as well as the provisions of extradition, to ensure individuals facing prosecution in a country cannot escape. Since the UK is no longer a member of the European Arrest Warrant system, the process of extradition will be more time-consuming than before. The TCA does not include continuous participation in Europol and will instead be replaced by a cooperation agreement with the EU law enforcement agency. The UK also lost access to the Schengen Information System, which is a centralized database for wanted or missing people or stolen and lost property (European Atomic Energy Community et al., 2021).

RTAs are also a tool for politicians that wants to increase international trade. Basic economic theory suggest that the largest welfare gains are reached if trade is undistorted by intervention, but politicians often resort to RTAs instead. The reason for this is that lowering tariffs for all countries can hurt the domestic market. RTAs allow politicians to selectively reduce tariffs and is often better received by the voters. This is because RTAs offers something in return from partners, rather than just reduced barriers for all international competitors (Ravenhill, 2020).

The economic motives for using RTAs are more mixed. An RTA allows countries to single out sectors, and the removal of tariffs on goods that are competitive, but still protect sectors that are unable to compete in an international market. Removing trade barriers could increase productivity in companies due to economies of scale. Economies of scale explains how increased production allows the fixed costs to be spread over more units, thereby making each unit cheaper to produce and the prices to go down. Whether economies of scale is beneficial for the country depends on a number of factors, but for large companies located in small countries it is often helpful to increase the domestic market as long as they are efficient at production (Ravenhill, 2020).

At the same time, a country is likely to avoid signing a trade agreement that would threaten a vital, non-competitive sector. Protecting a sector that cannot stand against international competition goes against economic theory, which states that the most efficient producers should be allowed to produce, to reach the largest welfare gain. However, there are important non-economic motives for protecting certain sectors. The negative externalities of removing an entire sector’s production could be greater than the gains of opening for international competition. Norway is one example of an open economy with much international trade, that

still chooses to protect the agricultural sector, despite the increase it causes to the food prices for the consumers (Isbrekken, 2020).

3.2 Trade creation and trade diversion

From a purely economic standpoint the intention of entering an RTA would be to make member countries better off in terms of trade. What the previous section explains is that countries enter RTAs for a number of reasons, and not all being economic. This opens up for the question of how an RTA could affect the welfare of member countries. Viner (1950) was one of the first to show how an RTA not necessarily create positive welfare effects. To explain if a country is better off in an RTA, it is common to use the terms trade creation and trade diversion (Freund & Ornelas, 2010).

Whether an RTA is creating a positive or negative welfare change is subject to how the productivity of production changes as a trade agreement is entered. If an RTA leads to higher productivity, we have trade creation. The increase in productivity comes from an increase in resources allocated to production where the country has a comparative advantage, as well as reducing the resources dedicated to production of goods that are less effective to produce. The shift in production will allow the most productive country to produce the good, meaning that the agreement moves production from an inefficient domestic producer to a more efficient producer in a member country. If, however, the creation of an RTA moves trade away from the most effective producer, meaning that a country starts trading with a member country instead of the most efficient producer outside of the agreement, we get trade diversion (Freund & Ornelas, 2010).

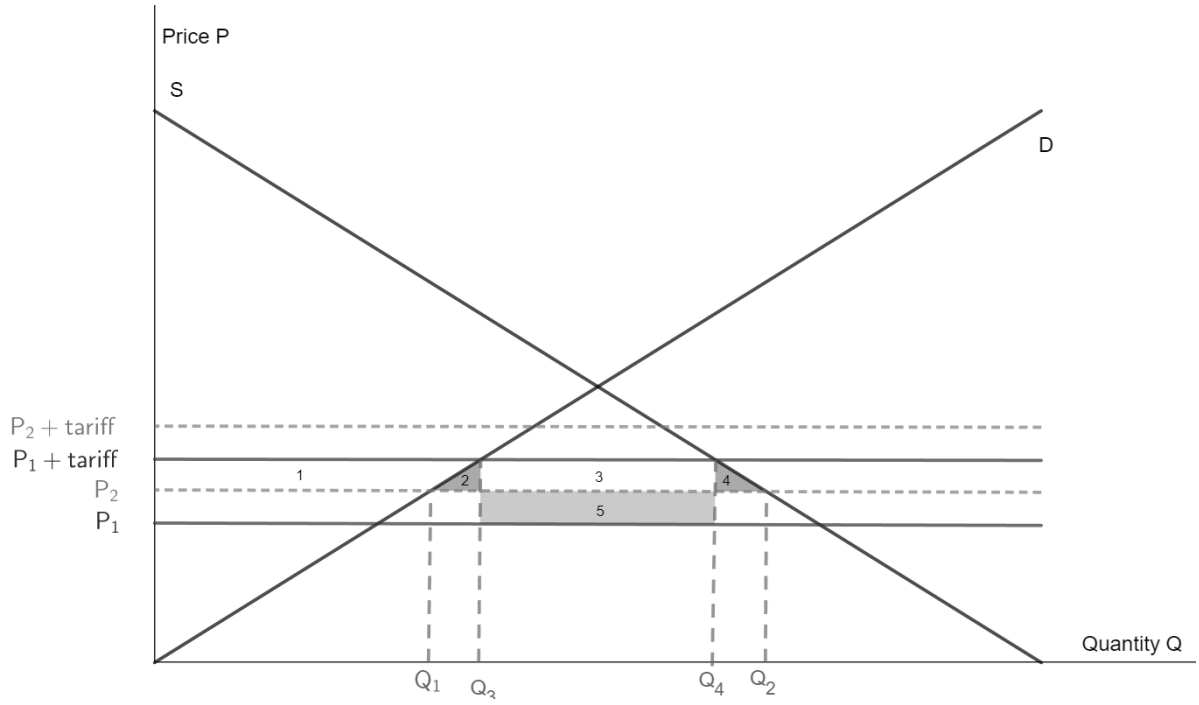

Figure 3.1: Trade diversion (Appleyard & Field, 2017).

Figure 3.1 shows the economic effects of trade diversion. In this scenario, we have the option of importing the same good from two different countries, 1 and 2. Without tariffs, it is most beneficial to import from country 1 at P_1, since this is the lowest price. When adding a tariff to both countries, the prices increase by the same amount, and the goods from Country 1 is still the cheapest, shown as P_1+tariff. When an RTA with Country 2 is signed, it removes all tariffs with Country 2. What we see then is that the price of Country 2 drops from P_2+tariffs, to P_2 in graph, making it more beneficial to import from Country 2, even though their good was initially more expensive. This results in a situation where the good could have been imported at a lower cost, if all tariffs were removed, and the most productive producer is no longer producing the good. In terms of welfare effects, the government loses tariff income (area 3+5), consumers gain from a lower price (area 1+2+3+4) and domestic producers loses income due to lower prices (area 1), resulting in a net gain of (2+4)-5. Whether there is a social welfare loss or welfare gain depends on the elasticity of demand, but in this scenario 5 > (2+4) which creates a net welfare loss (Appleyard & Field, 2017).

Estimating trade diversion is complicated, as the calculations has to be based on a set of assumptions carrying a high level of uncertainty. The changes that would have occurred in trade, had there not been an RTA present, is near impossible to calculate. While trade economists have feared increasing trade diversion with the rising number of RTAs, evidence

show that trade diversion might not be as big of a problem as previously feared (Freund & Ornelas, 2010).

Brexit is an interesting topic for economists that want to look into the effects of RTAs on trade. If the UK experience an increase in welfare after leaving the EU, it might be a sign that constricting RTAs can have a negative effect on trade, when the country also rely on trade outside of the RTA. If UK welfare experience negative effects of leaving the EU, one conclusion could be that RTAs promote trade creation. While the calculation of trade diversion is considerably more complicated than the idea proposed in this paragraph, as every country has its own unique trade pattern, it could give some indication on the effects of a strong RTA on a country trading both inside and outside of the agreement.

3.2.1 Rules of origin

One of the key elements of an FTA is that membering countries are allowed to choose their individual external tariffs. Countries that are dependent on imports from external countries may choose to keep their tariffs lower, while countries with non-competitive production keep a higher tariff to avoid external competition. This creates a problem when external trading partners start using transshipment to get access to the FTA at the lowest possible cost. Transshipment implies that the goods enter the FTA through the country with the lowest external tariff. Since there are no tariffs within the FTA the goods can freely move to countries with higher tariffs, and thereby still create competition (Appleyard & Field, 2017). To avoid this issue 'rules of origin' (ROO) has become an important element in FTAs.

Rules of origin is a set off conditions that countries in an FTA agree on, to ensure that goods travelling over state lines originate from the member countries, and not from an external trading partner. The criteria for ROOs can be quite different, and documenting ROO can be both time consuming and complicated, especially considering that goods created within the FTA contains components from external partners. A *value-added criterion* requires that a minimum percentage of the value on goods exported comes from the FTA member. A *change of tariff heading criterion* relies on the Harmonized System (HS). Each input has a HS code, and if the output is given a code stating it is originated in an FTA country, it is considered to be produced domestically, no matter the amount of external input in the good. A *specific processing criterion* limits which parts of the production that can happen in an external country. A *specific components criterion* states which components that must be produced in the member country, for the good to be declared tariff-free (Ravenhill, 2020). The rules of origin is only a concern

when discussing free trade areas, as customs unions, common markets and economic unions all have one external tariff.

If a country were to leave a trade agreement, it would lose access to the preferential tariffs with member countries. This could lead to a de-integration, as the country would have to negotiate new agreements. For an FTA, the ROO would no longer apply if the country chose to de-integrate, and would result in administrative costs, as new document requirements would need to be established. The former member would be faced with increased tariffs because the country is no longer under the ROO regulations and could impose as a threat to production within the FTA.

3.2.2 Existing literature on the subject

Since it became public that Brexit was a fact, many economists have estimated and simulated the effects that Brexit could have on UK trade. It is now two years since the official Brexit, and some short-term effects are starting to form. It is still, however, too early to talk about what long-term effects Brexit will have on the UK trade.

Dhingra et al. (2017), considered the costs and benefits of leaving the EU, just one year after the referendum. The analysis uses 2011 data from the World input-output Database to try to determine the medium- to long-term perspective of Brexit. The focus of the analysis was on trade and fiscal transfers between the EU and the UK. By using the standard quantitative trade method, they estimated the effects of two different negotiation outcomes, one where the UK would have stayed in the EU single market (a soft Brexit) and one where they would only trade under the World Trade Organization rules (a hard Brexit). The results show that a "soft Brexit" would decrease UK living standard by 1,3% and that a "hard Brexit" would reduce the living standards by twice that. The model does not consider the dynamic effect of trade on productivity, which is a weakness of the results. In conclusion, Brexit would have economic consequences for the UK and the EU, but to what extent would depend on the outcome of the negotiations. The study uses a trade model to try and determine the effects of Brexit, and while the standard quantitative method is used to estimate the impact for various factors of trade, it still helps the understanding of how the UK trade could be affected in the longer run.

The early effects of Brexit on the subject of trade was measured in an analysis by Douch et al. (2018). By looking at 14 EU and 14 non-EU countries, they analyzed the effects of the announcement shock following the referendum. The analysis uses monthly data from January 1999 – March 2018, and was conducted by using a Synthetic Control Model (SCM). The SCM

considers the assumption that one party will be affected more than the others. The results found that the Brexit announcement had a negative effect on UK trade for both exports and imports, with the latter being more affected. An interesting note is that imports from the EU have fallen less than non-EU countries, which could raise questions of the actual effects of the Brexit shock on EU trade. There is also evidence that the UK moved their trade towards Commonwealth countries, but the authors believe it can be explained by the campaigns used during the election period. While the paper uses a different approach, their discovery of the effects on the Commonwealth countries has been an important note when creating the gravity model (Douch et al., 2018).

There are also more recent reports that considers the effects of Brexit after they officially left in December 2020. Oberhofer and Pfaffermayr (2021) used a structural gravity model to estimate the trade and welfare effects of Brexit on manufacturing goods. They collect data from 65 countries for the time period 1994-2012. To test the welfare effects on the UK, they created two Brexit scenarios, one with an option of a Soft Brexit, and the other with a option of a Hard Brexit. They tested the welfare effects on bilateral trade flows between the UK and the EU by testing for different effects between a common market and a free trade area. Their results showed a decrease in welfare on real GDP somewhere between 0,3% and 5,7%. The evidence showed that a Hard Brexit would give the largest negative welfare effects, and that increasing FTAs with third countries, it would still not be enough to make up for the loss of trade with the EU. They also found that there would be an increase in domestic trade within the UK, but that this would give a negative welfare effect as well. The reason was that the UK would be switching out relatively cheap inputs with more expensive domestic goods. The limitation of this paper is that it only focuses on trade of manufacturing goods, not considering migration, trade in services or foreign direct investments. The authors argued that this was due to lack of available data, and that there were few suitable policy indicators. Since the data used in the analysis do not contain actual Brexit trade data, since the observations stop in 2012, the results are only estimations of the how Brexit could affect trade. It is still beneficial to use the paper as a guide when executing my analysis.

Freeman et al. (2022) analyzed the impact of Brexit on UK-EU trade, compared to trade with the rest of the world. The paper is called “UK trade in the wake of Brexit” and uses quarterly data from January 2013 – December 2021. The analysis considers both the “leaving period” and the “post-leaving period”, where the Trade and Cooperation Agreement was in place. Their finding was that the period between the referendum and 31 January 2021 had no significant

effect on UK-EU trade. The TCA did, however, create a shock. Imports fell with 25% from the EU, unlike exports which did not experience the same drop. By using a difference-in-difference event-study methodology, they separated the change in trade caused by Brexit and the Covid-19 pandemic. This allowed the conclusion that imports took a harder hit than exports when the TCA was implemented. It is important to note that exports with the individual countries might not have fallen significantly, but that there was a rapid decline in the number of trading partners. At the end they also saw a connection between the products and the change in trade, caused by the TCA agreement. The study is one of the few published analyses that uses the time period of Brexit as their data source. This makes the paper important, as they provide a very in-depth analysis for the time of Brexit. The end date also corresponds with the end date of my study.

Springford (2022) uses a doppelgänger approach to estimate the effects of Brexit by using quarterly data between Q1 2009 – Q1 2021. The doppelgängers are created by an algorithm which choses countries that had similar economic performances to the UK before Brexit. Four different doppelgängers were estimated to imitate GDP, investments, total services traded, and total goods traded. In the estimations Springford finds that the British GDP was reduced by 5,5%. Investments and trade of goods and services has decreased compared to the doppelgänger as well. Springford argues that the increased tax rates are an effect of Brexit. The model has been under a lot of criticism, mainly for being too narrow after the financial crisis and that the choice of countries in the doppelgänger gives a false image of the effects of Brexit. While the algorithm choses countries like the US and New Zealand, critics suggest to only compare the UK to similar countries in Europe, like Germany, France and Italy. Springford answers this criticism in the article and gives arguments explaining how his estimations are similar to other research. Covid-19 is seen as a weakness for this study. Springford uses the development of countries similar to the UK to assume an expected effect of Covid-19 on the UK. By removing the trade recovery similar countries have experienced, he is left with the effects of Brexit. The pandemic was handled very different in each country, and the economic rebound is therefore very individual. This makes it less likely that trade recovery in the UK would act similar to other countries. For my analysis, the paper gives an indication of Brexit effects, and while the paper is largely debated, it provides a nice overview of the changes in the actual trade data.

The study by Brakman et al. (2021) uses a structural gravity model to determine how several scenarios could affect the welfare and trade of the UK. The analysis is done on a total of 43 countries which makes up 90% of the world trade. The study does not provide a timeline for the analysis, but some figures use monthly data up to May 2021, while the source of the data

seems to be from 2020. The scenarios analyzed are Brexit, where only EU members have an FTA with the UK. They then add all FTAs the UK had enforced at the time of writing. Scenario three is an Anglo-American FTA where the UK, US and all non-EU trading partner sign a united FTA. They then tested the scenario of all non-EU countries having an FTA with the UK. The last scenario is a situation where Northern Ireland, Scotland and Wales choose to leave the United Kingdom. The results show that it will not be possible to avoid a welfare loss and decrease in trade for the UK. Dividing the UK will have the largest economic consequences, but the leaving states will be able recover a bit if they sign extensive FTAs with the EU. The data used in the study is very simple, and more refined data could benefit the study. It is also possible to extend the model to include sectors or additional trade barriers. The study provides me with a newer analysis that uses the gravity model to estimate Brexit's effects on UK trade. While the gravity models distinguish, the results are of great importance for my studies as I try to discover the same effects.

While there are a number of studies, both using a gravity model and other forms of estimations, there is still room for analyses that uses recent data. Since Brexit has only been a fact since 2021, there is little data available on the subject. There is also a lack of studies that look into the different sectors of trade. Learning more about how shocks have impacted the different sectors would allow for a greater understanding of the effects of Brexit (Bakker et al., 2022).

4 Data and methodology

This chapter will present the variables and the method I have chosen for this study. Since the analyses aims to look at international trade, I have chosen the generalized gravity model to investigate the possible effect of Brexit. The four data sets vary in the number of countries, but all contain observations for the period 2000 – 2021. Total exports include 66 countries (1452 observations), total imports include 48 countries (1056 observations), exports of F&A include 52 countries (1166 observations), and imports of F&A include 47 countries (1034 observations). The country selection is based on available data for the study period. This is done to not only explore the effects of major trading partners, but to also include the effects of smaller partners. Countries with missing data has been excluded, to allow for data sets with no missing variables. To ensure that the analyses consider the majority of trade, the chosen countries account for at least 70% of trade throughout the entire period in each sample.

4.1 Variable description

The variables selected for the analyses are gathered with the gravity model in mind. To create the data sets I had to first decide on the type of commodities. When the selection was made, the UN Comtrade database was used to collect yearly data on the value of trade between the UK and trading partners (UN Statistics Division, n.d.). The database also allows for commodity specifications following the standardized international trade classification (SITC). By using SITC I could ensure that the same types of goods were included in both F&A data sets. Data on food and live animals were collected with SITC 0, which includes all live animals, meat and dairy products, vegetables, coffee, tea, feeding stuff for animals, miscellaneous edible products, etc. (UN Statistics Division, 2006). The value of trade is expressed in US dollars and make up the dependent variable in the model. Table 4.1 gives a brief overview of the variables included.

Table 4.1: Summary of variables.

Abbreviation	Name	Type	Source
X	Value of exports from the UK to partner		(UN Statistics Division, n.d.)
M	Value of imports to the UK from partner		(UN Statistics Division, n.d.)
GDPi	Gross domestic product in constant $ of 2015		(The World Bank, 2023a)
GDPj	Gross domestic product in constant $ of 2015		(The World Bank, 2023a)
D	Distance between London and trading partner's capital		(European Commission, n.d.)
E	Exchange rate from £ sterling to partners currency		(The World Bank, 2023b)
GFC	Global financial crisis where 1 is the years 2008 and 2009, 0 otherwise	Dummy	(Jagannathan et al., 2013)
Brexit	The period after the referendum, where 1 is given to all EU countries in the period 2016-2021, and 0 otherwise.	Dummy	(Wright & Etherington, 2020)
Covid	The period of the Covid-19 pandemic where 1 is given to the years 2020 and 2021, 0 otherwise	Dummy	(IFR, 2022)
RTA	RTA between the UK and trading partner where 1 is the presence of a RTA in the year, 0 otherwise	Dummy	(WTO, 2023)
CW	Trading partner is a member of the Commonwealth where 1 is member, 0 otherwise	Dummy	(Ward, 2023)

Both UK's GDP and the trading partners' GDP is given in constant $ of 2015, allowing the use of real GDP in the model. Real GDP serves as a proxy for economic size and activity within the gravity model. The expectation is that GDP has a positive effect on trade, giving positive coefficients.

The distance variable is measured as the distance between London, the UK's capital, and the trading partners' capital. It is measured in kilometers and as a straight line. The variable does not consider possible changes in capital cities during the time period, and I have used the current

capitals for the entire period. Several studies (Berthelon & Freund, 2008; Disdier & Head, 2008; Egger, 2008) have been conducted on the effects of distance on trade flows, and there is agreement that increased distance have a negative effect on trade as it serves as a proxy for transportation costs. The expectation is that the distance variable will yield a negative coefficient.

The exchange rate variable is included to see if the exchange rate affects the value traded between countries. Since data on yearly exchange rates was only available for U.S. dollars or euros, I had to do my own estimations to find the pound sterling relative to foreign currency. The variable shows the price of £1 sterling in foreign currency. Former studies (Auboin & Ruta, 2013) have shown a negative relationship between exchange rate and trade, but not to the degree one might would expect. Although exporting firms are slightly more affected by the exchange rate than domestic producers, factors such as imports of input, seems to reduce the effects of exchange rates. In my study, I expect the sign of the exchange rate to change, depending on which of the models I am using. A increase in the exchange rate variable means that the pound sterling decrease in value, making foreign goods more expensive. This is likely to have a negative effect on imports. At the same time, an increase in the *E* variable is likely to have a positive effect on exports, as British goods become less expensive for trading partners. I expect a negative coefficient for the imports model, and a positive coefficient for the exports model.

The GFC is a dummy variable that account for the recession following the international financial crisis in 2008. The GFC affected international trade and could influence the trade pattern observed in the analyses negatively (Jagannathan et al., 2013). Since the raw data seem to show a drop in trade for the period around the crisis, I have found it necessary to catch the change with a dummy. The variable takes the value of 1 in the years 2008 and 2009, and 0 otherwise. If the estimation yields a significant result for the dummy, the presence of the GFC has had an effect on trade, and it is likely that this effect is negative.

The Brexit dummy is the variable that will show the effects of the UK leaving the EU. This dummy variable is given the of value 1 in the years 2016-2021 for all EU countries, to explore any possible changes in trade pattern for the period after the referendum (Wright & Etherington, 2020). While the formal transition period did not start until 2020, and no major changes in regulations were imposed before 2021, the results of the referendum could still have some effect on trade as firms prepare for future changes. To capture any such effect the dummy start in 2016 and a significant result would show that Brexit has had an effect on UK trade.

Similar to the GFC variable, I have also decided to include a Covid dummy to catch any changes caused by the Covid-19 pandemic. Due to lockdowns and travel restrictions in 2020 and 2021, the trade pattern is likely to be affected (IFR, 2022). A value of 1 is present in years 2020 and 2021, and 0 otherwise. The coefficient of the *Covid* dummy is expected to take a negative sign, as travel restrictions and lockdowns would have affected the international supply chains (Hayakawa & Mukunoki, 2021).

An RTA often symbolizes an increased interest in trade between countries. The presence of an RTA could therefore change the effects on value traded (Ravenhill, 2020). A value of 1 is assigned to all countries that have a signed trade agreement with the UK. Before 2021 the UK traded under the EU's trade agreements, and the value 1 in the years 2000 - 2021 is therefore assigned if the EU had a trade agreement with the countries. For this reason, the EU countries are not assigned the value 1 in this dummy. Since RTAs can be enforced throughout entire year, I have assigned the value 1 if the country has had an RTA in force for 6 months or more in that year. Otherwise, the RTA has not been included before the following year. I expect RTA to have a positive effect on trade, because the intention of a trade agreement is improving the trade relationship between the parties. However, due to the membership in the single market, the EU might have signed agreements with countries the UK did not have a trade relationship with. This could cause some disturbance to the coefficient sign of the RTA.

I have also chosen to include a Commonwealth dummy to account for any historical effects. The value of 1 is given to all countries that are member of the Commonwealth. The reason for including this variable is that the countries have a shared history with the UK. This could give an effect distance or economic size cannot explain. Fourteen members of the Commonwealth still have the British king as their head of state, which goes to show the historical connection that could be present between these countries (Ward, 2023). If the variable is found to be significant, it is assumed to have a positive coefficient.

All variables are to be included in the four trade models.

4.2 The gravity model

The gravity model has become a cornerstone in trade analysis, with its outspring from Newtonian physics. It uses the theory of how two objects are drawn towards each other by gravitation to explain trade flows between countries. The model has been used in economy since Tinbergen (1962), but was not fully incorporated into international trade theory before 1995. The first gravity models of trade used the relationship between economic mass and

distance to explain trade between two countries. While the model was used by several researchers, Linnemann (1966), Anderson (1979), Bergstrand (1985, 1989), and others, many were uncertain about how a model based on physics could explain economic analysis. Later work, by Eaton and Kortum (1997, 2002), Krugman (1997), Haveman and Hummels (2004), and others, have proven the stability the gravity model provides, as well as its importance for international trade theory (Rahman, 2010). Since the model was first employed, it has evolved to include several additional factors, such as common language, colonial ties, presence of trade agreements, etc. The use of the gravity model has also been developed to fit other forms of flows such as, foreign direct investment and immigration. The main problem with the model has always been to account for the endogeneity that could occur when trade between countries is caused by something outside of the basic model. While several of these problems can be captured by the inclusion of other variables, there has also been developed various techniques and models to account for the possible endogeneity problem. The gravity model is today considered one of the most important tools to explain trade flows (Anderson, 2011; Head & Mayer, 2014).

While the classic gravity model uses cross-sectional data to consider the trade relationship over a time period, it is also possible to include several time periods in the model. This gives the data a panel structure and allows the model to capture time variation. By increasing the number of observations on a country the results can be checked for consistency across several periods, increasing the robustness of the results. Increasing the number of observations in the analysis also allows for a better accuracy of the model, and thereby reduce the risk of type-I and type-II errors. The inclusion of more than one time period can help capture unobserved heterogeneity and to control for country-specific effects. If any of the variables on the right side of the equation are correlated with the error term, the ordinary least squares (OLS) estimation may yield biased results (Baier & Bergstrand, 2007). By using the panel data methodology potential biased can be avoided by using the fixed effects (FE) and random effects (RE) models. Because of the inclusion of several time periods in my data set, I have found the panel data methodology to be the best fit.

There are several different specifications of the gravity model, but the general gravity equation uses the value of exports/imports as a function of GDP and distance, creating the following equation:

$$T_{ij} = \beta_0 \frac{(Y_i)(Y_j)}{(D_{ij})} \quad (1)$$

where T_{ij} is the trade flow between country i and j, Y_i and Y_j is the economic size or activity in country i and j, D_{ij} is the distance between the countries, and β_0 is a constant. The Y_i and Y_j represents the economic size of the countries. Equation (1) explains how an increase in GDP in either of the countries will lead to an increase in the trade flow. D reflects the transportation costs, here defined by the distance between the two countries, and how an increase in transportation costs or distance, leads to a decrease in trade flow. The size of the firms also matters for the effects of distance. If more large companies are willing to trade over longer distances, and small countries are unwilling, distance will matter less. If we have small companies trading more over longer distances than large companies, the role of distance will increase. But, if the distribution of the firm sizes is stable, and bigger companies continue to export over longer distances than small companies, the overall trade will have a inversely proportional relationship with distance (Chaney, 2018).

To turn the intuitive gravity equation, into an empirical model, it is common to change the model into a log-linear form. This can be done by taking the natural log of the variables. Transforming model (1) to log-linear form in year t gives:

$$\ln(T_{ijt}) = \beta_0 + \beta_1 ln(Y_{it}) + \beta_2 \ln(Y_{jt}) + \beta_3 \ln(D_{ij}) + \varepsilon_{ij} \quad (2)$$

where β_0 is the intercept, β_1, β_2 and β_3 are the coefficients of Y_i, Y_j and D for countries i and j. ε_{ij} is the error term that captures all factors not accounted for in the model. Since the model is given in the natural logarithm, the coefficients also equal the elasticities, meaning that a 1% increase in Y_i will cause T_{ij} to change by β_1%.

4.3 Panel Unit-Root test

The first step of the analysis is to check the variables for stationarity. Panel unit-root testing is essential to ensure stationary variables, because running regression on a non-stationary data set would yield invalid results (Gujarati, 2004). Checking for stationarity in a panel data is done by using a unit root test, and there are many different types that can be used. If the tested variables are stationary, the variables can be used in the model without further changes. In this paper the Levin-Lin-Chu (LLC) test and the Im-Pesarian-Shin (IPS) test are chosen to check for stationarity. Both tests are modified versions of the Augmented Dickey-Fuller test. The null

hypothesis of LLC is that the variable contains a unit root, while the null hypothesis for the IPS is that all panels contain a unit root.

4.4 The gravity models for UK trade

To fit model (2) to the analysis, I use GDP as the economic size and distance to represent transportation costs. I also need to take the natural log of the export / import variable, GDP for country i and j, distance and exchange rate. Since I have chosen to analyze imports and exports separately, the dependent variable change in the two gravity equations. In addition to the standard variables, I will be including the exchange rate and a set of dummy variables to the models. This will allow the models to pick up additional effects. By modifying and adding variables to equation (2), the export flow from the UK to country j in year t can be expressed as:

$$\ln(X_{ijt}) = \beta_0 + \beta_1 ln(GDP_{it}) + \beta_2 \ln(GDP_{jt}) + \beta_3 \ln(D_{ij}) + \beta_4 \ln(E_{ij})_t + \beta_5 GFC_t + \beta_6 Covid_t + \beta_7 RTA_{ijt} + \beta_8 Brexit_t + \beta_9 CW_{jt} + \varepsilon_{ijt} \quad (3)$$

To analyze the imports to the UK from country j in year t, the model is expressed as:

$$\ln(M_{ijt}) = \beta_0 + \beta_1 ln(GDP_{it}) + \beta_2 \ln(GDP_{jt}) + \beta_3 \ln(D_{ij}) + \beta_4 \ln(E_{ij})_t + \beta_5 GFC_t + \beta_6 Covid_t + \beta_7 RTA_{ijt} + \beta_8 Brexit_t + \beta_9 CW_{jt} + \varepsilon_{ijt} \quad (4)$$

For modelling purposes, I created a set of new variables for the natural log. The new names for these variables are *ln_X / ln_M, ln_GDP$_i$, ln_GDP$_j$, ln_D* and *ln_E* and replace the original variables *X /M, GDP$_i$, GDP$_j$, D* and *E*.

4.4.1 Test for serial correlation

To ensure efficient results, testing for serial correlation is important. For a panel data, the presence of serial correlation means that there is correlation of the error terms for different time periods. There are a number of ways to test for serial correlation, but the chosen method here is the Wooldridge's test (Wooldridge, 2010). The null hypothesis indicates absence of serial correlation.

If the test is found to have a significant result, the null hypothesis is rejected, and serial correlation is present in the model. The most common way to correct for serial correlation is to add cluster robust standard errors (Wooldridge, 2015). For any panel data, the inclusion of cluster robust standard errors is common practice, regardless of tests, because it accounts for potential violation of the independence within the groups. Observations done on the same

country for multiple years will have correlation between observations, but adding cluster robust standard errors correct for this. In addition, the inclusion of cluster robust standard errors removes the concern of serial correlation and heteroskedasticity (Wooldridge, 2015).

4.5 Methodology

Since the gravity equation in this paper looks at the same units over different time periods, panel data techniques have been used. Panel data, or cross-sectional and time-series data allows the investigation of changes over time for multiple objects, entities or observations. The countries are the entities for this study. The advantages of using panel data instead of only time series is that panel data increases efficiency by including a greater number of observations, allows controlling of unobserved heterogeneity, modeling of dynamic behavior to understand the relationship between variables better, and investigating causality between variables (Kennedy, 2008).

To use the panel data technique on a data set there are several models that can be used. The main models are pooled OLS regression, fixed effects and random effects models. Pooled ordinary least squares is used when individual effects do not exist. Individual effects are the individual characteristics of each country that will affect the explanatory variables. The model analyzes the data by combing all observations across the objects, which makes it ignore the panel specific effects that may be present in the data. If the individual effects of the data are not zero or the countries included are not homogeneous, the pooled OLS will generate biased results (Park, 2011).

To improve the estimation, it is possible to use the FE model or the RE model. The FE model is the best option if there is correlation between the individual effects and explanatory variables. The FE model include an entity specific effect to capture the variation in the dependent variable which are unique for each country and constant over time (Kennedy, 2008). A disadvantage of the FE model is that all entity specific variables that are time invariant will yield an omitted result. This means that the FE model will provide omitted results for all my time invariant dummy variables (distance and CW) because they are included in the intercept (Kennedy, 2008). When the individual effects of the entities are not correlated with the explanatory variables, the RE model will be preferred. The RE model works by incorporating the variability that arises from the unobserved, random factors into the statistical analysis, and can estimate time invariant factors. While the RE model can be used as a solution for the problems arising in the FE model in some cases, it is not always the best alternative. The RE model requires a

sufficient number of countries and a balanced data to create unbiased estimates. As the focus of the RE model is to estimate the variability between the groups, the estimations can experience a loss of information as well (Kennedy, 2008).

If the tests find the FE model to be the most appropriate, it is possible to use a fourth estimation method to get the estimation for the omitted variables. This model is the correlated random effects model (CRE). The CRE model allows the correlation with the observed explanatory variables, similar to the fixed effects, but still view the unobserved effects as random effects. This gives identical estimations for the FE and the CRE, except that the CRE estimates the time-invariant variables. What the CRE model does is add a time-average variable, which is the cluster mean of the predictors (Wooldridge, 2015).

To find the best model for the data it is necessary to carefully consider the results of a series of tests. I start by testing for poolability of the observations. If the test is found significant it means that the data is not suited for pooling, and the FE model is preferred to the pooled OLS. To check the presents of random effects, I use a Lagrange multiplier (LM) Breusch-Pagan test. Similar to the results of the test of poolability, a significant result of the LM test indicates that random effects are present and that the RE model if preferred to the pooled OLS. In a situation where both FE and RE is preferred to the pooled OLS, it is necessary to impose a test to find the most appropriate model. The simplest way to do this is through a Hausman test. If the test statistic is large enough, the null hypothesis can be rejected, stating that there is no difference between the two models. However, the Hausman test do not allow the use of cluster robust standard errors, and the CRE model must be used to help determine the best fit for the models. After estimating the CRE model, a F-test is performed to check if the cluster mean variables are significantly different from zero. The null hypothesis suggest that the clustered means are significantly different from zero, which makes the RE model the best fit. If the F-statistic is high enough, the null hypothesis is rejected, making the cluster means a necessary element for the model, and the FE model is the most appropriate fit (Wooldridge, 2015).

I will also look at a subset of each of the samples, to investigate the effects on EU and ROW (rest of world) separately. When I look at the estimation of the EU, the variables RTA and CW will be omitted, because there are no EU countries in any of the variables. When I look at non-EU data, no countries will be included in the Brexit variable. This allows me to drop RTA and CW from the EU regression, and Brexit from the ROW regression.

5 Results

5.1 Unit root testing

Before testing and interpreting the results of the gravity model, the results of the panel unit root testing is presented. The test results for total exports and imports can be found in Table 5.1, and the results for exports and imports of food and live animals can be found in Table 5.2. The Levin-Lin-Chu (LLC) test statistics are significant at a 1% level for all variables in every data set, concluding that the variables are stationary. The Im-Pesaran-Shin (IPS) test statistics yield stationary results for *ln_X* and *ln_E* for total exports, and for *ln_M* in total imports. For the exports of F&A, the *ln_X* is stationary in the IPS test at a 10% level, while for imports, *ln_M* and *ln_E* are proven stationary. I have chosen to reject the unit root if at least one test proves the variables to be stationary.

Table 5.1: Summary of unit root test for total exports and imports.

	Total exports (X)		**Total imports (M)**	
Variable	**LLC**	**IPS**	**LLC**	**IPS**
	H_0: Unit root	*H_0: All unit root*	*H_0: Unit root*	*H_0: All unit root*
ln_X/ln_M	-7.4453 (0.000)***	-5.5710 (0.000)***	-8.3087 (0.000)***	-6.2028 (0.000)***
ln_GDPi	-11.1469 (0.000)***	-1.1584 (0.1234)	-9.6061 (0.000)***	-0.9879 (0.1616)
ln_GDPj	-6.4146 (0.000)***	-1.6934 (0.9548)	-6.0980 (0.000)***	1.2843 (0.9005)
ln_E	-7.4898 (0.000)***	-6.1132 (0.000)***	-3.256 (0.0006)***	-0.4860 (0.3135)

Note: P-values in parentheses, denotes statistical significance at the 10%, 5% and 1% level, respectively.

Table 5.2: Summary of unit root test for exports and imports of food and live animals.

	Exports food and live animals		**Imports food and live animals**	
Variable	**LLC**	**IPS**	**LLC**	**IPS**
	H_0: Unit root	*H_0: All unit root*	*H_0: Unit root*	*H_0: All unit root*
ln_X/ln_M	*-3.5094 (0.0002)****	*-1.3320 (0.0914)**	*-7.5036 (0.000)****	*-1.4688 (0.0709)**
ln_GDPi	*-9.9889 (0.000)****	*-1.0381 (0.1496)*	*-9.4066 (0.000)****	*-0.9775 (0.1642)*
ln_GDPj	*-8.0510 (0.000)****	*-0.7051 (0.7596)*	*-5.3700 (0.000)****	*0.2391 (0.9903)*
ln_E	*-3.256 (0.0006)****	*-0.4860 (0.3135)*	*-6.1282 (0.000)****	*-2.5611 (0.005)****

Note: P-values in parentheses, denotes statistical significance at the 10%, 5% and 1% level, respectively.

Having tested for stationarity, the gravity models for this study can be estimated as per equations (2) without further changes.

5.2 Testing for serial correlation

Even though serial correlation is controlled for by using cluster robust standard errors, it is still beneficial to explore the presence of serial correlation in the models. The results of the Wooldridge's test for serial correlation are provided in Table 5.3.

Table 5.3: Test results for the Wooldridge's test for serial correlation.

Wooldridge's test for serial correlation				
	Total exports	**Total imports**	**Exports of F&A**	**Imports of F&A**
F-value	23.354***	15.412***	126.181***	47.311***
Prob > F	0.0000	0.0003	0.0020	0.0000

Note: Denotes statistical significance at the 10%, 5% and 1% level, respectively.

The Prob > F is smaller than 0.05 for all models. This allows the rejection of the null hypothesis and proves that the model struggle with serial correlation. This is a regular occurrence in panel data, and will be controlled for with the cluster robust standard errors added to equations (3) and (4) (Wooldridge, 2010).

5.3 Testing the models

Since one of the models included in the results are considered more appropriate than the others, I will only focus on the results of that specific regression, while the other models work as a base for comparison. Each of the data sets report estimates for the pooled OLS, fixed effects (FE), random effects (RE) and the correlated random effects (CRE).

All four data sets need to be evaluated individually to find the most appropriate model. There has been conducted three tests to determine the best model of each of the data sets, and the results of the poolability test, LM-test and the F-test can be found in Table 5.4.

Table 5.4: Test results from the test of poolability, LM-test and F-test

Testing the models				
	Total exports	**Total imports**	**Exports of F&A**	**Imports of F&A**
Poolability	93.08 (0.000)***	37.87 (0.000)***	8.98 (0.000)***	107.13 (0.000)***
LM-test	9188.40 (0.000)***	3788.45 (0.000)***	791.14 (0.000)***	7295.02 (0.000)***
F-test	23.61 (0.0001)***	15.31 (0.004)***	1.06 (0.9002)	3.50 (0.4784)

Note: P-value in parentheses, denotes statistical significance at the 10%, 5% and 1% level, respectively.

Looking at the test results for total exports, the results of the poolability test equals 93.08, which is high enough to reject the null hypothesis and concludes that the FE model is preferred to the pooled OLS. The RE model is tested with the LM Breusch-Pagan test. The LM-test checks if

there are no individual effect from the entities. A test statistic of 9188.40 allows for rejection of the null hypothesis and suggests random effects is present in the model. Since both the random and fixed effects model is preferred over the pooled OLS, it is necessary to estimate the CRE. In order to decide between the RE and the FE model, a F-test on the time average variables has been conducted. These variables are only present in the CRE model, and the test checks if the time average variables are statistically different from zero. The results of the F-test give a p-value of 0.0001, which rejects the null hypothesis. Finding the presence of the time average variables necessary proves that the FE model is the best fit for this data. Since the FE model cannot estimate the time-invariant variables, and the CRE model provides identical estimation results, I will report the CRE results for total exports.

For imports, the test on poolability gave a test statistic of 37.87, which rejects the null hypothesis and makes the FE model more favorable than the pooled OLS. The LM-test also yielded a significant result, with a test statistic of 3788.45. To find the best fit between the FE and the RE model, I ran the F-test on the clustered mean variables, which gave a test statistic of 15.31 and a p-value of 0.004. This allows the rejection of the null hypothesis, and similar to exports, the FE model the most appropriate. Since the FE and CRE has identical estimates, except for the time-invariant variables, I will be reporting the results of the CRE model for total imports.

For exports of food and live animals, the test on poolability is significant at a test value of 8.98, and the LM Breusch-Pagan test was executed with a test result of 791.14. This is high enough to reject both null hypotheses, proving that of fixed effects and random effects are favored to the pooled OLS. The F-statistics show a p-value equal to 0.9002, which does not allow for rejection of the null hypothesis, and the RE model is preferred.

The last group in this study is the imports of food and live animals The poolability test generates a statistical value of 107.13, and the LM-test has a result of 7295.02. Both these tests proves that FE and RE is preferred to the pooled OLS. With a F-statistic equal to 3.50 is not high enough to reject the null hypothesis and the random effects model is the best fit. This makes the estimates for the CRE and FE models a less appropriate fit than the RE model, and I will therefore be reporting the RE regression results for imports of F&A.

After careful examination of the variables and models, the CRE model is the best fit for total exports and imports, while the RE model is preferred by exports and imports of food and live

animals. The equations created in chapter 4 is still a good fit for the data, and (3) has been used for regressions of total exports and exports of F&A,

$$\ln(X_{ijt}) = \beta_0 + \beta_1 ln(GDP_{it}) + \beta_2 \ln(GDP_{jt}) + \beta_3 \ln(D_{ij}) + \beta_4 \ln(E_{ij})_t + \beta_5 GFC_t + \beta_6 Covid_t + \beta_7 RTA_{ijt} + \beta_8 Brexit_t + \beta_9 CW_{jt} + \varepsilon_{ijt} \quad (3)$$

while (4) has been used in regressions of total imports and imports of F&A.

$$\ln(M_{ijt}) = \beta_0 + \beta_1 ln(GDP_{it}) + \beta_2 \ln(GDP_{jt}) + \beta_3 \ln(D_{ij}) + \beta_4 \ln(E_{ij})_t + \beta_5 GFC_t + \beta_6 Covid_t + \beta_7 RTA_{ijt} + \beta_8 Brexit_t + \beta_9 CW_{jt} + \varepsilon_{ijt} \quad (4)$$

5.4 Total exports

Table 5.5 shows the estimation results for the pooled OLS, fixed effects, random effects and correlated random effects for total exports, as well as the goodness of fit, R^2. The interpretation will be based on the results of the CRE model. All the regressions, with the exception of FE reports a R^2 of around 90%. This means that about 90% of the variation of the value of exports is explained by the independent variables included in the model.

Table 5.5: Regression results for total UK exports.

Variable	**Pooled OLS**		**Fixed effects**		**Random effects**		**Correlated RE**	
	Coefficient	*T-value*	*Coefficient*	*T-value*	*Coefficient*	*T-value*	*Coefficient*	*T-value*
ln_GDPi	0.712*	(1.89)	0.554	(1.22)	0.592**	(1.94)	0.554	(1.22)
ln_GDPj	0.997***	(20.18)	1.042***	(7.23)	1.027***	(19.33)	1.042***	(7.21)
ln_D	-0.757***	(-5.48)	-	-	-0.950***	(-7.32)	-0.570***	(-3.02)
ln_E	-0159***	(-3.69)	-0.000413	(-0.05)	-0.0181	(-1.24)	-0.000413	(-0.05)
GFC	-0.00793	(-0.16)	-0.00210	(-0.04)	-0.00281	(-0.06)	-0.00210	(-0.04)
Covid	-0.139***	(-2.66)	-0.135**	(-2.57)	-0.133***	(-2.90)	-0.135**	(-2.56)
Brexit	0.0686	(0.31)	-0.183*	(-1.77)	-0.178*	(-1.75)	-0.183*	(-1.76)
RTA	0.262*	(1.75)	0.0247	(0.34)	0.0331	(0.47)	0.0247	(0.34)
CW	0.342	(1.10)	-	-	0.649**	(2.01)	0.285	(0.96)
Constant	-18.98*	(-1.89)	-22.36**	(-2.16)	-15.13*	(-1.90)	-16.23	(-1.24)
Observations	1452		1452		1452		1452	
R^2	0.8950		0.9800		0.8937		0.8999	

Note: t statistics in parentheses, * p<0.1, ** p<0.05, *** p<0.01.

For total exports, the ln_GDP_j and *ln_D* are significant at the 1% level, *Covid* is significant at the 5% level, and *Brexit is* significant at the 10% level. These results are stable in terms of significance and signs across the estimations.

The variable ln_GDP_j has a positive coefficient of 1.042, meaning that a 1% increase in the GDP of the trading partner will lead to a 1.042% increase in the value exported to the same country. What this means is that an increase in GDP leads to an increased demand for imported goods from the UK. Since the GDP of the trading partner is significant, while the UK's GDP is not, it suggests that the economic activity of the trading partner is more important for UK exports than the UK's own GDP.

The distance variable, which measures the kilometers between capitals, is significant at a 1% level with a negative coefficient of 0.570. This is an expected sign for the variable and means that the longer the distance is between the capital, the less likely it is for trade to occur. The reason for this is the increase in transportation costs as the distance increases.

The *Covid* dummy yields a significant result at the 5% level, and the negative coefficient of 0.135 means the pandemic had a negative effect on the UK export. Since Covid-19 was an international pandemic, and lead to multiple lockdowns during the period between 2020 and 2021, international supply chains was affected, leading to less production and less exports. Hayakawa and Mukunoki (2021) examined the effects of Covid-19 on international supply chains and found a significant negative effect on exports from all countries during the pandemic, which is in line with my findings.

In regard to the question of *Brexit*, the dummy variable yields a significant result at the 10% level. With a negative coefficient of 0.183 it suggests that the period between 2016 and 2021 had a negative effect on the value of exports. Since both *Covid* and *Brexit* are present in 2020 and 2021, I ran an estimation where *Covid* was excluded to see how this would affect *Brexit*. This resulted in *Brexit* becoming significant at the 5% level. I believe that when I exclude the Covid dummy, the Brexit variable pick up more of the disturbance caused by the pandemic and have therefore chosen to keep both variables. I also replaced the dummies *Brexit, Covid and GFC* with yearly dummies to see if it was possible to spot any significance for each of the years between 2016 - 2021. The years 2016 and 2020 were significant at the 10% and 5% level. Both the variables have negative coefficients, which suggests that something happened in 2016 and 2020 that affected trade negatively. Assuming that 2020 is the result of Covid-19, there is something negatively affecting the trade in 2016, as well. This could be the uncertain situation linked to the 2016 referendum. Research done after on exports after 2016 shows an increased uncertainty within UK firms. This has led to a reduced trade participation for the UK, both within the EU and non-EU which is visible as reduced exports from the UK (Graziano et al., 2018; Graziano et al., 2020).

Since this data set includes countries from all over the world, I divided the sample to see if *Brexit* would behave differently when I only included EU countries. This left me with the disaggregated samples EU and ROW. The results of the regression on EU are quite different than for the aggregated exports, and the regression results can be found in Appendix 1. *ln_D* is still significant at the 1% level while *ln_GDPj* become significant at the 5% level. Unlike the aggregated exports, the ln_GDP_i proves significant at the 10% level when looking at the EU sample. This shows that GDP of both the importing and exporting country matter for the value of UK-EU exports. Exchange rate become significant at the 10% level with a positive coefficient, suggesting that a decrease in the value of the pound sterling has a positive effect on exports to the EU.

The *Covid* variable become insignificant, while the *Brexit* dummy is significant at the 1% level. The negative value of the coefficient has increased, which allows for the interesting interpretation that Brexit has had a larger negative effect on EU exports than overall exports. Since the result of the ROW is consistent with the total exports regression, it indicates that there has been an overall fall in exports around 2016, but that EU seem to have taken the hardest hit. This is in agreement with previous research, as the uncertainty of UK's future is to found to affect both EU and non-EU trade negatively (Hayakawa & Mukunoki, 2021).

5.5 Total imports

Table 5.6 shows the regression results for the pooled OLS, fixed effects, random effects, correlated random effects regressions and the R^2 for total imports. The most appropriate model was found the be the CRE, and the interpretation is based on the results from the CRE model. While there is more variation in the R^2 between the models, the model is still assumed appropriate for the data, with a R^2 of 89% for the CRE model.

Table 5.6: Regression results for total UK imports.

Variable	**Pooled OLS**		**Fixed effects**		**Random effects**		**Correlated RE**	
	Coefficient	*T-value*	*Coefficient*	*T-value*	*Coefficient*	*T-value*	*Coefficient*	*T-value*
ln_GDPi	-0.0621	(-0.07)	2.714***	(3.14)	0.921	(1.25)	2.714***	(3.13)
ln_GDPj	1.344***	(15.69)	0.526	(1.45)	1.243***	(14.98)	0.526	(1.45)
ln_D	-0.654***	(-3.10)	-	-	-0.738***	(-3.84)	-0.197	(-0.65)
ln_E	0.0138	(0.23)	-0.0731*	(-1.94)	-0.0490	(-1.50)	-0.0731*	(-1.94)
GFC	0.112	(1.68)	0.108	(1.56)	0.100	(1.44)	0.108	(1.56)
Covid	-0.148	(-0.79)	0.146	(0.63)	0.00708	(0.04)	0.146	(0.63)
Brexit	0.599***	(2.18)	-0.302*	(-1.75)	-0.117	(-0.76)	-0.302*	(-1.74)
RTA	0.227	(0.43	-0.520*	(-1.86)	-0.438*	(-1.74)	-0.520*	(-1.85)
CW	0.890**	(2.29)	-	-	0.889**	(2.52)	1.052***	(2.78)
Constant	-7.333	(-0.52)	-70.67***	(-3.41)	-31.85	(-1.46)	-90.96***	(-3.43)
Observations	1056		1056		1056		1056	
R^2	0.8758		0.9540		0.8688		0.8896	

Note: t statistics in parentheses, * p<0.1, ** p<0.05, *** p<0.01.

For total imports, *ln_GDPi* and *CW* is significant at the 1% level, while *ln_E, Brexit* and *RTA* are significant at 10%. In contrast to exports, ln_GDP_i is now significant, while ln_GDP_j is not. However, the results still agree that the GDP of the receiving country is what matters for the level of trade. With a positive coefficient of 2.714, a 1% increase in the UK's GDP, will give a 2,7% increase in imports. The effects GDP is found to have on import demand could be explained by how increased economic activity reflect less unemployment and increased spending.

The *ln_E* variable is significant at the 10% level, and has a negative coefficient of 0.0731, which indicates that a strengthening of the exchange variable will have a significantly negative effect on imports. This is in line with the expectations as an increase in the exchange variable means that less foreign currency is needed to get a dollar sterling, making imported goods more expensive, and UK imports will decrease.

An unexpected result is the negative sign of the RTA. The variable *RTA* is a dummy variable, and the negative coefficient indicates that having an RTA will reduce imports from that country. The purpose of an RTA is, in most situations, to improve the trade relationship with the country, and thereby increase trade. To investigate the reason for the negative coefficient, I looked into the data to explore trade patterns for countries that has entered into an RTA with the UK. One reason for the decrease of imports after an RTA could be that all RTAs were signed between EU and the third party for the period 2000 until 2020, and not directly with the UK. This could

mean that the RTA was not implemented to improve the relationship between the UK and trading partner directly, and that the decrease of imports stem from a situation not related to the RTAs. The rules of origin could also explain the effects on total imports. When countries enter into an RTA, it often includes a rule of origin-clause. If a trading partner uses inputs that are not in alignment with the rules of origin, an RTA with the country can prohibit imports of that specific good, and thereby create a negative correlation between RTAs and imports. What the data shows is that a few countries, Canada, Ghana, Côte de Ivoire and Zimbabwe, experienced a decrease in exports to the UK after the RTAs was enforced. When plotting these countries, Ghana shows the largest fluctuations, and when removing Ghana from the sample, the RTA variable become insignificant. When the UK left the EU, they could no longer trade under the EU's RTAs and had to create their own. This led to a lack of an RTA with Norway and Switzerland for most of 2021. At the same time, imports from Norway increased by 166% between 2020 and 2021. Most of the imports consisted of mineral oils and fuels (UN Statistics Division, n.d.). The missing RTA makes it appear as if leaving the RTA boosted the imports from Norway, but since the countries entered into a free trade agreement in December 2021, this disturbance to the variable seem to be caused by a political delay in negotiations rather than the countries not wanting to have an RTA.

The Commonwealth dummy seems to be of great importance for UK imports and are significant at the 1% level. Being a Commonwealth member has a significantly positive effect on UK imports but is found insignificant for exports. This suggests that the Commonwealth countries positively effects imports to the UK but is not important for UK exports.

The *Brexit* variable behave similarly for exports and imports, with a negative coefficient significant at the 10% level. The negative coefficient is larger, which suggest that the negative effects of Brexit are larger on imports than on exports. The *Covid* dummy is insignificant for imports, but when running the regression without the *Covid* dummy, *Brexit* change t-value from -1.74 to -2.01, meaning that the Covid dummy removes some disturbance from the Brexit dummy. When exploring the data with yearly dummies, none of the years yielded a significant result. This indicates that the changes in trade for the periods are explained by the variables present in the model, or that a dummy covering more than one year is necessary to see the effects of Covid or Brexit on imports.

For imports, the data was split into two samples as well, EU and ROW. For the EU sub-group, distance become significant at the 10% level, which suggests that distance has a stronger negative effect on aggregated imports, than imports from the EU alone. The variables ln_GDP_j

and *ln_GDP$_i$* become significant at the 1% level. Similar to total exports, both the exporting and importing countries GDP is of importance when looking at trade with the EU. *Brexit* and *ln_E* are significant at the 1% level, both with negative coefficients. This agrees with the results found for the aggregated total imports. The coefficient of the Brexit variable has changed from -0.3 to -0.5 and suggests that imports from the EU more negatively affected than the aggregated imports. The full regression can be found in Appendix 2. ROW results are consistent with the total imports.

5.6 Exports of food and live animals

To get a narrower view on the effects of Brexit, I have looked into agricultural goods, and more specifically food and live animals. This was done to see if a subset of exports would respond differently than the total trade, with regards to economic shocks.

Table 5.7 show the regression results for the pooled OLS, fixed effects, random effects, the correlated random effects models, as well as the goodness of fit for the exports of F&A. Since previous tests found RE to be the most appropriate model, I will be interpreting the estimates from this model. Looking at the goodness of fit, it is clear that the model is not as good of a fit for the exports of F&A as total trade. A R^2 equal to 0.4750, indicating that about half of the variations in the dependent variable can be explained by the independent variables.

Table 5.7: Regression results for UK exports of food and live animals.

Variable	**Pooled OLS**		**Fixed effects**		**Random effects**		**Correlated RE**	
	Coefficient	*T-value*	*Coefficient*	*T-value*	*Coefficient*	*T-value*	*Coefficient*	*T-value*
ln_GDPi	-1.175	(-0.68)	-1.461	(-0.54)	-1.035	(-0.60)	-1.461	(-0.64)
ln_GDPj	0.648***	(8.94)	0.829	(0.95)	0.648***	(7.26)	0.829	(1.56)
ln_D	-0.567***	(-4.09)	-	-	-0.562***	(-4.03)	-0.461**	(-2.81)
ln_E	-0.0961	(-1.51)	-0.149	(-1.10)	-0.109	(-1.51)	-0.149	(-1.10)
GFC	0.0291	(0.20)	0.0142	(0.09)	0.0235	(0.16)	0.0142	(0.10)
Covid	-0.0104	(-0.05)	-0.0120	(-0.05)	0.0115	(0.05)	-0.0120	(-0.01)
Brexit	-0.0365	(-0.06)	-0.168	(-0.28)	-0.167	(-0.29)	-0.168	(-0.30)
RTA	-0.0239	(-0.09)	-0.0970	(-0.23)	-0.0845	(-0.26)	-0.0970	(-0.16)
CW	0.402	(0.90)	-	-	0.381	(0.86)	0.442	(0.64)
Constant	38.87	(0.79)	38.05	(0.61)	34.87	(0.70)	46.12	(0.59)
Observations	1166		1166		1166		1166	
R^2	0.4753		0.6268		0.4750		0.4769	

Note: t statistics in parentheses, * p<0.1, ** p<0.05, *** p<0.01.

At first glance, the results of exports of F&A are quite different from the total exports. Both ln_GDP_j and *ln_D* are significant at the 1% level, but all other variables are insignificant.

Similar to total exports, ln_GDP_j has a positive coefficient, but the coefficient value is lower than for total exports. This means that exports of F&A will increase if the economic activity in the importing country increase, but less than for total exports. The other significant variable is the *ln_D.* The negative coefficient of 0.562 suggests that the longer the distance is, the lower the value of trade will be. This agrees with previous results in this study, as a longer distance means increased transportation costs.

While both *Covid* and *Brexit* had significant results for total trade, they do not seem to have an effect on aggregated exports of F&A. This indicates that there were no significant changes in exports of F&A after 2016. When replacing the *Covid* and *Brexit* dummies with one-year dummies for the period 2016 to 2021, none of the dummies yield a significant result, which strengthens the assumption that export of F&A has not been affected by policy implications or external shocks to a significant degree.

Just as for total exports and imports, I separated the data into subgroups to see if that made any changes to the results. The EU sub-group finds an insignificant estimation for the *ln_D* variable, while ln_GDP_j is significant at the 1% level and ln_GDP_i is significant at the 5% level. This means that GDP of both UK and the importing country matter for the value of UK exports to EU countries. *Brexit* is significant at the 1% level, with a negative coefficient of 0.95. This result show that Brexit has had a negative effect on exports to the EU, but not on aggregated exports. The explanation for this could be a redistribution of exports from EU to non-EU countries, which would lead to a decrease in exports to the EU, but not to aggregated exports. The full regression can be found in Appendix 3. The regression results on ROW are consistent with exports of F&A.

To look further into the possibility of redistribution, I compared the results of the regression with Figure 2.8, which shows the total trade as well as the divided samples of exports of food and live animals. Note that figure show exports to all countries, and not only the countries selected for this sample. Total exports of F&A show little changes in exports after 2016. No large changes in the value exported in 2020 indicates that the Covid-19 pandemic had very little effect on the exports of F&A, supporting the regression results. From 2018 there seems to be a steady decrease in exports of F&A animals for both the total and disaggregated groups, which could be the uncertainty linked to Brexit. The graph agrees with the results of the regression,

which strengthens the assumption that trade has started to move, to a certain degree, from EU to non-EU after 2016.

5.7 Imports of food and live animals

Results for the pooled OLS, fixed effects, random effects and the correlated random effects models, as well as the R^2 can be found in Table 5.8. The reported estimates come from the RE model, as this was found to be the most appropriate fit for the data. The fit of the model is better for imports than for exports of F&A, and the reported R^2 for is 0.5936.

Table 5.8: Regression results for UK imports of food and live animals.

Variable	**Pooled OLS**		**Fixed effects**		**Random effects**		**Correlated RE**	
	Coefficient	*T-value*	*Coefficient*	*T-value*	*Coefficient*	*T-value*	*Coefficient*	*T-value*
ln_GDPi	3.767***	(3.65)	3.482***	(3.45)	3.852***	(5.07)	3.482***	(3.43)
ln_GDPj	0.866***	(6.58)	1.126**	(2.65)	0.961***	(5.71)	1.126**	(2.64)
ln_D	-0.587**	(-2.07)	-	-	-0.615**	(-2.01)	-0.188	(-0.45)
ln_E	-0.113	(-0.82)	-0.0862	(-0.89)	-0.0836	(-1.02)	-0.0862	(-0.89)
GFC	0.135*	(1.87)	0.115	(1.52)	0.120	(1.64)	0.115	(1.52)
Covid	0.122	(0.93)	0.131	(1.24)	0.157	(1.64)	0.131	(1.23)
Brexit	0.333	(0.92)	0.0497	(0.26)	0.0264	(0.14)	0.0497	(0.26)
RTA	0.229	(0.50)	0.329	(1.47)	0.322	(1.46)	0.329	(1.47)
CW	0.966**	(2.26)	-	-	1.020*	(1.92)	0.949**	(2.44)
Constant	-107.4***	(-3.71)	-110.6***	(-4.69)	-112.1***	(-5.07)	-104.4***	(-3.43)
Observations	1034		1034		1034		1034	
R^2	0.5966		0.9306		0.5936		0.6086	

Note: t statistics in parentheses, * p<0.01, ** p<0.05, *** p<0.01.

For imports of food and live animals, *ln_GDPi* and *ln_GDPj* are significant at a 1% level, *ln_D* is significant at 5%, and *CW* is significant at the 10% level.

The variable *ln_GDPi* has a positive coefficient equal to 3.852 suggesting that increasing the UK's GDP will increase UK imports. The positive coefficient of *ln_GDPj* suggest that increasing the exporting partner's GDP also has a positive effect on UK's imports. While the other samples only have a significant result for the importing country's GDP, both the UK's and the trading partner's GDP seem to affect the imports of F&A. The coefficient of UK's GDP is higher, which allows for the assumption that UK's GDP has a larger effect on value imported than the trading partners.

Similar to exports of F&A, *ln_D* is still significant, but at a 5% level. The negative coefficient suggest that distance has a negative effect on trade, just as for all the other groups. The

coefficients are similar for both exports and imports, which makes it likely that distance has the same effect on exports as it does imports of food and live animals. From chapter 2, we know that the UK imports a lot more of F&A than they export, and that most of the imports come from non-EU countries. This could explain why distance is less important for imports than for exports, showed here by the different levels of significance.

CW is also found significant at the 10% level. Similar to total imports, being a member of the Commonwealth have an impact on imports of F&A. The coefficient is positive and equal to 1.020, suggesting that being a CW member increases the value of UK imports. Since the variable was not of significance with the exports of food and live animals, it allows for the assumption that former colony states are important for imports to the UK, but that the *CW* is not of importance for exports.

Neither *Covid, GFC* nor *Brexit* seems to have had an impact on the aggregated UK imports of F&A. When changing out the *Covid* and *Brexit* dummies with one-year dummies, the results suggest that the years 2019 and 2020 had a significant effect on imports of F&A at a 5% level. 2019 has a negative coefficient of 0.3112, which could be early effects of Covid-19. The result of 2020 does, however, have a positive coefficient of 0.2774. This indicates that the decrease in value that occurred in 2019, is almost completely back to pre-2019 values in 2020. Seeing an increase in value imported during the Covid-19 pandemic is very unusual, as decrease in international supply chains led to a decrease in trade (Hayakawa & Mukunoki, 2021). The reason for this increase in 2020 could be that this sample considers food, which is not something that can suddenly stop being produced or imported. This result indicates that while other traded goods were negatively affected by Covid-19, the imports of food to the UK were not.

When looking at the disaggregated sample of the EU, ln_GDP_j and ln_GDP_i remains significant at the 1% level, while *ln_D* becomes insignificant. Both *Covid* and *Brexit* becomes significant at the 1% level, and *ln_E* at the 5% level. The complete regression can be found in Appendix 4. The Brexit variable has a negative coefficient, suggesting that Brexit has had a negative effect on UK's imports from the EU. This follows the same pattern as for exports of F&A, and the negative effects on Brexit could stem from a redistribution between EU and non-EU. The *Covid* variable yields a positive coefficient, which strengthens the belief that food and live animals is not affected by global pandemics in the same way other types of goods are. For all other regressions that has shown *Covid* as significant, the coefficient has been negative, proving the negative effect of Covid-19 on trade. The reason for this positive coefficient could be that Covid led to an increased demand for food because less people traveled and stayed in the UK. Another

explanation could be that it was easier to import food and live animals from the EU because of restrictions, and that some of the import of F&A moved from non-EU countries to the EU. When looking at the results of Covid on ROW, the Covid variable is insignificant, which does not help support the possibility of a redistribution during Covid-19. Instead, it is more likely that the imports of food and live animals experienced increase in imports from the EU, not a redistribution. For the ROW subgroup, the rest of the results are consistent with total imports of F&A, with the exception of RTA becoming significant at a 10% level. The positive coefficient of 0.45 indicates that entering an RTA has had positive effect on the imports of F&A to the UK.

6 Conclusion

This study attempts to explore the UK trade patterns, and the effects Brexit has had on UK trade. The study considers total exports and imports, as well as imports and exports of food and live animals. During the study period 2000 – 2021, the global financial crisis and the Covid-19 pandemic occurred. While the study looks at the effects of these event, the intention is to spot any effects of the political decision of leaving the EU, which was taken in 2016. The construction of two standardized gravity models based on yearly data from the study period was done to help answer a total of four research questions. The first model was created using the value of exports from the UK as the dependent variable, and UK's gross domestic product (GDP), trading partners' GDP, distance, exchange rate, presence of regional trade agreements (RTA), membership of the Commonwealth, and dummies to represent the global financial crisis (GFC), Covid and Brexit as the independent variables. The second model used the value of imports as the dependent variable and kept the same independent variables as model one. Regressions on the models were done using pooled OLS, fixed effects, random effects models, and the correlated random effects model. All the regressions were put through a number of tests, to help determine the most appropriate model for each of the samples. In addition, the Brexit, Covid and GFC dummies were replaced by yearly dummies in the period between 2016 and 2021, to check for one-year time effects. Lastly, each of the data sets were divided between EU and non-EU to explore the effects on only EU.

The results show that GDP and distance is important to explain the value of trade between two countries. Distance is used as a proxy for transportation costs and was found to have a significant negative effect in all four data sets, strengthening existing research that finds distance to be a determining factor for trade. In chapter 1, I suggest that RTAs and the Commonwealth could challenge the effects of distance, but that does not seem to be the result. For total imports, the presents of the RTA show a surprising negative effect on UK imports, which implies that presence of an RTA actually reduce trade. Since the UK traded under EU's RTAs prior to 2021, the RTAs was not sign directly between the UK and the trading partner. This could affect the results of this observation, and the finding could benefit from further research. Import demand is found to be affected positively by the GDP, meaning that imports when the UK experience an increase in economic activity, and that exports will increase when the trading partners economic activity increases. For imports of food and live animals, the economic activity of both the UK and the trading partner matters for the value of UK imports.

The question on Commonwealth has a similar result for total trade and trade of F&A. For exports, members of the Commonwealth have no influence on UK trade, but the imports are positively influenced by the Commonwealth. In conclusion, there seem to be a link between Commonwealth and UK imports, but not between the Commonwealth and UK exports. It is important to note that only a small portion of the Commonwealth members are present in the samples, and that additional countries could affect the result.

The effects of Covid and Brexit are significantly negative for total imports and exports. The Brexit dummy include the years 2016 – 2021 and Covid is present for 2020 - 2021. The Brexit variable starts at the time of the referendum, and not at the time of the transition period to allow for any post-referendum effects to be included. Significant results for both exports and imports imply that Brexit has had a negative effect on both UK imports and UK exports. The results indicate that imports have taken the hardest hit. This finding builds under exiting studies that has found Brexit to influence UK trade negatively. Covid also show negative effects on trade for 2020.

Exports and imports of food and live animals is far less affected by the different factors. Besides imports being affected by the Commonwealth, the only factors that seem to influence trade of food and live animals is GDP and distance. On the question of Brexit, there seems to be no significant effect on total imports and exports, which shows that trade of necessity goods not necessarily experience the same effects of a shock as other goods. It could also be a result of redistribution, meaning trade of food and live animals has moved from EU countries to non-EU countries, and that this effect is not displayed with aggregated trade.

Since effects of Brexit could hide behind a redistribution of trade between EU and non-EU countries, I found it necessary to separate the samples to explore the effects on EU alone. When looking at the results of the EU sub-groups, the Brexit variable became significant for all four samples. This means that trade between the UK and the EU has developed in a negative direction since 2016, for both total trade and for food and live animals. The results allow for the conclusion that Brexit most likely led to a redistribution of trade from EU to non-EU, and that looking at the aggregated sample masks important effect of Brexit for the sector food and live animals. For total trade, Brexit was found significant for both the aggregated and disaggregated sample. But the coefficients indicate that trade with the EU has been more affected by Brexit than the overall trade. This shows that EU has experienced the largest decrease in trade after 2016, but that also non-EU trade has been affected. Since this study only considers the short-term effects of Brexit, this could be an indication that the UK is permanently

moving away from trade with the EU, and that the decreasing trend will continue in a longer perspective as well.

In addition to showing the effects of Brexit on UK trade, the EU subset removes the importance of distance for food and live animals. In neither of the samples, distance seem to matter for the value of trade with the EU. This could be seen as an effect of the single market and show how the European Union has accomplished the removal of borders to work as one large market. For the total exports and imports, the distance remains important for the value of trade within the EU. Because the largest share of trade of food and live animals is with non-EU, it is not unlikely that trade with the EU is kept to a small number of countries. This would remove some effects of distance, as the number of countries in the EU sample of food and live animals is small.

The results found in this study, support the theory that economy size and distance matters for the value of trade. By adding additional variables, the gravity model can be used to explain changes in trade patterns beyond basic gravity theory. The model can help determine if economic and political shocks matter for trade.

6.1 Limitations of the study

The first limitation is that while the study proves that Brexit has had an effect on trade, it cannot tell how much of an effect. This would require additional estimations that has not been done in this study. The precise effects of Brexit on the value of trade would provide the paper with even more robust answers.

The second limitation is the distance variable. The variable looks at the distance between two capitals but is in reality not the best estimate for transportation costs. Whether the goods are transported by planes, cargo ships or trailers will affect the costs of transportation. While it is faster and requires less involvement of other countries to trade close to home, using the actual costs of transportation could give more robust estimates for how costs of transportation affect trade.

The third limitation is the variables included in the model. Choosing the correct variables in a model is difficult, as there are so many factors that could influence the value of trade. I comprised a rather simple list of variables that covered the most fundamental elements of the gravity model, as well as the largest shocks for the study period. That does not remove the possibility that other factors could have influenced the trade pattern. One such factor could be the euro crisis following the global financial crisis, or the effects of having a joint border or the same language.

The fourth limitation is that the model does not take population or country size into consideration. As gravity theory suspect that countries trade because of equal size, using gross domestic product divided by population, or including a variable that considers country size, would allow for further investigation of how similar country size and economic size matters.

6.2 Suggestion for further research

Brexit is a political decision we have only seen the beginning of, and the effects of it will be studied for many years to come. Further research on a sectoral level could help determine if the trade patterns seen in the agricultural sector is uncommon, or if there are other sectors that act similar. This would be beneficial for the understanding of how the UK adjust to their new relationship with the EU. There is also room for investigation of redistribution of trade. Previous research suggest that the UK's welfare will decrease, but there are few studies that has tried to test the predictions with actual data. As time goes by, there will also be more data available, and the effects of Brexit in a longer period will start to show. As trade agreements take time to negotiate, and political decisions take time to implement, it will be beneficial to study the effects of Brexit in a longer perspective.

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Appendix 1: Total exports for the sub-group EU

Random-effects GLS regression — Number of obs = 176
Group variable: country1 — Number of groups = 8

R-squared:
Within = 0.5366
Between = 0.9743
Overall = 0.9643

Obs per group:
min = 22
avg = 22.0
max = 22

Wald chi2(7) = .
corr(u_i, X) = 0 (assumed) — Prob > chi2 = .

(Std. err. adjusted for 8 clusters in country1)

ln_X	Coefficient	Robust std. err.	z	P>|z|	[95% conf.	interval]
ln_GDPi	1.175573	.6975578	1.69	0.092	-.1916153	2.542761
ln_GDPj	1.103195	.5384387	2.05	0.040	.0478748	2.158516
m_GDPj	-.4504822	.5092952	-0.88	0.376	-1.448682	.547718
ln_D	-.8805969	.2242491	-3.93	0.000	-1.320117	-.4410767
ln_E	.0367339	.0204191	1.80	0.072	-.0032869	.0767546
m_E	-1.058116	.0914802	-11.57	0.000	-1.237413	-.8788176
GFC	.0567512	.0513701	1.10	0.269	-.0439325	.1574348
Covid	-.0321689	.0828566	-0.39	0.698	-.1945649	.130227
Brexit	-.3264287	.0316474	-10.31	0.000	-.3884564	-.264401
_cons	-21.67963	18.80696	-1.15	0.249	-58.5406	15.18134
sigma_u	.42453539					
sigma_e	.20439681					
rho	.81181764	(fraction of variance due to u_i)				

Appendix 1: CRE regression results of the EU subgroup for total exports

Appendix 2: Total imports for the sub-group EU

Random-effects GLS regression — Number of obs = 220
Group variable: country1 — Number of groups = 10

R-squared:
Within = 0.7990
Between = 0.9415
Overall = 0.9267

Obs per group:
min = 22
avg = 22.0
max = 22

Wald chi2(8) = 1456.81
corr(u_i, X) = 0 (assumed) — Prob > chi2 = 0.0000

(Std. err. adjusted for 10 clusters in country1)

ln_M	Coefficient	Robust std. err.	z	P>|z|	[95% conf.	interval]
ln_GDPi	1.878439	.5626944	3.34	0.001	.7755786	2.9813
ln_GDPj	2.121597	.5622638	3.77	0.000	1.01958	3.223613
m_GDPj	-1.188998	.6007168	-1.98	0.048	-2.366381	-.0116146
ln_D	-.5868333	.3297353	-1.78	0.075	-1.233103	.059436
ln_E	-.1754366	.0486124	-3.61	0.000	-.2707152	-.080158
m_E	.2696969	.0773818	3.49	0.000	.1180313	.4213624
GFC	.0174287	.0688754	0.25	0.800	-.1175646	.1524219
Brexit	-.5009679	.0578943	-8.65	0.000	-.6144386	-.3874972
_cons	-51.80961	15.96111	-3.25	0.001	-83.09281	-20.52641
sigma_u	.39761734					
sigma_e	.20228805					
rho	.79439024	(fraction of variance due to u_i)				

Appendix 1: CRE regression results of the EU subgroup for total exports

Appendix 3: Exports of food and live animals for the sub-group EU

Random-effects GLS regression — Number of obs = 286
Group variable: country1 — Number of groups = 13

R-squared:
Within = 0.0854
Between = 0.7328
Overall = 0.4290

Obs per group:
min = 22
avg = 22.0
max = 22

Wald chi2(7) = 51.05
corr(u_i, X) = 0 (assumed) — Prob > chi2 = 0.0000

ln_X	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
ln_GDPi	4.299147	1.639431	2.62	0.009	1.08592	7.512373
ln_GDPj	.8659201	.2125742	4.07	0.000	.4492824	1.282558
ln_D	-.5337024	.5143695	-1.04	0.299	-1.541848	.4744433
ln_E	-.1417202	.104527	-1.36	0.175	-.3465893	.0631489
Rec	.3281905	.3221116	1.02	0.308	-.3031367	.9595176
Covid	-.1207378	.3772324	-0.32	0.749	-.8600998	.6186242
Brexit	-.95081	.354619	-2.68	0.007	-1.64585	-.2557696
_cons	-123.545	46.54457	-2.65	0.008	-214.7707	-32.31935
sigma_u	.93637369					
sigma_e	1.5220073					
rho	.27457339	(fraction of variance due to u_i)				

Appendix 2: RE regression results of the EU subgroup for exports of food and live animals

Appendix 4: Imports of food and live animals for the sub-group EU

Random-effects GLS regression — Number of obs = **352**
Group variable: **country1** — Number of groups = **16**

R-squared:
Within = **0.6377**
Between = **0.7764**
Overall = **0.7573**

Obs per group:
min = **22**
avg = **22.0**
max = **22**

Wald chi2(**7**) = **154.25**
corr(u_i, X) = **0** (assumed) — Prob > chi2 = **0.0000**

(Std. err. adjusted for **16** clusters in **country1**)

ln_M	Coefficient	Robust std. err.	z	P>|z|	[95% conf.	interval]
ln_GDPi	5.880778	1.022488	5.75	0.000	3.876738	7.884818
ln_GDPj	1.670277	.4564193	3.66	0.000	.7757117	2.564842
ln_D	-.2818611	.9234203	-0.31	0.760	-2.091732	1.528009
ln_E	-.1333994	.0681388	-1.96	0.050	-.266949	.0001502
Rec	.0312028	.0899011	0.35	0.729	-.1450001	.2074056
Covid	.4106785	.080856	5.08	0.000	.2522036	.5691534
Brexit	-.5407931	.0838127	-6.45	0.000	-.7050629	-.3765233
_cons	-190.7063	39.34955	-4.85	0.000	-267.83	-113.5826
sigma_u	1.0237749					
sigma_e	.51331344					
rho	.79910831	(fraction of variance due to u_i)				

Appendix 3: RE regression results of the EU subgroup for the imports of food and live animals.

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