Dissertation

Analysis of Bilateral Trade Between the UK and Non-EU countries from 1973 to 2019

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Contents

Abstract

This dissertation proposes an analysis of bilateral trade between the UK and non-EU countries within the top 50 of UK trade partners. The empirical analysis encompasses the Gravity Model of Trade, using a panel data approach. Two different models will be produced, which include a Fixed Effects model and a Poisson Pseudo Maximum Likelihood model to estimate the impact of free trade agreements on British trade. The models will also produce estimates for other determinants of bilateral trade between the UK and non-EU countries. The models predict that free trade agreements do have a positive impact on bilateral trade, but also that the UK already trades more with larger economies that it does not have a free trade agreement with.

1 Introduction

1.1 Background

In June 2016, the British electorate voted to leave the European Union (EU) and in December 2020 a "soft-Brexit" position was secured for the UK. When the UK left the EU, there were 40 agreements set in place, covering 70 countries. Currently, the UK will continue to trade with 67 (FTA67) out the 70 countries in the same way. Due to Brexit, the UK is now capable of settling its own trade agreements with other countries. So far, the UK has come to an agreement with Japan (22nd October 2020) and is discussing potential agreements with the US, Australia and New Zealand.[1] The most recent statistics regarding trade indicate that in 2018 trade made up 63.5% of GDP in the UK, with exports at 31.1% of GDP. UK trade with the EU was valued at £659.5bn and UK trade with the ROW was valued at £683.3bn. Currently, the US is the most popular export destination for British goods and services at 18.8% of UK exports.[2]

Participation in global trade is a key driver of both economic growth and national welfare. Trade increases productivity because producers are exposed to new imported varieties (Broda et al., 2006). Product variety itself plays an important role in economic growth. Broda and Weinstein (2006) show that unmeasured growth in product variety from US imports has been an important source of national welfare gains in the US. Melitz and Redding (2014) argue a similar point in that, on a microeconomic level, heterogeneity is systematically related to trade

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[1] https://www.bbc.co.uk/news/uk-47213842

[2] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/868378/200227_UK_trade_in_Numbers_full_web_version_final.pdf

participation. Exporters tend to be larger and more productive than non-exporters.

This dissertation will cover the most important and relevant literature regarding trade policy. It will discuss the roots of the intuitive (basic) Gravity Model postulated by Tinbergen (1962). Then will go on to discussing the development of the structural model, with seminal contributions made by Anderson (1979) and Anderson and Van Wincoop (2003). Afterwards, this dissertation will discuss the advantages and disadvantages of different estimators.

A section will be dedicated to explaining the specification of the structural Gravity Model and will discuss the justification for the use of each variable. It will explain how the model will be transformed from the intuitive Gravity Model to the structural Gravity Model and explain the theory behind the specification.

This dissertation will not attempt to forecast bilateral trade after Brexit, rather it will try to analyse and understand key determinants of bilateral trade, which could be used for trade policy analysis. This empirical analysis of bilateral trade flows will be focusing on the determinants of bilateral trade between the UK and non-EU countries. This includes all the non-EU countries within the top 50 of UK trade partners, over the time span from 1973 to 2019. The analysis encompasses the Gravity Model of Trade, which has been the workhorse of trade policy since its inception in 1962. The Gravity Model has undergone a lot of modification since then and has transformed into the structural Gravity Model, which is now much more theoretically grounded. In this analysis, a Fixed Effects model and Poisson Pseudo Maximum Likelihood model will be used to estimate the determinants of bilateral trade.

1.2 Research question

To what extent do free trade agreements affect bilateral trade between the UK and its non-EU trade partners?

1.3 Aim

To critically analyse the impact of free trade agreements on British trade with its non-EU trade partners.

1.4 Objectives

1. To examine bilateral trade flows between the UK and non-EU countries which are in the top 50 of UK trade partners.
2. To understand the key determinants of bilateral trade flows between the UK and its non-EU trade partners.
3. To estimate the impact that free trade agreements have on British trade with non-EU countries within the top 50 of UK trade partners.
4. To provide additional information to the current literature of bilateral trade, which could aid in trade policy analysis.

1.5 Rationale

Most of the recent literature surrounding British trade focus on predictions of trade flows after Brexit. This dissertation will look at the determinants of trade between the UK and non-EU countries to hopefully provide additional information which can be used for trade policy analysis.

2 *Literature Review*

2.1 Theoretical Background

The gravity model is referred to as the workhorse of estimating the impact of trade policy on bilateral trade. The original gravity equation postulates two intuitive concepts: The greater the two countries' economies are (in terms of GDP), the higher the expected volume of trade; the further the distance is between the two countries, the lower the expected volume of trade (Tinbergen, 1962). Tinbergen's specification of the gravity equation is derived from the Newtonian equation of gravity, hence its name. The gravity equation takes a log-linear form (where every variable enters in the natural log form). The model has been widely used since the 1960's due to its consistently high explanatory power. However, the model is limited in its ability to forecast future values of bilateral trade due to the lack of strong theoretical foundations (Bergstrand, 1985). There are many factors which can affect bilateral trade, but not all of them can be accounted for because the data is difficult to find or it has not been recorded. Linnemann (1966) asserts that the model is an incomplete form of the four-part partial (PE) equilibrium model, as it analyses the effects of bilateral trade at the sectoral level, as well as at the national level. Critics such as Anderson (1979) and Leamer and Stern (1970) have described the model as "loose" and that it does not explain the multiplicative functional form. Though there have been many adjustments to the gravity model, the foundations of the basic model laid out the framework for international trade, which is still relevant today. In the following, we will discuss some key adaptations of the Gravity Model.

In the empirical work that examines the determinants of bilateral trade flows, almost all invariably control for distance. Distance effects are persistent in two senses: The first is that they are relevant even in a wide range of samples and methodologies. The second is that the relevance of distance is at least as important in studies that use different estimators (Disdier and Head, 2008). Distance effects of this magnitude present a problem in that they almost certainly do not solely arise from transport costs, which is usually used as the acceptable proxy in the estimation. However, in the recent literature of the Gravity Model, some specifications will instead use the remoteness of the partner country. This includes taking the natural log of the product of the partner countries' GDP values as a percentage of world GDP and distance. This variable – which can be used as a proxy for distance in the FE or PPML models – captures the relative importance of the partner's economy while accounting for distance. It is important to note that this specification is much more suitable for FE or PPML estimators because distance itself is a time-invariant variable (Beck, 2020). Remoteness also has more explanatory power than distance because countries which have a similar size economy to the UK may trade more with the UK, even if they are further away. Furthermore, since distance does not change over time, it would be omitted from the FE model because each individual entry minus its mean is replaced with zero (Katchova, 2013).

The intuitive gravity model faces difficulties once more advanced concepts are considered. One problem of the basic model is that it does not account for the impact on trade with country j if countries i and k enter a preferential trade agreement. The pervasive concepts of trade creation and trade diversion suggest that if trade costs change between countries i and k, it will affect trade flows between countries i and j.

A second problem with the basic model is that it does not distinguish between changes in absolute and relative trade costs. If we consider equal decreases in trade costs across all bilateral routes, including domestic ones, the model assumes proportional increases in trade across all bilateral routes. However, despite the changes in absolute trade costs, relative costs have not changed at all. Therefore, trade flows across all bilateral trade routes should remain constant (Shepherd, 2013).

Anderson (1979) asserts that the basic model is flawed as it does not account for "unidentified" factors, which have been discussed previously. Consequently, such exclusion of important factors would result in omitted variable bias, meaning the estimation and the inference of the coefficients would be invalid. The lack of theoretical foundations in the basic model hampered its use for policy evaluation. In fact, much of the development of the gravity model is accounting for potential factors that affect trade flows which were previously not considered. Anderson and Van Wincoop (2003) made a seminal contribution with the “Gravity with Gravitas” model, which paid attention to the impact of shared borders on trade flows. In particular, it was the inclusion of two vector terms, Π and P, which represent outward multilateral resistance and inward multilateral resistance, respectively. Π captures the fact that exports from country i to country j depend on trade costs across all export markets. P, likewise, captures the dependence of imports to country i from country j on trade costs across all possible suppliers. Together, these multilateral resistance terms are the key to the “Gravity with Gravitas” model (Shepherd, 2013).

Chaney (2008) states that one of the most widely used models to predict trade flows was developed by Krugman (1979). However, one of the assumptions made in this model does not necessarily hold true. The assumption is that every firm is identical and every firms exports to every country in the world. This has been addressed by more recent models such as Computable General Equilibrium (CGE) and Partial Equilibrium (PE) models.

Though the gravity model is still prominent in the recent literature, it is useful to be aware of alternative models when estimating the impact of trade policy on trade flows. CGE and gravity models are the most common form of empirical analysis when it comes to estimating the effects of trade policy. Both models are capable of estimating the impact of trade policy for an economy wide basis. CGE models are generally used for estimating the impact of trade policy on the welfare and distribution of income of economies (Ivus and Strong, 2007). Alternatively, PE models estimate the same effects as CGE models, but at a finer level of sectoral disaggregation. Yotov *et al.* (2016) integrate the recent developments of the structural gravity equation and offer recommendations to get reliable PE estimates. The finer level of detail from PE models is useful because trade policy does not affect every sector or every industry in the same way (Gasiorek et al., 2019). On the other hand, gravity models focus on the effect on bilateral trade flows (which is acceptable for the purpose of this dissertation).

Alternative estimators of the gravity model have also been considered in the recent literature. The conventional method of estimating the model has been using ordinary least squares (OLS) and the main contender is the Poisson Pseudo-Maximum Likelihood (PPML) estimator. Silva and Tenreyro (2006) argue that PPML is the more appropriate estimator because the OLS assumptions do not uphold with the functional form of the model. When the underlying assumptions of OLS for a linear regression are met, it produces the best coefficient estimates, therefore it is the conventional method of estimation. However, Silva and Tenreyro (2006) justify that since the functional form of the model is log-linear, the error terms are also in log terms. The mean of the term e_{ijt} depends on higher moments of e_{ijt}, including its variance. If the variance of the error term is heteroskedastic (not normally distributed), the coefficient estimates and the inference of the results would be biased (Shepherd, 2013). Additionally, since the model will be using panel data, consisting of cross-sectional and time series data, heteroskedasticity is likely to occur in practice due to the difference in cases (Wooldridge, 2010). This can also be accounted for in the FE or PPML models by using robust standard errors.

2.2 Empirical Review

Trade policy is a widely studied area and several scholars such as Gasiorek, Serwicka and Smith (2019), Lankhuizen and Thissen (2019), and Oberhofer and Pfaffermayr (2018) present models predicting the effects on bilateral trade from policy changes, such as Brexit. This dissertation will not attempt to forecast future effects of Brexit on UK trade, rather it will analyse possible determinants of bilateral trade between the UK and its non-EU trade partners. These partners include countries in the FTA67 and third countries. Nonetheless, the findings from different scholars provides additional information and allows preliminary expectations to be set which is useful for interpreting the results.

Going forward in the 2020’s the UK has secured a position retaining most of its membership in the European Single Market (SM), maintaining nearly all the free trade agreements (FTA’s) it has with the EU and third countries. Most of the recent empirical literature predicts that there will be a negative effect on UK bilateral trade and welfare from leaving the EU. So far, by leaving the EU, the UK has only increased its barriers to trade. However, depending on what trade agreements the UK can establish with third countries, the UK might be able to mitigate the predicted negative effects on trade and welfare. Gasiorek, Serwicka and Smith (2019) present a PE model, predicting the possible effects of Brexit on UK prices, imports, exports and output over 122 industries. The model presents estimates based off a few different Brexit scenarios which include:

(1) EEA Membership
(2) FTA with EU and FTA67
(3) No Trade Deals
(4) FTA with FTA67 and ROW
(5) Unilateral Free Trade

(Gasiorek et al., 2019)

Under scenario (4), the UK would lose its free trade agreement with the EU but retain it with the FTA67 and establish new ones with the rest of the world. The model predicts that exports would decrease by 12.8%, imports would decrease by 5.1% and output would decrease by 3.6%. The model also predicts that UK prices would increase by 3.9%.

Oberhofer and Pfaffermayr (2018) predict the effects on UK trade and welfare using a Constrained Poisson Pseudo Maximum Likelihood (CPPML) model. The CPPML model also produces estimates under different counterfactual scenarios of Brexit. Oberhofer and Pfaffermayr (2018) predict that UK exports to the EU are likely to decline between 7.2% and 45.7% six years after Brexit has taken place. In the same period, their model predicts that UK imports from the EU are likely to decline between 5.9% and 38.2%. According to the study, the effects just described could only be partially mitigated by increased trade with the FTA67 and third countries.

Lankhuizen and Thissen (2019) do not produce a model to forecast the post-Brexit effects on UK trade; rather they discuss accounting for re-exports to achieve more reliable results. They argue that accounting for re-exports is important in the policy implications for NAFTA and Brexit and not accounting for re-exports could lead to biased estimates. For example, in the Netherlands, re-exports constituted 54% of total exports in 2015. In this dissertation, all available data on exports and imports will be used to produce a variable representing total bilateral trade volume (with the variable being entered in at the natural log form). However, some of the data may not be available or is difficult to gain access to, which could potentially restrict the explanatory power of the model. In any case, the model which will be presented later in this dissertation will attempt to be as detailed as possible, but it is important to note where improvements in the data can be made for future studies.

The provision of more data is also important because it allows for the consideration of additional factors which affect trade. Some variables are difficult to find data for or are not recorded which can hamper the analyses of trade policy. Beck (2020) produces an analysis of international trade, specifically how being an EU member affects bilateral trade. They employ Bayesian model averaging to 71 potential determinants of international trade. The findings show that each year of being an EU member is associated with a growth rate of bilateral trade between 0.52% and 1.49%.

Looking at the findings from different scholars is important because they establish some preliminary expectations for future research. The recent empirical literature suggests that the effects of trading agreements such regional trade agreements (RTA's) and FTA's play an important role in trade creation. The goal of implementing new trade policies, such as Brexit, should always lead to trade creation and not diversion (Pfaffermayr, 2018). Most of the recent empirical literature suggests that new trade policies such as Brexit would have a negative effect on UK trade. However, the UK should now focus on analysing the trade relationships they currently have outside the EU and try to improve those relationships.

3 Methodology

3.1 Data

Data collected for this analysis will be in the form of secondary data. The models will use a panel data approach, which includes both a cross-sectional (cases) element and time series element (annual data). The cases will be a range of different UK trade partners outside the EU. This includes the countries in the FTA67 and other non-EU members which are in the top 50 of UK trade partners – excluding Russia because the World Bank Group does not include much of the data over the given time span. The time span will range from 1973 to 2019, which means the data set is large. This is advantageous because a greater number of observations allows for more degrees of freedom, which in turn increases the efficiency of the estimates and reduces the likelihood that they will be biased. This is known a Central Limit Theorem, which is ubiquitous in the literature of statistical analysis (Ganti, 2019).

Data regarding bilateral trade flows has been extracted from the IMF Direction of Trade Statistics database. The dependent variable $Trade_{ijt}$ is the total volume of trade between countries i and j over time t. Trade volume is comprised of: Goods, Value of Exports, Free-on-board (FIB), US$; Value of Imports, Cost, Insurance, Freight (CIF), US$; Value of Imports, FIB – US$. Data regarding the GDP (US$) of each country – including world GDP – and population was extracted from the World Bank database. The other variables include geographical distance, partner remoteness, common official language indicator variable.

3.2 The Model

The intuitive gravity equation establishes that bilateral trade flows between two countries i and j have a positive correlation with GDP. As GDP and national income increase, the amount of revenue to spend on imports increases. The model also establishes that trade between countries i and j have a negative correlation with distance because the greater the distance, the greater the transports costs are (Tinbergen, 1962). The intuitive gravity equation is denoted:

$$Trade_{ijt} = A * \frac{(Y_i * Y_j)^{\alpha}}{D_{ij}^{\beta}} \quad \text{(a)}$$

The model can be reparametrized into a linearised form by using the natural logs of each parameter. This can be expressed as:

$$lnTrade_{ijt} = ln(A) + \alpha_i \ln(Y_{it}) + \alpha_j \ln\,(Y_{jt}) - \beta lnD_{ijt} + ln\epsilon_{ijt} \quad \text{(b)}$$

Where $lnTrade_{ijt}$ is the natural log of the volume of trade between countries i and j. $ln(A)$ is a normalising constant term. $\alpha_i \ln(Y_{it})$ and $\alpha_j \ln\left(Y_{jt}\right)$ represent the natural logs of the nominal GDP terms of countries i and j, respectively. βlnD_{ijt} is the natural log of the geographical distance between the two countries. ϵ_{ijt} is the natural log of the error term, containing the unobserved factors that affect bilateral trade.

As Anderson (1979) highlights, however, the gravity equation in its most basic form suffers from omitted variable bias. To combat this, another term must be included to account for the omitted variables. This can be expressed in the equation:

$$lnTrade_{ijt} = \ln(A) + \alpha_i \ln(Y_{it}) + \alpha_j \ln\,(Y_{jt}) - \beta lnD_{ijt} + \gamma X_{ijt} + ln\epsilon_{ijt} \quad \text{(c)}$$

In the equation above we obtain a model which is similar to the model developed by Krugman (1979). Included in this specification of the gravity equation is the vector term, γ, multiplied by a matrix X. The new term is used to capture the effect of a range of factors that influence trade flows, including the impact of trading blocs or FTA's. The term γX_{ijt} represents a range of variables, for which their impact on trade will be tested (Beck, 2020). These variables include:

1. *FTA* = Dummy variable indicating the presence of a free trade agreement from the year it has taken effect
2. *ComOffLang* = Dummy variable indicating the presence of a common official language between the UK and the partner country
3. *GDPDist* = Distance between the UK and partner countries' GDP, entered in at the natural log
4. *GCFDist* = Distance between the UK and partner countries' capital gross formation – used as a proxy for investment

GCF is the gross capital formation of the country as %GDP. It is defined by the OECD as the acquisition of produced assets (including purchases of second-hand assets), including the production of such assets by producers for their own use, minus disposals. It is not entered in at the natural log because some of the values of GCF in the data set used in this analysis are negative.

3.3 Fixed Effects vs. PPML

Anderson and Van Wincoop's (2003) “gravity with gravitas” model made a seminal contribution to the gravity model (Oberhofer and Pfaffermayr, 2018). The “gravity with gravitas” model was estimated using ordinary least squares (OLS) regression. However, Silva and Tenreyro (2006) have put forward the argument that estimating the model using OLS produces invalid parameter estimates. If ϵ_{ijt} is heteroskedastic, which is likely in practice, then the expected value of the error term depends on one or more of the explanatory variables because it includes the variance term. This violates the first assumption of OLS and suggests that the estimator may be biased and inconsistent (Shepherd, 2013).

One solution to the problem of heteroscedasticity of the error term is to use a Fixed Effects (FE) model. An FE model is more appropriate for panel data because it does not look at the cases collectively, it looks at the in between or within effects of each individual case. This is also known as heterogeneity, which in this dissertation will be the effects on trade between the UK and each individual country. FE estimator has now become the standard for estimating the “gravity with gravitas” model (Prehn et al., 2016).

Alternatively, the Poisson Pseudo-Maximum Likelihood (PPML) estimator provides a solution to the problems previously mentioned. The PPML estimator has several advantages over other estimators; it deals appropriately with heteroscedasticity, model misspecification and excess zeros (Prehn et al., 2016).

Once the parameters have been estimated, the t-statistics can be used to indicate the statistical significance of the variables. Within the framework of the structural gravity model, a range of variables’ statistical significance towards trade will be tested. This will include the structural parameters, for which the model revolves around, and other specific parameters and their impact on trade (Mátyás, 1997).

It is important to note that future analysis of bilateral trade flows can be improved in the following ways. Firstly, most of the development of the Gravity Model stems from accounting for factors which were previously omitted. The provision of certain data can improve the efficiency of the estimation and reduce the likelihood that the model would be biased. Including variables such the countries' capital endowments – which accounts for the size of the labour force, the size of arable land and the physical capital of the countries – could increase the efficiency of estimation (Beck, 2020). However, a lot of the necessary data from public databases, such as the World Bank Group, is missing for the countries used in this analysis. Secondly, in larger scale studies, more sophisticated models such as CGE and PE models can be used to look at the effects on trade at the industry and sectoral level, resulting in a much more detailed analysis. However, for this analysis, the Gravity Model framework is still capable of capturing the general nation-wide effects on trade.

4 Results

4.1 Empirical Results

lnTrade	*Coefficient*	*t*	*P > |t|*
lnGDPProd	0.465	49.30	0.000
lnDist	-0.722	-24.01	0.000
Remoteness	0.408	24.79	0.000
Scale	-0.304	-25.74	0.000
GCFDist	0.021	8.10	0.000
ComOffLang	0.559	13.98	0.000
FTA	-0.106	-2.20	0.028
Const	11.931	18.15	0.000
R-squared		0.88	
Adj R-squared		0.88	

$Table\ .1 - OLS$

Table .1 above displays OLS coefficient estimates of the structural Gravity Model. The R-squared and adjusted R-squared are high which does not confirm nor deny the existence of the relationships displayed in the model; rather it shows that the data fits the model quite well. The fact that this model appears to have a lot of explanatory power in explaining bilateral trade flow is what made it the workhorse of trade policy analysis. However, it has already been established in the literature that estimation of the structural Gravity Model using OLS would lead to biased estimates and invalid inference. Namely that the model suffers from omitted variable bias or heteroscedasticity. Therefore, this analysis will not interpret the results of the OLS coefficient estimates.

Since the model is using panel data, the inference from the OLS estimates would be invalid because of heteroscedasticity. Fixed Effects (FE) and Random Effects (RE) estimation can be used for panel data analysis. FE and RE estimation are more suitable for estimating models which use panel data because they look at the specific (within) effects between the different cases. In this case it is the individual effects between the different countries. The Wu-Hausman test can be used to determine whether to use FE or RE. The Wu-Hausman statistic is denoted:

$$H = (b_1 - b_0)'(Var(b_0) - Var(b_1))^{\dagger}(b_1 - b_0)$$

The chi-squared distribution can be defined as: $\chi^2 = \sum \frac{(f_0 - f_e)^2}{f_e}$. Where f_o is the frequency of the observations and f_e is the expected frequency if no relationship exists between the variables. Under the alternative hypothesis, FE estimation is consistent and RE is not (Hausman and Taylor, 1978).

lnTrade	*FE Coeff (b)*	*RE Coeff (B)*	*Difference*
lnGDPProd	0.484	0.459	0.024
GDPDist	0.175	0.147	0.027
Remoteness	0.388	0.392	-0.003
Scale	-0.501	-0.332	-0.168
GCFDist	0.013	0.014	-0.000
FTA	0.172	0.170	0 .001
chi²(6)		29.72	
Prob > chi²		0.000	

$Table\ .2 - Hausman$

The *Prob > chi²* value is 0.000 which means the null hypothesis – H_O: Random Effects is the appropriate model – can be rejected.

A FE model can be created by using country identifiers, thereby setting it to panel data. The FE model will look at each individual case and account for heterogeneity.

lnTrade	*Coefficient*	*t*	*P > |t|*
lnGDPProd	0.484	8.91	0.000
GDPDist	0.175	1.65	0.111
Remoteness	0.388	2.39	0.024
Scale	-0.501	-1.55	0.132

GCFDist	0.013	2.70	0.012
FTA	0.172	1.10	0.282
Const	11.605	1.29	0.210
R-squared		0.708	
rho		0.855	

$Table\ .3 - Fixed\ Effects$

According to the t-statistic, only *lnGDPProd*, *Remoteness* and *GCFDist* are statistically significant at the 95% confidence interval. The R-squared value is 0.708 which indicates that the data fits the model well. FE models also produce a rho value which is the proportion of the variation which is explained by the specific effects. In this case, the rho value is 0.855 which suggests that variation is not idiosyncratic between cases. Since this is a FE estimation, the model will not estimate any variables that are time-invariant. Therefore, the Common Official Language dummy variable has been omitted from the model because the values do not vary over time.

lnGDPProd is 0.484, suggesting that there is a positive correlation between the combined size of the economies and bilateral trade. *GDPDist* is 0.175, suggesting there is a positive correlation between the difference in GDP values and bilateral trade. Remoteness is 0.388, suggesting there is a positive correlation between the relative importance of the partner country and bilateral trade. Scale is -0.501, suggesting there is a negative correlation between the scale of the countries' populations and bilateral trade. *GCFDist* is 0.013, suggesting there is a positive correlation between the difference in investment and bilateral trade. FTA is 0.172, suggesting there is a positive correlation between free trade agreements and bilateral trade.

A hypothesis test can be conducted to test whether one or more of the variables is statistically different from zero. The null hypothesis of the test can be written $H_0\text{: Scale} = 0$ against the alternative $H_A\text{: Scale} \neq 0$. This is to say that if the null can be accepted, the scale of the populations of the two countries does not impact bilateral trade flows between the UK and a non-EU partner. The t test can be calculated using the following equation: $t = \frac{m-\mu}{s/\sqrt{n}}$ (Wooldridge, 2016).

The hypothesis test can be applied to check the statistical significance of the FTA dummy variable. Where H_0: $\text{FTA} = 0$ against the alternative H_A: $\text{FTA} \neq 0$.

Test FTA	
(1) FTA = 0	
	F(1, 27) = 2.41
	Prob > F = 0.13

$Table\ .4$

Since $F = 2.41$ and the critical value for $F(1, 27)$ is approximately 4.24 (R_A= {F: F > 4.24}), the null hypothesis cannot be rejected, suggesting that the relationship between FTA's and bilateral trade is not statistically significant.

Another alternative to regular OLS estimation of the Gravity Model is the Poisson Pseudo-Maximum Likelihood (PPML) estimator. PPML is one of the most commonly used estimators of the structural Gravity Model in the recent literature (Shepherd, 2013). Silva and Tenreyro (2006) postulate that, under heteroscedasticity, the log-linearised function of the model would lead to biased coefficient estimates using OLS regression. Additionally, this type of estimator is useful in this application because it allows the use of time-invariant variables, such as the Common Official Language dummy variable.

lnTrade	*Coefficient*	*z*	*P > |z|*
lnGDPProd	0.023	49.71	0.000
GDPDist	-0.012	-8.91	0.000
Remoteness	0.004	4.64	0.000
Scale	-0.014	-27.49	0.000
GCFDist	0.000	5.67	0.000
ComOffLang	0.020	11.91	0.000
FTA	0.006	2.42	0.018
Const	2.353	82.48	0.000
R-squared		0.84	

$Table\ .5 - PPML$

PPML estimation produces a z statistic, in place of the t statistic, suggesting that every variable is statistically significant at the 95% confidence interval. The R-squared value has also increased from 0.71 in the FE model to 0.84 in the PPML model, suggesting the fit of the data has improved.

Table .5 shows results that display similar relationships to that of the FE model. However, the extent to how those factors affect bilateral trade between the UK and non-EU partner countries has changed. All of the variables, except one (*GDPDist*), display similar correlations. In the PPML estimation *GDPDist* has a coefficient estimate of -0.012, suggesting a negative correlation between the difference in GDP values and bilateral trade.

Test FTA
(1) FTA = 0
$chi^2(1) = 5.59$
Prob > chi^2 = 0.018

$Table$ .6

The Prob > chi^2 value suggests that, at the 95% confidence interval, the null hypothesis H_0: $\mathrm{FTA} = 0$ can be rejected, suggesting the relationship between FTA's and bilateral trade is statistically significant.

4.2 Discussion

The FE model suggests that there is a positive relationship between GDP and bilateral trade, which is supported by the literature. The greater the size of the two economies, the higher the expected volume of bilateral trade (Tinbergen, 1962). Partner remoteness and the scale of the populations display results that are in line with the expectations set out by Beck (2020). According to the model, partner remoteness has a positive relationship with bilateral trade. This accounts for the relative importance of the partner countries' economies and the distance from the UK. Countries which have larger scale economies, even when they are further away (like Australia or New Zealand) trade more with the UK. Scale has a negative relationship with bilateral trade which is probably due to the fact that larger countries have larger populations. There is a greater supply of labour and natural endowments in countries with larger populations, which means they are more likely to be self-sufficient. The model suggests that free trade agreements have a positive impact on bilateral trade between the UK and non-EU countries which is in line with the expectations set out by Gasiorek, Serwicka and Smith (2019), Lankhuizen and Thissen (2019), and Oberhofer and Pfaffermayr (2018). This finding is intuitive as FTAs eliminate tariffs and in turn reduce the barriers of trade. However, the variables which represent the distance between the two countries' GDP values and the distance between the two countries' GCF values are counter intuitive. Both of the variables appear to have a positive relationship with bilateral trade. It would be expected that the closer the size of the economies are and the closer the levels of investment are, the more the partner trades with the UK. Yet the results suggest the opposite effect. Nevertheless, the FE t statistics suggest that the majority of the variables are not statistically significant at the 95% confidence interval. Therefore, the relationships drawn from this model should not be confirmed as causal.

The PPML model suggests coefficient estimates similar to that of the FE model, but the extent to which the determinants affect trade appear to be much less potent. There is a still a positive relationship between the combined GDP values and bilateral trade. Remoteness still has a positive relationship with bilateral trade. Scale still has a negative relationship with bilateral trade, which is still in line with the expectations of Beck (2020). GCF distance also still has a positive relationship with bilateral trade, but the coefficient estimate of the PPML model is 0.000, which could suggest that this effect is negligible. One possibility for GCF distance being positive is that the UK trades much more with large economies such as the US and China. These economies are much larger in terms of arable land, workforce, capital and have more factor endowments.

Unlike the FE model, the PPML model produces a negative coefficient estimate for GDP distance. This finding is in line with the existing literature, as economies which are closer in size tend to trade more with each other. Additionally, the PPML model is capable of producing a coefficient estimate for the common official language dummy variable. The model suggests that there is a positive relationship between common official languages and bilateral trade. This means that partner countries that speak English trade more with the UK.

FE and PPML estimation suggest similar relationships between bilateral trade and the determinants of bilateral trade. The FE model shows that the effects of FTA's are stronger than what the PPML model suggests. This shows a stronger resemblance to the results of Gasiorek, Serwicka and Smith (2019), Lankhuizen and Thissen (2019), Oberhofer and Pfaffermayr (2018) and Beck (2020). However, t statistics and z statistics from the FE and PPML models, respectively, suggest that the PPML model is more reliable. The t statistics of the FE model suggest that GDP distance, Scale, FTA and the constant term are statistically insignificant at the 95% confidence interval. Whereas, the z statistics suggest that every variable of the PPML model is statistically significant at the 95% confidence interval. Furthermore, the hypothesis test which tests the statistical significance of the impact of FTAs on bilateral trade could not be rejected. This is also a counter intuitive finding because trade agreements are very important in the role of trade creation. A hypothesis test from the PPML model suggests the impact of FTAs on bilateral trade is statistically significant.

5 Conclusion

In this analysis of the determinants of bilateral trade between the UK and non-EU trade partners, the impact of FTAs on bilateral trade is arguably unquestionable. The UK has secured its position with Brexit, maintaining its SM free trade benefits and free trade with the FTA67. As Gasiorek et al. (2019) states, leaving the EU would inevitably increase barriers to trade at first, as new FTAs with third countries would not come into effect some years later. Nevertheless, it is important for the UK to now look for opportunities wherever they are. The UK has already started negotiations for potential trade agreements with countries such as Australia and New Zealand and secured a trade agreement with Japan. If the UK can also reduce trade barriers with bigger economies such as the US, China and Canada, the findings from this analysis hint that it could be extremely beneficial. Though this is not necessarily news, it is important to note countries such as the US and China account for a lot of British trade despite having no trade agreement. PPML coefficient estimates, such as the combined GDP product and GCF suggest support these claims.

For future analysis, it should be acknowledged that the models included in this analysis can be improved. For instance, accounting for a wider range of variables that affect bilateral trade can increase the efficiency of models. This would require access to databases which are more detailed. Moreover, in larger scale studies, alternate models such as CGE and PE models should be considered as they allow for more detailed analysis.

6 Appendix

Table .1 – OLS

```
. *OLS regression
. reg lnTrade lnGDPProd lnDist
```

Source	SS	df	MS
Model	2203.73823	2	1101.86911
Residual	725.536146	1,280	.566825114
Total	2929.27437	1,282	2.28492541

Number of obs	=	1,283
F(2, 1280)	=	1943.93
Prob > F	=	0.0000
R-squared	=	0.7523
Adj R-squared	=	0.7519
Root MSE	=	.75288

lnTrade	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnGDPProd	.5397011	.0086885	62.12	0.000	.5226557	.5567464
lnDist	-.2417563	.030937	-7.81	0.000	-.3024491	-.1810636
_cons	-5.130907	.4813513	-10.66	0.000	-6.075232	-4.186583

Table .2 – Hausman

```
. hausman fixed random
```

	Coefficients (b) fixed	Coefficients (B) random	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
lnGDPProd	.4837552	.4598894	.0238657	.0111289
GDPDist	.1742058	.1454734	.0287324	.0126643
Remoteness	.3872499	.3895409	-.002291	.0250521
Scale	-.4953224	-.3307794	-.164543	.0757699
GCFDist	.0143197	.0147216	-.0004019	.
FTA	.1708032	.1688812	.001922	.

```
                   b = consistent under Ho and Ha; obtained from xtreg
    B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test:  Ho:  difference in coefficients not systematic

              chi2(6) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                      =       29.66
            Prob>chi2 =      0.0000
            (V_b-V_B is not positive definite)
```

Table .3 – Fixed Effects

```
Fixed-effects (within) regression               Number of obs      =      1,281
Group variable: id                              Number of groups   =         28

R-sq:                                           Obs per group:
     within  = 0.8786                                         min =         22
     between = 0.6255                                         avg =       45.8
     overall = 0.7135                                         max =         47

                                                F(6,27)           =      68.76
corr(u_i, Xb)  = 0.1130                         Prob > F          =     0.0000

                                  (Std. Err. adjusted for 28 clusters in id)
```

lnTrade	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
lnGDPProd	.4837552	.0543217	8.91	0.000	.3722962	.5952141
GDPDist	.1742058	.1057658	1.65	0.111	-.0428076	.3912192
Remoteness	.3872499	.1619911	2.39	0.024	.0548716	.7196281
Scale	-.4953224	.3187812	-1.55	0.132	-1.149407	.1587627
GCFDist	.0143197	.0053032	2.70	0.012	.0034383	.025201
ComOffLang	0	(omitted)				
FTA	.1708032	.1554667	1.10	0.282	-.1481882	.4897946
_cons	11.43162	8.893632	1.29	0.210	-6.816605	29.67985
sigma_u	.76819978					
sigma_e	.31850033					
rho	.85331641	(fraction of variance due to u_i)				

Table .4 – FE Hypothesis Test

```
. test FTA

 ( 1)  FTA = 0

       F(  1,    27) =    1.21
            Prob > F =    0.2816
```

$Table\,.5 - PPML$

Number of parameters: 8
Number of observations: 1281
Pseudo log-likelihood: -3162.7451
R-squared: .84735404
Option strict is: off

lnTrade	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
lnGDPProd	.0231938	.0004655	49.83	0.000	.0222815	.0241062
GDPDist	-.0125194	.0014019	-8.93	0.000	-.0152672	-.0097717
Remoteness	.0049768	.0010706	4.65	0.000	.0028784	.0070752
Scale	-.0147555	.000533	-27.68	0.000	-.0158002	-.0137109
GCFDist	.0007787	.0001305	5.97	0.000	.0005229	.0010345
ComOffLang	.0202841	.0016695	12.15	0.000	.0170119	.0235562
FTA	.0065014	.0027509	2.36	0.018	.0011097	.0118931
_cons	2.353659	.028501	82.58	0.000	2.297798	2.40952

$Table\,.6 - PPML\ Hypothesis\ Test$

```
. test FTA

 ( 1)  FTA = 0

           chi2(  1) =    5.59
         Prob > chi2 =    0.0181
```

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