THE GRAVITY MODEL OF INTERNATIONAL TRADE: ECONOMETRIC PROPERTIES AND APPLICATIONS

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Research Thesis

The Gravity Model of International Trade: Econometric properties and applications

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To my grandfather, Joselyn Smith
(Janaury 28, 1917- May 29, 1993)

You were one of the first to impart knowledge and introduced me to work. To this day, I remember waking-up at about 4am or 5am every morning, putting on my rubber boots you purchased for me and going to work on the farm with you. First, we would milk the cows and then move them to different pastures and check the parameter fencing of the farm. I still remember the feeling of looking forward to our daily routine. I remember the destruction of our farm caused by Hurricane Gilbert in 1988 and the efforts that went into rebuilding it. I also remember when the milk stopped going out to commercial entities. At that time, I did not know why we stopped milking cows. I now realize why, around that same time Jamaica liberalised its markets and our farm was not equipped to compete on a global basis. Thanks to you, our survival was secured through diversification and persistence. Because of this, I have come to the understanding that trade could be welfare improving, but if not inclusive, it could result in many made worse off.

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Abstract

This thesis reviews the literature, simulates and applies the Gravity Model of International Trade. The gravity model is widely used in international trade to examine trade flows within a network of exporters and importers. It describes the push and pull factors of trade flows and is fast becoming the most favoured tool when estimating the welfare effects of a trade policy. Therefore, estimating an accurate baseline equation is critical to correctly identify the welfare effects of trade and accompanying trade policies. Recent developments in the literature on the gravity model have helped in this regard. Chapter 1 presents a summary. The literature identifies several estimation issues and prescribes several actions that could be taken to best estimate the gravity model and minimize potential bias in the coefficient(s) of interest. With the objective of minimizing the bias on the coefficient(s) of interest, this thesis, in Chapter 2, builds on the literature by simulating and estimating the gravity model using varying assumptions about the data generating process (dgp) of the errors, conditional mean and sample. The findings from these simulations are then used to guide the application (Chapter 3) of the gravity model to trade among Caribbean Community (CARICOM) members and trade between CARICOM members and the rest of the world (ROW). Subsequently, in Chapter 4, the gravity model is used as the basis for a general equilibrium framework to investigate the importance of international borders, regional trade agreements (RTAs) and the potential impact of deeper integration in the form of a currency union among CARICOM members. The welfare implications for CARICOM members, associated with being a member of the RTA and adapting a common currency, are presented in Chapter 4 along with several recommended trade policies and areas for future research.

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Introduction

"Newton's law of universal gravitation states that a particle attracts every other particle in the universe using a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between them."[1]

Taking this concept economists, primarily Tinbergen (1962)[2], applied the notion of gravity to international economics to describe the pull and push factors of goods, services, people and finance. These take the form of trade in good and services, migration and displacement of people and foreign direct investment (FDI). This thesis is concerned mainly with the use of the concept of gravity and its application to international trade in goods, although lessons learnt are transferable to other areas such as trade in services, migration and FDI flows. This research builds on the existing literature on how to estimate the gravity equation and examines the nature of bilateral trade flows considering the economic mass of trading partners, their inward and outward multilateral resistance and trade costs, which are usually proxy using distance, currency, regional trade agreements (RTAs), colonial ties/history, language, shared border, religion, infrastructure, institutions and or environment. Similar to Newton's Law of gravity, the export and import of goods and services are positive-proportionally related to economic mass, usually approximated by Gross Domestic Product (GDP), in the origin and destination countries respectively. Furthermore, the gravity model has consistently identified a negative relationship between trade flows

[1] Newton, I. (1792) In [experimental] philosophy particular propositions are inferred from the phenomena and afterwards rendered general by induction: "Principia", Book 3, General Scholium, at p.392 in Volume 2 of Andrew Motte's English translation published 1729

[2] Tinbergen, J. (1962). Shaping the world economy; suggestions for an international economic policy. Books (Jan Tinbergen).

and the geographic distance between trade partners. The literature on the gravity model has evolved from identifying only the elasticities associated with distance and economic mass to identifying the impacts of implementing regional trade agreements (RTAs), adopting common currency, imposing sanctions, among other changes in the relations between and among countries engaging in international trade.

When first used by Tinbergen (1962) there was no economic theory to support the idea of gravity in international trade; however, this has change. It has been shown that a gravity model like structure can be derived from most theoretical models of international trade. The ability to build structure into gravity models of international trade by linking them to theoretical models of international trade, has made them attractive tools for identifying and informing international trade policies and economic growth and development. Although research on the link between international trade and economic growth and development is still limited, gravity models present an opportunity to improve on the existing literature in this area. Anderson (2016)[3] puts it best,

> "*Structural gravity embedded in models of resource allocation across economic sectors has improved quantification of the consequences of globalization for trade patterns, the location of economic activity and the development of economies over time.*"

Despite this, there are several estimation and computation issues to consider when applying this model to data. These are mainly associated with the large number of countries and the heterogeneous nature of each coupled with the limiting, but evolving, nature of the statistical packages used by economists. It is against this background that this thesis delves into various aspects of the gravity model of international trade.

This thesis reviews and explores the gravity model of international trade by examining

[3] Anderson, J.E. (2016), The Gravity Model of Economic Interaction, Boston College and NBER. Retrieve on October 17, 2016 from: https://www2.bc.edu/james-anderson/GravityModel.pdf

its econometric properties and its application to trade in the context of regionalism. This thesis is divided into four chapters. Chapter 1 reviews the literature on the gravity model of international trade. It provides a general outline of one of the many theoretical derivation behind the gravity model. Additionally, Chapter 1 highlights some of the estimation issues associated the with gravity model, which includes heteroskedasticity, observed zero trade flows, identification using partial vs general equilibrium and estimation using cross-section vs panel data estimation.

Chapter 2 presents findings on the econometric properties of the gravity model. The existing literature on the gravity model has identified that it is imperative that the underlying data generating process of the errors are understood as well as the implications of eliminating observed bilateral zero and small trade flows. Using Monte Carlo simulations, Chapter 2 explores the implications of heteroskedasticity on gravity estimates for selected competing estimators; namely: (1) Pooled Ordinary Least Squares (OLS); (2) Least Squares Dummy Variable (LSDV); (3) Poisson Pseudo-Maximum Likelihood (PPML); and, (4) Negative Binomial Quasi-Generalised Pseudo-Maximum Likelihood (NB-QGPML) . Building on previous research on the topic it also explores methodologies, more specifically the Park-type/MaMu test and Gauss Newton Regression (GNR) test, that have been identified as useful when trying to ascertain the data generating process (dgp) of the errors and the presence of heteroskedasticity. Additionally, trade costs could vary across the distribution of exports, as such Chapter 2 considers the use of quantile regressions when estimating the gravity model. It also examines the potential bias of gravity model estimates if samples are drawn using a non-random sampling approach. This, as some studies have relied on sub-networks of international trade drawn using either regional or income groupings.

Chapter 3 demonstrates how the findings of Chapter 2 can be applied as well as other issues, such as the importance of the assumption about the multilateral resistance terms and controlling for these terms, that must be considered when applying the gravity model. In this chapter special interest is given to trade among Caribbean Community (CARICOM) members and trade between CARICOM members and the rest of the world (ROW). CARICOM has fifteen (15) member states, namely: Antigua and Barbuda, The Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Haiti, Jamaica, Montserrat, St. Kitts and Nevis, Saint Lucia, St. Vincent and the Grenadines, Suriname and Trinidad and Tobago; and five (5) associated members, namely: Anguilla, Bermuda, British Virgin Islands, Cayman Islands and Turks and Caicos Islands. The Common Market was established by the Treaty of Chaguaramas, with initial entrants Barbados, Jamaica, Guyana and Trinidad and Tobago in 1973. The motivation behind the focus on CARICOM is that since the 1950s the targeted group of countries have sought to strengthen economic and other relations through increasing trade, trade diversification and trade liberalisation in a manner that allowed for fair competition among members but at the same time protected infant enterprises and industries. Furthermore, CARICOM is concerned about how the benefits of free trade are distributed and how to foster the development of industries whilst removing customs duties on certain products. It is believed that putting in place policy(ies) to realize these would have enhance the competitiveness of The Region's[4] industries as well as the collective bargaining power of The Region in the global marketplace.

CARICOM states are considered small open economies that are deeply entrenched in international trade; however, the relative size of the economies to some of its major trade partners are significantly different. Although early attempts at regionalism (West Indian Federation, 1958) failed, there has been renewed efforts to promote greater trade relations and integration among CARICOM members. Two policies thus far are: the phased implementation of a common external tariff (CET) beginning 1993; and, the move toward a Caribbean Single Market and Economy (CSME), which was signed in 2006. Chapter 3, therefore, explores how these policies have impacted trade over time among CARICOM members and trade over time between CARICOM members and the ROW; that is, in the context of globalisation and trade liberalisation, are these policies trade-creating or trade-diverging? CET and CSME through the mechanisms of reduce trade barriers, access to greater potential capital

[4]The Region here and thereafter refers to the Caribbean, more specifically countries that are members of CARICOM.

and greater labour market efficient might have expanded market assess for regional firms; however, as trade cost trend to zero, that is greater globalization, firm's that are not able to compete on a global scale may have exited the market; hence, rendering these policies inadequate in the context of globalization.

Another issue considered in Chapter 3 is whether climate related disasters impact CARICOM's trade. The impending impact of climate change, which is associated with reduced but greater intensity in rainfall, rising temperature, increased frequency and sustained periods of drought and flooding and sea level rise, coupled with The Region's vulnerability to extreme climate conditions such as tropical cyclones could have significant impact on CARICOM members. Climate change and extreme climate conditions poses grave threats to some important sectors in CARICOM. These include agriculture, forestry, tourism, water, coastal zone and energy. Additionally, climate change associated with sea level rise and extreme climate conditions such as tropical cyclones could impact infrastructure such as sea ports and airports, which are vital for international trade. The potential adverse impacts on these sectors and infrastructure have far reaching implications for trade among CARICOM members and trade with the ROW.

This thesis concludes with Chapter 4, which explores the tractable and parsimonious attributes of the structural gravity model to identify the welfare implications of CARICOM, as well as explore the potential trade related welfare effects adopting a common currency could have on the economies of member states. Chapter 4 also provides trade policy recommendations as well as identifies several areas in which further research is needed to improve the accuracy of the gravity model and its use as a policy tool.

Chapter 1

Literature Review: Gravity Model of International Trade

This chapter reviews the literature on the Gravity Model of International Trade including: theoretical derivation, estimation issues, partial vs. general equilibrium and cross-section vs. panel data estimation.

1.1 Introduction: The Gravity Model

The gravity model is one of the most successful and widely used empirical model in research related to international trade, migration and foreign direct investment (FDI). It was first used in the field of International Trade by Tinbergen (1962) to describe the pull and push factors of international trade. More formally, it examines the nature of bilateral trade flows considering the economy mass of trade partners and trade cost usually proxy using distance, currency, regional trade agreements (RTA), colonial ties/history, language, shared border, religion, infrastructure, institutions or environment. It is widely established in the literature that trade flows (exports and imports) are positively related to economic mass, usually approximated by GDP, in the origin and destination countries as well as a there is negative relationship between trade flows and trade costs. The gravity model also identifies consistently a negative relationship between trade flows and the geographic distance between trading partners; whereas, RTAs are found to mostly have a positive impact on trade between those countries that opt into a RTA.

The traditional gravity model for a point in time, usually a year, takes the form:

$$X_{ni} = Y_n^{\beta_1} Y_i^{\beta_2} \prod_{m=3}^{M} (z_{ni}^m)^{\beta_m} \epsilon_{ni} \tag{1.1.1}$$

or, in its log-linear form:

$$\ln(X_{ni}) = \beta_1 \ln(Y_n) + \beta_2 \ln(Y_i) + \sum_{m=3}^{M} \beta_m \ln(z_{ni}^m) + \epsilon_{ni} \tag{1.1.2}$$

where X_{ni} is exports from country n to country i. Y_n and Y_i are GDP of country n and i respectively. β_m is a vector of coefficients that correspond to each variable in z_{ni}^m; where, z_{ni}^m is matrix of country-specific and bilateral characteristics such as distance, common currency, RTAs, colonial ties/history, common language, shared border, religion or environment. ϵ_{ni} is the idiosyncratic disturbance. The above functional form is known as the 'naive' gravity as it excludes the inward and outward multilateral resistance terms (Anderson and Van Wincoop, 2003). From a econometric standpoint the inward and outward multilateral resistance terms are unobservable country-specific characteristics; however, in Anderson and Van Wincoop (2003) these are defined as a summary of the average trade resistance between a country and its trading partners. The inward multilateral resistance reflects unobserved trade costs relative to a reference importer. A negative average inward resistance means less resistance to access that market relative to the reference importer. On the other hand, the outward multilateral resistance reflects unobserved trade costs relative to a reference exporter. A negative average outward resistance means less resistance to exports from that country relative to the reference exporter. Ignoring the inward and outward multilateral resistance terms when estimating the gravity equation results in bias results since the errors are correlated with the regressors.

Before Anderson and Van Wincoop (2003) brought this issue to light, several gravity equations were estimated without accounting for the inward and outward multilateral resistance terms. Baldwin and Taglioni (2006) identified three typical mistakes that were made in estimating gravity model (equation (1)). These were labeled gold, silver and bronze medal mistakes. The gold medal mistake is related to the exclusion of Anderson and Van Wincoop's (2003) inwards and outward multilateral resistance, which in Head and Ries (2001) and Baier and Bergstrand (2007) are measures of the degree of 'remoteness'. The gold medal mistake results in biased estimators as these omitted terms are correlated with the trade cost. The silver medal mistake, is made when the gravity model is estimated with a dependent variable that was calculated by summing exports and imports $(X_{ni} + X_{in})$ or averaging exports and imports $((X_{ni} + X_{in})/2)$ for a particular bilateral pair for a particular period of time. In recent applications of the gravity model this has been remedied with separate entries of exports and imports, that is, X_{ni} and X_{in} are separate entries. The bronze medal mistake, which is related to the gold medal mistake, involves deflating nominal GDP and trade flows using price indices such as consumer price indies (CPI) or GDP deflator. This mistake leads to bias estimation because these deflators are partial components of the multilateral resistance terms and are not the best proxy for the multilateral terms.

To avoiding the above mistakes the gravity model should be estimated as follows:

- in its multiplicative form:

$$X_{ni} = \frac{Y_n^{\beta_1} Y_i^{\beta_2}}{(\Omega_i \phi_n)^{1-\sigma}} \prod (z_{ni}^m)^{\beta_m} \epsilon_{ni} \tag{1.1.3}$$

- in its log-linear form:

$$\ln(X_{ni}) = \beta_1 \ln(Y_n) + \beta_2 \ln(Y_i) + \sum_{m=3}^{M} \beta_m \ln(z_{ni}^m) - (1-\sigma)\ln(\Omega_i) - (1-\sigma)\ln(\phi_n) + \epsilon_{ni} \tag{1.1.4}$$

where Ω_i and ϕ_n are the multilateral resistance terms; however, since these are unobservable terms, the multilateral resistance terms must either be controlled for, estimated or approximated. This is discussed later in this chapter. In the next section, a theoretical gravity model is presented for a deeper understanding of the gravity model and the functional forms presented above. Subsequently, there is further discussion on the multilateral resistance terms and econometric issues faced when estimating the gravity equation.

1.1.1 A Theoretical Construct of the Gravity Equation

There are several theoretical constructs including: Krugman(1980) with monopolistic competition; Ricardian, with comparative advantage; Eaton and Kortum (2001), and; Anderson and Van Wincoop (2003), among others. This chapter presents a theoretical construct similar to Eaton and Kortum (2001).

Assuming households exhibit constant elasticity of substitution (CES) preferences in each country. The household's utility function can be represented as follow:

$$U_n = \left[\int_{c \in C_n} (x_n(c))^{(\sigma-1)/\sigma} dc \right]^{\sigma/(\sigma-1)} \tag{1.1.5}$$

where $x_n(c)$ is consumption in country n and $\sigma > 1$ satisfies the CES assumption. The households in country n faces the following budget constraint.

$$Y_n = \left[\int_{c \in C_n} p_n(c)(x_n(c)) dc \right] \tag{1.1.6}$$

where Y_n is income of country n which it spends on consumption $(p_n(c)(x_n(c))$. The households maximization problem can be represented by the Lagrangian.

$$L = \left[\int_{c \in C_n} (x_n(c))^{(\sigma-1)/\sigma} dc \right]^{\sigma/(\sigma-1)} - \lambda \left[\int_{c \in C_n} p_n(c)(x_n(c))dc - Y_n \right] \tag{1.1.7}$$

To maximize the household consumption problem, the Lagrangian (equation (1.1.7)) is differentiated with respect to $x_n(c)$ and the first order condition set equal to zero.

$$L^{'} = \frac{\sigma}{\sigma-1} \left[\int_{c \in C_n} (x_n(c))^{(\sigma-1)/\sigma} dc \right]^{\frac{\sigma}{\sigma-1}-1} \frac{\sigma-1}{\sigma} x_n(c)^{-\frac{1}{\sigma}} - \lambda p_n(c) = 0 \tag{1.1.8}$$

To derive further intuition, we need to find the $x_n(c)$ at which households maximize consumption. For ease and clarity, lets define Γ as

$$\Gamma = \left[\int (x_n(c))^{(\sigma-1)/\sigma} dc \right]^{\frac{\sigma}{\sigma-1}} \tag{1.1.9}$$

substituting Γ into the first order condition (equation (1.1.8)), $x_n(c)$ can be written as:

$$x_n(c) = \left(\frac{\int_{c \in C_n} (x_n(c))^{(\sigma-1)/\sigma} dc}{\Gamma} \lambda p_n(c) \right)^{-\sigma} \tag{1.1.10}$$

note that $x_n(c)$ is a function of the Lagrangian multiplier. To find an expression for this term, multiply equation (1.1.8) by price ($p_n(c)$) and aggregate over all households. This results in,

$$\int_{c \in C_n} p_n(c) x_n(c) = \left[\frac{\Gamma}{\int_{c \in C_n} (x_n(c))^{(\sigma-1)/\sigma} dc} \right]^{\sigma} \lambda^{-\sigma} \int_{c \in C_n} [p_n(c)]^{1-\sigma} dc \tag{1.1.11}$$

From equation (1.1.6), $\int_{c \in C_n} p_n(c) x_n(c) dc = Y_n$; therefore, substituting this into equation (1.1.11) and solving for λ yields,

$$\lambda = \frac{\Gamma}{\int_{c\in C_n}(x_n(c))^{(\sigma-1)/\sigma}dc}\left(\frac{\int_{c\in C_n}[p_n(c)]^{1-\sigma}dc}{Y_n}\right)^{1/\sigma} \tag{1.1.12}$$

substituting equation (1.1.12) into equation (1.1.10) gives the $x_n(c)$ which maximizes the household utility.

$$x_n(c) = \left[\frac{\Gamma}{\int_{c\in C_n}(x_n(c))^{(\sigma-1)/\sigma}dc}\right]^{\sigma}\left[\frac{\Gamma}{\int_{c\in C_n}(x_n(c))^{(\sigma-1)/\sigma}dc}\right]^{-\sigma}\left(\frac{\int_{c\in C_n}[p_n(c)]^{1-\sigma}dc}{Y_n}\right)^{-1}[p_n(c)]^{-\sigma} \tag{1.1.13}$$

$$x_n(c) = \frac{[p_n(c)]^{-\sigma}}{\int_{c\in C_n}[p_n(c)]^{1-\sigma}dc}Y_n \tag{1.1.14}$$

written formally, equation (1.1.14) can be written as:

$$x_n(c) = \left[\frac{p_n(c)}{P_n}\right]^{-\sigma}\frac{Y_n}{P_n} \tag{1.1.15}$$

where: $P_n = \left(\int_{c\in C_n}[p_n(c)]^{1-\sigma}dc\right)^{1/(1-\sigma)}$ is the appropriate deflator of income and prices in the economy.

Lets consider the implications of trade with 'iceberg' trade cost τ_{ni}. Given the constant elasticity of consumption, which results in constant markup for firms and further assuming trade cost is the same across all varieties ($x_n(c)$), $p_i = \tau_{ni}p_n(c)$. That is, the price paid in country i for a good imported from country n is scaled by/equal to the cost of getting it from country n to households in country i times the prices of producing the good in country n. It follows that with trade the appropriate deflator in country i can be written as:

$$P_i = \left(\int_{c\in C_n}[\tau_{ni}p_n(c)]^{1-\sigma}dc\right)^{1/(1-\sigma)} \tag{1.1.16}$$

The total value of exports from country n to i is given by $x_{ni}(c) = p_{ni}x_i(c)$; therefore, bilateral trade maybe described as:

$$x_{ni}(c) = \tau_{ni}p_n(c)\left[\frac{\tau_{ni}p_n(c)}{P_n}\right]^{-\sigma}\frac{Y_n}{P_n} \tag{1.1.17}$$

$$x_{ni}(c) = \left[\frac{\tau_{ni}p_n(c)}{P_n}\right]^{1-\sigma}Y_n \tag{1.1.18}$$

For ease of computation, lets assuming balance trade, that is, $x_{ni} = x_{in}$. It follows then that:

$$x_{ni}(c) = \left[\frac{\tau_{ni}p_n(c)}{P_i}\right]^{1-\sigma}Y_i \tag{1.1.19}$$

Given that the total consumption expenditure by country i must equal to the total income of country n ($Y_n = \sum_{i=1}^{N} x_{ni}$), it follows that,

$$Y_n = [p_n(c)]^{1-\sigma}\sum_{i=1}^{N}\left[\frac{\tau_{ni}}{P_n}\right]^{1-\sigma}Y_i \tag{1.1.20}$$

solving for $p_n(c)^{1-\sigma}$

$$[p_n(c)]^{1-\sigma} = \frac{Y_n}{\sum_{i=1}^{N}\left[\frac{\tau_{ni}}{P_n}\right]^{1-\sigma}Y_i} \tag{1.1.21}$$

and substituting into equation (1.1.20), results in bilateral trade flow from country n to i

$$x_{ni}(c) = \left[\frac{\tau_{ni}}{P_i}\right]^{1-\sigma}\frac{Y_iY_n}{\sum_{i=1}^{N}\left[\frac{\tau_{ni}}{P_n}\right]^{1-\sigma}Y_i} \tag{1.1.22}$$

This can be written generally as:

$$x_{ni}(c) = \frac{Y_nY_i}{Y_k}\left[\frac{\tau_{ni}}{P_i\Pi_n}\right]^{1-\sigma} \tag{1.1.23}$$

The above is the general form of the gravity equation, where: Y_k is world's total output; and

$$\Pi_n = \sum_{i=1}^{N} \left[\frac{\tau_{ni}}{P_i}\right]^{1-\sigma} \frac{Y_i}{Y_k} \tag{1.1.24}$$

and

$$P_i = \sum_{n=1}^{N} \left[\frac{\tau_{ni}}{\Pi_n}\right]^{1-\sigma} \frac{Y_n}{Y_k} \tag{1.1.25}$$

Note P_i and Π_n are the multilateral resistance terms, which correspond to Ω_i and ϕ_n respectively in equation (1.1.3) and (1.1.4). When estimating the gravity model controlling for, estimating or approximating these multilateral resistance terms are critical to deriving unbiased estimates of the parameters of interest. In the next section several approaches to control for, estimate or approximate these multilateral resistance terms are discussed.

1.1.2 Multilateral Resistance in Gravity

The gravity equation is used to estimate the dynamics of trade and inform trade policies' development and implementation with an aim of welfare improvement; therefore, obtaining unbiased and consistent estimates is important to this process. Imperative to achieving this objective is controlling for, estimating or approximating these multilateral resistance terms; however, the multilateral resistance terms are not directly observable as such a suitable approach must be adapted to isolate, estimate or approximate these multilateral resistance terms. This subsection identifies some ways of controlling for, estimating or approximating the multilateral resistance terms.

One way to account for the multilateral resistance terms is to estimate the gravity equation using fixed effects or the within group estimator. Feenstra (2004) details the usefulness of this approach. If the gravity equation is estimated using a Pooled Ordinary Least Squares (Pooled OLS) and there exist cross-sectional heterogeneity, OLS is biased and an inconsistent estimators as the error terms, which encompasses, at least in part, the multilateral resistances, is correlated with the regressors. Therefore, to control for the unobserved multilateral resistance terms most studies utilize fixed effects panel data models. These fixed effects are introduced by including: (1) exporters and importers dummies; (2) exporters and importers dummies with time dummies; (3) bilateral pair dummies; (4) bilateral pair and time dummies; (5) exporters-time and importers-time dummies, and; (6) bilateral pair-time dummies (see Table 1.1). The aforementioned fixed effects represent the most basic functional application as some studies use other possible combinations, such as bilateral pair with time and importer dummies, which captures only the exporter's propensity to export.

A fixed effect gravity model with exporters and importers dummy variables controls for the unobserved characteristics which affect the propensity of a country to export and import respectively. These dummies can also be viewed as capturing the relative remoteness of a country or allowing for country heterogeneity. The estimators are unbiased under the assumption that the multilateral resistance terms are constant over time. If the multilateral terms vary with time the estimated coefficients are biased. It is important to understand and qualify the assumption(s) of how the multilateral terms may or may not evolve over time. In the presence of time varying multilateral resistance, the model should be specified with exporters' and importers' dummies and time dummies, which captures the heterogeneous characteristics of exporters and importers and changes in the multilateral resistance terms over time. The inclusion of exporters' and importers' dummies with time dummies captures the heterogeneous characteristics across countries and over time.

Table 1.1: Some Fixed Effects used in the Gravity Models

Fixed Effects	**Log-linear Specification**	**Description**	**Pros**	**Cons**
Exporters and Importers dummies	$\ln(X_{nit}) = \beta_1 \ln(Y_{nt}) + \beta_2 \ln(Y_{it}) + \Sigma_{m=3}^{M} \beta_m \ln(z_{nit}^m) + D_n + D_i + \epsilon_{ni}$	D_n and D_i are matrices of exporters' and importers' dummies that do not vary with time	Allows for exporters and importers heterogeneity.	Does not control for idiosyncratic bilateral trade factors and assumes multilateral resistance is constant over time
Bilateral Pair	$\ln(X_{nit}) = \beta_1 \ln(Y_{nt}) + \beta_2 \ln(Y_{it}) + \Sigma_{m=3}^{M} \beta_m \ln(z_{nit}^m) + D_{ni} + \epsilon_{nit}$	D_{ni} is a matrix of bilateral pair dummies that does not varies with time	Controls for idiosyncratic bilateral trade factors.	Does not allow for exporters and importers heterogeneity and does not allow for multilateral resistance terms to vary with time
Time dummies	$\ln(X_{nit}) = \beta_1 \ln(Y_{nt}) + \beta_2 \ln(Y_{it}) + \Sigma_{m=3}^{M} \beta_m \ln(z_{nit}^m) + D_t + \epsilon_{nit}$	D_t is a matrix of time dummies	Allows for multilateral term to vary with time.	Does not allow for exporters and importers heterogeneity or control for cross-bilateral pair correlation
Exporters, Importers and Time dummies	$\ln(X_{nit}) = \beta_1 \ln(Y_{nt}) + \beta_2 \ln(Y_{it}) + \Sigma_{m=3}^{M} \beta_m \ln(z_{nit}^m) + D_n + D_i + D_t + \epsilon_{nit}$	D_n and D_i are matrices of exporters' and importers' dummies that do not vary with time combined with a matrix of time dummies (D_t)	Allows for exporters and importers heterogeneity and captures, in part, the multilateral resistance terms that vary with time.	Does not control for idiosyncratic bilateral trade factors.
Bilateral Pair and Time dummies	$\ln(X_{nit}) = \beta_1 \ln(Y_{nt}) + \beta_2 \ln(Y_{it}) + \Sigma_{m=3}^{M} \beta_m \ln(z_{nit}^m) + D_{ni} + D_t + \epsilon_{nit}$	D_{ni} is matrix of bilateral pair dummies that does not varies with time combined with a matrix of time dummies (D_t)	Controls for idiosyncratic bilateral trade factors and captures, in part, the multilateral resistance terms that vary with time.	Does not allow for exporters and importers heterogeneity.

Continued on next page

Table 1.1 - continued from previous page.

Fixed Effects	Log-linear Specification	Description	Pros	Cons
Exporters-time and Importers-time dummies	$\ln(X_{nit}) = \beta_1 \ln(Y_{nt}) + \beta_2 \ln(Y_{it}) + \Sigma_{m=3}^{M} \beta_m \ln(z_{nit}^m) + D_{nt} + D_{it} + \epsilon_{nit}$	D_{nt} and D_{it} are matrices of exporters' and importers' dummies that do vary with time (t)	Allows for exporters and importers heterogeneity and captures the multilateral resistance terms that vary with time.	Does not control for idiosyncratic bilateral trade factors as well as it can be cumbersome when N and T is large.
Bilateral Pair and Time dummies	$\ln(X_{nit}) = \beta_1 \ln(Y_{nt}) + \beta_2 \ln(Y_{it}) + \Sigma_{m=3}^{M} \beta_m \ln(z_{nit}^m) + D_{nit} + \epsilon_{nit}$	D_{nit} is matrix of bilateral pair-time dummies that varies with time (t)	Controls for bilateral trade factors and captures the multilateral resistance terms that vary with time.	Does not allow for exporters and importers heterogeneity as well as it is difficult to estimate, especially with large N and large T.

Another specification of the gravity model involves the inclusion of bilateral pair dummies (no exporters and importers dummies). This controls for the possibility that the bilateral regressors, such as common language, distance, common colonizer and common currency, could be correlated with the multilateral resistance terms. The inclusions of these dummies control for time invariant bilateral pair heterogeneity and as such the coefficient of regressors, such as common language, distance, common colonizer and common currency, would be undetermined, however, the coefficient for time varying bilateral pairs independent variables can be identified. The inclusion of bilateral pair and time dummies is another commonly used fixed effect model. The inclusion of time dummies captures, in part, the time varying properties of the multilateral resistance terms, whereas the bilateral pair dummies eliminates any possible cross-bilateral pair correlation. However, these estimates still remain biased as they do not capture or control for the multilateral resistance terms fully. Ideally, a gravity model specified with exporter-time and importer-time dummies would capture the multilateral resistance terms but estimating such a regression might be cumbersome and most statistical packages cannot handle such large expansion in variables.

Similarly, a gravity model specified with bilateral pair-time dummies would capture the multilateral resistance; however, this is in full if the multilateral resistance terms are identical for both countries that constitute that bilateral pair. Otherwise, unless the model is well specified and include important country-specific variables, to capture these idiosyncrasies, country specific characteristics will be ignored. Estimating this model could prove to be difficult; however, recent development by Guimaraes and Portugal (2010) following Abowd et al. (1999) and Guimaraes (2014) have helped to circumvent the issues associated with multidimensional fixed effects estimation. They have developed 'reg2hdfe' and 'poi2hdfe' respectively. These estimators are variant of the Least Squared Dummy Variable (LSDV) estimator and the Poisson Pseudo-Maximum Likelihood (PPML) estimator. Although the 'reg2hdfe' estimator usually generate identical estimates to the LSDV approach, in some instances the 'poi2hdfe' estimator generates different estimates from the Poisson PML estimator. The most recent additions to the literature is the Stata routine developed by Zylkin (2016) called $PPML\_PANEL\_SG$. This is a PPML based routine which was developed specifically to estimate the gravity model with large number of fixed effects.

Besides the fixed effects approach, some researchers have attempted to, control for, estimate or proxy using iterative processes and network analysis. The most cited approximation method was proposed by Baier and Bergstrand (2009), which was derived from Anderson and Van Wincoop (2003) approximation method.

Assuming symmetric trade cost, Anderson and Van Wincoop (2003) proposed estimating the following gravity equation:

$$\ln\left(\frac{X_{ni}}{Y_nY_i}\right) = \beta_0 + \sum_{m=1}^{M} \beta_m \ln(z_{ni}^m) - (1-\sigma)\ln(\Omega_i) - (1-\sigma)\ln(\phi_n) + \epsilon_{ni} \quad (1.1.26)$$

subject to a system of multilateral resistance for each country n, where $n = 1, 2, 3, ...k$; that is:

$$\phi_n = \sum_{i=1}^{k} {\Omega_i}^{\sigma-1}\left(\frac{Y_n}{Y_k}\right) \exp^{\sum_{m=1}^{M} \beta_m \ln(z_{ni}^m)} \quad (1.1.27)$$

where $\beta_0 = -\ln(Y_k)$ is a constant and the elasticities in $\sum_{m=1}^{M} \beta_m$ are depend on the elasticity of substitution (σ) and recall that Y_k is world's total output. The system of equations is estimated using Non-Linear Least Squares (NLLS); however, this methodology is not widely used in the literature, which could be attributed to the computational difficulties involve in estimation as well as its sensitive to the estimated value of the elasticity of substitution (Anderson and Yotov (2010) and Bergstrand, Egger and Larch (2013))

While Anderson and Van Wincoop's (2003) approach approximates the multilateral resistance terms on the assumption of symmetric trade cost, Baier and Bergstrand (2009) proposed a Bonus Vetus OLS (BVW, GDP-weighted), which uses a first order Taylor series expansion of the importer and exporter multilateral resistance terms hence allowing for the estimation of asymmetric trade cost. They show that although $\tau_{in} = \tau_{ni}$, the weights on trade cost, $\frac{Y_n}{Y_k}$ and $\frac{Y_i}{Y_k}$, need not be equal. Their transformation of the multilateral resistance terms and hence the gravity equation resembles:

$$\ln(X_{ni}) = \beta_0 + \beta_1 \ln(Y_n) + \beta_2 \ln(Y_i) - (1-\sigma)\ln(\tau_{ni})$$
$$- (1-\sigma)\Bigg[\sum_{i=1}^{k}\left(\frac{Y_i}{Y_k}\right)\ln(\tau_{in}) - \frac{1}{2}\Bigg(\sum_{i=1}^{k}\sum_{n=1}^{k}\left(\frac{Y_i}{Y_k}\right)\left(\frac{Y_n}{Y_k}\right)\ln(\tau_{in})\Bigg)\Bigg]$$
$$- (1-\sigma)\Bigg[\sum_{n=1}^{k}\left(\frac{Y_n}{Y_k}\right)\ln(\tau_{ni}) - \frac{1}{2}\Bigg(\sum_{i=1}^{k}\sum_{n=1}^{k}\left(\frac{Y_n}{Y_k}\right)\left(\frac{Y_i}{Y_k}\right)\ln(\tau_{ni})\Bigg)\Bigg] + \epsilon_{ni} \quad (1.1.28)$$

where:

$$\ln \phi_n^{\sigma-1} = (\sigma-1)\Bigg[\sum_{n=1}^{k}\left(\frac{Y_n}{Y_k}\right)\ln(\tau_{ni}) - \frac{1}{2}\Bigg(\sum_{i=1}^{k}\sum_{n=1}^{k}\left(\frac{Y_n}{Y_k}\right)\left(\frac{Y_i}{Y_k}\right)\ln(\tau_{ni})\Bigg)\Bigg] \quad (1.1.29)$$

and;

$$\ln \Omega_i^{\sigma-1} = (\sigma-1)\Bigg[\sum_{i=1}^{k}\left(\frac{Y_i}{Y_k}\right)\ln(\tau_{in}) - \frac{1}{2}\Bigg(\sum_{i=1}^{k}\sum_{n=1}^{k}\left(\frac{Y_i}{Y_k}\right)\left(\frac{Y_n}{Y_k}\right)\ln(\tau_{in})\Bigg)\Bigg] \quad (1.1.30)$$

and $\beta_0 = -\ln(Y_k)$ and τ_{ni} is a broad definition of transport cost. Baier and Bergstrand (2009), using Monte Carlo simulation, found that the first-order Taylor series works well in approximating the multilateral resistance terms. Baier and Bergstrand (2010) revising this methodology by centering the first-order Taylor series on a symmetric world, where countries have identical economic size (GDP) and trade cost greater than one ($\tau_{ni} \geq 1$). Given the assumption that countries have identical economic size, the GDP-weights, $\frac{Y_n}{Y_k}$ and $\frac{Y_i}{Y_k}$, are replaced by simple averages or identical GDP shares (equal weighing of $\frac{1}{k}$). Therefore, the multilateral resistance terms and hence the gravity equation is estimated as:

$$
\begin{aligned}
\ln(X_{ni}) = \beta_0 + \beta_1 \ln(Y_n) + \beta_2 \ln(Y_i) - (1-\sigma)\ln(\tau_{ni}) \\
- (1-\sigma)\Bigg[\frac{1}{k}\sum_{n=1}^{k}\ln(\tau_{ni}) - \frac{1}{2}\frac{1}{k^2}\Bigg(\sum_{n=1}^{k}\sum_{i=1}^{k}\ln(\tau_{ni})\Bigg)\Bigg] \\
- (1-\sigma)\Bigg[\frac{1}{k}\sum_{n=1}^{k}\ln(\tau_{ni}) - \frac{1}{2}\frac{1}{k^2}\Bigg(\sum_{n=1}^{k}\sum_{i=1}^{k}\ln(\tau_{ni})\Bigg)\Bigg] + \epsilon_{ni} \quad (1.1.31)
\end{aligned}
$$

where: $\beta_0 = -\ln(Y_k) - \left[\frac{1}{k}\left(\sum_{n=1}^{k}\ln\left(\frac{Y_n}{Y_k}\right)\right) - \ln\left(\frac{1}{k}\right)\right]$ is a constant across country pairs, and;

$$
\ln \phi_n^{\sigma-1} = (\sigma-1)\Bigg[\frac{1}{k}\sum_{n=1}^{k}\ln(\tau_{ni}) - \frac{1}{2}\frac{1}{k^2}\Bigg(\sum_{n=1}^{k}\sum_{i=1}^{k}\ln(\tau_{ni})\Bigg)\Bigg] - \frac{1}{2}\Bigg[\frac{1}{k}\Bigg(\sum_{n=1}^{k}\ln\left(\frac{Y_n}{Y_k}\right)\Bigg) - \ln\left(\frac{1}{k}\right)\Bigg] \quad (1.1.32)
$$

and similarly,

$$
\ln \Omega_i^{\sigma-1} = (\sigma-1)\Bigg[\frac{1}{k}\sum_{i=1}^{k}\ln(\tau_{in}) - \frac{1}{2}\frac{1}{k^2}\Bigg(\sum_{i=1}^{k}\sum_{n=1}^{k}\ln(\tau_{in})\Bigg)\Bigg] - \frac{1}{2}\Bigg[\frac{1}{k}\Bigg(\sum_{i=1}^{k}\ln\left(\frac{Y_i}{Y_k}\right)\Bigg) - \ln\left(\frac{1}{k}\right)\Bigg] \quad (1.1.33)
$$

By examining equations (1.1.30) and (1.1.31), Baier and Bergstrand (2010) concluded that the more GDP shares are asymmetrical, the higher is the multilateral resistance and the greater the bilateral trade flow. That is, holding bilateral determinants constant, bilateral trade from country n to i will be greater the more the asymmetric are all region's economic sizes.

Similar to Baier and Bergstrand (2009) and (2010), Koch and LeSage (2009) and Straathof (2008) derived and illustrated the use of first-order linearisation to approximate the multilateral terms. One limitation to these methodologies is the possible introduction of endogeneity into the estimation of the gravity equation since the weights are computed as GDP-share.

De Bruyne et al. (2013) suggest an approach to estimate, in part, and capture, in part, the multilateral resistance terms. This methodology involves decomposing the multilateral resistance terms using first-order and second-order network effects to estimate what they call 'revealed' multilateral trade resistance (RMTR). The RMTR is decomposed to identify in and out-degrees (first order openness of importer and first order competitiveness of exporter respectively) and clustering (second order). De Bruyne et al. (2013) interpret these as import openness (in degree), international competitiveness (out-degree) and competition effects (clustering).

In their model setup and estimation procedures, countries are represented by nodes which consist of exporters and importers. If trade flow/volume between two countries is greater than zero (0) that constitute what is called an 'edge' (a_{ni}). a_{ni} is binary; equal one if trade flow/volume is positive and zero otherwise. Edges are weighted by trade volume. To calculate the out-degree, the total number of active export destinations (active export edges) are weighted by the trade volume associated with each edge; whereas, for the in-degree, the total number of active import destinations (active import edges) are weight by the trade volume associated with each edge. De Bruyne et al. (2013) defines clustering as a property of the network and uses this as a measure of the potential competition effects. The higher clustering coefficient the more competition a country faces. The clustering coefficient is calculated as the expected or average probability that a pair of exporter i's trading partners is itself a trading pair; given that a_{ni} and a_{in} exist. With these, the gravity equation is augmented with the components of the RMTR as regressors and their effects identified while controlling for any remaining unobserved third country dependence factors and exporter, importer and time heterogeneity. The empirical gravity equation estimated resembles:

$$\ln(X_{nit}) = \beta_0 + \beta_1 \ln(Y_{nt}) + \beta_2 \ln(Y_{it}) + \sum_{m=3}^{M} \beta_m \ln(z_{nit}^m)$$
$$+ \alpha_1 \ln(\kappa_{nt}^{out}) + \alpha_2 \ln(\kappa_{it}^{in}) + \alpha_3 \ln(C_{nt}) + \alpha_4 \ln(C_{it}) + D_n + D_i + D_t + \epsilon_{nit} \quad (1.1.34)$$

Where κ_{nt}^{out} and κ_{it}^{in} are out-degree and in-degree respectively and C_{nt} and C_{it} are exporter and importer clustering measures respectively. The gravity equation is estimated using: OLS with country fixed effects; Pseudo-Maximum Likelihood (PPML), to take into consideration the presents of zero trade flow, and; Bonus Vetus OLS. The in-degree and out-degree are found to be positively related to bilateral trade, while clustering is negative. Put differently, import openness and international competitiveness has a positive impact on bilateral trade, whereas, potential competition effects have a negative impact on bilateral trade.

Of all the methodologies for accounting for the multilateral resistance terms reviewed, the fixed effects approach is the most widely used. It is attractive because it is easy to implement regardless of the choice of estimator. This advantage is highlighted in the findings of Feenstra (2004) and Head and Mayer (2014).

1.1.3 Other Econometric Issues

Despite refinement of the functional form and efforts to control, estimate and proxy the multilateral terms, the gravity model estimation is still marred by uncertainty surrounding what estimation procedures are best and under what underpinning conditions. Selecting the best estimator or a group of the best estimators must consider three major issues. These include: heteroskedasticity in the error term of the multiplicative models; the large number of observed zero trade flows usually present in the data sets, and; endogeneity of regressors such GDP and RTA. Santos Silva and Tenreyro (2006) and Header and Mayer (2014) provides significant insight into addressing these issues.

Heteroskedasticity

In the presence of heteroskedasticity the log-linearise gravity equation could lead to biased estimates. Santos Silva and Tenreyro (2006) found that in the presence of heteroskedasticity, even controlling for the multilateral resistance terms using fixed effects, the log-linearised gravity equation estimated using OLS tend to generate bias estimates. This can be attribute to fact that the gravity equation is multiplicative in levels and when log-linearised it ignores Jensen's inequality that the logarithm expectation of the errors is not equal to expectation of logarithm of errors ($E(\ln \epsilon_{ni}) \neq \ln E(\epsilon_{ni})$). Following Santos Silva and Tenreyro (2006), Head and Mayer (2014) used simulation procedures to shed light on the appropriate estimation procedure to use in the presence of log-normal low variance (Constant Coefficient of Variation (CVV))and heteroskedastic variance (Constant Variance of Mean Ratio (CVMR)). They explore four estimators, namely: OLS, Poisson PML, Gamma PML and Negative Binomial PML. The latter was found by Head and Mayer (2014) to lack the robustness properties of the other PML. Furthermore, its estimates are sensitive to the unit of measurement of the dependent variable as well as it does not nest the CVMR assumption. In the next chapter these simulations are replicated and extended to provide further insight into the appropriateness of these estimators and under what conditions.

To approach the issue of heteroskedasticity, Santos Silva and Tenreyro (2006) propose using Park-type/MaMu Test and Gauss-Newton regression to identify the if the error are heteroskedastic or not. These test are described further in Chapter 2 as well as their usefulness examined using Monte Carlo simulations.

Large number of zero trade flows

Another issue encountered when estimating the gravity equation is the treatment of zero trade flows. Head and Mayer (2014) tackle this problem meticulously to prescribe ways in which the gravity model can be estimated to obtain the most likely unbiased, efficient and consistent estimates. They examined six possible treatments of zero trade flows and estimation procedures which could be used to estimate the gravity equation. These include[1]:

- LSDV, which treats zero trade flows as missing values;
- Eaton and Tumura (1994), which involves estimating a Tobit with $(\ln(\alpha+X_{ni}))$ as the RHS variable and α is a parameter to be estimated. However, it is difficult to convey an economic interpretation of α;
- Eaton and Kortum (2001), which involves identifying the minimum observed trade flow $(Xmin_{ni})$ for a country, where $Xmin_{ni} \neq 0$ and replacing all observe zero trade flow with $(Xmin_{ni})$. The gravity equation is estimated using a Tobit with a RHS variable of $\ln(X_{ni})$, which range from $\ln(Xmin_{ni})$ to $\ln(Xmax_{ni})$;
- Poisson PML and Gamma PML, which are scale invariant and do not require the trade flow to be transformed hence allowing for the inclusion of observed zero trade flows; and,
- Multinomial PML (EKS), which involves transforming trade flows into shares of total expenditure of the importing country. This bounds the dependent variable between 0 and 1. This transformation reduces the scale effects in trade flows.

Head and Mayer (2014) found that in the presence of large number of zero trade flows, the LSDV and Eaton and Tamura (1994) Tobit are found to biased, with

[1]Note, Head and Mayer (2014) did not consider the practice of adding one (1) to trade flow and taking logs as it widely known that interpretation of the elasticity become difficult and furthermore the estimated elasticities are sensitive to the units of measurement (i.e thousands, millions, billions).

the Tobit outperforming the LSDV. Eaton and Kortum (2001) Tobit is preferred to the aforementioned (LSDV and Eaton and Tamura (1994) Tobit); however, it is inconsistency when there is departure from homoscedastic variance. The Gamma PML is found to be biased under the assumption of CVV and CVMR, exhibiting the largest bias. The Poisson and Multinomial PMLs are biased under the assumption of CVV; however, they are unbiased under the assumption of CVMR. Under the CVMR assumption, the Multinomial PML is preferred to the Poisson as it has the a smaller bias. Under the assumption of CVV, the Eaton and Kortum (2001) Tobit is preferred. Similarly, Martin and Pham (2011) found that the Eaton and Kortum (2001) Tobit outperforms the Poisson PML when the errors are homoscedasticity.

Another modeling procedure identified in the literature for dealing with the exclusion of zero trade flows is Heckman (1979) in Helpman et al. (2008). Helpman et al. (2008) use the sample selection correction introduced by Heckman (1979) by dividing the data set along the lines of trade flows equal zero ($X_{ni} = 0$) and trade flows strictly greater than zero ($X_{ni} > 0$) and a two-stage selection model estimated.

The first stage involves estimating a probability type model (probit). The probit type model must include the explanatory variables used in original gravity equation plus an instrument which best explains selection into trade. This instrument is best if it does not explain trade flows but is able to explain the selection into trade. The probit type estimates are used to calculate the inverse Mill's ratio, which is measured as the ratio of the probability density function to the cumulative distribution function (Shepherd, 2013).

In the second stage regression, the Mill's ratio enters the original gravity model, which is usually estimated with OLS[2] and excludes zero trade flow, to correct for the sample

[2] Xiong and Chen (2014) proposed a similar estimator which used the PPML estimator to estimate the second-stage regression

selection bias if present. Sample selection bias is present if the error terms of original gravity equation and the probit are correlated. The difficulty with this procedure is finding an appropriated instrument that describes the sample selection process. This procedure was described in Head and Mayer (2014); however, no simulation exercise was conducted to compare its usefulness and robustness against other estimation procedure. Since this procedure does not seems to address the issue of heteroskedasticity in the error structure and the original gravity model is estimated using OLS, it might only produce unbiased estimates if the dgp of the errors is CCV.

Endogeneity

Endogeneity issues may arise because of the exclusion of regressors, measurement error and/or the inclusion of regressors that may not be truly defined outside the model[3]. For the gravity model the endogeneity bias is in part related to omission of the multilateral resistance terms since independent variables are correlated with the omitted multilateral resistance terms which are absorbed by the errors. As was discussed above, correcting this problem can be achieved by estimating, approximating or controlling for the multilateral resistance terms.

Another source of endogeneity bias in the gravity model is simultaneity or bi-directional causation. The literature points to variables such as GDP and RTA as possibly not been exogenously determined, hence introducing endogeneity bias and distorting estimated coefficients. RTAs are widely seen as trade improving; however, there might be reverse causation in that trade could be the reason countries enter into RTAs. In other words, countries sign RTAs because there is considerable trade between them. Alternatively, countries might enter into trade agreements because they are in close proximity to each other. Correcting for endogeneity is therefore important so as

[3]For the gravity model, measurement errors are taken as given, however, the exclusion of zero trade flows could result in sample selection bias.

to obtain the true parameter estimate of the regressors and hence assess the policy implications of RTAs. This can be achieved through instrumental variables (IV) estimations. The challenge with IV is finding an appropriate instrument. An appropriate instrument is one that is significantly correlated with the offending regressor, in this case RTA, but has no direct impact on the trade. Work in this area is limited as most researchers have opt to alter their identification strategy to deal with the issue of endogeneity rather than using instrument/IV estimation.

Static vs. Panel Gravity Model

In addition to the estimation issues identified above, majority of the gravity models derived from the theories of International Trade have the pitfall of only producing static forms of the gravity model. However, the static form of the gravity model does not allow for the identification of the evolution of trade over time. This is highlighted by Head and Mayer (2014). They pointed to the fact that "all the micro-foundations of gravity are static models. They provide a derivation for a cross-section but are questionable bases for panel estimation". To overcome this short-coming many researchers sub-scripts the static form with time (t) and estimate using panel data.

A panel data gravity model has both a cross-sectional dimension, in this case bilateral trade pairs, and a time series dimension; whereas, the static form of gravity model is built on observed bilateral trade flows for a given point in time, usually a year. Furthermore, in panel data gravity model there is concern not only with the cross-sectional heterogeneity but also time heterogeneity. The unobserved time heterogeneity could be capture using time dummies but with this added dimension to the gravity this is not as straight forward. As discussed in the section on multilateral resistance, controlling for the unobserved terms is dependent on the assumptions made about multilateral resistance terms. If the assumptions is that the multilateral resistance terms are varying across cross-sections, bilateral pair, and over time then it is desirable to control for these using bilateral pair-time dummies; however, if the assumptions is that multilateral resistance terms are varying across exporters independently of it variation across importers as well as varying over time then exporter-time and importer-time dummies are most desirable. In this respect, there is limited guidance from the theories of international trade.

Another complexity added to the gravity model when it is estimated in a panel data framework is the introduction of heteroskedasticity in the time dimension. In the static form of the gravity model, Santos Silva and Tenreyro (2006) illustrated that the estimates of the gravity model are inconsistent when estimated using OLS in presences of heteroskedasticity; therefore, in a panel framework there is not only the concern about cross-sectional heteroskedasticity but heteroskedasticity in the time dimension and how its presence affect the estimates of different estimators. Furthermore, with a long time dimension issues such as unit roots, structural breaks, trends and co-integration that are associated with the estimation of long-run structural models could arise. The literature on implications of these additional complexities for the gravity model and estimation strategies are limited and as such further research is needed in this area. The literature on panel data modeling and tests for heteroskedasticity in panel data models could serve as a starting point. Unfortunately, this thesis does not delve into these issues but they are on the agenda for future research.

1.1.4 Summary

In summary, the most recent literature on the gravity equation, most notably Santos Silva and Tenreyro (2006), Head and Mayer (2014) and Shepherd (2013), have conducted broad literature reviews and simulations to shed light on the most appropriate methodology to estimate the gravity equation[4]. Controlling for the multilateral resistance, Santos Silva and Tenreyro (2006) prefer the PPML over the OLS. Head and Mayer (2014) suggest that to decide on the estimation procedure most suitable for estimating the gravity equation, it is imperative that the underlying data generating process of the errors are understood as well as the implications of eliminating observed zero and small trade flows. Under the assumption of CVMR the Gamma, Poisson and Multinomial PMLs are possible candidates, with the Gamma preferred over the Poisson when ignoring zero trade flows and the Multinomial preferred over Poisson preferred over the Gamma when including zero trade flow. Under the assumption of CVV, OLS and Gamma can be used when ignoring zero trade flow, however, when including observed zero trade flow the Eaton and Kortum (2001) Tobit is preferred. Shepherd (2013) concludes that the gravity model should be grounded in theory and efforts to control for the multilateral resistance terms considered. These include estimation using fixed effects or Baier and Bergstand (2009) methodology. Care must also be taken to correct for endogeneity, such as using instrumental variables/two stage least square, since endogeneity introduces bias and possibly incorrect inferences about policy impact on trade. It is therefore important that a suit of procedures, with varying specifications, are used to estimate the gravity model, with robustness and sensitivity checks.

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[4] Santos Silva and Tenreyro (2006), Head and Mayer (2014) and Shepherd (2013) did not consider long-run estimation or spatial econometric estimation methods.

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Chapter 2

Econometric Properties of the Gravity Equation

This chapter examines the bias, root mean squared error and standard errors of gravity model estimates, under varying assumptions about the data generating process (dgp) of the errors, for several estimators including Ordinary Least Squares (OLS), Poisson Pseudo Maximum Likelihood (PPML), Gamma Pseudo Maximum Likelihood (GPML) and the Negative Binomial Quasi-Generalised Pseudo-Maximum Likelihood (NB-QGPML). These estimators are assessed using the structural gravity model and adopting Head and Mayer (2014) simulation procedure with predetermined parameters to simulate features of international trade. This chapter also considers the effects of non-random sampling and non-constant elasticities on the estimates of the gravity equation. Lastly, it explores ways to identify the dgp of the errors, which is essential in avoiding biased estimates of the gravity equation, and provides a general guideline for estimating the gravity equation.

2.1 Introduction

Thanks to Santos Silva and Tenreyro (2006) seminal 'Log of Gravity', the Poisson Pseudo Maximum Likelihood (Poisson PML/PPML[1]) estimator is becoming widely

[1] The PPML estimator proposed by Santos Silva and Tenreyro (2006) produces the same results as the Poisson PML; however, they Poisson PML was adjusted so that convergent issue were mitigated.

known and used in the estimation of the gravity equation of international trade. With keen attention to the issue of heteroskedasticity, Santos Silva and Tenreyro (2006) suggest that the OLS estimator, which pre-2006 was the most widely used estimator, in the presence of heteroskedasticity "can generate strikingly different estimates when the gravity equation is log-linearised, rather than estimated in levels". Unlike Ordinary Least Squares (OLS) which minimizes the residuals sum of squares, the PPML estimator estimates the parameter(s) that maximizes the Poisson log-likelihood function to predict the sample data that has been observed. The underlying assumptions of the PPML estimator are that the conditional mean is correctly specified and the conditional variance is proportional to its conditional mean. Additionally, the PPML estimator assigns equal weighting to bilateral trade flows making it less susceptible to heteroskedasticity (Santos Silva and Tenreyro, 2006). An added bonus of using the PPML estimator when estimating the gravity equation is its ability to accommodate observed zero trade flows, which the log linearised gravity equation would eliminate.

Since the recommendations of Santos Silva and Tenreyro (2006), several other estimators, belonging to the linear exponential family (LEF) or the generalized linear models, are being used to estimate the gravity equation. These include the Gamma Pseudo Maximum Likelihood (Gamma PML), Negative Binomial Pseudo Maximum Likelihood (NB PML), Gaussian Pseudo Maximum Likelihood (Gaussian PML) and Inverse-Gaussian Pseudo Maximum Likelihood (Inverse-Gaussian PML). Egger and Staub (2015) compared the performance of these estimators using Monte Carlo simulation and found that the Poisson and Negative Binomial PML estimators performed best for both small and large samples as well as under the assumption of various stochastic processes. The Inverse-Gaussian PML performed worse both when simulated and applied to real data. The Poisson, Gamma and Negative Binomial are consistent estimators if the conditional mean is correctly specified; however, efficiency

Henceforth the PPML and Poisson PML estimators are use interchangeable could depend on the stochastic properties of the disturbance term. Additionally, the Negative Binomial PML, at least in its purest form, is known to produce estimated coefficients that are dependent on the unit/scale of measurement of the dependent variable and as such it is not recommended for estimating the gravity equation; however, researchers such as Bosquet and Boulhol (2014) explored this weakness of the Negative Binomial PML and proposed a class of Negative Binomial Quasi-Generalised Pseudo Maximum Likelihood (NB QGPML) estimators which are scale independent.

This chapter examines the bias, root mean squared error and standard errors of several of the aforementioned mentioned estimators when used to estimate the gravity equation. It replicates Head and Mayer (2014) 'Gravity's errors' simulations with the inclusion of the class of NB QGPML estimators proposed by Bosquet and Boulhol (2014) and explore 30 times more heteroskedastic parameter values under the assumption of constant variance to mean ratio (CVMR), 'Poisson-type' errors. Additionally, this chapter extends the work of Head and Mayer (2014) to consider a 'greater' degree of parameter heterogeneity, which is a scenario of conditional mean mis-specification. This follows from evidence of differences in trade cost across quantiles in the gravity model estimated for the period 1995-2006 as well as the findings of Baltagi and Egger (2015), which suggest that the assumption of constant trade cost across quantiles might not be valid as there are statistical and quantitative differences in the trade cost estimated for each quantile. This has far reaching implications for the distribution of welfare derived from international trade. Despite these recent findings the gravity model is still widely estimated using constant elasticity models which could be attributed to the fact that the theories of international trade have not yet embraced to a large extent parameter heterogeneity or economists have not yet fully understand how to model such heterogeneity.

Another issue considered in this thesis is the identification of the data generating process (dgp) of the errors and testing for heteroskedasticity. Within this chapter, the MaMu/Park-type test which was proposed by Santos Silva and Tenreyro (2006) and Head and Mayer (2014) and the GNR test suggested by Santos Silva and Tenreyro (2006) are explored as a means of examining the error structure and deciding on the most appropriate estimator. Since 30 times more heteroskedastic parameter values, than Head and Mayer (2014), are considered under the CVMR ('Poisson-type' errors) assumptions, a richer analysis of the performance of these tests emerges.

Although not the main focus of this chapter, the implications of non-random sampling on the estimates of the gravity equation is also considered. Quite often in the literature, researchers have sampled exporters and importers from a specific income or regional grouping, but there has not been any research to disentangle the sampling bias, if any, caused by this non-random sampling approach as well as the bias due to the data generating process and the estimators chosen.

The main finding of this chapter is that, given the 'Poisson-type' errors considered, the Poisson PML estimator is not outperformed by the class of NB QGPML estimators considered. In fact, the class of NB QGPML estimators considered should be estimated along with the Poisson PML especially when there are concerns about sources of nuisance such as sampling and missing trade flow; however, one might encounter difficulty implementing these estimators as the nuisance parameter, which is necessary to correct the scale dependence, must be positive but in some instances it is found to be negative. If it is found to be negative, one should estimate the Poisson PML. Additionally, it is critical that the dgp of the errors are understood. To achieve this objective, both the MaMu/Park-type test and GNR test should be conducted. The MaMu/Park type test could be misleading even when the errors are of 'Poisson-type', at least when it is estimated using OLS, as such more weight should be given to the GNR test as 99% of the times it identifies when the errors are of ‘Poisson-type’. Before estimating the gravity equation testing for heteroskedasticity using the traditional Breusch-Pagan (1979) and Cook-Weisberg (1983) and White (1980) test for heteroskedasticity is recommended as the hypotheses associated with the MaMu/Park-type test and GNR test are much broader than heteroskedasticity. The test statistic for the Breusch-Pagan (1979) and Cook-Weisberg (1983) and White’s test for heteroskedasticity compliments the MaMu/Park-type test when assessing heteroskedasticity and more generally the dgp of the errors.

With mis-specification of the conditional expectation of distance, and assuming log-normal errors, the Poisson PML estimator puts more emphasis on high-expected-trade (large trade flows) observations, that is, its estimates are closer to the coefficient associated with distances that are less than the average distance observed in international trade. However, we find that the Poisson PML estimates distance coefficients that are significantly downward biased, in absolute terms; whereas, the OLS and GPML estimators are significantly upward biased. Also, in absolute terms, the distance coefficient estimated by the Poisson PML estimator is smaller than the distance coefficient of the lowest quantile; whereas, the distance coefficient estimated by the OLS and GPML estimators are larger than the distance coefficient of the highest quantile. Head and Mayer (2014) find that OLS and Gamma PML return distance coefficients closer to the average distance coefficients; however, we find that the OLS and Gamma PML estimates are further away from the average than the Poisson PML. The two step Negative Binomial estimator proposed by Bosquet and Boulhol (2014) is least biased. With mis-specification of the conditional expectation of distance and assuming ‘Poisson-type’ errors the findings are similar; however, the Poisson PML and the NB QGPML estimators return distance coefficients that are approximately equal to the distance coefficient of the lower quantile and OLS and Gamma PML estimators estimates are significantly greater than the distance coefficient of the highest quantile.

Lastly, sampling according to World Bank's income and regional grouping, when compared to the entire sample, we find that it is important to consider sampling bias, although such bias is minimized once the dgp of the errors are identified and the appropriate estimator selected. We find that with Poisson-type errors the coefficients estimated by the Piosson PML estimators are not significantly affected by non-random sampling of exporters by income and regional groupings; however, it seems the RTA effects identified using OLS, even when the errors are log-normal, can be distorted by non-random sample if the sample is drawn for a region where the countries exhibit significant heterogeneity. The remainder of this chapter is as follows: Section 2.2, gives a brief review of the gravity equation and reviews the literature on the competing estimators including OLS, Poisson PML, Gamma PML and the Negative Binomial QGPML proposed by Bosquet and Boulhol (2014) and Wooldridge (1999); Section 2.3, describes the design of the Monte Carlo experiment; Section 2.4, presents the findings of the Monte Carlo simulations; and, Section 2.5, concludes and provides some recommended procedures for estimating the gravity equation.

2.2 The Gravity Model: Competing estimators

Recall the following specification of the gravity model from Chapter 1:

- in its log-linear form

$$\ln(X_{ni}) = \beta_1 \ln(Y_n) + \beta_2 \ln(Y_i) + \sum_{m=3}^{M} \beta_m \ln(z_{ni}^m) - (1-\sigma)\ln(\Omega_i) - (1-\sigma)\ln(\phi_n) + \epsilon_{ni} \tag{2.2.1}$$

- in its multiplicative form

$$X_{ni} = \frac{Y_n^{\beta_1} Y_i^{\beta_2}}{(\Omega_i \phi_n)^{1-\sigma}} \prod_{m=3}^{M} (z_{ni}^m)^{\beta_m} \epsilon_{ni} \tag{2.2.2}$$

where Ω_i and ϕ_n are the multilateral resistance terms.

To correctly estimate equations (2.2.1) and (2.2.2) there are several estimation issues to consider. These include controlling for, estimating or approximating the multilateral resistance terms, heteroskedasticity and estimation with or without zero trade flows. To achieve unbiased and consistent estimators of the gravity model, the multilateral resistance terms, which are not directly observable, need to either be isolated, estimated or approximated. As mentioned in the previous chapter, there are several methods identified in the literature to control for, estimate or approximate the multilateral resistance terms. These include: (1)the dummy variable approach, which involves including importer, exporter and time fixed effects or bilateral pair and time fixed effects; (2)Anderson and Van Wincoop (2003) and Baier and Bergstrand (2009) approximation methods, which uses a first order Taylor expansion of the importer and exporter multilateral resistance terms; and, (3)De Bruyne et al. (2013), which involves decomposing the multilateral resistance terms using first-order and second-order network effects to estimate what they call 'revealed' multilateral trade resistance (RMTR).

Another estimation issue to consider is heteroskedasticity. Santos Silva and Tenreyro (2006) identify that since OLS is inconsistent in the presence of heteroskedasticity, the Poisson PML estimator is a better choice. Additionally, the Poisson PML can estimate the gravity model in its multiplicative form and is not dependent on the implications of violating Jensen's inequality that $E(lnX_{ni}) \neq lnE(X_{ni})$. The Poisson PML is also able to accommodate zero trade flows that would not be include in the estimated model when the gravity model is log-linearised. The Poisson PML estimator is not unique in this regard as other estimators, such as the NB PML and Gamma PML, of the Generalized Linear Family (GLF) possess these same attributes, with differences among these estimators relate to assumptions made about the relationship between the conditional mean and the conditional variance. Other methods for including zero trade flows involves estimating two stage estimators, which examine trade flows at the extensive and intensive margins such as estimating Heckman's selection estimator, which involves estimating a probit-type estimator in the first stage and OLS in the second stage. Some researchers, particularly Xiong and Chen (2014), argue that the traditional Heckman estimator suffers from the same issues highlighted by Santos Silva and Tenreyro (2006) at least in the second stage. To circumvent this issue, Xiong and Chen (2014) proposed a similar estimation procedure that uses the Poisson PML instead of OLS in the second stage. Therefore, whether the objective is to estimate a single equation or two-stage approach, the use of Generalized Linear Models (GLMs) to estimate the gravity equation is widespread and have helped to address some of the issues related to heteroskedasticity and the large number of observed zero trade flows.

Although several estimators have been used to estimate the gravity equation, previous research, including Monte Carlo simulations by Santos Silva and Tenreyro (2006), Head and Mayer (2014) and Egger and Staub (2015), have aided in narrowing the number of estimators considered. In this chapter consideration is given to four competing estimators, namely: Ordinary Least Squares (OLS), Poisson Pseudo Maximum Likelihood (Poisson PML), Gamma Pseudo Maximum Likelihood (Gamma PML) and a class of NB QGPML estimators. This experiment exclude estimators, such as the EK Tobit, Non-linear Least Squares, Multinomial PML, Inverse Gaussian PML and Gaussian PML, on the basis that previous simulations found these estimators are less advantageous and robust. For comparison and parameterisation purposes, the gravity model is also estimated using quantile regression.

2.2.1 Ordinary Least Squares (OLS)

Ordinary Least Squared (OLS) is the most widely used method for estimating the elasticities of the gravity equation. The method minimizes the sum of the squared residuals, which is the difference between the observed dependent variable and its predicted values. OLS is considered the Best Linear Unbiased Estimator (BLUE) when, as is stated by Gauss-Markov theorem, the model is linear (estimated as linear) and the expected value of the error is zero. Other assumptions of OLS includes no multicollinearity among the independent variables, independent and identically distributed random variables, no measurement errors and homoskedasticity. Violation of these latter assumptions does not necessarily mean that OLS is biased; however, it might not be best as a violation of one such assumption affect the efficiency of the OLS estimator.

In terms of the gravity model, it has been identified in the literature that heteroskedasticity is an issue to consider when estimating the gravity model (Santos Silva and Tenreyro (2006), Head and Mayer (2014) and Egger and Staub (2015)). In the presence of heteroskedasticity, OLS is still unbiased; however, its estimates are inefficient, and hence hypothesis testing using the F-statistic and t-statistic are inconclusive. To correct the inconsistent estimation of the variance-covariance matrix, many researchers use robust standard errors most notably those generated using White's heteroskedasticity-consistent estimator. Although many research have corrected for the inconsistency in the variance-covariance matrix, the gravity model when estimated using OLS tend to exhibit significantly greater bias[2] than other estimators; however, this might point to the violation of other assumption(s) such as the linear specification assumption and homogeneous elasticities.

[2]see Santos Silva and Tenreyro (2006) and Head and Mayer (2014)

2.2.2 Quantile Regression

Most gravity models assume constant trade cost elasticities across all quantiles. Fidrmuc(2009), Dufennot et al. (2010), Ker and Cairns (2013), Figueiredo et al. (2014) and Baltagi and Egger (2015) are a few exceptions, who have considered estimating the gravity model using unconditional and conditional quantile regressions. Estimating the gravity model using quantile regression for several quantiles, instead of 'straight-forward' OLS, allows for characterization of the data over the entire distribution of bilateral trade flows rather than about the conditional mean of the distribution. Huarng and Yu (2014) in Paniagua et al. (2015) put it differently. They suggest that quantile regressions are more adequate than other methods to understand the relationship between variables whose effects may vary with outcome levels. Unlike OLS, quantile regressions are not susceptible to outliers and skewed data. Additionally, OLS is inefficient if the errors are highly non-normal; whereas, quantile regressions are more robust to non-normal errors and outliers (Baum, 2013).

An attractive feature of quantile regressions is that they are invariant to monotonic transformations, that is, a transformation of a random variable, say $f(X_{ni})$, are the transformed quantiles of X_{ni}. Consider Jensen's inequality, which suggest that $E(\log(Y_i)) \neq \log(E(Y_i))$, where Y_i is a random variables; and keep in mind Santos Silva and Tenreyro (2006) argument that the log transformation of the gravity model estimated using OLS does not necessitate $E(\log(X_{ni})) = \log(E(X_{ni}))$ and hence the interpretation of the coefficients estimated by OLS in the presence of heteroskedasticity can be misleading. This is not the case with quantile regressions because the monotonic transformation in-variance property of quantile regressions implies that:

$$h(Q_{X_{ni}|M_{ni}}(q)) \equiv Q_{h(X_{ni})|M_{ni}}(q) \tag{2.2.3}$$

where M_{ni} is matrix of independent variables and q is the q^{th} quantile of the independent variable. In the case of the log linearise gravity model one should think of $h(X_{ni})$ as the log transformations of X_{ni}. In other words, if $x_{ni} = ln(X_{ni})$ and $Q_{X_{ni}|M_{ni}}(q) = M_{ni}^{'}\beta_q$, then:

$$Q_{x_{ni}|M_{ni}}(q) = exp(M_{ni}^{'}\beta_q) \tag{2.2.4}$$

The mean regression (OLS) lacks this property since $E[\log(X_{ni})] \neq \log(E(X_{ni})$. Unlike OLS, which minimize the summed of squared residuals, $(\sum \varepsilon_{ni}^2 = \sum(X_{ni} - \hat{X}_{ni})^2)$, the quantile regress relies on the minimization of the sum of absolute values of the residuals, $(\sum |\varepsilon_{ni}| = \sum |X_{ni} - \hat{X}_{ni}|)$; and, the objective function for the q^{th} quantile is:

$$Q(\beta_q) = \sum_{i:X_{ni} \geq M_{ni}^{'}\beta}^{N} q|X_{ni} - M_{ni}^{'}\beta_q| + \sum_{i:X_{ni} < M_{ni}^{'}\beta}^{N} (1-q)|X_{ni} - M_{ni}^{'}\beta_q| \tag{2.2.5}$$

where the slope is q when $X_{ni} \geq M_{ni}^{'}\beta$ and $1 - q$ when $X_{ni} < M_{ni}^{'}\beta$ and the objective is to find the β_q which minimizes $Q(\beta_q)$ resulting in best fit for the q^{th} quantile of the distribution of X_{ni} conditional on M_{ni}. To minimize equation (2.2.5), the estimator relies on linear programming techniques (see Koenker (2005) for more details), that involves iterating until β_q that minimizes $Q(\beta_q)$ is achieved. This estimator can be implemented in Stata statistical package and the commands: *qreg*, which is *qth* quantile regression; *bsqreg*, which the *qth* quantile regression with robust standard errors; *iqreg*, which is the interquantile range regression; and, *sqreg*, which is the simultaneous quantile regression. The *qreg* estimator is asymptotically normal and assumes that the errors are independent and identically distributed; however, one might want to relax the assumption of identically distributed errors in order to derive robust standard errors in which case the *bsqreg*, *iqreg* and *sqreg* are more favourable since bootstrap standard errors are produced.

Later in this chapter, the simultaneous quantile regression (*sqreg*) is used to estimate the gravity model as it estimates several quantile regressions simultaneously and allow for the comparison of coefficients in terms of magnitude, sign and statistical significance across quantiles.

2.2.3 Generalized Linear Models (GLMs)

Generalized Linear Models (GLMs) are now widely used to estimate the gravity model of international trade. As mentioned before research by Santos Silva and Tenreyro (2006), Head and Mayer (2014) and Egger and Staub (2015) contributed largely to the literature on estimating the gravity model using GLMs. This class of estimators provide consistent parameter estimates as long as the conditional mean is correctly specified. Introduced by Nelder and Baker (1972) and Wedderburn (1974), GLMs provide a straightforward way of modeling non-normal data when usual regression assumptions are not satisfied (Jorgensen, 2013). For this reason, they are widely used in several sub-disciplines in Economics such as Health Economics, Environmental Economics and International Economics, among others.

There are two important features of GLMs, the monotonic link function and the positive variance function. The link function is necessary to transform the equation into a linear functional form without transformation of the dependent variable. In other words, it linearises the relationship between the expected value of the response variable and the linear predictor of the explanatory variables. GLMs assume a linear relationship between the transformed response and the explanatory variables via a link function, but not a linear relationship between the dependent variable and the independent variables. Unlike estimation with OLS, where the model is log-linearised then estimated, the gravity model is linearised by the GLM estimators. Generally, the link function associated with the estimation of the Gravity Model using GLMs is the log-link function. This is consistent with the specification and estimation of the gravity model in its log-linear form rather than it multiplicative form and since with these class of GLM estimators the dependent variable is not transformed, it is possible to estimate the gravity model with observed zero trade flow.

The variance function is dependent on the choice of GLM estimator (See Table 2.1). Generally, the variance of GLMs can be written as:

$$Var[X_{ni}|M_{ni}] = a\mu_{ni} + b\mu_{ni}^2 \tag{2.2.6}$$

where $E[X_{ni}|M_{ni}] = \mu_{ni}$ and 'a' and 'b' are scale parameters. As can be seen from Table 2.1, if 'a' is greater than zero ($a > 0$) and 'b' equal zero ($b = 0$) the Poisson PML variance is defined; however, if both 'a' and 'b' are greater than zero ($a > 0$) and ($b > 0$), then the Negative Binomial variance is defined; and, if 'a' is equal to zero ($a = 0$) and 'b' greater than zero ($b > 0$) then the Gamma estimator variance is defined. The variance for the Negative Binomial includes a η, which is a shape/nuisance parameter. Table 2.1 also shows the weights used by each estimator. The Poisson estimator places equal weighting on each observation; whereas, the Gamma and Negative Binomial PML use weights that are a function of the conditional mean.

Table 2.1: Summary of the properties of selected GLMs

Estimator	Variance ($V(X_{ni})$)	Weights (w_{ni})	Canonical link	Unit deviance
Normal	1	*variance*	μ_{ni}	$(x_{ni} - \mu_{ni})^2$
Poisson	μ_{ni}	1	$ln\mu_{ni}$	$2(x_{ni}ln\frac{x_{ni}}{\mu_{ni}} + \mu - x_{ni})$
Gamma	μ_{ni}^2	μ_{ni}^{-1}	$-1/\mu_{ni}$	$2(\frac{x_{ni}}{\mu_{ni}} - ln\frac{x_{ni}}{\mu_{ni}} - 1)$
Negative Binomial	$\mu_{ni}(1 + \frac{\mu_{ni}}{\eta})$	$(1 + \mu_{ni})^{-1}$	$ln\frac{\mu_{ni}}{\eta+\mu_{ni}}$	$2(x_{ni}ln\frac{x_{ni}}{\mu_{ni}} + (\eta + \mu - x_{ni})ln\frac{\eta+\mu_{ni}}{m+x_{ni}})$

Notes: Source: Jorgensen (2013)

In establishing these results, lets assume that X_{ni} is from a linear exponential family (LEF) density and as such can be written as:

$$f(X_{ni}) = exp\bigg(\frac{X_{ni}\theta_{ni} - b(\theta_{ni})}{a(\eta)} + c(\eta, X_{ij})\bigg) \tag{2.2.7}$$

where η is a nuisance parameter and θ_{ni} is the canonical link, which describes the link between the independent variables and the dependent variables. The function $a(\cdot)$, $b(\cdot)$ and $c(\cdot)$ are arbitrary functions; however, $b(\cdot)$ is twice differentiable such that the $E[X_{ni}] = b^{'}(\theta_{ni})$ and $Var(X_{ni}) = a(\eta)b^{''}(\theta_{ni})$. $a(\eta) = \eta$ is strictly positive and $c(\cdot)$ is a normalizing constant. Given equation (2.3.7), the likelihood function can be written as:

$$\mathcal{L} = exp\bigg(\frac{X_{ni}\theta_{ni} - b(\theta_{ni})}{a(\eta)} + c(\eta, X_{ij})\bigg) \tag{2.2.8}$$

Differentiating equation (2.3.8) with respect to θ_{ni} results in equation (2.3.9), the score,

$$\mathcal{S} = \frac{\partial \mathcal{L}}{\partial \theta_{ni}} = \frac{X_{ni} - b^{'}(\theta_{ni})}{a(\eta)} \tag{2.2.9}$$

Setting the expected value of the score equal to zero (0),

$$E[\mathcal{S}] = \frac{E[X_{ni}] - b^{'}(\theta_{ni})}{a(\eta)} = 0 \tag{2.2.10}$$

it can be seen that $E[X_{ni}] = b^{'}(\theta_{ni})$. The function that results in $\mu = E[X_{ni}] = b^{'}(\theta_{ni}) = b^{'}(\theta_{ni}(M^{'}_{ni}\beta))$ is known as the link function assuming θ_{ni} is being evaluated at $M^{'}_{ni}\beta$. Rewriting equation (2.3.7) as a function of $M^{'}_{ni}\beta$ the likelihood function can be evaluated at $\hat{\beta}$.

$$\mathcal{L} = exp\bigg(\frac{X_{ni}b^{'}(\theta_{ni}(M^{'}_{ni}\beta)) - b^{'}(\theta_{ni}(M^{'}_{ni}\beta))}{a(\eta)} + c(\eta, X_{ij})\bigg) \tag{2.2.11}$$

and the corresponding score evaluated at $\hat{\beta}$ can be written as

$$\mathcal{S} = \frac{X_{ni} - b'(\theta_{ni})}{a(\eta)} \frac{\partial \theta_{ni}}{\partial \beta} \tag{2.2.12}$$

which, given that $Var(X_{ni}) = a(\eta)b''(\theta_{ni})$, can be written as

$$\mathcal{S} = \frac{X_{ni} - b'(\theta_{ni})}{a(\eta)} \frac{\partial \theta_{ni}}{\partial \mu_{ni}} \frac{\partial \mu_{ni}}{\partial \beta} = \frac{X_{ni} - b'(\theta_{ni})}{a(\eta)b''(\theta_{ni})} \frac{\partial \mu_{ni}}{\partial \beta} = \frac{1}{\omega_{ni}}(X_{ni} - b'(\theta_{ni}))\frac{\partial \mu_{ni}}{\partial \beta} = 0 \tag{2.2.13}$$

where $v_{ni} = a(\eta)b''(\theta_{ni})$ is the variance function, which is a function of a nuisance parameter.

Under the assumption that the density function is correctly specified and of the linear exponential family,

$$\sqrt{N}(\hat{\beta} - \beta) \longrightarrow N[0, A^{-1}] \tag{2.2.14}$$

where

$$A = \lim_{\underset{N \to \infty}{\longrightarrow}} \frac{1}{N} \sum_{i=1}^{I} \sum_{n=1}^{N} \frac{1}{v_{ni}} \frac{\partial \mu_{ni}}{\partial \beta} \frac{\partial \mu_{ni}}{\partial \beta'} \tag{2.2.15}$$

Assume (X_{ni}, M_{ni}) are independent over 'ni', the conditional mean of X_{ni} is correctly specified as $E[X_{ni}|M_{ni}] = \mu(M_{ni}, \beta)$, and $var[X_{ni}|M_{ni}] = v_{ni}$ is finite.

It is not necessarily the case that $v_{ni} = \omega_{ni}$. Where ω_{ni} is the true variance. Gourieroux et al. (1984b) show that if $v_{ni} \neq \omega_{ni}$, the maximum likelihood estimate is still consistent so long as the conditional mean is correctly specified; however, if the conditional variance is mis-specified, the variance matrix, A^{-1}, is inefficient. There are two possible ways of dealing with this inconsistent variance matrix. To correct this inefficient variance-covariance, the variance can be adjusted by using weights such that the variance resembles $A^{-1}BA^{-1}$. This variance-covariance matrix is similar to that used in the weighted least squares estimator.

To illustrate this, Gourieroux et al. (1984b) show that if

$$E[\frac{1}{v_{ni}}(X_{ni} - \mu_{ni})\frac{\partial \mu_{ni}}{\partial \beta}] = 0 \tag{2.2.16}$$

holds and so long as the conditional mean is correctly specified then $\hat{\beta} \longrightarrow \beta$. That is, $E[X_{ni} - \mu(M_{ni}, \beta)] = 0$ and

$$\sqrt{N}(\hat{\beta} - \beta) \longrightarrow N[0, A^{-1}BA^{-1}] \tag{2.2.17}$$

where A is as defined in equation (2.3.15) and

$$B = \lim_{\overrightarrow{N \to \infty}} \frac{1}{N} \sum_{i=1}^{I} \sum_{n=1}^{N} \frac{\omega_{ni}}{v_{ni}^2} \frac{\partial \mu_{ni}}{\partial \beta} \frac{\partial \mu_{ni}}{\partial \beta'} \tag{2.2.18}$$

Therefore, the consistency of the estimators are independent of the data generating process (dgp) of the data of X_{ni}. It is the assumed density of gravity model that must be LEF not the dgp of X_{ni}. In practice, implementing White (1980) estimate of $\hat{\omega}_{ni} = (X_{ni} - \hat{\mu}_{ni})^2$ as weights should help circumvent this issue.

One drawback to the above approach is that it assumes that the nuisance parameter is multiplicative in the variance function; hence, solving the first order condition is possible without knowledge of η. As an alternative to the above approach, Gourieroux et al. (1984b) suggest the use of a Negative Binomial Quasi-Generalized Pseudo Maximum Likelihood (NB QGPML) estimator.

Gourieroux et al. (1984b) NB QGPML estimator and Nelder and Baker (1972) and Wedderburn (1974) GLMs are asymptotically equivalent and can both be implemented using maximum likelihood procedures; however, the GLMs restricts the conditional mean function to a linear combination of the regressors; whereas, the NB QGPML places no restriction on the conditional mean function (Cameron and Trivedi, 1998). Additionally, GLMs assumes a variance function of the form $v_{ni} = a(\eta)b^{''}(\theta_{ni})$, which is multiplicative in the nuisance parameter; whereas, the NB QGPML assumes a more general functional form. Consider $\omega_{ni} = \omega(M_{ni}, \beta, \eta)$, where ω_{ni} could take on a particular linear exponential family (LEF) density and η is a finite nuisance parameter, which is strictly positive, say $\eta = \gamma^2$. $\hat{\omega}_{ni}$ could be estimated so long as an appropriate consistent estimate of η, say $\hat{\eta}$, can be obtained. Gourieroux et al. (1984b) suggest the use of a quasi-generalized pseudo-maximum likelihood (QGPML) estimator that is more efficient when $\omega_{ni} \neq v_{ni}$. Consider the variance function $\omega_{ni} = \omega(\mu(M_{ni}, \beta), \eta)$ and the LEF

$$f(X_{ni}|\mu_{ni}, \eta) = \exp\left(a(\mu_{ni}, \eta) + b(X_{ni}, \eta) + c(\mu_{ni}, \eta)X_{ni}\right) \tag{2.2.19}$$

where $E[X_{ni}] = \mu_{ni}$, $var[X_{ni}] = \omega_{ni}(\mu_{ni}\eta_{ni})$ and $\eta_{ni} = (\mu_{ni}, \omega_{ni})$. (.) is a differentiable function that defines a one to one relationship between η_{ni} and ω_{ni}. Additionally, the LEF function must satisfy the following conditions:

$$E[X_{ni}] = -c^{'}(\mu_{ni}, \eta_{ni})^{-1}a^{'}(\mu_{ni}, \eta_{ni}) \tag{2.2.20}$$

and

$$var[X_{ni}] = [c^{'}(\mu_{ni}, \eta_{ni})]^{-1} \tag{2.2.21}$$

then estimates of μ_{ni}, η_{ni} and β can be derived by maximizing the log-likelihood function (equation 2.2.22) with respect to $\tilde{\mu}_{ni}$, $\tilde{\eta}_{ni}$ and $\tilde{\beta}$

$$\mathcal{L} = \sum a(\mu_{ni}, \omega_{ni}(\tilde{\mu}_{ni}, \tilde{\eta}_{ni})) + b(X_{ni}, \omega_{ni}(\tilde{\mu}_{ni}, \tilde{\eta}_{ni})) + c(\mu_{ni}, \omega_{ni}(\tilde{\mu}_{ni}, \tilde{\eta}_{ni}))X_{ni} \quad (2.2.22)$$

where $\tilde{\beta}$ and $\tilde{\eta}_{ni}$ are consistent estimates of β and η_{ni} respectively and $\tilde{\mu}_{ni} = \mu(M_{ni}, \tilde{\beta})$. This yields a first order condition (FOC) similar to equation (2.2.11), however, the FOC is a function of the general variance function ω_{ni}.

$$\sum \frac{1}{\tilde{\omega}_{ni}}(X_{ni} - \mu_{ni})\frac{d\mu_{ni}}{d\beta} = 0 \quad (2.2.23)$$

If the conditional mean and variance are correctly specified, $\hat{\beta}_{LEF} \longrightarrow \beta$, then the QGPML estimator is a consistent estimator of β. Additionally,

$$\sqrt{N}(\hat{\beta} - \beta) \longrightarrow N[0, A^{-1}] \quad (2.2.24)$$

$$A = \lim_{\overrightarrow{N \to \infty}} \frac{1}{N} \sum \frac{1}{\omega_{ni}} \frac{d\mu_{ni}}{d\beta} \frac{d\mu_{ni}}{d\beta'} \quad (2.2.25)$$

which is a consistent estimate of the variance matrix so long as the conditional mean and $\hat{\omega}_{ni}$ is correctly specified.

Gourieroux et al. (1984b) show that the QGPML with a nuisance parameter can be implemented by estimating η_{ni}, the nuisance parameter, and the βs. All the estimators of the LEF are consistent and have the same asymptotic covariance matrix; however, if $\eta_{ni} = 0$, the NB QGPML can be replace by the Poisson PML, since the Poisson PML estimator is most efficient of all LEF estimators. On the other hand, if $\eta_{ni} \neq 0$ and or the assumption that the conditional variance is correctly specified breaks down, then the Poisson PML's covariance matrix is smaller than the true one. In this case, the NB QGPML gives a more consistent estimate of the covariance matrix. With large sample size, such as the case with majority of international trade data set, there may be little reason to search for a more efficient estimator; however, it is important to know if the correctly specified conditional variance is rejected by data (Wooldridge, 1999).

In this chapter we consider a class of NB QGPML estimators that are invariant to the scale of the dependent variable. As illustrated in Bosquet and Boulhol (2014) and Annex C of this chapter, the 'regular' Negative Binomial (one-step) estimator and the two step approach proposed by Head, Mayer and Ries (2009) are sensitive to the scale/unit of measure (thousands, million, billion etc) of the dependent variable, in this case exports. Using the theoretical model highlighted above, Head, Mayer and Ries (2009), Wooldridge (1999), Bosquet and Boulhol (2014) proposed the use of two step Negative Binomial estimators (NB QGPML) that have been used to estimate the gravity equation. Additionally, we consider the Poisson PML and Gamma PML. These are briefly described below.

Poisson PML

The Poisson PML estimator prescribed to estimate the gravity equation of international trade by Santos Silva and Tenreyro (2006) is a special case of the Negative Binomial II (NG2) (Cameron and Pravin, 1998). As pointed out in the previous section and reiterated by Santos Silva and Tenreyro (2006), so long as the conditional mean is correctly specified, the Poisson PML is a consistent estimator for the gravity equation and its estimates are not sensitive to estimation with an inflated number of zero trade flow or over-/under- dispersion. These properties makes it attractive given the persistent identification of the presence of heteroskedasticity and the share number of zero trade flows observed in international trade data set, especially at the industry and product level. The Poisson PML was considered in Head and Mayer

(2014) and found to be least biased when the errors exhibit constant variance to mean ratio, i.e $Var[X_{ni}|.] \propto E[X_{ni}|.]$ (CVMR); however, as pointed out in the previous section the covariance matrix might not be the most efficient as such the Gamma PML and the class of NB QGPML estimators considered in the following sub-section could possibly improve this aspect.

Gamma PML

Similar to the Poisson PML, the Gamma PML is also a consistent estimator for the gravity model so long as the conditional mean is correctly specified. The major difference between the Poisson and Gamma PML is in how the conditional mean relates to the conditional variance. Consider the general form of the variance, $a\mu+b\mu^2$, the Gamma PML is more efficient if $a = 0$ and $b \neq 0$. Additionally, the first moments of the Gamma PML is determined by the ratio of the difference between the observed trade flows and predicted trade flows $(X_{ni} - \hat{X}_{ni})$ to the predicted trade flows $(\hat{X}_{ni})$; whereas, the Poisson PML is concerned with the difference between the observed trade flows and predicted trade flows $(X_{ni} - \hat{X}_{ni})$.

Negative Binomial Quasi-generalized Pseudo-maximum Likelihood (NB QGPML)

Cameron and Trivedi (1986) present several mixture models that has the potential to deal with unobserved heterogeneity. One such model is the Negative Binomial Quasi-Generalized Pseudo Maximum Likelihood[3], which is a mixture of the Poisson and Gamma PML. Cameron and Trivedi (1998) show that for a specific value of the scale parameter the Negative Binomial 2 (NB2) converges to the Poisson distribution; therefore, it seems an attractive alternative given that there are no restriction on the relationship between the variance and the conditional mean. Below we consider a

[3]identified as the NB2 QGPML

class of NB QGPML estimators (two-step Negative Binomial estimators) which have the same attribute, scale invariant and account for the nuisance/shape parameter.

Head, Mayer and Ries (2009) uses a NB QGPML with what Gourieroux et al. (1984b) in Cameron and Trivedi (1998) calls the nuisance parameter, η_{ni}, set equal to 1 in the first stage and the second stage is estimated using the NB PML with the estimated nuisance parameter; however, Bosquet and Boulhol (2014) argues that, and as is illustrated in Annex C, this estimator is dependent on the unit/scale of measurement of the dependent variable. Wooldridge (1999) proposed the uses of Ordinary Least Squares (OLS) in the first stage to estimate the equation and the errors used to estimate η_{ni}, and in the second stage the NB PML is estimated with the estimated nuisance parameter. Bosquet and Boulhol (2014) building on Wooldridge (1999) propose a two-step approach that is scale invariant (see Annex C[4]). In the first stage the Poisson PML estimator is used to estimate the gravity equation and the error used to estimate η_{ni}; and, in the second stage, the gravity equation is estimated using the NB PML with the estimated nuisance parameter. The motivation surrounds the fact that the NB QGPML estimator converges to the Poisson PML estimator at one extreme and the Gamma PML estimator at the other extreme (see Annex C for this result) . Additionally, the NB QGPML estimator could potential be more efficient than the Poisson PML and Gamma PML estimators. In this chapter, the NB QGPML proposed by Wooldridge (1999) in Bosquet and Boulhol (2014) and Bosquet and Boulhol (2014) are labeled $NEGBI^{GLM}_{OLS}$ and $NEGBI^{GLM}_{WLS}$ respectively.

The difference between $NEGBI^{GLM}_{OLS}$ and $NEGBI^{GLM}_{WLS}$ is related to how η_{ni} is estimated. For $NEGBI^{GLM}_{OLS}$, $\eta_{ni} = \frac{\hat{\alpha}_2}{\hat{\alpha}_1}$, where $\hat{\alpha}_1$ and $\hat{\alpha}_2$ are from,

$$\hat{\varepsilon}^2_{ni} = \hat{\alpha}_1 \hat{X}_{ni} + \hat{\alpha}_2 \hat{X}^2_{ni} \tag{2.2.26}$$

[4]Similar to Bosquet and Boulhol (2014) we label these estimators $NEGBI^{GLM}_{OLS}$ and $NEGBI^{GLM}_{WLS}$

estimated using OLS and $\hat{X}_{ni}$ are the predicted trade flows of the first stage estimates using the Poisson PML. $\hat{\varepsilon}^2_{ni}$ are the squared residuals. On the other hand, for $NEGBI^{GLM}_{WLS}$, $\eta_{ni} = \frac{\hat{\alpha}_1}{\hat{\alpha}_0}$, where $\hat{\alpha}_0$ and $\hat{\alpha}_1$ are from,

$$\hat{\varepsilon}^2_{ni} = \hat{\alpha}_0 + \hat{\alpha}_1 \hat{X}_{ni} \tag{2.2.27}$$

estimated using OLS and $\hat{X}_{ni}$ and $\hat{\varepsilon}^2_{ni}$ are as described above.

The major drawback to estimating these two-step approach estimators is that in some instances η_{ni} can be negative in which case the estimator is not appropriate. That is, if the nuisance parameter is found to be negative, the second step cannot be estimated using the NB PML estimator; therefore, the Poisson PML estimator is most efficient. As an alternative, Cameron and Trivedi (1986) identify that instead of employing the two-step approach, it is possible to estimate η_{ni} and the β at the same time; however, this is only possible if one assumes that the data generating processes of dependent and independent variables are Negative Binomial. A violation of this assumption results generally in inconsistent estimates by the NB PML (Wooldridge, 1999). Additionally, the NB PML suffer from scale-dependence and as such simultaneously solving for the two might not aid in mitigating this problem.

Previous simulation by Head and Mayer (2013) and Egger and Staub (2015) have considered the one-step and two step NB PML estimators. Head and Mayer (2013) identified that when compared to other PML estimators the one-step NB PML are not as robust as it does not nest the CVMR assumption and convergence is often not achieved when trying to estimate the gravity model. In their simulation of the gravity model, they considered the one-step approach and the two-step approach suggested by Head, Mayer and Ries (2009) but dropped these estimators because of the aforementioned limitations of these estimators. Egger and Staub (2015) considered the

Head, Mayer and Ries (2009) and Bosquet and Boulhol (2014) two-step approaches. They found that the Head, Mayer and Ries (2009) two-step approach displays no bias and present small standard deviations and although there should be efficiency gains from estimating Bosquet and Boulhol (2014) two-step approach, they found negligible efficiency gains and encountered difficulties trying to simulated the estimator given their experimental designed. It is important to note that Head and Mayer (2014), and hence this simulation, uses actual data for 170 countries in 2006, and as such the source of country heterogeneity comes from the actual data; whereas, Egger and Staub (2015) simulated a baseline of 10 countries and a scenario of at most 50 countries. Egger and Staub (2015) find that the Poisson and NB QGPML estimator as well as the Quasi-difference Generalized Method of Moment (GMM) estimators appear to be the best all-round estimators for small as well as large sample cases for various stochastic processes considered.

Against this background, the one-step NB PML and Head, Mayer and Ries (2009) estimators are excluded from this experiment. In the case of the one-step NB PML, there is overwhelming evidence regarding its lack of robustness. Head, Mayer and Ries (2009) two-step approach was considered in Head and Mayer (2014) and as well as in this experiment; however, implementing the estimator proved difficult. Egger and Staub (2015) included this estimator in their experiment and found it to be one of the best all round estimators for small and large samples with various stochastic processes but unfortunately it could not be nested into this experiment. Furthermore, it is not robust given that is it sensitive to the unit/scale of measurement of dependent variable. However, Wooldridge (1999) and Bosquet and Boulhol (2014) two-step approaches are included. To overcome the major drawback mentioned above, that is, in some instances the nuisance parameter is found to be negative, the estimator is modified slightly to allow for a smooth simulation of the estimators by considering 'union' estimators, that is:

$$UNION1 = \begin{cases} PPML & \text{if } \eta_{ni} \leq 0. \\ NEGBI_{OLS}^{GLM} & \text{if } \eta_{ni} > 0. \end{cases} \tag{2.2.28}$$

and

$$UNION2 = \begin{cases} PPML & \text{if } \eta_{ni} \leq 0. \\ NEGBI_{WLS}^{GLM} & \text{if } \eta_{ni} > 0. \end{cases} \tag{2.2.29}$$

Where UNION1 refers to $NEGBI_{OLS}^{GLM}$ combined with the Poisson PML and UNION2 refers to $NEGBI_{WLS}^{GLM}$ combined with the Poisson PML. In simulating the estimator, if η_{ni} is found to be negative using Wooldridge (1999) approach the Poisson PML estimator would be estimated; however, if η_{ni} is found to be positive the NB QGPML is estimated. Similarly, if η_{ni} is found to be negative using Bosquet and Boulhol (2014) approach the Poisson PML estimator would be estimated; however, if η_{ni} is found to be positive the NB QGPML is estimated. These 'union' estimators are compare to the two-step approaches, $NEGBI_{OLS}^{GLM}$ and $NEGBI_{WLS}^{GLM}$ as well as other competing estimators.

2.3 Monte Carlo Design

We follow Head and Mayer's (2014) Monte Carlo design; however, it is modified to include the $NEGBI_{OLS}^{GLM}$ and $NEGBI_{WLS}^{GLM}$ as well as 30 times more heteroskedastic parameters under the assumption of constant variance to mean ratio (CVMR) or 'Poisson-type' errors. Similar to Head and Mayer (2014), mis-specification of the conditional mean is also considered since the existing literature suggests that trade costs might not be constant across quantile. We also estimate the gravity equation using quantile regression for each year over the period 1995-2006 and observe differences in trade costs across quantiles.

The data for the Monte Carlo simulation is generated by using the structural gravity and actual data for 170 countries in 2006. For consistency and comparison with Head and Mayer (2014), the determinants included are GDP of the exporters and importers, bilateral distance, RTA and the multilateral resistance terms. The simulation procedure entails three steps. First, trade cost/accessibility is defined and estimated as:

$$\phi_{ni} = exp(\beta_{ldist} lndist_{ni} + \beta_{rta} RTA_{ni})\epsilon_{ni} \tag{2.3.1}$$

where *lndist* is logarithm of the geographic distances between bilateral pair and RTA is a dummy variable which take a value of one (1) if two countries have entered into a regional trade agreement. It is assumed that the coefficient on *lndist*, β_{ldist}, and RTA, β_{rta} are -1 and 0.5 respectively. ϵ_{ni} is the stochastic component, which is generated using a data generating process (dgp) that results in errors that are either constant coefficient of variation (CVV) or constant variance to mean ratio (CVMR).

In the case of the constant coefficient of variation (CVV), the errors are log-normal; that is, $ln\epsilon_{ni} = lnX_{ni} - ln\hat{X}_{ni}$, assuming that ϵ_{ni} is normally distributed and by taking the natural logarithm results in a log-normal error structure. In this case, ϵ_{ni}s are defined as:

$$\epsilon_{ni} = exp(0 + 1 * \xi_{ni}) \tag{2.3.2}$$

where ξ_{ni} is random variable that is normally distributed with mean 0 and variance 1. In the case of the CVMR, the dgp of the conditional variance follows from the general form:

$$Var[X_{ni}|M_{ni}] = \lambda_0 E[X_{ni}|M_{ni}]^{\lambda_1} \tag{2.3.3}$$

which can also be written as:

$$Var[X_{ni}|M_{ni}] = a\mu_{ni} + b\mu_{ni}^2 \tag{2.3.4}$$

where, as discussed before, 'a' and 'b' are scale parameters. If 'a' is greater than zero ($a > 0$) and 'b' equal zero ($b = 0$) the Poisson PML variance is defined; however, if both 'a' and 'b' are greater than zero ($a > 0$) and ($b > 0$), then the NB QGPML variance assumption is defined. If 'a' is equal to zero ($a = 0$) and 'b' greater than zero ($b > 0$) then GPML is variance assumption is defined. Similar to Head and Mayer (2014), we consider the case where 'a' greater than zero ($a > 0$) and 'b' equal zero ($b = 0$), which is identified as CVMR. The errors under the CVMR scenario are not strictly Poisson as defined by the general form hence why they are referred to as 'Poisson-type', i.e.

$$\epsilon_{ni} = exp\left(0.5ln(1 + \frac{w}{\hat{X}_{ni}}) + ln(1 + \frac{w}{\hat{X}_{ni}}) * \xi_{ni}\right) \tag{2.3.5}$$

where ξ is as was defined above and 'w' is a strictly positive heteroskedastic parameter which takes values in the range $(0, +\infty]$, ($0 <$ '$w' \leq +\infty$). For these experiments 'w' takes on values in the range (0, 10,000]. 'w' is inversely related to 'a' and hence influences the size of the proportionality of the variance to the conditional mean. The larger is 'w' the smaller the proportionality of the variance to the conditional mean. Put differently, with small values of 'w' the $E[X_{ni}|M_{ni}]$ dominates the errors; whereas, with large values of 'w' the role of the $E[X_{ni}|M_{ni}]$ in shaping the dgp of the errors is reduced. By altering the proportional relationship between the variance and the conditional mean it allows us to examine the performance of the competing estimators, and as discuss later the MaMu/Park-type and GNR tests, over a wider spectrum of heteroskedastic parameters.

The second step of the experiment involves substituting ϕ_{ni} (equation (2.3.1)) into the multilateral resistance terms (Anderson and van Wincoop, 2003) defined as:

$$\Phi_n = \sum \frac{\phi_{ni} Y_i}{\Omega_i} \tag{2.3.6}$$

and

$$\Omega_i = \sum \frac{\phi_{ni} Y_n}{\Phi_n} \tag{2.3.7}$$

where Y_i and Y_n are GDP for the exporter and importer respectively.

Equations (2.3.6) and (2.3.7) are solved simultaneously using an iterative process. Once Φ_n and Ω_i converge to a solution, they are used in step 3. Step 3 involves calculating the trade flows ($\widetilde{X}_{ni}$), which are calculated using the following equation.

$$\widetilde{X}_{ni} = \frac{Y_i Y_n}{\Phi_n \Omega_i} \phi_{ni} \tag{2.3.8}$$

Another source of variation in the simulation is in terms of the amount of randomly missing data. The data on international trade is usually observed as having missing data which can be as a result of statistical and or reporting error. Similar to Head and Mayer (2014), this experiment takes this into consideration by allowing for 1, 5 and 25 percent randomly missing trade flows. Another feature of international flows is the large number of observed zero trade flows. To mimic this feature, Head and Mayer (2014), built additional structure into the gravity model by considering the high fixed cost of entry (f_n) into exports.

Assuming a model of monopolistic competition with constant elasticity of substitution (CES), firms make zero profit if $X_{ni} = \sigma f_n$. Therefore, if $X_{ni} < \sigma f_n$ the firms has no incentive to enter into trade. To account for this Head and Mayer (2014) redefine trade cost/accessibility as:

$$\phi_{ni} = exp(\beta_{ldist} lndist_{ni} + \beta_{rta} RTA_{ni})\epsilon_{ni} f_n^{-[\frac{\theta}{\sigma-1}-1]} \tag{2.3.9}$$

$$\phi_{ni} = \tau_{ni}^{-\theta} f_n^{-[\frac{\theta}{\sigma-1}-1]} \tag{2.3.10}$$

where τ_{ni} is trade cost, θ is the elasticity of trade with respect to trade cost and is assumed to equal 5, as is typical in the literature, and $\sigma = 3$ given that $\frac{\theta}{\sigma-1} = 2.5$. f_n is estimated by drawing a random sample of 1, 5 or 25 percent of exporters and assume that the average exports by these exporters can be used in approximating the enter cost into trade, i.e, $ln(f_n) = ln(X_{ni}) - ln(\sigma)$. Variation in the fixed cost of entry into trade across countries is achieved by adding a standard normal random distributed variable. Equation (2.3.9), (2.3.6) and (2.3.7) are solved simultaneously and, if convergence is achieved, equation (2.3.8) is used to estimate the trade flows, $\widetilde{X}_{ni}$. If in simulation $\widetilde{X}_{ni} \leqslant \sigma f_n$ then $\widetilde{X}_{ni}$ is set equal to zero. Taking the log of zero results in missing trade flows.

Subsequently, the bias and efficiency of the competing estimators are compared by varying the variance structure and considering the presence of zero or missing trade flow by estimating the following equations.

Equation (2.3.11) is estimated by OLS,

$$ln(\widetilde{X}_{ni}) = \widetilde{\beta}_{ldist} lndist_{ni} + \widetilde{\beta}_{rta} RTA_{ni} + \Omega_i + \phi_n + \epsilon_{ni}^* \tag{2.3.11}$$

and equation (2.3.12) is estimated by Poisson, Gamma and Negative Binomial PML:

$$\widetilde{X}_{ni} = exp(\widetilde{\beta}_{ldist} lndist_{ni} + \widetilde{\beta}_{rta} RTA_{ni} + \Phi_n + \Omega_i)\epsilon_{ni}^* \tag{2.3.12}$$

where: $\widetilde{\beta}_{ldist}$ and $\widetilde{\beta}_{rta}$ are the estimated distance and RTA coefficients respectively. These are compared to the true parameter values of $\beta_{ldist} = -1$ and $\beta_{rta} = 0.5$. Φ_n and Ω_i are exporter and importer specific characteristics, which are controlled for using exporter and importer dummy variables.

Our expectations are aligned with Head and Mayer (2014) findings that under a CCV (log-normal) error structure the OLS and GPML estimators will perform better than the Poisson PML and the NB QGPML; whereas, under the a CVMR ('Poisson-type') error structure the Poisson PML and NB QGPML estimators are expected to perform better than the OLS and GPML estimators.

2.3.1 Non-Random Sampling

The Monte Carlo design detailed above is modified to allow for the examination of the potential bias associated with non-random sampling. This is particularly interesting because many gravity related studies in international trade consider trade within and among region(s), trading blocs or a particular group of countries which fall within a particular income or regional classification. Using the same data described above for 170 countries in 2006, we simulate trade flows as above by considering trade flows for the network of countries under the assumption of log-normal and 'Poisson-type' errors. Subsequent to simulating the network of trade for the 170 countries via equation (2.3.4), non-random samples of exporters are selected based on the World Bank's income and geographic classifications. These income and geography classifications include: for income- High Income (OECD and Non-OECD), Upper Middle Income, Lower Middle Income and Lower Income; and, for geographic- Industrial, Latin America and Caribbean, Sub-Saharan African and Europe and Central Asia. See Table 2.2 and 2.3 for the sample size related to each category of the World Bank's income and geographic classifications. Non-random samples drawn base on these different categories and a combination of these categories allows us to explore and possibly identify source(s) of the of bias when estimating the distance and RTA coefficients in the gravity model. In other words, the performance of the competing estimators in terms of bias, root mean squared error (RMSE) and standard errors when estimating the true parameters using a subset of the global network of trade.

Table 2.2: World Bank Income Classification

Samples	**Observations**	**%**
Total	22302	100%
High Income (OECD and Non-OECD)	5515	25%
High Income (NON-OECD)	1275	6%
High Income (OECD)	4240	19%
Upper Middle Income	5455	24%
Lower Middle Income	6291	28%
Lower Income	4947	22%
Former Country	94	0%

Table 2.3: World Bank Geographic Classification

Samples	**Observations**	**%**
Total	22302	100%
Latin America & Caribbean	4029	18%
Europe & Central Asia	3579	16%
East Asia & Pacific	2697	12%
Sub-Saharan Africa	5757	26%
Industrial	3591	16%
Middle East and North Africa	1590	7%
South Asia	1062	5%

2.3.2 Mis-specification of the Conditional Mean

The Monte Carlo design is further modified to examine the implications of mis-specification of the conditional mean. To violate the assumption of a homogeneous

β, the conditional mean is mis-specified by assigning different βs informed by simultaneous quantile regressions, estimated for each year of the period 1995-2006. For comparison, the gravity model is also estimated using the Poisson PML and OLS estimators. Similarly, Baltagi and Egger (2015) showed, using simultaneous quantiles regression and data for 2008, that trade costs differ both quantitatively and statistically across quantiles of the conditional distribution of bilateral exports. Given these findings and those presented later in this chapter, the Monte Carlo design is modified to simulated trade flow using β_q; where the subscript 'q' refers to different quantiles and the trade cost/accessibility (equation (2.3.13)) is rewritten as:

$$\phi_{ni} = exp(\beta_{ldistq} lndist_{ni} + \beta_{rta} RTA_{ni})\epsilon_{ni} f_n^{-[\frac{\theta}{\sigma-1}-1]} \tag{2.3.13}$$

where, the distance coefficient (β_{ldist}), in absolute terms, is allowed to vary between 0.8-1.5 with an average of 1.15. The simulated trade flows for the q^{th} quantile is generated using the corresponding estimated distance coefficient for that quantile. The RTA coefficient (β_{rta}) is held constant across all quantiles. The resulting trade flows are a function of the β_{ldistq}. The errors are as defined above, either log-normal or 'Poisson-type'. This experiment is similar to Head and Mayer (2014); however, the difference here is that we allow for greater variation in the beta's. They used two possible values for β_{ldistq}, -0.5 and -1.5, which were assigned by identifying whether trade flows were below or above the mean/median trade flow. Here, we utilize beta's estimated from the quantiles regression to identify and assign the coefficients.

2.3.3 Heteroskedasticity and Specification Tests

Given the importance of identifying the dgp of the errors and understanding the nature of heteroskedasticity associated with the gravity model, we return to the Monte Carlo design with CVV and CVMR errors and constant β_{ldist} and β_{rta} set equal to -1 and 0.5 respectively. We introduce the the Breusch-Pagan (1979) and Cook-Weisberg (1983) and White (1980) tests for heteroskedasticity. Additionally, we include the MaMu/Park-type test (Manning and Mullahy, 2001) and Gauss-Newton regression (GNR test) (Davidson and Mackinnon, 1993) with the aim of testing for heteroskedasticity and more broadly assess the performance of these tests in identifying the dgp of the errors.

The MaMu/Park-type test involves estimating using Pooled OLS:

$$\ln(\hat{\epsilon}_{ni}^2) = \alpha + \lambda \widehat{\ln(X_{ni})} \tag{2.3.14}$$

where: $\hat{\epsilon}_{ni} = X_{ni} - \hat{X}_{ni} = X_{ni} - \exp(M'_{ni}\hat{\beta})$, which is the difference between observed and predicted trade flows; $\widehat{\ln(X_{ni})} = E[M'_{ni}\hat{\beta}]$, which is predicted value of log exports from a gravity model estimated using OLS; α is a constant; M'_{ni} is a matrix of exporters and importers fixed effects and a set of explanatory variables; β is a vector of coefficients on the variables in M'_{ni}; and, λ is the elasticity related to $\widehat{\ln(X_{ni})}$. This vector of elasticities is important in underpinning whether the errors exhibits a CVV or CVMR structure and hence what estimation procedure is appropriate. If the errors and the vector of explanatory variables are correlated, the GLMs result in consistent estimates of β since it only requires that the conditional mean is correctly specified; however, OLS consistency is achieved only under the assumption that $E(\epsilon) = 0$ and that the errors and the independent variables are uncorrelated (Wooldridge, 2015). The efficiency of the estimators are dependent on the how well the estimated variance of trade flows (sample variance) matches the observed variance of trade flows (population variance). The parameter λ is a measure of this relationship. Theoretically, $\lambda = 0$ corresponds to the constant variance assumption, $\lambda = 1$ corresponds to conditional variance being proportional to the conditional mean and $\lambda = 2$ corresponds to a special case in which OLS estimation of the log linear model is consistent; however, in practice given that the dgp of the errors is known, when estimating or simulating this test, especially as it related to the gravity literature, λ is not found to be equal to its true/expected parameter. Santos Silva and Tenreyro (2006) simulated the MaMu/Park-type test and found values of: 0.58955 when the true value is zero (0); 1.29821 when the true value is 1; and, 1.98705 when the true value is 2. Assuming CVMR and CVV errors, which corresponds to the latter two scenarios of Santos Silva and Tenreyro (2006) respectively, Head and Mayer (2014) found that a λ less than 2 (range of 1.6-1.7) corresponds to CVMR and a λ greater than or equal to 2 corresponds to CVV.

The are several drawbacks to using the MaMu/Park-type test to test for heteroskedasticity. When compared to other conventional forms of homoskedasticity test such as Breusch-Pagan or White (1980) tests, Wooldridge (2012) notes that the null hypothesis of the MaMu/Park-type test must be something stronger than homoskedasticity; that is, the null should be that the residuals and independent variables are independent of each other. This is not required in the Breusch-Pagan or White tests. Another issue with the Park-Type regression is that using the OLS squared residuals in place of 'true errors' can cause the F-statistic to deviate from the F-distribution, even in large sample sizes. This is not an issue in the Breusch-Pagan or White tests. For these reasons, it is not recommended that the MaMu/Park-type test be used for heteroscedasticity but for a broader understanding of the dgp of the errors. Similarly, Santos Silva and Tenreyro (2006) points out that the MaMu/Park-type test might not be the most appropriate test if the conditional mean cannot be estimated from the log linear form[5] of $Var[X_{ni}|M_{ni}] = \lambda_0 E[X_{ni}|M_{ni}]^{\lambda_1}$. They therefore suggest that

[5]This same regression can be estimated using a multiplicative function and estimator like the Poisson PML; however, we attempted to implement the same test from the gravity model using the Poisson PML and found convergence to be an issue. Therefore, we consider only the log-linearise form estimated using OLS.

the MaMu/Park-type test could be complemented with GNR test.

The GNR test involves estimating:

$$\epsilon_{ni}^2 = \lambda_0 \hat{X}_{ni} + \lambda_0(\lambda_1 - 1)(lnX_{ni})\hat{X}_{ni} + \zeta_{ni} \tag{2.3.15}$$

using OLS; however, because it is expected that the errors, ζ_{ni}, will be heteroskedastic, it is therefore best estimated using weighted least square, weighted by predicted trade flows, $\hat{X}_{ni}$. That is, estimating equation (2.3.45) using OLS.

$$\frac{\epsilon_{ni}^2}{\sqrt{\hat{X}_{ni}}} = \lambda_0 \sqrt{\hat{X}_{ni}} + \kappa(\ln \hat{X}_{ni})\sqrt{\hat{X}_{ni}} + \nu_{ni} \tag{2.3.16}$$

where $\kappa = \lambda_0(\lambda_1 - 1)$. The hypothesis that $Var[X_{ni}|\cdot] \propto E[X_{ni}|\cdot]$ can be test by examining the statistical significance of κ. A significant κ means failing to reject the null that $Var[X_{ni}|\cdot] \propto E[X_{ni}|\cdot]$.

Head and Mayer (2014) in their simulation considered one heteroskedastic parameter under the assumption of constant mean-variance ratio (CVMR), which is the case where the variance is proportional to the conditional mean. Unlike Head and Mayer (2014), we allow for greater variation in the proportionality of the conditional variance to the conditional mean through the heteroskedastic parameter identified above. As mentioned above, the heteroskedastic parameter ('w') is allowed to vary between 0 and 10,000 with various width in between (See Annex D); whereas, this was set equal to 100 in Head and Mayer (2014) simulation. If 'w' is equal to zero, by design, the errors are made to resemble the log-normal (CVV) case. For each value of 'w' there are 1000 iterations[6]. Therefore, one could analysis the performance of the

[6]This is a computationally demanding process which would not have been possible without the use of the University of Nottingham HPC. It would require considerable more resources to consider upwards of 1000 replications for each value of 'w'. Head and Mayer (2014) in its definition of their 'Poisson-type' error considered only one value of 'w' in their simulation but in this design another 29 values of 'w' is considered. Head and Mayer (2014) concluded that the MaMu/Park-type test seems to preform considerable well with 1000 or more iterations; therefore, this should be sufficient

competing estimators for each value of 'w'; however, by allowing for this variation in 'w', we generate a distribution of test statistic, λ, for the MaMu/Park-type test which ranges for significantly more values of λ than those presented in Head and Mayer (2014). In Head and Mayer (2014), under the assumption of CVMR the heteroskedastic parameter was set equal to 100 resulting in λ values ranging from 1.6-1.7; however, by considering more heteroskedastic parameters in the range (0, 10,000], we generate λ values ranging from 1.6-2.01.

In practice, researchers do not explicitly observe the heteroskedastic parameters; however, they can estimate and observe λ from the MaMu/Park-type test. With this, one could ignore the value of 'w' and examine the estimators over a wider range of λ values. Similarly the significance of κ is examined for the entire distribution. The power of both the MaMu/Park-type and GNR tests are considered.

2.4 Findings

Here we present the findings of four different sets of experiments. The first, involves examining the biases, root mean squared errors (RMSE) and standard errors of the competing estimators under the assumption of CVV or CVMR errors and either 1, 5 or 25 percent missing or zero trade flows. The second set of experiments considers the implications of non-random sampling on biases, RMSE and standard errors of the competing estimators. Thirdly, the conditional mean is mis-specified and the competing estimators assessed along the same lines. Lastly, tests for heteroskedasticity and more broadly identification of the dgp of the errors are assessed.

In the first set of experiments, $\beta_{ldist} = -1$ and $\beta_{rta} = 0.5$. The errors are assumed to either be CVV (log-normal) or CVMR ('Poisson-type') with either 1, 5 or 25 percent missing or zero trade flows (see Annex A for the results associated with 1 and 25 percent missing or zero trade flow). This set of experiments are similar to Head and Mayer (2014) with the major difference being the inclusion of the NB QGPML estimators proposed by Wooldridge (1999) and Bosquet and Boulhol (2014) as well as the results of combining these estimators with the Poisson PML (UNION1 and UNION2). These results are summarised in Table 2.4.

We find that with log-normal errors, OLS and Gamma PML are the least biased estimators irrespective of the proportions of missing or zero trade flows; however, with 'Poisson-type' errors the Poisson PML is least biased. The class of NB QGPML estimators considered are also fairly unbiased when the errors are 'Poisson-type'. With 1% zero trade flows the NB QGPML proposed by Wooldridge (1999) is marginally less biased than the PPML when estimating the distance related impact. The combination of the PPML and $NEGBI_{OLS}^{GLM}$ (UNION1) and PPML and $NEGBI_{WLS}^{GLM}$ (UNION2) do not result in improved biased over the PPML estimator, especially when the variance is proportional to the conditional mean but perform at least as well as the PPML estimator; especially as the number of zero/missing trade flow increases. As is expected with 'Poisson-type' errors, the PPML is found to have the smallest standard error; however, this is match by the combination of the PPML and $NEGBI_{OLS}^{GLM}$ (UNION1) and PPML and $NEGBI_{WLS}^{GLM}$ (UNION2). In essence, this confirms what Wooldridge (1999) pointed out, that is, with large samples size there may be little reason to expect efficiency gains. We also find that in all replications when the errors are log-normal the $NEGBI_{WLS}^{GLM}$ and UNION2 are the same. This is because in all replications η_{ni} was positive; however, this is not true when the errors are 'Poisson-type'. This points to robustness issues and the difficult the NB QGPML has in nesting the CVMR assumption as was highlighted by Head and Mayer (2014).

Table 2.4: Bias, RMSE and Standard Errors of the Competing Estimators with 5% Missing Trade Flow

	$\hat{\beta}_{ldist}$			$\hat{\beta}_{rta}$		
Method	% Bias	RMSE	S.E.	% Bias	RMSE	S.E.
	Log-Normal Errors					
OLS	-6.4398	6.4398	0.0200	18.4531	18.4531	0.0545
GPML	0.2254	0.2287	0.0290	-0.9413	0.9472	0.0797
PPML	-27.2061	27.2065	0.1098	-43.2934	43.2955	0.2727
$NEGBI_{OLS}^{GLM}$	-27.0961	27.0965	0.1055	-42.4567	42.4586	0.2668
UNION1	-27.1792	27.1796	0.1075	-42.4121	42.4140	0.2701
$NEGBI_{WLS}^{GLM}$	-18.0115	18.0117	0.0612	-23.4494	23.4502	0.1553
UNION2	-18.0115	18.0117	0.0612	-23.4494	23.4502	0.1553
	Poisson-type Errors					
OLS	27.0886	27.0886	0.0163	8.6316	8.6317	0.0443
GPML	6.5283	6.5284	0.0213	-12.0854	12.0856	0.0477
PPML	0.0007	0.0027	0.0023	0.0310	0.0316	0.0056
$NEGBI_{OLS}^{GLM}$	0.0008	0.0027	0.0024	0.0331	0.0337	0.0056
UNION1	0.0010	0.0028	0.0023	0.0326	0.0332	0.0056
$NEGBI_{WLS}^{GLM}$	0.0005	0.0026	0.0023	0.0318	0.0325	0.0056
UNION2	0.0007	0.0027	0.0023	0.0315	0.0321	0.0056

When the errors are log-normal, OLS and Gamma PML become increasingly biased as the percentage of missing trade flow increases; whereas, the bias associated with the Poisson PML estimator remains stable. The bias in β_{ldist} for OLS increased from 2 percent, associated with 1 percent missing trade flows, to 6.4 percent, associated with 5 percent missing trade flows, to 18.7 percent, associated with 25 percent missing trade flows. The bias for β_{rta} is more pronounced with 7.1 percent to 18.5 percent to 27.2 percent associated with 1, 5 and 25 percent missing trade flows respectively. The Gamma PML exhibits the same pattern. For β_{ldist}, the bias when there is 1 percent missing trade flows is -0.16 percent, with 5 percent missing trade flows the bias is 0.22

percent and with 25 percent missing trade flows it is 5.3 percent. Like OLS, the bias is even more severe for β_{rta}; 0.5 percent at 1 percent missing trade flows, -0.9 percent at 5 percent missing trade flows and -16.6 percent for 25 percent missing trade flows.

Unlike OLS and Gamma PML, with log-normal errors the Poisson PML, NB QGPML and Unions are not sensitive to the percentage of missing trade flows. The Poisson PML, $NEGBI_{OLS}^{GLM}$ and UNION1 are bias by about -27 percent and -42 percent for β_{ldist} and β_{rta} respectively, irrespective of the percentage of missing trade flows. Similarly, the $NEGBI_{WLS}^{GLM}$ and UNION2 exhibit biases, which are invariant to percentage missing trade flows, of -18 percent and 23 percent for β_{ldist} and β_{rta} respectively. Note that when the errors are log-normal the $NEGBI_{WLS}^{GLM}$ and UNION2 are less biased than the Poisson PML, $NEGBI_{OLS}^{GLM}$ and UNION1.

When the errors are 'Poisson-type', both OLS and Gamma PML exhibit increases in bias for β_{ldist} and β_{rta} as the percentage of missing trade flows increase from 1 percent to 25 percent; however, the bias associated with the Poisson PML, NB QGPML and Unions are marginal and invariant to changes in the percentage missing trade flows. This is similar to when errors are log-normal.

Without knowledge of the dgp of the errors, if the gravity model is estimated using OLS and the errors are log-normal, β_{ldist} is likely to be downward biased, in absolute terms, and β_{rta} is likely to be upward biased; whereas, the direction of the bias for the Gamma PML dependents on the number of missing trade flows. For the Poisson PML, NB QGPML and Unions it is likely that both β_{ldist} and β_{rta} are will be downward biased. However, when the errors are 'Poisson-type' these patterns are reserved. With 'Poisson-type' errors, the Gamma PML produces estimates of β_{ldist} that is likely to be downward biased, in absolute terms, and β_{rta} is likely to be upward biased; whereas, the direction of the bias for OLS dependents on the number of missing trade flows. On the other hand, the Poisson PML, NB QGPML and Unions are likely to produce estimates for both β_{ldist} and β_{rta} that are upward biased, Albeit less than a 0.1 percent, .

Aligned with the above findings related to biases of the competing estimators, OLS and Gamma PML has the smallest RMSE and standard errors when the errors are log-normal irrespective of the percentage missing trade flows; whereas, with 'Poisson-type' errors, the Poisson PML, NB QGPML and Unions have the smallest RMSE and standard errors.

2.4.1 Non-Random Sampling

In the second set of experiments, we explore the implications of non-random sampling based on World Bank Income or Geographic/Regional classifications when estimating the gravity equation. We consider if non-random sampling impacts the bias of the coefficients estimated for the gravity equation. Here, the competing estimators considered are OLS, Gamma PML and Poisson PML. Since in the fist set of experiments the class of NB QGPML estimators considered perform at least as good as the Poisson PML, they are not considered in this round of analysis. These results are summarised in Table 2.5 and Table 2.6 for non-random sampling based on World Bank Income Classifications and World Bank Geographic/Regional Classifications respectively.

Using World Bank Income Classification, we find that with log-normal errors the biases for OLS across all income grouping are below the bias estimated when the entire simulated dataset is used. This holds for both β_{ldist} and β_{rta}. From Table 2.5, the bias associated with β_{ldist} when the entire simulated data set is used to estimate the gravity equation using OLS is -6.4 percent; however, the sub-sample biases range from -4.7 percent for lower income to -1.9 percent for High Income. Similarly, the overall bias in β_{rta} when estimated using OLS is about 18.45 percent, with sub-sample biases ranging from -5.7 percent for lower income to 8.8 percent upper middle income. In contrast to OLS, the Gamma PML produces biases, although relatively smaller than OLS, for upper middle income and high income that are larger than the bias estimated when the entire simulated data set is used. This holds true for both β_{ldist} and β_{rta}. As is known from the above discussion, the Poisson PML under conditions of log-normal errors has a huge bias. This is still the case when samples are drawn by income groups, where the coefficients estimated using a sample with only high income exporters have the largest bias and a sample with only low income exporters have the smallest bias.

With log-normal errors, the pattern of bias differed across the three estimators and income categories. For OLS, we observe that β_{ldist} is almost always upward biased, whereas, the β_{rta} is upward biased for lower middle to high income countries and downward biased for lower income countries. For Gamma PML, β_{ldist} are upward biased for high income and lower middle income countries and downward biased for lower income and upper middle income countries. Similarly, β_{rta} is downward biased for all income groupings. Across all income groupings, β_{ldist} is upward biased when estimated by the Poisson PML; whereas β_{rta} is downward biased when estimated by the Poisson PML. These findings highlight the issue of heteroskedasticity and exporters' heterogeneity on the OLS estimates. When countries of the same income group are sampled and the gravity equation is estimated using OLS the results are more likely to be reliable but that is dependent on identifying that the data generating process is log-normal.

Considering 'Poisson-type' errors, as is expected, the Poisson PML is least biased with an overall upward bias of 0.001 percent for β_{ldist} and 0.03 percent for β_{rta}. Sampling lower income countries results in the largest bias for β_{ldist} and β_{rta} of all income groups, albeit negligible. Although the biases are small, sampling high income, upper middle income or lower income and estimation by the Poisson PML results in larger biases for β_{ldist} and β_{rta} than when the entire simulated data set is used to estimate the gravity equation. In fact, with 'Poisson-type' errors, the Poisson PML exhibits marginal differences across income classifications. On the other hand, the OLS and Gamma PML exhibit large biases and difference across income groups. OLS exhibits an inverse relationship between income groupings and the biases of β_{ldist} and β_{rta}. That is, the high income group has the smallest biases and the low income group has the largest biases. Similarly, the Gamma PML exhibits smallest bias for β_{ldist} and β_{rta} when high income exporters are sampled and the largest bias when low income exporters are sampled.

Using Worldbank's geographic/regional classification for namely: Industrial; Sub-Saharan Africa; Europe and Central Asia; and, Latin America and Caribbean, we examine the biases of the competing estimators given log-normal and 'Poisson-type' errors.

With log-normal errors, estimation by OLS and a sample of exporters drawn from Sub-Saharan Africa or Latin America and Caribbean the biases for β_{ldist} are significantly larger (over 5 percent difference) when compared to samples drawn from Europe and Central Asia or Industrial countries. For β_{rta}, sampling exporters from Latin America and Caribbean only results in a bias of 17.5 percent compared with biases of -0.07, 0.46 and -1.03 percent for Europe and Central Asia, Sub-Saharan Africa, and Industrial countries respectively. In terms of direction the biases, OLS tends to upward bias β_{ldist} for all income grouping and upward bias β_{rta} for Europe and Central Asia and Industrial groups. This finding is critical as it reveals that the RTA effects identified using OLS, even when the errors are log-normal, can be distorted by non-random sampling of the exporter by region. This finding might be as a result of greater heterogeneity in trade relations of members of a particular region.

Table 2.5: Bias, RMSE and Standard Errors of the Competing Estimators with Non-Random Sampling based on World Bank Income Classification and 5% Missing Trade Flows

	$\hat{\beta}_{ldist}$								
	GPML			**OLS**			**PPML**		
	% Bias	**RMSE**	**SE**	**% Bias**	**RMSE**	**SE**	**% Bias**	**RMSE**	**SE**
Log-Normal Errors									
Total	0.2254	0.2287	0.0290	-6.4398	6.4398	0.0200	-27.2061	27.2065	0.1098
High Income	-0.4258	0.4360	0.0626	-1.9329	1.9338	0.0587	-30.2298	30.2306	0.1693
Upper Middle Income	0.2254	0.2360	0.0492	-4.2441	4.2443	0.0456	-22.2321	22.2343	0.2012
Lower Middle Income	-0.0619	0.0915	0.0477	-3.9849	3.9851	0.0431	-23.4967	23.4999	0.2096
Lower Income	0.2058	0.2303	0.0683	-4.7206	4.7210	0.0643	-17.2236	17.2267	0.2234
Poisson-type Errors									
Total	6.5283	6.5284	0.0213	27.0886	27.0886	0.0163	0.0007	0.0027	0.0023
High Income	5.9230	5.9232	0.0313	22.8576	22.8577	0.0356	-0.0102	0.0114	0.0046
Upper Middle Income	9.1476	9.1477	0.0319	29.1087	29.1087	0.0334	0.0343	0.0357	0.0091
Lower Middle Income	8.7660	8.7661	0.0340	30.6134	30.6134	0.0334	-0.0004	0.0121	0.0109
Lower Income	12.1833	12.1836	0.0537	34.6479	34.6479	0.0541	0.0606	0.0733	0.0387

	$\hat{\beta}_{rta}$								
	GPML			**OLS**			**PPML**		
	% Bias	**RMSE**	**SE**	**% Bias**	**RMSE**	**SE**	**% Bias**	**RMSE**	**SE**
Log-Normal Errors									
Total	-0.9413	0.9472	0.0797	18.4531	18.4531	0.0545	-43.2934	43.2955	0.2727
High Income	-1.3213	1.3403	0.1496	4.2342	4.2364	0.1399	-37.7502	37.7541	0.3879
Upper Middle Income	-1.3480	1.3589	0.1228	8.8907	8.8914	0.1128	-34.5397	34.5437	0.3789
Lower Middle Income	-0.0013	0.2021	0.1396	5.7433	5.7448	0.1240	-3.6262	3.6670	0.4251
Lower Income	-0.7020	0.7460	0.1713	-5.7234	5.7255	0.1608	-17.6384	17.6551	0.4939
Poisson-type Errors									
Total	-12.0854	12.0856	0.0477	8.6316	8.6317	0.0443	0.0310	0.0316	0.0056
High Income	-8.1814	8.1819	0.0694	-4.2311	4.2317	0.0850	0.1229	0.1234	0.0102
Upper Middle Income	-8.1966	8.1971	0.0677	9.3737	9.3739	0.0827	-0.0274	0.0331	0.0166
Lower Middle Income	-1.9332	1.9364	0.0813	26.1958	26.1959	0.0962	0.0527	0.0594	0.0253
Lower Income	12.6048	12.6062	0.1324	39.3239	39.3241	0.1351	-0.8030	0.8092	0.0862

Unlike OLS with log-normal errors, the Gamma PML produces biases that closely match those generated when the entire simulated data set is used. For Gamma PML, the bias for each grouping is marginally above or below the bias for the entire dataset. β_{ldist} is upward bias for Europe and Central Asia, Sub-Saharan Africa and Industrial; whereas, β_{rta} is downward bias for all regional groupings. As described before, the Poisson PML estimator is significantly bias under the assumption of log-normal errors and this holds true for samples drawn based on region. The largest biases for both β_{ldist} and β_{rta} are observed for a sample drawn using Industrial countries; whereas, the smallest bias for β_{ldist} is associated with samples drawn from Sub-Saharan Africa and smallest bias for β_{rta} is associated with samples drawn from Europe and Central Asia. With log-normal errors, Poisson PML estimates are upward biased for all regional groupings for both β_{ldist} and β_{rta}.

Turning to 'Poisson-type' errors, the Poisson PML is still least biased across all geographic groupings. The differences across groupings are marginal; however, it is still worth noting that biases for β_{ldist} and β_{rta} associated with all regional groupings are larger, although marginal, than those observed when the entire simulated dataset is used. For β_{ldist}, Sub-Saharan Africa exhibits the largest bias (0.13 percent), albeit marginal; whereas, for β_{rta}, Europe and Central Asia exhibits the largest bias (-0.15 percent). In terms of the direction of the bias, with 'Poisson-type' errors, β_{ldist} and β_{rta} estimated using the Poisson PML are downward biased for Latin-America and Caribbean, Sub-Saharan Africa and Europe and Central Asia; whereas, although known to be less desired with 'Poisson-type' errors, OLS and the Gamma PML are downward biased β_{ldist} for all regional groups and upward biased β_{rta} for Europe and Central Asia, Sub-Saharan Africa and Industrial groups. Most notably are the biases associated with estimating the gravity model using OLS or Gamma PML and sampling Latin America and Caribbean or Sub-Saharan Africa under assumption of 'Poisson-type' errors. These findings suggest that besides understanding the dgp of the errors, it is important that sampling bias is considered, although such bias is minimized once the dgp of the errors are identified and the appropriate estimator selected.

Table 2.6: Bias, RMSE and Standard Errors of the Competing Estimators with Non-Random Sampling based on World Bank Geographic/Regional Classification and 5% Missing Trade Flows

	$\hat{\beta}_{ldist}$								
	GPML			**OLS**			**PPML**		
	% Bias	**RMSE**	**SE**	**% Bias**	**RMSE**	**SE**	**% Bias**	**RMSE**	**SE**
Log-Normal Errors									
Total	0.2254	0.2287	0.0290	-6.4398	6.4398	0.0200	-27.2061	27.2065	0.1098
Latin America & Caribbean	0.1579	0.2275	0.1074	-6.7603	6.7611	0.1039	-21.9197	21.9374	0.4036
Europe & Central Asia	-0.1532	0.2113	0.0967	-1.1508	1.1550	0.0962	-16.8592	16.8659	0.3327
Sub-Saharan Africa	-0.0834	0.1470	0.0843	-6.8160	6.8164	0.0771	-13.6322	13.6427	0.3276
Industrial	-0.1442	0.1944	0.0861	-0.5926	0.5988	0.0885	-30.9543	30.9554	0.1926
Poisson-type Errors									
Total	6.5283	6.5284	0.0213	27.0886	27.0886	0.0163	0.0007	0.0027	0.0023
Latin America & Caribbean	14.7438	14.7442	0.0769	36.2388	36.2389	0.0834	0.0725	0.0759	0.0189
Europe & Central Asia	7.2818	7.2821	0.0528	28.3880	28.3881	0.0677	0.0533	0.0578	0.0208
Sub-Saharan Africa	12.8046	12.8051	0.0699	35.6051	35.6051	0.0640	0.1309	0.1398	0.0451
Industrial	3.9145	3.9147	0.0349	15.7626	15.7627	0.0458	-0.0092	0.0108	0.0051
	$\hat{\beta}_{rta}$								
	GPML			**OLS**			**PPML**		
	% Bias	**RMSE**	**SE**	**% Bias**	**RMSE**	**SE**	**% Bias**	**RMSE**	**SE**
Log-Normal Errors									
Total	-0.9413	0.9472	0.0797	18.4531	18.4531	0.0545	-43.2934	43.2955	0.2727
Latin America & Caribbean	-0.0891	0.2473	0.1617	17.5126	17.5132	0.1556	-33.1833	33.1908	0.4469
Europe & Central Asia	-0.2110	0.2884	0.1284	-0.0654	0.1429	0.1272	-23.8157	23.8252	0.4233
Sub-Saharan Africa	-1.1069	1.1313	0.1589	0.4566	0.4777	0.1429	-27.5025	27.5172	0.4032
Industrial	-1.5469	1.5743	0.1913	-1.0281	1.0478	0.1970	-35.7181	35.7229	0.4129
Poisson-type Errors									
Total	-12.0854	12.0856	0.0477	8.6316	8.6317	0.0443	0.0310	0.0316	0.0056
Latin America & Caribbean	-20.3976	20.3982	0.1038	-5.9085	5.9094	0.1251	-0.0429	0.0504	0.0238
Europe & Central Asia	2.1174	2.1194	0.0680	19.1340	19.1341	0.0896	-0.1553	0.1575	0.0228
Sub-Saharan Africa	3.8028	3.8066	0.1180	35.3957	35.3959	0.1187	-0.0732	0.0881	0.0423
Industrial	1.8089	1.8107	0.0642	10.9948	10.9950	0.1019	0.1236	0.1242	0.0106

Overall, we find that with Poisson-type errors the estimates of β_{ldist} and β_{rta} by the

PPML estimators are not significantly affected by non-random sampling of exporters from different income or regional groupings; however, if the errors are 'Poisson-type' the OLS and Gamma PML estimates of β_{ldist} and β_{rta} for different income and regional groups can be distorted significantly. When compared to the bias associated with using the entire simulated dataset, we observe smaller biases when the sample is made up of lower income, lower middle income or upper middle income countries; however, estimates of the RTA effects by OLS, even when the errors are log-normal, can be distorted by non-random sample if the sample is drawn for a region where the countries exhibit significant heterogeneity. We also find that with log-normal errors, OLS estimates are less biased when the non-random sample selected is based on the income classification of the exporter. These findings highlight the issue of heteroskedasticity and exporters' heterogeneity on the OLS estimates. This also points to, supported by Baltagi and Egger (2015), the need to use quantiles regressions to estimate the gravity equation, at the least when the errors can be considered log-normal.

2.4.2 Quantile Regressions and Mis-specification of the Conditional Mean

Following from the findings in the previous set of experiments, we consider the use of quantile regressions to estimate the gravity equation. Using Head and Mayer (2014) data set, simultaneous quantile regressions are used to estimate the gravity model for each year of the period 1995-2006. For comparison, the gravity model is also estimated using the Poisson PML and OLS estimators. We estimate the following gravity equation:

$$X_{ni} = \beta_{ldist} lndist_{ni} + \beta_{rta} RTA_{ni} + \sum_{m=3}^{M} \beta_m \ln(M_{ni}^m) + \Omega_i + \phi_n + \epsilon_{ni} \qquad (2.4.1)$$

where: X_{ni} are exports from country n to i; $lndist_{ni}$ is the log of the geographic distance; RTA_{ni} is a dummy variable which take a value one (1) if the bilateral pair is in the same regional trade agreement; M_{ni} contains other bilateral characteristics including colony, common language, common colonizer, colony after 1945 and contiguity; Ω_i and ϕ_n are exporters' and importers' specific characteristic respectively; and, ϵ_{ni} is the error term. Equation (2.4.46) is estimated using OLS, Poisson PML, $NEGBI_{OLS}^{GLM}$, $NEGBI_{wLS}^{GLM}$ and simultaneous quantile regressions for each year over the period 1995-2006. The OLS and quantile regression results can be seen in Figure 2.1. The results for the Poisson PML are presented in Table 2.7.

Table 2.7: Gravity Model Estimates by the PPML/Poisson PML Estimator for the period 1995-2006

Dependent Variable: Exports	(1995)	(1996)	(1997)	(1998)	(1999)	(2000)	(2001)	(2002)	(2003)	(2004)	(2005)	(2006)
Log Distance	-0.620***	-0.610***	-0.613***	-0.609***	-0.616***	-0.607***	-0.638***	-0.664***	-0.693***	-0.714***	-0.744***	-0.806***
	(-17.67)	(-17.15)	(-17.25)	(-16.97)	(-17.80)	(-17.54)	(-19.43)	(-20.42)	(-21.40)	(-21.66)	(-21.11)	(-22.53)
RTA	0.627***	0.666***	0.662***	0.731***	0.775***	0.812***	0.764***	0.731***	0.722***	0.663***	0.561***	0.443***
	(7.22)	(7.93)	(7.91)	(9.08)	(9.85)	(10.26)	(10.31)	(10.00)	(10.39)	(9.49)	(7.32)	(5.90)
Contiguity	0.609***	0.623***	0.615***	0.578***	0.544***	0.547***	0.524***	0.492***	0.404***	0.399***	0.399***	0.383***
	(7.10)	(7.39)	(7.31)	(7.21)	(6.85)	(6.87)	(7.25)	(7.14)	(6.11)	(6.20)	(6.07)	(6.07)
Colony	0.00825	0.0215	0.0470	0.0618	0.0663	0.105	0.110	0.0917	0.0520	0.0750	0.0822	0.0956
	(0.10)	(0.26)	(0.56)	(0.74)	(0.79)	(1.24)	(1.31)	(1.04)	(0.53)	(0.78)	(0.87)	(1.05)
Common Language	0.239***	0.233***	0.213**	0.200**	0.199**	0.196**	0.197**	0.193**	0.279***	0.257***	0.222**	0.220**
	(3.63)	(3.54)	(3.22)	(3.09)	(3.11)	(3.03)	(3.19)	(3.07)	(4.28)	(3.89)	(3.21)	(3.17)
Common Colonizer	-0.0530	-0.0530	-0.0509	0.00362	0.0227	0.0316	0.0589	0.0872	0.130	0.173	0.179	0.138
	(-0.38)	(-0.38)	(-0.37)	(0.03)	(0.17)	(0.24)	(0.47)	(0.72)	(1.08)	(1.42)	(1.41)	(0.83)
Colony after 1945	0.304*	0.284	0.251	0.296	0.255	0.170	0.164	0.168	0.243	0.228	0.234	0.225
	(1.99)	(1.82)	(1.60)	(1.89)	(1.67)	(1.11)	(1.04)	(1.03)	(1.44)	(1.30)	(1.27)	(1.15)
Constant	5.992***	6.080***	6.243***	5.873***	5.714***	5.313***	5.219***	6.000***	6.200***	6.024***	6.453***	7.044***
	(10.28)	(10.91)	(10.77)	(10.74)	(9.86)	(8.93)	(8.78)	(10.29)	(8.38)	(9.92)	(10.55)	(11.62)
N	24704	25646	26017	26126	26435	26967	27020	27030	26837	26241	25581	22588
Exporter and Importer FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

Notes:

t statistics in parentheses and standard errors are clustered at the country-pair level.

***denotes significance at the 0.1 percent, **denotes 1 percent, and *denotes 0.5 percent

Exporter and importer fixed effects are not reported.

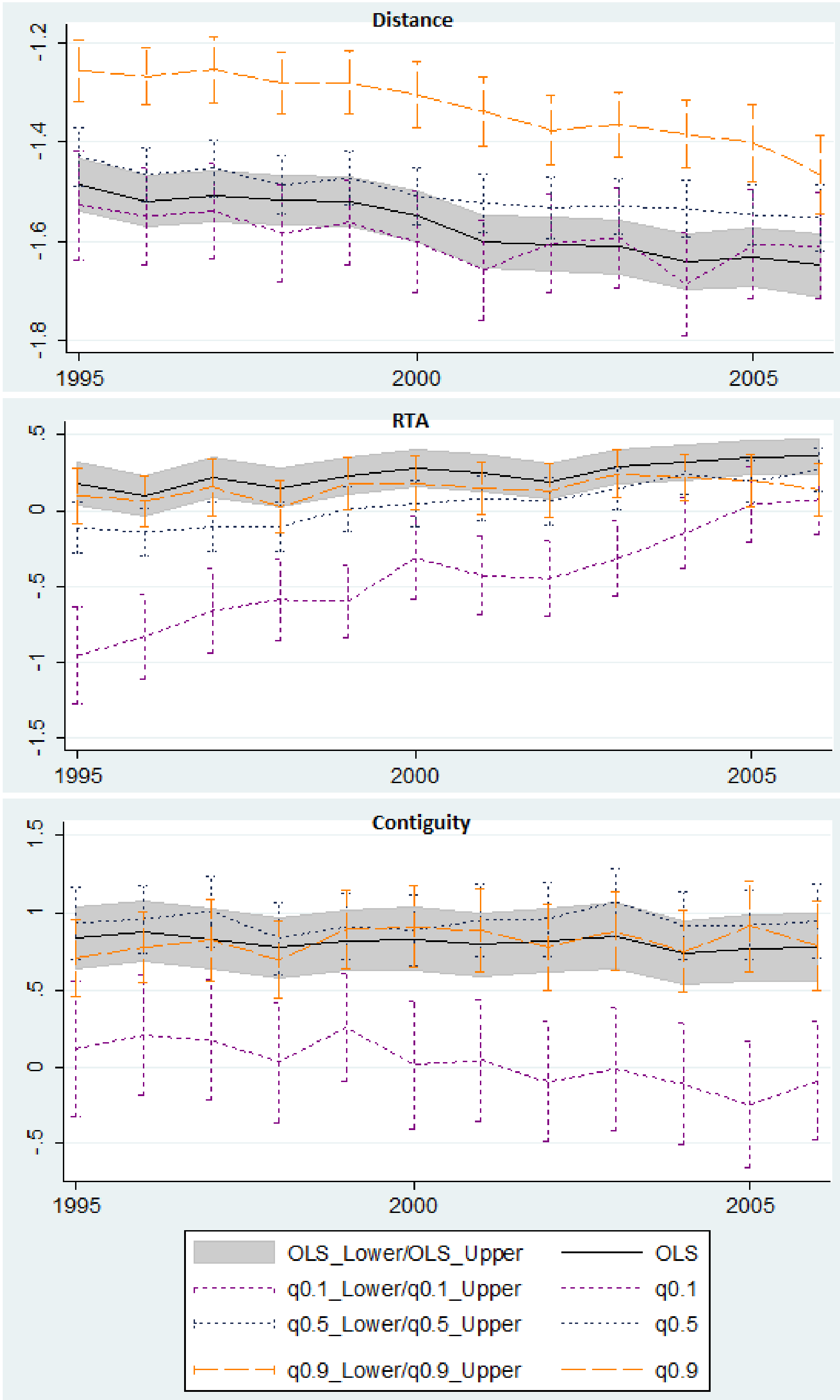

Figure 2.1: OLS and Quantile Regression Estimates for Distance, RTA and Contiguity

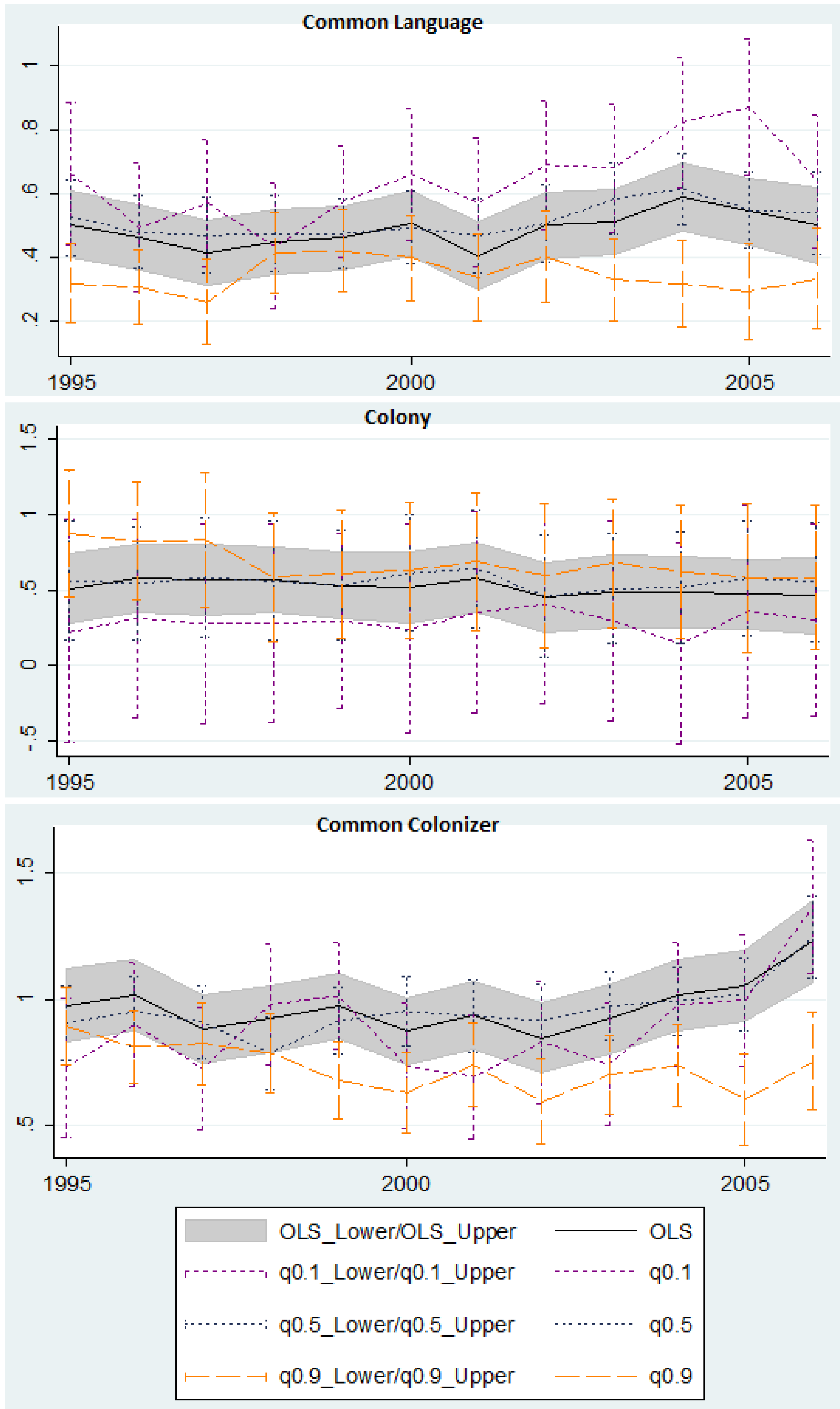

Figure 2.2: OLS and Quantile Regression Estimates for Common Language, Colony and Common Colonizer

We find that OLS estimates a distance elasticity that is above the elasticity estimated by median quantile regression; however, this is not statistically significant from the OLS estimate. Similarly, the estimates for the 10th to 40th percentile are not significantly different from the OLS estimate; however, the distance elasticities estimated for the 80th and 90th percentile are significantly different from the OLS estimates for the year 1995-2004. For the years 1995-2004, the estimates for the 80th and 90th percentile were significantly below those estimate by OLS for the corresponding years; however, this difference becomes insignificant by 2006, i.e, the difference between the estimated distance elasticity for the 'top-end' and 'bottom-end' of the distribution seems relatively smaller and insignificant (See Figure 2.1 for these results). On the other hand, the Poisson PML estimates distance elasticities that are significantly smaller, in absolute terms, than those estimated by the quantile regressions and OLS (See Table 2.7 for the Poisson PML results). In fact, they are significantly different from those estimated by the quantile regressions and OLS, falling outside the confidence interval and up to half the size of the median regression. Like OLS and the quantile regressions, the Poisson PML estimates distance effects on trade that are generally upward trending (larger negative effect).

Turning to RTA, OLS estimates positive effects for RTA for the years considered; however, the quantile regressions estimate only positive effect for the top half (60th-90th percentile) of the distribution. The median regression estimated a negative coefficient on RTA for each year up until 1999 (See Figure 2.1). For the 10th percentile the RTA coefficient is negative until 2005 and for 20th percentile the RTA effect is negative until 2004. Like OLS, the Poisson PML estimates positive RTA effects; however, its estimates are two to three (3-4) times those estimated by OLS[7]. If one were to interpret the results of the quantile regressions, it could be concluded that

[7]To compare the OLS with Poisson estimates, RTA effects for the Poisson PML are calculate using: $e^{\beta} - 1$. The effects for contiguity, colony, common language, common colonizer and colony after 1945 are calculated using the same formula

before 2004 RTAs benefited countries whose exports were above the 20th percentile; however, these results are more illustrative than conclusive. Further research is needed to concretely draw such inferences.

The estimates for contiguity by OLS and quantile regressions are not significantly different for all percentile except the 10th percentile; however, closer examinations reveal that this variable is insignificant for all years for the 10th percentile (see Figure 2.2). The Poisson PML estimates are also aligned with those estimated by OLS and the quantile regression. Similarly, there is no significant difference between the OLS and the quantile regressions estimates for common language; however, the Poison PML estimates are different from the average effects estimated by OLS and the median regression but are considerably close to the estimates for 80th and 90th percentiles. The Poisson PML consistently estimates no statistical significant relationship between variables colony, common colonizer and colony after 1945. The statistical significance of these variables are mixed for OLS and the quantile regressions despite no identifiable significant differences in the coefficients estimated.

Given the above findings, the Monte Carlo design is modified to allow for parameter heterogeneity. That is, the distance coefficient (β_{ldist}) is allowed to vary between -1.5 and -0.8. The simulated trade flows for the q^{th} quantile is generated using the corresponding estimated distance coefficient for that quantile. The RTA coefficient (β_{rta}) is held constant across all quantiles. This experiment is also similar to Head and Mayer (2014); however, the difference here is that we allow for great variation in the beta's. They used two possible outcome for the beta's -0.5 and -1.5, which were assigned by identifying whether trade flows were below or above the mean/median trade flow; however, this experiment utilizes five beta's estimated using unconditional quantile regressions to identify and assign the coefficients. In other words, we use observed heterogeneity to allow for mis-specification in the conditional mean assuming that there are trade cost differences across quantile; whereas, Head and Mayer (2014) split the data according to the observed median of the dependent variable. Misspecification as a result of greater degree of heterogeneity should shed light on the implications of assuming constant elasticity/constant trade costs when in fact trade costs varies significantly across quantiles. This is an issue that has received limited attention in the gravity literature.

The findings for this set of Monte Carlo experiments are summarised in Table 2.8 (The results for 1 percent missing/zero trade flows are reported in Table 2.17 in the Appendix). The main finding is that the assumption of constant elasticity/trade cost across quantile is critical. If this assumption does not hold true, inferences about to impact and magnitude of trade policies are suspect and must be taken with a grain of salt. We find that irrespective of the error structure and the number of missing/zero trade flows, the Poisson PML and NB QGPML estimators are biased downward when estimating the distance elasticity. The Poisson PML and NB QGPML estimates are closer to, or below, the coefficient associated with the lower quantile (-0.8). On the other hand, the OLS and Gamma PML estimators exhibit upward bias with an estimate above the coefficient associated with the upper quantile. Compared to the findings of Head and Mayer (2014), our findings suggest that with greater parameter heterogeneity the OLS and Gamma PML estimates will be biased upward instead of estimating the average of the beta's. Another observation is that model misspecification, in this case parameter heterogeneity associated with distance, affect the coefficient estimated for other explanatory variables. All the estimators exhibit even greater bias for the coefficient estimated for RTA when the distance coefficient is varied across quantiles, although less biased when the variance is assumed to be proportional to the mean. When the errors are assumed to be log-normal the coefficients estimated for RTA by the Poisson PML and NB QGPML estimators exhibit larger biases. The OLS and Gamma PML exhibit some bias but these biases are relatively small. As was the result in the first set of experiments, the class of NB QGPML estimators considered in this experiment did not outperform the Poisson PML; however, they exhibit some desirable properties needed to estimate the gravity model especially when the data generating process of the errors resembles a constant variance to mean ratio and there is the possibility of increase nuisance in the data.

Table 2.8: Mis-specification of the conditional mean and the Competing Estimators with 5% Missing Trade Flow

5% Missing Trade Flow	Distance			RTA		
Method	$\overline{\hat{\beta}}_{ldist}$	$\overline{\hat{\beta}}_{ldist} - \overline{\beta}_{ldist}$	S.E.	$\overline{\hat{\beta}}_{rta}$	$\overline{\hat{\beta}}_{rta} - \overline{\beta}_{rta}$	S.E.
Log-normal						
OLS	-1.818158	0.668158	0.028981	0.522894	0.022894	0.069195
GPML	-1.969070	0.819070	0.038441	0.516966	0.016966	0.092193
PPML	-0.539409	-0.610591	0.143308	0.297979	-0.202021	0.302640
$NEGBI_{OLS}^{GLM}$	-0.571216	-0.578784	0.126420	0.296572	-0.203428	0.270510
UNION1	-0.551575	-0.598425	0.133047	0.310660	-0.189341	0.282635
$NEGBI_{WLS}^{GLM}$	-0.722385	-0.427615	0.080986	0.363632	-0.136368	0.174685
UNION2	-0.722385	-0.427615	0.080986	0.363632	-0.136368	0.174685
Poisson						
OLS	-2.522240	1.372240	0.033936	0.567869	0.067869	0.074869
GPML	-2.187316	1.037316	0.036862	0.481773	-0.018227	0.077569
PPML	-0.805210	-0.344790	0.003741	0.520594	0.020594	0.008483
$NEGBI_{OLS}^{GLM}$	-0.806378	-0.343622	0.004532	0.529333	0.029333	0.010704
UNION1	-0.805991	-0.344009	0.004208	0.525622	0.025622	0.009809
$NEGBI_{WLS}^{GLM}$	-0.804758	-0.345242	0.004410	0.529333	0.029330	0.010529
UNION2	-0.804758	-0.345242	0.004410	0.529331	0.029330	0.010529

2.4.3 Heteroskedasticity and Specification Tests

The final set of experiments carried out are aimed at distinguishing between the log-normal (CVV) and 'Poisson-type' (CVMR) errors as well as identifying the presence and severity of heteroskedasticity. Given the potential for incorrect inference if one or another estimator is used without identifying or understanding the dgp of the errors, we consider the usefulness of the MaMu/Park-type test and GNR test in identifying the data generating process of the errors. Additionally, we consider the how Cook-Weisberg (1983) (BP) and White (1980) tests for heteroskedasticity could help in identifying, not only heteroskedasticity, but the dgp of the errors. As mentioned before, Head and Mayer (2014) simulated the MaMu/Park-type test and found that a λ less than 2 corresponds to CVMR and a λ greater than or equal to 2 corresponds to CVV; however, there are concerns about whether Head and Mayer (2014) interpretation of the MaMu/Park-type test statistics is necessary the best and only indicator of the dgp of the errors.

Unlike Head and Mayer (2014), we vary the heteroskedastic parameter, (w), which is inverse related to the proportion by which the variance is related to the conditional mean, over the range $(0, 10,000]$. By varying w, we generate a distribution of test statistic, λ, for the MaMu/Park-type test ranging from 1.6 to 2.1. See Figure 2.3 and 2.4. This differs from Head and Mayer (2014) step-up which set $w = 100$ hence generating λ values ranging from 1.6-1.7 under the assumption of CVMR ('Poisson-type' errors). Given the range of λ values generated, we analysis the performance of the competing estimators (OLS, Gamma PML, Poisson PML, $NEGBI_{OLS}^{GLM}$, $NEGBI_{WLS}^{GLM}$, UNION1 and UNION2) for each value of w selected within the range $(0, 10,000]$ (See Table 2.18 in the Appendix) as well as over the entire distribution of λ irrespective of the value of w (see Table 2.9). We consider two cases: 1. the performance of the competing estimators when λ is not statistically different from 2; 2. the performance of the competing estimators when λ is significantly different from 2. In the latter case, we consider λ significantly greater than 2 and λ significantly less than 2.

Table 2.18 reported in the Appendix, presents the findings for all values of w. As was expected for $w > 0$, which corresponds to the CVMR errors, the Poisson PML, which is closely matched by the $NEGBI_{OLS}^{GLM}$ and $NEGBI_{WLS}^{GLM}$, is most desirable;

whereas, when $w = 0$, which as mentioned before corresponds to CVV errors, the OLS estimator is least biased; however, the $NEGBI_{WLS}^{GLM}$ is less biased than the OLS estimator. Since these results were established earlier, here the concern is with the performance of the competing estimators given the observed estimates of the test statistic from the MaMu/Park-type test and its significance.

As mentioned before, the distribution of λ is divided into three parts: $\lambda = 2$, $\lambda > 2$ and $\lambda < 2$. We find that if λ is not significantly different from 2 then the Poisson PML, $NEGBI_{OLS}^{GLM}$ and $NEGBI_{WLS}^{GLM}$ are the most appropriate estimators of those considered as they have the smallest bias, root mean squared errors (RMSE) and bias in standard errors. Closer examination reveals that the cases where λ was not statistically different from 2 were mostly related to CVMR errors generated when w is very large ($w > 6000$). When $w = 0$ and hence CVV errors exist the λ value is found to statistically significantly greater than 2, in which case the OLS estimators are least biased and has the smallest root mean squared errors (RMSE). Similar, to Head and Mayer (2014) finding, λ statistically less than 2 are unambiguously relate to CVMR and the Poisson PML, $NEGBI_{OLS}^{GLM}$ and $NEGBI_{WLS}^{GLM}$ are the least biased estimator. In this design the Gamma PML has the largest biased across all values of λ.

Table 2.9: Performance of competing estimators given the significance of λ

	% Bias		RMSE		SE		% Bias SE	
Method	$\hat{\beta}_{ldist}$	$\hat{\beta}_{rta}$	$\hat{\beta}_{ldist}$	$\hat{\beta}_{rta}$	$\hat{\beta}_{ldist}$	$\hat{\beta}_{rta}$	$\hat{\beta}_{ldist}$	$\hat{\beta}_{rta}$
$\lambda = 2$ **(N=8084)**								
GPML	43.13	-72.14	43.13	72.14	0.05	0.11	1669.48	2336.99
OLS	-13.16	41.18	13.16	41.18	0.02	0.06	4731.45	4767.97
PPML	0.11	0.04	0.11	0.07	0.02	0.05	847.75	880.21
$NEGBI^{GLM}_{OLS}$	0.10	0.00	0.11	0.05	0.02	0.05	852.28	886.03
UNION1	0.10	0.02	0.11	0.06	0.02	0.05	848.36	880.95
$NEGBI^{GLM}_{WLS}$	0.10	-0.20	0.10	0.21	0.02	0.05	871.83	892.96
UNION2	0.10	-0.20	0.10	0.21	0.02	0.05	871.83	892.96
$\lambda > 2$ **(N=1062)**								
GPML	63.02	-126.66	63.02	126.66	0.04	0.07	746.81	631.27
OLS	-12.03	10.94	12.03	10.94	0.01	0.03	369.35	379.60
PPML	-8.49	-19.86	8.50	19.87	0.06	0.15	308.98	293.47
$NEGBI^{GLM}_{OLS}$	-8.43	-18.94	8.43	18.94	0.06	0.15	314.12	300.98
UNION1	-8.43	-18.93	8.43	18.93	0.06	0.15	309.54	296.39
$NEGBI^{GLM}_{WLS}$	-4.44	-6.01	4.44	6.01	0.03	0.08	663.16	646.23
UNION2	-4.44	-6.01	4.44	6.01	0.03	0.08	663.16	646.23
$\lambda < 2$ **(N=20854)**								
GPML	39.89	-79.43	39.89	79.43	0.04	0.09	712.11	592.10
OLS	-9.10	37.65	9.10	37.65	0.02	0.04	363.36	366.67
PPML	0.05	-0.04	0.05	0.05	0.01	0.02	65.13	64.41
$NEGBI^{GLM}_{OLS}$	0.05	-0.05	0.05	0.05	0.01	0.02	65.25	64.53
UNION1	0.05	-0.04	0.05	0.05	0.01	0.02	65.15	64.43
$NEGBI^{GLM}_{WLS}$	0.05	-0.08	0.05	0.08	0.01	0.02	63.72	61.96
UNION2	0.05	-0.08	0.05	0.08	0.01	0.02	63.65	61.86

The simulated resulted was also split into parts based on the statistical significance of κ and the biases and RMSE of the competing estimators examined. As was expected, when κ is insignificant the OLS and $NEGBI^{GLM}_{WLS}$ estimators are best of those considered. When κ is statistically significant the Poisson PML, $NEGBI^{GLM}_{OLS}$ and $NEGBI^{GLM}_{WLS}$ are least biased. Armed with these findings, we proceed to analyze the performance of these tests and hence make decision about what estimator is best suited given some criteria.

As shown in Table 2.10, the MaMu/Park-type test generates a λ that is statistically greater than 2 when the errors are CVV. Under the alternative of 'Poisson-type' errors, for small values of w, say $0 < w < 7000$, the MaMu/Park-type test does very well in identifying the presences of 'Poisson-type' errors; however, for large values of w, say $w > 7000$, it seems the MaMu/Park-type test is likely to generate values closer to 2, which are more likely to be statistically insignificant. Therefore, decisions cannot be made solely by using the MaMu/Park-type test since an estimated λ of 2 or close to 2 does not imply CVV/log-normal errors. In fact, a λ statistically greater than 2 is likely to correspond to log-normal errors (See column 7 of Table 2.10). This can be seen by examining the average value of λ as shown in Table 2.10, Column 2. For CVV errors, the average λ value is 2.08 but similarly as w gets large it trend towards the average λ associated with CVV errors. As w gets large the MaMu/Park-type test fails to reject the null that $\lambda = 2$. Unlike the MaMu/Park-type test, the GNR test is able to identify with greater precision at the 1 percent level of significance when the errors are 'Poisson-type' (CVMR), as κ is found to be significant almost 100% of the time (See column 8 of Table 2.10). When the errors are CVV, κ is found to be insignificant 52 percent of the time. From Table 2.10, we see that the MaMu/Park-type test identifies CVV errors 100 percent of the times suggesting that λ must be significantly greater than 2; whereas, GNR test identifies CVMR errors 100 percent of the times where κ is statistically different from zero.

Table 2.10: Rate of Rejection by the MaMu/Park-type and GNR Tests at 5% level of significance

Het. Parameter	**MaMu/ Park Type Test**					**GNR Test**
	Summary Statistics		**Rate of Rejection**			**Rate of Rejection**
w	Avg. λ Value	$\lambda < 2$ (%)	$\lambda = 2$	$\lambda < 2$	$\lambda > 2$	$Var[X_{ni}\vert.] \propto E[X_{ni}\vert.]$
0	2.084	0%	0.000	0.000	1.000	0.519
50	1.594	100%	0.000	1.000	0.000	1.000
100	1.634	100%	0.000	1.000	0.000	0.999
150	1.663	100%	0.000	1.000	0.000	0.997
200	1.685	100%	0.000	1.000	0.000	0.998
250	1.704	100%	0.000	1.000	0.000	1.000
300	1.719	100%	0.000	1.000	0.000	0.999
350	1.732	100%	0.000	1.000	0.000	0.997
400	1.744	100%	0.000	1.000	0.000	0.996
450	1.754	100%	0.000	1.000	0.000	1.000
500	1.764	100%	0.000	1.000	0.000	0.997
1000	1.825	100%	0.000	1.000	0.000	1.000
1500	1.860	100%	0.000	1.000	0.000	1.000
2000	1.885	100%	0.000	1.000	0.000	1.000
2500	1.903	100%	0.000	1.000	0.000	1.000
3000	1.918	100%	0.000	1.000	0.000	1.000
3500	1.930	100%	0.000	1.000	0.000	1.000
4000	1.941	100%	0.000	1.000	0.000	1.000
4500	1.950	100%	0.011	0.989	0.000	1.000
5000	1.958	100%	0.050	0.950	0.000	1.000
5500	1.966	100%	0.218	0.782	0.000	1.000
6000	1.972	100%	0.459	0.541	0.000	1.000
6500	1.978	98%	0.659	0.341	0.000	1.000
7000	1.984	93%	0.855	0.145	0.000	1.000
7500	1.989	87%	0.933	0.067	0.000	1.000
8000	1.994	72%	0.975	0.025	0.000	1.000
8500	1.998	58%	0.988	0.009	0.003	1.000
9000	2.002	44%	0.99	0.004	0.006	1.000
9500	2.006	27%	0.985	0.001	0.014	1.000
10000	2.010	17%	0.961	0.000	0.039	1.000

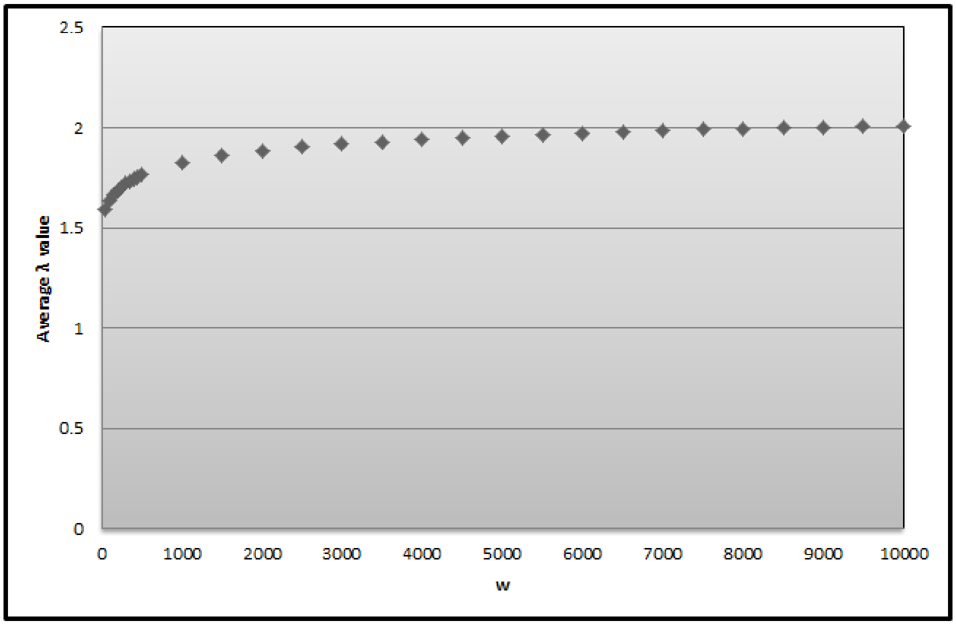

Figure 2.3: Average λ for all heteroskedastic parameter considered with CVMR errors

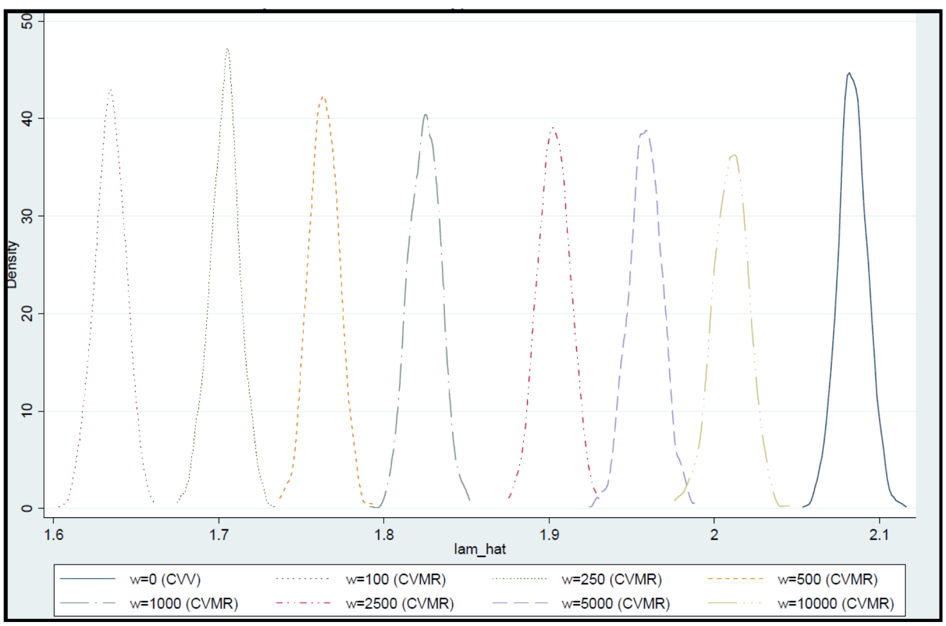

Figure 2.4: The distribution of λ's for selected heteroskedastic parameter with CVMR errors

It is therefore recommended that both tests are used when trying to ascertain the dgp of the errors. Since the null under both tests are different they complement each other and increase the likelihood of correctly identifying the dgp of the errors and hence the appropriate estimator. A λ significantly greater than 2 and an insignificant κ is likely associated with CVV. A λ significantly less than 2 and a statistically significant κ is likely associated with CVMR. An insignificant λ, that is, λ statistically equal to 2 and a statistically insignificant κ is most likely associated with CVV. A insignificant λ, that is, λ statistically equal to 2 and a statistically significant κ is most likely associated with CVMR. The latter case is likely to be most problematic as it could also be CVV but in this case more weight should be given to the GNR test.

We modify our Monte Carlo design to include Breusch-Pagan (1979) and Cook-Weisberg (1983) (BP) and White (1980) to see if any useful insight could be gather from using these test. As was expected these test for heteroskedasticity confirm the presence of heteroskedasticity under both CVV and CVMR assumptions considered; however, we observe significantly large differences in the test statistic under each assumption. The test static for White's test is on average 7-9 times larger with the assumption of CVMR errors than with CCV errors and BP is 9-15 times larger with the assumption of CVMR errors than CCV errors. These sizable differences between the test statistics across error structures provide some hints about the extent of the heteroskedasticity, but more importantly is that as the variance of the regression increases proportionally to the conditional mean, the test statistic of both White and BP increases. These test results are summarised in Table 2.11.

Figure 2.5 below summarises our main findings in this chapter and gives a general approach for estimating the gravity equation; however, as more research on the topic become available, this general approach should be modified to reflect these new insights.

Table 2.11: Summary Statistics for Heteroskedasticity Tests using Head and Mayer (2014) Structural Gravity Simulations (25% missing/zero trade flow)

Het. Test	**Mean**	**Std. Dev.**	**Min**	**Max**
		Log-normal		
MaMu	2.10	0.01	2.07	2.12
White	340.85	41.09	230.91	473.31
BP	345.69	42.60	239.28	490.32
		Poisson-type		
MaMu	1.60	0.01	1.58	1.62
White	2498.18	67.33	2306.53	2696.91
BP	4052.18	114.72	3649.18	4485.94

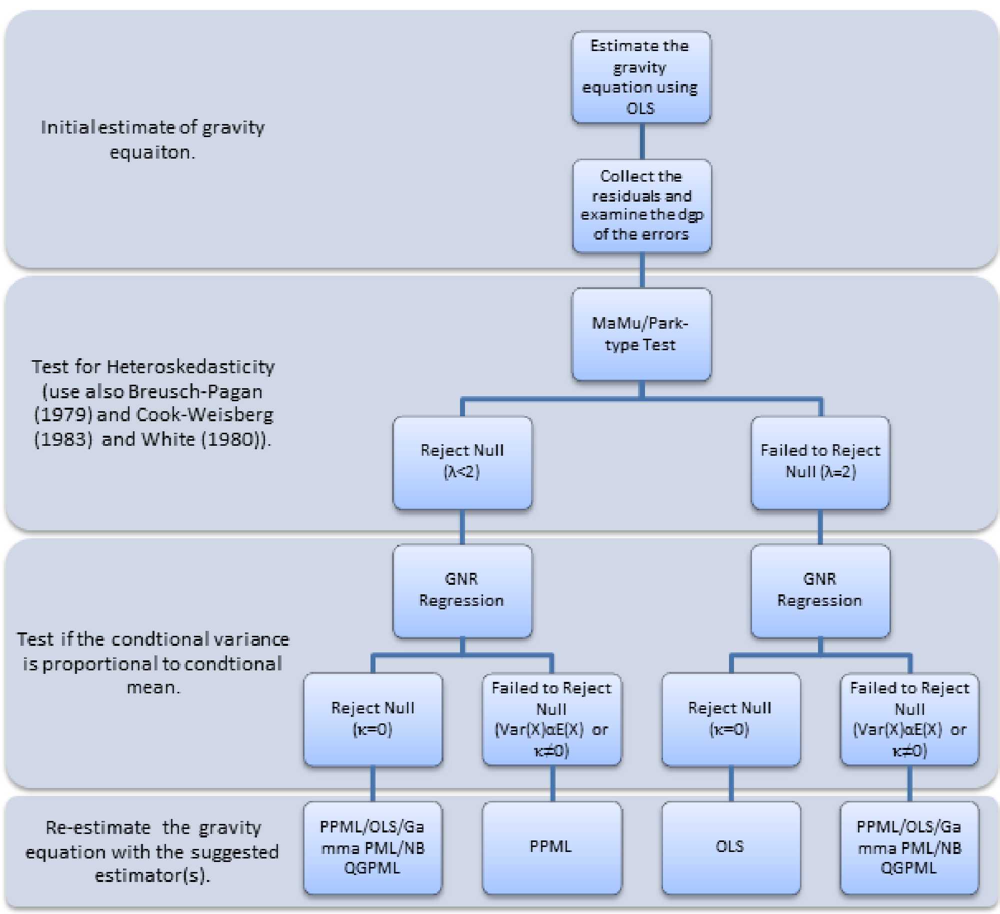

Figure 2.5: Summary of The Procedure for Estimating the Gravity Equation

2.5 Conclusion and Recommendations

The sets of experiments considered in this chapter have shed some light on how best to estimate the gravity equation. This chapter builds on the work of Santos Silva and Tenreyro (2006) and Head and Mayer (2014) in providing guidance to identifying the dgp of the errors and hence selecting the most appropriate estimator. It also gives insights into the potential implications of non-random sampling of exporters on the coefficients estimated from the gravity equation as well as the implications of violating the assumption that the conditional mean of the gravity model follows from a constant elasticity model.

The starting point for estimating a gravity model is selecting the appropriate sample. We find that, although non-random sampling of the exporters by income and regional groupings could have implications for the estimates of the gravity model, the greatest threat to correctly estimating the gravity model is not identifying the dgp of the errors. Subsequent to selecting a sample, whether random or non-random, the first step should involve identifying the dgp of the errors. Understanding the data generating process of the errors is important in deciding on the most appropriate estimator and hence minimizing the bias in the estimates of the gravity equation. The use of the MaMu/Park-type test and GNR test, which have opposing null hypothesis, should aid this process.

We find that under the null hypothesis of $\lambda > 2$, which corresponds to log-normal/CVV errors, the MaMu/Park-type test is most likely to fail to reject the null hypothesis if the null is true; whereas, under the null hypothesis that the variance is proportional to the conditional mean (CVMR) the GNR test is most likely to fail to reject the null hypothesis if the null is true. Combining these two tests could lead to the identification of the dgp of the errors especially if both tests point to the same conclusion.

The limitation to using these tests are that if they are contradicting each other then identification of the dgp of the errors may not be possible. Our recommendation would be that the Breusch-Pagan (1979) and Cook-Weisberg (1983) and or White's test for heteroskedasticity be used to identify the extent of heteroskedasticity and subsequently the gravity equation should be estimated using several of the competing estimators discussed here, among others, and their coefficients compared. This practice is also recommended even when both tests point to a specific dgp of the errors.

Once the dgp of the errors has been identified, selecting the most appropriate estimator is easy. If the errors resemble 'Poisson-type' then PPML or the class of NB QGPML estimators considered in this experiment are least biased and should be used to estimated the gravity model. With 'Poisson-type' errors, the Poisson PML and NB QGPML are least biased. Additionally, if the error are 'Poisson-type' the estimates for the gravity equation by Poisson PML are not significantly affected by non-random sampling of the exporters by income and regional groupings; however, the estimates by OLS and Gamma PML can be significantly distorted. Our recommendation is that if the dgp of the errors are 'Poisson-type' both Poisson PML and NB QGPML estimators should be used to estimated gravity model. Although the Poisson PML is robust to changes in the heteroskedastic parameter, the class NB QGPML estimators considered can be used to estimated the gravity model, if not as the first choice for comparison, especially when the data generating process of the errors resembles a constant variance to mean ratio and there is the possibility of increased nuisance given the number of randomly missing/zero trade flows.

With log-normal/CVV errors, OLS is least biased. Additionally, if the gravity equation is estimated using OLS when the errors are log-normal and non-random subsamples are drawn from the same income grouping the biases are smaller than the bias for all 170 countries. This points to two possible sources of the bias observed for the entire sample, namely: 1. greater heteroskedasticity; and, 2. greater exporters' heterogeneity. One way to overcome this problem, especially with the case of log-normal errors, is to estimate the gravity equation using quantile regressions. With non-random samples and log-normal errors, the Gamma PML is also still less biased and the sub-sample biases are not significantly affected by non-random sampling; whereas, the sub-sample biases for Poisson PML are significantly large.

Generally, GLMs have their advantages in estimating the gravity equation especially because they are not susceptible to heteroskedasticity and other sources of nuisance; however, they are dependent on the assumption that the conditional mean is correctly specified. This assumption is aligned with the gravity equations put forward by theories of international trade, which assume constant elasticities. However, with evidence mounting, albeit weak at the moment, that trade costs might not be constant across the distribution of global trade. The implications of doing away with such an assumption would discredit several gravity estimates irrespective of the estimator used, the error structure and the number of missing/zero trade flows. One possible candidate for estimating the gravity model if the assumption of constant trade cost changes to allow for heterogeneity trade cost is quantile regressions. This chapter show that a violation of the constant conditional mean assumption causes the Poisson PML and NB QGPML to produce estimates that are closer to, or below, the coefficient associated with the lower end of the distribution; whereas, the OLS and Gamma PML exhibit significant upward bias with an estimate above the coefficient associated with the upper end of the distribution.

Although, this chapter as well as Baltagi and Egger (2015) among others, demonstrate how the gravity equation could be estimated using quantile regressions and explore the implications of heterogeneity trade costs, further research is needed to ascertain its suitability and under what conditions. For example, the quantile regressions were not simulated on the CVV and CVMR errors used in this chapter. This, along with research related to panel data gravity models, qunatile panel data gravity models and spatial econometrics techniques for estimating the gravity model, are future research topics that will be explored.

2.6 Appendix

2.6.1 Annex A: Bias, RMSE and Standard Errors of the Competing Estimators with 1% and 25% Missing Trade Flow

Table 2.12: Bias, RMSE and Standard Errors of the Competing Estimators with 1% Missing Trade Flow

	$\hat{\beta}_{ldist}$			$\hat{\beta}_{rta}$		
Method	% Bias	RMSE	S.E.	% Bias	RMSE	S.E.
	Log-Normal Errors					
OLS	-1.9588	1.9589	0.0201	7.1272	7.1274	0.0552
GPML	-0.1628	0.1672	0.0288	0.5059	0.5169	0.0795
PPML	-27.2061	27.2065	0.1098	-43.2933	43.2954	0.2727
$NEGBI^{GLM}_{OLS}$	-27.0961	27.0965	0.1055	-42.4567	42.4586	0.2668
UNION1	-27.1792	27.1796	0.1075	-42.4121	42.4140	0.2701
$NEGBI^{GLM}_{WLS}$	-18.0115	18.0117	0.0612	-23.4494	23.4502	0.1553
UNION2	-18.0115	18.0117	0.0612	-23.4494	23.4502	0.1553
	Poisson-type Errors					
OLS	34.4908	34.4908	0.0172	-13.3935	13.3935	0.0474
GPML	6.4604	6.4605	0.0212	-11.8296	11.8298	0.0476
PPML	0.0007	0.0027	0.0023	0.0310	0.0316	0.0056
$NEGBI^{GLM}_{OLS}$	0.0008	0.0027	0.0024	0.0331	0.0337	0.0056
UNION1	0.0010	0.0028	0.0023	0.0326	0.0332	0.0056
$NEGBI^{GLM}_{WLS}$	0.0005	0.0026	0.0023	0.0318	0.0325	0.0056
UNION2	0.0007	0.0027	0.0023	0.0315	0.0321	0.0056

Table 2.13: Bias, RMSE and Standard Errors of the Competing Estimators with 25% Missing Trade Flow

	$\hat{\beta}_{ldist}$			$\hat{\beta}_{rta}$		
Method	% Bias	RMSE	S.E.	% Bias	RMSE	S.E.
	Log-Normal Errors					
OLS	-18.7306	18.7306	0.0207	27.1775	27.1776	0.0542
GPML	5.2659	5.2661	0.0312	-16.6561	16.6565	0.0828
PPML	-27.2057	27.2061	0.1098	-43.2953	43.2974	0.2727
$NEGBI_{OLS}^{GLM}$	-27.0957	27.0961	0.1055	-42.4585	42.4603	0.2668
UNION1	-27.1788	27.1791	0.1075	-42.4139	42.4158	0.2701
$NEGBI_{WLS}^{GLM}$	-18.0101	18.0103	0.0612	-23.4517	23.4525	0.1553
UNION2	-18.0101	18.0103	0.0612	-23.4517	23.4525	0.1553
	Poisson-type Errors					
OLS	7.3556	7.3556	0.0140	38.7307	38.7307	0.0365
GPML	10.0685	10.0686	0.0234	-23.0680	23.0681	0.0513
PPML	0.0013	0.0029	0.0023	0.0282	0.0289	0.0056
$NEGBI_{OLS}^{GLM}$	0.0014	0.0029	0.0024	0.0304	0.0311	0.0056
UNION1	0.0016	0.0030	0.0023	0.0299	0.0306	0.0056
$NEGBI_{WLS}^{GLM}$	0.0010	0.0028	0.0023	0.0291	0.0298	0.0056
UNION2	0.0013	0.0029	0.0023	0.0288	0.0295	0.0056

2.6.2 Annex B: Bias and RMSE of the Competing Estimators with Non-Random Sampling based on World Bank Income and Geographic/Regional Classification and 1% Missing Trade Flows

Table 2.14: Bias and RMSE of the Competing Estimators with Non-Random Sampling based on World Bank Income Classification and 1% Missing Trade Flows

				$\hat{\beta}_{ldist}$					
	GPML			**OLS**			**PPML**		
	% Bias	**RMSE**	**SE**	**% Bias**	**RMSE**	**SE**	**% Bias**	**RMSE**	**SE**
				Log-Normal					
Total	-0.1628	0.1672	0.0288	-1.9588	1.9589	0.0201	-27.2061	27.2065	0.1098
High Income	-0.4701	0.4793	0.0626	-0.3948	0.3990	0.0589	-30.2298	30.2306	0.1693
Upper Middle Income	-0.0359	0.0784	0.0490	-1.0434	1.0443	0.0458	-22.2321	22.2343	0.2012
Lower Middle Income	-0.2360	0.2453	0.0475	-0.9990	0.9999	0.0432	-23.4967	23.5000	0.2096
Lower Income	0.0427	0.1114	0.0681	-0.6556	0.6588	0.0650	-17.2237	17.2268	0.2234
				Poisson					
Total	6.4604	6.4605	0.0212	34.4908	34.4908	0.0172	0.0007	0.0027	0.0023
High Income	5.9184	5.9186	0.0313	24.6820	24.6820	0.0365	-0.0102	0.0114	0.0046
Upper Middle Income	9.1040	9.1041	0.0318	34.0244	34.0244	0.0349	0.0343	0.0357	0.0091
Lower Middle Income	8.7349	8.7351	0.0340	34.6244	34.6244	0.0348	-0.0004	0.0121	0.0109
Lower Income	12.1586	12.1589	0.0536	39.3906	39.3906	0.0560	0.0606	0.0733	0.0387
				$\hat{\beta}_{rta}$					
	GPML			**OLS**			**PPML**		
	% Bias	**RMSE**	**SE**	**% Bias**	**RMSE**	**SE**	**% Bias**	**RMSE**	**SE**
				Log-Normal					
Total	0.5059	0.5169	0.0795	7.1272	7.1274	0.0552	-43.2933	43.2954	0.2727
High Income	-1.1646	1.1861	0.1495	0.5043	0.5226	0.1406	-37.7502	37.7541	0.3879
Upper Middle Income	-0.6776	0.6990	0.1226	3.0838	3.0857	0.1138	-34.5397	34.5436	0.3789
Lower Middle Income	0.5100	0.5484	0.1394	2.7237	2.7267	0.1253	-3.6262	3.6670	0.4251
Lower Income	-0.8639	0.8999	0.1710	-1.4379	1.4468	0.1627	-17.6388	17.6555	0.4939
				Poisson					
Total	-11.8296	11.8298	0.0476	-13.3935	13.3935	0.0474	0.0310	0.0316	0.0056
High Income	-8.1617	8.1622	0.0694	-10.6270	10.6272	0.0872	0.1229	0.1234	0.0102
Upper Middle Income	-8.0872	8.0878	0.0677	-1.4364	1.4379	0.0867	-0.0274	0.0331	0.0166
Lower Middle Income	-1.8485	1.8518	0.0812	18.1304	18.1306	0.1010	0.0527	0.0594	0.0253
Lower Income	12.5728	12.5742	0.1323	43.4807	43.4809	0.1403	-0.8030	0.8092	0.0862

Table 2.15: Bias and RMSE of the Competing Estimators with Non-Random Sampling based on World Bank Geographic/Regional Classification and 1% Missing Trade Flows

	$\hat{\beta}_{ldist}$								
	GPML			**OLS**			**PPML**		
	% Bias	**RMSE**	**SE**	**% Bias**	**RMSE**	**SE**	**% Bias**	**RMSE**	**SE**
	Log-Normal								
Total	-0.1628	0.1672	0.0288	-1.9588	1.9589	0.0201	-27.2061	27.2065	0.1098
Latin America & Caribbean	-0.3080	0.3485	0.1070	-1.9921	1.9949	0.1046	-21.9197	21.9374	0.4036
Europe & Central Asia	-0.1732	0.2263	0.0967	-0.0090	0.1000	0.0972	-16.8592	16.8659	0.3327
Sub-Saharan Africa	-0.3704	0.3895	0.0840	-1.3775	1.3795	0.0774	-13.6324	13.6430	0.3276
Industrial	-0.1522	0.2004	0.0860	-0.0048	0.0864	0.0889	-30.9543	30.9554	0.1926
	Poisson								
Total	6.4604	6.4605	0.0212	34.4908	34.4908	0.0172	0.0007	0.0027	0.0023
Latin America & Caribbean	14.6510	14.6514	0.0768	43.1633	43.1634	0.0872	0.0725	0.0759	0.0189
Europe & Central Asia	7.2804	7.2808	0.0528	28.8907	28.8907	0.0700	0.0533	0.0578	0.0208
Sub-Saharan Africa	12.7515	12.7519	0.0698	42.7739	42.7740	0.0661	0.1309	0.1398	0.0451
Industrial	3.9142	3.9145	0.0349	15.9813	15.9813	0.0463	-0.0092	0.0108	0.0051
	$\hat{\beta}_{rta}$								
	GPML			**OLS**			**PPML**		
	% Bias	**RMSE**	**SE**	**% Bias**	**RMSE**	**SE**	**% Bias**	**RMSE**	**SE**
	Log-Normal								
Total	0.5059	0.5169	0.0795	7.1272	7.1274	0.0552	-43.2933	43.2954	0.2727
Latin America & Caribbean	0.9482	0.9758	0.1611	6.3282	6.3300	0.1568	-33.1832	33.1907	0.4469
Europe & Central Asia	-0.1828	0.2684	0.1284	-0.4105	0.4298	0.1286	-23.8157	23.8252	0.4233
Sub-Saharan Africa	-0.6823	0.7210	0.1586	0.3004	0.3324	0.1446	-27.5026	27.5172	0.4032
Industrial	-1.5464	1.5738	0.1913	-1.2243	1.2409	0.1978	-35.7181	35.7229	0.4129
	Poisson								
Total	-11.8296	11.8298	0.0476	-13.3935	13.3935	0.0474	0.0310	0.0316	0.0056
Latin America & Caribbean	-20.2209	20.2215	0.1037	-24.3151	24.3153	0.1307	-0.0429	0.0504	0.0238
Europe & Central Asia	2.1245	2.1264	0.0680	18.2686	18.2688	0.0926	-0.1553	0.1575	0.0228
Sub-Saharan Africa	3.9022	3.9059	0.1179	32.0730	32.0732	0.1236	-0.0732	0.0881	0.0423
Industrial	1.8087	1.8105	0.0642	11.0785	11.0787	0.1031	0.1236	0.1242	0.0106

2.6.3 Annex C: Scale/unit of measurement (in)dependence of the Negative Binomial and Mis-specification of the conditional mean and the Competing Estimators with 1% Missing Trade Flow

Table 2.16: Shows the scale/unit of measurement (in)dependence of the Negative Binomial estimates of the Gravity Model, 2006.

Dependent Variable: Exports	PPML	NEGBIREG			NEGBIHMR			$NEGBI_{OLS}^{GLM}$			$NEGBI_{WLS}^{GLM}$			GPML
Unit of Measurement	US$Mn	US$Bn	US$Mn	US$'000	US$Bn	US$Mn	US$'000	US$Bn	US$Mn	US$'000	US$Bn	US$Mn	US$'000	US$Mn
main														
Log Distance	-0.806***	-1.086***	-1.544***	-1.763***	-1.039***	-1.543***	-1.763***	-0.806***	-0.806***	-0.806***	-1.016***	-1.016***	-1.016***	-1.833***
	(-22.53)	(-36.24)	(-54.40)	(-50.87)	(-31.81)	(-54.50)	(-50.87)	(-22.54)	(-22.54)	(-22.54)	(-29.58)	(-29.58)	(-29.58)	(-50.98)
RTA	0.443***	0.206***	0.0636	0.0377	0.242***	0.0638	0.0377	0.442***	0.442***	0.442***	0.259***	0.259***	0.259***	-0.0104
	(5.90)	(4.43)	(1.22)	(0.57)	(4.89)	(1.22)	(0.57)	(5.89)	(5.89)	(5.89)	(5.04)	(5.04)	(5.04)	(-0.15)
Contiguity	0.383***	0.505***	0.795***	0.833***	0.444***	0.793***	0.833***	0.382***	0.382***	0.382***	0.422***	0.422***	0.422***	0.797***
	(6.07)	(7.51)	(8.37)	(6.71)	(6.78)	(8.37)	(6.71)	(6.07)	(6.07)	(6.07)	(6.43)	(6.43)	(6.43)	(6.27)
Colony	0.0956	0.399***	0.521***	0.540***	0.389***	0.523***	0.540***	0.0963	0.0963	0.0963	0.376***	0.376***	0.376***	0.553***
	(1.05)	(5.40)	(5.53)	(4.76)	(5.05)	(5.56)	(4.76)	(1.06)	(1.06)	(1.06)	(4.71)	(4.71)	(4.71)	(4.73)
Common Language	0.220**	0.231***	0.385***	0.287***	0.191***	0.384***	0.287***	0.220**	0.220**	0.220**	0.179***	0.179***	0.179***	0.263***
	(3.17)	(4.50)	(7.02)	(4.45)	(3.64)	(7.04)	(4.45)	(3.18)	(3.18)	(3.18)	(3.32)	(3.32)	(3.32)	(4.01)
Common Colonizer	0.138	0.588***	0.732***	0.909***	0.502***	0.733***	0.909***	0.138	0.138	0.138	0.459***	0.459***	0.459***	0.943***
	(0.83)	(5.37)	(10.32)	(10.93)	(4.41)	(10.35)	(10.93)	(0.83)	(0.83)	(0.83)	(3.92)	(3.92)	(3.92)	(11.12)
Colony after 1945	0.225	0.653***	0.969***	1.160***	0.598***	0.937***	1.160***	0.225	0.225	0.225	0.574***	0.574***	0.574***	1.284***
	(1.15)	(5.89)	(6.24)	(6.41)	(5.14)	(6.31)	(6.41)	(1.15)	(1.15)	(1.15)	(4.63)	(4.63)	(4.63)	(6.81)
Constant	-16.45***	-7.814***	-4.0e+09***	11.52***	-8.086***	-9.7e+06	11.52***	-9.542***	-2.634***	4.273***	-8.222***	-1.314*	5.594***	-8.967***
	(-25.34)	(-14.00)	(-760.89)	(17.80)	(-14.31)	(-1.82)	(17.80)	(-14.70)	(-4.06)	(6.58)	(-14.42)	(-2.31)	(9.81)	(-14.83)
N	22588	22588	22588	22588	22588	22588	22588	22588	22588	22588	22588	22588	22588	22588
Fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes		

Notes:

t statistics in parentheses and standard errors are clustered at the country-pair level.

***denotes significance at the 0.1 percent, **denotes 1 percent, and *denotes 0.5 percent

Exporter and importer fixed effects are not reported.

Table 2.17: Mis-specification of the conditional mean and the Competing Estimators with 1% Missing Trade Flow

1% Missing Trade Flow	Distance			RTA		
Method	$\bar{\hat{\beta}}_{ldist}$	$\bar{\hat{\beta}}_{ldist} - \bar{\beta}_{ldist}$	S.E.	$\bar{\hat{\beta}}_{rta}$	$\bar{\hat{\beta}}_{rta} - \bar{\beta}_{rta}$	S.E.
Log-normal						
OLS	-1.902321	0.752321	0.029082	0.481588	-0.018412	0.069829
GPML	-1.953461	0.803461	0.038141	0.533502	0.033502	0.091979
PPML	-0.553177	-0.596823	0.144255	0.280950	-0.219050	0.302417
$NEGBI_{OLS}^{GLM}$	-0.572777	-0.577223	0.126253	0.307415	-0.192585	0.266350
UNION1	-0.567610	-0.582390	0.133755	0.284351	-0.215649	0.281496
$NEGBI_{WLS}^{GLM}$	-0.721772	-0.428228	0.080840	0.356312	-0.143688	0.173637
UNION2	-0.721772	-0.428228	0.080840	0.356312	-0.143688	0.173637
Poisson						
OLS	-2.693507	1.543507	0.035418	0.445579	-0.054421	0.078172
GPML	-2.180477	1.030477	0.036845	0.491516	-0.008484	0.077628
PPML	-0.805340	-0.344661	0.003749	0.520441	0.020441	0.008516
$NEGBI_{OLS}^{GLM}$	-0.807352	-0.342648	0.004631	0.529264	0.029264	0.010979
UNION1	-0.806271	-0.343729	0.004226	0.525422	0.025422	0.009853
$NEGBI_{WLS}^{GLM}$	-0.804807	-0.345193	0.004411	0.529321	0.029321	0.010561
UNION2	-0.804817	-0.345183	0.004410	0.529287	0.029287	0.010558

2.6.4 Annex D: Bias, RMSE and Standard Errors of the Competing Estimators with 5% missing trade flow for selected Heteroskedastic Parameter (w)

Table 2.18: Bias, RMSE and Standard Errors of the Competing Estimators with 5% missing trade flow for selected Heteroskedastic Parameter (w)

Heteroskedastic Parameter		% Bias		RMSE		Standard Error (SE)		**% Bias SE**	
w	**Method**	$\hat{\beta}_{ldist}$	$\hat{\beta}_{rta}$	$\hat{\beta}_{ldist}$	$\hat{\beta}_{rta}$	$\hat{\beta}_{ldist}$	$\hat{\beta}_{rta}$	$\hat{\beta}_{ldist}$	$\hat{\beta}_{rta}$
	GPML	64.257	-130.260	64.257	130.260	0.035	0.071	1319.952	1676.037
	OLS	-11.897	8.988	11.897	8.988	0.012	0.030	7574.132	10564.380
	PPML	-9.014	-21.101	9.014	21.103	0.061	0.160	454.174	434.522
0	$NEGBI^{GLM}_{OLS}$	-8.975	-19.308	8.975	19.310	0.059	0.157	462.402	453.305
	UNION1	-8.982	-19.294	8.982	19.295	0.060	0.159	454.191	443.968
	$NEGBI^{GLM}_{WLS}$	-4.743	-5.975	4.743	5.976	0.033	0.085	976.914	983.491
	UNION2	-4.743	-5.975	4.743	5.976	0.033	0.085	976.914	983.491
	GPML	35.810	-82.827	35.810	82.827	0.033	0.067	1792.126	2363.654
	OLS	-6.743	23.317	6.743	23.317	0.010	0.026	12407.990	12595.200
	PPML	0.017	-0.043	0.017	0.043	0.002	0.004	1817.622	1721.691
50	$NEGBI^{GLM}_{OLS}$	0.017	-0.040	0.017	0.040	0.002	0.004	1857.047	1764.020
	UNION1	0.017	-0.040	0.017	0.040	0.002	0.004	1828.859	1729.213
	$NEGBI^{GLM}_{WLS}$	0.017	-0.040	0.017	0.040	0.002	0.004	1862.369	1785.463
	UNION2	0.017	-0.040	0.017	0.040	0.002	0.004	1814.798	1722.936
	GPML	36.501	-83.865	36.501	83.865	0.035	0.073	1885.154	2393.295
	OLS	-6.876	27.675	6.876	27.675	0.012	0.030	12919.630	13160.380
	PPML	0.017	-0.053	0.017	0.054	0.002	0.006	1737.129	1744.524
100	$NEGBI^{GLM}_{OLS}$	0.019	-0.056	0.019	0.056	0.002	0.006	1759.304	1765.553
	UNION1	0.019	-0.056	0.019	0.056	0.002	0.006	1734.024	1738.452
	$NEGBI^{GLM}_{WLS}$	0.019	-0.055	0.019	0.055	0.002	0.006	1764.314	1777.180
	UNION2	0.019	-0.054	0.019	0.055	0.002	0.006	1724.489	1727.167
	GPML	36.837	-83.028	36.837	83.028	0.037	0.076	1891.446	2271.486
	OLS	-7.045	30.280	7.045	30.280	0.013	0.032	12747.580	13050.950
	PPML	0.010	-0.049	0.011	0.050	0.003	0.007	1852.731	1784.037
150	$NEGBI^{GLM}_{OLS}$	0.008	-0.037	0.008	0.038	0.003	0.007	1854.997	1784.369
	UNION1	0.007	-0.037	0.008	0.038	0.003	0.007	1825.483	1756.338
	$NEGBI^{GLM}_{WLS}$	0.007	-0.036	0.008	0.037	0.003	0.007	1849.026	1781.812
	UNION2	0.007	-0.037	0.008	0.038	0.003	0.007	1825.833	1753.031
	GPML	37.276	-82.408	37.276	82.408	0.038	0.078	1883.108	2414.745
	OLS	-7.084	32.106	7.084	32.106	0.014	0.034	12599.030	12569.370
	PPML	0.014	-0.053	0.015	0.054	0.003	0.008	1744.713	1731.340
200	$NEGBI^{GLM}_{OLS}$	0.018	-0.049	0.018	0.049	0.003	0.008	1738.117	1724.306
	UNION1	0.018	-0.049	0.018	0.049	0.003	0.008	1712.733	1703.334
	$NEGBI^{GLM}_{WLS}$	0.018	-0.049	0.018	0.050	0.003	0.008	1721.504	1700.380
	UNION2	0.017	-0.049	0.018	0.050	0.003	0.008	1707.562	1686.108

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Table 2.18 continued from previous page.

Heteroskedastic Parameter		% Bias		RMSE		Standard Error (SE)		**% Bias SE**	
w	**Method**	$\hat{\beta}_{ldist}$	$\hat{\beta}_{rta}$	$\hat{\beta}_{ldist}$	$\hat{\beta}_{rta}$	$\hat{\beta}_{ldist}$	$\hat{\beta}_{rta}$	$\hat{\beta}_{ldist}$	$\hat{\beta}_{rta}$
	GPML	37.636	-82.758	37.636	82.758	0.038	0.080	1726.926	2368.860
	OLS	-7.266	33.506	7.266	33.506	0.014	0.035	12171.210	12208.830
	PPML	-0.003	0.032	0.005	0.034	0.004	0.009	1726.496	1705.047
250	$NEGBI_{OLS}^{GLM}$	-0.004	0.035	0.006	0.036	0.004	0.009	1752.828	1729.544
	UNION1	-0.004	0.035	0.006	0.037	0.004	0.009	1732.097	1708.603
	$NEGBI_{WLS}^{GLM}$	-0.004	0.032	0.006	0.033	0.004	0.009	1731.987	1687.447
	UNION2	-0.004	0.032	0.006	0.034	0.004	0.009	1719.656	1673.311
	GPML	38.407	-83.695	38.407	83.695	0.039	0.082	1783.975	2433.228
	OLS	-7.332	34.336	7.332	34.336	0.015	0.036	12800.600	12751.910
	PPML	0.019	-0.061	0.019	0.062	0.004	0.010	1713.778	1766.934
300	$NEGBI_{OLS}^{GLM}$	0.019	-0.042	0.020	0.044	0.004	0.010	1737.686	1774.799
	UNION1	0.019	-0.042	0.020	0.044	0.004	0.010	1712.381	1752.503
	$NEGBI_{WLS}^{GLM}$	0.019	-0.045	0.020	0.046	0.004	0.010	1725.531	1747.838
	UNION2	0.019	-0.045	0.020	0.046	0.004	0.010	1715.193	1737.788
	GPML	38.163	-80.721	38.163	80.722	0.039	0.083	1845.111	2512.237
	OLS	-7.456	35.616	7.456	35.616	0.015	0.037	12638.920	12744.960
	PPML	0.021	-0.081	0.021	0.082	0.004	0.010	1746.185	1773.557
350	$NEGBI_{OLS}^{GLM}$	0.021	-0.080	0.022	0.081	0.004	0.010	1776.785	1804.558
	UNION1	0.021	-0.081	0.021	0.082	0.004	0.010	1751.332	1773.896
	$NEGBI_{WLS}^{GLM}$	0.022	-0.076	0.023	0.077	0.004	0.010	1762.703	1765.235
	UNION2	0.022	-0.077	0.023	0.078	0.004	0.010	1754.452	1752.241
	GPML	38.091	-80.451	38.091	80.451	0.040	0.084	1816.791	2537.777
	OLS	-7.629	36.500	7.629	36.500	0.016	0.038	13238.130	13483.590
	PPML	0.027	0.005	0.027	0.013	0.005	0.011	1721.687	1662.866
400	$NEGBI_{OLS}^{GLM}$	0.028	0.004	0.028	0.012	0.005	0.011	1752.078	1697.870
	UNION1	0.027	0.005	0.028	0.012	0.005	0.011	1730.299	1664.255
	$NEGBI_{WLS}^{GLM}$	0.029	0.010	0.029	0.015	0.005	0.011	1740.349	1677.325
	UNION2	0.028	0.011	0.029	0.016	0.005	0.011	1736.921	1671.946
	GPML	38.623	-81.793	38.623	81.793	0.040	0.086	1880.701	2517.845
	OLS	-7.704	36.893	7.704	36.893	0.016	0.039	13098.750	13484.180
	PPML	0.027	-0.047	0.028	0.048	0.005	0.012	1654.716	1678.066
450	$NEGBI_{OLS}^{GLM}$	0.028	-0.048	0.028	0.050	0.005	0.012	1681.060	1704.359
	UNION1	0.027	-0.047	0.028	0.049	0.005	0.012	1658.703	1680.722
	$NEGBI_{WLS}^{GLM}$	0.028	-0.044	0.029	0.046	0.005	0.012	1672.790	1666.012
	UNION2	0.029	-0.045	0.029	0.046	0.005	0.012	1666.123	1657.417

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Table 2.18 continued from previous page.

Heteroskedastic Parameter		% Bias		RMSE		Standard Error (SE)		**% Bias SE**	
w	**Method**	$\hat{\beta}_{ldist}$	$\hat{\beta}_{rta}$	$\hat{\beta}_{ldist}$	$\hat{\beta}_{rta}$	$\hat{\beta}_{ldist}$	$\hat{\beta}_{rta}$	$\hat{\beta}_{ldist}$	$\hat{\beta}_{rta}$
500	GPML	38.595	-81.718	38.596	81.718	0.040	0.086	1842.385	2294.154
	OLS	-7.819	37.273	7.819	37.273	0.016	0.040	12767.900	13205.400
	PPML	0.010	-0.026	0.012	0.030	0.005	0.012	1780.595	1731.819
	$NEGBI_{OLS}^{GLM}$	0.011	-0.025	0.012	0.029	0.005	0.012	1804.047	1752.618
	UNION1	0.011	-0.025	0.013	0.029	0.005	0.012	1779.227	1728.649
	$NEGBI_{WLS}^{GLM}$	0.010	-0.024	0.012	0.028	0.005	0.012	1799.496	1725.484
	UNION2	0.010	-0.024	0.012	0.028	0.005	0.012	1797.552	1721.294
1000	GPML	40.155	-80.660	40.155	80.660	0.043	0.093	1804.654	2499.103
	OLS	-8.584	40.533	8.584	40.533	0.018	0.044	12287.410	12559.630
	PPML	0.023	-0.027	0.024	0.033	0.007	0.017	1581.663	1613.819
	$NEGBI_{OLS}^{GLM}$	0.024	-0.025	0.025	0.032	0.007	0.017	1602.123	1631.837
	UNION1	0.024	-0.023	0.025	0.030	0.007	0.017	1584.902	1613.262
	$NEGBI_{WLS}^{GLM}$	0.023	-0.022	0.024	0.029	0.007	0.018	1614.103	1620.409
	UNION2	0.023	-0.021	0.024	0.029	0.007	0.018	1612.638	1619.566
1500	GPML	40.530	-78.698	40.530	78.699	0.044	0.096	1711.624	2418.441
	OLS	-9.333	41.864	9.333	41.864	0.019	0.047	11559.980	11865.700
	PPML	-0.009	0.172	0.013	0.174	0.009	0.021	1546.689	1579.725
	$NEGBI_{OLS}^{GLM}$	-0.008	0.168	0.013	0.169	0.009	0.021	1565.059	1603.306
	UNION1	-0.009	0.172	0.013	0.173	0.009	0.021	1548.519	1585.280
	$NEGBI_{WLS}^{GLM}$	-0.006	0.152	0.012	0.154	0.009	0.021	1582.035	1575.709
	UNION2	-0.006	0.152	0.012	0.154	0.009	0.021	1581.241	1575.000
2000	GPML	41.690	-79.495	41.690	79.495	0.045	0.099	1727.263	2487.137
	OLS	-9.703	41.791	9.703	41.791	0.020	0.049	11709.050	12284.660
	PPML	0.048	-0.055	0.049	0.061	0.010	0.024	1442.502	1546.954
	$NEGBI_{OLS}^{GLM}$	0.047	-0.061	0.048	0.066	0.010	0.024	1458.019	1567.347
	UNION1	0.047	-0.057	0.049	0.063	0.010	0.024	1444.736	1551.415
	$NEGBI_{WLS}^{GLM}$	0.044	-0.086	0.046	0.090	0.010	0.025	1483.281	1573.098
	UNION2	0.044	-0.086	0.046	0.090	0.010	0.025	1485.234	1573.190
2500	GPML	41.513	-76.599	41.513	76.599	0.046	0.101	1725.593	2472.465
	OLS	-10.208	42.454	10.208	42.454	0.021	0.050	11354.860	11881.480
	PPML	0.090	-0.044	0.091	0.053	0.011	0.027	1417.548	1483.125
	$NEGBI_{OLS}^{GLM}$	0.090	-0.051	0.090	0.059	0.011	0.027	1432.926	1507.631
	UNION1	0.090	-0.048	0.091	0.056	0.011	0.027	1418.810	1486.163
	$NEGBI_{WLS}^{GLM}$	0.088	-0.068	0.089	0.074	0.011	0.027	1472.096	1533.801
	UNION2	0.088	-0.068	0.089	0.074	0.011	0.027	1473.558	1533.866

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Table 2.18 continued from previous page.

Heteroskedastic Parameter		% Bias		RMSE		Standard Error (SE)		**% Bias SE**	
w	**Method**	$\hat{\beta}_{ldist}$	$\hat{\beta}_{rta}$	$\hat{\beta}_{ldist}$	$\hat{\beta}_{rta}$	$\hat{\beta}_{ldist}$	$\hat{\beta}_{rta}$	$\hat{\beta}_{ldist}$	$\hat{\beta}_{rta}$
3000	GPML	41.381	-75.067	41.381	75.067	0.046	0.102	1745.847	2439.144
	OLS	-10.648	42.721	10.648	42.721	0.021	0.052	11653.760	11651.610
	PPML	0.003	0.301	0.014	0.303	0.012	0.029	1372.371	1471.929
	$NEGBI^{GLM}_{OLS}$	0.003	0.280	0.014	0.282	0.012	0.029	1388.720	1487.320
	UNION1	0.002	0.296	0.014	0.298	0.012	0.029	1375.377	1472.066
	$NEGBI^{GLM}_{WLS}$	0.004	0.197	0.014	0.200	0.012	0.030	1434.626	1499.703
	UNION2	0.004	0.197	0.014	0.200	0.012	0.030	1434.626	1499.703
3500	GPML	42.128	-75.575	42.128	75.575	0.047	0.104	1747.176	2463.871
	OLS	-10.962	42.630	10.962	42.630	0.022	0.053	10936.940	11414.330
	PPML	0.066	-0.112	0.068	0.117	0.013	0.031	1367.421	1409.359
	$NEGBI^{GLM}_{OLS}$	0.065	-0.127	0.066	0.132	0.013	0.031	1382.408	1424.829
	UNION1	0.065	-0.119	0.067	0.124	0.013	0.031	1370.564	1412.665
	$NEGBI^{GLM}_{WLS}$	0.062	-0.190	0.064	0.193	0.013	0.032	1421.947	1423.025
	UNION2	0.062	-0.190	0.064	0.193	0.013	0.032	1421.947	1423.025
4000	GPML	42.149	-74.859	42.149	74.859	0.047	0.105	1762.167	2480.754
	OLS	-11.340	43.003	11.340	43.003	0.022	0.053	10648.050	11441.280
	PPML	0.145	-0.212	0.145	0.216	0.014	0.033	1328.881	1402.655
	$NEGBI^{GLM}_{OLS}$	0.143	-0.236	0.144	0.239	0.014	0.033	1339.843	1415.898
	UNION1	0.144	-0.220	0.145	0.224	0.014	0.033	1327.895	1401.003
	$NEGBI^{GLM}_{WLS}$	0.142	-0.294	0.143	0.297	0.014	0.034	1391.205	1436.672
	UNION2	0.142	-0.294	0.143	0.297	0.014	0.034	1391.205	1436.672
4500	GPML	42.573	-74.887	42.573	74.887	0.048	0.106	1752.540	2479.161
	OLS	-11.675	42.965	11.675	42.965	0.022	0.054	11290.790	11921.240
	PPML	0.114	-0.037	0.116	0.055	0.015	0.035	1278.487	1327.962
	$NEGBI^{GLM}_{OLS}$	0.113	-0.053	0.115	0.067	0.015	0.035	1290.523	1346.357
	UNION1	0.113	-0.043	0.114	0.059	0.015	0.035	1280.693	1332.268
	$NEGBI^{GLM}_{WLS}$	0.115	-0.102	0.116	0.109	0.015	0.036	1315.674	1367.306
	UNION2	0.115	-0.102	0.116	0.109	0.015	0.036	1315.674	1367.306
5000	GPML	42.607	-74.779	42.607	74.779	0.048	0.107	1705.751	2539.465
	OLS	-11.695	42.331	11.695	42.331	0.022	0.055	10713.040	11298.360
	PPML	0.052	0.106	0.054	0.114	0.015	0.037	1241.035	1328.349
	$NEGBI^{GLM}_{OLS}$	0.049	0.074	0.052	0.085	0.015	0.037	1251.579	1345.369
	UNION1	0.050	0.095	0.053	0.104	0.015	0.037	1243.023	1328.752
	$NEGBI^{GLM}_{WLS}$	0.041	-0.053	0.045	0.067	0.016	0.038	1288.120	1389.324
	UNION2	0.041	-0.053	0.045	0.067	0.016	0.038	1288.120	1389.322

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Table 2.18 continued from previous page.

Heteroskedastic Parameter		% Bias		RMSE		Standard Error (SE)		**% Bias SE**	
w	**Method**	$\hat{\beta}_{ldist}$	$\hat{\beta}_{rta}$	$\hat{\beta}_{ldist}$	$\hat{\beta}_{rta}$	$\hat{\beta}_{ldist}$	$\hat{\beta}_{rta}$	$\hat{\beta}_{ldist}$	$\hat{\beta}_{rta}$
	GPML	42.818	-74.427	42.818	74.427	0.048	0.108	1677.196	2471.284
	OLS	-12.018	41.845	12.018	41.845	0.023	0.055	10912.600	11162.160
	PPML	0.160	-0.360	0.161	0.362	0.016	0.038	1230.941	1350.337
5500	$NEGBI^{GLM}_{OLS}$	0.158	-0.399	0.159	0.401	0.016	0.038	1229.874	1340.176
	UNION1	0.160	-0.368	0.161	0.371	0.016	0.038	1228.849	1348.059
	$NEGBI^{GLM}_{WLS}$	0.162	-0.545	0.163	0.547	0.016	0.040	1285.213	1415.939
	UNION2	0.162	-0.545	0.163	0.547	0.016	0.040	1285.213	1415.939
	GPML	43.028	-75.861	43.028	75.861	0.048	0.108	1773.898	2581.324
	OLS	-12.454	42.231	12.454	42.231	0.023	0.056	11223.980	11298.280
	PPML	-0.005	0.234	0.020	0.238	0.017	0.040	1260.380	1400.057
6000	$NEGBI^{GLM}_{OLS}$	-0.008	0.212	0.020	0.217	0.017	0.040	1272.130	1414.229
	UNION1	-0.007	0.218	0.020	0.223	0.017	0.040	1264.135	1401.289
	$NEGBI^{GLM}_{WLS}$	-0.008	0.162	0.021	0.168	0.017	0.041	1316.268	1426.231
	UNION2	-0.008	0.162	0.021	0.168	0.017	0.041	1316.268	1426.231
	GPML	43.040	-73.094	43.040	73.094	0.049	0.109	1678.647	2451.500
	OLS	-12.491	41.439	12.491	41.439	0.023	0.057	10348.890	10943.500
	PPML	0.165	-0.059	0.166	0.075	0.017	0.041	1213.895	1308.140
6500	$NEGBI^{GLM}_{OLS}$	0.161	-0.084	0.163	0.096	0.017	0.041	1223.145	1327.461
	UNION1	0.163	-0.072	0.164	0.086	0.017	0.041	1214.336	1310.928
	$NEGBI^{GLM}_{WLS}$	0.152	-0.195	0.153	0.200	0.018	0.043	1268.770	1381.849
	UNION2	0.152	-0.195	0.153	0.200	0.018	0.043	1268.770	1381.849
	GPML	42.574	-71.606	42.574	71.606	0.049	0.110	1707.469	2453.340
	OLS	-12.767	41.702	12.767	41.702	0.023	0.057	10914.250	10995.140
	PPML	0.017	0.507	0.026	0.509	0.018	0.043	1184.186	1303.728
7000	$NEGBI^{GLM}_{OLS}$	0.015	0.462	0.025	0.464	0.018	0.043	1196.130	1317.581
	UNION1	0.015	0.492	0.025	0.495	0.018	0.043	1186.752	1304.898
	$NEGBI^{GLM}_{WLS}$	0.011	0.214	0.023	0.220	0.018	0.044	1244.705	1346.402
	UNION2	0.011	0.214	0.023	0.220	0.018	0.044	1244.705	1346.402
	GPML	43.333	-72.504	43.333	72.505	0.049	0.111	1689.458	2428.406
	OLS	-12.914	41.265	12.914	41.265	0.024	0.057	10223.560	10715.340
	PPML	0.117	-0.156	0.119	0.163	0.018	0.044	1195.233	1259.577
7500	$NEGBI^{GLM}_{OLS}$	0.112	-0.189	0.114	0.196	0.018	0.044	1205.354	1271.843
	UNION1	0.114	-0.172	0.116	0.179	0.018	0.044	1197.050	1262.144
	$NEGBI^{GLM}_{WLS}$	0.103	-0.376	0.105	0.379	0.019	0.046	1255.569	1289.198
	UNION2	0.103	-0.376	0.105	0.379	0.019	0.046	1255.569	1289.198

Continued on next page

Table 2.18 continued from previous page.

Heteroskedastic Parameter		% Bias		RMSE		Standard Error (SE)		**% Bias SE**	
w	**Method**	$\hat{\beta}_{ldist}$	$\hat{\beta}_{rta}$	$\hat{\beta}_{ldist}$	$\hat{\beta}_{rta}$	$\hat{\beta}_{ldist}$	$\hat{\beta}_{rta}$	$\hat{\beta}_{ldist}$	$\hat{\beta}_{rta}$
	GPML	43.207	-71.945	43.207	71.945	0.049	0.111	1705.064	2478.659
	OLS	-13.154	41.553	13.154	41.553	0.024	0.058	10177.720	11034.680
	PPML	0.218	-0.300	0.219	0.305	0.019	0.045	1184.531	1264.683
8000	$NEGBI_{OLS}^{GLM}$	0.214	-0.352	0.215	0.356	0.019	0.045	1188.268	1264.633
	UNION1	0.217	-0.309	0.218	0.313	0.019	0.045	1185.237	1266.605
	$NEGBI_{WLS}^{GLM}$	0.205	-0.532	0.206	0.534	0.019	0.047	1251.723	1307.386
	UNION2	0.205	-0.532	0.206	0.534	0.019	0.047	1251.723	1307.386
	GPML	43.489	-72.192	43.489	72.192	0.049	0.112	1757.166	2478.384
	OLS	-13.382	41.335	13.382	41.335	0.024	0.058	10505.960	11116.580
	PPML	0.174	-0.080	0.175	0.097	0.019	0.047	1131.384	1202.237
8500	$NEGBI_{OLS}^{GLM}$	0.171	-0.112	0.172	0.124	0.019	0.047	1139.207	1217.901
	UNION1	0.172	-0.092	0.173	0.106	0.019	0.047	1131.882	1205.631
	$NEGBI_{WLS}^{GLM}$	0.167	-0.275	0.169	0.280	0.020	0.048	1166.381	1256.254
	UNION2	0.167	-0.275	0.169	0.280	0.020	0.048	1166.381	1256.254
	GPML	43.517	-72.416	43.517	72.416	0.050	0.112	1673.814	2516.774
	OLS	-13.273	40.714	13.273	40.714	0.024	0.059	10216.980	10813.140
	PPML	0.083	0.133	0.086	0.143	0.020	0.048	1118.769	1211.959
9000	$NEGBI_{OLS}^{GLM}$	0.078	0.078	0.081	0.095	0.020	0.048	1126.423	1227.560
	UNION1	0.079	0.113	0.082	0.125	0.020	0.048	1120.185	1212.819
	$NEGBI_{WLS}^{GLM}$	0.059	-0.197	0.063	0.204	0.020	0.049	1163.198	1281.071
	UNION2	0.059	-0.197	0.063	0.204	0.020	0.049	1163.198	1281.071
	GPML	43.608	-71.956	43.608	71.957	0.050	0.112	1642.974	2445.694
	OLS	-13.530	40.271	13.530	40.271	0.024	0.059	10314.340	10543.460
	PPML	0.211	-0.422	0.212	0.426	0.020	0.049	1109.934	1241.523
9500	$NEGBI_{OLS}^{GLM}$	0.207	-0.478	0.208	0.482	0.020	0.049	1116.352	1255.973
	UNION1	0.209	-0.438	0.211	0.442	0.020	0.049	1108.368	1239.938
	$NEGBI_{WLS}^{GLM}$	0.205	-0.784	0.207	0.786	0.021	0.050	1166.680	1323.759
	UNION2	0.205	-0.784	0.207	0.786	0.021	0.050	1166.680	1323.759
	GPML	43.802	-73.927	43.802	73.928	0.050	0.113	1751.279	2560.973
	OLS	-13.874	40.642	13.874	40.642	0.024	0.059	10588.770	10825.830
	PPML	0.002	0.307	0.024	0.312	0.021	0.050	1148.781	1291.384
10000	$NEGBI_{OLS}^{GLM}$	-0.003	0.266	0.024	0.272	0.021	0.050	1158.772	1302.843
	UNION1	-0.001	0.281	0.024	0.287	0.021	0.050	1151.553	1292.129
	$NEGBI_{WLS}^{GLM}$	-0.010	0.111	0.026	0.124	0.021	0.052	1209.180	1320.452
	UNION2	-0.010	0.111	0.026	0.124	0.021	0.052	1209.180	1320.452

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Chapter 3

An Application of the Gravity Model to Trade among and with Caribbean Community (CARICOM)

The gravity model is widely used in international trade to examine trade flows within a network of exporters and importers. This chapter estimates a gravity model with special interest in trade among and with CARICOM members. A gravity model is estimated using the following estimators: (1) Pooled Ordinary Least Squares (OLS), (2) Least Squares Dummy Variable (LSDV) and (3) Poisson Pseudo-Maximum Likelihood (PPML). This chapter focuses on: (1) Regional Trade Agreement (RTA) decomposed into the common external tariff (CET) implement in 1993 and the Caribbean Single Market and Economy (CSME) implemented in 2006; and, (2) climatic natural disasters comprised of floods, droughts and tropical cyclones. This gives insight into whether CARICOM and associated policies, CET and CSME, are trade-creating or trade-diverging. Natural climatic disasters are a feature of the climatic conditions of the Caribbean and coupled with climate change these could have damming effects on trade among and with CARICOM members; therefore, this chapter also models the impact of climatic natural disasters on trade among CARICOM members and trade between CARICOM members and the rest of the world (ROW). From a methodological standpoint, this chapter departs from the usual cross-sectional data set and uses a panel framework for a period of over 30 years (1980-2012) to estimate the gravity equation. Keen attention is given to how the underlying assumptions about the multilateral resistance terms can distort the confidence in inferences made about the effects of trade costs and policies on international trade.

3.1 Introduction

As demonstrated in the previous chapter (Chapter 2) and the most recent literature on the gravity equation, most notably Santos Silva and Tenreyro (2006) and Head and Mayer (2014), there are several issues to consider when a researcher decides to utilize the gravity equation of international trade. Through broad literature reviews and simulations, we are now better able to decide on the most appropriate methodology to estimate the gravity equation. Here, we draw on these findings to guide our application of the gravity model to a regional and international network of trade.

In this chapter the gravity model is applied to international trade with special interest in the regional trade bloc of the Caribbean, hereafter referred to as CARICOM. CARICOM members are considered small open economies that are deeply entrenched in trade; however, the relative size of the economies to some of their major trade partners are significantly different. Therefore, while a gravity model set in a global context might predict that economic size and distance are important, for countries like those of CARICOM, the magnitude of the coefficients can be significantly different from the global estimates. Therefore, consideration must be given to region-specific heterogeneity and the likely significance of region-specific factors and policies that impact trade. While these region-specific factors and policies might seem insignificant in a global context they have striking importance at a regional level, especially in the context of small open economies. It is against this background that this chapter considers the impacts of: (1) CET, implemented on a phased basis after 1993; (2) CSME, signed in 2006 and current still being implemented; and (3) climatic natural disasters, in the form of tropical cyclones, flooding and droughts.

This research is timely as there have been recent calls from some members of CARICOM to review its institutions, frameworks and operations. One such member is Jamaica. On June 28, 2016, Jamaica's Prime Minister, Andrew Holness, launched a CARICOM Review Commission which is mandated: to evaluate the effects that Jamaica's participation in CARICOM has on its economic growth and development; analyze CARICOM's performance against the goals and objectives outlined in the revised Treaty of Chaguaramas, the treaty that established CARICOM, and to identify the causes of the shortcomings; assess the value of Jamaica's membership in CARICOM on its influence in critical international fora and with third state trade and development partners; and, assess whether the CARICOM dispute settlement provisions provide realistic options for settlement of disputes for Jamaica (CARICOM, 2016). This comes against the backdrop of growing discontent between Jamaica and Trinidad and Tobago about issues related to trade and migration. Additionally, the recent vote by the United Kingdom to exit the European Union has fueled further debate about the importance of regional trade agreements and, more broadly, the creation of regional single markets. This chapter contributes to this debate by considering whether trade policies, CET and CSME, implemented by CARICOM members are trade-creating or trade-diverging. Consideration is also given to other trade agreements signed by CARICOM members with third parties (Rest of the World (ROW)). In this chapter the effects of CARICOM are identified at a regional level rather than at a country level; however, in the next chapter we identify some welfare effects for individual members of CARICOM.

The Region[1] is vulnerable to climatic natural disasters, which continue to impede growth and development in The Region. This is, in part, related to the geographic location of The Region and the land mass/size of member states. Tropical cyclones are a permanent feature of the climatic conditions of the Caribbean and coupled with the impending impact of climate change, they could have far-reaching consequences for some of the major economic sectors and hence trade. Climatic natural disasters have the potential to disrupt the production, value chains, distribution and hence trade among and with CARICOM members. In this chapter the climatic natural disasters are assessed using a dummy variable approach by identifying the years CARICOM exporters were affected by a climatic natural disaster.

Following from findings in Chapter 2 and the recommendations of Santos Silva and Tenreyro (2006) and Head and Mayer (2014), on estimators and dealing with estimation issues related to heteroscedasticity and the large number of observed zero trade flow, several estimators, namely Pooled Ordinary Least Squares (OLS), Least Squares Dummy Variable (LSDV) and Poisson Pseudo-Maximum Likelihood (PPML), are utilized to estimate the gravity equation and robustness checks conducted. The datasets are comprised of trade among 13 of 15 members of CARICOM for the period 1980-2012 and trade among members of CARICOM and 57 major trade partners of CARICOM for the period 1980-2012.

Methodologically, this chapter demonstrates the importance of controlling for the multilateral resistances terms as well as how controlling for the multilateral resistance terms can limit the analysis. This paper contributes to the gravity literature by examining how parameter estimates and their economic and statistical significance change across estimators with selected 'sub-networks' of exporters and importers un-

[1]The Region here and thereafter refers to the Caribbean, more specifically countries that are members of CARICOM.

der different assumptions about the multilateral resistance terms controlled for using exporter, importer, time, exporter-time and importer-time fixed effects. It compares and contrast estimates of the gravity model for CARICOM and a subset of the global trade network considering region-specific factors and policies.

The main findings suggest that CARICOM as a trading block over the sample period increased exports among CARICOM members but there is no evidence of trade creation or divergence. CARICOM members trade 4 times more with each other than with the ROW. On the other hand, CET seems to have significantly impacted regional trade; however, it appears to have resulted in trade divergence as subsequent to the implementation of CET exports to, and import from, the ROW decreased significantly. CARICOM members market share in third party countries declined by between 140 to 197 percent. These finding suggest that this policy did not increase the competitiveness of CARICOM members but instead facilitated the reallocation of market shares from outside The Region to within. In contrast, subsequent to the implementation of CSME, the Region's trade with its major trade partners increased by between 22 to 26 percent; however, trade among CARICOM members have been negatively impacted. This suggest that subsequent to the implementation of CSME there was some reversal in the effects of the CET.

The distance between countries in The Region does have implications for how much trade can be achieved among members of CARICOM as geographic proximity does influence market power and the movement of goods; however, adopting a common currency could increase trade regionally. We find that bilateral pairs where both members have fixed exchange rate regimes trade 2.5 times more with each other than if one member has a flexible exchange rate regime. If both members had flexible exchange rate regimes the effect is not significantly different from that if only one member has a flexible exchange rate regime. Further research is needed to identify the welfare implications of adopting a common currency and to inform the next step in the integration process. Lastly, the impact of climatic natural disasters on exports are more pronounced at a regional level than in a global context. We find that if a CARICOM exporter is impacted by a climatic natural disaster, exports to other CARICOM members decrease by approximately 17 percent in the year of impact; however, this effect, although found to be negative, is insignificant when the total exports by CARICOM members are considered. This points to the vulnerability of the basket of goods traded regionally to climatic natural disasters when compared to goods traded with the ROW.

The rest of this chapter is organized as follows: section 3.2 contains a concise background of CARICOM and reviews relevant trade literature for the Caribbean; section 3.3 highlights papers that have use the gravity model to estimate trade flow, especially those related to CARICOM; section 3.4 presents the econometric model adopted and estimated; section 3.5 describes the data and methodology used to estimate the gravity model; section 3.6 presents the empirical results and; the paper concludes in section 3.7.

3.2 Background: CARICOM

The Caribbean Community and Common Market (CARICOM) has fifteen (15) member states (see Figure 3.1), namely: Antigua and Barbuda, The Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Haiti, Jamaica, Montserrat, St. Kitts and Nevis, Saint Lucia, St. Vincent and the Grenadines, Suriname and Trinidad and Tobago; and five (5) associated members, namely: Anguilla, Bermuda, British Virgin Islands, Cayman Islands and Turks and Caicos Islands. The Common Market was established by the Treaty of Chaguaramas, with initial entrants Barbados, Jamaica, Guyana and Trinidad and Tobago in 1973. This, after failed attempts, between 1958 and 1962, aimed at strengthening regional integration through the West Indies Federation.

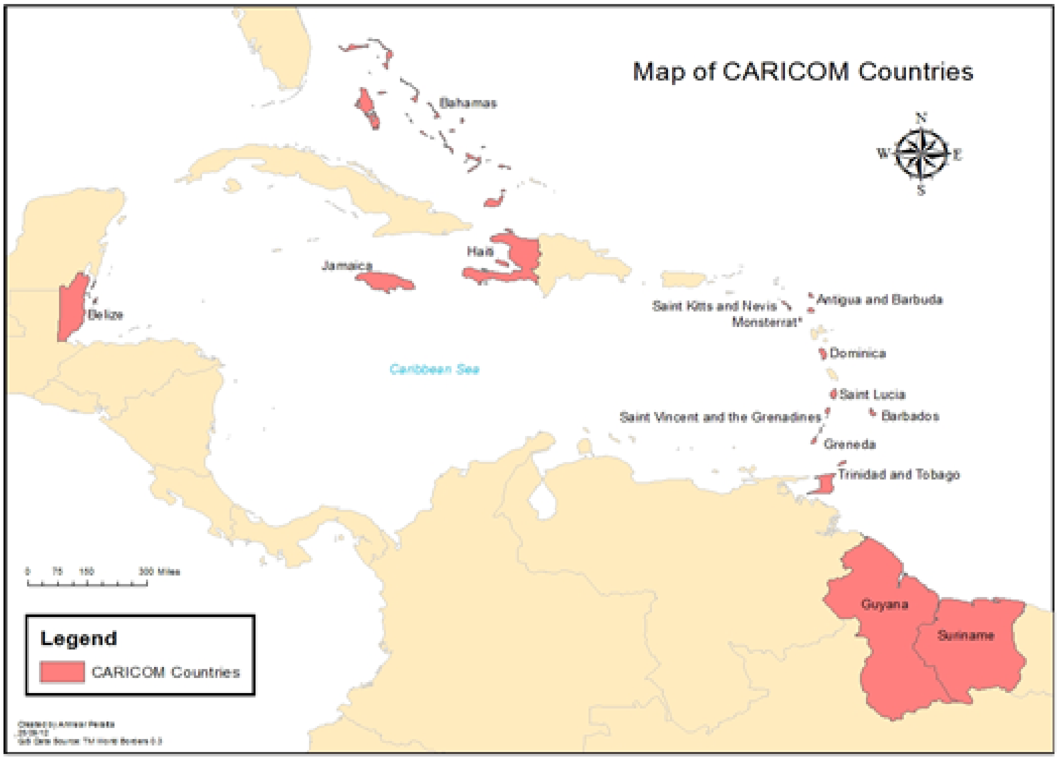


Figure 3.1: Map showing CARICOM Members

After the West Indian Federation failed, The Caribbean Free Trade Association (CARIFTA) was founded in 1965, which included Antigua and Barbuda, Barbados, Guyana and Trinidad and Tobago. CARIFTA was later expanded, in 1968, when Dominica, Grenada, Jamaica, Montserrat, St. Kitts-Nevis, Anguilla, Saint Lucia, St. Vincent and the Grenadines and, in 1971, Belize joined. CARIFTA was established with the hope of increasing trade and trade diversification, liberalizing trade in a manner that allowed for fair competition among members but at the same time protected infant enterprises and industries. More specifically, CARIFTA targeted the distribution of benefits from free trade, the development of industries and phased removal of customs duties on certain products. These actions, it is believed, would have given The Region collective bargaining power with the rest of the world.

CARIFTA's aims formed the basis for CARICOM, and the trade polices, CET and CSME, that were later implemented. The implementation of the CET was aimed at boosting the Region's competitiveness through a structure of discriminating tariff rate for competing and non-competing imports and inputs, intermediate inputs and final goods. Competing imports were defined as those imports that the Region could satisfy 75 percent of the regional demand and as such they attracted the highest tariffs. Tariffs rates depended on the classification of the products ranging from minimums of 0 percent, 5 percent, 10 percent and 15 percent to a maximum of 40 percent (Sadikov, 2014). The maximum of 40 percent was applied to agricultural goods as the industry was seen as vital for employment creation, rural development, foreign exchange earnings and an instrument of protection from dumping.

In 2001, The Treaty of Chaguaramas, which established CARICOM in 1973 was revised to broaden its objectives and define the functions of established regional organizations[2]. One component of the revised Treaty of Chaguaramas is the CSME, which is aimed at encouraging and expanding trade among CARICOM members by creating a single economic space within which goods, services, capital and labour can move freely and the right of establishment is secured. Currently, the CSME is widely recognized and compliance by members is about 64 percent (CARICOM, 2013). This can be disaggregated as: free movement of skills, 66 percent; free movement of goods, 80 percent; free movement of services, 37 percent; movement of capital, 72 percent and; right of establishment, 64 percent. Progress has lagged in establishing the CARICOM Single Economy's legal, administrative, and institutional framework (CARICOM, 2013).

Despite the significant level of compliance, CSME still has its faults as the Region's response to trade liberalization and globalization. CET and CSME through the

[2]see Annex A for the objectives of CARICOM and principal organizations.

mechanisms of reduce trade barriers, access to greater potential capital and greater labour market efficient might have expanded market access for regional firms; however, as trade cost trended to zero, that is greater globalization, firms that were not able to compete on a global scale exited the market and those who survived because of their ability to compete globally have access to the larger global market (Melitz, 2003). It is against this background that Kendall (2008) suggests that,

"*the CSME is very broad in scope and very comprehensive and can be considered a strong though not adequate response to the challenges of trade liberalisation and globalization... Management of the integration process has to recognise that much more needs to be done in terms of supportive/development policies to prepare the region for competition internationally.*"

CSME, thus far, has only sought to deepen regional integration with the hope that the market will allocate resource efficiently and hence lead to growth and development; however, there needs to be a multifaceted approach to increase competitiveness such that firms can compete in the global market place. To compete on a global scale, The Region needs to: become more innovative; improve the quality of, and access to, education; invest in human capital; improve the physical capital and infrastructure; undertake debt restructuring and exercise fiscal discipline; and, mitigate the effects of, and adaptation to, climate change.

3.2.1 Economy

The economies of the Caribbean can be characterized as having small open economies that are dependent largely on their primary and tertiary sectors, highly dependent on trade, indebted and vulnerable to climate change and extreme climatic events such as tropical cyclones.

The small open economies of CARICOM are dependent mainly on their primary and tertiary sectors as majority have limited secondary sector activities. Over the period 1980 to 2012, regional real GDP moved from about US$23 billion to over US$50 billion (see Table 3.9 in the Appendices). The growth in real GDP over the sample period can be categorically attributed to: value added to GDP from services which moved from 56.5 percent in 1980 to 69.6 percent in 2012, exhibiting a steady increase over the period; value added from industry was 25.7 percent in 1980 and 24.0 percent in 2012, showing a consistent contribution of around 24.6 percent over the period; value added from agriculture showing a steady decline over the period moving 17.7 percent to 6.4 percent; and manufacturing declined from 11.7 percent to 6.7 percent over the period (see Table 3.9 in the Appendices).

Services value added dominates from a regional perspective; however, this is not true for Trinidad and Tobago as since 2002 industry value added dominates services. Trinidad and Tobago's economy is today largely dependent on natural gas, oil and chemicals. All the other members are highly dependent on services. The Bahamas, Barbados, Jamaica and the islands of the Eastern Caribbean Currency Union (ECCU) [3] are mainly dependent on services with on average value added of services to GDP of over 70 percent over the decade 2003 to 2012. Although dependent on services: Suriname since 2002 shows significant increase in manufacturing; Jamaica's industrial sector declined over the sample period and showed significantly greater decline after the global financial crisis, 2008; Guyana is highly dependent on its agricultural sector and; Dominica and Belize have value added of agriculture to GDP that is significantly higher than the regional average.

Excluding Haiti, over the last decade of the sample (2003-2012), GDP per capita on average ranged from as low as US$1,139 for Guyana and a high of US$22,366 for The

[3] Antigua and Barbuda, Dominica, Grenada, St. Kitts, St. Lucia, St. Vincent and Grenadines.

Bahamas. For comparison, Haiti's average GDP per capita was US$456 for the same period (see Table 3.9 in the Appendices). All CARICOM countries, except Haiti, are classified according to World Bank standards into categories of low middle-income to high-income countries.

Although majority of the economies of CARICOM fall within the categories low middle income to high middle income and the majority share a common language and culture, there is some degree of heterogeneity. Some of the factors that influence this include: history, income distribution, land/size, natural resources, human capital, infrastructure, institutions and governance and other demographic factors. As such, to stimulate growth in each member state and also regionally a multi-factor productivity (MFP) approach is necessary i.e policies geared towards improved efficiency through new technologies, economies of scale, managerial skills, institutions and improved backward and forward linkages. Most member states of CARICOM have moved to employ such an approach after previous strategies including: structural approach (1950-1967) and; eclectic- activist approach (1968-1988); failed to electrify the economies and result in desired outcomes (CARICOM, 2010).

3.2.2 Trade

The economies of the region are heavily dependent on trade. This, despite efforts to promote local produce. In 1980 all CARICOM member states, with the exception of Trinidad and Tobago (89 percent), had trade to GDP ratio of over 100 percent ranging from 102 percent for Jamaica to 175 percent for Guyana. By 2012, Bahamas, Guyana, St. Lucia and Trinidad and Tobago had trade to GDP ratio of over 100 percent. Guyana and Trinidad and Tobago exhibiting increase in trade to GDP ratio over the period. Guyana in particular became more open with trade to GDP ratio of over 200 percent (see Table 3.9 in the Appendices). All other countries had steady decline in their susceptibility to trade.

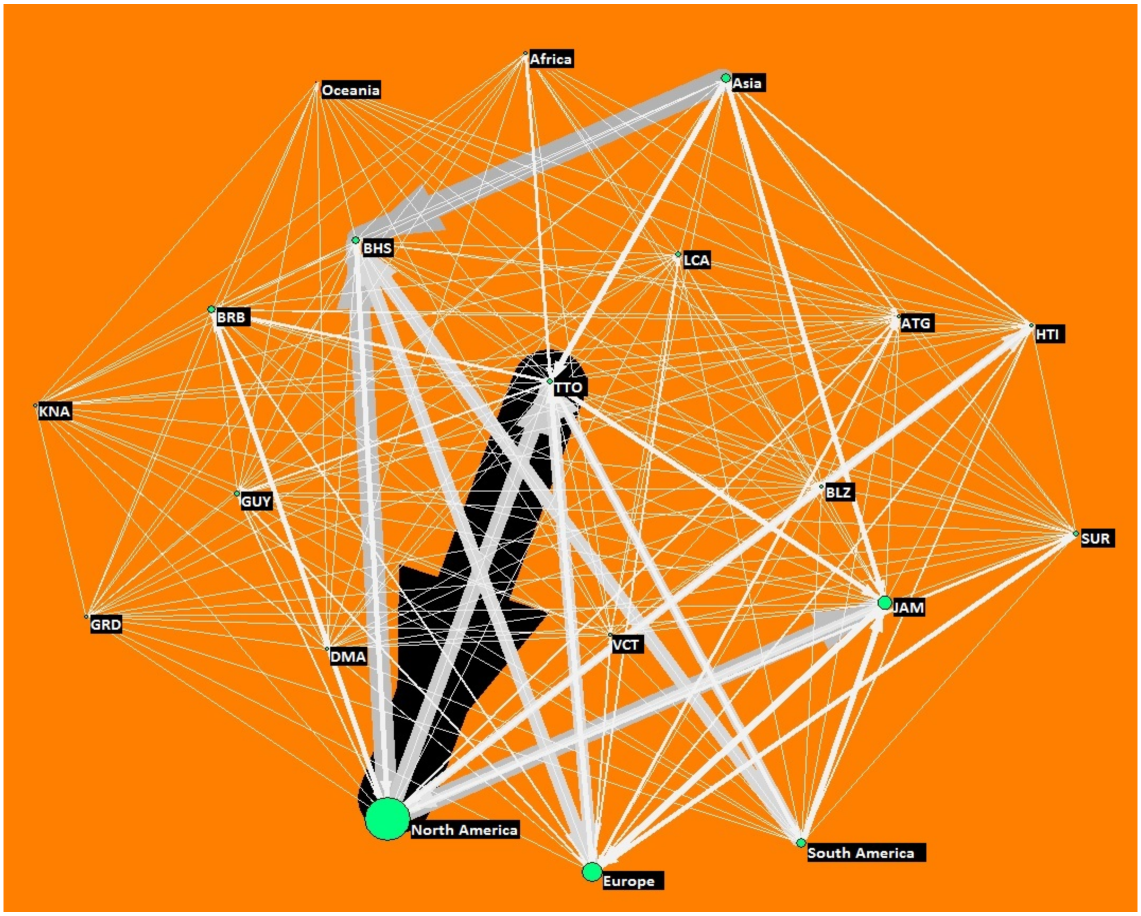
With the exception of Trinidad and Tobago and Suriname, members of CARICOM have persistently exhibited negative net trade balances in goods and services. The Region as a whole has exhibited a negative trade balance. In 2005 this balance was about -US$6.1 billion, for 2009, this balance was -US$11.2 billion and by 2012, the balance stood at -US$2.6 billion. The year to year negative net trade balance along with other factors such as external shocks, fiscal indiscipline and government mismanagement has resulted in external debt and exchange rate depreciation in some CARICOM members[4]. In 2012, Grenada and Jamaica had a external debt to exports of goods, services and primary income ratio of over 200 percent. Belize, Barbados, Dominica and St. Vincent and the Grenadines had external debt to exports of goods, services and primary income ratio of over 100 percent.

Using Pakjek, a software used for network analysis, we analyse CARICOM trade for the year 2000. This is presented in Figure 3.2. The nodes[5] in Figure 3.2 depict the importance of each country or region to the network of trade considered; whereas, the size and direction of the arrows are representative of the size and direction of trade flows between countries. It is important to note; however, that the network of trade ignores trade across regions such as North America and Asia. This is because trade with CARICOM members is the main focus and ignoring cross region trade reduces the noise and amplifies CARICOM Trade. From Figure 3.2, it clear that trade with North America is critical. Figure 3.2 shows that North America is the largest exports market for CARICOM goods. Similarly, imports from North America are significant

[4]Later in this chapter we discuss exchange rate regimes in The Region and in the next chapter (Chapter 4), using econometric analysis, we explore the effects of exchange rate on CARICOM Trade

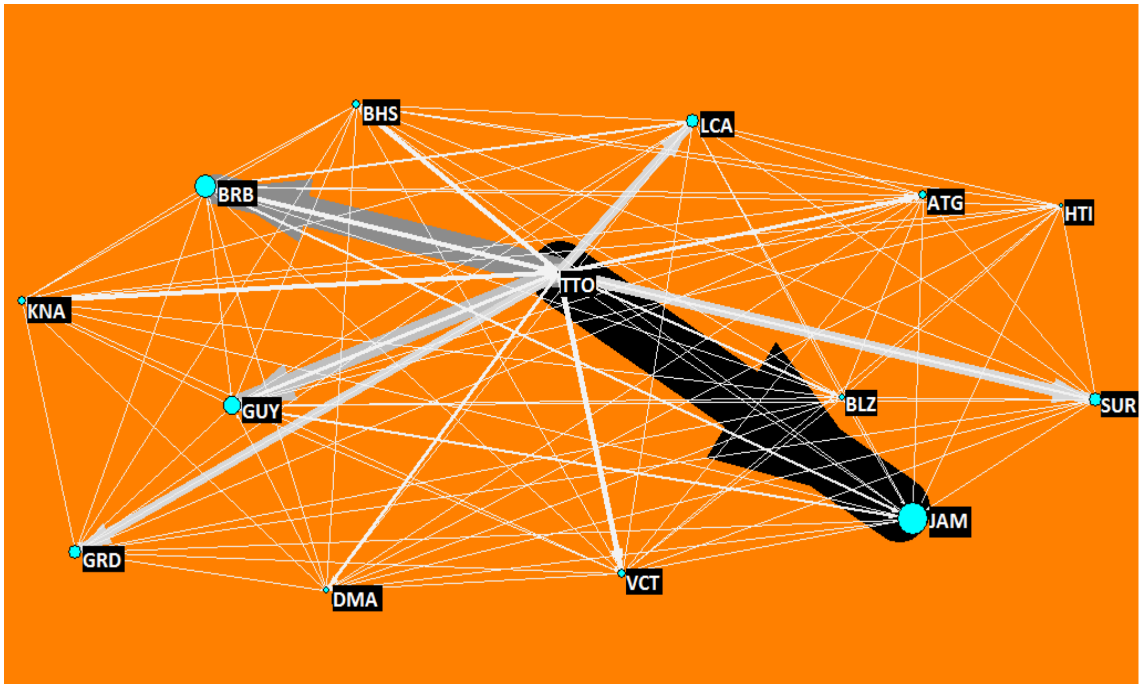
[5]The size of the nodes denote combined scores of hubs and authorities. Countries that are more pointed-to by hubs, becoming authorities; and countries that point to more authorities, becoming hubs. The inward and outward connectivity are weighed by the size of trade flows between between countries.

when compared to other regions. Additionally, North America has the largest node, suggesting that CARICOM is most significantly connect to North America in terms of inward and outward connectiviness. Second to North America in terms of inward and outward connectiviness to CARICOM members is Europe followed by South America and Asia. Although Trinidad and Tobago has significantly large amounts of trade both regionally and extra-regionally, it is not an important hub and authority for CARICOM Trade. The most important hub and authority for CARICOM trade is Jamaica, followed by Barbados, Bahamas and Guyana. This can be seen much clearer in Figure 3.3. These countries are more connected in the network of trade both regionally and internationally, that is, importing from, and exporting to, more countries than Trinidad and Tobago and other CARICOM members.



Notes: The size of nodes signify the importance (inward and outward connectivity) of that country to trade. The size and gray scale of arrows represent the value of trade between two countries.

Figure 3.2: Network of Trade, 2000: CARICOM Members and Continents.



Notes: The size of nodes signify the importance (inward and outward connectivity) of that country to trade. The size and gray scale of arrows represent the value of trade between two countries.

Figure 3.3: Network of Trade for CARICOM Members, 2000.

A closer analysis of intra-regional exports and imports for selected CARICOM members, when controlling for market size, gives a better picture of the trade relationship among members. It is observed that Trinidad and Tobago is the largest exporter in The Region. This is not surprising since a large proportion of the exports from Trinidad and Tobago are mineral fuels, oils, distillation products and related products. An examination of the imports in 2000 of Belize, Guyana, St. Lucia, Jamaica and Barbados as ratio of the Trinidad and Tobago's GDP for 2000, reveals that Trinidad and Tobago exports dominates all other CARICOM members. Controlling for market size, Trinidad and Tobago's exports as a ratio a of the GDP of the importer is largest for Guyana, Barbados, Suriname and the Eastern Caribbean countries; although, exhibiting a negative relationship with distance from it CARICOM neigbours. Generally, for most CARICOM members, the adverse effects of distance seems to be more dominant on the supply side (exports as ratio of the importer's GDP) rather than on the demand side (imports as ratio of the exporter's GDP).

Similar to that identified from the network diagram (Figure 3.2), Figure 3.4 illustrates that extra-regional trade is predominantly with North America, more specifically, the United States of America (USA). In Figure 3.4, CARICOM exports (imports) are presented as a ratio of CARICOM exports (imports) to the USA and the importer (exporter) GDP relative to USA's GDP. From the top panels of Figure 3.4, it is observed that in 2000 trade with the USA significantly dominates trade with other countries. In the bottom panels of Figure 3.4, we observe that in 2000, besides the USA, the other major export markets for CARICOM were the United Kingdom, France, Canada, Jamaica, Netherlands, Norway, Barbados, Spain and Germany; whereas, besides the USA, the other major source of imports were the Bolivarian Republic of Venezuela, Trinidad and Tobago, Italy, Japan, Korea, Germany, United Kingdom and France.

As is established in the literature on international trade, distance has a negative relationship on trade. This relationship is depicted in Figure 3.5. From Figure 3.5 we observe, for 2000, a negative relationship between both CARICOM's exports and imports and distance[6]; however, as is highlighted in the previous chapters there is the issue of heteroskedasticity. Although not controlling for several other pertinent variables, the top panels of Figure 3.5, shows the presences of heteroskedasticity since the variance in trade with countries closer to CARICOM is smaller when compared to the variance in trade associated those further away from CARICOM members.

[6]Figure 3.4 plots the relationship between the logarithm of exports and distance. For this plot distance from CARICOM can be thought of as the distance from a random sample of CARICOM members

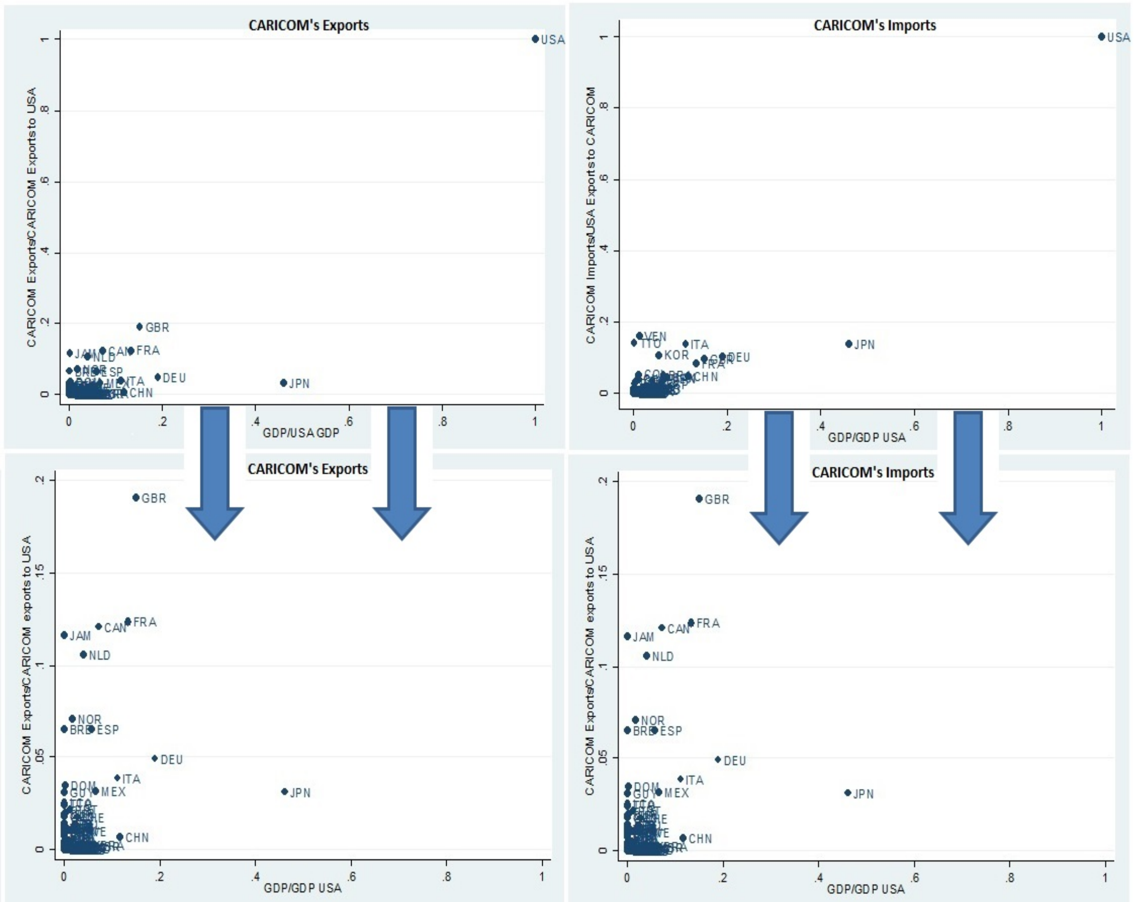


Figure 3.4: Summary of CARICOM Trade, 2000.

Controlling for market size, we take CARICOM's exports (imports) for 2000 as a ratio of the importer's (exporter's) GDP in 2000 and plot these against the logarithm of distance. This is presented in Figure 3.6. It revealing the importance of CARICOM members to The Region exports and imports.

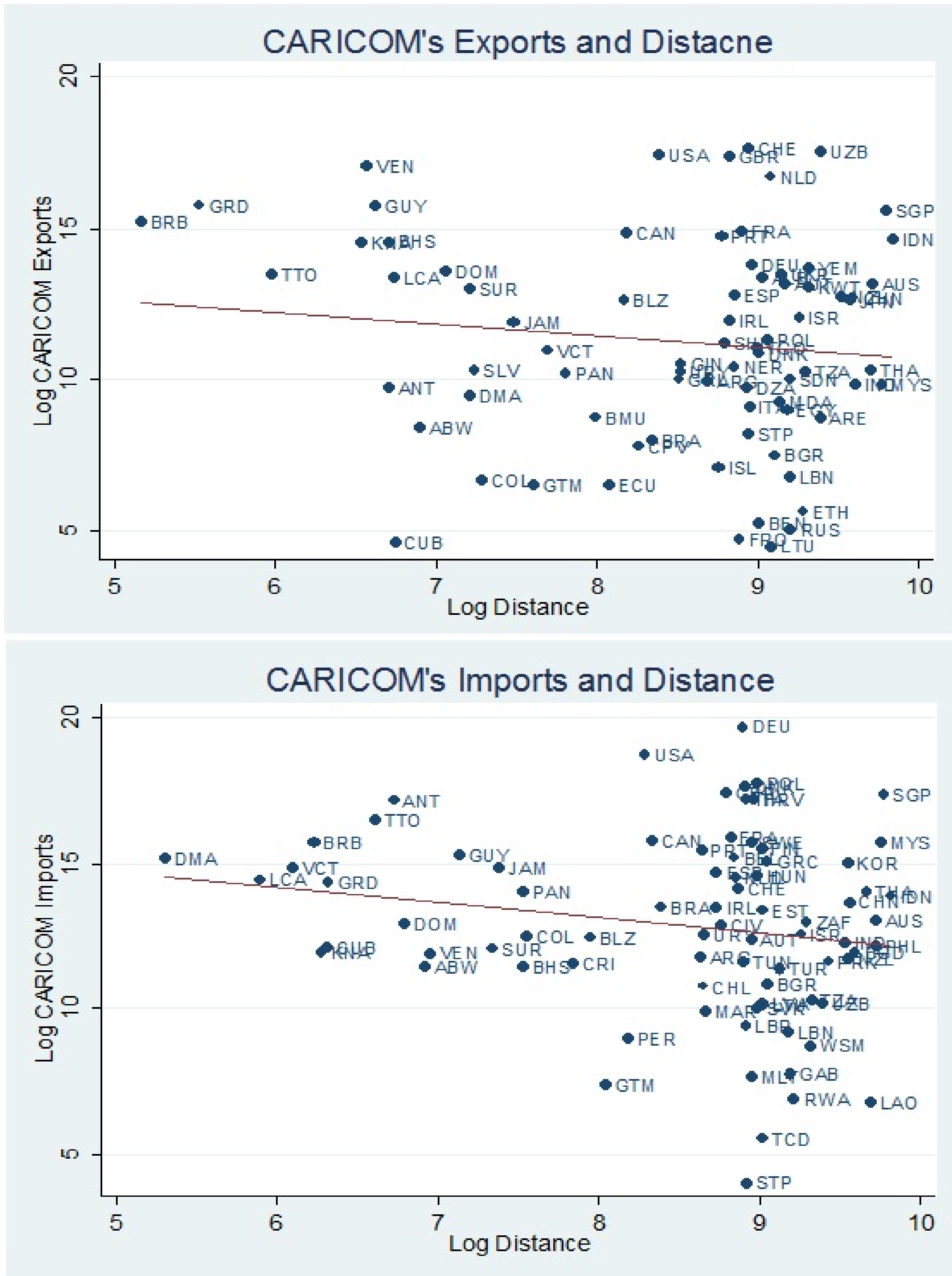


Figure 3.5: CARICOM Trade and Distance, 2000.

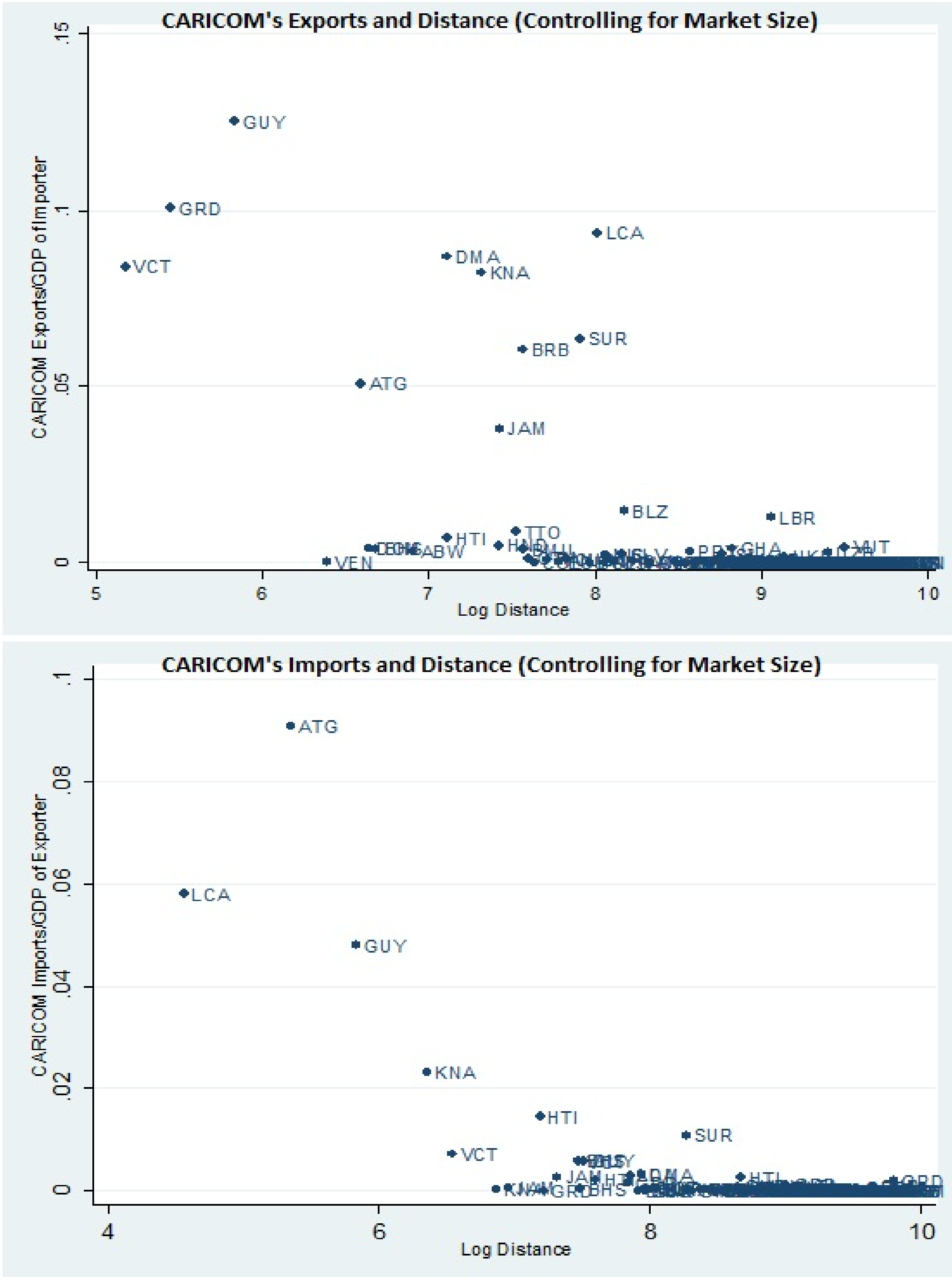


Figure 3.6: CARICOM Trade and Distance, 2000.

CARICOM members exports (imports) as a ratio of the importer's (exporter's) GDP are larger for its members than non-members suggesting that in 2000 CARICOM trade accounted for a large share of the economies of The Region. These and the above identified attributes of CARICOM trade can be explained by its drive towards greater integrated markets, the characteristics of its industries, exports and economic environments. Below we describe CARICOM's trade at the 2 Digit Standard International Trade Classification (SITC) (ITC, 2014)[7] and aggregate trade in goods over the period 1980-2012/14 (Dots, 2014).

The export base of CARICOM is relatively small when compared to its major trading partners. Given the limitations of the manufacturing sector, CARICOM has primarily sought to take advantage of its comparative advantage in services, industrial outputs and to a lesser extent agricultural outputs. Excluding trade in services, in 2012, CARICOM's top twenty (20) exports out of one hundred, as set out by the 2 Digit Standard International Trade Classification (SITC), were valued at US$25.5 billion, which is approximately 95 percent of The Region's total exports. Of that percentage, the category mineral fuels, oils, distillation products, etc contributed 50 percent, followed by: Inorganic chemicals, precious metal compound and isotopes, which contributed 13 percent; Organic chemicals, which contributed 7 percent, and; Iron and steel, which contributed 6 percent. See Table 3.10 in the Appendices for further breakdown. The region's main export markets for these items are United States of America, European Union, Canada, Jamaica, Argentina, Barbados and Suriname.

In 2012, the top ten imports for CARICOM were valued at US$22 billion, which is 75 percent of CARICOM's total imports in that year. These include: mineral fuels, oils, distillation products, etc, which contributed 26 percent; machinery, nuclear reactors, boilers, etc, which contributed 8 percent; electrical, electronic equipment, which

[7]Data presented from ITC is based on availability

accounted for 5 percent, and; vehicles other than railway, tramway which accounted for 6 percent. See Table 3.11 in the Appendices for more details. In 2012, the top 10 exporters to CARICOM were the United States of America, Trinidad and Tobago, Gabon, Colombia, Venezuela, China, Brazil, Russian Federation, Canada and Mexico. In 2011, imports from these countries accounted for 73.2 percent of total imports into The Region.

In comparison to extra-regional trade, exports by CARICOM members to other CARICOM members is dominated mainly by mineral fuels, oils, distillation products, etc (see Table 3.12 in the Appendices). In 2012, mineral fuels, oils, distillation products, etc. accounted for 62 percent of total exports within CARICOM. In that same year, the top 20 categories of exports within CARICOM accounted for 92 percent of total exports within CARICOM. To a large extent, trade in goods within the Region is limited mainly to the primary sectors, especially primary sector outputs closely related to agriculture and mining and industry. Besides mineral fuels, oils, distillation products, etc, some of the other main products exported within the Region are:

- Beverages, spirits and vinegar, which is about 5 percent of total trade in 2012;
- Cereals, accounts for 3 percent;
- Cereal, flour, starch, milk preparations and products, 2 percent;
- Vegetable, fruit, nut, etc food preparations, 2 percent;
- Fish, crustaceans, molluscs, aquatic invertebrates, 2 percent;
- Soaps, lubricants, waxes, candles, modelling pastes, 2 percent and;
- Sugars and sugar confectionery, 2 percent.

On aggregate over time, CARICOM exports has exhibit adjustments in growth rate consistent with the goings-on of regional and global trade. For the sample period 1980 to 2012/2014 there are several periods that special consideration must be given to as there are exogenous factors/events that may have caused structural breaks in regional and global trends. These include from a regional perspective: the phased implementation of the CET, post 1992; the erosion of preferential trade agreements between CARICOM members and EU and other third parties beginning in the 1990s; The implementation of CSME in 2006; and, CARIFORUM - EU Economic Partnership Agreement signed in October 2008. From a global perspective, these include: the oil price shock of 1978-1979, which had implications for the early 1980s; trade liberilization through change in WTO rules and entrance and exit as well as increases in the number of bilateral and multilateral RTAs signed among different countries; the dot-com bubble crisis; 9/11 attacks in the U.S.A; and, global financial crisis, which began in 2008.

Over time the period 1980 to 2012/2014, extra-regional trade makes up approximately 90 percent of CARICOM's trade. This can be seen from Figures 3.7 and 3.8. In the top panel of Figure 3.7, it is clear that extra-regional exports dominated intra-regional exports as for every US$1 billion worth of intra-regional trade there is US$7-10 million in extra-regional trade. Furthermore, the curve representing CARICOM's total exports closely resemble exports to the Rest of the World. Although intra-regional exports is small relative to extra-regional exports, intra-regional exports have increased in the share of total exports and value over the sample period. Prior to 2000 intra-regional exports grew at rate above extra-regional exports; however, post 2000, growth in intra-regional exports follows more closely the trends in exports to the Rest of the World. Between 1980-1986, CARICOM total exports declined. This could be attributed to the effects of the global regression triggered by oil price shocks of the late 1970s and early 1980s. Between 1986 and 1993 total exports and extra-regional exports remained relative steady; however, for this period intra-regional exports exhibit marginal increases. During this period several CARICOM members were going through several structural adjustment programmes under the guidance of the International Monetary Fund (IMF). One aspect of these structural adjustment programmes was the liberalisation of trade and currency markets. Post 1993, total exports from CARICOM and extra-regional exports increased marginally but these growth in exports were below those observed for intra-regional exports. 1993 marks the beginning of the phase implementation of the CET, which resulted in zero tariffs on some categories of goods within the community by the latest 2001. Subsequent to 2001, CARICOM exports, both intra-regional and extra-regional exports, increased significantly, this when compared to previous years from 1980 to 2001. CARICOM's exports peaked in 2008, but falling sharply between 2008 and 2010 cause the global financial crisis which began in 2008. CARICOM exports recovered, post 2010, surpassing 2008 levels in 2012.

In the bottom panel of Figure 3.7, trends in CARICOM's exports and imports as a ratio of CARICOM's GDP is considered. For the period 1980 to 1998 there was a steady decline in CARICOM's extra-regional exports as a ratio of CARICOM's GDP from over 80 percent in 1980 to less than 20 percent in 1998. Post 1998, CARICOM's extra-regional exports as a ratio of CARICOM's GDP increased from less than 20 percent to 35 percent of its GDP. A similar pattern is observed for CARICOM's extra-regional imports as a ratio of CARICOM's GDP. For the period 1980 to 1999 there has been a steady decline in CARICOM's extra-regional imports as a ratio of CARICOM's GDP from 59 percent in 1980 to 36 percent in 1999. Post 1999, CARICOM's extra-regional imports as a ratio of CARICOM's GDP increased from 36 percent of its GDP to 50 percent of its GDP in 2012. The pattern of trade within CARICOM is sightly different. Exports as a ratio of GDP among CARICOM members fell from approximately 4.9 percent of GDP in 1980 to 2.2 percent of GDP in 1986. For the period 1986 to 1992, exports as a ratio of GDP among CARICOM members fluctuated between 2.2 percent and 3 percent. Since 1993, exports as a ratio of GDP among CARICOM members has increase from marginal above 3 percent to approximately 5.7 percent of GDP in 2008. During the global financial crisis (2008-2010), exports among CARICOM members decline to as low as 4.2 percent of GDP; however by 2011, exports to 5.5 percent of The Region's GDP.

Figure 3.8 shows the intra-regional share of CARICOM's exports (imports) and extra-regional share of CARICOM exports (imports) for the period 1980-2014. Between the period 1980 to 1985 there was a marginal decline in the share of CARICOM exports to member states; however, from 1986 to 2001 there were increases in the share of regional trade. During this period, 1986 to 2001, the growth rate in the share of exports to members states was slower for the years before 1993. For the period 1993 to 2001, which corresponds to the implementation of the CET, the share of exports to members states increase from approximately 8 percent to 16.5 percent. Although in 2000, the share of CARICOM's exports to members declined but in the following year it increased to levels higher than 1999. Subsequent to 2001, the share of CARICOM's exports to members fell from a high of approximately 16.5 percent to 12.5 percent. This level was maintained until 2008. During the financial crisis, 2008, the share of CARICOM exports to members increased from approximately 12.5 percent to marginally below 15 percent. In recent years, as the economies of the world recover from the effects of the global financial crisis, the share of CARICOM exports to members is declining.

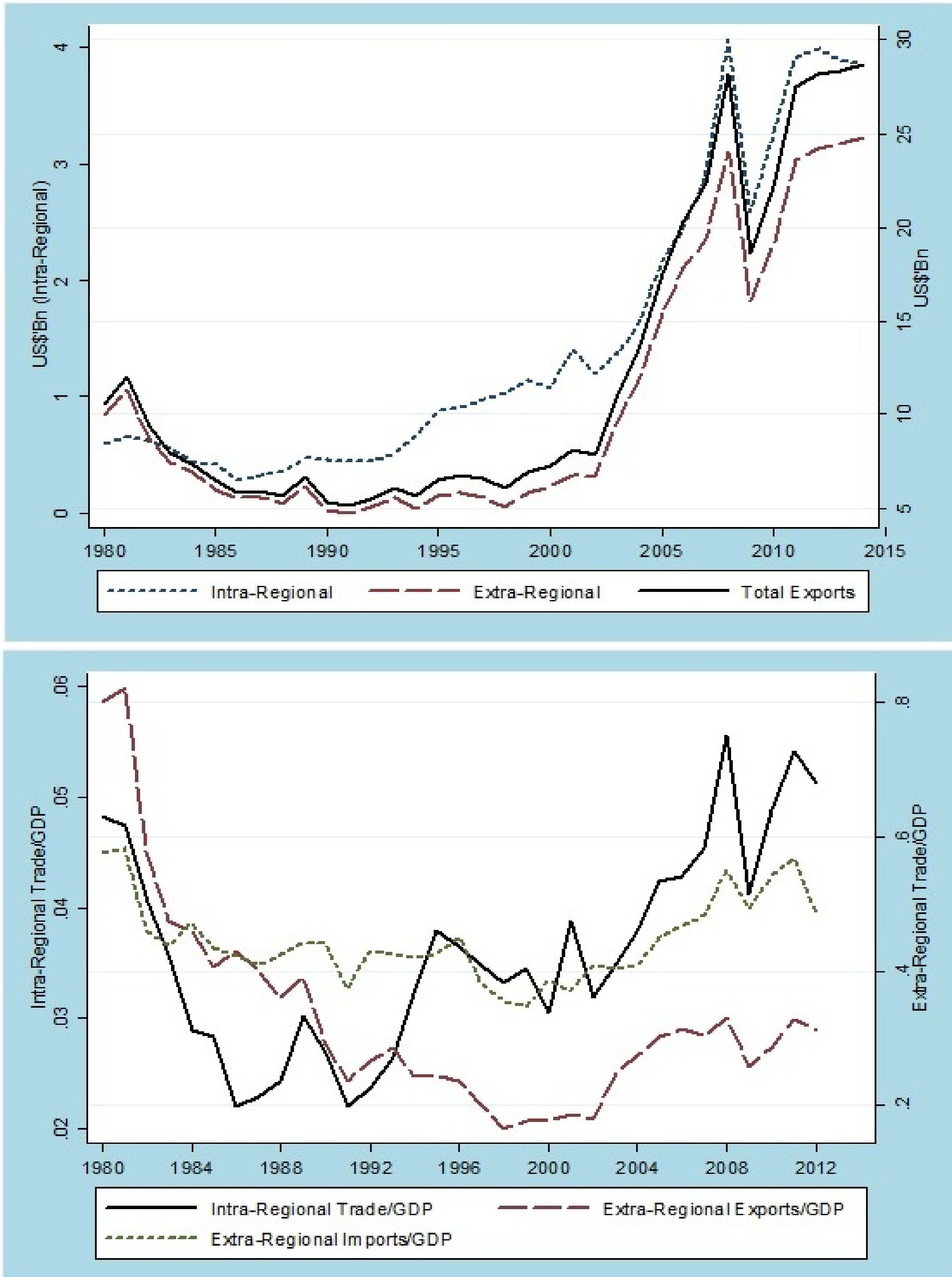


Figure 3.7: Summary of CARICOM Trade for the period 1980-2012.

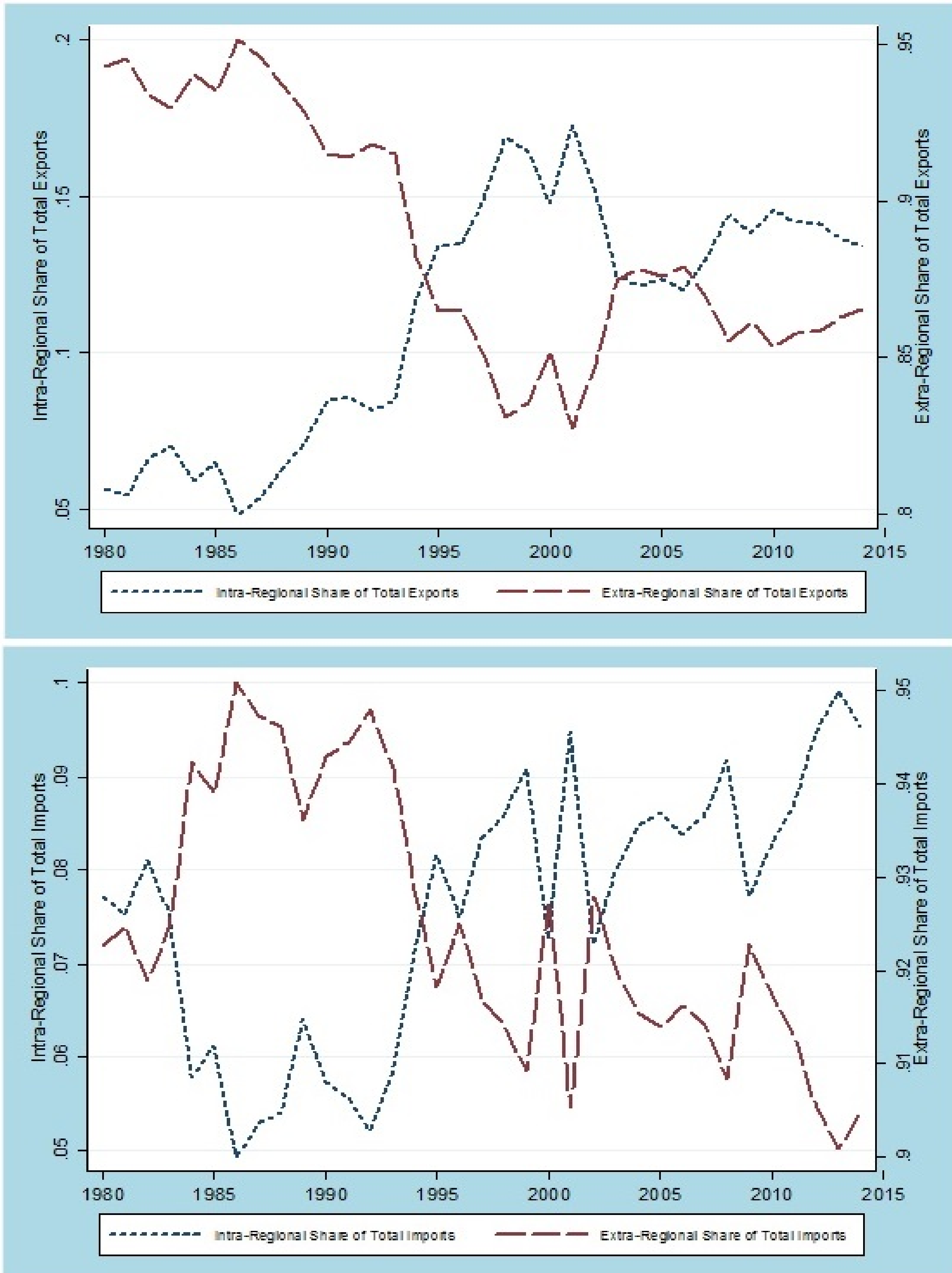


Figure 3.8: Intra-regional Vs. Extra-Regional Exports and Imports for the period 1980-2012.

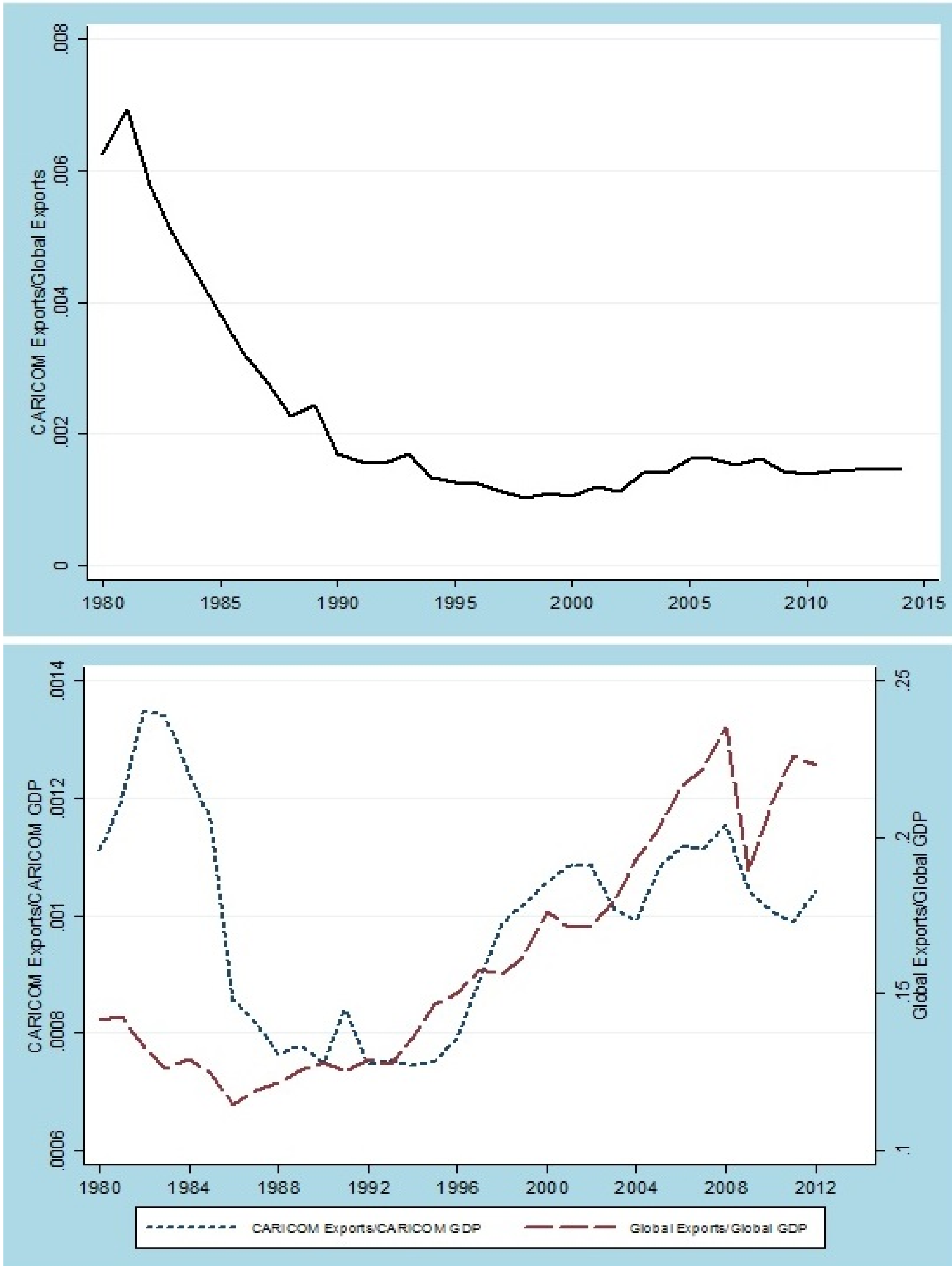


Figure 3.9: Market Share Vs. Global Trends for the period 1980-2012.

On the other hand, the share of CARICOM imports from members declined from 1980 to 1986 (See Figure 3.8). After 1986, the share of CARICOM imports from members increased up until 1989 and decline subsequently until 1992. After the implementation of the CET in 1993, the share of CARICOM imports and exports from members increased significantly up until 1999; however, it declined in 2000 only to increase in 2001 to a level beyond 1999, approximately 9.5 percent. The share of CARICOM imports from members fell sharply after 2001 but rose steadily back to a level comparable to 2001 by 2008. After 2008, share of CARICOM imports from members fell sharply but by 2010 it started increase steadily. In 2014, there was a slight decline from the peak of approximately 10 percent observed in 2013.

CARICOM share of the export market moved from a high of approximately 0.07 percent of total global exports in 1981 to under 0.02 percent of global exports in 1990 (See the top panel of Figure 3.9). Since 1990, there have been marginal changes in CARICOM's share of global exports. Although the top panel of Figure 3.9 suggests that CARICOM's exports share of the export market is decline, its total exports as a share of GDP tell a different story (See the bottom panel of Figure 3.9). The bottom panel of Figure 3.9 suggests that when compared to the global trend, CARICOM has not consistently increased the share of GDP that is exported. For the period 1980 to 1990, the total exports of CARICOM as share of its GDP declined at a faster rate when compared to the rest of the world. Since 1990, global exports as a share of global GDP increased steadily until the global financial crisis, 2008. On the other hand, CARICOM's exports as a share of it GDP increased over the period 1995 to 2008, with a major decline observed in 2002 and 2003 from 2001 levels; however, in 2004 CARICOM's exports as a share of it GDP increased above 2001 levels. The decline in global demand resulted in a decline in exports globally, this is evident by the decline in CARICOM's exports as a share CARICOM's GDP. Subsequent to the global financial crisis, global exports as a share of global GDP recovered faster than CARICOM's exports as a share of CARICOM's GDP.

To summarise, CARICOM is deeply entrenched into the global trade network with a narrow export base. This is evident by the degree of openness and dependence on trade in agriculture, services and industrial output in a global context. With such high dependence on trade and a narrow export base, The Region is vulnerable to exogenous demand and supply shocks to international trade. Shocks to the price of crude oil and the recent financial crisis provide supporting evidence. Except for Trinidad and Tobago, all other members of CARICOM are dependent on imported fossil fuels. Other countries such as Barbados and Belize have limited oil stock, however, the necessary technology needed to refine it is not in place, and as such it is exported for refinement. This dependence on imported fossil fuels makes member states vulnerable to fluctuations in global oil prices. This vulnerability is not only limited to the price of fossil fuel, as countries like Jamaica and Guyana that export industrial and agricultural output, such as bauxite and rice, are also vulnerable to changes in the prices of commodities. The recent global financial crisis caused the region to lose revenue mainly in the industrial and services sectors as evidenced by several bauxite plants closing or cutting production in Jamaica and significant reduction in tourism revenue across The Region. Evidently, CARICOM members increased involvement in global trade makes their economies vulnerable to global shocks;however, CARICOM is dependent on trade not only among members but also with the rest of the world. Where, trade within CARICOM provides greater market access to many firms, and trade with the rest of the world is important for the Region to satisfy its love for variety and access to goods not produced by member states.

Given the identified characteristics of the economies of CARICOM states, and its reliance on trade in the wake of globalization and increased international competitiveness, there are challenges to achieving trade expansion and economic development. Some of these challenges the Region grapples with are physical isolation, small population, geographical dispersal and distance from major markets, small, fragmented and highly imperfect markets, minimal export diversification and dependency upon very few export markets, inadequate infrastructure, low competitiveness, economic rigidity with high adjustment costs, high transport and transit costs, and considerable difficulties in attracting foreign investment (CARICOM, 2013).

3.2.3 Exchange Rate Regimes in CARICOM

Exchange rate regime classification is based on the degree of flexibility of one country's currency relative to another. There are three main categories: pegged (fixed) exchange rate; limited flexibility; and, managed and fully flexible. In a fixed exchange rate regime, a country's currency or mediums of exchange is fixed at a single rate with that of another country. A country with limited exchange rate flexibility allows the ratio between its currency and another country to fluctuate within a band. A fully flexible (free floating) exchange rate regime is one in which fluctuation in the currency is determined purely by the market; that is, the demand and supply for the currency with no intervention by the monetary authorities. Intervention by the monetary authorities, either to inject foreign currencies into the market or purchase excess foreign currencies, is usually aimed at clearing the market and keeping the currency at a certain level. This is known as a managed float.

CARICOM members can broadly be classified into fixed and flexible exchange rate regime. Countries within CARICOM with fixed exchange regime include: Bahamas, Barbados, Belize and the Organization of Eastern Caribbean States[8] (OECS); whereas,

[8]The Organization of Eastern Caribbean States is a regional sub-grouping made up of Antigua and Barbuda, Dominica, Grenada, St. Lucia, St. Kitts and Nevis and St. Vincent and the Grenadines. This sub-grouping has adopted a monetary union and common currency fixed to the US dollar.

countries with flexible (managed float) exchange rate regime are: Guyana, Jamaica, Suriname (Haiti) and Trinidad and Tobago. All the countries listed as having flexible exchange rate today, moved from fixed exchange rate regimes in the 1990s; however, the degree of currency flexibility differs across countries and is dependent on the frequency and nature of intervention by the Central Bank in each country.

Given the differences in exchange rate regimes across CARICOM members, why then should it implement a common currency? The answer to this question is beyond the scope of this research as this research is only one piece of the puzzle. Other considerations must be given to monetary policy implementation and implications. However, this research could speak to the impact of implementing such a currency union on trade and output. In the next chapter we shed some light on this issue, but here we outline some expectations and concerns. The establishment of currency broad[9]/ union among CARICOM members is expected to bring about greater discipline and confidence (less uncertainty) hence greater credibility; however, it could lead to greater constraining credit policy and the ability of the authority to adjust the exchange rate par (Rajapatirana and Secrattan, 2000). Other concerns includes the susceptibility of the economies of the CARICOM to external shocks and monetary authorities ability to adequately respond to these shocks using policy instruments and providing liquidity support as the lender of last resort. In the context of regional trade, if all CARICOM members adopt a common currency, those who benefit from exchange differential within The Region will be negatively impacted; furthermore, countries that also benefited from currency depreciation, making their exports cheaper to the rest of the world, could see reduction in the gains from trade if the common currency is pegged to currency that on average increases in value. On the other hand, a common currency could facilitate increase flow of capital among members and less uncertainty

[9]A currency board is essentially an extension of pegged exchange regimes the difference between these two regime types is largely one of degree (Rajapatirana and Secrattan, 2000).

will improve the business and economic environment.

Historically, Over the sample period 1980-2012, Suriname, Guyana, Jamaica, Haiti and Trinidad and Tobago have seen significant depreciation/devaluation in their currency. Guyana's currency moved from GUY$2.55 per US$1 in 1980 to GUY$204.36 per US$1, a depreciation of almost 8000 percent. Similarly, Jamaica's exchange rate depreciated by almost 5000 percent, moving from JA$1.78 per US$1 in 1980 to JA$88.75 per US$1 in 2012. Vis-*à*-vis, The Eastern Caribbean currency union is pegged to the US dollar at ECU$2.7:US$1; Bahamas, BAH$1:US$1; Barbados, BB$2:US$1; Belize, BZ$2:US$1 and; Suriname, SR$3.3:US$1 (see Table 3.1).

Table 3.1: Official Exchange Rate and Regime of CARICOM Members (LCU per US$, period average)

Country	**1980**	**1990**	**2000**	**2006**	**2010**	**2012**	**% Δ (1980-2012)**	**Regime (2012)**
Antigua and Barbuda	2.70	2.70	2.70	2.70	2.70	2.70	0.0%	Fixed
Bahamas, The	1.00	1.00	1.00	1.00	1.00	1.00	0.0%	Fixed
Barbados	2.00	2.00	2.00	2.00	2.00	2.00	0.0%	Fixed
Belize	2.00	2.00	2.00	2.00	2.00	2.00	0.0%	Fixed
Dominica	2.70	2.70	2.70	2.70	2.70	2.70	0.0%	Fixed
Grenada	2.70	2.70	2.70	2.70	2.70	2.70	0.0%	Fixed
Guyana	2.55	39.53	182.43	200.19	203.64	204.36	7914.1%	Flexible
Haiti	5.00	5.00	21.17	40.41	39.80	41.95	739.0%	Flexible
Jamaica	1.78	7.18	42.99	65.74	87.20	88.75	4882.0%	Flexible
St. Kitts and Nevis	2.70	2.70	2.70	2.70	2.70	2.70	0.0%	Fixed
St. Lucia	2.70	2.70	2.70	2.70	2.70	2.70	0.0%	Fixed
St. Vincent and the Grenadines	2.70	2.70	2.70	2.70	2.70	2.70	0.0%	Fixed
Suriname	0.00	0.00	1.32	2.74	2.75	3.30	184773.9%	Flexible
Trinidad and Tobago	2.40	4.25	6.30	6.31	6.38	6.43	167.9%	Flexible

Source: World Bank, World Development Indicators

3.2.4 Environment and Climate

CARICOM is comprised of member states that have at least a border bounded by the Caribbean sea. The Community is made up of: small islands (OECS and Barbados) to the east; The Bahamas, Jamaica and Haiti in the north; the twin island Republic of Trinidad and Tobago in the south; Belize which is south of Mexico in Central America; and, Guyana and Suriname in the South American mainland. The size of member states varies from 103 square kilometers (Montserrat) to 214,970 square kilometers (Guyana). The total land mass of CARICOM is approximately 404,900 square kilometers and the four largest Member States: Guyana, Suriname, Haiti and Belize account for 92.79 percent of that total. Although, Guyana, Suriname and Belize are counted among the largest in terms of land size, they only account for about 10 percent of CARICOM's population in 2012. In 2012, the total population of CARICOM was approximately 17 million, ranging from 0.005 million in St. Kitts and Nevis to 10.1 million in Haiti. Haiti accounts for the greatest proportion (59 percent) of The Region's population. Over the period 1980 to 2012, the population of CARICOM grew by approximately 53 percent, excluding Haiti the growth rate was approximately 26 percent.

The climate in the Caribbean may be classified into two seasons, dry and wet. The wet season usually runs from May through to October. This period is closely related to the hurricane season which runs from June to November. Tropical storms and hurricanes are a permanent feature of the climatic environment. They are costly to countries in the Caribbean as they have the ability to significantly impact economic activities. The size of tropical storms and hurricane, which could span a diameter of between 100 and 4,000 km (62 and 2,485 miles), has the ability to cover an entire island of CARICOM, halting economic activities in that country. They also have the ability to damage essential infrastructure, agricultural crops and livestock and disrupt livelihood. For illustration, Grenada, a small island in the eastern Caribbean, was devastated by hurricanes Ivan in September 2004 and Emily in July 2005. These hurricanes damaged infrastructure, housing, industry and agriculture, costing approximately 200 percent of GDP. Prior to 2004, Grenada supplied about 25 percent of the world's nutmeg; however, hurricanes Ivan and Emily toppled 90 percent of nutmeg trees causing nutmeg exports from Grenada to decrease from over 2,300 tonnes in 2002 to approximately 1,100 tonnes in 2006. Exports decreased further to 250 tonnes in 2008 and by 2009, exports of nutmeg from Grenada was about 200 tonnes. This is as a result of trees dying and efforts to replant trees that were uprooted. Grenada's export of nutmeg has still not recovered as a newly planted nutmeg tree take between 7-9 years to reach maturity.

Regionally, over the period 1980-2012, a total of 123 tropical cyclones were reported by the Centre for Research on the Epidemiology of Disasters (CRED) as affecting a CARICOM member. Over the same period, 4,601 persons were killed and another 4.9 million affected with total damages of US$10.4 million (see Table 3.2). The impacts on individual countries are not uniform. Guyana and Suriname were unaffected by a tropical cyclone over the sample period but this is as a result of their location on the South American mainland. Countries such as Haiti, Jamaica and Bahamas in the north of the Caribbean were most impacted by tropical cyclones. One possible reason for this, is the fact that tropical cyclones usually form off the West Coast of Africa and travel north-easterly through the Caribbean.

Table 3.2: Impact of Tropical Cyclone, 1980-2012.

Country	Tropical Cyclones	Killed	Total Affected	Damages (US$'000)
Antigua and Barbuda	8	8	50,514	543
Bahamas	14	20	32,200	2,590
Barbados	6	1	10,617	107
Belize	9	63	172,570	542
Dominica	9	9	24,371	237
Grenada	5	40	62,860	900
Haiti	27	4,239	2,991,629	1,027
Jamaica	18	123	1,458,875	2,574
St. Kitts and Nevis	6	6	14,280	684
Saint Lucia	10	87	81,950	1,129
St. Vincent and the Grenadines	7	4	28,442	63
Trinidad and Tobago	4	1	1,560	1

Source: Centre for Research on the Epidemiology of Disaster (CRED)

The impending impact of climate change, which is associated with reduced but greater intensity in rainfall, rising temperature, increased frequency and sustained periods of drought and flooding and sea level rise coupled with the increased frequency and strength of tropical cyclones, could have significant impact on CARICOM. The Caribbean Community Climate Change Center (CCCCC), which has the mandate to coordinate The Region's response to climate change, identifies that climate change poses a threat to some important sectors of the region. These include: agriculture and forestry, tourism, water resources, coastal zone and energy (CCCCC, 2011). The linkages between these vital sectors coupled with the impact of climate change could have far reaching impact on the economies of CARICOM and; furthermore, trade within, and with, CARICOM. Additionally, climate change associated with sea level rise coupled with tropical storm could impact infrastructure such as sea ports and air ports, which are vital for international trade. Although Guyana and Suriname are not as vulnerable to tropical cyclones, they remain vulnerable to climate change as their coastlines, which are occupied by about 90 percent of the population, lie below sea level but is protected by sea walls. Similarly, a significant part of Belize's coastline is also below sea level but is protected by a sea wall.

3.3 CARICOM Trade: Gravity Models

The majority of the gravity equations estimated for CARICOM and the Caribbean fall short of the newly found 'best practices'. Some commit the gold, silver and bronze medal mistakes (Baldwin and Taglioni, 2006). Here, I discuss some empirical papers for CARICOM and the Caribbean highlighting the rationale, data and methodologies used and findings.

Bossogo and Mendis (2002) examined trade and integration in the Caribbean using data from 1980-1999 to test empirically if CARICOM has been trade creating or trade diverting. They found that regional integration increased trade both intra-regionally and extra-regionally. Although relevant and important to the implementation of the CSME, Bossogo and Mendis' (2002) findings were established using data before the formal establishment of CSME, which allowed for the free movement goods, services, capital and labour and the right of establishment is secured. Their methodology involved averaging and estimating a gravity model over five year periods and for selected years. Along similar lines, Moreira and Mendoza (2007) examined, using an empirical growth model and a gravity model, whether or not trade related gains from regional integration in the Caribbean have been limited due to the countries' high degree of openness, limited size of the common enlarged market and similar factor endowments. They argue that "gains in the area of "non-tradable" due to economies of scale, which cannot be mitigated by trade and openness, can be substantial". They find that regional integration has a moderate positive impact on intra-regional trade, confirming the creation of trade by the integration process; however, the authors suggested that the model offered no credible estimate from which inference could be made about the magnitude of the impact. The gravity model is estimated using: (1) Pooled OLS; (2) Random Effects, whilst controlling for country-pair heterogeneity; and (3) Random Effects, whilst controlling for time trends and country-pair unobservable effects. The data set included 69 countries, including 12 countries from CARICOM, for the period 1970-2003.

Elliot (2007) committed the gold and silver medal mistakes when he estimated a gravity model to shed light on the potential impact of greater regional integration in the Caribbean on regional and extra-regional trade. Using times-series data for Barbados, Jamaica and Trinidad and Tobago for the period 1968-2003, he infers that regional integration may or may not have a positive impact on trade flows. Further suggesting that, "trade is neither inherently good nor bad for developing countries...trade offers an opportunity for economic gains that is best realized within an environment that supports skilled resources, sound and credible government institutions, and technological development."

Gasiorek et al. (2006) used a gravity model approach to look at the potential impact that liberalization, in the context of an Economic Partnership Agreement, could have on the Caribbean. The paper looks at the differences between countries and sub-regions (Organization of Eastern Caribbean States (OECS) and Non-OECS) within the Caribbean in terms of the evolution of the regional integration process. They find that intra-CARICOM trade for the non-OECS economies (large economies) is consistently high relative to OECS countries (small economies) for the period investigated. Although there were increases in intra-regional trade over the sample period, their gravity model did not return findings that is was statistically significant as well as there was no significant evidence of trade divergence to the rest the world. Methodologically, consideration was given to how well the gravity model explained trade flows among the small island of Caribbean and were estimated using Pooled OLS and fixed effects.

Although not primarily focusing on CARICOM, Martinez-Zaroso et al. (2009) utilized a static and a dynamic gravity model[10] on data for 47 countries from 1980-1999 to evaluate the effects of preferential agreements on trade between trade group members and non-member. The paper investigates if regionalisation fostered intra and or extra regional trade by isolating the effects of preferential agreements, controlling for geographic proximity, income levels, population and cultural similarities between several economic blocs and areas, namely: European Union (EU), North-American Free Trade Area (NAFTA), Caribbean Community (CARICOM), Centro-American Common Market (CACM) and other Mediterranean countries (MEDIT). Variants of OLS are used to estimate the static model for specific years and the averages for the period. Variants of the panel fix effect model are used to estimate the dynamic gravity model, controlling for time trends, multilateral resistance and endogeneity. Their main finding is that regionalism, especially for EU and NAFTA, has had large positive effects on intra and extra bloc trade more so for developed countries, especially EU and NAFTA countries, than developing countries. The results for CARICOM are mixed as the coefficients were found in some instances to be positive and insignificant and, in others, negative and significant .

The most recent papers that utilize a gravity equation to model CARICOM trade flows are by Hosein and Khadan (2013) and Hosein and Seecharan (2013). Hosein and Khadan (2013) explored the notion of a 'natural' trading partner in reference to the Caribbean Community (CARICOM). They utilize the trade intensity index model,

[10] A dynamic panel data gravity model is gravity model in which the lag of the dependent variable (lag exports) enters as a regressor. These are usually estimated using Pooled OLS, Fixed Effects (within-group), Random Effects, First-difference Generalized Method of Moments (GMM) and System GMM.

which involves calculating the trade complementarity index, the trade bias index and trade intensity index, to assess intra-CARICOM and extra-CARICOM trade. They find that intra-CARICOM trade complementarity is low and concentrated in a few primary industries. Additionally, trade complementarity is low between CARICOM countries and their proposed FTA partners in the European Union (EU) and North America. As a trading bloc, CARICOM's top 'natural' trading partners were identified as Central America, Asia, Mercosur, BRICs and Latin America. At a national level, the United States, which is currently one of the region's most significant trade partners, is not listed in the top ten of each country's 'natural' trading partners. In fact, only Jamaica has a North American country, Canada, in its top ten 'natural' trading partners. They used data for ten years, 2001-2010, encompassing 852 bilateral trade relationship involving CARICOM countries, 12 CARICOM members and 60 non-CARICOM members from SITC revision 3 of United Nation Commercial Trade Database.

On the other hand, Hosein and Seecharan (2013) examine the determinants of intra-industry trade (IIT), measured by the Grubel Lloyd Index [11], between CARICOM and selected extra regional trade partners. They utilized a static and dynamic panel data approaches to estimate the gravity equation while controlling for country specific characteristics. The static model is estimated by averaging over the sample period 1999-2010; whereas, the dynamic panel gravity model was estimated for the period 1999-2010 using pooled OLS, fixed effects, random effects, and system GMM. The IIT index is estimated and used to match CARICOM members with their extra-regional partners. Hosein and Seecharan (2013) find that IIT is positively impacted by the differences in per capita income between CARICOM members and its trading partners. Additionally, a smaller significant impact is found for a variety of differentiated

[11] The Grubel-Lloyd Index, introduced by Grubel and Lloyd (1971), is measure of intra-industry trade (IIT), where intra-industry trade is the import and export of similar goods or services belonging to a particular industry.

commodities and economies of scale on IIT. Distance between CARICOM and its extra regional trading partners as a proxy for travel cost was found to be negatively related to IIT.

Generally, the majority of the gravity equations estimated for CARICOM find positive but moderate impact of regional integration on trade; however, the majority used data sets with ending dates somewhere in the later 1990s to early 2000s and as such ignores the implementation of the CSME and other developments in CARICOM. Furthermore, most of the papers fail to adequately address the unobserved multilateral resistance terms, which if not controlled for or capture properly could lead to inconsistent estimates and hence inaccurate inferences. Additionally, the majority of the models failed to address the issues of heteroskedasticity and estimation with the presence of large number of zero trade flows. Although this chapter is similar to some of those reviewed, in terms of identifying the impact of regional integration on trade, it will consider some of the estimation short falls as well as estimate the exogenous impact of climatic natural disasters on trade among and with CARICOM members. There is no known paper that has estimated, using a gravity model, the impact of climatic natural disasters on trade among and with CARICOM members. Given that climatic natural disasters, especially tropical cyclones, are a permanent feature of the climatic conditions of CARICOM coupled with the impending impact of climate change, it is imperative to estimated the historical impact of such climatic natural disasters on trade as a way of suggesting possible actions that could help mitigate losses in export revenue and essential imports.

3.4 The Model

This chapter departs from the studies highlighted in the previous section by estimating a suite of regressions which include Pooled OLS, LSDV and PPML. Further, the gravity model is estimated using panel data spanning the period 1980-2012 considering the issues associated with heteroscedasticity and the large number of observed bilateral zero trade while accounting for the multilateral resistance terms. There is also a distinction in terms of estimating the impact of the Region's RTA on trade; the papers reviewed in the previous section estimated the impact of the CARICOM's RTA broadly; however, in this chapter, we estimates the impact of the RTA on a 'phased' basis by decomposing the RTA variable into phases, namely: the common external tariff implemented post 1992; and, the Caribbean Single Market and Economy (CSME) implemented in 2006. Additionally, this chapter estimates the impact of CARICOM's RTA in a global context by creating a sub-network of trade relations to examine if CARICOM as a trading block over the sample period (1980-2012) is trade-creating or trade-diverging. Another innovation of this chapter includes the estimation of the impacts of climatic natural disasters on trade within CARICOM and CARICOM's trade with its major trading partners.

The model adopted in this chapter follows from the typical gravity equation identified in Chapter 1 but is modified to represent the focus of this chapter and the characteristics of CARICOM. That is, the gravity equation is used to estimate the effects of two policies, associated with the RTA, on trade within The Region as well as extra-regionally. The gravity equation is also modified to capture the exogenous impact of climatic natural disasters. The functional forms of the gravity equation estimated is dependent on whether dependent variable is exports or market share as well as the assumptions made about the multilateral resistance terms and the sample used to estimated the equation. Market share is defined as $X_{ni}/\sum_{n}^{N} X_{ni}$ for each year, which is exports to of country n to i divided by total imports of country i[12].

[12]Although no specified below, when considering effects of the CET, CSME and climatic natural disasters on market share within The Region as well as extra-regionally the gravity equations specified below are estimated with $X_{ni}/\sum_{n}^{N} X_{ni}$ as the dependent variable.

Ignoring the multilateral resistance terms for now, the general functional form of the estimable equation is:

$$\ln(X_{nit}) = \beta_1 \ln(Y_{nt}) + \beta_2 \ln(Y_{it}) + \sum_{m=3}^{M} \beta_m \ln(z_{ni}^m) + \alpha_1 FlexRate_{nit} + \alpha_2 FixedRate_{nit} + \alpha_3 CET_{nit} + \alpha_4 CSME_{nit} + \alpha_5 CARI\_NaturalD_{nt} + \epsilon_{nit} \quad (3.4.1)$$

where, X_{nit} is exports from member n to i at time t. Y_{nt} and Y_{it} is GDP of the exporting and importing member respectively. z_{ni} contains the following variables: distance, which is a simple average of the geographic distances in CEPII's database. This is calculated based on the distance between the most important cities and the distance between the capital cities; contiguity, which is a dummy variable that captures whether a bilateral pair is contiguous; and, common languages, which is a dummy variable that take a value of one if two countries share the same language (if at least 9 percent of the population in both countries speak the same language). $FlexRate_{nit}$ is a dummy variable, which takes a value of one if both exporter and importer have a flexible exchange rate regime; whereas, $FixedRate_{nit}$ is a dummy variable, which takes a value of one if both exporter and importer have a fixed exchange rate regime. $FlexRate_{nit}$ and $FixedRate_{nit}$ also accounts for changes in exchange rate regime overtime. Although not the main focus of this chapter, these exchange rate variables are expected to shed light on the potential impact that adopting a common currency could have on regional trade.

CET_{nit} is a dummy variable that take a value of one after the implementation of the Common External Tariff in 1993. Similarly, $CSME_{nit}$ is a shift dummy that takes a value of one after implementation of CSME in 2006. CET_{nit} and $CSME_{nit}$ can be considered policy moves that would lead to a permanent upward shift in trade/exports in The Region, that is, trade creation within The Region. $CARI\_NaturalD_{it}$ is a dummy variable that captures the exogenous impact of climatic natural disasters on exports. $CARI\_NaturalD_{it}$ takes a value of one when the exporter is impacted by a hurricane, tropical storm, flooding or drought in a particular year. It is expected that such climatic events will have a negative impact on the exporter as it restricts the country's ability to produce for its export markets. ϵ_{nit} is the disturbance term, which in the case of equation (3.4.1) is not suited for conducting hypothesis testing since the equation does not account for the multilateral resistance terms.

Therefore, equations (3.4.1) is estimated with three different assumptions about the multilateral resistance terms. First, it is assumed that the multilateral resistance terms can be represented by Ω_i and ϕ_n, suggesting that they are country-specific and time-invariant for the entire sample period. In this case, exporter and importer fixed effects are used to capture these unobservables country-specific and time-invariant heterogeneity. Second, the multilateral resistance terms are assumed to be country-specific and time-invariant for the entire sample period; however, the inclusion year dummies allows the gravity equation to having different constant for each year. With this specification it is not possible to estimate the effect of CET_{nit} and $CSME_{nit}$ since these variables a perfectly correlated with year dummies, $Year_t$. Lastly, the multilateral resistance terms are assumed to be Ω_{it} and ϕ_{nt}; that is they are country-specific and varies with time, hence the use of exporter-time and importer-time fixed effects, which captures all time-varying country-specific and time-varying heterogeneity. The inclusion of exporter-time and importer-time fixed effects further limits our ability to estimate the effects on some pertinent variables such as Y_{nt}, ln(Y_{it}, CET_{nit}, $CSME_{nit}$ and $CARI\_NaturalD_{nt}$[13].

Given the limitations of the above due to the restrictions placed on the sample and the fixed effects introduced, the data set is expanded to include the exports of CARICOM

[13]The author acknowledge that a two stage approach similar to that discussed in the next chapter could be used to identify these effects. This aspect will be revisited in future research.

members to its major trade partners as well as trade among the major trade partners. This creates a network of trade of which CARICOM is the reference region. With these added dimensions and linkages created by expanding the trade network, the model is modified and estimated as:

$$\ln(X_{nit}) = \beta_1 \ln(Y_{nt}) + \beta_2 \ln(Y_{it}) + \sum_{m=3}^{M} \beta_m \ln(z_{ni}^m) + \alpha_1 CARICOM_{nit} + \alpha_2 CARICOM_{nt} + \alpha_3 CARICOM_{it} + \alpha_4 CET_{nit} + \alpha_5 CET_{nt} + \alpha_6 CET_{it} + \alpha_7 CSME_{nit} + \alpha_8 CSME_{nt} + \alpha_9 CSME_{it} - \alpha_{10} NaturalD_{nt} - \alpha_{11} CARI\_NaturalD_{nt} - \alpha_{12} CRISIS_{ni} + \sum_{j=1}^{J} \eta_j RTAs_{nit} + \epsilon_{nit} \quad (3.4.2)$$

where, z_{ni} also now includes dummy variables for: common currency, a common colonizer, a colonial link, a colonial relationship after 1945 and a current colonial relationship. Additionally, dummy variables were included to capture possible trade diversion and creation outside of The Region. $CARICOM_{nit}$ is a dummy variable that takes a value of one when the bilateral pair are members of CARICOM; whereas, $CARICOM_{nt}$ takes a value of one when the exporter is a member of CARICOM exporting to the rest of the world and $CARICOM_{it}$ takes a value of one when the importer is a member of CARICOM importing from the rest of the world. The latter two dummies are aimed at identifying possible trade diversion and or creation caused by the creation of the regional trading bloc, CARICOM. Similarly, CET_{nit} takes a value of one when the bilateral pair consist of members of CARICOM who adopted the CET. To capture possible trade diversion caused by the implementation of the CET in CARICOM, CET_{nt}, which is a dummy variable that takes a value of one when only the exporter is has adopted the CET, is included in a bilateral pair that include one CARICOM member. CET_{it}, another dummy variable, is included to capture possible trade creation caused by the CET outside of The Region. It takes a value of one if only the importer adopted the CET and is importing from outside The Region. A similar set of dummy variables were created for the CSME, that is: $CSME_{nit}$, which captures trade creation within CARICOM; $CSME_{nt}$, which captures possible trade diversion; and, $CSME_{it}$, which captures trade creation outside of The Region. $NaturalD_{nt}$ is a dummy variable that capture the exogenous impact of climatic natural disasters on exports for all countries including CARICOM members. $NaturalD_{nt}$ takes a value of one when the exporter is impacted by a hurricane, tropical storm, flooding or drought in a particular year.

$CRISIS_{ni}$ is a dummy variable which takes a value of one subsequent to the start the of financial crisis, 2008 to 2011, for each bilateral pair.[14] The assumption and hence specification of the this variable is very restrictive as it only captures the average impact of the financial crisis on the countries in the panel; however, in reality this impact is heterogeneous. Its used is more as control than to give insight into the impact of the global financial crisis on exports. $RTAs_{nit}$ are other time varying bilateral and multilateral trade agreements of the countries within the sample[15].

Similar to equation 3.4.4 above, Equation 3.4.6 assumes that the multilateral resistance terms are country-specific and varies with time, hence the use of exporter-time and importer-time fixed effects. The inclusion of exporter-time and importer-time makes it impossible to estimate the effects for Y_{nt}, $\ln(Y_{it}$, $CARICOM_{nt}$, $CARICOM_{nt}$, CET_{nt}, CET_{it} $CSME_{nt}$, $CSME_{it}$, $NaturalD_{nt}$, $CARI_{N}aturalD_{nt}$ and $CRISIS_{ni}$; however, it is possible to estimate the effects of CARICOM, CET and CSME on intra-regional trade in this specification.

[14] Robustness checks were carried out by dropping the period 2008-2012. See Tables 3.17 and 3.18 in the Appendices.

[15] see Table 3.14 in Appendices for list of bilateral and multilateral trade agreements included in the model.

$$\ln(X_{nit}) = \beta_1 \ln(Y_{nt}) + \beta_2 \ln(Y_{it}) + \sum_{m=3}^{M} \beta_m \ln(z_{ni}^m) + \alpha_1 CARICOM_{nit} + \alpha_2 CET_{nit}$$
$$+ \alpha_3 CSME_{nit} + \sum_{j=1}^{J} \eta_j RTAs_{nit} - (1-\sigma)\ln(\Omega_{it}) - (1-\sigma)\ln(\phi_{nt}) + \epsilon_{nit} \quad (3.4.3)$$

3.5 Methodology and Data

The models are each estimated using two different data sets. First, Equation (35) is estimated with trade data for CARICOM members only. This is aimed at ascertaining the significance of 'regional' factors under consideration and for comparison with other gravity models estimated for CARICOM as well as the gravity model set in a much broader global context. Second, the data set is expanded to include trade among CARICOM members and 57 of their major trade partners. This subset of the global trade network accounts for on average 80 percent of global trade over the sample period.

The gravity model is estimated using this subset of the global trade network to examine the impact the 'regional' factors have had on exports both regionally and extra-regionally; that is, identifying the importance and the impact of CARICOM on trade, given the network of possible markets and trade agreement that exist in the panel created. More specifically, the aim is to identify if the policies, CET and CSME, had trade creating or diverging impact as well as whether climatic natural disasters have any major impact on exports in a global context.

The models are estimated using a combination of the procedures recommended by Santos Silva and Tenreyro (2006, 2011a, 2011b) and Head and Mayor (2014). First, the models are estimated in their log-linear form using Pooled OLS and LSDV with a combination of exporter and importer dummy variables and year dummy variables. Second, the residuals are captured and the MaMu/Park-type and GNR tests conducted to better understand the data generating process of the errors. Third, a suite of regressions are estimated and their results analyzed and checked for robustness and sensitivity.

This methodology has a few limitations. First, in this chapter, our sample was reduced from 150 countries to 70 countries because reducing the number of countries made controlling for the multilateral resistance terms using exporter-time and importer-time dummies computationally tractable. At the time of this reearch, the time required to estimate a gravity equation could be considered a polynomial function of the size of the input (number of exporters, importers and years).[16] This can be attributed mostly to software limitation as it is cumbersome to estimate using exporter-time and importer-time dummies; especially with the PPML estimator, which on average took 2.5 days to converge given the 70 countries selected. The second limitation is that this chapter only used the dummy variable (fixed effect) methodology when controlling for the multilateral resistance terms; however, there are other approaches that could have been considered. These include Baier and Bergstrand (2009) iterative technique, Head et al. (2010) tetrad approach and De Bruyne (2013) network analysis; however, these methodology are not as direct when implemented and would require considerable more time. Third, the Heckman selection model has been found to be useful in estimating the static gravity model and disentangling the intensive and extensive margins; however, further research is needed to program and possible use the estimator in a panel framework. Other issues related to the gravity model but not considered in this chapter, or dealt with in the literature, include unit root, structural break, trends and cointegration.

[16]The author acknowledge that there have been recent developments in this area, which allows for estimation with larger samples. This will be revisited in future research.

The data used in this paper is drawn from several sources. These include: World Development Indicators (WDI), which provided macroeconomic and socio-economic indicators such as GDP, GDP per capita, population, value-added of agriculture, industry, manufacturing and services to GDP, external debt, current account balance and exchange rate; International Monetary Fund Direction of Trade (IMF-DOTs) (1980-2012), from which exports and imports data was garnered; CEPII, provided geographic bilateral and cultural data; World Trade Organization (W.T.O) and Sousa (2012), which provided sufficient information on existing bilateral and multilateral trade agreements; Centre for Research on the Epidemiology of Disasters (CRED), which provided climatic disasters; Economic Commission for Latin American and the Caribbean (ECLAC), which provided additional macroeconomic and socio-economic indicators especially for the Caribbean and Latin American region.

3.6 Results

Drawing on our findings from Chapter 2, which suggest that it is critical to understand the dgp of the errors, we conduct the MaMu/Park-type test for heteroskedasticity along with the Gauss Newton Regression (GNR) to establish if the conditional variance is proportional to the conditional mean. We find that when the gravity model is estimated using OLS with and without fixed effects, ignoring zero trade flows, the residuals exhibit heteroskedasticity. Table 3.3 shows the results for the MaMu/Park-type tests for heteroskedasticity for trade among and with CARICOM members. These results confirmed the presence of heteroskedastic errors when the gravity model is estimated using OLS with: (1) no fixed effects; (2) exporter and importer fixed effects; (3) exporter, importer and time fixed effects, and; (4) exporter-time and importer-time fixed effects. Under the null hypothesis of homoskedastic errors, i.e. $\lambda = 2$, the MaMu test consistently estimates $\lambda < 2$ and the Wald tests confirmed that these λ's are significantly less than 2 (see Table 3.3); therefore, rejecting the null that the errors are homoskedastic.

Although the MaMu/Park-type test for heteroskedasticity suggests the presence of heteroskedasticity, it is still useful to compare these findings to the GNR test, which under the null hypothesis assumes that the conditional variance is proportional to conditional mean. The results for the GNR test are presented in Table 3.4. Recall from Chapter 2, that a significant κ means a failure to reject the null hypothesis; therefore, the GNR test fails to reject the null hypothesis that the conditional variance is proportional to the conditional mean. Aligned with Santos Silva and Tenreyro (2006), these tests confirm that OLS is not best suited to estimated the gravity equation.

The PPML and NB QGPML estimators are best suited; however, due to the time needed to estimate one PPML regression, the NB QGPML is not considered. Additionally, our findings in Chapter 2 suggest that its performance is similar to the PPML estimator and exhibit negligible gains in efficiency. Although the Pooled OLS and LSDV estimators are not best suited, they are estimated for comparison with the PPML estimator. Similar to the findings of Santos Silva and Tenreyro (2006), the PPML estimators are found to produce estimates that differ significantly from the models estimated using Pooled OLS and LSDV. Additionally, using fixed effects to control for heterogeneity also results in significant variation in the coefficients of the gravity model. This signifies the importance of controlling for the multilateral resistance terms. Henceforth, the report ignores all estimators that does not include fixed effects; however, they are presented along with the other regression outputs in Tables 3.5 to 3.8. The results in Tables 3.5 and 3.6 are from gravity equations estimated using only trade among CARICOM members; whereas, Tables 3.7 and 3.8 using trade data for 70 countries including 13 CARICOM members.

Table 3.3: MaMu Test for Heteroskedasticity

	(1)	(2)	(3)	(4)
	Pooled OLS	LSDV	LSDV	LSDV
	Log squared errors	Log squared errors	Log squared errors	Log squared errors
Exporter and Importer fixed effects	No	Yes	Yes	No
Time fixed effect	No	No	Yes	No
Exporter- and importer- time	No	No	No	Yes
14 CARICOM members				
N	4212	4212	4212	4351
Ho: $\lambda = 2$				
λ	1.801^{***}	1.693^{***}	1.693^{***}	1.737^{***}
Wald Test F(k, $n-k$)	(56.99)	(331.15)	(323.48)	(268.39)
70 Countries				
N	121385	121385	121385	123783
Ho: $\lambda = 2$				
λ	1.765^{***}	1.772^{***}	1.771^{***}	1.785^{***}
Wald Test F(k, $n-k$)	(7999.40)	(8837.52)	(8895.28)	(8588.38)

Notes:

F(k, $n-k$) in parentheses

***denotes significance at the 0.1 percent, ** denotes 1 percent, *denotes 0.5 percent and $^{+}$denotes 10 percent.

Table 3.4: GNR Test for Heteroskedasticity

	(1)	(2)	(3)	(4)
	Pooled OLS	LSDV	LSDV	LSDV
	Log squared errors	Log squared errors	Log squared errors	Log squared errors
Exporter and Importer fixed effects	No	Yes	Yes	No
Time fixed effect	No	No	Yes	No
Exporter- and importer- time	No	No	No	Yes
14 CARICOM members				
N	4212	4212	4212	4351
Ho: $\kappa = 0$				
κ	1.913^{+}	2.616^{**}	2.622^{**}	4.664^{***}
Wald Test F(k, $n-k$)	(3.66)	(6.87)	(6.87)	(21.67)
70 Countries				
N	121385	121385	121385	123783
Ho: $\kappa = 0$				
κ	8.038^{***}	11.975^{***}	14.118^{***}	13.732^{***}
Wald Test F(k, $n-k$)	(64.61)	(143.54)	(199.55)	(188.38)

Notes:

F(k, $n-k$) in parentheses

κ is the standardized coefficient of the log predicted exports squared

***denotes significance at the 0.1 percent, **denotes 1 percent, *denotes 0.5 percent and $^{+}$denotes 10 percent.

3.6.1 Regional Perspective

Table 3.5 presents results for the gravity model of intra-regional exports and Table 3.6 presents the gravity estimates of market share, i.e. exports from country n to i as a share of country i's total imports. These specifications allow us to identify the effects on exports (Table 3.5) as well as the effects on market power (Table 3.6).

Table 3.5 shows that all estimators consistently estimate the negative impact of distance on exports; however, the coefficients estimated by the PPML are smaller than those returned by the LSDV. Controlling for the multilateral resistance terms using exporter and importer fixed effects (Regression 2 and 6), the PPML estimates that the elasticity associated with distance is -0.433 whereas the elasticity estimated by LSDV is -0.664. If time fixed effects are included, the PPML estimate increases slightly; however, LSDV estimate is unchanged. Assuming that the multilateral resistance terms are country-specific and time varying, i.e. estimation using exporter-time and importer-time fixed effects (Regression 4 and 8), the distance elasticity estimated by the PPML is -0.480 whereas the LSDV estimates an elasticity of -0.714, which is almost 50 percent larger than that estimated by the PPML. The elasticity of distance on market share estimated using the PPML is: -0.516 when the model is estimated with exporter and importer fixed effects; -0.518 when the model is estimated with exporter, importer and time fixed effects; and, -0.604 when the model is estimated with exporter-time and importer-time fixed effects. On average, the estimated elasticity for distance on market share is 25 percent larger than distance on exports. This suggest that the distance between countries in The Region does have implications for how much trade could be achieved among members of CARICOM. Additionally, geographic proximity does influence market power of CARICOM member even more so than the movement of goods.

All regressions consistently suggest a positive relationship between common language and exports; however, the PPML estimator with exporter-time and importer-time suggest that there is no statistical significant relationship of common language on exports and common language on market share. This is not surprising given that most members of CARICOM, except for Haiti and Suriname, have English as their official language. Although other studies have found contiguity to have a positive impact on exports, both the LSDV and PPML estimators consistently estimate a negative coefficient, albeit insignificant for all regressions estimated using the PPML estimator. This is also not surprising since the only two CARICOM members sharing a common border are Suriname and Guyana. What this variable suggests is that trade between these countries is not significantly different from trade with others members in The Region.

The sub-region of the East Caribbean Currency Union (ECCU) is found in all regressions to have a positive impact on exports within The Region. It is estimated that members of ECCU trade 3.8 times more with each other than with rest of CARICOM. ECCU is also found to have a positive impact on market shares of members. Similarly, the PPML with exporter-time and importer-time fixed effects suggest that bilateral pairs where both trade partners have fixed exchange regime trade 2.5 times more with each other, and have market shares which is 133 percent more, than bilateral pairs where one partner has a different exchange rate regime. The effects on market share remains significant, although smaller, when exporter and importer fixed effects with and without time fixed effects are used. On the other hand, we find a negative coefficient if the parties of a bilateral pair both have flexible exchange rate regimes. With the multilateral resistance terms controlled for using exporter-time and importer-time fixed effects, this coefficient is insignificant for the regressions with exports as the dependent variable but significant with market share as dependent variable. We find that if trade partners have a flexible exchange regimes, their market shares are 44 percent less than if the partners had different exchange rate regimes. Although tempting, these coefficients should not be interpreted as effects due to the type of exchange rate regime these countries have as these dummy variable capture all bilateral characteristics common to the subset of countries; however, it points to the need for further research into why countries with fixed exchange rate regime trade more with each other than with others within The Region.

As highlighted in the methodology, it is only possible to identify changes in exports after the implementation of CET and CSME and the effects of economic size and climatic natural disaster if we relaxing the assumption that the multilateral resistance terms are country-specific and time varying and assume that multilateral resistance terms are country-specific. That is, exporter and importer fixed effects are used to control for the multilateral resistance terms; therefore, these results must be taken with "a grain of salt" because the assumptions about the multilateral resistance terms are not the most rigorous. As is expected GDP of the exporter and importer has positive impact on trade within The Region; however, when we assume separate constant for each year, i.e include time fixed effects, these effects are reduced. Assuming that the multilateral resistance terms are country-specific, we also find that exports within The Region increased after the implementation of CET and CSME. The PPML estimates that exports increased by on average 34 percent after the implementation of CET and a further 52 percent after the implementation of CSME. The said effects cannot be identified if year dummies are included since these dummy variables, CET and CSME, are time-shift dummies, which are usually used in time series and panel data models to capture structural break, are absorb by the time fixed effects. We find no such break in the market shares of CARICOM members after the implementation of both CET and CSME.

Lastly, the impacts of climatic natural disasters on exports, controlling for the multilateral resistance terms using exporter and importer fixed effects, is found to be negative, albeit statistically insignificant. On the other hand, when we include year dummies, we find a negative and statistically significant coefficient. We find that if an exporting country is impacted by a climatic natural disaster, exports decrease by about 17 percent in the year of impact. Climatic natural disasters on market shares is also found to be negative. Controlling for the multilateral resistance terms using exporter and importer fixed effects, the impact is found to be a 11 percent reduction in market shares. With the inclusion of year dummies, the estimated impact of climatic natural disasters on market shares is a 20 percent reduction in the impacted country market shares.

Table 3.5: Gravity model estimates for CARICOM's Intra-Regional Trade for the period 1980-2012.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Pooled OLS	LSDV	LSDV	LSDV	PPML	PPML	PPML	PPML
Dependent variable	Log Exports	Log Exports	Log Exports	Log Exports	Exports	Exports	Exports	Exports
Exporter fixed effect	No	Yes	Yes	No	No	Yes	Yes	No
Importer fixed effect	No	Yes	Yes	No	No	Yes	Yes	No
Time fixed effect	No	No	Yes	No	No	No	Yes	No
Exporter-time	No	No	No	Yes	No	No	No	Yes
Importer-time	No	No	No	Yes	No	No	No	Yes
Log GDP Exporter	0.774***	0.211	0.110		1.405***	0.668***	0.274*	
	(4.95)	(1.21)	(0.53)		(6.90)	(5.14)	(2.34)	
Log GDP Importer	0.462**	0.496**	0.407*		0.729***	0.505**	0.354*	
	(2.65)	(3.18)	(2.14)		(4.20)	(3.18)	(2.38)	
Log Distance	-1.256***	-0.664***	-0.664***	-0.714***	-0.615**	-0.433***	-0.437***	-0.480***
	(-5.96)	(-4.72)	(-4.72)	(-4.62)	(-2.78)	(-4.82)	(-4.87)	(-5.37)
Contiguity	-0.874*	-1.224^{+}	-1.212^{+}	-1.295	0.652	-0.627	-0.612	-0.447
	(-2.35)	(-1.68)	(-1.69)	(-1.43)	(1.54)	(-1.12)	(-1.09)	(-0.83)
Common Language	2.479***	1.434**	1.423**	1.575**	0.773	0.883*	0.871*	0.598
	(5.56)	(2.76)	(2.81)	(2.76)	(1.28)	(2.37)	(2.31)	(1.46)
Flexible Exchange Rate (bilateral)	2.708***	-0.680^{+}	-0.691^{+}	-0.630	2.939***	0.142	0.141	-0.253
	(5.26)	(-1.80)	(-1.80)	(-1.58)	(6.41)	(0.32)	(0.33)	(-0.90)
Fixed Exchange Rate (bilateral)	-3.085***	0.426	0.438	0.343	-2.694***	0.561	0.574	0.902***
	(-7.16)	(1.09)	(1.11)	(0.83)	(-7.38)	(1.53)	(1.61)	(3.29)
ECCU	0.459	2.127***	2.129***	2.143***	0.312	1.274***	1.273***	1.329***
	(1.08)	(7.64)	(7.60)	(6.93)	(0.88)	(5.41)	(5.40)	(5.54)
CET (1993)	-0.353^{+}	0.277*			-0.637**	0.296*		
	(-1.81)	(2.07)			(-2.74)	(2.11)		
CSME (2006)	-0.250	0.801***			-1.210**	0.419*		
	(-0.72)	(4.17)			(-2.79)	(2.29)		
Natural Disaster	-0.190^{+}	0.0655	0.0301		-0.563***	-0.0604	-0.188**	
	(-1.69)	(1.19)	(0.44)		(-5.19)	(-1.36)	(-2.66)	
Constant	10.96***	5.414*	8.328*	11.69***	2.100	10.77***	16.63***	23.27***
	(4.50)	(2.49)	(2.50)	(7.27)	(0.69)	(5.34)	(7.10)	(29.54)
N	4212	4212	4212	4351	5173	5173	5173	5173
R^2	0.419	0.730	0.733	0.786	0.554	0.929	0.934	0.992

Notes:

t statistics in parentheses and standard errors are clustered at the country-pair level.

***denotes significance at the 0.1 percent, **denotes 1 percent, *denotes 0.5 percent and $^{+}$denotes 10 percent.

Constant, exporter, importer, exporter-time and importer-time fixed effects are not reported. Estimation results are based on equation (3.4.1).

Table 3.6: Gravity model estimates for CARICOM's Intra-Regional Trade for the period 1980-2012 (dependent variable market share).

	(1)	(2)	(3)	(4)
	PPML	PPML	PPML	PPML
Dependent variable	Market Share	Market Share	Market Share	Market Share
Exporter fixed effect	No	Yes	Yes	No
Importer fixed effect	No	Yes	Yes	No
Time fixed effect	No	No	Yes	No
Exporter-time	No	No	No	Yes
Importer-time	No	No	No	Yes
Log GDP Exporter	0.731***	-0.187*	-0.336**	
	(6.02)	(-2.30)	(-2.73)	
Log GDP Importer	0.220+	0.0346	-0.0331	
	(1.68)	(0.31)	(-0.25)	
Log Distance	-0.526**	-0.516***	-0.518***	-0.604***
	(-3.16)	(-4.54)	(-4.57)	(-4.63)
Contiguity	-1.045***	-1.369*	-1.344*	-1.291*
	(-4.01)	(-2.23)	(-2.19)	(-2.02)
Common Language	0.605	0.461	0.428	0.170
	(1.22)	(1.09)	(1.01)	(0.39)
Flexible Exchange Rate (bilateral)	1.529***	-0.118	-0.143	-0.586*
	(6.23)	(-0.64)	(-0.78)	(-2.30)
Fixed Exchange Rate (bilateral)	-1.804***	0.533*	0.544*	0.846***
	(-5.05)	(2.43)	(2.48)	(3.39)
ECCU	0.265	1.671***	1.670***	1.668***
	(0.73)	(6.75)	(6.75)	(6.22)
CET(1993)	-0.700***	0.0796		
	(-4.11)	(0.80)		
CSME(2006)	-1.384***	0.197		
	(-4.84)	(1.35)		
Natural Disaster	-0.333***	-0.120***	-0.232***	
	(-4.82)	(-3.58)	(-5.23)	
Constant	-6.281**	4.673***	7.068***	4.876***
	(-2.91)	(3.60)	(3.58)	(5.12)
N	5173	5173	5173	5173
R^2	0.303	0.715	0.721	0.815

Notes:

t statistics in parentheses and standard errors are clustered at the country-pair level.

***denotes significance at the 0.1 percent, **denotes 1 percent, *denotes 0.5 percent and +denotes 10 percent.

Constant, exporter, importer, exporter-time and importer-time fixed effects are not reported.

Estimation results are based on equation (3.4.1) with market share as the dependent variable. Market Share is defined as $X_{ni}/\sum_n^N X_{ni}$

3.6.2 Global Perspective

The panel is expanded to include the major trading partners of CARICOM accounting for 80 percent of global trade and encompasses 16 percent zero trade flows. The gravity model is estimated using the aforementioned estimators with bilateral and multilateral trade agreements among the the major trading partners of CARICOM. The model is also estimated with a dummy variable to capture the impact of the recent financial crisis[17].

As is a known stylized facts in the gravity literature, economic size of the exporters and importers are positively related to exports and geographic distance between trading partners is negatively related to exports. The PPML estimated with exporter-time and importer-time fixed effects, finds a distance elasticity of -0.686, which is approximately half that estimated by the LSDV. These distance elasticities are also significantly larger (42 percent) than those estimated using trade among CARICOM members and presented in Table 3.5. This suggest that the average distance effect on trade among CARICOM members is smaller than the average distance effect on global trade. We also find common currency, contiguity, common language and common colonizer are positively related to exports. The PPML, estimated with exporter-time and importer-time fixed effects, returns a positive coefficient for RTA on exports. We find that countries in a RTA on average export 30 percent more than those not in an RTA. Although the PPML suggests a positive effect, the LSDV with varying combination of fixed effects return insignificant negative coefficient; however, the region-specific RTA included are mostly significant. Both the PPML and LSDV find positive statistically significant effects of NAFTA, EU, MERCOSUR, CACM, SADC and EAC on exports. The LSDV, but not the PPML, finds positive statistically significant effects of COMESA on exports.

CARICOM as a trading block has increase trade flows among CARICOM members.

[17]This period was included as it would provided additional time period for which CSME was implemented. To carry out sensitive analysis the period 2008-2012, which is associated with the financial crisis was dropped from the sample; however, this did not significantly impact the results(see Table 3.17 and 3.18 in Appendices for these regression outputs).

There are empirical evidence across all estimators and regressions that CARICOM is trade creating within The Region. The PPML, estimated with exporter-time and importer-time fixed effects, estimates that CARICOM members trade 4 times more with each other than with the ROW. On the contrary, there is no evidence to suggest that CARICOM as a trading bloc is trade creating outside of the Region or trade diverging. These findings are based on the identification of The Region as a trading block since 1980 and relaxing the assumption that the multilateral resistance terms are country-specific and time varying. The PPML and LSDV, with exporter and importer fixed effects, return a coefficient that is negative and insignificant if the exporter is a member of CARICOM exporting to a Non-CARICOM member. The same holds true when time fixed effects are introduced. Similarly, the PPML with exporter and importer fixed effects returns a negative but insignificant coefficient if the importer is a member of CARICOM importing from a Non-CARICOM member; however, the LSDV returns negative but significant coefficients. The same is observed when time fixed effects are included in the regression. In terms of market shares, there is no statistical evidence CARICOM has had any effect on the market share held by CARICOM members in member countries and Non-CARICOM member countries.

A closer look at the policies, CET and CSME, implemented tells a different story. In a global context, after the implementation of CET exports significantly increased within CARICOM; however, exports to the ROW and imports from the ROW declined. This is evident by the positive coefficient for CET estimated by the PPML and LSDV estimators, when controlling for the multilateral resistance terms using exporter-time and importer-time fixed effects. The PPML estimate suggests that CET increased exports within The Region by 182 percent; however, using exporter and importer fixed effects instead of exporter-time and importer-time fixed effects, the PPML estimate becomes insignificant. By introducing time fixed effect, it becomes significant and suggests 50 percent increase in exports. On the other hand, LSDV, with exporter-time and importer-time fixed effects, estimates a positive significant effect of 50 percent but significant negative effects if exporter and importer fixed effects or exporter, importer and time fixed effects are included. If the exporter is a signature to the CET and the importer is a non-signature, the PPML, with exporter and importer fixed effects, estimates a negative coefficient suggesting that exports to the ROW decrease. If time fixed effects is introduced a negative insignificant coefficient is returned. On the contrary, with exporter and importer fixed effects or exporter, importer and time fixed effects, the LSDV returns negative significant coefficients. The story is similar if the importer is a signature to the CET and the exporter is a non-signature. The PPML, with exporter and importer fixed effects, suggests that imports from the ROW decreased; however, with the introduction of time fixed effects this decrease is statistically insignificant.

Table 3.8 shows that after the implementation of CET, the market share held by a CARICOM member in other members increased; however, the market share held by CARICOM members in Non-CARICOM members declined. We find a negative coefficient if the exporter is a signature to the CET and the importer is a non-signature when the gravity model is estimated using the PPML with exporter and importer fixed effects or exporter importer and time fixed effects. This suggests that the market share held by CARICOM members prior to 1993 declined by between 140 and 197 percent subsequent to the implementation of CET. No statistical significant result is found when the importer is a signature to the CET and the exporter is a non-signature. These findings seem to suggest that subsequent to the implementation of CET, CARICOM exporters increased their market share in member counties but decreased in third parties. i.e. this policy did not increase their competitiveness globally.

The PPML, estimated with exporter-time and importer-time fixed effects, suggests that post-CSME trade decreased among CARICOM members. The LSDV estimated with exporter-time and importer-time fixed effects is also negative but insignificant. Similarly, negative and insignificant results are observed when the dependent variable is market shares. When the exporter is a member of the CSME and is exporting to the ROW or when the importer is a member of the CSME and is importing from the ROW, the PPML associates positive significant coefficients with these variables. Regressions (6) and (7) of Table 3.7 suggest that subsequent to the implementation of CSME, exports from CARICOM members to the ROW increased by 22 to 26 percent. Similarly, imports by CARICOM members from the ROW increased by 23 to 26 percent. There was no statistical significant change in market shares if the exporter is a member of the CSME and is exporting to the ROW or if the importer is a member of the CSME and is importing from the ROW. With this, we can conclude that subsequent to the implementation of CSME trade within The Region decline when compared to the period before implementation but trade with the ROW increased, which could be seen as a reversal in the effects, in part, of the CET.

According to the PPML, estimated with exporter-time and importer-time fixed effects, the trade agreements signed by CARICOM with third parties, namely: United States of America (USA), Cuba, Dominica, Columbia and Costa Rica, have significant positive impacts on exports. The PPML identifies a positive impact of the trade agreement between Canada and CARICOM, and Venezuela and CARICOM on exports but there is no statistical evidence it is significant. All estimators suggest that the Economic Partnership agreement between CARIFORUM and the European Union is negatively related to exports; however, this agreement is in its infancy and was signed during the financial crisis therefore conclusion about its impact on exports between the parties involves could be distorted.

Recall that from the gravity model estimated using only trade among CARICOM members, we found some evidence that climatic natural disasters impact intra-regional exports; however, at a global level, there is no evidence that climatic natural disasters significantly impact CARICOM's exports adversely. The PPML estimates negative coefficients for climatic natural disasters on CARICOM exporters; however, these coefficients are not statistically significant. This result was unexpected but not surprising since the greater portion of exports is to the ROW and are mainly industrialise output that are not overly vulnerable to climatic natural disasters; whereas at a regional level this impact is more pronounced given the vulnerability of the primary sector, especially agriculture, to climatic natural disasters, and its importance and share of trade within CARICOM.

3.6.3 Sensitivity Analysis

Several sensitive checks where carried out. These include: (1) estimating the gravity equation with GDP per capita instead of GDP given that the climatic natural disaster dummy might be correlated with GDP; (2) omitting bilateral and multilateral trade agreements not related to CARICOM; and, (3) estimating the gravity equation with a sample which excludes the period associated with the Global Financial Crisis (2008-2011).

None of aforementioned scenarios, (1) to (3), significantly affected the findings detailed in the previous section. The regression outputs for scenarios (1) to (3) can be seen in Tables 3.17 to 3.18 in Appendices.

Table 3.7: Gravity model estimates for 70 countries for the period 1980-2012.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Pooled OLS	LSDV	LSDV	LSDV	PPML	PPML	PPML	PPML
Dependent variable	Log Exports	Log Exports	Log Exports	Log Exports	Exports	Exports	Exports	Exports
Exporter fixed effect	No	Yes	Yes	No	No	Yes	Yes	No
Importer fixed effect	No	Yes	Yes	No	No	Yes	Yes	No
Time fixed effect	No	No	Yes	No	No	No	Yes	No
Exporter-time	No	No	No	Yes	No	No	No	Yes
Importer-time	No	No	No	Yes	No	No	No	Yes
Log GDP Exporter	1.133***	0.589***	0.731***		0.773***	0.603***	0.701***	
	(88.22)	(21.78)	(19.12)		(39.11)	(28.64)	(22.62)	
Log GDP Importer	0.862***	0.655***	0.790***		0.798***	0.549***	0.656***	
	(70.62)	(24.77)	(23.03)		(26.72)	(23.69)	(18.22)	
Log Distance	-1.154***	-1.458***	-1.456***	-1.451***	-0.690***	-0.702***	-0.702***	-0.686***
	(-28.48)	(-35.61)	(-35.57)	(-35.81)	(-11.25)	(-17.08)	(-17.40)	(-17.36)
RTA(All)	-0.0134	-0.0770	-0.0583	-0.135	-0.0905	0.223***	0.216***	0.267***
	(-0.18)	(-0.98)	(-0.73)	(-1.54)	(-0.87)	(3.65)	(3.48)	(3.75)
Natural Disaster(All)	-0.427***	-0.0747***	-0.0670***		-0.192***	0.00913	0.0341**	
	(-10.61)	(-5.11)	(-4.58)		(-3.73)	(0.78)	(2.71)	
Natural Disaster (CARICOM)	-0.142	0.0347	0.0313		-0.405***	-0.130	-0.155	
	(-1.49)	(0.93)	(0.83)		(-4.45)	(-0.86)	(-1.07)	
CARICOM	3.308***	2.195***	2.234***	3.212***	1.550***	0.975+	0.899+	1.619***
	(14.27)	(5.65)	(5.74)	(12.77)	(4.22)	(1.72)	(1.61)	(4.47)
CARICOM Exporter	-0.116	-0.522	-0.488		0.152	-0.292	-0.366	
	(-0.82)	(-1.64)	(-1.53)		(0.42)	(-0.48)	(-0.60)	
CARICOM Importer	0.424***	-0.580**	-0.544**		0.121	-0.152	-0.228	
	(4.16)	(-3.13)	(-2.93)		(0.58)	(-0.67)	(-1.01)	
CET (1993)	-1.034***	-0.407**	-0.463***	0.428*	0.00386	0.295	0.407*	1.037***
	(-7.59)	(-3.11)	(-3.48)	(2.45)	(0.02)	(1.44)	(1.96)	(3.38)
CET (1993) Exporter	-1.061***	-0.474***	-0.511***		-1.060*	-0.743+	-0.640	
	(-10.28)	(-4.87)	(-5.12)		(-2.57)	(-1.82)	(-1.53)	
CET (1993) Importer	-0.671***	-0.108	-0.162*		-0.419***	-0.171*	-0.0957	
	(-10.39)	(-1.72)	(-2.47)		(-4.18)	(-1.96)	(-1.06)	
CSME (2006)	-0.713***	-0.153	-0.0628	-0.0512	-0.0976	0.141+	0.119	-0.392*
	(-6.02)	(-1.57)	(-0.63)	(-0.31)	(-1.16)	(1.67)	(1.34)	(-2.10)
CSME (2006) Exporter	-0.771***	-0.0723	-0.0198		0.0534	0.229**	0.204*	
	(-8.50)	(-0.84)	(-0.22)		(0.60)	(2.75)	(2.39)	
CSME (2006) Importer	-0.482***	0.0265	0.0846		-0.00197	0.227*	0.216+	
	(-7.42)	(0.42)	(1.32)		(-0.02)	(2.05)	(1.89)	

Continued on next page

Table 3.7 continued from previous page

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
CARICOM EU	-0.260	-0.270*	-0.213	-0.0846	-0.803***	-0.547***	-0.503**	-0.553**
	(-1.95)	(-2.18)	(-1.70)	(-0.61)	(-4.47)	(-3.36)	(-3.08)	(-3.20)
CARICOM Dominica Rep.	0.629*	1.239***	1.220***	1.350***	1.664**	1.860***	1.864***	1.848***
	(2.00)	(3.83)	(3.77)	(4.03)	(3.18)	(3.87)	(3.87)	(3.82)
CARICOM Venezuela	-0.449	-0.296	-0.277	0.0170	0.682	0.631	0.639	0.611
	(-1.50)	(-1.00)	(-0.93)	(0.05)	(1.60)	(1.51)	(1.53)	(1.41)
CARICOM Colombia	-0.443	-0.116	-0.122	-0.185	0.379	0.825**	0.824**	0.832**
	(-1.29)	(-0.38)	(-0.40)	(-0.61)	(1.14)	(2.80)	(2.79)	(2.79)
CARICOM Cuba	-1.024	0.0932	0.132	0.166	-0.278	1.103+	1.114+	1.078+
	(-1.39)	(0.15)	(0.21)	(0.26)	(-0.52)	(1.81)	(1.83)	(1.79)
CARICOM USA	1.026***	0.628***	0.649***	0.706***	0.389	0.190	0.199	0.330*
	(4.14)	(3.61)	(3.71)	(3.94)	(1.72)	(1.14)	(1.18)	(2.08)
CARICOM Costa Rica	0.959*	0.862**	0.868**	0.950**	0.574*	0.864***	0.859***	0.877**
	(2.56)	(2.70)	(2.71)	(2.99)	(2.06)	(3.43)	(3.42)	(3.29)
CARICOM Canada	1.027***	0.939***	0.948***	1.002***	-0.0884	0.268	0.283	0.402
	(3.52)	(3.90)	(3.94)	(4.17)	(-0.40)	(0.93)	(0.99)	(1.49)
NAFTA	0.0726	0.638**	0.627**	0.593**	0.764***	0.690***	0.727***	1.000***
	(0.33)	(2.81)	(2.78)	(2.80)	(4.84)	(3.73)	(4.10)	(7.69)
EU	-0.490***	-1.226***	-1.228***	-1.188***	-0.0692	0.250**	0.252**	0.285*
	(-5.45)	(-9.81)	(-9.78)	(-9.13)	(-0.72)	(2.59)	(2.63)	(2.46)
MERCOSUR	0.485	1.115**	1.092**	1.232***	0.433*	1.196***	1.216***	1.105***
	(1.70)	(3.00)	(2.93)	(3.44)	(2.56)	(6.92)	(7.04)	(5.97)
CACM	1.867***	2.174***	2.137***	2.299***	1.007***	2.384***	2.396***	2.360***
	(7.51)	(7.72)	(7.57)	(7.77)	(4.44)	(11.29)	(11.28)	(10.00)
EFTA	0.359	0.505	0.483	0.504	-0.167	0.184	0.157	0.139
	(1.44)	(1.44)	(1.38)	(1.37)	(-0.58)	(0.74)	(0.64)	(0.51)
ASEAN	2.296***	0.0941	0.0431	-0.119	1.644***	-0.211	-0.210	-0.138
	(14.03)	(0.34)	(0.15)	(-0.40)	(9.02)	(-1.16)	(-1.13)	(-0.77)
COMESA	1.331***	2.266***	2.259***	2.691***	-0.311	0.588	0.621	0.714
	(6.45)	(8.22)	(8.35)	(9.72)	(-0.95)	(1.24)	(1.30)	(1.35)
SADC	1.365***	2.160***	2.175***	2.898***	1.260***	1.972***	1.989***	2.079***
	(3.93)	(5.65)	(5.78)	(7.26)	(3.45)	(5.29)	(5.31)	(4.95)
EAC	0.809	2.137***	2.081***	2.799***	-0.231	2.315***	2.317***	2.458***
	(1.35)	(4.30)	(4.18)	(5.37)	(-0.45)	(4.72)	(4.73)	(4.50)

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Table 3.7 continued from previous page

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Common Currency	0.455***	0.482**	0.496***	0.528**	0.135*	0.145**	0.165**	0.0518
	(3.38)	(3.27)	(3.36)	(3.28)	(2.02)	(2.99)	(3.09)	(0.60)
Contiguity	0.457***	-0.118	-0.120	-0.119	0.301***	0.371***	0.361***	0.320***
	(3.97)	(-0.88)	(-0.90)	(-0.91)	(3.44)	(4.90)	(4.82)	(4.42)
Common Language	0.269***	0.403***	0.403***	0.402***	0.281***	0.162*	0.163*	0.177*
	(3.98)	(6.12)	(6.12)	(6.08)	(3.46)	(2.35)	(2.36)	(2.49)
Colony	0.580***	0.626***	0.629***	0.628***	-0.320*	0.0271	0.0299	0.0557
	(4.30)	(3.96)	(3.99)	(3.98)	(-2.52)	(0.27)	(0.30)	(0.57)
Common Colonizer	0.248	0.149	0.151	0.129	0.570**	0.443*	0.439*	0.488**
	(1.90)	(1.20)	(1.22)	(1.05)	(2.87)	(2.35)	(2.33)	(2.71)
Colony after 1945	1.226***	0.866***	0.862***	0.831**	0.215	-0.302	-0.307	-0.280
	(5.35)	(3.33)	(3.32)	(3.21)	(1.10)	(-1.42)	(-1.44)	(-1.34)
Same Country	0.192	0.151	0.159	0.105	0.150	-0.378*	-0.381*	-0.378*
	(0.82)	(0.63)	(0.66)	(0.45)	(1.00)	(-2.40)	(-2.41)	(-2.41)
Financial Crisis (2008-2011)	-0.588***	-0.104***			-0.180***	-0.0804***		
	(-27.81)	(-7.04)			(-10.04)	(-9.12)		
Constant	-22.96***	-3.618***	-11.53***	16.33***	-15.05***	-7.194***	-12.10***	18.56***
	(-44.22)	(-5.13)	(-9.92)	(14.29)	(-11.02)	(-10.48)	(-8.64)	(24.63)
N	121385	121385	121385	123783	143573	143573	143573	147346
R^2	0.732	0.808	0.808	0.823	0.791	0.914	0.916	0.933

Notes:

t statistics in parentheses and standard errors are clustered at the country-pair level.

***denotes significance at the 0.1 percent, **denotes 1 percent, *denotes 0.5 percent and +denotes 10 percent.

Constant, exporter, importer, exporter-time and importer-time fixed effects are not reported. Estimation results are based on equation (3.4.2).

Table 3.8: Gravity model estimates for 70 countries for the period 1980-2012 (dependent variable market share)

	(1)	(2)	(3)	(4)
	PPML	PPML	PPML	PPML
Dependent variable	Market Share	Market Share	Market Share	Market Share
Exporter fixed effect	No	Yes	Yes	No
Importer fixed effect	No	Yes	Yes	No
Time fixed effect	No	No	Yes	No
Exporter-time	No	No	No	Yes
Importer-time	No	No	No	Yes
Log GDP Exporter	0.742***	0.365***	0.670***	
	(43.67)	(13.16)	(20.45)	
Log GDP Importer	-0.112***	-0.339***	-0.0309	
	(-7.62)	(-14.05)	(-0.93)	
Log Distance	-0.765***	-0.926***	-0.919***	-0.930***
	(-15.99)	(-20.07)	(-20.05)	(-20.45)
RTA(All)	-0.292**	0.328***	0.332***	0.450***
	(-3.12)	(5.42)	(5.34)	(6.04)
Natural Disaster(All)	-0.291***	-0.0738***	-0.0210	
	(-8.01)	(-4.91)	(-1.51)	
Natural Disaster(CARICOM)	-0.0295	0.0855**	0.0758*	
	(-0.42)	(2.64)	(2.30)	
CARICOM	1.550***	-0.263	-0.320	0.768
	(5.68)	(-0.58)	(-0.70)	(1.40)
CARICOM Exporter	0.414	-0.837	-0.949	
	(0.81)	(-1.37)	(-1.54)	
CARICOM Importer	-0.328**	-0.101	-0.145	
	(-2.96)	(-0.63)	(-0.90)	
CET (1993)	-0.126	0.315+	0.508**	1.023*
	(-0.72)	(1.91)	(3.01)	(2.24)
CET (1993) Exporter	-1.434***	-1.088**	-0.875*	
	(-3.59)	(-2.93)	(-2.39)	
CET (1993) Importer	-0.479***	-0.0390	0.0477	
	(-5.67)	(-0.45)	(0.55)	
CSME (2006)	-0.283***	0.133+	0.151*	-0.151
	(-4.04)	(1.78)	(2.04)	(-0.57)
CSME (2006) Exporter	-0.143	0.259	0.222	
	(-0.56)	(1.06)	(0.90)	
CSME (2006) Importer	-0.296***	0.0215	0.0771	
	(-3.88)	(0.27)	(0.97)	

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Table 3.8 continued from previous page

	(1)	(2)	(3)	(4)
CARICOM EU	-0.436*	-0.901***	-0.820***	-0.878***
	(-2.44)	(-5.37)	(-4.96)	(-4.97)
CARICOM Dominica Rep.	1.215*	1.256***	1.200***	0.978***
	(2.30)	(3.78)	(3.62)	(4.50)
CARICOM Venezuela	0.338	-0.187	-0.133	-0.274
	(1.08)	(-0.63)	(-0.44)	(-0.66)
CARICOM Colombia	-0.108	0.280	0.247	0.0579
	(-0.30)	(0.80)	(0.70)	(0.16)
CARICOM CUBA	0.603	1.679**	1.756***	1.387*
	(1.02)	(3.24)	(3.39)	(2.51)
CARICOM USA	0.464***	0.00721	0.0255	0.0221
	(3.40)	(0.06)	(0.22)	(0.18)
CARICOM Costa Rica	0.338	0.450	0.407	0.677**
	(1.60)	(1.56)	(1.43)	(2.72)
CARICOM Canada	-0.320	-0.0865	-0.0612	-0.0199
	(-1.46)	(-0.40)	(-0.29)	(-0.09)
NAFTA	0.684***	0.211	0.315*	0.547***
	(4.19)	(1.27)	(2.03)	(4.21)
EU	-0.170+	-0.132+	-0.102+	-0.231*
	(-1.77)	(-1.68)	(-1.24)	(-2.21)
MERCOSUR	1.058***	0.507**	0.539**	0.512**
	(4.41)	(2.87)	(3.07)	(2.84)
CACM	0.997***	0.844**	0.870**	1.365***
	(5.30)	(3.10)	(3.23)	(4.86)
EFTA	0.318	0.633**	0.546**	0.770***
	(1.25)	(3.14)	(2.62)	(3.36)
ASEAN	1.031***	-0.191	-0.283	-0.253
	(5.56)	(-1.34)	(-1.74)	(-1.36)
COMESA	-0.106	0.549	0.703	1.210***
	(-0.23)	(1.43)	(1.95)	(4.36)
SADC	1.995***	1.317***	1.404***	2.480***
	(6.04)	(4.73)	(5.29)	(7.84)
EAC	0.728	1.402***	1.375***	2.142***
	(1.33)	(4.11)	(3.95)	(5.99)

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Table 3.8 continued from previous page

	(1)	(2)	(3)	(4)
Common Currency	-0.172	-0.105	-0.0199	-0.188
	(-1.96)	(-1.01)	(-0.18)	(-1.30)
Contiguity	0.429***	0.265***	0.258**	0.236**
	(4.06)	(3.33)	(3.28)	(3.16)
Common Language	0.165*	0.298***	0.295***	0.281***
	(2.31)	(4.27)	(4.21)	(4.09)
Colony	0.186	0.390**	0.407**	0.417***
	(1.53)	(3.04)	(3.20)	(3.37)
Common Colonizer	0.422**	0.376*	0.365*	0.413**
	(2.96)	(2.33)	(2.25)	(2.60)
Colony after 1945	0.605***	0.373*	0.359+	0.349+
	(3.41)	(1.96)	(1.89)	(1.85)
Same Country	-0.231	-0.275*	-0.271*	-0.313*
	(-1.32)	(-2.00)	(-1.98)	(-2.45)
Financial Crisis (2008-2011)	-0.326***	-0.0289**		
	(-16.87)	(-2.72)		
Constant	-14.21***	-0.0109	-14.72***	-3.539***
	(-23.86)	(-0.01)	(-10.98)	(-5.27)
N	143573	143573	143573	147346
R^2	0.556	0.716	0.720	0.752

Notes:

t statistics in parentheses and standard errors are clustered at the country-pair level.

***denotes significance at the 0.1 percent, **denotes 1 percent, *denotes 0.5 percent and +denotes 10 percent.

Constant, exporter, importer, exporter-time and importer-time fixed effects are not reported.

Estimation results are based on equation (3.4.2) with market share as the dependent variable. Market Share is defined as $X_{ni}/\sum_n^N X_{ni}$

3.7 Conclusion

The gravity model is the 'workhorse' for analyzing international trade flows. This chapter examines the impact of Regional Trade Agreement (RTA), decomposed into the common external tariff (CET) implemented in 1993 and the Caribbean Single Market and Economy (CSME) implemented in 2006, and climatic natural disasters, comprised of floods, droughts and tropical cyclones on trade among CARICOM members and the rest of the world (ROW) using a gravity model. The gravity model is estimated using the LSDV and PPML estimators with data for 70 countries, which account for 80 percent of global trade and includes 16 percent zero trade flows. The MaMu/Park-type test for heteroskedasticity confirmed the presence of a non-constant variance of the error and the GNR test failed to reject the null that the conditional variance is proportional to conditional mean. Under this condition, aligned with the literature and our finding in Chapter 2, the PPML estimator is least biased.

The main findings are that CARICOM as a trading bloc over the sample 1980-2012 period increased exports among members but there is no evidence that it has trade created or diverged outside The Region. Further, the CET implementation on a phased basis post 1993, increased trade within The Region; however, this increase in trade within CARICOM has come at the expense of exports to, and imports from, the ROW. On the other hand, after the implementation of CSME trade among CARICOM members decline; however, exports to, and imports from, the ROW increased. Generally, CET and CSME, thus far, have been found to be ineffective and insufficient responses to globalization and increased international competitiveness. It seems these policies have only led to the reallocation of market shares from firms outside of The Region to firms within CARICOM, instead of, achieving reallocation of market share by increasing the productivity of regional firms and furthermore creating greater global reach. Notwithstanding, the implementation of a currency union could be trade enhancing for The Region; however, further research is required to better understand these implications and inform the way forward. In the following chapter we attempt to explore this aspect further.

Another finding is that the distance between CARICOM members does have implications for how much trade could be achieved within The Region since geographic proximity does influence market power and the movement of goods. Similarly, climatic natural disasters adversely impact intra-regional exports from affected CARICOM members. At a regional level, CARICOM exporters are impacted significantly by climatic natural disasters; however, there seems to be no statistical significant evidence to suggest that climatic natural disasters have had significant impact on CARICOM's exports globally. One possible explanation for this is that trade with the ROW is mainly comprised of industrial outputs that are not overly vulnerable to climatic natural disasters; whereas goods, such as agricultural produce, traded at a regional level are more vulnerable to climatic natural disasters and account for a larger market share of regional exports. It is therefore imperative that the countries of The Region continue to collaborate when dealing with, and hence mitigating, the impacts of climatic natural disasters on their economies. Additionally, trade with the rest of the world could also help to mitigate scarcity created by climatic natural disasters.

Methodologically, following 'best practices' on how to estimate the gravity equation, the gravity model is estimated with exporter, importer, time, exporter-time and importer-time fixed effects to control for the unobserved multilateral resistance associated with international trade. Consideration is also given to the presence of heteroskedasticity and observed zero trade flows. Test for heteroskedasticity using MaMu/Park-type test confirmed its presence and the GNR test suggested that the conditional variance is proportional to conditional mean. Given these findings coupled with 16 percent observed bilateral zero trade flows the data set, the PPML estimator is considered to be most appropriate; however, the LSDV is used for comparison and robustness checks.

Controlling for the multilateral resistance terms, the gravity models estimated in most instances confine to the established findings in the literature; such as, economic size is positively related to exports and distance is inversely related to exports.

3.8 Appendix

3.8.1 Annex A: CARICOM Objectives and Organizations

CARICOM's objectives (CARICOM, 2001):

- improved standards of living and work;
- full employment of labour and other factors of production;
- accelerated, co-ordinated and sustained economic development and convergence;
- expansion of trade and economic relations with third States;
- enhanced levels of international competitiveness;
- organization for increased production and productivity;
- the achievement of a greater measure of economic leverage and effectiveness of Member States in dealing with third States, groups of States and entities of any description;
- enhanced co-ordination of Member States' foreign and [foreign] economic policies; and
- enhanced functional co-operation, including
  - more efficient operation of common services and activities for the benefit of its peoples o accelerated promotion of greater understanding among its peoples and the advancement of their social, cultural and technological development
  - intensified activities in areas such as health, education, transportation and telecommunications.

Two principal organizations of CARICOM:

- The Conference of Heads of Government; and
- The Community Council of Ministers.

The principal organizations are aided by the following:

- The Council for Finance and Planning;
- The Council for Trade and Economic Development;
- The Council for Foreign and Community Relations; and
- The Council for Human and Social Development.

3.8.2 Annex B: Data, Descriptive Statistics and Regression Outputs

Table 3.9: Selected Economic Statistics for CARICOM (1980-2012)

Country	1980	1990	2000	2006	2010	2012
Population (Million)						
Antigua and Barbuda	0.07	0.06	0.08	0.08	0.09	0.09
Bahamas, The	0.21	0.26	0.30	0.34	0.36	0.37
Barbados	0.25	0.26	0.27	0.27	0.28	0.28
Belize	0.14	0.19	0.24	0.28	0.31	0.32
Dominica	0.08	0.07	0.07	0.07	0.07	0.07
Grenada	0.09	0.10	0.10	0.10	0.10	0.11
Guyana	0.78	0.73	0.74	0.77	0.79	0.80
Haiti	5.69	7.11	8.58	9.39	9.90	10.17
Jamaica	2.13	2.39	2.59	2.66	2.70	2.71
St. Kitts and Nevis	0.04	0.04	0.05	0.05	0.05	0.05
St. Lucia	0.12	0.14	0.16	0.17	0.18	0.18
St. Vincent and the Grenadines	0.10	0.11	0.11	0.11	0.11	0.11
Suriname	0.37	0.41	0.47	0.51	0.52	0.53
Trinidad and Tobago	1.09	1.22	1.27	1.30	1.33	1.34
Total Population of CARICOM	11.15	13.07	15.01	16.10	16.79	17.14
Total Population of CARICOM (exclude Haiti)	5.46	5.96	6.43	6.71	6.89	6.97
Trade (% of GDP)						
Antigua and Barbuda	154.0	175.9	126.7	119.7	103.7	103.0
Bahamas, The	133.3	110.1	105.9	100.1	90.2	107.7
Barbados	142.2	86.0	88.8	94.4	96.9	96.8
Belize	124.0	122.3	126.7	122.8	115.6	N/A
Dominica	114.6	135.1	101.0	89.8	91.6	91.5
Grenada	126.7	105.2	104.3	80.1	69.7	76.7
Guyana	174.9	142.6	206.8	N/A	N/A	N/A
Haiti	N/A	N/A	46.1	59.5	74.5	61.2
Jamaica	102.1	99.9	N/A	100.8	80.9	83.4
St. Kitts and Nevis	164.0	134.9	95.8	88.4	79.1	76.6
St. Lucia	161.2	156.7	107.6	112.7	117.0	110.3
St. Vincent and the Grenadines	160.1	142.6	95.6	88.0	84.9	83.5
Suriname	143.0	86.5	52.9	N/A	94.2	N/A
Trinidad and Tobago	89.4	74.0	104.6	118.7	92.4	N/A

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Table 3.9 - continued from previous page.

Country	1980	1990	2000	2006	2010	2012
GDP (constant 2005 US$Mn)						
Antigua and Barbuda	332.0	599.3	847.1	1,137.6	1,009.4	1,007.1
Bahamas, The	4,242.3	5,738.7	7,099.1	7,900.2	7,575.5	7,842.3
Barbados	2,819.1	3,168.3	3,687.6	4,113.6	4,033.1	4,064.1
Belize	297.7	482.2	856.7	1,166.5	1,277.5	1,376.5
Dominica	178.7	300.2	336.9	396.0	459.4	450.2
Grenada	239.0	409.4	560.4	673.4	672.7	683.4
Guyana	697.0	494.0	796.3	867.2	918.9	1,015.5
Haiti	N/A	N/A	4,270.0	4,247.9	4,307.7	4,676.9
Jamaica	N/A	N/A	N/A	N/A	N/A	N/A
St. Kitts and Nevis	178.7	301.4	442.7	561.5	548.8	599.5
St. Lucia	316.3	626.7	858.2	993.0	1,067.2	1,085.8
St. Vincent and the Grenadines	186.1	334.2	444.6	593.7	591.9	606.3
Suriname	1,420.4	1,269.3	1,358.0	1,862.5	2,188.9	2,394.1
Trinidad and Tobago	10,065.7	8,022.4	10,957.0	18,299.7	18,989.0	18,969.2
GDP per capita (current US$)						
Antigua and Barbuda	1,565.6	6,325.2	10,144.4	13,675.1	13,315.2	12,733.5
Bahamas, The	6,338.6	12,350.9	21,250.6	23,733.8	21,881.1	21,908.3
Barbados	3,458.6	7,801.9	11,675.2	15,691.8	15,812.3	14,917.1
Belize	1,351.0	2,202.3	3,486.2	4,363.9	4,529.9	N/A
Dominica	784.7	2,344.9	4,656.6	5,408.1	6,630.2	6,691.7
Grenada	939.5	2,296.0	5,149.1	6,825.1	7,485.9	7,266.7
Guyana	776.4	547.0	957.3	1,905.6	2,874.0	3,584.0
Haiti	N/A	N/A	427.2	519.7	670.4	771.0
Jamaica	1,256.2	1,921.4	3,479.1	4,469.6	4,887.8	5,440.5
St. Kitts and Nevis	1,111.0	3,898.8	9,146.5	12,635.0	12,904.1	14,314.0
St. Lucia	1,130.8	2,874.5	4,870.7	6,072.3	6,814.4	6,848.2
St. Vincent and the Grenadines	600.0	1,843.6	3,683.6	5,610.6	6,172.6	6,515.2
Suriname	2,174.1	954.6	1,911.8	5,198.3	8,320.6	9,376.5
Trinidad and Tobago	5,745.7	4,147.7	6,430.9	14,162.8	15,561.8	17,436.5
Regional Average Value Added % of GDP						
Agriculture	17.7	13.4	8.5	7.3	6.8	6.4
Industry	25.7	23.5	23.8	24.9	24.0	
Manufacturing	11.7	9.2	7.2	7.4	7.1	6.7
Services	56.6	63.1	67.7	66.9	68.3	70.7

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Table 3.9 - continued from previous page.

Country	1980	1990	2000	2006	2010	2012
Total debt service (% of exports of goods, services and primary income)						
Antigua and Barbuda	N/A	N/A	N/A	N/A	N/A	N/A
Bahamas, The	N/A	N/A	N/A	N/A	N/A	N/A
Barbados	N/A	N/A	N/A	N/A	N/A	N/A
Belize	N/A	7.2	15.3	16.7	14.6	11.3
Dominica	N/A	6.6	7.4	12.7	8.6	10.0
Grenada	6.0	4.3	6.0	8.8	14.0	7.7
Guyana	23.2		10.2	4.4	2.7	8.7
Haiti	9.9	11.9	9.2	8.5	15.7	0.3
Jamaica	19.7	27.9	18.6	16.0	27.9	38.2
St. Kitts and Nevis	N/A	N/A	N/A	N/A	N/A	N/A
St. Lucia	N/A	2.2	7.9	7.5	7.4	6.9
St. Vincent and the Grenadines	1.1	3.3	7.2	14.8	16.1	16.6
Suriname	N/A	N/A	N/A	N/A	N/A	N/A
Trinidad and Tobago	N/A	N/A	N/A	N/A	N/A	N/A

Source: World Bank, World Development Indicators

Table 3.10: Top Twenty Exports by CARICOM (SITC 2 Digit Groups, US$'000)

Product code	Product label	Value in 2005	%	Value in 2007	%	Value in 2009	%	Value in 2012	%
27	Mineral fuels, oils, distillation products, etc	7,101,170	49%	9,617,479	48%	7,709,740	51%	13,294,981	50%
28	Inorganic chemicals, precious metal compound, isotopes	1,813,630	13%	2,301,423	12%	715,223	5%	3,592,480	13%
29	Organic chemicals	759,189	5%	1,065,050	5%	414,241	3%	1,990,533	7%
72	Iron and steel	359,005	2%	637,253	3%	358,222	2%	1,502,745	6%
31	Fertilizers	145,512	1%	233,601	1%	153,890	1%	961,270	4%
61	Articles of apparel, accessories, knit or crochet	438,986	3%	468,896	2%	464,917	3%	631,951	2%
71	Pearls, precious stones, metals, coins, etc	435,724	3%	670,935	3%	325,489	2%	586,675	2%
22	Beverages, spirits and vinegar	360,335	3%	434,963	2%	493,161	3%	538,831	2%
03	Fish, crustaceans, molluscs, aquatic invertebrates nes	213,222	1%	201,480	1%	174,222	1%	345,257	1%
17	Sugars and sugar confectionery	322,981	2%	347,170	2%	267,486	2%	341,129	1%
26	Ores, slag and ash	156,016	1%	652,080	3%	407,496	3%	308,877	1%
10	Cereals	63,700	0%	96,324	0%	143,081	1%	247,215	1%
39	Plastics and articles thereof	165,077	1%	460,601	2%	173,680	1%	202,037	1%
62	Articles of apparel, accessories, not knit or crochet	66,802	0%	104,702	1%	124,072	1%	193,586	1%
08	Edible fruit, nuts, peel of citrus fruit, melons	103,733	1%	104,533	1%	128,337	1%	172,863	1%
85	Electrical, electronic equipment	153,199	1%	188,477	1%	144,418	1%	158,189	1%
20	Vegetable, fruit, nut, etc food preparations	105,926	1%	129,985	1%	112,327	1%	130,870	0%
84	Machinery, nuclear reactors, boilers, etc	126,972	1%	248,214	1%	166,576	1%	118,478	0%
44	Wood and articles of wood, wood charcoal	67,008	0%	87,553	0%	60,436	0%	105,354	0%
99	Commodities not elsewhere specified	548,157	4%	736,024	4%	1,243,550	8%	96,845	0%
Sub-total	Top 20 imports	13,506,344	94%	18,786,743	94%	13,780,564	92%	25,520,166	95%
-	Others	872,977	6%	1,196,836	6%	1,248,609	8%	1,271,348	5%
TOTAL	All products	14,379,321	100%	19,983,579	100%	15,029,173	100%	26,791,514	100%

Source: International Trade Centre (ITC)

Table 3.11: Top Twenty Imports by CARICOM (SITC 2 Digit Groups, US$'000)

Product code	Product label	Value in 2005	%	Value in 2007	%	Value in 2009	%	Value in 2012	%
27	Mineral fuels, oils, distillation products, etc	5,055,540	25%	6,418,355	25%	7,962,198	30%	7,564,170	26%
84	Machinery, nuclear reactors, boilers, etc	2,003,195	10%	2,439,144	9%	2,457,029	9%	2,439,065	8%
85	Electrical, electronic equipment	1,244,639	6%	1,679,895	6%	1,354,446	5%	1,419,434	5%
87	Vehicles other than railway, tramway	1,301,007	6%	1,588,934	6%	1,116,946	4%	1,638,302	6%
39	Plastics and articles thereof	640,372	3%	774,706	3%	726,990	3%	863,874	3%
73	Articles of iron or steel	600,080	3%	831,449	3%	814,308	3%	666,400	2%
99	Commodities not elsewhere specified	313,517	2%	415,985	2%	482,323	2%	1,056,004	4%
22	Beverages, spirits and vinegar	328,028	2%	485,244	2%	558,723	2%	819,301	3%
10	Cereals	357,006	2%	460,976	2%	583,532	2%	669,097	2%
48	Paper and paperboard, articles of pulp, paper and board	437,768	2%	474,387	2%	473,569	2%	468,985	2%
30	Pharmaceutical products	369,906	2%	410,434	2%	538,687	2%	452,716	2%
72	Iron and steel	379,267	2%	474,356	2%	332,123	1%	452,481	2%
94	Furniture, lighting, signs, prefabricated buildings	339,457	2%	444,166	2%	339,866	1%	397,168	1%
04	Dairy products, eggs, honey, edible animal product nes	313,035	2%	359,654	1%	340,823	1%	458,628	2%
26	Ores, slag and ash	196,291	1%	479,670	2%	144,291	1%	628,796	2%
02	Meat and edible meat offal	267,514	1%	323,968	1%	335,511	1%	476,064	2%
21	Miscellaneous edible preparations	263,349	1%	293,487	1%	343,468	1%	395,887	1%
19	Cereal, flour, starch, milk preparations and products	209,638	1%	252,974	1%	320,419	1%	391,365	1%
90	Optical, photo, technical, medical, etc apparatus	234,512	1%	310,412	1%	265,919	1%	362,369	1%
17	Sugars and sugar confectionery	191,287	1%	266,933	1%	267,394	1%	355,553	1%
Sub-total	Top 20 imports	15,045,408	74%	19,185,129	74%	19,758,565	75%	21,975,659	75%
-	Others	5,420,376	26%	6,770,390	26%	6,514,346	25%	7,507,671	25%
TOTAL	All products	20,465,784	100%	25,955,519	100%	26,272,911	100%	29,483,330	100%

Source: International Trade Centre (ITC)

Table 3.12: Top Twenty Products Traded within CARICOM (SITC 2 Digit Groups, US$'000)

Product code	Product label	Value in 2005	%	Value in 2007	%	Value in 2009	%	Value in 2012	%
'27	Mineral fuels, oils, distillation products, etc	1,650,796	64%	1,328,516	54%	1,093,667	50%	1,596,074	62%
'22	Beverages, spirits and vinegar	93,373	4%	115,447	5%	104,362	5%	118,013	5%
'10	Cereals	32,524	1%	51,221	2%	80,230	4%	81,761	3%
'19	Cereal, flour, starch, milk preparations and products	46,076	2%	56,476	2%	56,870	3%	63,691	2%
'48	Paper and paperboard, articles of pulp, paper and board	70,807	3%	90,248	4%	73,520	3%	56,073	2%
'03	Fish, crustaceans, molluscs, aquatic invertebrates nes	20,955	1%	28,245	1%	25,133	1%	45,052	2%
'17	Sugars and sugar confectionery	50,012	2%	38,269	2%	16,017	1%	43,598	2%
'20	Vegetable, fruit, nut, etc food preparations	40,976	2%	60,782	2%	43,485	2%	40,140	2%
'34	Soaps, lubricants, waxes, candles, modelling pastes	33,780	1%	44,887	2%	43,024	2%	39,783	2%
'30	Pharmaceutical products	22,757	1%	18,025	1%	27,888	1%	37,960	1%
'39	Plastics and articles thereof	39,137	2%	44,123	2%	40,183	2%	30,059	1%
'25	Salt, sulphur, earth, stone, plaster, lime and cement	26,800	1%	37,797	2%	41,095	2%	29,418	1%
'24	Tobacco and manufactured tobacco substitutes	25,005	1%	30,295	1%	40,032	2%	27,947	1%
'11	Milling products, malt, starches, inulin, wheat gluten	14,430	1%	19,971	1%	21,787	1%	27,129	1%
'72	Iron and steel	48,278	2%	65,144	3%	58,133	3%	24,004	1%
'85	Electrical, electronic equipment	42,812	2%	50,221	2%	33,605	2%	23,537	1%
'31	Fertilizers	7,929	0%	19,540	1%	8,044	0%	23,207	1%
'86	Railway, tramway locomotives, rolling stock, equipment	1,074	0%	288	0%	395	0%	22,485	1%
'15	Animal,vegetable fats and oils, cleavage products, etc	22,723	1%	23,924	1%	29,640	1%	21,124	1%
'84	Machinery, nuclear reactors, boilers, etc	20,323	1%	21,657	1%	14,399	1%	21,122	1%
Sub-total	Top 20 traded product categories of CARICOM	2,310,567	89%	2,145,076	87%	1,851,509	85%	2,372,177	92%
-	Others	286,476	11%	329,406	13%	315,756	15%	219,573	8%
TOTAL	All products	2,597,043	100%	2,474,482	100%	2,167,265	100%	2,591,750	100%

Source: International Trade Centre (ITC)

Table 3.13: List of Countries in the Panel

CARICOM Members	Major Trade Partners				
Bahamas	Argentina	Dominican Republic	Kenya	Philippines	United States of America
Barbados	Australia	El Salvador	Korea, Republic of	Poland	Uruguay
Belize	Austria	France	Malaysia	Russian Federation	Venezuela (Bolivarian Republic of)
Dominica	Belgium	Germany	Martinique	Saudi Arabia	Zambia
Grenada	Bermuda	Ghana	Mexico	Singapore	Zimbabwe
Guyana	Brazil	Greece	Netherlands	South Africa	
Haiti	Canada	Guatemala	Netherlands Antilles	Spain	
Jamaica	China	Honduras	New Zealand	Sweden	
Saint Kitts and Nevis	Colombia	Iceland	Nigeria	Switzerland	
Saint Lucia	Costa Rica	India	Norway	Tanzania, United Republic of	
Saint Vincent and Grenadines	Cte d'Ivoire	Ireland	Pakistan	Thailand	
Suriname	Cuba	Italy	Panama	United Arab Emirates	
Trinidad and Tobago	Denmark	Japan	Peru	United Kingdom	

Table 3.14: List of Bilateral and Multilateral Trade Agreements

RTA Name	Coverage	Type	Date of Notification	Date of entry into force	Status
ASEAN - China	Goods & Services	FTA & EIA	21-Sep-2005(G) / 26-Jun-2008(S)	01-Jan-2005(G) / 01-Jul-2007(S)	In Force
ASEAN - India	Goods	FTA	19-Aug-10	01-Jan-10	In Force
ASEAN - Japan	Goods	FTA	23-Nov-09	01-Dec-08	In Force
ASEAN - Korea, Republic of	Goods & Services	FTA & EIA		01-Jan-2010(G) / 01-May-2009(S)	In Force
ASEAN Free Trade Area (AFTA)	Goods	FTA	30-Oct-92	28-Jan-92	In Force
Asia Pacific Trade Agreement (APTA)	Goods	PSA	02-Nov-76	17-Jun-76	In Force
Asia Pacific Trade Agreement (APTA) - Accession of China	Goods	PSA	30-Apr-04	01-Jan-02	In Force
Canada - Colombia	Goods & Services	FTA & EIA	07-Oct-11	15-Aug-11	In Force
Canada - Costa Rica	Goods	FTA	13-Jan-03	01-Nov-02	In Force
Canada - Peru	Goods & Services	FTA & EIA	31-Jul-09	01-Aug-09	In Force
Caribbean Community and Common Market (CARICOM)	Goods & Services	CU & EIA	14-Oct-1974(G) / 19-Feb-2003(S)	01-Aug-1973(G) / 04-Jul-2002(S)	In Force
Central American Common Market (CACM)	Goods	CU	24-Feb-61	04-Jun-61	In Force
China - Singapore	Goods & Services	FTA & EIA	02-Mar-09	01-Jan-09	In Force
Colombia - Mexico	Goods & Services	FTA & EIA	13-Sep-10	01-Jan-95	In Force
Colombia - Northern Triangle (El Salvador, Guatemala, Honduras)	Goods & Services	FTA & EIA	31-Aug-12	12-Nov-09	In Force
Common Market for Eastern and Southern Africa (COMESA)	Goods	CU	04-May-95	08-Dec-94	In Force
Dominican Republic - Central America	Goods & Services	FTA & EIA	06-Jan-12	04-Oct-01	In Force
Dominican Republic - Central America - United States (CAFTA-DR)	Goods & Services	FTA & EIA	17-Mar-06	01-Mar-06	In Force
EFTA - Accession of Iceland	Goods	FTA	30-Jan-70	01-Mar-70	In Force
EFTA - Canada	Goods	FTA	04-Aug-09	01-Jul-09	In Force
EFTA - Colombia	Goods & Services	FTA & EIA	14-Sep-11	01-Jul-11	In Force
EFTA - Korea, Republic of	Goods & Services	FTA & EIA	23-Aug-06	01-Sep-06	In Force
EFTA - Mexico	Goods & Services	FTA & EIA	25-Jul-01	01-Jul-01	In Force
EFTA - Peru	Goods	FTA	30-Jun-11	01-Jul-11	In Force
EFTA - Singapore	Goods & Services	FTA & EIA	14-Jan-03	01-Jan-03	In Force
El Salvador- Honduras - Chinese Taipei	Goods & Services	FTA & EIA	06-Apr-10	01-Mar-08	In Force
EU - CARIFORUM States EPA	Goods & Services	FTA & EIA	16-Oct-08	01-Nov-08	In Force
EU - Iceland	Goods	FTA	24-Nov-72	01-Apr-73	In Force
EU - Korea, Republic of	Goods & Services	FTA & EIA	07-Jul-11	01-Jul-11	In Force
EU - Mexico	Goods & Services	FTA & EIA	25-Jul-2000(G) / 21-Jun-2002(S)	01-Jul-2000(G) / 01-Oct-2000(S)	In Force
EU - Norway	Goods	FTA	13-Jul-73	01-Jul-73	In Force
EU Overseas Countries and Territories (OCT)	Goods	FTA	14-Dec-70	01-Jan-71	In Force
EU - South Africa	Goods	FTA	02-Nov-00	01-Jan-00	In Force
EU - Switzerland - Liechtenstein	Goods	FTA	27-Oct-72	01-Jan-73	In Force
European Free Trade Association (EFTA)	Goods & Services	FTA & EIA	14-Nov-1959(G) / 15-Jul-2002(S)	03-May-1960(G) / 01-Jun-2002(S)	In Force
Guatemala - Chinese Taipei	Goods & Services	FTA & EIA	11-Jul-11	01-Jul-06	In Force
India - Japan	Goods & Services	FTA & EIA	14-Sep-11	01-Aug-11	In Force
India - Singapore	Goods & Services	FTA & EIA	03-May-07	01-Aug-05	In Force
Japan - Mexico	Goods & Services	FTA & EIA	31-Mar-05	01-Apr-05	In Force
Japan - Singapore	Goods & Services	FTA & EIA	08-Nov-02	30-Nov-02	In Force
Japan - Switzerland	Goods & Services	FTA & EIA	01-Sep-09	01-Sep-09	In Force
Korea, Republic of - India	Goods & Services	FTA & EIA		01-Jan-10	In Force
Korea, Republic of - Singapore	Goods & Services	FTA & EIA	21-Feb-06	02-Mar-06	In Force
North American Free Trade Agreement (NAFTA)	Goods & Services	FTA & EIA	29-Jan-1993(G) / 01-Mar-1995(S)	01-Jan-94	In Force
Panama - Chinese Taipei	Goods & Services	FTA & EIA	28-Jul-09	01-Jan-04	In Force
Panama - Costa Rica (Panama - Central America)	Goods & Services	FTA & EIA	07-Apr-09	23-Nov-08	In Force
Panama - El Salvador (Panama - Central America)	Goods & Services	FTA & EIA	24-Feb-05	11-Apr-03	In Force
Panama - Guatemala (Panama - Central America)	Goods & Services	FTA & EIA	22-Apr-13	20-Jun-09	In Force
Panama - Singapore	Goods & Services	FTA & EIA	04-Apr-07	24-Jul-06	In Force
Pan-Arab Free Trade Area (PAFTA)	Goods	FTA	03-Oct-06	01-Jan-98	In Force
Peru - China	Goods & Services	FTA & EIA	03-Mar-10	01-Mar-10	In Force
Peru - Korea, Republic of	Goods & Services	FTA & EIA	09-Aug-11	01-Aug-11	In Force
Peru - Singapore	Goods & Services	FTA & EIA	30-Jul-09	01-Aug-09	In Force
US - Peru	Goods & Services	FTA & EIA	03-Feb-09	01-Feb-09	In Force
US - Singapore	Goods & Services	FTA & EIA	17-Dec-03	01-Jan-04	In Force
Ukraine - Russian Federation	Goods	FTA	18-Aug-08	21-Feb-94	In Force

This list does not include the following agreements: CARICOM-USA, CARICOM-Canada, CARICOM-CUBA, CARICOM-Dominica, CARICOM-Columbia and CARICOM-Venezuela.

Source: World Trade Organization (WTO)

Table 3.15: Gravity model estimates for CARICOM's Intra-Regional Trade for the period 1980-2007

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Pooled OLS	LSDV	LSDV	LSDV	PPML	PPML	PPML	PPML
Dependent variable	Log Exports	Log Exports	Log Exports	Log Exports	Exports	Exports	Exports	Exports
Exporter fixed effect	No	Yes	Yes	No	No	Yes	Yes	No
Importer fixed effect	No	Yes	Yes	No	No	Yes	Yes	No
Time fixed effect	No	No	Yes	No	No	No	Yes	No
Exporter-time	No	No	No	Yes	No	No	No	Yes
Importer-time	No	No	No	Yes	No	No	No	Yes
Log GDP Exporter	0.735***	0.367*	0.131		1.050***	0.453***	0.146	.
	(5.12)	(2.14)	(0.54)		(7.54)	(3.47)	(1.20)	
Log GDP Importer	0.471**	0.682***	0.464*		0.539***	0.998***	0.906***	.
	(3.11)	(4.33)	(2.27)		(3.89)	(8.70)	(7.60)	
Log Distance	-1.272***	-0.701***	-0.704***	-0.759***	-0.616**	-0.479***	-0.484***	-0.530***
	(-6.15)	(-4.95)	(-4.98)	(-4.73)	(-2.72)	(-5.25)	(-5.29)	(-5.85)
Contiguity	-1.009*	-1.033+	-0.958+	-1.060	-0.144	-1.102*	-1.080*	-0.846
	(-2.49)	(-1.93)	(-1.79)	(-1.48)	(-0.46)	(-2.25)	(-2.16)	(-1.65)
Common Language	2.449***	1.071*	0.965*	1.139*	0.776	0.643	0.610	0.202
	(5.11)	(2.25)	(1.98)	(2.11)	(1.08)	(1.57)	(1.42)	(0.43)
Flexible Exchange Rate (bilateral)	2.557***	-0.645	-0.745 +	-0.765+	2.658***	0.144	0.144	-0.487*
	(4.81)	(-1.56)	(-1.74)	(-1.93)	(5.74)	(0.37)	(0.37)	(-2.23)
Fixed Exchange Rate (bilateral)	-3.107***	0.399	0.464	0.391	-2.682***	0.605+	0.620+	1.060***
	(-7.56)	(0.95)	(1.09)	(0.91)	(-7.99)	(1.92)	(1.93)	(4.21)
ECCU	0.397	1.981***	1.983***	2.025***	0.102	1.180***	1.183***	1.267***
	(0.98)	(7.62)	(7.58)	(6.96)	(0.32)	(4.83)	(4.83)	(5.03)
CET (1993)	-0.263*	0.00573			-0.0511	0.0616		
	(-2.37)	(0.08)			(-0.49)	(0.85)		
Natural Disaster	-0.277**	0.0357	0.00980		-0.332***	-0.0607	-0.138*	
	(-2.71)	(0.61)	(0.14)		(-3.98)	(-1.35)	(-2.17)	
Constant	11.31***	3.430*	7.528*	12.48***	6.216*	9.126***	13.04***	24.22***
	(5.32)	(2.10)	(2.48)	(7.60)	(2.38)	(5.50)	(5.22)	(28.21)
N	3470	3470	3470	3591	4353	4353	4353	4353
R^2	0.405	0.725	0.729	0.786	0.471	0.898	0.910	0.991

Notes:

t statistics in parentheses and standard errors are clustered at the country-pair level.

***denotes significance at the 0.1 percent, **denotes 1 percent, *denotes 0.5 percent and +denotes 10 percent.

Constant, exporter, importer, exporter-time and importer-time fixed effects are not reported. Estimation results are based on equation (3.4.1).

Table 3.16: Gravity model estimates for CARICOM's Intra-Regional Trade for the period 1980-2007 (dependent variable market share)

	(1)	(2)	(3)	(4)
	PPML	PPML	PPML	PPML
Dependent variable	Market Share	Market Share	Market Share	Market Share
Exporter fixed effect	No	Yes	Yes	No
Importer fixed effect	No	Yes	Yes	No
Time fixed effect	No	No	Yes	No
Exporter-time	No	No	No	Yes
Importer-time	No	No	No	Yes
Log GDP Exporter	0.483^{***}	-0.210^{*}	-0.459^{***}	
	(5.13)	(-2.57)	(-3.31)	
Log GDP Importer	0.0470	0.121	-0.0395	
	(0.40)	(1.03)	(-0.28)	
Log Distance	-0.538^{**}	-0.534^{***}	-0.537^{***}	-0.625^{***}
	(-3.13)	(-4.23)	(-4.28)	(-4.31)
Contiguity	-1.653^{***}	-1.414^{*}	-1.334^{*}	-1.310^{*}
	(-5.41)	(-2.56)	(-2.42)	(-2.29)
Common Language	0.796	0.208	0.104	-0.152
	(1.43)	(0.46)	(0.22)	(-0.33)
Flexible Exchange Rate (bilateral)	1.176^{***}	-0.164	-0.263	-0.828^{**}
	(4.43)	(-0.91)	(-1.36)	(-3.16)
Fixed Exchange Rate (bilateral)	-1.629^{***}	0.678^{**}	0.718^{**}	1.070^{***}
	(-4.55)	(2.84)	(3.00)	(3.98)
ECCU	0.0787	1.667^{***}	1.665^{***}	1.658^{***}
	(0.22)	(6.18)	(6.19)	(5.67)
CET(1993)	-0.280^{**}	0.0210		
	(-2.76)	(0.38)		
Natural Disaster	-0.247^{***}	-0.0856^{**}	-0.190^{***}	
	(-3.98)	(-2.84)	(-5.14)	
Constant	-3.227^{+}	4.482^{***}	8.717^{***}	6.038^{***}
	(-1.68)	(3.38)	(3.95)	(5.64)
N	4353	4353	4353	4353
R^2	0.247	0.699	0.708	0.804

Notes:

t statistics in parentheses and standard errors are clustered at the country-pair level.

***denotes significance at the 0.1 percent, **denotes 1 percent, *denotes 0.5 percent and $^{+}$denotes 10 percent.

Constant, exporter, importer, exporter-time and importer-time fixed effects are not reported.

Estimation results are based on equation (3.4.1) with market share as the dependent variable. Market Share is defined as $X_{ni}/\sum_n^N X_{ni}$

Table 3.17: Gravity model estimates for 70 countries for the period 1980-2007

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Pooled OLS	LSDV	LSDV	LSDV	PPML	PPML	PPML	PPML
	Log Exports	Log Exports	Log Exports	Log Exports	Exports	Exports	Exports	Exports
Exporter fixed effect	No	Yes	Yes	No	No	Yes	Yes	No
Importer fixed effect	No	Yes	Yes	No	No	Yes	Yes	No
Time fixed effect	No	No	Yes	No	No	No	Yes	No
Exporter-time	No	No	No	Yes	No	No	No	Yes
Importer-time	No	No	No	Yes	No	No	No	Yes
Log GDP Exporter	1.146***	0.620***	0.743***		0.771***	0.636***	0.789***	
	(85.24)	(21.56)	(17.48)		(37.10)	(13.48)	(16.69)	
Log GDP Importer	0.881***	0.651***	0.761***		0.801***	0.531***	0.703***	
	(69.28)	(21.66)	(20.02)		(26.07)	(12.37)	(16.30)	
Log Distance	-1.173***	-1.479***	-1.478***	-1.465***	-0.719***	-0.700***	-0.699***	-0.678***
	(-27.40)	(-35.28)	(-35.28)	(-35.38)	(-10.33)	(-18.57)	(-19.29)	(-18.42)
RTA(All)	-0.181+	-0.353***	-0.352***	-0.401***	-0.383**	0.383***	0.374***	0.443***
	(-1.91)	(-3.34)	(-3.33)	(-3.57)	(-2.95)	(5.68)	(5.69)	(5.53)
Natural Disaster(All)	-0.408***	-0.0628***	-0.0527***		-0.207***	-0.0122	0.0227*	
	(-9.92)	(-4.08)	(-3.41)		(-4.31)	(-0.91)	(1.96)	
Natural Disaster (CARICOM)	-0.301**	0.00318	0.0100		-0.375***	-0.127	-0.129	
	(-2.94)	(0.08)	(0.24)		(-3.49)	(-0.82)	(-0.84)	
CARICOM	3.486***	2.322***	2.428***	3.548***	1.639***	1.036*	1.012*	1.572***
	(14.60)	(5.66)	(5.90)	(13.62)	(4.75)	(2.15)	(2.14)	(4.50)
CARICOM Exporter	-0.199	-0.717*	-0.650*		-0.0498	-0.201	-0.241	
	(-1.40)	(-2.17)	(-1.96)		(-0.14)	(-0.36)	(-0.42)	
CARICOM Importer	0.324**	-0.556**	-0.493*		-0.0296	-0.228	-0.272	
	(3.18)	(-2.85)	(-2.52)		(-0.15)	(-1.10)	(-1.36)	
CET (1993)	-1.173***	-0.482***	-0.529***	0.364*	-0.0306	0.261	0.366+	0.866**
	(-8.42)	(-3.59)	(-3.88)	(2.05)	(-0.15)	(1.20)	(1.67)	(2.81)
CET (1993) Exporter	-1.171***	-0.498***	-0.532***		-1.015*	-0.671	-0.583	
	(-11.10)	(-5.12)	(-5.31)		(-2.43)	(-1.56)	(-1.31)	
CET (1993) Importer	-0.737***	-0.102	-0.148*		-0.426***	-0.114	-0.0495	
	(-11.18)	(-1.63)	(-2.27)		(-4.36)	(-1.29)	(-0.56)	

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Table 3.17 continued from previous page.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
CARICOM Dominica Rep.	0.397	1.216***	1.206***	1.356***	1.317*	0.882+	0.866+	0.754+
	(1.30)	(3.73)	(3.69)	(3.92)	(2.36)	(1.81)	(1.77)	(1.61)
CARICOM Venezuela	-0.160	-0.127	-0.105	0.249	0.814*	0.691*	0.727*	0.787*
	(-0.58)	(-0.48)	(-0.39)	(0.86)	(2.55)	(2.23)	(2.35)	(2.31)
CARICOM Colombia	-0.579	-0.235	-0.242	-0.278	0.168	0.553	0.556	0.589
	(-1.53)	(-0.72)	(-0.74)	(-0.86)	(0.44)	(1.49)	(1.49)	(1.59)
CARICOM Cuba	-1.076	0.111	0.150	0.276	-0.265	1.055+	1.061+	1.109+
	(-1.40)	(0.17)	(0.23)	(0.41)	(-0.48)	(1.68)	(1.69)	(1.83)
CARICOM USA	0.887***	0.583***	0.601***	0.675***	0.341+	0.0567	0.0718	0.259+
	(3.52)	(3.43)	(3.53)	(3.80)	(1.69)	(0.34)	(0.42)	(1.64)
CARICOM Costa Rica	0.723	0.748*	0.769*	0.796*	0.694**	0.839**	0.816**	0.642*
	(1.88)	(2.14)	(2.19)	(2.20)	(2.72)	(3.23)	(3.14)	(2.21)
CARICOM Canada	0.950**	0.919***	0.923***	0.989***	-0.110	0.143	0.154	0.278
	(3.24)	(3.84)	(3.85)	(4.14)	(-0.44)	(0.47)	(0.51)	(0.94)
NAFTA	-0.00665	0.874***	0.859***	0.839***	0.916***	0.416**	0.457***	0.783***
	(-0.03)	(3.65)	(3.63)	(3.75)	(4.99)	(3.10)	(3.38)	(6.33)
EU	-0.417***	-1.067***	-1.064***	-1.019***	0.111	0.155*	0.165*	0.170+
	(-4.42)	(-7.96)	(-7.93)	(-7.28)	(1.16)	(2.01)	(2.15)	(1.66)
MERCOSUR	0.662*	1.392***	1.384***	1.395***	0.788***	1.180***	1.204***	1.222***
	(2.27)	(3.60)	(3.57)	(3.48)	(4.39)	(7.55)	(7.60)	(7.43)
CACM	1.997***	2.323***	2.294***	2.420***	1.197***	2.063***	2.083***	1.975***
	(7.77)	(8.06)	(7.96)	(7.85)	(5.94)	(10.95)	(11.05)	(8.75)
EFTA	0.394+	0.590+	0.592+	0.603+	0.0675	0.277	0.250	0.287
	(1.68)	(1.84)	(1.84)	(1.80)	(0.29)	(1.53)	(1.38)	(1.32)
ASEAN	2.513***	0.460+	0.425	0.208	2.190***	-0.329*	-0.335*	-0.352*
	(14.04)	(1.66)	(1.52)	(0.71)	(12.09)	(-2.23)	(-2.19)	(-2.12)
COMESA	1.566***	2.285***	2.282***	2.767***	0.183	1.114*	1.186*	1.272**
	(7.38)	(8.77)	(8.88)	(10.62)	(0.50)	(2.41)	(2.57)	(2.85)
SADC	1.750***	2.305***	2.341***	3.127***	1.531***	1.847***	1.901***	2.170***
	(5.03)	(5.89)	(6.08)	(7.48)	(5.10)	(6.48)	(6.70)	(6.92)
EAC	1.210+	2.186***	2.151***	2.886***	0.392	2.401***	2.385***	2.674***
	(1.78)	(3.81)	(3.74)	(4.79)	(0.70)	(4.58)	(4.56)	(4.52)

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Table 3.17 continued from previous page

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Common Currency	0.496***	0.480**	0.475**	0.491**	0.104+	0.172***	0.185***	0.0588
	(3.48)	(3.11)	(3.07)	(2.92)	(1.92)	(4.32)	(4.22)	(0.76)
Contiguity	0.446***	-0.0711	-0.0709	-0.0610	0.324***	0.409***	0.403***	0.369***
	(3.69)	(-0.53)	(-0.53)	(-0.46)	(3.72)	(5.86)	(5.80)	(5.33)
Common Language	0.301***	0.427***	0.427***	0.420***	0.399***	0.205**	0.206**	0.212**
	(4.27)	(6.29)	(6.30)	(6.19)	(5.07)	(3.17)	(3.17)	(3.17)
Colony	0.493***	0.612***	0.612***	0.602***	-0.409***	-0.0424	-0.0379	0.000210
	(3.42)	(3.69)	(3.70)	(3.64)	(-3.34)	(-0.46)	(-0.41)	(0.00)
Common Colonizer	0.192	0.0587	0.0629	0.0372	0.476**	0.178	0.181	0.280+
	(1.42)	(0.46)	(0.50)	(0.29)	(2.69)	(1.06)	(1.09)	(1.78)
Colony after 1945	1.389***	0.920***	0.919***	0.911***	0.264	-0.239	-0.242	-0.236
	(5.77)	(3.40)	(3.40)	(3.39)	(1.23)	(-1.13)	(-1.15)	(-1.13)
Same Country	0.180	0.146	0.155	0.123	0.0398	-0.328*	-0.332*	-0.315*
	(0.74)	(0.60)	(0.64)	(0.52)	(0.30)	(-2.34)	(-2.37)	(-2.23)
Constant	-23.44***	1.629*	-5.062**	16.44***	-14.71***	-7.220***	-14.83***	18.02***
	(-41.68)	(2.30)	(-2.90)	(14.36)	(-10.37)	(-9.27)	(-9.97)	(34.46)
N	93345	93345	93345	95408	113176	113176	113176	116560
R^2	0.731	0.805	0.806	0.820	0.816	0.933	0.936	0.953

Notes:

t statistics in parentheses and standard errors are clustered at the country-pair level.

***denotes significance at the 0.1 percent, **denotes 1 percent, *denotes 0.5 percent and +denotes 10 percent.

Constant, exporter, importer, exporter-time and importer-time fixed effects are not reported. Estimation results are based on equation (3.4.2).

Table 3.18: Gravity model estimates for 70 countries for the period 1980-2007 (dependent variable market share)

	(1)	(2)	(3)	(4)
	PPML	PPML	PPML	PPML
Dependent variable	Market Share	Market Share	Market Share	Market Share
Exporter fixed effect	No	Yes	Yes	No
Importer fixed effect	No	Yes	Yes	No
Time fixed effect	No	No	Yes	No
Exporter-time	No	No	No	Yes
Importer-time	No	No	No	Yes
Log GDP Exporter	0.750***	0.217***	0.544***	
	(45.03)	(7.16)	(13.25)	
Log GDP Importer	-0.0853***	-0.217***	-0.0119	
	(-5.62)	(-7.45)	(-0.32)	
Log Distance	-0.766***	-0.921***	-0.917***	-0.930***
	(-14.93)	(-19.52)	(-19.47)	(-19.82)
RTA(All)	-0.428***	0.353***	0.358***	0.453***
	(-3.51)	(4.36)	(4.33)	(4.59)
Natural Disaster(All)	-0.314***	-0.0638***	-0.0282*	
	(-8.58)	(-4.40)	(-2.01)	
Natural Disaster(CARICOM)	0.0845	0.0685	0.0874*	
	(1.16)	(1.88)	(2.39)	
CARICOM	1.650***	-0.237	-0.163	0.799
	(5.68)	(-0.57)	(-0.39)	(1.47)
CARICOM Exporter	0.306	-0.869	-0.872	
	(0.59)	(-1.50)	(-1.51)	
CARICOM Importer	-0.352**	-0.133	-0.101	
	(-3.29)	(-0.96)	(-0.74)	
CET (1993)	-0.226	0.282+	0.439**	0.990*
	(-1.32)	(1.79)	(2.67)	(2.14)
CET (1993) Exporter	-1.516***	-1.072**	-0.915*	
	(-3.70)	(-2.78)	(-2.41)	
CET (1993) Importer	-0.556***	-0.0218	0.0385	
	(-6.54)	(-0.26)	(0.44)	

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Table 3.18 continued from previous page

	(1)	(2)	(3)	(4)
CARICOM Dominica Rep.	0.652	0.566	0.505	0.259
	(1.43)	(1.63)	(1.44)	(0.89)
CARICOM Venezuela	0.509^{+}	-0.0468	0.0419	-0.0532
	(1.69)	(-0.17)	(0.15)	(-0.17)
CARICOM Colombia	-0.221	0.166	0.145	-0.112
	(-0.56)	(0.42)	(0.36)	(-0.28)
CARICOM CUBA	0.657	1.777***	1.835***	1.560**
	(1.13)	(3.55)	(3.63)	(2.95)
CARICOM USA	0.436***	0.0307	0.0307	0.00354
	(3.48)	(0.30)	(0.29)	(0.03)
CARICOM Costa Rica	0.330^{+}	0.453	0.426	0.587*
	(1.69)	(1.55)	(1.47)	(2.48)
CARICOM Canada	-0.297	-0.0709	-0.0636	-0.0381
	(-1.39)	(-0.33)	(-0.29)	(-0.18)
NAFTA	0.672***	0.137	0.197	0.515***
	(3.59)	(0.86)	(1.25)	(3.63)
EU	-0.110	-0.178*	-0.162^{+}	-0.293**
	(-1.06)	(-2.17)	(-1.91)	(-2.70)
MERCOSUR	1.256***	0.546**	0.571**	0.666***
	(5.06)	(3.13)	(3.29)	(4.11)
CACM	1.064***	0.621*	0.638*	1.203***
	(5.20)	(2.20)	(2.28)	(4.37)
EFTA	0.343	0.608***	0.558**	0.745***
	(1.41)	(3.55)	(3.20)	(3.79)
ASEAN	1.221***	-0.181	-0.276	-0.328
	(6.23)	(-1.32)	(-1.83)	(-1.73)
COMESA	0.395	0.647^{+}	0.817*	1.244***
	(0.85)	(1.82)	(2.55)	(3.93)
SADC	2.161***	1.045***	1.143***	2.548***
	(6.46)	(3.63)	(4.16)	(8.19)
EAC	1.205*	1.434***	1.464***	2.193***
	(2.11)	(4.36)	(4.48)	(5.69)

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Table 3.18 continued from previous page

	(1)	(2)	(3)	(4)
Common Currency	-0.172^{+}	-0.130	-0.0845	-0.237
	(-1.78)	(-1.11)	(-0.68)	(-1.46)
Contiguity	0.421***	0.288***	0.285***	0.257***
	(3.91)	(3.67)	(3.66)	(3.49)
Common Language 0.221**	0.309***	0.310***	0.298***	
	(3.06)	(4.43)	(4.44)	(4.35)
Colony	0.131	0.357**	0.364**	0.372**
	(1.03)	(2.72)	(2.79)	(2.97)
Common Colonizer	0.418**	0.326*	0.319^{+}	0.360*
	(2.62)	(1.99)	(1.94)	(2.24)
Colony after 1945	0.689***	0.443*	0.437*	0.433*
	(3.65)	(2.36)	(2.33)	(2.34)
Same Country	-0.180	-0.206	-0.205	-0.229^{+}
	(-0.96)	(-1.51)	(-1.50)	(-1.81)
Constant	-14.92***	1.035	-11.60***	-2.756***
	(-23.66)	(1.40)	(-8.10)	(-4.15)
N	113176	113176	113176	116560
R^2	0.570	0.726	0.728	0.756

Notes:

t statistics in parentheses and standard errors are clustered at the country-pair level.

***denotes significance at the 0.1 percent, **denotes 1 percent, *denotes 0.5 percent and $^{+}$denotes 10 percent.

Constant, exporter, importer, exporter-time and importer-time fixed effects are not reported.

Estimation results are based on equation (3.4.2) with market share as the dependent variable. Market Share is defined as $X_{ni}/\sum_{n}^{N} X_{ni}$

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Chapter 4

Estimating General Equilibrium Trade Policy Effects: Caribbean Community (CARICOM)

This chapter uses a structural gravity model as a basis for a general equilibrium framework to investigate the importance of international borders, regional trade agreements(RTA) and the potential impact of deeper integration in the form of a currency union within CARICOM. Using panel data for the period 1986-2001, with 3 year intervals, the gravity model is estimated using Poisson Pseudo Maximum Likelihood(PPML) and subsequently used to derive general equilibrium effects. We find that CARICOM is trade-creating within The Region and there is evidence suggesting that currency depreciation of CARICOM members increases The Region's exports to the rest of the world. Most importantly, CARICOM is essential for member states with the smallest economies, and deeper integration in the form of a common currency could be welfare improving for all CARICOM members.

4.1 Introduction

The gravity model used in international trade, to estimate and identify the effects of trade policy, trade cost, geographic and other economic indicators, is one of the most widely used and successful empirical models in economics. It is a tractable representation of economic interaction between any country and the rest of the world. When linked to theories of international trade, the gravity model is attractive as a general equilibrium framework of international trade from which counter-factuals can be derived and the welfare effects of changes in trade policies and cost can be assessed.

This chapter uses a structural gravity model to create a general equilibrium framework to investigate the importance of international borders, regional trade agreement and the potential impact of deeper integration in the form of a currency union within CARICOM. (1) It quantifies the welfare implications of the regional trade agreement, hereafter referred to as CARICOM, on economies of the The Region. (2) It considers the pass-through effects of exchange rate to trade cost within The Region and the implications that removing such pass-through effects could have on regional trade and the welfare of the The Region. Quantifying the overall and country-specific welfare effects of CARICOM is important to foster a greater understanding of the outcome of policies geared towards deeper economic integration within The Region. Furthermore, it is important that the next phase of the Caribbean Single Market and Economy (CSME), which includes adopting a common currency, is informed by economic analysis. This chapter intends to identify, quantify and project the welfare impact of trade policies geared towards greater regional integration.

Adopting the Anderson et al.(2015) General Equilibrium Poisson Pseudo Maximum Likelihood (GE-PPML) approach, the 'conditional' and 'full-endowment' welfare impacts of CARICOM and exchange rate are identified. This general equilibrium framework allows for the estimation of the 'conditional' effects, which are calculated as the percentage difference between baseline estimates and estimates conditional on some constraint, holding exporter's output/income and importer's expenditure constant; whereas, the 'full endowment' effects are identified by assuming that the balance of trade ratio remains constant in the counter-factual and income and expenditure are endogenously determined.

Trade, both intra- and extra-regional, is an integral part of the drive towards regional integration in the Caribbean. Given globalisation and trade liberalisation and the importance of trade to its economies, The Region recognized the need to increase its competitiveness and integrate into the global economy. From a regional perspective, deeper integration has the potential to improve The Region's negotiating capacity both in relation to trade and foreign affairs issues as well as taking advantage of economies of scale, reallocating capital and labour, and establishing businesses to foster growth. Regional markets are small; therefore, external markets are critical to these economies achieving greater growth and hence improved welfare of its people. Generally, deeper regional integration of CARICOM members is aimed at creating internal economic advantage as well as striking better trade deals and improved foreign relations with other third parties, both bilateral and multilateral.

As mentioned in the previous chapter, the policy response to foster deeper integration within The Region, thus far, has taken the form of a Common External Tariff (CET) and a Caribbean Single Market and Economy (CSME). The CET framework is aligned with market liberalisation and export promotion, that is, reducing trade costs among members and applying a common tariff on the rest of the world whilst promoting greater trade among members. Following a phased implementation of CET after 1993, the implementation of CSME, which signals the need for firms to increase their regional and international competitiveness, is lagging. The CSME provides a framework for strengthening integration predicted on broader comparative advantage-based production and trade integration and development cooperation. Additionally, embedded into this policy are efforts to foster enterprise, investment, innovation and a flexible integrated labour force; however several aspects, such as the free movement of labour and capital, have not been fully implemented. Most notably is the implementation of a common currency, which should have been implemented in 2015 but has been delayed.

A common currency could have several benefits to The Region especially related to trade and the free movement of capital and labour income; however, the implementation of such a currency needs to be informed by studies that are empirically sound and considers critical stakeholders. A key step associated with achieving this objective is the establishment of a monetary authority that has the ability to back the currency through monetary policy instruments and actions. This aspect is beyond the scope of this research. Here, we consider the implications of a common currency in fostering trade and hence the welfare effects for CARICOM members. From the perspective of trade, the implementation of the common currency will foster a better business environment with less uncertainty, which is critical to expanding the manufacturing sectors of CARICOM members. The adoption of a common currency could facilitate increased flow of capital among members as well as reduce uncertainty, which will improve the business and economic environment. However, the differences in exchange rate regimes across CARICOM members could prove a hindrance given the differences in political philosophy and policies used in the management of the exchange rate (pegged or flexible). Furthermore, in the context of regional trade, if all CARICOM members adopt a common currency, those who currently benefit from exchange rate differential within The Region will be negatively impacted. Additionally, countries that also benefited from currency depreciation, making their exports cheaper to the rest of the world, could see reduction in the gains from trade if the common currency is pegged to a currency or currencies that on average increase in value, hence making its exports more expensive to the rest of the world. However, with greater business confidence (less uncertainty) and greater credibility this could foster greater investment, which includes greater movement of capital within The Region, and technological transfer hence increased trade and growth for the economies of The Region and with the rest of the world. Notwithstanding, there are potential drawbacks, which include: greater constraint on credit in an effort to maintain a currency peg (assuming a pegged currency is adopted); the limiting ability of the monetary authority to adjust the par value of the currency; the susceptibility of the economies of the CARICOM to external shocks; and, the monetary authority's ability to adequately respond to these shocks. These latter aspects are beyond the scope of this chapter.

By exploring the differences in exchange rate regime and the depreciation/devaluation of the currencies of the the economies of The Region, it is possible to identify their effects on trade. Usually, the depreciation in a country's exchange rate is theoretically treated as equivalent to a tax on imports and a subsidy on exports (Anderson et al., 2016). In this chapter, Anderson et. al. (2016) theoretical gravity model framework, which is set out in detail below, is adopted to explore the pass-through effects of exchange rate on trade.

Recent developments in the derivation and estimation of the gravity model have allowed for more robust estimates of the impact of regional trade agreements (RTAs) or more broadly economic integration agreements EIAs on trade. These developments include: (1) exploring the process of integration over time by taking advantage of the information available in a panel; and, (2) considering issues related to variable endogeneity and residual heteroskedasticity. This involves using the Poisson Pseudo Maximum Likelihood(PPML) to estimate the gravity specifications with fixed effects to capture the multilateral resistance terms and bilateral time-invariant effects. This approach is hinged on the findings in the second chapter as well as Fally (2015), who examined the pros and cons of a suite of estimators given different distributional assumptions.

The debate on how to estimate the gravity model has been guided by seminal pieces including: Anderson and van Wincoop (2003), who shed light on the omitted variable bias associated with not taking into consideration the inward and outward multilateral resistance terms; Santos Silva and Tenreyro (2006), who highlighted the issue of heteroskedasticity and the implications for estimates by Ordinary Least Squares (OLS) and further championing the use of the PPML estimator; Haveman and Hummels (2004) and Helpman et all (2008), who documented the frequency of zero trade flows and identified possible issues associated with selection into trade; Baier and Bergstrand (2007), Anderson et al. (2010), Yotov (2012) and Bergstrand et al. (2014), who researched the role of distance in trade, dubbed the distance puzzle; and, Head and Mayer (2014), Bosquet and Boulhol (2014), Egger and Staub (2015) and Fally (2015), among others, who examined the properties of several estimators, including the OLS, NLS Gamma PML, PPML and Negative Binomial, when estimating the gravity model. To a large extent, the PPML estimator is found to be least biased and most robust under various distributional assumptions of the error structure and has the added bonus of accommodating zero trade flows.

The baseline for this framework is established using parameter estimates from the literature and a baseline gravity model estimated using the PPML estimator for selected years. We find that CARICOM is trade-creating within The Region. Additionally, there is evidence that currency depreciation of CARICOM members increases trade both within The Region and exports to the rest of the world. In terms of the general equilibrium effects we impose constraints on CARICOM and exchange rate variation within CARICOM and find that CARICOM is essential for member states with the smallest economies, such as Saint Lucia, Grenada, Belize and Barbados. Dismantling CARICOM will cause a decline in these small economies and an overall effect on The Region of -0.28 percent change in real GDP. On the other hand, further integration in The Region in the form of a common currency could be welfare-improving for all CARICOM members. Adopting a common currency could increase real GDP of The Region by 0.5 percent with the greatest beneficiaries being Saint Lucia, Belize, Barbados and Trinidad and Tobago. Further research is required to determine if this common currency should be allowed to float or be pegged to the US$ or a basket of currencies.

The rest of the chapter is divided into four sections. section 4.2 covers the general equilibrium gravity model; section 4.3 develops and illustrates the model estimated; section 4.4 describes the data and simulation procedure used; section 4.5 presents the findings; and, the chapter concludes with section 4.6.

4.2 Structural Gravity

Recent research efforts have shown that a gravity representation can be derived from several theoretical models of international trade. These include: Anderson (1979), who assumed Armington (1969) Constant Elasticity of Substitution (CES) preference for national varieties across countries; Krugman's (1979) model of monopolistic competition and international trade; Eaton and Kortum (2001) using a Ricardian trade model based on differences in technology; and, Melitz (2003) trade model of intra-industry reallocation and aggregate industry productivity. Most of these gravity models, grounded in theories of international trade, are quite parsimonious. They are also tractable representation of economic interaction in a many country world when compared to the usual two/three countries/sectors theoretical models (Anderson, 2011). In other words, whether grounded in theories of international trade or not, gravity models make it easy to derive economic insight from, and make inference about, a complex network of trade among all or a subset of countries; however, when backed by theories of international trade it is useful general equilibrium tool.

The structural gravity model is an appealing tool for deriving counter-factual and hence welfare measures associated with changes in trade policies and cost. This is usually achieved by building a general equilibrium model of trade which incorporate both intra-national (trade with self)and international trade. Anderson and van Wincoop (2004) explain that trade separability/modularity, which is the observation that goods are typically supplied from multiple locations, permits research and inference about the distributional costs that cause this distributional pattern in both goods and factor markets. This is one reason why the gravity model is an attractive tool for modelling trade flows. Additionally, the task of drawing inference about distributional cost associated with trade, as opposed to determining the total supplies of goods from all destinations or total demand for all goods or factors from all origins, is straightforward. Furthermore, inference about the distribution of goods or factors is consistent with many plausible general equilibrium models of national/regional production and consumption (Anderson, 2011).

Within the gravity framework with iceberg trade cost (Samuels, 1952), trade cost is proportional to goods shipped from county n to country j and plays a critical role in understanding the distributional pattern of trade. Trade cost can be broadly defined as including "all costs incurred in getting a good to a final user other than the marginal cost of producing the good itself: transportation costs (both freight costs and time costs), policy barriers (tariffs and non-tariff barriers), information costs, contract enforcement costs, costs associated with the use of different currencies, legal and regulatory costs, and local distribution costs (wholesale and retail)"(Anderson and van Wincoop (2003) in Snorrason, 2012, p. 26). Trade costs are large and are closely linked to economic policies; therefore, they have far-reaching welfare implications. The current practice in the gravity literature is to estimate trade costs using bilateral characteristics such a distance, RTA, common currency, common language, colonial link and common border; however, to correctly estimate trade cost using these factors, consideration must be given to inward and outward multilateral resistances; i.e. country (exporter and importer) specific characteristics/price indexes/incidence of trade (Anderson and van Wincoop, 2003). This is critical because it allows for unbiased and more robust estimates of trade costs. The most widely used method to control for the multilateral resistance terms is fixed effects, primarily, exporter-time, importer-time and/or bilateral pair fixed effects.

The general equilibrium framework adopted for this chapter assumes that changes in trade costs alter the multilateral resistance terms. This inter-dependence between the the multilateral resistance terms and trade costs was first pointed out by Anderson and van Wincoop (2003). They found that by exploiting changes in the multilateral resistance terms caused by a change in trade costs one could derive some measure of welfare implications of such a change. Holding GDP and expenditure (income and output) constant, changes in the multilateral resistance terms as a result of a change in the trade costs is what Head and Mayer (2014) call Partial Trade Impact (PTI) and Anderson et al. (2015) call the 'Conditional' General Equilibrium Indexes. Since output and expenditure are not endogenously determined the resulting effects are partial and limited to a first order conditional change in trade costs. On the other hand, in a 'full' general equilibrium framework GDP is dependent on factor prices and as such any changes in the multilateral terms/prices indexes should also impact output and expenditure. In other words, A 'full' general equilibrium framework is one in which factor prices, output (GDP) and expenditure are endogenously determined. Head and Mayer (2014) call this General Equilibrium Trade Impact (GETI) whilst in Anderson et al. (2015) this is called the 'Full Endowment' General Equilibrium effects.

This chapter adopts Anderson et al. (2015) General Equilibrium PPML estimation technique. This methodology hinges on two main assumptions: 1. this framework assumes balanced trade which is imposed by the market clearing condition; and, 2. estimation of the multilateral resistance terms, approximated by fixed effects using the PPML estimator, is sufficient to validate the structural gravity and in subsequent stages conduct counter-factual analysis. These assumptions are described below.

Equations (4.2.1) to (4.2.4) below are represented from the theoretical gravity model constructed using CES preference in Chapter 1.

$$X_{nj}(c) = \frac{Y_n Y_j}{Y_k}\left[\frac{\tau_{nj}}{P_j \Pi_n}\right]^{1-\sigma} \tag{4.2.1}$$

$$\Pi_n = \sum_{j=1}^{J}\left[\frac{\tau_{nj}}{P_j}\right]^{1-\sigma}\frac{Y_j}{Y_k} \tag{4.2.2}$$

$$P_j = \sum_{n=1}^{J}\left[\frac{\tau_{nj}}{\Pi_n}\right]^{1-\sigma}\frac{Y_n}{Y_k} \tag{4.2.3}$$

$$p_j = \frac{Y_j^{\frac{1}{1-\sigma}}}{\gamma_j \Pi_j} \tag{4.2.4}$$

Equation (4.2.1) characterizes trade flows and equations (4.2.2), and (4.2.3) are the multilateral resistance terms as described by Anderson and van Wincoop (2003). Anderson (2011) describes the inward and outward multilateral resistance terms as measures of buyers and sellers incidence of trade cost, respectively. Equation (4.2.4) is the market clearing condition. These four equations form the basis of the general equilibrium framework.

Equation (4.2.4), the market clearing condition is implied by the assumption that total consumption expenditure by country n must equal to the total income of country n ($Y_n = \sum_{j=1}^{J} x_{nj}$). It follows that,

$$[p_n(c)]^{1-\sigma} = \frac{Y_n}{\sum_{j=1}^{J} \left[\frac{\tau_{nj}}{P_n}\right]^{1-\sigma} Y_j} \tag{4.2.5}$$

therefore,

$$Y_n = [p_n(c)]^{1-\sigma} \sum_{j=1}^{J} \left[\frac{\tau_{nj}}{P_n}\right]^{1-\sigma} Y_j \tag{4.2.6}$$

for all n, where $p_n(c)$ is the exporter's supply price of country j. Dividing both sides by world output, Y_k, and using equation (4.2.3) yields equation (4.2.4). The γ_j included in equation (4.2.4) is a positive distribution parameter of the CES utility function[1], that is, the utility function for the theoretical construct presented in Chapter 1 would change from:

$$U_n = \left[\int_{c \in C_n} (x_n(c))^{(\sigma-1)/\sigma} dc\right]^{\sigma/(\sigma-1)} \tag{4.2.7}$$

to

$$U_n = \left[\int_{c \in C_n} \gamma_n (x_n(c))^{(\sigma-1)/\sigma} dc\right]^{\sigma/(\sigma-1)} \tag{4.2.8}$$

but equations (4.2.1)-(4.2.3) are the same irrespective of the inclusion of γ_n.

The constant elasticity of substitution, σ, can be estimated using the gravity model or, as is common in the literature, it can be parameterised using secondary sources. See Table 4.1 for a summary of the elasticity from the literature by Head and Mayer (2014)

[1] γ_j is included for consistence with Anderson et al. (2015)

Table 4.1: Price Elasticities Estimates

	Median	Mean	s.d.	# of estimates*
Total sample of estimates	-3.19	-4.51	8.93	744
Native Gravity estimates	-1.31	-1.35	5.17	122
Structural Gravity estimates	-3.78	-5.13	9.37	622
Estimation method includes country fixed effects	-3.5	-4.12	8.2	447
Estimation method uses ratios	-4.82	-7.7	11.49	175
Identifying variables include tariffs or freight rates	-5.03	-6.74	9.3	435
Identifying variables include price, wage or exchange rate	-1.12	-1.38	8.46	187

*Data contained in this table is the summary statistics of estimates garnered from 32 papers.

Source: Head and Mayer (2014)

The second binding assumption of this framework is the fixed effects approximations of the multilateral resistance terms, first proposed by Feenstra (2004); however, as pointed out by Head and Mayer (2014), size effects and explanatory power cannot be interpreted as support for the theory. That is, the theoretically constructed multilateral resistance terms may not be statistically equivalent to importer and exporter fixed effects when controlling for size effects.

According to the existing theory, the multilateral resistance terms should have the same unit elasticities as the size effects controls; however, in most findings this is not the case (Head and Mayer, 2014). In more recent work, Fally (2015) demonstrates that the fixed effects estimated using the PPML estimator are consistent with the structural gravity terms. He suggests and shows that if the gravity model is estimated using PPML with exporter and importer fixed effects, the multilateral-resistance terms are the unique solutions of equations (4.2.2) and (4.2.3); however, comparing unconstrained fixed effects and theory-consistent multilateral resistance terms as a test of structural gravity is not really a test because the PPML, once implemented successfully, is consistent with the properties of a structural gravity. Furthermore, Fally (2015)explains that the PPML estimator is the only estimator, of those considered, for which the sum of the fitted values of GDPs and expenditures are equal to the sum of observed values of GDPs and expenditures, which is a desired property to guarantee that the fixed effects from the estimated gravity model are consistent with the structural gravity terms[2]. Such consistency is not guaranteed with OLS, NLLS or Gamma PML.

Estimation using OLS with exporter and importer fixed effects does not imply that $\Sigma_j \log \hat{X}_{nj} = \Sigma_j \log X_{nj}$ and $\Sigma_n \log \hat{X}_{nj} = \Sigma_n \log X_{nj}$ nor does estimation using Non-Linear Least Squares (NLLS) with exporter and importer fixed effects imply that $\Sigma_j \hat{X}_{nj} X_{nj} = \Sigma_j \log X_{nj}^2$ and $\Sigma_n \hat{X}_{nj} X_{nj} = \Sigma_n \log X_{nj}^2$. Similarly, estimation via the Gamma PML with exporter and importer fixed effects does not imply $\Sigma_j \hat{X}_{nj} = \Sigma_j X_{nj}$ and $\Sigma_n \hat{X}_{nj} = \Sigma_n X_{nj}$ nor does using trade shares (X_{nj}/Y_j) as the dependent variable when estimating using the Poisson PML with exporter and importer fixed effects (Fally, 2015). Admittedly, the OLS, NLLS and Gamma PML estimators could be used to establish the baseline model, however, given Fally's findings and consideration for other issues such as zero trade flow and heteroskedasticity[3], the PPML estimator is preferred here.

Another limitation to consider, which is amplified because this chapter focuses mainly on CARICOM, is the need to identify intra-national trade (internal trade/trade with self), x_{ii}. Data on internal trade is very limited, especially in the case of CARICOM members; however, it can be inferred from GDP and production data as the difference between GDP or production of country n and total exports from country n i.e $X_{nn} = Y_n - \sum_{n \neq j} X_{nj}$. Head and Mayer (2014) suggest that the use of GDP could be more problematic than production, since GDP includes services that are rarely traded and, as a value-added measure, excludes purchases of intermediates that should be included

[2]A similar argument is made by Arvis and Shepherd (2013)

[3]The MaMu Test suggest that heteroskedasticity is present and the GNR regression (test) failed to the reject null that the variance is proportional to the conditional mean

in intra-national trade. The treatment of intra-national trade in this chapter is dealt with in the section describing the data.

4.2.1 Exchange Rate Effects on Trade: A Theoretical Framework

There are several avenues from which to approach the literature of exchange rate on trade. Mostly, the literature looks at the impact of exchange rate volatility and misalignment on trade; however, few consider exchange regime on trade. Generally, exchange rate volatility and uncertainty is found to have a negative effect on international trade (see Karemera et al. (2015), Chit et al. (2010), Schanbl (2008), Clark et al. (2004), among others). Similarly, misaligned currencies, which could either be over- or under- valued, distort the competitive equilibrium of trade. It affects the competitiveness of all producers of tradable goods and services in a country relative to producers in trading partners by changing the foreign currency price of home exports and domestic currency price of foreign imports (UNCTDA, 2012). The negative effects of exchange rate volatility on trade is closely related to uncertainty about pricing; whereas, the negative effect of misalignment is related to one country pricing its goods more or less expensive. Here, our concern is more along the lines of changes in the exchange over time; that is, changes in the exchange rate year on year. Additionally, since CARICOM is of interest and the next steps in the integration process is adopting a common currency, against the background that many of the members of CARICOM have fixed exchange rate regime, it is important to understand how fixed exchange rate regimes and the formation of currency union could impact trade.

Schanbl (2008) argues that, relative to a flexible exchange rate regime, fixed exchange rate provides a more stable framework for the adjustment of assets and labour market, especially for countries in the economic catch-up process. Similarly, Klein and

Shambaugh (2006) find that fixed exchange rate regimes have large significant effects on bilateral trade between a base country and a country that pegs to it. They further suggest that the web of fixed exchange rates created when countries link to a common base also promotes trade, but only when these countries are part of a wider system. On the contrary, Bacchetta and Van Wincoop, (2000) argue, using a theoretical model, that in general both trade and welfare can be higher under either exchange-rate system, depending on the preferences and on the monetary-policy rules followed under each system. Furthermore, they suggest that there is no one-to-one relationship between the levels of trade and welfare across exchange-rate system. It is against this background, that we hypothesis that changes in exchange rate over time is not the only avenue through which exchange rate impacts trade, but also through the level (scale) difference in exchange rate across members of CARICOM. Adopting a common currency could benefit The Region since it mitigates some trade frictions between members.

To model exchange rate on trade, this chapter follows the framework developed by Anderson et al. (2016b), which involves specifying trade cost explicitly as a function of exchange rate.

Consider the following specification of the iceberg trade cost, τ_{nj}, such that the pass-through effects of exchange rate on trade can be represented as:

$$\tau_{nj} = \tau'_{nj}\left(\frac{e_n}{e_j}\right)^{\rho_j} V_{nj}^{\phi_{nj}} \tag{4.2.9}$$

where e_n and e_j are the respective appreciation factor of the currency relative to the US$ for country n and country j. Relative to each other, these capture the bilateral appreciation factor that increases the cost of n's shipments to j. τ'_{nj} represents that part of the iceberg trade cost that is determined by the standard variables used in the literature, which include distance, common currency, common language, colonial link and common border. V_{nj} is the volume of goods shipped from n to j. Assuming $V_{nj} = X_{nj}/\tau_{nj}$, which implies that volume depends on trade cost or vice-versa, trade cost depends on volume. Additionally, assume $\phi_{nj} = \phi_j B_{nj}$, where B_{nj} is an indicator variable which takes a value of 1 when a bilateral pair trade internationally and 0 when trade is intra-national. ρ_j is the pass-through elasticity of exchange rate. The subscript j is essential to the model as it assumes that the exchange rate pass-through is non-uniform, such that the pass-through to prices paid in the importing country is different for all j. In cases where the pass-through effects are constant for all j it is impossible to identify these effects, because they cannot be disentangled from the multilateral resistances terms and when estimated with dummy variable fixed effects will be absorbed by the dummies.

Rewriting equation (4.2.1), such that exporter- and importer- specific characteristics are captured by the terms O_n and D_j, yields equation (4.2.10).

$$X_{nj} = O_n D_j \tau_{nj}^{1-\sigma} \tag{4.2.10}$$

The equation above is the standard identity used to estimate gravity models when exporter and importer fixed effects are used in the model. If equation (4.2.10) was subscript by time then exporter-time and importer-time fixed effects are used. Defining trade volume as X_{nj}/τ_{nj} and using equations (4.2.9) and (4.2.10), trade volume can be written as:[4]

$$V_{nj} = \left[O_n D_j \tau_{nj}^{'} \left(\frac{e_n}{e_j} \right)^{-1-\rho_j \sigma} \right]^{1/(1+\sigma\phi_{nj})} \tag{4.2.11}$$

Substituting this into equation (4.2.9) yields:

[4] Anderson et al. (2016b) suggested that by defining export volume as X_{nj}/τ_{nj}, τ_{nj} removes both the exchange rate effects and the volume used up in trade cost (ice-berg trade cost).

$$\tau_{nj} = \tau_{nj}^{'} \left(\frac{e_n}{e_j}\right)^{\rho j} \left[O_n D_j \tau_{nj}^{'}{}^{-\sigma} \left(\frac{e_n}{e_j}\right)^{-1-\rho_j \sigma}\right]^{\phi_{nj}/(1+\sigma\phi_{nj})} \tag{4.2.12}$$

which simplifies to a trade cost function of:

$$\tau_{nj} = \left[\tau_{nj}^{'} (O_n D_j)^{\phi_{nj}} \left(\frac{e_n}{e_j}\right)^{\rho_j - \phi_{nj}}\right]^{\phi_{nj}/(1+\sigma\phi_{nj})} \tag{4.2.13}$$

This trade cost function differs from other specifications in the literature since it explicitly express trade cost as a function of exchange rate pass-through. Furthermore, trade cost is raised to the power $1 + \phi_{nj}\sigma$ whereas in the simplest form of the gravity model as presented in Chapter 1, it is raised to the power $1-\sigma$. Substituting equation (4.2.13) into equation (4.2.10) yields a gravity equation, which when sub-scripted with time t can be written as:

$$X_{njt} = (O_{nt} D_{jt})^{(1+\phi_{nj})/(1+\phi_{nj}\sigma)} \tau_{nj}^{'}{}^{(1+\sigma)/(1+\phi_{nj}\sigma)} \left(\frac{e_{nt}}{e_{jt}}\right)^{(\rho_j - \phi_{nj})(1-\sigma)/(1+\phi_{nj}\sigma)} \tag{4.2.14}$$

where $\tau_{nj}^{'}$ includes all other time invariant trade cost determinants such as distance, colonial link, common language and contiguity. Recall that O_n and D_j are exporter- and importer- specific characteristics that vary with time.

Econometric Specification

Following from equation (4.2.14) in the previous section and assume $\phi_{nj} = \phi_{nJ} = \phi_J B_{nj}$ for all j in J, where B_{nj} is an indicator variable which takes a value of one for international trade and zero otherwise. When $B_{nj} = 0$, which corresponds to trade with self, $\phi_{nj} = 0$ and when $B_{nj} = 1$, which corresponds to international trade, the estimable gravity equation can be specified as follow[5]:

[5] The following specification is only concerned with $B_{nj} = 1$, which corresponds to international trade.

$$X_{njt} = exp\left[\frac{1+\phi_J}{1+\phi_J\sigma}lnO_{nt}+\frac{1+\phi_J}{1+\phi_J\sigma}lnD_{jt}+\frac{1+\sigma}{1+\phi_J\sigma)}\tau^{'}_{nj}+\frac{(\rho_j-\phi_J)(1-\sigma)}{1+\phi_J\sigma}ln\left(\frac{e_{nt}}{e_{jt}}\right)\right]+\epsilon_{nj} \quad (4.2.15)$$

where lnO_{nt} and lnD_{jt} are time-varying country-specific characteristics that are controlled for using exporter-time and importer-time fixed effects; $\tau^{'}_{nj}$ includes time-invariant bilateral pair-specific characteristics such as distance, colony, common language and contiguity; and, $\frac{e_{nt}}{e_{jt}}$ is exporter's currency per unit of US$ relative to importer's currency per unit of US$, which is equivalent to the exchange rate between the bilateral pair. If e_{nt} is rising relatively to e_{jt} then the exporter currency is depreciating, which according to the J-curve theory, Davies (1962), should result in exports increasing and imports decreasing. Therefore $\frac{(\rho_j-\phi_J)(1-\sigma)}{1+\phi_J\sigma}$ captures the net effect of exchange rate on both exports on imports[6]. Consider a bilateral pair say Jamaica-Belize, then if $\frac{(\rho_{BLZ}-\phi_{BLZ})(1-\sigma)}{1+\phi_{BLZ}\sigma} > 0$, and the Jamaican dollar has depreciated against the Belizean dollar, Jamaican exports to Belize should increase. On the other hand, if $\frac{(\rho_{JAM}-\phi_{JAM})(1-\sigma)}{1+\phi_{JAM}\sigma} > 0$, and the Jamaican dollar has depreciated against the Belizean dollar, then Jamaican imports from Belize should fall.

In this chapter, we model the impact of implementing a common currency among CARICOM members on trade within CARICOM and with the rest of the world by disentangling the exchange rate effects to capture the within region and extra-regional effects. This is done by interacting $\frac{e_{nt}}{e_{jt}}$ with regional and extra-regional dummy variables. We interact $\frac{e_{nt}}{e_{jt}}$ with $CARI_{njt}$, which takes a value of one if both exporter and importer are members of CARICOM and zero otherwise; and, $\frac{e_{nt}}{e_{jt}}$ with $CARI\_EXP_{njt}$, which takes as value of one if the exporter is a CARICOM member exporting to a Non-CARICOM country. The latter interaction only captures the impact of exchange rate on CARICOM's exports to the rest of world. To capture the

[6] This is demonstrated in Anderson et al.(2016).

net effect on trade, $\frac{e_{nt}}{e_{jt}}$ is interacted with $CARI\_Trade_{njt}$, which takes a value of one if extra-regional trade between a bilateral pair involves a CARICOM member. This chapter is primarily concerned with the former two interactions as such the estimable equation can be specified as:

$$X_{njt} = exp\Bigg[\tau'_{nj} + \alpha_1 BDER_{njt} + \alpha_2 * CARI_{njt} * \left(\frac{e_{nt}}{e_{jt}}\right) + \alpha_3 * CARI\_EXP_{njt} * \left(\frac{e_{nt}}{e_{jt}}\right) + P_{jt} + \Pi_{nt}\Bigg] + \epsilon_{njt} \tag{4.2.16}$$

where $\tau'_{nj} = \sum_{m=1}^{M} \beta_m z_{nj}^m$, which include distance, colonial link, common language and contiguity. $BDER_{njt}$ is a dummy, which takes the value one if the trade flow is across national borders and zero for intra-national trade. The identification of the exchange rate effects is dependent on estimation with: (1) internal trade (trade with self), which includes a country's home bias; and, (2) exchange rate, which by specification is equal to zero when a bilateral pair is the same country. However, this approach to estimating the exchange rate effects is limiting since identification should ideally consider intra-national trade across provinces, firms or industries. One way to circumvent this limitation is to consider the 9 CARICOM members[7] with fixed exchange rate regimes as one country and assume the pass-through effect for these countries is the same; however, data limitation prevents such an endeavour. Furthermore, the aim of this exercise is to identify the exchange rate effect among CARICOM members and its impact on exports to third party countries.

Consideration is also given to the impact of RTAs. The model is therefore re-specified as:

[7] Antigua and Barbuda, Bahamas, Barbados, Belize, Dominica, Grenada, St. Kitts and Nevis, Saint Lucia and St. Vincent and Grenadines

$$X_{njt} = exp\Bigg[\tau'_{nj} + \alpha_1 BDER_{njt} + \alpha_2 * CARI * \left(\frac{e_{nt}}{e_{jt}}\right) + \alpha_3 * CARI\_EXP_{njt} * \left(\frac{e_{nt}}{e_{jt}}\right)$$
$$+\alpha_4 RTA_{njt} + \alpha_5 CCOM_{njt} + P_{jt} + \Pi_{nt}\Bigg] + \epsilon_{njt} \quad (4.2.17)$$

where RTA_{njt} is a dummy variable, which takes a value of one if the bilateral pair are in a regional trade agreement, and $CCOM_{njt}$ is dummy which takes value of one if the bilateral pair are members of CARICOM. RTA_{njt} is a generic measure of the impact regional trade agreement on trade, capturing the average global effect of RTAs on trade whereas $CCOM_{njt}$ identifies the region-specific impact of CARICOM on trade among CARICOM members. P_{jt} and Π_{nt} are the multilateral resistance terms, which are controlled for using fixed effects. ϵ_{njt} is the error term. In the next section, the estimation techniques are further detailed.

4.3 Baseline, Estimation and Counter-factual

In this section, the baseline model is described along with the estimation procedure used and justification for the use of this procedure. Additionally, the counter-factual design used is documented.

4.3.1 Baseline

Following Anderson et al. (2015), the baseline estimates for the general equilibrium model could be established in two ways, namely: (1) parameterization using the existing literature, or (2) estimating a baseline model. For this chapter, the baseline model is estimated and its estimates are compared with those found in the literature.

Disdier and Head (2008) surveyed numerous papers that estimated the gravity model of international trade, and found that the average distance elasticity is approximately -.93, contiguity is on average 0.53, common language 0.54, colonial link 0.91, RTA 0.59, common currency 0.87 and intra-national trade 1.96 (see Table 4.2 for more details). However, these meta results do not distinguish between estimators nor is there any indication of differences in the samples used to estimate each coefficient. Using random effect (RE) and OLS on survey data of 1,467 distance elasticities from 103 papers, Disdier and Head (2008) estimate using regression analysis that only 2% of the variation in the estimated distance elasticity is explained by the sampling error defined as chance errors in estimating a population parameter arising from the finite sample drawn from that population. The remaining variation in the estimated distance elasticity is attributed to the 'structural' heterogeneity, which is defined as differences in parameters across sub-populations of the data; and, 'method' heterogeneity, which is defined as differences in statistical technique. They find that the PPML is likely to return a distance coefficient that is on average between 20-30% smaller than the average of all other estimators. Additionally, they find that there are correlations between distance and sampling, level of data aggregation and other right hand side (RHS) variables usually used in the estimation of the gravity model. Variation in the estimated distance coefficient is found to be explained by papers that used no developed economies, total or disaggregated bilateral trade data, adjacency control, common language control, country fixed effects and whether or not zero trade flows were included.

Table 4.2: Estimates of Typical Gravity Model

	All Gravity				Structural Gravity			
Variables	Median	Mean	s.d	# of papers	Median	Mean	s.d	# of papers
Distance	-0.89	-0.93	0.4	1835	-1.14	-1.1	0.41	328
Contiguity	0.49	0.53	0.57	1066	0.52	0.66	0.65	266
Common Language	0.49	0.54	0.44	680	0.33	0.39	0.29	205
Colonial Link	0.91	0.92	0.61	147	0.84	0.75	0.49	60
RTA/FTA	0.47	0.59	0.5	257	0.28	0.36	0.42	108
Common Currency	0.87	0.79	0.48	104	0.98	0.86	0.39	37
Intra-national Trade	1.93	1.96	1.28	279	1.55	1.9	1.68	71

Source: Head and Mayer (2014)

Although this chapter is not about further investigating the distance puzzle, these findings are important to estimate and hence establishing the baseline for this chapter. Against this background several specifications of the gravity model are considered when establishing the estimated baseline. First, consideration is given to equation (4.2.17), which includes only time-varying exporter and importer characteristics. Second, equation (4.2.17 is re-specified to resemble Bergstrand et al. (2007)[8]:

$$X_{njt} = exp\Bigg[\sum_{t=1}^{T} \beta_t DBDER_{nj,t} + \alpha_2 * CARI_{njt} * \left(\frac{e_n}{e_j}\right) + \alpha_3 * CARI\_EXP_{njt} * \left(\frac{e_{nt}}{e_{jt}}\right) + \alpha_4 RTA_{njt} + \alpha_5 CCOM_{njt} + P_{jt} + \Pi_{nt} + \Lambda_{nj}\Bigg] + \epsilon_{njt} \tag{4.3.1}$$

where Λ_{nj} are bilateral-pair fixed effects, which controls for unobserved bilateral time invariant heterogeneity. $DBDER_{nj,t}$ is the international border effects ($BDER_{njt}$) interacted with time dummies, $Year^*$. In this specification Bergstrand et al. (2007) do away with the assumption that all country-pairs have the same international border-effects by estimating equation (4.2.17) in a panel specification and including country-

[8]This specification proved difficult to implement; however, it is critical to highlight that it was considered.

pair fixed effects; suggesting that since both the fixed and variable costs of exporting varies with time it is possible to separate the international border effects from the Economic Integration Agreement/Regional Trade Agreement (EIA/RTA) effects. By including the country-pair fixed effect any change in $DBDER_{nj,t}$ over time is associated with the change in the cost of international trade relative to intra-national trade, given a reference year. On the other hand, the effects of changes in bilateral trade policies, such as entry into or exit from EIAs/RTAs, will be captured by the EIA/RTA dummy. Note that the ETA/RTA dummy will explain variation in trade flows in the 'bilateral-pair-time' dimension; whereas, $DBDER_{nj,t}$ is explaining trade flows in the 'bilateral-pair' dimension year on year. In equation (4.3.1) all the other variables are allowed to change with time, i.e 'bilateral-pair-time' dimension. It is important to note that identification of the variables in τ'_{nj} is not possible with the inclusion of bilateral pair fixed effects; however, interacting distance with time will allow for the identification of the effects of distance over time Bergstrand et al. (2014). Bergstrand et al. (2014) do this to great effect and find that the elasticity on distance has declined over time. Anderson et al. (2016a) also use equation (4.3.1) as a robustness check for the estimates of equation (4.2.17). This specification has the advantage of mitigating possible endogeneity, associated with selection into RTA, in equation (4.2.17).

However, the above approach, while useful for dealing with the issue of endogeneity, is difficult to implement when there are large number of exporters and importers and several years to consider. Additionally, the variables of interest, $CARI * \left(\frac{e_{nt}}{e_{jt}}\right)$ and $CCOM_{njt}$, in equation (4.2.17) have limited variation over time. That is, besides Haiti and Suriname, all CARICOM members were and remained a part of the RTA for the entire sample period as well as 5 of the 9 CARICOM members sampled have fixed exchange rate regimes and another 2 have limited variation over time because their exchange rates are managed. Therefore, if the gravity model is estimated using equation (4.3.1), the bilateral pair fixed effects will absorb, and is correlated in part with, these effects since they control for all possible (observable and unobservable) time-invariant trade costs at the bilateral level. To mitigate this problem we adopt Anderson and Yotov (2016) approach by estimating the gravity equation using a two-stage procedure. The first stage involves estimating equation (4.3.2) and capturing the bilateral pair fixed effects. These bilateral pair fixed effects are used as the dependent variable in the second stage regression.

$$
\begin{aligned}
X_{njt} = exp\Bigg[\alpha_1 * CARI_{njt} * \left(\frac{e_n}{e_j}\right) + \alpha_2 * CARI\_EXP_{njt} * \left(\frac{e_{nt}}{e_{jt}}\right) \\
+\alpha_3 RTA_{njt} + \Lambda_{nj}\Bigg] + \epsilon_{njt}
\end{aligned}
\tag{4.3.2}
$$

The second stage regression involves regressing the standard variables used to estimate trade costs as well as $CARI * \left(\frac{e_{nt}}{e_{jt}}\right)$, $CARI\_EXP_{njt} * \left(\frac{e_{nt}}{e_{jt}}\right)$ and $CCOM_{njt}$ on the bilateral pair fixed effects obtained from equation (4.3.2) controlling for exporters and importers specific characteristics. That is, estimating the following:

$$
\begin{aligned}
\Lambda_{nj} = exp\Bigg[\tau'_{nj} + \beta_1 BDER_{njt} + \beta_2 * CARI * \left(\frac{e_{nt}}{e_{jt}}\right) + \beta_3 * CARI\_EXP_{njt} \\
* \left(\frac{e_{nt}}{e_{jt}}\right) + \beta_4 CCOM_{njt} + P_{jt} + \Pi_{nt}\Bigg] + \epsilon_{njt}
\end{aligned}
\tag{4.3.3}
$$

This two-stage approach is easier to implemented than estimating equation (4.3.1) and is useful when examining to what extent selection into RTA is problem and how it may distort the estimates of the gravity equation.

4.3.2 Baseline Estimation

Aligned with the finding in Chapter 2 as well as the recommendations of Santos Silva and Tenreyro (2006), Anderson et al. (2015) and Fally (2015), among others, the baseline model is estimated using the PPML estimator with importer and exporter fixed effects for selected years. The PPML estimator is from the family of Generalize Linear Model (GLM) and is found to be a consistent estimator of the coefficients of the gravity model even in the presence of heteroskedasticity, when the test statistic of a MaMu/Park-type test is significantly different from 2 (Head and Mayer, 2014). Additionally, as mentioned before Fally (2015) demonstrates that the gravity model estimated using PPML with exporter and importer fixed effects is consistent with the structural gravity estimation approach. Unique to the PPML estimator is its ability to perfectly match predicted output and expenditures with observed output and expenditures respectively (Fally, 2015). He considers other estimators, OLS and Gamma PML, and finds that in practice the multilateral resistance terms are biased as well as the output and expenditure prediction of these estimators are significantly different from observed.

As an added bonus, the PPML estimator also accommodates zero trade flows, hence allowing information related to observed zero trade flow to be taken into consideration when estimating the model. Other approaches that could be used to accommodate zero trade flow include EK tobit, Heckman Selection and Xiong and Chen (2014). (The EK tobit and Heckman section are described in Chapter 1, however, they are briefly described here.) To estimate the EK tobit a marginal number is added to trade flows (usually one) before the log of the dependent variable is taken. By doing so, zero trade flows remain in the data set since the log of one is zero. Heckman selection is a two-stage estimator where in the first stage the gravity model is estimated using Probit with a binary dependent variable taking the value one when bilateral trade flow is observed to be greater than zero, and zero otherwise. From the first stage estimation the inverse Mills ratio is derived and included in the second stage regression which only considers, trade flows greater than one. Xiong and Chen (2014) propose a similar two stage approach, however, in the second stage the gravity model is estimated using a Method of Moment estimator rather than OLS as is the case with Heckman selection. Their concern was aligned with Santos Silva and Tenreyro (2006), that OLS is an inconsistent estimator of the gravity model in the presence of heteroskedasticity. However, this estimator is not found to outperform the PPML, although it has the advantage of disentangling the effects on trade flows at the intensive and extensive margin.

Against this background the PPML estimator is the only estimator considered here in the estimation of the baseline gravity model. The estimates of the baseline model are compared with those established in the literature and analysis carried using some of these established parameter estimates.

4.3.3 Counter-factual Design

There are three major steps involved in deriving counter-factuals. These include:

- Step 1: Establish Baseline Gravity Model
  - Step 1a: Estimate the baseline gravity model or use existing literature to derive parameter estimates
  - Step 1b: Construct 'Baseline' General Equilibrium Indexes
- Step 2: Estimate Conditional Gravity Model and General Equilibrium Effects
  - Step 2a: Estimate Conditional Gravity Model
  - Step 2b: Construct Conditional General Equilibrium Indexes

- Step 3: Estimate Full Endowment General Equilibrium Effects
    - Step 3a: Estimate 'Full Endowment' Gravity Model
    - Step 3b: Construct 'Full Endowment' General Equilibrium Indexes

Step 1a is mostly described in the previous subsection. It should be noted that the baseline regression is estimated without a constant. This is to avoid the dummy variable trap or perfect collinearity; furthermore, it is necessary to normalize the regression on a selected country's multilateral resistance. Besides being a econometric requirement, this normalization is also a necessary condition to solve the structural gravity system. Subsequent to correctly specifying and estimating the baseline gravity model, the estimated multilateral resistance terms (exporter and importer fixed effects) are used to construct the baseline indexes or the sellers and buyers incidence of trade respectively (Step 1b).

In step 2 the conditional general equilibrium gravity estimates are derived by allowing changes in the outward and inward multilateral resistance, holding changes in output and expenditure constant. These indexes are called Conditional General Equilibrium Indexes. For this chapter, the interest is to estimate the impact that CARICOM has on it members as well as to identify the welfare implications of implementing a common currency among CARICOM members. Given these objectives, in Step 2a, the coefficient associated with CARICOM is set to zero. In an alternative scenario the coefficients associated with currency deviation between CARICOM members is restricted to ascertain the potential impact of adopting a common currency. In this step of the analysis the baseline data remain unchanged and inferences are made only through the observed changes in the outward and inward multilateral terms. The gravity equation is re-estimated with the aforementioned constraints imposed. Similar to step 1b, the conditional counter-factual outward and inward multilateral terms are generated. These are compared with the baseline outward and inward multilateral terms from step 1b. Differences in these indexes can be considered measures of welfare since the fixed effects are capturing all country-specific attributes, which in this model are limited to real GDP; however, all changes in real GDP are relative to a reference country.

Unlike in Step 2 where changes in output and expenditure are considered exogenous and hence the general equilibrium effects are conditional, Step 3 considers the full endowment effects associated with the same constraints imposed in Step 2. In Step 3a it is assumed that the trade (im)balance ratio stays the same in the counter-factual for each country and that output and expenditure are endogenous. That is, output and expenditure are allowed to change given the constraints imposed on the model. These endogenous changes in output and expenditure will also cause changes in the multilateral resistance terms and changes in the multilateral resistance terms will result in changes in the trade flows which in turn result in changes in output and expenditure and so forth. Using equation (4.2.1) and taking advantage of the fact that the PPML estimator is consistent and guarantees that the sum of the fitted values of output and expenditure is equal to the sum of the observed values of output and expenditure respectively the system of equations (4.2.1)-(4.2.4)) can be solved.

The mechanism by which the general equilibrium effects are derived can be described as follow. Using the Conditional General Equilibrium effects obtained in Step 2a and the market clearing conditions, $p_j = \left(\frac{Y_j}{Y}\right)^{\frac{1}{1-\sigma}} \frac{1}{\gamma_j \Pi_j}$, changes in the factory-gate prices are derived. Changes in the factory-gate prices result in changes in output and expenditure. By endogenizing (country-specific and world output) output and expenditure, changes in both will trigger changes in trade flows via equation (4.2.1). With these new trade flows and new outputs and expenditures, 'second-order' multilateral responses are derived. These will trigger another round of changes in factory-gate prices, which cause changes in output and expenditure and so forth. This process continues until convergence is achieved. Once convergence is achieved the Full Endowment General Equilibrium Indexes can be retrieved.

Similar to Step 2b, the percentage differences between the baseline indexes and the indexes generated from Step 3a are considered the Full Endowment General Equilibrium effects and are measures of changes in welfare.

4.4 Data

The data used in this chapter is drawn from several sources. Trade flow data is taken from De Sousa et al. (2012), which is available via CEPII's 'TradeProd' database[9]. This dataset also includes production, tariff, manufactured value-added, wages and labour data for 26 industrial sectors in the International Standard Industrial Classification (ISIC) for 151 exporting and importing countries over the period 1980-2006. Their original sources of the data were: The Trade, Production and Protection 1976-2004 database made available by the World Bank (Nicita and Olarreaga, 2007); The BACI international trade database at the product level (Gaulier and Zignago (2010)); The United Nations Industrial Development Organization (UNIDO) database, which is the main source of manufacturing production data in Nicita and Olarreaga, 2007; and, Penn World Tables v.6.3 for GDP and relative price data.

Other macroeconomic and socio-economic indicators such as GDP per capita, population, value-added to GDP by agriculture, manufacture, industry and services, and exchange rates were sourced from the World Bank World Development Indicators. De Sousa et al. (2012) was merged with CEPII's geographical bilateral and cultural data set, which includes variables such as distance, common language, colony and

[9] CEPII's TradeProd database is publicly available via $http://www.cepii.fr/anglaisgraph/bdd/TradeProd.htm$

Table 4.3: Available Production Data for CARICOM

Country	**ISO code**	**Data Available**
Bahamas	BHS	1986-1987, 1989-1992 & 1995-1998
Belize	BLZ	1989-1992
Barbados	BRB	1980-1997
Grenada	GRD	1989-1993
Haiti	HTI	1988-1997
Jamaica	JAM	1980-1992
St. Lucia	LCA	1993-1997
Suriname	SUR	1980-1993 & 1996-2004
Trinidad and Tobago	TTO	1981-1987, 1989-1995 & 2000-2002

Source: CEPII's 'TradeProd' database, De Sousa et al. (2012).

contiguity[10]. Currency unions and region-specific RTAs are derived from De Sousa (2012).

To achieve the objectives of this chapter the dataset is updated to include intra-national trade (trade with self). Intra-national trade (trade with self) is an essential part of this general equilibrium framework. It is a necessary components to estimating the total production/income/expenditure of each country; however, data coverage is limited. This is a major limitation to our analysis especially since the interest is in CARICOM trade and there are several data limitations in this respect. Recall that intra-national trade is approximated using the difference between production of country n and total exports from country n; however, production data is missing for several CARICOM members at different points in time. See Table 4.3 for a summary of data available for CARICOM members. The period 1989-1992 has the greatest amount of data available; however, this time interval would be restrictive.

The main concern with using the data available for the period 1989-1992 is that using such a short time period would limit our analysis in identifying CARICOM and exchange rate effects within a period that does not consider the common external tariff implemented post 1992 (deeper economic integration) as well as it coincide with

[10]CEPII's geographical bilateral and cultural dataset is publicly available via $http://www.cepii.fr/CEPII/fr/bdd_modele/download.asp?id=6$

exchange rate and trade liberalisation in some CARICOM members. Against this background, the time dimension of the panel is extended to cover the period 1986-2001. If production data is missing for a CARICOM member during this period, estimated production data is used to fill the gap. The estimation of missing data involves identifying the ratio of GDP to production or manufacturing GDP to production for the years available then estimating a model with a linear trend and a constant or other functional form and subsequently predicting the ratio. The predicted ratio is then combined with observed GDP figures to back out an estimate of production for the years there are missing data[11]. With this, the baseline model is estimated using an unbalanced panel data for 90 countries with three years interval over the period 1986-2001. When estimating equation (4.3.1) the '$PPML\_PANEL\_SQ$' coded by Zylkin, T. (2016) in Stata was used as there are a large number of bilateral pair fixed effects; however, this routine is not adaptable to Anderson and Yotov (2016) two-stage procedure (equations (4.3.2) and (4.3.3)) since it does not allow for the specification of the equation with only bilateral pair fixed effects. It requires that either exporter and importer fixed effects or export-time and importer-time fixed effects are included. Equations (4.2.17), (4.3.2) and (4.3.3) are estimated using the PPML estimator proposed by Santos Silva and Tenreyro (2006).

4.5 Findings and Discussion

In this section we present the results for equation (4.2.17) and subsequently the results for equations (4.3.1), (4.3.2) and (4.3.3). For comparison, equation (4.2.17) is estimated in the first instance with exporter and importer fixed effects (regressions 1-4 in Table 4.4) and then with exporter time and importer-time fixed effects (regressions 5-8 in Table 4.4). Generally, the results for equation (4.2.17) are suspect as

[11]see Annex B for specification about the procedure used to estimated missing for each country

the equation seems to suffer from the well-documented issue of endogeneity in this specification of the gravity equation, hence, several variants of equation (4.2.17) is estimated both with and without RTA. The results for equation (4.2.17) are presented in Table 4.4 and Table 4.8 in the Appendix. Concerned about endogeneity, equation (4.3.1) is estimated and its estimates compared to those of equation (4.2.17). The results for equation (4.3.1) are presented in Table 4.5; whereas, the results for the two-stage procedure are presented in Table 4.6. Subsequently, regression (7) of Table 4.4, because of its parsimony, tractability and the size of the elasticities relative to those estimated by all other regressions, is used to estimate the general equilibrium effects.

As is expected log distance is estimated as having a negative effect on exports; however, the elasticities estimated by equation (4.2.17) are small, in absolute terms, relative to those established in the literature. According to the literature the median distance elasticity is -0.89 (see Table 4.2) but here we find distance elasticities ranging from -0.495 to -0.757. Additionally, this range of the distance elasticity is dependent on whether or not RTA is included in the specification. Researchers have argued that the inclusion of RTA biases the results because distance and RTA are correlated. Markedly, the inclusion of RTA introduces endogeneity. One argument is that countries are more likely to sign a regional trade agreements if they are closer to each other, hence the introduction of RTA would distort the distance effect and vice-versa. This can be seen by comparing the results for regressions (2) with (3) and regression (6) with (7) in Table 4.4. For regressions (6) and (7) of Table 4.4, which includes exporter-time and importer-time fixed effects, the distance effects moves from -0.495 when RTA is included to -0.726 when RTA is excluded. Similarly, the RTA effects differ from the median effect identified in the literature surveyed by Disdier and Head (2008). The estimated RTA effects using equation (4.2.17) are very large when compared to those established in the literature. From Table 4.2, the median RTA effect is 0.47; however here it is in on average 0.8, suggesting that countries in a regional trade agreement trade 123 percent more with each other than those that are not party to RTAs. Although this estimate is large and at first seems suspect, it is important to contextualize that our estimates consider intra-national trade as such this could account for some of the differences between these estimates and the literature; nonetheless, these differences cannot be solely due to the introduction of intra-national trade because the distance effect increases when the RTA dummy is removed pointing to issues of endogeneity.

In terms of the other traditional variables contained in $\tau^{'}_{nj}$, we observe that the coefficient associated with common language are comparable with estimates found in the literature; however, it decreases when RTA is excludes. Similarly, the coefficient associated with contiguity is in line with the literature but changes when RTA is excluded from the equation. Unlike the coefficient associated with common language, the coefficient associated with contiguity increases when RTA is excluded in the regression. The estimated coefficient for colonial link is smaller than those observed in the literature and is insignificant once RTA is excluded from the regression. $BDER_{njt}$, which is a dummy variable that takes a value of one when there is international trade and zero otherwise, is found to statistically significant and with coefficients ranging from -2.364 to -2.515 suggesting that on average if all trade costs associated with national borders went to zero, trade would increase by approximately 90 percent. This is in line with some estimates in the literature but above the median of 75-85 percent identified in the literature by Head and Mayer (2014). We also observe that when RTA is excluded the coefficient associated with $BDER_{njt}$ increase increases, albeit margin. In terms of statistical significance, common language, contiguity and $BDER_{njt}$ are significant at the 0.1 percent level of confidence; whereas, colonial link is found to be significant at the 5 and 10 percent level of confidence except when RTA is included in the regression and insignificant when RTA is omitted from the regression. The seeming dependence of the statistical significance of colonial link on the inclusion or exclusion of RTA as well as the sized effects of distance, common language, contiguity and $BDER_{njt}$ points to concerns associated with endogeneity in the specification and estimation of equation (4.2.17).

In assessing the estimates related to CARICOM, we find that the estimates on the main variables of interest are not sensitive to inclusion of RTA in the regression. We find a positive effect for the implementation of CARICOM. These effects are statistically significant and large, increasing in size as we move from exporter and importer fixed effects to exporter-time and importer-time fixed effects. From regression (6) of Table 4.4, we find that CARICOM members trade 15 (exp(2.772)) times more among themselves than with others. The same signed and sized effect is found in regression (7), i.e., the exclusion of RTA has no effect on this coefficient. We also find that border effects in among CARICOM members is significantly, albeit at the 10 percent level of significance, from the border effects estimated for all exporter and importers), including CARICOM members. Regression (7) suggests that on average if all trade costs associated with national borders went to zero, trade would increase among CARICOM members by approximately 83 percent. This is 7 percent smaller than the estimated global average as stated above (90 percent).

The other variables of interest are those related to exchange rates. First, for exchange rate within CARICOM, $CARI_{njt} * \left(\frac{e_{nt}}{e_{jt}}\right)$, which is the change in the exchange rate between a bilateral pair that is a member of CARICOM, we find consistently across all regressions in Table 4.4 that the net effect of exchange rate depreciation and or exchange differential within The Region positively impact trade. As can be seen from regression (6) in Table 4.4, the elasticity associated with exchange rates within

CARICOM is 0.263 suggesting that a 10 percent depreciation leads to an increase of 2.6 percent in exports within The Region. When RTA is exclude from the regression (regression (7)) this increases slightly to 0.286. For the second exchange rates variable, $CARI\_EXP_{njt} * \left(\frac{e_{nt}}{e_{jt}}\right)$, which considers changes in exchange rate between *CARICOM exporters* and the rest of world, we find an unambiguous statistically significant positive relationship between the depreciation of currencies in CARICOM and exports from CARICOM members to the rest of the world. From regression (6) in Table 4.4, the associated elasticity, α_3, is 0.574 suggesting that 10 percent depreciation leads to an increase of 5.74 percent in exports to the rest of the world. When RTA is exclude from the regression (regression (7)) this increases slightly to 0.591. Although the coefficients on CARICOM and the exchange variables are not sensitive to RTA, there seems to be some relationship with CARICOM and the exchange rate variables. Whenever, CARICOM is excluded from the regression, the coefficients associated with the exchange rate variables decreases. This is somewhat not surprising since 5 of the 9 CARICOM members sampled have fixed exchange rate regimes and as such there will be some correlation; however, the exchange rate variables is picking up scale effects of exchange rate differential across countries. This becomes more apparent in the following set of results.

Table 4.4: PPML Panel Gravity Estimates using Equation (4.2.17) for the period 1986-2001

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Exporter & Importer fixed effects	Yes	Yes	Yes	Yes	No	No	No	No
Exporter- & Importer- time fixed effects	No	No	No	No	Yes	Yes	Yes	Yes
DV: Exports								
Log Distance	-0.510***	-0.504***	-0.757***	-0.510***	-0.502***	-0.495***	-0.726***	-0.502***
	(-7.65)	(-7.53)	(-11.59)	(-7.65)	(-7.63)	(-7.51)	(-11.36)	(-7.63)
BDER	-2.364***	-2.368***	-2.469***	-2.364***	-2.430***	-2.434***	-2.515***	-2.430***
	(-20.10)	(-20.06)	(-17.47)	(-20.10)	(-20.85)	(-20.79)	(-18.04)	(-20.85)
BDER(CARICOM)	-0.727	-2.099***	-1.425*	-0.727	0.854+	0.0391	0.715+	0.854+
	(-1.44)	(-3.51)	(-2.42)	(-1.44)	(1.69)	(0.10)	(1.88)	(1.69)
RTA	0.864***	0.865***		0.864***	0.788***	0.788***		0.788***
	(8.21)	(8.21)		(8.21)	(7.40)	(7.40)		(7.40)
Contiguity	0.433***	0.436***	0.560***	0.433***	0.471***	0.474***	0.596***	0.471***
	(4.81)	(4.82)	(4.94)	(4.81)	(5.25)	(5.26)	(5.36)	(5.25)
Common Language	0.432***	0.437***	0.357***	0.432***	0.397***	0.403***	0.338***	0.397***
	(4.42)	(4.48)	(3.76)	(4.42)	(4.17)	(4.25)	(3.63)	(4.17)
Colonial Link	0.219+	0.217+	0.0371	0.219+	0.195+	0.192+	0.0211	0.195+
	(1.93)	(1.90)	(0.36)	(1.93)	(1.74)	(1.71)	(0.21)	(1.74)
Exchange Rate (within CARICOM)	0.168+	0.311*	0.270*	0.168+	0.229***	0.263***	0.286***	0.229***
	(1.91)	(2.21)	(2.17)	(1.91)	(3.33)	(3.47)	(4.07)	(3.33)
Exchange Rate (CARICOM Exporter)	0.406***	0.472***	0.481***	0.406***	0.465***	0.574***	0.591***	0.465***
	(10.26)	(14.56)	(14.19)	(10.26)	(5.77)	(8.20)	(7.70)	(5.77)
CARICOM		2.259***	2.204***			2.772***	2.773***	
		(5.71)	(5.69)			(5.92)	(5.91)	
N	25812	25812	25812	25812	25812	25812	25812	25812
R^2	.962	.962	.962	.963	.997	.997	.997	.997

Notes:

t statistics in parentheses and standard errors are clustered at the country-pair level.

***denotes significance at the 0.1 percent, **denotes 1 percent, *denotes 0.5 percent and $^{+}$denotes 10 percent.

Constant, exporter, importer, exporter-time and importer-time fixed effects are not reported. Estimation results are based on equation (4.2.17).

Given our concerns about endogeneity, RTA is omitted from the estimation of equation (4.2.17) and region-specific RTA are included in the regressions. These regressions((3) and (7)), among others (all excluding RTA), are presented in Table 4.10 in the Appendix. Generally, estimating with exporter and importer fixed effects or exporter-time and importer-time fixed effects results in significant differences in the coefficients on most region specific RTAs. We find that there is little to no impact on the distance elasticity when region specific RTAs are used instead of an overarching RTA variable. When the results in Table 4.4 is compared to the results in Table 4.10

in the Appendices, the removal of RTA or estimation with region-specific RTAs results in an increase in the distance elasticity although still below the median observed in the literature. The coefficients associated with $BDER_{njt}$, contiguity and common language are similar to those in Table 4.2. The coefficient associated with common language become more aligned with the literature. The elasticities associated with exchange rates *(within CARICOM)* and exchange rate *(CARICOM Exporter)* seems robust to the removal of RTA and estimation with region-specific RTAs; although CARICOM seemingly modify their magnitude.

In order to better identify the overarching effect of RTA, we estimate equation (4.3.1). These results are presented in Table 4.5. Without control for national border effects, the regression is estimated with RTA, CARICOM and the exchange rate variables, along with exporter-time, importer-time and bilateral pair fixed effects. We find that a RTA coefficient of 0.658, which is small that those derived from equation (4.2.17). Furthermore, CARICOM and exchange rate (within CARICOM) are not statistically significant. As was noted before, there is limited variation over time in CARICOM and exchange rate (within CARICOM); therefore, it is not surprising that they in not significant in this specification. We find, however, that if the currency of a CARICOM member depreciation, it increases CARICOM's exports to the rest of the world. This estimate is small than that identified in Table 4.4. This is because this regression picks up pure changes in the exchange rate over time; whereas, the estimate in Table 4.4 is capturing both the changes over time and the scale effects of differences in exchange rate across nations. A similar argument can be made about exchange rate within CARICOM. Changes in the exchange rate over time within CARICOM does not significantly affect trade; however, it is the scale effects of differences in exchange rate across CARICOM members relative to the US$ that matters.

If we control for border effects relative to 1986, the RTA effects is 0.313, which is half that when the border effects are not controlled for. This estimate is in line with the median estimate identified in the literature. On the other hand, with this specification the exchange rate variables are both insignificant. This is because the BDER interacted with year dummies absorbs year on year changes in the bilateral dimension (changes in exchange rate over time) and bilateral pair fixed effect absorbs all time invariant observable and unobservable effects (scale effects of exchange rate). From regression (2) of Table 4.5, we observe that relative to 1986 levels the border effects on international trade has been declining at decreasing rate.

Table 4.5: PPML Panel Gravity Estimates using Equation (4.3.1) for the period 1986-2001

	(1)	(2)
Bilateral Pair fixed effects	Yes	Yes
DV: Exports		
RTA	0.658***	0.313***
	(8.66)	(3.82)
CARICOM	0.0856	0.405
	(0.27)	(1.35)
Exchange Rate (within CARICOM)	0.0295	0.0325
	(0.26)	(0.32)
Exchange Rate (CARICOM Exporter)	0.109*	-0.0150
	(2.05)	(-0.32)
BDER(2001)		-0.0572***
		(-4.40)
BDER(1998)		-0.240***
		(-13.15)
BDER(1995)		-0.490***
		(-11.74)
BDER(1992)		-0.606***
		(-11.82)
BDER(1989)		-0.643***
		(-18.32)
N	25074	25074
R^2	0.999	1.000

Notes:

t statistics in parentheses and standard errors are clustered at the country-pair level.

***denotes significance at the 0.1 percent, **denotes 1 percent, *denotes 0.5 percent and +denotes 10 percent.

Constant, exporter-time, importer-time and pairwise fixed effects are not reported. Estimation results are based on equation (4.3.1).

Given that equation 4.3.1 is very restrictive and eliminates the effects we are trying to analyse, we follow Anderson and Yotov (2016) by estimating equation (4.3.2) and (4.3.3). Equation (4.3.2), which is estimated with all time varying variables and bilateral pair fixed effects, estimates an RTA effects of 1.014, which is larger than those estimated by equation (4.2.17) in Table 4.4 and equation (4.3.1) in Table 4.5. On the other hand, the exchange effects are similar for equations (4.3.1) and (4.3.2). It suggests that depreciation of the currency of a CARICOM member increases exports to the rest of the world; however, there is no statistical evidence that depreciation increases trade within The Region. On the other hand, the second stage regression (equation (4.3.3)- regression (3) of Table 4.4) returns a positive and significant effect of exchange rate on trade, suggesting that exchange rate differential within The Region has significant effect on trade within the Region. Put differently, variation in the exchange rate over time have had no effects on trade within The Region; however, differences in exchange rate across bilateral pairs have significant impact on trade within The Region. These estimations are not without fault since from regression (2) and (3) it is observed that if the exchange rate variables are excluding from equation (4.3.3), the estimated CARICOM effect is approximately half that when the exchange rate variables are included. This possibly points to the collinearity issue mentioned before; however, from Table 4.4, the exclusion of CARICOM has marginal effects on the coefficients estimated for the exchange rate variables.

Table 4.6: Two-Stage PPML Panel Gravity Estimates using Equations (4.3.2) and (4.3.3) for the period 1986-2001

	(1)	(2)	(3)
	First Stage Regression	Second Stage Regression	Second Stage Regression
	Exports	Bilateral Pair FE	Bilateral Pair FE
Bilateral Pair fixed effects	Yes	No	No
Exporter- & Importer- time fixed effects	No	Yes	Yes
RTA	1.014***		
	(12.18)		
Exchange Rate (within CARICOM)	-0.0932		0.342***
	(-0.54)		(5.14)
Exchange Rate (CARICOM Exporter)	0.104**		0.554***
	(3.11)		(8.24)
Log Distance		-0.429***	-0.411***
		(-7.26)	(-7.02)
BDER		-3.448***	-3.478***
		(-24.89)	(-25.16)
BDER(CARICOM)		-0.239	-0.274
		(-0.71)	(-0.78)
CARICOM		1.638***	2.900***
		(4.74)	(5.80)
Contiguity		0.431***	0.439***
		(3.75)	(3.83)
Common Language		0.417***	0.404***
		(3.68)	(3.60)
Colonial Link		0.245*	0.242*
		(1.98)	(1.98)
N	25812	25812	25812
R^2	0.964	0.962	0.962

Notes:

t statistics in parentheses and standard errors are clustered at the country-pair level.

***denotes significance at the 0.1 percent, **denotes 1 percent, *denotes 0.5 percent and +denotes 10 percent.

Constant, exporter-time, importer-time and pairwise fixed effects are not reported. Estimation results are based on equations (4.3.2) and (4.3.3).

Despite the challenges associated with accurately identifying the effects of CARICOM and exchange rate differential among members, we conduct counter-facual analysis using Regression (7) of Table 4.4 to quantify: (1) the effects removing the regional trade agreement (CARICOM) could have on the welfare of CARICOM members; or, (2) implementing a common currency with the regional trade agreement (CARICOM) in place could have on the welfare of CARICOM members. Regression (7) of Table

4.4 is used as the baseline model because of its parsimony and tractability when estimated. Furthermore, it excludes the overarching RTA variable and includes only the CARICOM specific trade agreement as well as the coefficients on the variables of interest, CARICOM and exchange rate (within CARICOM), are closest to those estimated by equation (4.3.3). Equation (4.3.2) and (4.3.3) could have been used as an alternative baseline model; however, it's not as tractable and its a estimates are not far from those estimated by equation (4.2.17) (regression (7) in Table 4.4). The large number of bilateral pair fixed effects involved in estimating equation (4.3.1) and the computational resources needed to nest equation (4.3.1) in our general equilibrium framework makes it unattractive as the baseline model; however, with advancements in statistical packages and more efficient coding, the implementation of equation (4.3.1) as a baseline model will become more attractive.

Given the highlighted limitations and concerns about the issue of endogeniety and the fact that it has not been fully addressed[12], these result can be interpreted, maybe not in terms of magnitude but in term of the heterogeneous distribution of welfare, as the expected effects of CARICOM or a common currency on CARICOM members. It is not likely that CARICOM or a common currency on CARICOM members has or will have a uniform impact on all members; therefore, identifying those that benefit more/less remains a useful input for is policy development and implementation. Rather than informing policy using the estimated average regional effects, the properties of the PPML estimator and the structural gravity, through an iterative process, enables the identification and quantification of the welfare effects for each member of CARICOM and hence a broader approach to policy implementation.

First we consider the effects of removing the existing regional trade agreement, CARI-

[12]Addressing the issue of endogeneity in gravity models, especially as it relates to the one highlighted above, requires substantially more research and guidelines.

COM, which has a baseline estimate of 2.773. This effect is set equal zero holding all other effects constant in the counter-factual analysis. These results are presented in Table 4.7 Without endogenously determined output and expenditure and relative to Jamaica IMR (importer-year fixed effect), the conditional real GDP of Bahamas, Barbados, Belize, Grenada and Saint Lucia would decrease relative to Jamaica. Barbados, Grenada and Saint Lucia are the largest loser with decreases in GDP of 0.57, 0.99 and 0.78 percent relative to Jamaica. The conditional welfare implications for Haiti and Suriname relative to Jamaica is negotiable; whereas, conditional welfare implications for Trinidad and Tobago is a 0.28 percent increase in real GDP relative to Jamaica. The story is slight different when we endogenise output and expenditure.

With endogenous output and expenditure, which means the effects are no longer relative to Jamaica, removing CARICOM's regional trade agreement will result in decline in all but two member states, Haiti and Suriname. Suriname is not affected as there will be no change in its Real GDP; whereas, Haiti will see an estimated 0.031 percent increase in its GDP. Grenada, St. Lucia and Belize are expected to suffer the greater reduction in real GDP, with changes of -1.87, -1.43 and -0.82 percent respectively. Barbados' real GDP rate will change by -0.561 percent and Bahamas by -0.238 percent. Trinidad and Tobago and Jamaica will be least impacted by the dismantling of CARICOM's regional trade agreement with estimated changes in real GDP of -0.26 and -0.21 percent respectively. The overall effect on The Region is 0.28 percent reduction in real GDP.

Table 4.7: Estimated general equilibrium effects of removing CARICOM's Regional Trade Agreementt

Country	Conditional			Full Endowment		
	%Δ in IMR	%Δ in OMR	%Δ in Real GDP	%Δ in IMR	%Δ in OMR	%Δ in Real GDP
Bahamas	-2.542	-0.317	-0.244	1.494	-18.192	-0.238
Belize	-0.699	-4.146	-0.128	-5.891	2.789	-0.820
Barbados	-3.377	-0.519	-0.571	-5.082	-9.901	-0.561
Grenada	-7.495	-7.668	-0.995	-5.322	-19.908	-1.869
Haiti	0.081	-0.118	0.016	-11.704	14.428	0.031
Jamaica	0.000	-1.201	0.000	0.000	-4.917	-0.208
Saint Lucia	-4.389	-4.227	-0.783	-4.959	-2.669	-1.431
Suriname	-0.055	-3.536	0.033	289.682	-4.480	0.000
Trinidad and Tobago	1.704	-2.686	0.283	-4.722	-6.736	-0.258

Author's estimates. General Equilibrium estimates based on Regression (7) of Table 4.4.

These findings are striking. As was suspected by the architects of the The Region's regional trade agreement, CARICOM is critical for the smaller islands member states. We find that states such as Jamaica and Trinidad and Tobago would be least impacted by the removal of the trade agreement, which could be a result of their firms' ability to compete globally when compared to the smaller island such Grenada, Saint Lucia and Barbados. Another finding worth highlighting is the limiting impact on Suriname and Haiti. These are countries that joined the trading bloc later than the others and have been slow to implement components of the regional trade agreement. This could be the reason why there is limited impact on these countries. In case of Suriname, this analysis excludes Guyana, one of Suriname major trading partner and neighbour as such the welfare effects for Suriname may be under estimated. The same could be said for CARICOM members that have substantial trade with Guyana. Given the scale of CARICOM's trade in the global network of trade, the estimated general equilibrium effects of CARICOM on the rest of the world is minimal (See Table 4.11 in the Appendices).

Another important stage in the process of regional integration is the adoption of a common currency. We explore the implications of exchange rate differential on intra-regional trade by restricting the effects of the exchange rate (within CARICOM) whilst holding all other variables constant, including the effects of CARICOM and the coefficient associated with exchange rate *CARICOM exporter*. With this, we are assuming that the exchange rate applied to the rest of the world is a weight average of previous exchange rates between CARICOM members and third parties. We acknowledge that this assumption is not necessarily the approach that the regional entity might take if it decides to implement a common currency. In fact, given the number of fixed exchange rate regimes and their importance to these countries, it is likely that if a regional currency is to be implemented it will be pegged to the US$ or basket of other currencies. Further research is needed to ascertain if this will be welfare improving for The Region.

Table 4.8 identifies the welfare effects removing currency differences within CARICOM, without changing the current exchange rate arrangements with the rest of the world, could have on the welfare of member states. Setting the coefficient on exchange rate (within CARICOM) equal zero, ceteris paribus, we find generally that relative to Jamaica the conditional effects are negative for most CARICOM members if a common currency is implemented; whereas, the full endowments welfare effects are positive.

Relative to Jamaica, the conditional change in real GDP for all CARICOM members, except Trinidad and Tobago, is negative. Suriname has the largest conditional change in real GDP of -2.251 percent relative to Jamaica; whereas, Saint Lucia has the smallest conditional change of -0.07 percent. Trinidad and Tobago conditional welfare increase by 0.14 percent relative to Jamaica. This suggest that if we ignore the secondary and higher welfare benefits, i.e. the effects of changes in factory gate prices, output and expenditure, adopting a common current will benefit Jamaica and

Trinidad and Tobago more than other members of CARICOM. These conditional results does convey the direction of effects on real GDP as changes in real GDP are relative to Jamaica's.

Although the conditional welfare effects are mostly negative, when consideration is given to the feedback effects of factory gate prices, output and expenditure, the impact on regional trade from the removal of exchange rate differential within CARICOM is positive for The Region and all CARICOM members. Removing the scaled effects of exchange rate (since there is no estimated/identified time varying effects) within CARICOM results in a 0.5 percent increase in real GDP of The Region. Saint Lucia is expected to benefit the most with an increase in its real GDP of 1.5 percent. Belize, Barbados, Trinidad and Tobago and Grenada with see increases between 0.5-1 percent; whereas, Jamaica and Bahamas real GDP is expected to increase by 0.4 and 0.1 percent respectively. There is virtually no effect on Haiti and Suriname. Similar to the effects of CARICOM, the smaller economies in Eastern Caribbean would benefit more from the implementation of a common currency, at least as it relates to trade. Generally, adopting a common currency will improve the welfare of CARICOM members; however, further research is needed to understand fully the channels through which these benefits are derived.

Table 4.8: Estimated General Equilibrium effects of implementing a Common Currency among CARICOM members

Country	Conditional			Full Endowment		
	%Δ in IMR	%Δ in OMR	%Δ in Real GDP	%Δ in IMR	%Δ in OMR	%Δ in Real GDP
Bahamas	-5.487	11.950	-1.139	-3.545	-8.717	0.105
Belize	-3.823	5.935	-0.595	-8.662	15.585	0.711
Barbados	0.522	6.737	-0.366	0.038	-3.634	0.694
Grenada	-1.146	7.556	-0.227	3.641	-3.570	0.538
Haiti	-2.910	3.155	-0.457	-14.955	18.322	0.007
Jamaica	0.000	3.996	0.000	0.000	-0.347	0.353
Saint Lucia	3.558	0.982	-0.071	7.862	7.587	1.487
Suriname	-12.004	11.035	-2.251	239.893	16.382	0.005
Trinidad and Tobago	2.001	1.221	0.139	-2.663	-2.149	0.617

Author's estimates. General Equilibrium estimates based on Regression (7) of Table 4.4.

4.6 Conclusion and Trade Policy Recommendations

This chapter uses a structural gravity model as a basis for a general equilibrium framework to investigate the importance of international borders, regional trade agreements(RTA) and the potential impact of deeper integration in the form of a currency union among CARICOM members. Using panel data for the period 1986-2001, with 3 year intervals, the gravity model is estimated using Poisson Pseudo Maximum Likelihood(PPML) and subsequently used to derive general equilibrium effects. By exploring the differences in exchange rate regime and the depreciation/devaluation of the currencies of the the economies of The Region, it is possible to identify their effects on trade. Usually, the depreciation in a country's exchange rate is theoretically treated as equivalent to a tax on imports and a subsidy on exports (Anderson et al., 2016). In this chapter, Anderson et. al. (2016) theoretical gravity model framework is adopted to explore the pass-through effects of exchange rate on trade.

We grapple with the effects of endogeneity in gravity model caused by selection into RTA due to the proximity of trading partners; however, several methodologies are employed to mitigate this issue. Additionally, production data needed to estimate intra-national trade, which are essential for this general equilibrium framework, are limited, especially for CARICOM members. Approximation and estimation procedures were used to circumvent this limitation; however, six CARICOM members were still excluded from the analysis. Despite these limitations, for the most part, the objectives of this chapter were met; however, as better data become available then these estimates should be revised.

Like in Chapter 3, we find positive and significant effect of CARICOM on trade among members. Furthermore, changes in the exchange rate over time within CARICOM does not significantly affect trade among members; however, it is the scale effects of differences in exchange rate across CARICOM members relative to the US$ that matters for intra-regional trade. On the other hand, changes in both the exchange rate over time and cross country differences in exchange rate matter for exports to the rest of the world. We also find that the effect of international borders on intra-regional trade is no different from the global average effects of international border on trade.

This framework does not explicitly model the free movement of labour and capital, which is paramount to economic growth and development; however, it benchmark the welfare implications of CARICOM and removal of exchange rate differences, at least as it relates to trade. We find that both these are welfare improving. A world without CARICOM would reduce the GDP of almost all CARICOM member. The overall effect on The Region is estimated at -0.28 percent. The largest loser been the small island states of the Eastern Caribbean, namely: Grenada and Saint Lucia. These islands' real GDP would decline by 1.8 and 1.4 percent respectively. The larger economies of Jamaica and Trinidad and Tobago will be least impacted with declines of 0.21 and 0.26 percent in real GDP respectively. The estimated effects for Haiti and Suriname are negligible. The said virtually zero welfare effects are estimated for Haiti and Suriname when the removal of exchange rate differences among CARICOM members is considered. The removal of exchange rate differences among CARICOM members will benefit The Region and all CARICOM members. With this, increases in real GDP above 0.5 percent is expected for all countries with fixed exchange regime, except for Bahamas. Trinidad and Tobago's real GDP is expected to increased by 0.6 percent and Jamaica's real GDP is expected to increased by 0.4 percent. Overall, adopting a common currency could increase The Region GDP by 0.5 percent.

As mentioned above, more detailed analysis is required to better understand the channels through which these welfare benefits are derived. Furthermore, research is need to determine if this common currency should be pegged to the US$ or a basket of currencies or allowed to float. It would also be useful to evaluate, using firm level data, how exchange rate pass-through or adopting a common currency could affect the bottom line of firms' in each member state. Similarly, assessing the impact of the current tariff structure on exporting and non-exporting firms could provide a much richer analysis of the usefulness of the CET. In fact, any analysis using firm level data for CARICOM would advance the literature on firms and trade in CARICOM, since such research is limited. This is primarily because of limited data availability and where it does exist it is not easily accessible. Each member state has their own statistical institute, which usually limits access to its dis-aggregated data on firms and households. Collecting and centralising dis-aggregated data on firms and households for members of CARICOM is a challenge; however, dis-aggregated data is required to better model the progress and shape the benefits of the CSME.

4.6.1 Trade Policy Recommendations

The growing discontent with RTAs is nested in economic phenomena, such as increasing unemployment, stagnant wages, growing inequality and a general mistrust for leaders and politicians (political economy), around the world. Recent events such as: the United Kingdom (UK) voting to leave the European Union (EU); President Donald Trump's decision to immediately withdraw from Trans-Pacific Partnership, which is one of the largest Free Trade Agreement of this decade; and, Prime Minister of Jamaica, Andrew Holness, launching a Review Commission into Jamaica's participation in CARICOM, are all signs that leaders are being given the mandate to critically scrutinise RTAs and exit those that contribute little to the masses. Using a gravity model and methodology quite similar to those used in this chapter, the United Kingdom (UK) treasurer published a report suggesting that the gains for the UK from being a member of the European Union (EU) were significant and an exit could cost the economic 7.8 percent(Dhaingra et al., 2016); however, in the end there was a vote to leave.

Despite what models, like the gravity model covered in this thesis, say about the welfare effects of trade, the onus is on our leaders and politicians to pursue and develop the best trade deals and implement policies that will foster greater distribution of the welfare gains from trade. These models are mere tools that help to identify and quantify the effects of various trade policies. Like the results presented in this chapter, most of these estimates are at a macro-level but it seems the trickle-down economics that underpins the distribution of benefits to the masses is void in most instances.

Considering the findings of this thesis, particularly those related to Chapters 3 and 4, we make the following general recommends to enhance trade and the equitable distribution of welfare gains from trade among CARICOM members. CARICOM has increased trade among members and has been welfare improving; however, there are still barriers to trade among members. These include: import licenses and bans, complex/discriminatory rules of origin, unreasonable/unjustified packaging, labeling, product standards, complex and heterogeneous regulatory and legislative environment, occupational safety and health laws and regulations, multiplicity and controls of foreign exchange market, inadequate infrastructure such as road, airports and ports, “buy local” policy, corruption, crime and time consuming customs procedures. CARICOM members must work to reduce these non-tariff barriers to trade and harmonise as much as possible cross country issues that could impede trade and economic development.

It is also recommended that The Region adapts a data driven approach to estimate and monitor trade costs among members as well as how significant these trade costs are when compared to the ROW. Besides aiming to reduce trade cost among CARICOM members, CARICOM should aim to reduce the trade costs associated with third parties. When negotiating with third party countries, we encourage continued negotiation as a collective unit serving the interest of all members both at micro- and macro- levels.

Although CARICOM has been trade-creating among members, the policies of CET and CSME, thus far, are ineffective and insufficient responses to globalization and increased international competitiveness. We therefore recommend that CARICOM members place greater efforts towards improving their business and economic environments. These include:

- making it easier to invest and establish businesses;
- improvement in ease of doing business;
- encouraging businesses, especially small and medium size businesses, to take advantage of the existing regional free trade agreement;

- highlighting, periodically, firms that are already using the RTA to its advantage as well as the challenges been faced;
- developing an open source database from which CARICOM firms could assess information about potential markets. The database should aim to link supplies with potential buyer both regional and international;
- developing a supply chain strategy, which recognises the importance of freight and transport infrastructure (ports, airports, road and intermodal facilities) in linking exporters with markets; and,
- completing the implementation of the CSME, which includes adopting a common currency.

The cost of travel between CARICOM members is expensive. Furthermore, we find that distance between members does have implications for how much trade could be achieved within The Region. Therefore, it is recommended that greater efforts are placed into reducing the cost of travel and shipping. One way to achieve this is to bolster regional travel and regional tourism. Critical to achieving this is changing the mind-set of persons in The Region from one of a 'nationalist' to a 'regionalist'. Changing the mind-set requires using several mediums such as social media, mainstream media houses, schools and other institutions to educate and promote a regional and inclusive approach to economic development. This approach should not be restricted to urban areas but play a key role in shaping rural communities as well as cut across several pertinent industries and sectors. Secondly, encourage healthy competition among shipping and airline carriers in The Region so as to drive down the cost of travel between member countries. Increased traffic between member states will encourage greater trade.

It is important also to build greater climate resilience into the Regional Trade Strategy. Climate change and extreme climate events have the potential to gravely limit the development of CARICOM members. We find that regional trade are more vulnerable to natural climatic disasters, and as such, we recommend building greater resilience in industries that are most vulnerable to these events. One such industry is Agriculture, which is critical to food security of The Region. There are several initiatives already on the way but more needs to be done.

4.7 Appendices

4.7.1 Annex A: Sample of Countries

Table 4.9: Countries included in the Panel

ISO Code	Country	ISO Code	Country	ISO Code	Country
CARICOM Members					
BHS	Bahamas	BLZ	Belize	BRB	Barbados
GRD	Grenada	HTI	Haiti	JAM	Jamaica
LCA	Saint Lucia	SUR	Suriname	TTO	Trinidad and Tobago
Rest of the World					
ALB	Albania	FIN	Finland	NLD	Netherlands
ARG	Argentina	FRA	France	NOR	Norway
AUS	Australia	GAB	Gabon	NZL	New Zealand
AUT	Austria	GBR	United Kingdom	PAK	Pakistan
BGD	Bangladesh	GHA	Ghana	PAN	Panama
BHR	Bahrain	GRC	Greece	PER	Peru
BOL	Bolivia	GTM	Guatemala	PHL	Philippines
BRA	Brazil	HND	Honduras	POL	Poland
CAF	Central African Republic	HRV	Croatia	PRT	Portugal
CAN	Canada	HUN	Hungary	RUS	Russian Federation
CHE	Switzerland	IDN	Indonesia	SAU	Saudi Arabia
CHL	Chile	IND	India	SDN	Sudan
CHN	China	IRL	Ireland	SGP	Singapore
CMR	Cameroon	IRN	Iran, Islamic Republic of	SLV	El Salvador
COL	Colombia	ISL	Iceland	SVK	Slovakia
CRI	Costa Rica	ISR	Israel	SWE	Sweden
CUB	Cuba	ITA	Italy	THA	Thailand
CYP	Cyprus	JPN	Japan	TUN	Tunisia
CZE	Czech Republic	KEN	Kenya	TUR	Turkey
DEU	Germany	KOR	Korea, Republic of	TZA	Tanzania *, United Republic of
DNK	Denmark	LBN	Lebanon	UGA	Uganda
DZA	Algeria	LKA	Sri Lanka	URY	Uruguay
ECU	Ecuador	MAR	Morocco	USA	United States of America
EGY	Egypt	MDG	Madagascar	VEN	Venezuela (Bolivarian Republic of)
ESP	Spain	MEX	Mexico	VNM	Viet Nam
EST	Estonia	MYS	Malaysia	YEM	Yemen
ETH	Ethiopia	NGA	Nigeria	ZWE	Zimbabwe

4.7.2 Annex B: Estimated Production Data for CARICOM

- Jamaica: Recognizing that the share of manufacturing in GDP has decline over time, the ratio of GDP to production is estimated for the period 1980 to 1992.

This is period for which production data is available for Jamaica. A model with a linear trend and a constant is estimated and subsequently the ratio is project. This ratio is then combined with observed GDP figures to backout an estimated of production for the year 1996 and 2001.

- Trinidad and Tobago: Data is missing for a couple years in middle of the sample, 1988, 1996 and 1997 for Trinidad and Tobago. The only year of concern is 1996. A model with a linear trend and a constant is estimated and subsequently the ratio is project. This ratio is then combined with observed GDP figures to backout an estimated of production for the year 1996.

- Barbados: There is data available for Barbados from 1980 to 1997. Although this is a short times series, the data for Barbados rejects the assumption of a linear trend as such a AR(1) model is estimated and used to predict observation for later years. The AR(1) has the lowest mean squared error. Note that only 2001 estimated data was needed for.

- Bahamas: Unlike all the aforementioned countries, manufacturing valued added, instead of GDP, is used for Bahamas since the ratio to GDP exhibit significant volatility and a steep slope; whereas, the ratio to manufacture value add seems to be a lot more stable and the model estimated and the in sample projections better.

- Others: Because of the limited number of years of data for Belize, Grenada Haiti and St. Lucia, no regression methodology was used to estimated and project the missing data. In these cases, the average ratio of GDP to production for the years available are held constant to compute the missing data.

4.7.3 Annex C: Robustness Check and General Equilibrium Results

Table 4.10: PPML Panel Gravity Estimates without RTA for the period 1986-2001

DV: Exports	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Exporter & Importer fixed effects	Yes	Yes	Yes	Yes	No	No	No	No
Exporter- & Importer- time fixed effects	No	No	No	No	Yes	Yes	Yes	Yes
Log Distance	-0.762***	-0.757***	-0.683***	-0.762***	-0.732***	-0.726***	-0.721***	-0.732***
	(-11.69)	(-11.59)	(-10.73)	(-11.69)	(-11.46)	(-11.36)	(-12.18)	(-11.46)
BDER	-2.467***	-2.469***	-2.436***	-2.467***	-2.513***	-2.515***	-2.531***	-2.513***
	(-17.52)	(-17.47)	(-18.71)	(-17.52)	(-18.10)	(-18.04)	(-18.34)	(-18.10)
BDER (CARICOM)	-0.387	-1.425*	-1.738**	-0.387	1.015+	0.715+	0.724+	1.015+
	(-0.75)	(-2.42)	(-2.86)	(-0.75)	(1.80)	(1.88)	(1.90)	(1.80)
Contiguity	0.558***	0.560***	0.549***	0.558***	0.594***	0.596***	0.652***	0.594***
	(4.93)	(4.94)	(5.29)	(4.93)	(5.36)	(5.36)	(6.05)	(5.36)
Common Language	0.351***	0.357***	0.385***	0.351***	0.332***	0.338***	0.302***	0.332***
	(3.70)	(3.76)	(4.29)	(3.70)	(3.55)	(3.63)	(3.47)	(3.55)
Colonial Link	0.0404	0.0371	0.101	0.0404	0.0259	0.0211	0.00438	0.0259
	(0.39)	(0.36)	(1.02)	(0.39)	(0.25)	(0.21)	(0.05)	(0.25)
Exchange Rate (within CARICOM)	0.145+	0.270*	0.288*	0.145+	0.231**	0.286***	0.304***	0.231**
	(1.80)	(2.17)	(2.22)	(1.80)	(3.17)	(4.07)	(4.36)	(3.17)
Exchange Rate (CARICOM Exporter)	0.414***	0.481***	0.495***	0.414***	0.477***	0.591***	0.616***	0.477***
	(10.20)	(14.19)	(14.59)	(10.20)	(5.49)	(7.70)	(7.53)	(5.49)
CARICOM		2.204***	2.469***			2.773***	2.888***	
		(5.69)	(6.18)			(5.91)	(6.07)	
NAFTA			0.306***				-0.550**	
			(7.62)				(-2.95)	
EU			0.503***				0.298*	
			(3.88)				(1.97)	
MERCOSUR			1.406***				1.848***	
			(3.60)				(8.72)	
COMESA			1.733*				3.626***	
			(2.37)				(11.33)	
SADC			-0.297				-1.088*	
			(-0.36)				(-1.99)	
ASEAN			-0.138				-1.598***	
			(-0.66)				(-4.33)	
PAFTA			0.950*				1.890***	
			(2.12)				(6.50)	
N	25812	25812	25812	25812	25812	25812	25812	25812
R^2	.962	.962	.974	.962	.997	.997	.997	.997

Notes:

t statistics in parentheses and standard errors are clustered at the country-pair level.

***denotes significance at the 0.1 percent, **denotes 1 percent, *denotes 0.5 percent and $^{+}$denotes 10 percent.

Constant, exporter, importer, exporter-time and importer-time fixed effects are not reported. Estimation results are based on equation (4.2.17).

Table 4.11: Estimated general equilibrium effects of removing CARICOM's Regional Trade Agreement

Country	Conditional			Full Endowment		
	%Δ in IMR	%Δ in OMR	%Δ in Real GDP	%Δ in IMR	%Δ in OMR	%Δ in Real GDP
Rest of the World						
ALB	0.060	-0.059	0.010	-22.219	28.707	0.025
ARG	0.103	-0.114	0.016	-3.194	-0.155	0.010
AUS	0.231	-0.203	0.036	33.537	-26.985	0.001
AUT	0.128	-0.141	0.021	4.417	-8.010	0.003
BGD	0.007	-0.106	0.003	7.496	-11.924	0.005
BHR	0.262	-0.262	0.044	36.199	-30.263	0.000
BOL	0.111	-0.110	0.012	-0.798	4.475	0.040
BRA	0.118	-0.119	0.018	-8.029	13.131	0.015
CAF	0.201	-0.177	0.034	46.723	-34.575	0.000
CAN	0.126	-0.140	0.021	4.140	-8.039	0.008
CHE	0.242	-0.206	0.038	35.194	-26.853	0.000
CHL	0.024	-0.093	0.002	10.698	-10.040	0.008
CHN	0.114	-0.139	0.020	-8.390	-5.683	0.004
CMR	0.088	-0.099	0.015	-9.429	8.706	0.025
COL	0.040	-0.104	0.009	12.986	-12.318	0.012
CRI	0.110	-0.118	0.016	-0.746	-0.558	0.020
CUB	0.000	0.000	0.000	62.272	-39.731	0.000
CYP	0.121	-0.122	0.019	0.156	-1.958	0.007
CZE	0.076	-0.085	0.013	-18.537	26.294	0.008
DEU	0.138	-0.147	0.024	6.816	-9.226	0.002
DNK	0.129	-0.139	0.021	4.231	-7.505	0.004
DZA	0.242	-0.209	0.038	34.416	-24.301	0.001
ECU	0.103	-0.119	0.012	-0.311	-1.046	0.027
EGY	0.034	-0.099	0.008	13.837	-12.811	0.003
ESP	0.124	-0.135	0.020	3.269	-6.175	0.003
EST	0.078	-0.078	0.013	-21.188	26.520	0.018
ETH	0.076	-0.082	0.012	-20.968	25.559	0.028
FIN	0.122	-0.135	0.019	1.396	-8.191	0.005
FRA	0.128	-0.141	0.021	4.954	-8.180	0.002
GAB	0.264	-0.264	0.044	15.673	-12.494	0.007
GBR	0.125	-0.135	0.020	4.963	-7.842	0.002
GHA	0.296	-0.288	0.049	27.140	-17.269	0.008
GRC	0.057	-0.106	0.014	16.607	-13.074	0.002
GTM	0.019	-0.103	0.000	6.793	-3.836	0.012
HND	0.241	-0.217	0.038	31.401	-24.248	0.005
HRV	0.233	-0.261	0.040	39.185	-30.296	0.000
HUN	0.125	-0.138	0.022	-0.722	-4.784	0.006

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Table 4.11 continued from previous page

Country	Conditional			Full Endowment		
	%Δ in IMR	%Δ in OMR	%Δ in Real GDP	%Δ in IMR	%Δ in OMR	%Δ in Real GDP
IDN	0.132	-0.167	0.028	-2.887	-10.482	0.007
IND	0.119	-0.143	0.021	-1.024	-9.288	0.005
IRL	0.130	-0.134	0.020	-2.078	-6.241	0.008
IRN	0.111	-0.118	0.023	-12.740	6.473	0.008
ISL	0.241	-0.206	0.038	32.691	-25.967	0.002
ISR	0.114	-0.131	0.019	-4.999	-0.992	0.004
ITA	0.117	-0.135	0.018	2.531	-6.332	0.003
JPN	0.132	-0.145	0.024	7.927	-8.221	0.001
KEN	0.110	-0.128	0.017	-1.818	-0.730	0.014
KOR	0.117	-0.160	0.026	-2.826	-7.711	0.003
LBN	-0.388	0.391	-0.065	-29.981	51.685	0.012
LKA	0.118	-0.135	0.018	-3.797	-4.359	0.010
MAR	0.118	-0.129	0.018	-0.124	-3.745	0.012
MDG	0.051	-0.011	0.019	-15.572	32.577	0.038
MEX	0.019	-0.100	-0.001	10.528	-12.682	0.005
MYS	0.296	-0.228	0.047	2.091	-14.975	0.005
NGA	0.264	-0.264	0.044	17.548	-15.418	0.004
NLD	0.133	-0.141	0.022	5.402	-6.746	0.003
NOR	0.124	-0.138	0.020	3.479	-8.284	0.005
NZL	0.122	-0.145	0.022	2.133	-9.153	0.009
PAK	0.191	-0.147	0.027	61.478	-36.421	0.000
PAN	0.083	-0.086	0.012	1.430	1.097	0.019
PER	0.253	-0.209	0.037	32.661	-26.005	0.003
PHL	0.103	-0.132	0.015	-5.004	-6.777	0.008
POL	0.100	-0.095	0.015	-9.700	4.014	0.005
PRT	0.121	-0.134	0.019	2.746	-4.961	0.006
RUS	0.080	-0.082	0.019	-19.747	26.457	0.010
SAU	0.011	-0.011	0.002	28.883	-25.623	0.000
SDN	0.370	-0.362	0.062	-33.558	61.641	0.046
SGP	0.098	-0.167	0.019	1.224	-2.484	0.001
SLV	-0.108	0.023	-0.025	-14.415	18.595	0.020
SVK	0.077	-0.078	0.013	-20.793	26.533	0.011
SWE	0.121	-0.137	0.019	3.725	-8.658	0.004
THA	-0.206	-0.019	-0.025	-1.324	-17.873	0.004
TUN	0.216	-0.181	0.036	20.755	-19.268	0.002
TUR	0.125	-0.130	0.019	0.924	-5.180	0.005
TZA	-0.044	-0.038	-0.007	-1.503	6.352	0.021

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Table 4.11 continued from previous page

Country	Conditional			Full Endowment		
	%Δ in IMR	%Δ in OMR	%Δ in Real GDP	%Δ in IMR	%Δ in OMR	%Δ in Real GDP
UGA	0.011	-0.011	0.002	28.882	-25.623	0.000
URY	0.113	-0.123	0.018	0.036	-1.926	0.015
USA	0.119	-0.144	0.020	4.599	-7.522	0.003
VEN	0.060	-0.111	0.009	14.712	-11.803	0.022
VNM	0.053	0.035	0.024	-32.120	56.321	0.015
YEM	0.103	-0.103	0.024	-14.604	19.448	0.017
ZWE	0.270	-0.225	0.039	33.682	-25.377	0.004

Author's estimates. General Equilibrium estimates based on Regression (7) of Table 4.4.

Table 4.12: Estimated General Equilibrium effects of implementing a Common Currency among CARICOM members

Country	Conditional			Full Endowment		
	%Δ in IMR	%Δ in OMR	%Δ in Real GDP	%Δ in IMR	%Δ in OMR	%Δ in Real GDP
Rest of the World						
ALB	-1.902	1.556	-0.324	-23.871	31.795	0.024
ARG	-3.346	4.881	-0.664	-8.087	3.816	0.009
AUS	-6.854	7.431	-1.147	22.629	-21.768	0.000
AUT	-4.939	6.397	-0.882	-2.701	-2.755	0.003
BGD	-4.485	5.951	-0.629	0.985	-7.334	0.005
BHR	-13.094	15.066	-2.312	18.293	-17.799	0.000
BOL	-4.334	4.804	-0.616	-6.789	9.102	0.039
BRA	-4.310	4.569	-0.709	-13.186	18.191	0.013
CAF	-9.629	9.850	-1.719	31.397	-27.902	0.000
CAN	-4.857	6.500	-0.845	-2.845	-2.765	0.007
CHE	-7.167	7.608	-1.114	23.539	-21.455	0.000
CHL	-4.884	6.160	-0.750	3.459	-5.204	0.008
CHN	-3.815	5.896	-0.671	-13.252	-0.718	0.003
CMR	-2.919	2.833	-0.529	-12.665	12.203	0.024
COL	-5.260	6.466	-0.828	5.064	-7.430	0.012
CRI	-4.312	5.787	-0.722	-6.711	4.517	0.019
CUB	0.000	0.000	0.000	44.012	-33.481	0.000
CYP	-4.428	5.473	-0.726	-5.987	2.938	0.007
CZE	-1.803	1.500	-0.301	-20.674	29.264	0.007
DEU	-5.194	6.529	-0.921	-0.828	-3.919	0.001
DNK	-4.937	6.414	-0.855	-2.860	-2.257	0.004
DZA	-6.870	6.555	-1.280	23.185	-19.581	0.001
ECU	-4.366	5.588	-0.683	-6.409	3.883	0.026
EGY	-5.086	6.163	-0.852	6.028	-8.161	0.003
ESP	-4.866	6.135	-0.809	-3.654	-0.980	0.003
EST	-1.857	1.501	-0.320	-22.765	29.494	0.018
ETH	-1.845	1.473	-0.297	-22.547	28.472	0.028
FIN	-4.594	6.138	-0.766	-5.092	-3.173	0.005
FRA	-5.048	6.438	-0.877	-2.355	-2.893	0.002
GAB	-4.425	3.957	-0.814	9.563	-8.897	0.006
GBR	-5.032	6.310	-0.867	-2.283	-2.655	0.002
GHA	-4.335	4.762	-0.663	18.865	-14.181	0.008
GRC	-5.615	6.463	-0.985	7.933	-8.109	0.002
GTM	-5.106	7.225	-0.749	-0.730	1.930	0.011
HND	-6.272	6.839	-0.952	21.284	-19.308	0.002
HRV	-11.598	15.009	-2.130	21.236	-17.858	0.000
HUN	-4.667	6.316	-0.883	-7.172	0.536	0.006

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Table 4.12 continued from previous page

Country	Conditional			Full Endowment		
	%Δ in IMR	%Δ in OMR	%Δ in Real GDP	%Δ in IMR	%Δ in OMR	%Δ in Real GDP
IDN	-4.258	6.348	-0.743	-8.648	-5.300	0.007
IND	-4.392	6.423	-0.805	-7.081	-4.133	0.005
IRL	-4.445	6.255	-0.677	-8.161	-1.031	0.008
IRN	-3.497	5.456	-0.530	-16.989	11.772	0.008
ISL	-6.514	7.298	-1.142	22.105	-20.723	0.002
ISR	-3.978	5.475	-0.671	-10.334	3.841	0.004
ITA	-4.787	6.215	-0.790	-4.272	-1.115	0.002
JPN	-5.384	5.953	-0.888	-0.048	-3.255	0.001
KEN	-4.610	6.113	-0.801	-8.176	4.602	0.013
KOR	-4.251	5.710	-0.706	-8.538	-2.812	0.003
LBN	-1.871	1.907	-0.314	-31.254	54.965	0.012
LKA	-4.381	6.198	-0.740	-9.803	0.916	0.009
MAR	-4.492	5.755	-0.729	-6.320	1.236	0.012
MDG	-4.175	6.010	-1.064	-21.328	38.639	0.037
MEX	-4.910	6.748	-0.755	3.279	-7.528	0.005
MYS	-4.711	6.408	-0.717	-4.468	-9.771	0.005
NGA	-5.222	5.781	-0.588	10.354	-10.365	0.004
NLD	-5.089	6.326	-0.870	-1.996	-1.495	0.003
NOR	-4.842	6.551	-0.880	-3.446	-2.985	0.005
NZL	-4.632	6.261	-0.845	-4.450	-4.127	0.008
PAK	-8.635	8.006	-1.309	44.859	-31.874	0.000
PAN	-5.674	7.718	-1.046	-6.611	7.667	0.018
PER	-6.818	7.144	-1.057	21.662	-20.965	0.002
PHL	-4.277	5.978	-0.703	-10.721	-1.758	0.008
POL	-3.242	3.819	-0.497	-13.361	8.178	0.004
PRT	-4.808	6.148	-0.818	-4.099	0.312	0.006
RUS	-1.826	1.503	-0.272	-21.958	29.429	0.010
SAU	-0.674	0.677	-0.113	28.031	-25.046	0.000
SDN	-2.781	2.861	-0.469	-35.896	68.524	0.045
SGP	-4.785	4.903	-0.679	-5.707	2.077	0.001
SLV	-1.323	1.163	-0.237	-15.526	20.545	0.020
SVK	-1.842	1.502	-0.294	-22.471	29.501	0.011
SWE	-4.861	6.438	-0.873	-3.232	-3.404	0.004
THA	-3.668	5.325	-0.506	-6.807	-14.402	0.004
TUN	-4.805	4.468	-0.785	14.157	-15.394	0.001
TUR	-4.580	5.974	-0.809	-5.442	-0.085	0.005
TZA	-3.018	4.620	-0.744	-6.125	9.998	0.021

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Table 4.12 continued from previous page

Country	Conditional			Full Endowment		
	%Δ in IMR	%Δ in OMR	%Δ in Real GDP	%Δ in IMR	%Δ in OMR	%Δ in Real GDP
UGA	-0.681	0.687	-0.114	28.025	-25.039	0.000
URY	-4.368	5.518	-0.790	-6.065	2.897	0.014
USA	-4.933	6.644	-0.858	-2.509	-2.141	0.002
VEN	-5.531	6.928	-0.970	6.136	-6.544	0.019
VNM	-2.404	2.357	-0.424	-34.013	61.296	0.015
YEM	-3.421	3.661	-0.626	-18.396	24.018	0.016
ZWE	-7.186	7.321	-1.124	22.043	-20.199	0.001

Author's estimates. General Equilibrium estimates based on Regression (7) of Table 4.4.

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Conclusion

This thesis contributes to the literature on gravity model econometric properties and its application to international trade flow, particularly trade flow among CARICOM member and trade between CARICOM and the ROW. It builds on the work of several researchers, most notably Santos Silva and Tenreyro (2006), Head and Mayer (2014), Anderson et al. (2015) and Anderson et al. (2016b). This thesis covers in three main chapters: simulation and estimation of the gravity model using varying assumptions about the data generating process (dgp) of the errors, implication of conditional mean assumption and sampling; the application of the gravity model to trade among Caribbean Community (CARICOM) members and trade between CARICOM members and the ROW; and, develops and estimates a general equilibrium model to investigate the importance of international borders, regional trade agreements (RTAs) and the welfare implications for CARICOM members from entry into The Regions RTA and deeper integration in the form of a currency union among CARICOM members.

Chapter 1 reviews the literature, identifying the gaps and highlighting some of the estimation issues associated the with gravity model, including heteroskedasticity, observed zero trade flows, cross-section and panel data gravity model and general equilibrium estimation of welfare effects. This review informed the work done in Chapter 2, which fills the gap between simulations of the gravity model done by Santos Silva and Tenreyro (2006) and Head and Mayer (2014). The merger of these two papers allows for the simulation of the gravity model to identify the underlying assumptions of the errors and the most appropriate estimators given some underlying conditions. The starting point for estimating a gravity model is selecting the appropriate sample. This study finds that, although non-random sampling of the exporters by income and regional groupings could have implications for the estimates of the gravity model, the greatest threat to correctly estimating the gravity model is not identifying the dgp of the errors. Subsequent to selecting a sample, whether random or non-random, the first step should involve identifying the dgp of the errors. The findings uncover that understanding the data generating process of the errors is important in deciding on the most appropriate estimator and hence minimizing the bias in the estimates of the gravity equation. The process was aided by the use of the MaMu/Park-type test and GNR test, which have opposing null hypothesis. This thesis considered the two dgp of the errors (CVV/log-normal and CVMR/Poisson-type), and in its findings reaffirmed that the OLS and Gamma PML are least biased when the dgp of the errors are CVV and Poisson PML and NB QGPML estimators proposed by Bosquet and Boulhol (2014).

Chapter 3 and 4 primarily focuses on the application of the gravity model to CARICOM trade both among members and between members and the ROW. We find that CARICOM is welfare improving and there is evidence to suggest that a currency union could benefit The Region. Dismantling CARICOM would reduce the GDP of almost all CARICOM member with overall effect on The Region is estimated at -0.28 percent. The small island states, especially those of the Eastern Caribbean, would decline the most and significantly when compared to the larger economies of Jamaica and Trinidad and Tobago. Implementing a common currency among CARICOM members will benefit The Region and all CARICOM members. The overall effects of adopting a common currency is estimated at a 0.5 percent increase the real

GDP of The Region. Countries with fixed exchange rate, except for Bahamas, is expected to see increases in real GDP above 0.5 percent; whereas, Trinidad and Tobago and Jamaica will experience increase in real GDP of 0.6 percent and 0.4 percent respectively.

This thesis also finds that changes in the exchange rate over time within CARICOM does not significantly affect trade among members. The scale effects of differences in exchange rate across CARICOM members, however, relative to the US$ matters for intra-regional trade; whereas, changes in both the exchange rate over time and cross country differences in exchange rate matter for exports to the rest of the world. We also found that the effect of international borders on intra-regional trade is no different from the global average effects of international border on trade. The CET and CSME, thus far, are ineffective and insufficient responses to globalization and increased international competitiveness. It seems these policies have only reallocation of market shares from firms outside of The Region to firms within CARICOM, instead of, achieving reallocation of market share by increasing the productivity of regional firms and furthermore creating greater global reach.

We also observe that the distance between CARICOM members does have implications for how much trade could be achieved within The Region. Additionally, climatic natural disasters do have effects on exports from affected countries. These effects are more pronounce at the regional level than at the global level. With this, the main trade policy recommendations are: the Region should adapt a data driven approach to estimate and monitor trade costs among members as well as how significant these trade costs are when compared to the ROW; the Region should place greater efforts into reducing the cost of travel and shipping. One way to achieve this is to bolster regional travel and regional tourism. Increased traffic between member states will encourage greater trade; and, climate change and climatic natural disasters should be incorporated into The Region trade and development strategies.

This thesis is not without its limitations; however, these present opportunities for future work. Some of the limitations are: the lack of firm-level data, which limited the scope of the analysis; limited tariff data for CARICOM, which limited this thesis to using indicator/shift dummies for the CET and CSME policies; the simulation of the gravity model did consider panel data, which might not be appropriated to inform panel data estimation of the gravity model; and, the treatment of potential endogeneity related to selection in RTAs. Against this background, there are several areas that require additional research to advance the use and accuracy of the gravity model as a policy tool.

One area for research is trade on RTA with consideration for whether RTAs benefit some countries more than others; such as, does low income countries benefit more than high income countries or does the starting point matters for entry into a RTA. From a methodological perspective, further research is needed to advance methods for dealing with endogeneity. Although past research have advanced and identified ways to deal with the multilateral resistance terms, most of these research, including those included in this thesis, focuses on simulating the gravity equation using cross-section data. An experiment that allows for different assumptions about the multilateral terms would be ideal and informative, especially when estimating the gravity equation using panel data. Additionally, future research should consider unit root tests, structural breaks, trends and cointegration in panel data gravity models. Finally, researchers should simulate and explore the usefulness of quantile regressions and compared their performance against those identified in Chapter 2 of this thesis.