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# Fitting the Gravity Model when Zero Trade Flows are Frequent: a Comparison of Estimation Techniques using Africa's Trade Data

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## Abstract

*The issues of zero trade observations and the validity of the log linear transformation of the gravity equation have generated a number of debates in the literature with differing claims about the most suitable estimation technique. To produce unbiased and consistent estimates for policy making, we undertake a careful comparison of a number of widely used estimators to investigate if EU fish standards are protectionist following reoccurring rejection of African fish products at the EU border. Analysis was based on a dataset of Africa's fish exports to the European Union between 2007 and 2012, which contains about 63% zero trade observations. Our results from the robustness checks are in favour of only the Multinomial Poisson Maximum Likelihood (MPML) technique as the most consistent estimator in relation to the impacts of standards and other explanatory variables. In addition, we find EU standards are indeed non-protectionist in spite of the high level of African fish exports rejected since 2008 at the EU border. Thus, a deeper trade agreement between these trading partners involving a significant transfer in science and technology to the Africa could help improve their compliance rate to EU standards and ensure increased export penetration.*

**Keywords** Gravity model, Zero trade, Estimation techniques, Food safety standards, European Union, African Exports

**JEL Classification** C18 F13 F14 L15

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## 1. INTRODUCTION

Gravity model of trade has emerged as an important model in predicting bilateral trade flows. While its theoretical justification is no longer in doubt, its empirical application has however generated several controversies. These specifically concern the appropriate estimation technique in the presence of both zero trade flows and logarithm transformation of the gravity equation. The first challenge arises from the choice of the estimation technique that produces unbiased and consistent estimates in the presence of zero trade values, which are particularly pervasive in disaggregated trade data. The second arises from the proposition that the log linear gravity equations, which is usually estimated with linear estimation techniques, fails to produce homoscedasticity residuals. Concerning this, Santos Silva and Tenreyro (2006) has pointed out that due to the logarithmic transformation of the equation, linear estimators may be inconsistent in the presence of heteroscedasticity and non-linear estimators, precisely the poisson pseudo maximum likelihood (PPML) should be used. They justified that the method is consistent in the presence of heteroscedasticity and deals naturally with zero trade flows and thus, they deem it fit to be a workhorse for estimating the gravity equation.

However, their assertion has generated a lot of debates in the literature and alternative estimation techniques that accommodate zero trade values have been recommended by others using Monte Carlo simulations. These include the zero inflated models (Burger et al. 2009); sample selection models (Martin and Pham 2008; Gomez-Herrera 2012); feasible generalized least square (Martinez-Zarzoso 2013); Tobit model (Eaton and Kotum 2001); etcetera. However, Head and Mayer (2014) posited that there is no best estimation technique, as choosing the best method depends on the dataset, the research questions and a lot of robustness tests. This conclusion was has also been recently supported by Santos Silva et al. (2015) who posited that the choice of the most appropriate estimation is contingent on the dataset. In other words, these estimation techniques might outperform one another under specific circumstance.

In their search for the most appropriate model, the aforementioned studies have explored the gravity model and estimated the effects of free trade agreement in their gravity model (Santos Silva and Tenreyro 2006; Burger et al. 2009; Martinez-Zarzoso 2013; etc). However, as a departure, we model the trade effects of non-tariff barrier, specifically, sanitary and phyto-sanitary standards in a gravity model setting. By definition, standards are measures aimed at ensuring plant, animal, wildlife and human safety and health. Theoretically, standards have been posited to be capable of having both trade promoting or inhibiting effects. On the one hand, standard can be a catalyst to trade as it helps in building value into certified goods and services and provides consumers with information and assurance about their health and safety, therefore stimulating import demand. On the other hand, the proposition is that standards can constitute technical barrier to trade because meeting stringent standards implies excessive costs of compliance on producers which might erode export competitiveness and affect profitability of the export product particularly those from developing countries(Fisher and Serra, 2000; Xiong and Beghin 2014). For instance, the higher cost of compliance may drive out less productive firms and discourage potential exporters from entering the exports market, which might result into zero trade flows. In addition, the imposition of standards can result in the rejection of non-conforming products at the importing countries' border, consequently leading to the presence of zero trade flows in the affected product's trade flow matrix. Non-compliance to standards can also bring about decisions not to exports thereby aggravating the occurrence of zeros in the trade flow matrix. This is particularly true for many African countries whose exports have been allegedly rejected at the EU border due to non-conformity to its standards.

This study is thus motivated by the methodological challenges which can be posed by food safety standards as it is anticipated that its imposition can bring about zero trade flows. While it is true that some of the zeros can be attributed to statistical zeros such as rounding up or a declaration threshold, however, many of these zeros may reflect inability to trade due to the lack of export profitability resulting from prohibitive high compliance costs of meeting food safety standards. As an empirical application, we investigate the implications of EU standards on Africa's exports using trade data from 2007 to 2012 across a sample of EU 27 and 40 African countries. We did this by focusing on the fish and fishery products. Our choice of fish trade hinges on the premise that these products attracts a relatively significant number of standards than other products due to their highly perishability nature. In addition, available evidence show that the products are the most often rejected export product of Africa at the EU border, constituting about 70% rejection of all African food exports refused entry into the EU due to not meeting the required EU food safety standards (EU RASFF 2014). More so, the stringency of standards has increased in the EU (Felbermayr and Jung 2012). EU standards is said to be overly stringent compared to the international ones, and this might make it more tedious for the exporting countries to meet. Thus, our objective is to investigate if EU fish standard is indeed protectionist in nature such that it increasingly constitutes to rejections of these countries at the border. This is based on antecedent concerns that standards can also be used for protectionist purposes particularly when such standards are more restrictive than required (Xiong and Beghin 2014).

Our study makes two important contributions to the existing literature. Firstly, we investigate if EU stringent standards are indeed protectionist in nature. However, with the exception of Xiong and Beghin (2014), empirical investigation of protectionist extent of standards are rare due to the difficulty and complexity of measuring the stringency of standards and lack of an acceptable globally recognized benchmark which distinguish standards with legitimate intent from those with protectionist intent. Secondly, we also make a methodological contribution by consistently estimating the trade impact of standards when zeros are frequent, probably due to the high stringency of standards which prevents exporters from exporting to the EU. Given the peculiarity of Africa's dataset in terms of missing data and or missing trade which necessitates the comparison of different estimators, we thus find it interesting to apply several of the recommended techniques compare their performances using the appropriate robustness analyses in order to provide policy makers with unbiased and consistent estimates that could be used as tool in future trade negotiations with the EU. Extensive methodological rigour is important so as not to distort the information provided to policy makers. In other words, naive approach to estimation may lead to biased and frequently misinterpreted results capable of straining already established trade relationships between any two trading partners.

The rest of the paper is structured as follows. The next section reviews the theoretical framework of the gravity model. Section 3 provides a short review of various gravity model estimation techniques and the challenges presented by them in the presence of heteroscedasticity and zero trade flows; and also reviews related empirical literature. Section 4 previews the construction of the standard data while Section 5 provides the methodology. Section 6 discusses the results while the final section concludes.

## 2.0 THEORETICAL LITERATURE

The gravity equation was first used by Ravenstein (1889) in which the gravity equation was used to analyze migration patterns in the United Kindom. However, the first formal usage of the model in analyzing trade flows back to Tinbergen (1962). According to the early version of the model, bilateral exports between from country *i* to country *j* are explained by exporters and importers economic masses proxy by their income and the geographical distance between the country-pairs.

## 2.1 Heterogeneity, Zeros in the Gravity Model

After more than two decades of an influx of models providing theoretical justification for the empirical success of the gravity equation, emphasis thereafter turned to ensuring that the empirical results of the gravity equation is well defined on theoretical grounds. One important contribution in this regard relates to the structural form of the equation and the implication of mis-specification or omitted variable bias. These relate to way trade costs and firm heterogeneous behavior is incorporated into the gravity equation.

One important contribution relates to the incorporation of multilateral trade resistance trade cost into a micro-founded gravity equation (Anderon and van Wincoop, 2003, 2004).A second important contribution relates to the structural form of the equation. This relates to way firm heterogeneous behavior is incorporated into the gravity equation. An important area of contribution relates to methodological issue associated with the presence and behavior of heterogeneous firms operating in international markets which was spearheaded by Melitz (2003) and Bernard et al., (2003). Firm heterogeneity arises as not all existing firms in a country exports; only a minority of these firms participate in international market (Bernard et al, 2003). Furthermore, not all exporting firms export to all the countries in the rest of the world; they are only active in just a subset of countries and may choose not to sell specific products to specific markets (due to their inability to do so). The reason for this heterogeneity in firm behavior is because fixed costs are market specific and higher for international trade than for domestic markets. Thus, only the most productive firms are able to cover these costs, and firms' inability to exports may be due to the high cost involved. Consequently, the bilateral trade flows matrix will not be full as many cells will have zero entries. This case is seen at the aggregated level of bilateral trade flows but more often in greater levels of product data disaggregation such as HS6 and HS8.

The prevalence of zero bilateral trade flows has important implication for modelling the gravity equation as the observed zeros might contain important information about the countries (such as why they are not trading) which should be exploited for efficient estimation (Helpman, Melitz and Rubinstein, 2008). Standard gravity equation usually neglect the issue of the prevalence of zero bilateral trade flows and predict theory consistent with only positive bilateral trade flows. However, Helpman, Melitz and Rubinstein (2008); Chaney, 2008; Melitz and Ottaviano, 2008; Chen and Novy 2011; etc) derived theoretical gravity equation which highlight the presences of zero trade records and gives theoretical interpretations for them. The 'new new' trade model of international trade with firm heterogeneity which was spear-headed by Metlitz (2003) is usually adopted in giving the gravity equation a theoretical basis.

Helpman et al. (2008) argue that "by disregarding countries that do not trade with each other, these studies give up important information contained in the data" (Helpman et al. 2008 p442), and that symmetric relationship imposed by the standard gravity model biases the estimates as it is inconsistent with the data. To correct for this bias, Helpman et al (2008) provides a theoretical gravity equation that explains/incorporates firm heterogeneity and positive asymmetric and was thus able to predict both positive and zero trade flows between country-pairs. Given firm level heterogeneity, they assume products are differentiated and firms are faced with both fixed costs and variable costs of exporting. Firms vary by productivity, such that only the more productive firms find it profitable to export; with the profitability of exports varying by destination. Since not all firms found it profitably, this gives rise to positive and zero trade flows across country-pairs. Furthermore, this difference in productivity gives rise to asymmetric positive trade flows in both directions for some pairs of countries. These positive asymmetric trade and zero bilateral trade flows then determine the extensive margin of trade flows (number of firms that exports). Moreover, given that firms in country '*j*' are not productive enough to enable them profitably export to country *i*, this implies that will be zero trade flows from country *j* to *i* for some pairs of countries. This generates a model of firm heterogeneity that predicts zero trade flow from countries *j* to *i* but positive exports from country *i* to *j* for some pairs of countries, and zero bilateral trade flows between countries in both direction.

In sum, a more recent wave of contributions in the gravity equation is the development of theoretical gravity equation that provides a theoretical basis for the occurrences of both observed and unobserved trade – zero trade flows. This is coupled with an influx of theoretically consistent estimation techniques and those that would take care of the zero trade flows. This study therefore undertake a careful consideration of the appropriate estimation techniques since it is now clear that injudicious approaches to estimation may lead to biased results.

## 3.0 EMPIRICAL LITERATURE

The gravity model is very popular in explaining trade relations. First, this is due to the rigorous theoretical foundation given to it with the advent of trade theories especially the new trade theory. Second and more important, this is due to its empirical success in the analysis of foreign trade relations. However, in spite of the popularity it enjoys, there are still questions about the proper specification of the model as well as the proper econometric estimation technique(s) that would give consistent estimates when zeros are frequent in the dependent variable. This section therefore shed light on the various estimation techniques used to tackle this problem. Particular attention is focused on the problems or and advantages of each techniques in the presence of zero trade flows in the data, the occurrence of which is prominent as a result of disaggregated dataset in which over 50% of trade values are found to be zero. The section ends by reviewing the techniques employed in empirical studies of standard-trade literature. A summary of the critics and debate about the best performing variable is thereafter provided in Table A1 in the appendix.

### 3.1 Estimation Issues in Gravity Modeling – The Debate

Early empirical studies rely on cross sectional data to estimate the gravity model, thus the economic framework for the model was cross-sectional analysis, (c.f. Anderson, 1979; Bergstrand, 1985, 1989; McCallum, 1995; and Deardorff, 1998; etcetera). For such cross-sectional analysis, the ordinary least square (OLS) estimation technique or pooled OLS technique is normally employed. However, the traditional cross-sectional approach is affected by severe misspecification problems and thus previous estimates are likely to be unreliable (Carrerè, 2006). This is because the traditional cross sectional gravity model usually include time invariant variables (e.g. distance, common language, historical and cultural dummies, border effects), but the model suffers from misspecification problems as it fail to account for country specific time invariant unobservable effects. This unobservable country specific time invariant determinants of trade are therefore captured by the error term. However, these unobserved variables are likely to be correlated with observed regressors and since OLS technique is usually used, this renders the least square estimator to be inconsistent, which makes one its classical assumptions invalid. In addition, OLS does not control for heterogeneity among the individual countries, which has the potential of resulting into estimation bias as the estimated parameters may vary depending on the countries considered. Therefore, estimating cross sectional formulation without the inclusion of these country specific unobservable effects gives a bias estimate of the intended effects on trade. This renders the conclusions on cross sectional based trade estimates problematic *(ibid)*.

However, over the last decade, there has been an increasing use of panel data in gravity modeling and the use of panel econometric methods (c.f. Egger, 2000; Rose and van Wincoop, 2001; Baltagi, 2003; Egger and Pfaffermayr, 2003; Egger and Pfaffermayr, 2004; Melitz, 2007; and many others). The panel specification is much more adequate as the extra time series data points gives more degree of freedom, results in more accurate estimates. A unique advantage of panel data is that the panel framework allows the modeling of the evolvement of variables through time and space which helps in controlling for omitted variables in form of unobserved heterogeneity which if not accounted for can cause omitted variable bias (Baltagi, 2008). In addition, with panel data, the time invariant unobserved trade effects can easily be modeled by including country specific effects such as time dummies, and thus avoiding the consistency issue mentioned above.

With the availability of panel data, the two common techniques used in fitting the data are the fixed effects and random effect estimation techniques, where the choice between the two hinges on their a priori assumptions. The fixed effect assumes that the unobserved heterogeneity is correlated with the error term. In contrast, the random effect assumes that the unobserved heterogeneity is strictly exogenous i.e. it does not impose any correlation between the unobserved heterogeneity (individual effects) and the regressors. Under the null hypothesis of zero correlation, the random effect model is efficient; both models are consistent, but the random model is more consistent. If however the null hypothesis is rejected, the fixed effect is consistent and the random effect is neither consistent nor efficient. There are however, some drawbacks in the fixed effect model in the sense that all time invariant explanatory variables (are deem to be perfectly collinear with the fixed effects) would be dropped from the model. Consequently, fixed effect model eliminates some important theoretically relevant variables from the gravity equation which are distance, common language, common borders, and the effects of these variables cannot be established. In addition, studies have also applied the OLS technique to panel data. However, pooled OLS can only give precise estimators and test statistics with more power if the relationship between the dependent variable and the regressors remain constant over time.

Early gravity model estimation techniques used to estimate the equation by ordinary least squares, where the model is usually log linearized as a common practice. The validity of a log-linear gravity model hinges on the homoscedastic assumption, as the error term and the log must be statistically independent of the regressors. However, in recent times, Santos Silva and Tenreyro, (2006) have identified flaws with this practice. Their position is that due to the nature of trade data that are intrinsic to heteroscedasticity and pervasive zero trade observations, log linearizing the gravity equation and then applying OLS is problematic.

First, problems arise in logarithmic transformation due to heteroscedasticity which is usually present in trade data. As noted by Santos Silva and Tenreyro (2006) in their influential paper, the common practice of log linearizing the gravity equation and then estimating using OLS is inappropriate because, expected values of the log linearized error term will depend on the covariates of the regression and hence OLS will be inconsistent even if all observations of the dependent variables are strictly positive. This is because a logarithmic transformation of the gravity model changes the properties of the error term. In other words, OLS will produce consistent estimates as long as the error term $(\varepsilon_{ij})$ of the log linear specification $(\ln \varepsilon_{ij})$ is a linear function of the regressors, i.e., if $E[\ln(\varepsilon_{ijt} \mid x_{ijt})] = 0$ ,which is the homoscedasticity assumption. However, logarithmic transformation generates estimates of $E(\ln \varepsilon_{ij})$ and not $\ln E(\varepsilon_{ij})$ , but $E(\ln \varepsilon_{ij}) \neq \ln E(\varepsilon_{ij})$ , where $\ln E(\varepsilon_{ijt} \mid x_{ijt}) = 0; E(\ln \varepsilon_{ijt} \mid x_{ijt}) \neq 0$ , which is the well-known Jensen's inequality[1].

Consequently, due to Jansen's inequality, the error term $(\varepsilon_{ijt})$ is not equal to the log of the error term $(\ln \varepsilon_{ij})$ as the error terms in the log linear specification of the gravity equation are not statistically independent of the regressors but are rather heteroskedastic, leading to inconsistent estimates of the elasticity coefficients. Given this Jansen's inequality, Santos Silva and Tenreyro (2006) argue that the log linear transformation of the gravity model is intrinsic to heteroscedasticity and applying OLS results into biased and inefficient estimates. They argue that even though economists have long known about Jensen's inequality and that the concavity

[1] Jensen's inequality is named after Johan Jensen, the Danish mathematician who in 1906 discovered that: the secant line of all convex function (i.e., the means of the convex function) lies above graph of the function (i.e., the convex function of the weighted means) at every point. The reverse is true for a concave function. His inequality has appeared in many contexts and an example in this case is the arithmetic mean inequality. Thus, in simplified terms, his inequality states that the convex (or concave) transformation of a mean is less or equal to (greater or equal to) to the mean after a convex (concave) transformation. Thereafter, Economists have adopted his intuition to show that the logarithm transformation of an equation generates the expected value (mean) of the logarithmic transformation of the dependent variable $E(\ln Y_{ij})$ and not the logarithm of the mean of the dependent variable $\ln E(Y_{ij})$ ; and $E(\ln Y_{ij}) \neq \ln E(Y_{ij})$ .

of the logarithm function could create a download bias when employing OLS, this important drawback has however been overlooked in bilateral trade studies. They confirm their argument as they found evidence of the presence of heteroskedastisity and inconsistency in the normal log-linear representation of the gravity model; which renders the estimates of elasticity obtained from least squares estimation technique to be both inefficient and inconsistent.

Second and probably more problematic is the presence of zero trade flows in the trade matrix and the appropriate estimation technique. While the Newtonian gravity theory from which the gravity model of trade was derived allows for very small gravitational force but not zero force, however, in trade, there are frequent occurrences of zero[2] valued bilateral trade flows and the practice of estimating the log linear gravity model in the presence of such zero trade flows implies both theoretical and methodological problems; especially in cases where the presence of such zero values are excessive. In estimating the gravity model, the gravity model is log linearized and estimated using these linear regression techniques. However, given the predominance of zero trade records in the trade matrix, particularly at the more disaggregated level, where zero records can account for even more than 50% of trade flows, the logarithm transformation of the dependent variable is therefore problematic at least in cases in which the zeros contain relevant information. This is so because the logarithm of zero is indeterminate or not feasible.

However, the common practice in the literature employed to deal with the problem of zero records in the data are the truncation and censoring methods and thereafter applying linear estimation techniques. In the case of truncation method, the zero valued trade flows are dropped completely from the trade matrix, whereas, the censoring method involves substituting the zeros by a small positive arbitrary value. These methods are however arbitrary and are without any strong theoretical or empirical justification and can distort the results significantly, leading to inconsistent estimates (c.f. Flowerdew and Aitkin, 1982; Eichengreen and Irwin, 1998; Linders and Groot, 2006; Burger et al., 2009; Gomez-Herrera, 2013). In addition, Flowerdew and Aitkin[3] (1982) show that the results are sensitive to (small) differences in the constant substituted, which can cause serious distortion in the results. Eichengreen and Irwin (1998) noted that deleting these zero values led to loss of information as important information

[2]Frankel (1997) argued that these zero values arises as a result of lack of trade between countries, or from rounding errors when trade between countries does not reach a minimum value or can arise when they are rounded-down as zero, it can also results from measurement errors where observations are mistakenly recorded as zeros.

[3]They vary the substituted constant between 0.01 and 1 and found that the regression coefficient decreases with the size of the chosen constant.

on the zero trade levels is left out of the model and this can generate biased results if the zero trade flows are not randomly distributed; while Heckman (1979) and Helpman et. al., (2008) posit that omitting these zero trade observations can result into sample selection bias. The loss of information is said to reduce efficiency and omission of data produces biased estimates (Xiong and Beghin, 2011; Gomez-Herrera, 2012). In addition, Xiong and Beghin (2011) noted that deleting the zero trade observations prevents the possibility of exploring the extensive margin of trade – the creation of new bilateral trade relations, which implies that estimates are conditioned on trade that already took place – the intensive margin of trade. They concur that ignoring zeros limits the economic interpretation of the model as nothing can be said on the implication for new trade.

Likewise, Linder and Groot kicked against truncating and censoring and argued that zero trade observations may provide important information for understanding the bilateral trade patterns and therefore should not be eliminated a-priori. Disregarding the zero trade flows can bias the results if they do not randomly occur. This is because zero trade flows provide information about the probability to engage in bilateral trade. thus, if distance, low levels of GDP, the lack of historical or cultural links, etcetera makes trade to be non-profitable, thereby reducing trade or bringing about no trade, then eliminating zero flows from the analysis is tantamount to sample selection bias and applying OLS will lead to underestimating of the gravity equation coefficients (downward bias).

Therefore, in recent years, attention has been on the appropriateness of the estimation technique especially those relating to the problems of zero trade costs and logarithmic transformation of the gravity equation, and the constant emphasis on the inappropriateness of linear estimators in taking care of these two problems. Consequently, more appropriate estimation techniques are being increasingly employed to deal with these two issues in the context of gravity trade literature. The Tobit and Probit models, truncated regression, Poisson and modified Poisson models, Nonlinear Least Square (NLS), Feasible Generalized Least Square (FGLS) and the Helpman, Melitz and Rubinstein (2008) approach have all been used to deal with the problem associated with log normal formulation and the excessive zero valued trade flows.

Early studies have relied on the Tobit model to deal with the zero trade problems. For instance, the Tobit model has been employed by Rose (2004) and Andersen and Marcouiller (2002) to deal with the problem of zero valued trade flows that resulted either because the actual trade flows are not observable or due to measurement errors from rounding. The Tobit estimator is applied to fit the data when outcome/data are only observable over some range. It is applied in cases of measurement errors (e.g rounding up) or when actual outcomes cannot seem to reflect the desired outcomes. The Tobit censoring method involves rounding (censoring) part of the observation to zero or rounding up the zero trade flows below some positive value.

Nevertheless, (Linder and Groot, 2006) have debated on the appropriateness of using the Tobit model to the Tobit model to fit zero valued trade flows in a gravity model will depend on whether the desired trade could be negative or whether rounding up of trade flows is important. Their argument is that in the gravity model, the zero trade flows cannot be censored at zero as the desired trade cannot be negative in the gravity equation; this can only occur if the GDP of one or country pair is equal to zero which is unlikely in real life. They further argue that censoring at a positive value is not also appropriate. The intuition is that the UN COMTRADE database reports trade values, even for very small values (up to $1), indicating that rounding to zeros is not an important cause of zero observation as most zeros are caused by economic reasons such as lack of profitability. This implies that zero trade flows is likely to occur from binary decision making about the profitability of engaging in trade, and not from rounding up (censoring), thus the model might not be appropriate for taking care of zero trade flows. In addition, Frankel (1977) and Rose (2000) noted that the Tobit estimator involves an artificial censoring of positive albeit small trade values, however, the trade flow is subject to measurement errors, and they may have a high influence on the regression results.

Furthermore, Martin and Pham (2008) show that although both truncated OLS and censored Tobit model lead to bias results but the censored method generally produced much worse results in comparison to the truncated method, and suggested that Eaton and Tamura (1994) threshold Tobit model gives the lowest bias and outperform all other estimators in a simulation exercise. However, in contrast, in a simulation exercise, Santos Silva and Tenreyro (2011) found the Tobit model of Eaton and Tamura (1994) to have large bias, which increases with sample size, which also confirm its inconsistency as an estimator. Nevertheless, Head and Mayer (2013) recently propose the use of an alternative Tobit procedure that avoids the problem of selecting a value for small trade flows without any criteria. In particular, based on Eaton and Kortum (2001) they propose to replace the zeros by the minimum level of trade for a given *i* from all destination *j*, which we denote as $\underline{y}_{ij}$. To estimate the model, all the observed zeros in $y_{ij}$ (the dependent variable) are replaced with $\underline{y}_{ij}$ and the new bottom-coded $\ln y_{ij}$ is the dependent variable in a Tobit model that allows for a user-specified lower limit of $\ln \underline{y}_{ij}$. The EK Tobit, as this method is referred to by them, has two advantages. First, it does not require any exclusion restrictions and second, it is easily estimated using Stata's ***intreg*** command.

Attention has also been shifted to the use of the Poisson and the modified Poisson specifications of the gravity model. Santos Silva and Tenreyro (2006; 2011) used the Poission Psuedo Maximum Likelihood (PPML) method to deal with the zero valued trade flow and the logarithm transformation. According to them, in the presence of zero valued observations and also due to the logarithm transformation of the gravity equation, OLS (both truncated and censored OLS) are inconsistent and have very large bias which do not vanish as the sample size increase which confirm that they are inconsistent (Santos Silva and Tenreyro 2011). However, the PPML estimates the gravity equation in levels instead of taking its logarithms and this is said to avoid the problem posed by using OLS under logarithm transformation. According to them, this model is appropriate: first, the Poisson model takes account of observed heterogeneity. Second, the fixed effects PPML estimation technique gives a natural way to deal with zero valued trade flows because of its multiplicative form. Third, the method also avoids the under-prediction of large trade volumes and flows by generating estimates of trade flows and not the log of the trade flows. In their 2006 influential paper, they find the PPML estimator, which need not be does not need to be log-linearized, to be the best performing estimator that naturally deal with zero trade flows, consistent and gives the lowest bias among the other estimators. They therefore suggest it as the new workhorse for the estimation of the typical constant elasticity models, such as the gravity model.

However, their influential paper has however generated some controversies in the literature (c.f. Martinez-Zarzosoet al., 2007; Martin and Pham 2008; Burger et al., 2009; etcetera). For instance, Burger et al. (2009) identified some important limitations of the PPML model. They noted that the model is vulnerable to the problem of overdispersion in the dependent variable and excess zero flows. They posit that the model only takes account of observed heterogeneity and not unobserved ones and this is an important limitation of the PPML model. While an important condition of the PPML is the assumption of equi-dispersion (the conditional variance is equal to the conditional mean) in the dependent variable, however, due to the presence of unobserved heterogeneity which are not accounted for in the model, there is an over-dispersion in the trade flows (dependent variable). The over-dispersion is said to generate consistent but inefficient estimates of trade flow (Burger, et al. 2009; Turkson, 2010).

Contrary to Burger et al. (2009) who noted that the model is vulnerable to the problem of over-dispersion in the dependent variable and excess zero flows, which generate consistent but inefficient trade estimates, Santos Sliver and Tenreyro (2011), find that PPML is consistent and generally well-behaved even in the presence of overdispersion in the dependent variable (i.e. when the conditional variance is not equal to the conditional mean) and that the predominance of large proportion of zeros does not affect its performance. In addition, Soren and Bruemmer (2012) find that the PPML performs quite well under over-dispersion, and show that the PPML is well-behaved under bimodal distributed trade data. More recentlyHead and Mayer (2014) claim that a Multinomial Psuedo Maximum Likelihood (MPML) approach perform better in simulations than the PPML. Assuming that it is reasonable to assume that market shares, ($Y_{ij}/Y_j$),are an appropriate dependent variable for the gravity model, then, the Multinomial PML is the solution advanced by Eaton et al. (2012) for the case of finite numbers of firms. The Multinomial PML can be estimated by applying the ***'poisson'*** command to the market share variable $Y_{ij}/Y_j$, along with exporter and importers fixed effects(Head and Mayer, 2014).

Nonetheless, attempts have also been made to correct for the over-dispersion in the dependent variable and the vulnerability of the PPML to excessive zero flows using other estimation techniques apart from the PPML. These are the Negative Binomial Pseudo Maximum Likelihood (NBPML) and the Zero-inflated models which are Zero-inflated Pseudo Maximum Likelihood technique (ZIPML) and Zero-inflated Binomial Pseudo Maximum Likelihood technique (NIBPML) (Burger et al. 2009). They posit that the NBPML corrects for the overdispersion the estimator incorporates unobserved heterogeneity into the conditional mean and thus, takes care of unobserved heterogeneity. However, an important drawback of the NBPML and PPML relates to the excessive number of zero in the observation which means that the number of zero flows is greater than what the models predicts; where excessive zeros is said to be derived from the 'non-Poissoness'[4] of the model (Johnson and Kotz, 1969). Thus,

[4]Burger et al. (2009) identified that one important cause of non-Poissoness is when some zeros in the observation are produced by a different process compared to the remaining observations (including some other zeros)

Burger et al. (2009) posit that even though the Poisson model and the NBPML model can technically handle with zero flows, both models are however not well suited to handle cases where the number of observed zero valued trade flows is greater than the number of zeros predicted by the model.

They posit that the zero inflated models (ZIPPML and ZINBPML) perform better as correct for excess zeros and overdispersion in the dependent variable. They also noted that zero-inflated models has an added advantage as they theoretically well suited in modeling the origin of zero counts because the models account for two different types of zero trade flows, which are countries that have never trade (the non-poisson group), implying a data that strictly have zero counts; and countries that presently do not trade but potentially could, i.e. those that have a non-zero probability of having non-zero counts(the poisson group[5]). Thus, these models make allowances for the possibility to separate the probability to trade from trade volume as it provides additional information on the causes of the probability of the different kinds of zero valued flows. Given these, Turkson (2011) argued that the choice of the model to use will depend on whether the sample has excessive zero trade flow or not. However, Burger et al. (2009) posit that the Poisson model and the NBPML model are not well suited to handle cases where the number of observed zero valued trade flows is greater than the number of zeros predicted by the model.

Head and Mayer (2014) also finds that the PPML and Gamma PML remain consistent even under over-disperion and adviced that finding that the variance exceeds the mean does not justify the usage of the NBPML. This is because estimates obtained by NBPML method vary according to the dependent variable's units of measurement (Boulhol and Bosquet, 2012). For instance, they show that measuring trade in thousands of dollars instead of billions of dollars leads to large changes in the magnitude of the estimates and also reverses the signs obtained on some of the explanatory variables.

Contrary to Burger et al. (2009), Staub and Winkelmann (2012) also find that the PPML is consistent even when zeros are excessive. They also show that both ZIPPML and ZINBPML are inconsistent if the underlying assumptions of the distribution of model are violated, i.e. if

[5]The zero inflated models consider two different groups within the population: the poisson group and the non-poisson group. The non-poisson group are countries which have strict zero probability of trading but do not trade at all. The non-poisson zeros might be caused by lack of trade due to bans or other trade embargoes or simply the lack of resources. The poisson group consist of those countries with non-zero probability to trade and are actually trading, and countries that have non-zero probability to trade but however do not trade. The poisson zeros might be caused by huge distance or large differences in country pairs preferences and specialization.

the models are mis-specified. They instead recommend the use of zero inflated Poisson Quasi Likelihood (PQL) estimator which was shown to be consistent in the presence of excessive zeros and it is unaffected by unobserved heterogeneity and found to robust to mis-specification as it consistently estimate the regression coefficients irrespective of the true distribution of the counts while ZIPPML and ZINBPPML demonstrate considerable bias in medium sample. They also noted that the PQL can be less efficient compared to zero inflated estimators if the zero inflated model is correctly specified.

Similar to Burger et al., (2009), Martinez-Zarzoso (2013) also find out that the PPML estimator proposed by Santos Silva and Tenreyro (2006) is not always the best estimator as its estimates are outperformed by both the OLS and FGLS estimates in out of sample forecast. In addition, the PPML assumption regarding the pattern of heteroscedasticity is rejected by the data in most cases. However Santos Silva and Tenreyro (2008) responded by justifying the use of PPML as the best estimator in the context of gravity model, but also acknowledged that PPML estimator can be outperformed by other estimators in some cases.

Furthermore, Martinez-Zarzoso (2013) also finds the PPML to be outperformed by both the OLS and FGLS estimates in out of sample forecast and deduced that it is not always the best estimator. She findst hat PPML assumption regarding the pattern of heteroscedasticity is rejected by the data in most cases. She opined that even in the presence of unknown form of heteroscedasticity, FGLS can still be applied as FGLS is an efficient estimator within the class of least squared estimator, but the variance of the disturbances should then be re-estimated to correct for heteroscedasticity errors. They pointed out that FGLS is well suited to estimating parameters in the presence of heteroscedasticity, so, the comparison[6] of the best performing estimator should be between FGLS and the class of generalized linear models[7] (GLM) such as the Non-linear least square (NLS), Gamma Poisson Maximum Likelihood (GPML), and PPML. However Santos Silva and Tenreyro (2008) in their response, provided justification for the PPML estimator in the context of log linear gravity model, and acknowledged the fact that in some specific situations, the PPML estimator can be outperformed by other estimators.

Martinez-Zarzoso (2013)compares the performance of different estimators via a Monte Carlo simulation exercise and find that although PPML to be less affected by heteroscedasticity

[6]Santos Sliver and Tenreyro (2006) paper have majorly centred on comparing OLS to the class of GLS, particularly PPML
[7]Generalized linear models are class of multiplicative models.

compared to FGLS, NLS and GPML, nonetheless, its performance is found to be similar both in terms of bias and standard errors to the performance of the FGLS estimator, particularly for small sample size; with the lowest bias and standard errors found in the GPML in the simulations which has non-zero values in the dependent variable. Further empirical analysis using three different real datasets[8] reveal that the choice of the performance of the model is sensitive to the sample size; for small sample size, FGLS could be perfect way to deal with the heteroscedasticity problem, while the PPML will be appropriate when the sample size is large and there is measurement error in the dependent variable. However, for large sample size, PPML bias is found to decrease in large sample size while FGLS bias is found to remain almost constant. In addition, the PPML standard error falls considerably but it still remains twice the FGLS standard errors. Conclusively, Martinez-Zarzoso (2013) find that the choice of the best estimator is dependent on the specific dataset, and there is no generally best estimator for these three datasets; thus the appropriate estimator for any application is data specific which could be determined using a number of model selection tests.

Martin and Pham (2008) has also challenge Santos Sliver and Tenreyro (2006) findings and posit that although the PPML estimator is less subject to bias resulting from heteroscedasticity problem, however, it is not robust to the joint problems of zero trade flows and heteroscedasticity. Based on this, they conclude that the estimator could be appropriate for other multiplicative models[9] which have relatively few zero observations. They proposed that the Eaton and Tamura (1994) threshold Tobit model perform better than the PPML and other estimators considered as it recorded the smallest bias in a simulation exercise.

The Monte Carlo simulation done by Santos Silva and Tenreyro (2006), has also generated some debates. Although the authors find that the PPML is able to deal with zero trade flows, interestingly, their simulation done in order to determine the best performing model were without any zeros, except where the dependent variable was contaminated with measurement errors. This has made some studies to question the performance of the PPML in cases where there are excessive zeros in the dependent variable (c.f. Martinez et. al., 2007; Martinez-Zarzoso, 2013; Martin and Pham, 2008). Martin and Pham (2008) therefore used a data

[8]The 3 dataset consist of about 13%, 15%, 25% of zero trade values.

[9]For instance the Cobb-Douglas production function, the consumer-demand systems and the Stochastic impact by regression on population, affluence and technology, which is a popular model used in environmental economics.

generation process[10] different from that used by Santos Sliver and Tenreyro (2006), which include a high proportion of zero values and show PPML to be highly vulnerable to bias in the presence of high percentage of zero values in the dependent variable. Similar result has been found by Martinez-Zarzoso (2013). However these results have been challenged by Santos Silva and Tenreyro (2011).

In response to these studies, Santos Silva and Tenreyro (2011), argued that both of the simulations done by Martinez-Zarzoso et al., (2007); Martin and Pham (2008) and Martinez-Zarzoso (2013) reveal no information on the performance of the PPML model of constant elasticity model as the data used in their simulation exercises are not generated by a constant elasticity model. Santos Silva and Tenreyro (2011), however, further investigate the performance of the PPML estimator when the dependent variable has large percentage of zeros and when the data generating process is given by a constant elasticity model (both of which are typical in trade data used in gravity modeling). Similar to their 2006 findings, they also find the PPML estimator to be consistent and generally well-behaved in the presence of high proportion of zeros, and to be more robust to departures from the heteroscedasticity assumption (overdispersion); as its performance is not affected even with the overdispersion in the dependent variable and the presence of excessive zero values.

It is worth to notice however that the simulation results presented by Head and Mayer (2013) support the findings of Martinez-Zarzoso (2013) and indicate that the selection of the most appropriate estimation has to be made in accordance with the process generating the error term. They propose that other methods should be used along with the PPML ‘‘rather than selecting the Poisson PML as the single ‘workhorse’ estimator of the gravity equation’’ (Head and Mayer, 2013, p44). According to their simulations, under a Poisson-like error (the Poisson assumption of variance proportional to the mean), a Multinomial PML is preferred, whereas under the log-normal error (the normality assumption), the EK Tobit is the preferred estimator.

Among the class of the generalized linear models, the Gamma Pseudo Maximum Likelihood (GPML) technique has also been used in taking care of the zero trade values and associated problem of the logarithm transformation (c.f. Manny and Mullay, 2001). Similar to the log

[10] Santos Silva and Tenreyro (2006) used a data generating process that generates no zero values but only positive values. Martin and Pham adopted similar design to Santos Silva and Tenreyro (2006) Monte Carlo simulation but however modified it by including a threshold trade level that must be exceeded before positive trade levels are observed. Where the chosen threshold generates zero trade frequencies, which is similar to those observed in studies using aggregate trade flows.

linear model, the GMPL is said to be a more efficient estimator under the assumption that the conditional variance is a function of higher powers of the conditional mean, as it gives more weights to the conditional mean. Santos and Silva and Tenreyro (2011) found that the GPML is consistent and well behaved under Monte Carlo simulation in the presence of excessive zero values whose data generation process follows the constant elasticity model. However, it is found to have a larger bias than the PPML suggesting that the PPML the best performing estimator (c.f. Santos Sliver and Tenreyro, 2011). In addition, Martinez-Zarzoso (2013) noted that the GPML may also suffer from substantial loss of precision particularly if the variance function is mis-specified or if the log-scale residuals have high kurtosis.

Another class of the generalized linear model is the nonlinear least square (NLS) technique, which has also been used in the trade literature (c.f. Frankel and Wei, 1993) or used in comparison with other non-linear estimators (e.g. Santos Silva and Tenreyro 2006; Gomez-Herrera, 2012; Martinez-Zarzoso, 2013). Santos Silva and Tenreyro (2006) however show that although both GPML and NLS can be take care of these two problems, the PPML is still the preferred estimator as the NLS technique assign more weight to noisier observations, which reduces the efficiency of the estimator. This is because while PPML gives the same weights to all observations, and assumes that the conditional variance is proportional to the conditional mean, however, GPLM and NLS give more weights to observations with large mean. This is because the curvature of the conditional mean is more pronounced here, which are also generally observations with large variance, implying nosier observations In addition, *ibid* noted that the estimator can also be very inefficient because it generally ignores the heteroscedasticity in the data.

Another approach that is not considered in the simulation comparison by Head and Mayer (2014) is Heckman (1979) sample selection model[11] and it has also been frequently used in the literature. Noting that the standard practice of excluding zero bilateral trade observations can potentially give rise to sample selection bias, especially if the eliminated zeros are not randomly done, and estimating non-randomly selected sample is a specification error and can potentially bias the results. Heckman, therefore, developed a model that corrects for this sample selection bias which is a two-step statistical approach in which the model is estimated

[11] Heckmanmodel is also referred to as sample selection or Tobit II model. The model makes a selection of trading and non-trading country pairs – sample selection.

under the normality assumption. The first step of the Heckman model involves estimating an equation (Probit regression) for the probability of exporting at the firm level based on the decisions of the firms and then using it in estimating the volume of trade. Heckman (1979) correction model allows one to correct for selection bias in non-randomly selected samples and has also been frequently used in the gravity model trade literature to correct for problems relation to zero valued trade flows (c.f. Linder and Groot, 2006; Munasib andRoy, 2011). Linder and Groot, (2006) noted that sample selection model uses the information provided by the zero valued trade observations; thus, providing information on the underlying decision process regarding the zero trade flows, while arbitrary truncating and censoring are ad-hoc crude methods and they do not give accurate results compared to the sample selection model. They argued that unlike truncated OLS, without sound theoretical background, the samples election model is theoretically sound and offers an econometrically elegant solution to estimate gravity equation that includes zero trade flows.

However, in a methodological paper, Helpman, Melitz and Rubinstein (2008) (thereafter HMR), noted that the estimation of bilateral trade flows using the gravity equation is not only subjected to sample selection bias (if the non-zero exports do not occur randomly), but that estimates may also be vulnerable to omitted variable bias if the number of exporting firms within an industry (extensive margin of trade) is not accounted for. The idea is that due to trade costs, firms differ in productivity (firm heterogeneity) and only firms with productivity level beyond a threshold end up exporting.

HMR therefore extended Heckman (1979) procedure by controlling for both sample selection bias and firm heterogeneity bias and approached the zero issue by also developing a two-steps estimation procedure which exploits the non-random presence of zero trade flows in the aggregate bilateral trade data. The aim of the HMR two-step procedure is to correct both the sample selection bias resulting from eliminating zero trade flows when estimating the logarithmic form of the gravity equation and the bias caused by unobserved firm heterogeneity which result from omitted variable, which also measures the effect of the number of exporting firms (extensive margin). The first step involves estimating an equation (Probit regression) for the probability of exporting at the firm level based on the decisions of the firms and then using it in estimating the effects on the extensive margin of trade (the decision to export from country *i* to *j*). The second step is a gravity equation estimated in its logarithm form and involves using the predicted probabilities obtained in the first step to estimate the effects on the intensive margin of trade (the number of exporting firms from country *i* to *j*).

Helpman et al., (2008) posit that the excluded variable must not be correlated with the error term of the second stage equation but must be correlated with trade volume (the dependent variable). In addition, the excluded variable must be influence trade through fixed trade cost and not through variable trade cost because the latter impact on the extent of trade volume, and as such, is not uncorrelated with the second stage equation. However, Burger et al., (2009) noted that one important drawback of the Heckman (1979) and Helpman et al. (2008) models is that it is difficult to satisfy the exclusion restriction as the instrumental variable is most often difficult to find. Examples of exclusion variables used in the literature are common religion and common language variables (Helpman et al., 2008); governance indicators of regulatory quality (Shepotylo, 2009); historical frequency of positive trade between country pairs (Linder and de Groot, 2006; Haq et al., 2010 and Bouet et al., 2008). However, both Linder and de Groot (2006) and Haq et al., (2010) include the excluded variable in both equations and impose the normality of the error term in the two equations – an identification condition implying a zero covariance between both equations.

Notwithstanding the aforementioned advantages of the HMR model, some limitations have been identified regarding its application. Both the Heckman (1979) and the HMR trade flow equations are usually transformed to the logarithmic form before estimated and might cause biased coefficient (Haworth and Vincent, 1979; Santos Silva and Tenreyro. 2006). In addition, Santos Silva and Tenreyro (2009) and Flam and Nordström (2011) also show that HMR model does not control for heteroscedasticity which is usually pervasive in most trade data, but this can be done using available procedures. For instance, Santos Silva and Tenreyro (2009) show that the assumption of homoscedasticity[12] error term for all country pairs by the HMR's results in serious misspecifications as HMR does not control for heteroscedasticity, consequently casting doubts on the validity of inferences drawn from the model. They also pointed out that in contrast to models which can be made robust to the presence of heteroscedasticity, the consistency of the HMR model is only possible under the 'unrealistic' homoscedasticity assumption, which they identified as the most important drawback of the model as it is too strong to make it applicable or practicable to trade data in which heteroscedasticity is

[12]The Helpman et al., (2008) model hinges heavily on both the homoscedasticity and normality assumptions to be consistent.

pervasive. They therefore posit that the presence of heteroscedasticity in the data preclude the estimation of any model that purports to identify the effects of the covariates in the intensive and extensive margins, at least with the current econometric technology (Santos Silva and Tenreyro, 2009).

In sum, as noted in the review, each technique has its pros and cons and the 'workhorse' or best performing model for the estimation of the gravity equation still remains unclear as the consensus on a commonly accepted solution has not yet been reached. Therefore, given the pros and cons of each estimator, the determination of the best performing estimator (given our set of data application) remains an empirical issue.

### 3.2. Empirical Literature on Food Safety Standards

With the increasing role of food safety standards in as a non-tariff trade barrier, several studies have empirically investigated the impact of these standards on international trade, and more specifically on agri-food trade using both aggregated and disaggregated data. In most cases, gravity models are typically used in evaluating the empirical role that standards exert on trade flows. As previously identified, the estimated gravity model within the standard-trade literature might show scope for improvement especially in two areas: the econometric estimation technique and the proper specification of the model, especially given the peculiarities of the countries studied. Early studies on food standard-trade have estimated the standard log linear gravity model using OLS both with the occurrence and non-occurrence of zero trade flows. For instance, study by Otsuki et al. (2001a) (which is perhaps the most cited literature) which investigate the impact of a proposed 1998 EU stricter aflatoxin standard on African exports of groundnut products, have applied OLS estimation techniques and took care of zero trade flows data by adding one to them. The study found food safety standards to have a statistically significant negative impact. A significant negative trade impact was also found by Otsuki et al. (2001b) in their investigation of aflatoxin standards on world trade using OLS. This method is nonetheless said to suffer from deliberate measurement error (Winchester, et al., 2012). However, since the publication of these papers, there have been two main developments in the gravity modelling. The first is Anderson and van Wincoop (2003) theoretical paper which show that trade costs should be measured as multilateral trade costs in addition to the usual bilateral trade cost employed. The second and most important development is the issue of zero trade records and the proper estimation technique to tackle it and the problem posed by the logarithmic transformation of the gravity model (Santos Sliver and Tenreyro, 2006).

Various estimation techniques that incorporate zero trade record in the empirical analysis were therefore adopted. For instance, studies by Frahan and Vancautereen (2006), Fontagne, Mimouni and Pasteels (2006); went beyond the OLS technique and instead used the censored Tobit model with random effects in order to deal with the zero trade flows. The former find a positive trade effects of standard on agricultural food products while the later study found negative trade effects in agricultural products and positive trade effects in manufacturing and processed agricultural sectors. However, the Heckman model were employed by Chevassus-Lozza et al. (2008), Jayasinghe et al. (2009), Vigani et al. (2010), Disdier and Marette (2010) to tackle the selection bias resulting from eliminating the non-random occurring zero trade flows from the trade matrix. These studies find negative impact of standards on trade except for Vigani et al. (2010) which find a mixed effect. Other studies have taken advantages of the availability of panel data and employed either the random or fixed effect model or both (c.f. Disdier et al., 2008; Jonguanish, 2009; Melo et al., 2012; etc) where the model is log linearized, with the zero trade flows truncated or deliberately deleted.

However, following Santos Sliver and Tenreyro (2006) proposition that the PPML model is best suited to in dealing with the presence of zero trade flows observations and heteroscedasticity inherent in trade data, studies by Disdier and Fontagne, (2010), Wilson and Bray (2010), Gerrais et al. (2011), Shepherd and Wilson (2013), have applied the PPML to investigate the impact of standards on trade flows and to deal specifically with the presence of zero trade flows observations. While the first two studies found a negative impact on trade using PPML, the last two however found mixed effects depending on the standards considered.

There are also a few studies which compare different estimation techniques in the presence of zero trade flows (c.f. Drogue and DeMaria, 2010; Xiong and Beghin, 2011) to determine the best performing estimator. However, these studies compare only few of the estimators and chose the best performing model within these limited models considered. Drogue and DeMaria (2011) considered between 3 estimation methods (OLS, PPML and ZINB) but relied on the ZINB model as providing the best fit and parsimonious specification among the models. Estimating their gravity equation with country-pairs and time fixed effects, they find negative impact of dissimilarity in standards on trade and vice versa. Similarly, included country-pairs and time fixed effects, Xiong and Beghin (2011) ecompared between 5 estimation techniques to investigate the impact of standards on the extensive and intensive margins of trade across 3 groundnuts products. Based on some diagnostic tests, their preferred models are ZINB and Heckman models in order of preference. They find similar results for both the Helpman and ZINB estimation techniques. For these two models they find no significant impact of standards on shelled groundnut and groundnut oil exports but positive impact on edible groundnuts exports. Similarly, Drogue and Demaria (2010) also obtained similar when different estimators (Hurdle, Heckman, and ZIP) were considered, indicating that the results are insensitive to the estimation used.

An important limitation of many of these studies lie in the in the invariability of their measure of standards, which makes the identification of the impact difficult. Drogue and DeMaria (2010) measure of standard is the dis(similarity) between the maximum residual limits (MRL) of pesticides in force in country *i* and *j* in force between 2000 and 2009 and it is time invariant as they are reported to be the same over this period. Xiong and Beghin (2011), however used MRL on aflatoxin B1 imposed by each importer in each year. This measure is not bilateral in nature as it is the same measure faced by all trading partners without regards to the origin (*i*). However, Head and Mayer (2014) noted that variables that affect imports (exports) without regards to the country of origin can no longer be identified[13] in a gravity equation setting estimated with exporter and importer fixed effects.

Thus, our approach of measuring standards will be devour of this identified limitation as our measurement is constructed to ensure variability over time and between country *i* and *j*, as would be shown in the proceeding session. In addition, our study departs from previous studies which only consider a few estimation techniques, our analysis is wider in scope and more encompassing as we include a wide coverage of estimation techniques in order to objectively identify the most suitable estimator for our data.

## 4 DATA AND CONSTRUCTING STANDARDS

We collated EU food safety standards by matching the total number of standards in each year against the appropriate standard international trade classification (SITC). A standard is said to be in force in a particular year if it was published in that year or published prior to the year considered but it still exists or has not been withdrawn. Amendments to existing standards are treated as additional standards and all draft standards are excluded from our dataset (see also

[13] As a solution, they proposed that the trade impact can be identified by dropping one or more of the country dummies, or by creating new dyadic bilateral variables which have straightforward interpretation. See Head and Mayer (2013) for other factors that cannot also be identified, and possible solutions to this.

Shepherd and Wilson, 2013). Likewise standards which denotes 'terminology' or vocabulary' of a products are deem not to be substantive and are also excluded. We have differentiated between two standards: the EU standards defined as those developed and adopted by all EU Member State, and international standards which we define by the Codex Alimentarius Commission, (hereafter Codex). The latter are those developed jointly by the Food and Agriculture Organization (FAO) and World Health Organization (WHO). Data on food safety standards on fish was obtained from Perinorm[14] database, a rich and subscription-based database that house different types of standards collated over the years. We collate all EU mandatory standards in force over the period of 2007 to 2012 by mapping each standard to a standard trade classification (ICS 2007).

### 4.1 Constructing Protectionism Indices of Standards

To avoid using standard as a protectionist tool, the WTO obliged its members to employ internationally scientific based standards such as the Codex's standards whenever it is possible[15]. We define protectionism as the fraction of a country's standards that is more stringent than the standards internationally recognized by the WTO. Thus, our measure of protectionism is constructed by measuring the differences in EU standard against an international benchmark. We employ Codex standards as the 'non-protectionist' scientifically based benchmark. Following Li and Beghin (2013), we developed a simple criterion of protectionism: EU standards that exceed those set by Codex are taken to be protectionist, while those that are laxer than Codex's is defined to be anti-protectionist. Our trade weighted product level protectionism indices for fish standard is given as:

$$P_{ijt} = \frac{Codex_{std_t} - EU_{std_t}}{100} w_{ijt} \qquad (1)$$

Where $P_{ijt}$ measures the extent of protectionism of EU fish standard imposed by a given importer on country *i* exports at time *t*; $EU_{std_t}$ denotes the EU fish standards at time t; $Codex_{std_t}$ is the international codex standard in fish at time *t*. $w_{ijt}$ is the weight[16] of the import value of

[14]Perinorm is a subscription-only database covering standards on 22 countries including those set by international bodies such as CODEX, ISO and CEN.

[15] However, the WTO also allows it members to use precautionary principle by setting their own appropriate level of protection different from international one, in as long as their national standards are non-discriminatory, have scientific backings and least trade restrictive (WTO SPS agreement).

[16] Ideally, for a given country weights should reflect the dead-weight loss of the product aggregated over all products. Unfortunately, data dead-weight loss are not readily available, thus, we instead substitute import value.

fish (the product affected by standards) in world imports in fish. More specifically, $w_{ijt}$ is given as:

$$w_{ijt} = {IM_{ijt}}\Big/{IM_t} \qquad (2)$$

$IM_{ijt}$ is the share of bilateral fish import values from country *j* to *i* in a given year, and $IM_t$ is world fish imports in the corresponding year. $w_{ijt}$ also known as the import coverage ratio is a popular way of calculating trade weighted standard measure in the literature (see Disdier, Fontagne and Mimouni (2008), de Frahan and Vancauteren, 2006; etc). While the first part of the measure $(Codex_{std_t} - EU_{std_t})$ covers the stringency of the standard, the second part $(w_{ijt})$ is similar to the coverage ratio and captures the extent of trade covered by standard. More specifically, the coverage ratio of standard in any country *i* in a particular year is the share of bilateral import values from country *j* to *i* in the affected product in a given year in total world exports in the affected product that year. Thus our measure of standards introduces variability across importers, exporters and time.

Equation (1) results into indices that are lower and upper bounded, negative values indicate protectionism while positive values are indicative of anti-protection, and zero values implies neutrality of standards between EU and Codex. The higher the deviation of EU standards from international codex, the more negative the index becomes and vice versa. The lower the index is (i.e. the more negative it is), the higher its stringency, and the harder it becomes to comply with for exporters.

## 5.0. METHODOLOGY

In line with the gravity model, the volume of bilateral trade flow between any trading country-pairs can be represented in either the multiplicative or logarithmic forms. Our objective is to investigate the impact of standards on African exports. We did this by focusing on the fish and fishery products. This is based on the premise that these products attracts a relatively significant number of standards than other products due to their highly perishability nature. In addition, available evidence show that they products are the most often rejected export product of Africa at the EU border, resulting in a case of about 70% rejection of all African food exports refused entry into the EU due to not meeting the required EU food safety standards.

Thus, we proceed by investigating if indeed these EU standards are overly stringent to the extent of being protectionist using a variety of estimation techniques.

### 5.1 Model Specification and Estimation Techniques

We begin with the following gravity equation and for the sake of comparison and completeness, we adopt the Anderson and van Wincoop (2003) equation as our preferred model. This is specified in log linear form as:

$$\begin{aligned}\ln y_{ijt} &= \beta_0 + \beta_1 \ln GDP_{it} + \beta_2 \ln GDP_{jt} + \beta_3 S_{jt} + \beta_4 \ln Dist_{ij} + \beta_5 Lang_{ij} \\ &+ \beta_6 Col_{ij} + \beta_7 \ln Llock_{ij} + \beta_8 RTA_{ij} + \varepsilon_{ijt}\end{aligned} \quad (3)$$

Where ln denotes the natural logarithms of the variables; *i* and *j* are exporter and importer subscripts respectively while t denotes time period; $y_{ijt}$ is exports value from country *i* to country *j* in time *t* in current US dollars, obtained from United Nations COMTRADE database at the SITC Revision 1 product code[17]; $GDP_{it}$ and $GDP_{jt}$ are respectively is the gross domestic products of countries *i* and *j* in time *t* in current US dollars, sourced from the World Bank. $S_{jt}$ denotes European Union food safety standards on fish products, which can be otherwise called a non-tariff barrier and it is the main variable of interest in this study. This variable is obtained from the Perinorm database. $Dist_{ij}$ is the geographical distance between the major cities of countries *i* and *j*. $Lang_{ij}$ $Col_{ij}$ $Llock_{ij}$ $RTA_{ij}$ respectively are dummies that take the value of 1 when countries *i* and *j* speak the same official language; when countries *i* had been colonized by country j in the past; when at least one of the country-pair is a landlocked countries; when trading countries belong to similar trade agreement; zero otherwise and $\varepsilon_{ijt}$ is the disturbance term. Data on distance, language, colony landlocked were obtained from the Centre d'Etudes Prospectives et d'Informations Internationales (CEPII) database, while data used to construct the regional agreement dummy comes from the World Trade Organisation.

[17]SITC Revision 1 code 0444 is used as the product categories for fish, crusteacean, mollusc and other invertebrates.

Our dataset covers bilateral trade on fish exports between the 27 European Union countries and 40 African countries between 2007 and 2012 and this gives a balanced panel dataset of 6480 observations. A list of countries included in the analysis is available in Table A2 in the appendix. The choice of our period of analysis is hinge on two factors. First, analysis from 2007 enables us to include all the existing 27 EU countries who have adopted the harmonised EU standards. Second, this period is an important period in which food safety standards were standardized. Third, the period also capture the period of the global financial crisis, which it is posited that the EU region tightened its non-tariff barrier, become and restrict market access in response to the financial crisis (Bussière, et al., 2011). In particular, it was speculated that standards becomes more protectionist in nature during this period, thus, our focus on this time period.

We control for MRT using the Baier and Bergstrand (2010) Taylor series approach. Baier and Bergstrand first order log linear Taylor series approximation of Anderson and van Wincoop's nonlinear systems of price equation also give rise to theoretically motivated MRT (Head and Mayer, 2014). We apply a first order Taylor expansion to the trade costs variables and then used the newly transformed variables in the regression. Simple averages weights (1/N) are used in their construction as shown in Baier and Bergstrand (2010). With symmetric but non-zero trade costs, the first order Taylor series approximation of the gravity model for panel data in log form is given as:

$$\ln y_{ijt} = \ln GDP_{it} + \ln GDP_{jt} - (\sigma - 1)\ln t_{ijt} + (\sigma - 1)\left[\frac{1}{N}\right]\sum_{j=1}^{N}\ln t_{ijt} - \frac{1}{2}\frac{1}{N^2}\sum_{i=1}^{N}\sum_{j=1}^{N}\ln t_{ijt} + (\sigma - 1)\left[\frac{1}{N}\sum_{i=1}^{N}\ln t_{jit} - \frac{1}{2}\frac{1}{N^2}\sum_{i=1}^{N}\sum_{j=1}^{N}\ln t_{jit}\right] \quad (4)$$

In equation (4), $t_{ij}$ refers to any of the bilateral trade cost variables associated the coefficients of B3 to B8 in equation (3). In our case, these are food safety standards, distance, common language, colony landlocked and RTA. The first term on the right hand side is the simple average of gross trade cost costs facing exporter *i* across all importer *j*. The second term on the right hand side denotes the simple average of all trade costs faced by importer *j* across all exporters *i*. Using distance variable as an example), each bilateral trade cost variables are transformed using the following approximation:

$$\ln Dist_{MRTij} = \ln Dist_{ij} - \frac{1}{N}\sum_{j=1}^{N}\ln Dist_{ij} - \frac{1}{2}\frac{1}{N^2}\sum_{i=1}^{N_r}\sum_{j=1}^{N}\ln Dist_{ij} \tag{5}$$

The transformed variable $\ln dist_{ijMRT}$ is defined as exporter and importer time fixed effects, and similar definition holds for the other trade costs. Using the definition given by equation (5) gives the transformed log linear model in equation (4) to one which fully accounts for the influence of MTR:

$$\begin{aligned}\ln y_{ijt} &= \beta_0 + \beta_1 \ln GDP_{it} + \beta_2 \ln GDP_{jt} - (\sigma-1)\beta_3 S_{jtMRT} - (\sigma-1)\beta_4 \ln Dist_{ijMRT} - \\ &(\sigma-1)\beta_5 Lang_{ijMRT} - (\sigma-1)\beta_6 Col_{ijMRT} - (\sigma-1)\beta_7 Llock_{ijMRT} - (\sigma-1)\beta_8 RTA - RTA_{itMRT} + \varepsilon_{ijt}\end{aligned} \tag{6}$$

The list of the variables considered in the analysis and the summary statistics are displayed in Table A3 in the appendix.

### 5.2 Estimation Techniques

There are some unique features of our data which is worth mentioning. About 63% of the bilateral trade flows between these trading countries are zeros. While some of these zeros may be due to statistical zeros such as rounding up or incompleteness of UN COMTRADE database, but majority of the zeros are more likely to be a result of African exporters' inability to trade due to some prohibitive fixed cost they have to bear in establishing trade partnership with the EU countries. One of these prohibitive fixed costs is compliance costs of meeting the food safety standards set by the EU. Due to firm heterogeneity, firms vary by productivity, such that only the more productive firms will find it profitable to export to the EU after adding the huge cost of complying with EU standards to its cost of production. However, not all firms will find it profitably, this gives rise to positive trade flows when country-pairs trade or and zero trade flows if two country pairs do not trade in a given year. Thus, the high frequency of zeros in our dependent variable demands the use of an appropriate method that would allow for consistent estimates. To account for the presence of zeros in the dependent variable, two major set of estimation techniques have been widely used. These are the linear models and non-linear models. A brief overview of the major estimation techniques that have been used in the literature is provided below.

### 5.2.1 Log-Linear Models

We employ six of the most important linear[18] methods in estimating equation (6). The first method we employed is the truncated pooled OLS. Although the technique can sometimes be applied to panel data, it would only give precise estimators and strong test statistics if the relationship between the dependent variable and the regressors remain constant over time. Following the early practice in the literature, we took the logarithm of the dependent variable in which case all zero observations are lost as the log of zero is simply impossible. In addition, we took advantage of the panel framework to control for unobserved heterogeneity using panel data estimators, which are the two traditional panel data model - fixed and random effects models. In addition, we have also employed the Feasible Generalized Least Square (FGLS) panel estimator technique. It corrects for heteroscedastic error structure across panels and the presence of autocorrelation with panels as well as cross sectional correlations. This method has been found by Martinez-Zarzoso (2013) to be an efficient estimator within the class of least squared estimator in the presence of unknown form of heteroscedasticity. Similar to Porojan (2001) who attempted to deal separately with heteroskedasticity problem, Martinez-Zarzoso (2013) posited that that FGLS method is also a perfect way to deal separately with the heteroscedasticity inherent in trade data. For instance, in a Monte Carlo simulation exercise, she show that its estimates outperformed other linear and non-linear estimators in out of sample forecast using datasets in which zeros are pervasive.

We also employed the two variants of the Tobit model which has also been frequently used to deal with the zero trade problems that resulted from actual zero trade between country-pairs; a level of trade below some threshold; or a choice by the exporter to report only data aggregated over several sources. The first is the Eaton and Tamura (1994) threshold Tobit model, referred to as 'ET Tobit'. As commonly practice in the literature, we also replaced all the zeros in the dependent variable by one before taking the log. The method defines an observable dependent variable $y_{ijt}$, a strictly positive latent variable $y_{ijt}^{*}$ and a threshold of zero, in such a way that the observed dependent variable is said to equal the latent variable when the latent variable is greater than zero, and zero, otherwise. The model which is expressed in terms of the latent variable is specified as follows.

[18] Although the sample selection models are also used to deal with zeros, however we did not consider them here. The reason is because they are designed to estimate an entirely different set of parameters in contrast to the other approaches which give estimates that combine both the intensive and extensive margins of trade (Head and Mayer, 2014).

$$y_{ijt} = 0 \text{ if } y^*_{ijt} \leq 0 \text{ or} \tag{7}$$

$$y_{ijt} = y^*_{ijt} \text{ if } y^*_{ijt} > 0 \tag{8}$$

Secondly, there is an alternative Tobit procedure by Eaton and Kortum (2001) which was proposed by Head and Mayer (2015) which avoids the problem of replacing the zero trade flows with a small constant without any criteria. In particular, following Eaton and Kortum (2001), they propose to replace the zeros by the minimum level of trade for a given *i* from all destination *j*, which we denote as $\underline{y}_{ij}$. For each exporter *i*, the bilateral zero trade flow $y_{ij}$ (the dependent variable) is replaced by the minimum trade flow value $\underline{y}_{ij}$ taken over all destination country *j* appearing in the data. The new dependent variable is then plugged into equation (7) and then estimated as a Tobit model. EK Tobit, as this method is referred to by Head and Mayer, has the three advantages. First it does not require exclusion restrictions; second, it has a sound structural interpretation and; third, it can easily be estimated in Stata with the *xtintreg* command (Head and Mayer, 2014).

### 5.1.2 Non-linear Methods

Furthermore, we also estimated equation (6) with the dependent variable in levels instead of taking its logarithms using two alternative non-linear methods. Firstly, we used the PPML estimator proposed by Santos Silva and Tenreyro (2006; 2011) in dealing with the zero valued trade flow. According to them, in the presence of zero valued observations and also due to the logarithm transformation of the gravity equation, OLS and other linear models are inconsistent. According to them, this model is appropriate because: first, the Poisson model takes account of observed heterogeneity. Second, the fixed effects PPML estimation technique gives a natural way to deal with zero valued trade flows because of its multiplicative form. Third, the method also avoids the under-prediction of large trade volumes and flows by generating estimates of trade flows and not the log of the trade flows. In addition, they find the PPML estimator to be the best performing estimator that naturally deals with zero trade flows, consistent and gives the lowest bias among other linear and non-linear estimators.

Secondly, we alternatively employed the Multinomial Poisson Pseudo Maximum Likelihood (MPPML) model to deal appropriately with the occurrence of zero or missing trade (c.f. Eaton et al, 2012; Head and Mayer, 2014). Assuming that market shares are appropriate dependent variable in our gravity equation, thus for a finite number of firms, the dependent variable then takes the form:

$$\pi_{ij} = \frac{y_{ij}}{y_j} \tag{9}$$

Where $\pi_{ij}$ represents country *i* market share in *j*; $x_{ij}$ is the exports of fish to country *j* from country *i*; $x_j$ is world exports of fish to country *j*. Since the sum of $\pi_{ij}$ sums up to me across all destinations *i* (for any *j*), the gravity variables can thus be estimated using the multinomial pseudo maximum likelihood estimator. This is the estimation technique advanced by Eaton et al., (2012) for the case of a finite number of buyers and sellers and also used by Head and Mayer (2014) in their study. One advantage of the MPML is that it is closer to the PPML approach as the estimator also tackles the zero problems. Furthermore, as proved by Sebastian Sotelo in his unpublished notes, the model is easily estimated in Stata by applying the *poisson* command to the market share variable $y_{ij} / y_j$ (see Head and Mayer, 2013). Eaton et al, 2012 in a footnote highlights the properties of this model as distinct from the log linear and PPML models. Their distinction is in terms of the penalties (weights) they give to deviations in large and small trade flows. The log linear approach treats proportional deviations as equally likely across large and small trade flows; while PPML assigns a greater penalty to proportional deviations in large trade flows than in small trade flows. However, MPML normalizes bilateral trade flows by the importers' total trade absorption, (it gives less importance to large levels of trade and shares prevents the dependent variable from obtaining values over one), it thereby eliminates different penalties for proportional deviations in the large and small trade flows.

# 6.0 RESULTS AND DISCUSSION

To give more insight into the estimation techniques, first we start by checking their adequacy using some robustness tests before placing policy emphasis on them.

### 6.1 Robustness Checks

In other to consistently estimate the trade impacts of EU fish standards, our approach is to investigate how zero values in the dependent variable affect the performance of our estimators. The preferred estimator depends on the assumptions about how the conditional variance of the dependent variable relates to its expected value.In particular, firstly, we are interested in determining the efficient estimator which is able to accommodate a dependent variable in which zeros are frequent. Secondly, we are interested in investigating if the structure and assumption about the structure of the error term of each estimator holds in the presence of zero trade flows. In other words, we are interested in if the patterns of heteroscedasticity assumed by the various estimators are acceptable. Given the estimators considered in this study, the pattern of heteroscedasticity assumed by the models is either the Constant Coefficient of Variance (CCV) assumption or the Constant Variance to Mean Ratio (CVMR) type of heteroscedasticity (c.f. Head and Mayer, 2014). On the one hand, the log linear model has log normal errors with constant variance (homoscedasticity assumption) and exhibits CCV pattern of heteroscedasticity. That is, its standard deviation is assumed to be proportional to its mean - the CCV heteroscedasticity type. On the other hand, the two non-linear models considered in this study - PPML and MPML have the CVMR heteroscedasticity type of pattern where it is assumed that their means are proportional to their variances.

Following Santos Silva and Tenreyro (2006) and Martinez-Zarzoso (2013), comparison of the performances of the various estimation techniques are based on the MaMu test also known as Park test. This Park-type test (Park, 1966) is used to check for the adequacy of the log linear model versus the GLM models as well as to determine the pattern of heteroscedasticity assumed by the estimators. In addition, the Ramsey Reset test (Ramsey, 1969) is also used to check for the adequacy and misspecification of all the estimators. Lastly, the performances among the estimators are checked using AIC and BIC.

First, we proceed by determining if the patterns of heteroscedasticity assumed by the estimators are accepted. This we did by checking if the variance functions assumed by the estimators are consistent with their properties. The general form of the variance function of the GLM and log-linear model is given as

$$v(y \mid x) = k(\mu(y\beta))^{\lambda} \qquad (10)$$

where $\lambda$ is non-negative and finite and its value determines the difference between log-linear and non-linear models. For instance, for values of $\lambda_1 = 1$, we obtain the Poisson model; when $\lambda_1 = 2$, we obtain the log-linear estimators. The more efficient estimator now depends on the assumption about how its variance relates to its mean. On the one hand, the log linear model have CCV pattern of heteroscedasticity with a data generating process that satisfies $\lambda_1 = 2$. This holds if its standard deviation is proportional to its mean. On the other hand, PPML and MPML have the CVMR heteroscedasticity type of pattern – i.e. heteroscedasticity *a la* Poisson, with $\lambda_1 = 1$ assumed.

Given the above variance function, Manning and, Mullaby, (2001) suggest that the choice of the appropriate estimator could be based on a Park-type regression – a test statistic to diagnose the error term and determine the pattern of heteroscedasticity assumed by the estimators. It is a reliable method of distinguishing between the log-normal data generating process and the CVMR data generating process (Head and Mayer, 2014). The test consists of estimating the following equation which can be directly derived from equation (10). This is specified as:

$$\ln(y_i - \hat{y}_i)^2 = \ln(\lambda_0) + \lambda_1 \ln \hat{y}_i + \mu_i \qquad (11)$$

Based on a non-robust covariance estimator, the null hypothesis is that Ho: $\lambda_1 = 2$ (that the model is a log-linear one) is tested against the alternative that it is not. The hypothesis is accepted if the appropriate confidence interval for $\lambda_1$ contains 2. Acceptance of this null hypothesis would be in favour of log linear model. However, because logarithmic transformation of equation (11) is only valid under restricted conditions of the conditional distribution of the dependent variable, Manning and Mullahy, (2001) therefore suggested to estimate modified version of the Park regression a more robust alternative as:

$$(y_i - \hat{y}_i)^2 = \lambda_0 (\hat{y}_i)^{\lambda_i} + \eta_i \qquad (12)$$

We estimated equation (12) using the appropriate non-linear estimator based on the Eicker-White robust covariance matrix estimator. Here, the dependent variable now is $(y_i - \hat{y}_i)^2$ while the regressors are $x\beta$ from each of the non-linear estimators of y on x. Manning and Mullahy (2001) 'straightforward approach' gives a confidence interval for $\lambda_1$. The null hypothesis that $H_o : \lambda_1 = 1$ is tested against the alternative that it is not. The hypothesis is accepted if the appropriate confidence interval for $\lambda_1$ contains 1 and or if the rho value of) the hypothesis test result is not statistically different from zero.

The result of the Park test is presented in Table 1. We report both the confidence interval of the (park) test and the rho values gotten from the test of the hypotheses both of which check whether the pattern of heteroscedasticity assumed by each models is appropriate. Out of all the estimators, only the MPML model passed the test which suggests that the other models are inadequate given the dataset considered. In the case of the MPML estimator, first, the p-value of the statistical test of the hypothesis indicates that the estimated coefficients on $\lambda_1 = 1$ is statistically insignificantly different from zero at the 5% conventional significance level (see column 2 in Table 3). Second, as shown in column 3 of Table 1, the estimated 95% confidence interval of the coefficient on $\lambda_1$ contains the value of 1, (-2.139, 2.202). Thus, based on these evidence, the null hypothesis that $\lambda_1 = 1$ could not be rejected. This result is in favour of MPML and implies that the Poisson proportionality assumption of the conditional mean being equal to the conditional variance cannot be rejected at the 5% significance level, thus reinforcing that the multinomial poisson distribution is appropriate. Our result is in line with that of Head and Mayer (2014) who find that the selection of the most appropriate estimator to be contingent on the process generating the error term and whose simulation results reveal that that the MPML estimator is preferable under a Poisson-like error where a constant variance to mean ratio is assumed.

**Table 1: Testing for the Pattern of Heteroscedasticity**

| Estimator | Park Test (P-value) | 95% Confidence Interval | |
|---|---|---|---|
| Trun OLS | 0.000 | -0.198 | 0.178 |
| FGLS | 0.000 | -0.360 | 0.032 |
| FE | 0.000 | 2.773 | 6.169 |
| RE | 0.000 | -0.275 | 0.052 |
| ET Tobit | 0.000 | - 0.642 | 0.877 |
| EK Tobit | 0.000 | -0.445 | -0.177 |
| PPML | 0.000 | 2.497 | 4.782 |
| MPML | 0.382 | -2.139 | 2.202 |

Note: For the log linear estimator, the Park-type test that $\lambda_i = 1$ were based on a non-robust covariance estimator. Whereas, for both PPML and MPML , modified park test testing that $\lambda_i = 2$ were based on a robust covariance estimator.

In contrast, PPML and all the log linear estimators did not pass the Park test. More specifically, the confidence interval of the Park test for PPML did not contain 1, and the p-value of the hypothesis of the test is statistically significantly, thus, the null hypothesis that $\lambda_1 = 1$ is unequivocally rejected. This result show that PPML is inefficient as the poisson-like heteroscedasticity type was not satisfied for this estimator. Similarly, none of the confidence interval of the entire log linear estimators contain the value of 2. Furthermore, for all the log linear models, the p-value of the hypothesis of the tests are statistically significantly, thus their null hypotheses that $\lambda_1 = 2$ were outrightly rejected. These results are indications that all the log linear estimators exhibit worse case performance.

Secondly, we also used the heteroscedasticity-robust Ramsey Reset Test (Ramsey, 1969) to check the adequacy of all the estimated models. In essence, it is a test of the functional form of the model and checks if the conditional expectations are correctly specified. The test is performed by checking the significance of an additionally constructed regressor specified as $(x'b)^2$, where $b$ is the vector of the estimated the parameters. The null hypothesis is that the coefficient on the test variable is zero or insignificant. The probability values of the test are provided in the second column of Table 2. The test reveal a statistically significant pvalue for MPML estimator signifying that the estimator passed the functional form test. This points to the appropriateness of the MPML estimator for our dataset. Similar results are evidenced for truncated OLS, FGLS, fixed effects and PPML estimators. However, random effects model, ET Tobit and EK Tobit models did not pass the test as the test reject the null hypothesis that the coefficients of their test statistics are significantly different from zero.

**Table 2: Ramsey Reset and Information Criterion Tests**

| **Estimators** | ***Ramsey Reset Test*** | **AIC** | ***BIC*** |
|---|---|---|---|
| Pooled OLS | 0.646 | 10551.544 | 10608.451l |
| FGLS | 0.152 | .. | .. |
| Fixed Effects | 0.282 | 5433.016 | 5460.685 |
| Random Effects | 0.014 | .. | .. |
| ET Tobit | 0.012 | 12595.81 | 12670.35 |
| EK Tobit | 0.033 | 16010.19 | 16084.73 |
| PPML | 0.222 | 2.09e+06 | 2.09e+06 |
| MPML | 0.137 | 2709.765 | 2777.530 |

Note: (..) implies not available after for the estimator.

Thirdly, the performance of the log linear estimators and GLM are also tested using the Akaike information criterion (AIC) and the Bayesian information criterion (BIC). However, the results for the log linear and non-linear estimators are not directly comparable due to the differences in the number of observations and differences in the specification of the dependent variables of the estimators. The results are presented at the last two columns of Table 2. Among the log linear estimator, the FGLS model presents the lowest AIC and BIC values, while MPML model presents the lowest AIC and BIC results among the GLM estimators, once again reinforcing its appropriateness and adequacy.

Overall, first, for this particular African dataset, we find evidence that the underlying data generating process follows a CVMR heteroscedasticity type, which indicate a strong support for the MPML estimator. Second, there is no evidence of its functional form misspecification based on the Ramsey Reset test. Third, among its class of estimator, it presents a lower AIC and BIC statistics. Therefore, as pointed out by these robust checks points, the prediction of the MPLM technique is rather very good for our kind of dataset which is characterized by very low trade values and many zeros.

**6.2 Estimated Results**

The results determining if EU standards have protectionism intent are presented in Table 3.The dependent variable for the log linear models is the logarithm of exports and for the PPML and MPML models, the dependent variables are respectively exports and export share in levels. As a first step, we detected the presence autocorrelation in our data. Thus, we estimated both the fixed and random effects models with the *"xtregar"* command in Stata. In addition, in the FGLS model, we chose the options that corrects for both panel heteroscedasticity and autocorrelation of order one within panel. All other models were estimated using cluster robust standard errors.

First we make a brief comparison of all models and thereafter emphasize the policy implications of our preferred model. For all models, the coefficients on the income elasticities of exporters' GDP are far below the theoretical value of 1. Exception to this is the EK Tobit model whose coefficient is about 1.5.  However, there have been justifications for the coefficients on exporter and importers' elasticities of income to fall below or above one in the literature (c.f. Rahman, 2009).  Furthermore, the coefficients are insignificant when the gravity equation is estimated by PPML and fixed effect models. However, most of the coefficients on importers' income elasticities are closer to the theoretical value of 1. All the coefficients are also statistically significant except for the PPML and fixed effect models.

More importantly, concerning EU fish standards, our protectionism indicator shows all models including our preferred estimator (MPML) have insignificant negative effect on African export at least at the 5% conventional significance level. Exceptions to the above result are the ET and EK Tobit models whose coefficients turn out to be positively significant indicating that EU fish regulations are less restrictive than those regulated by Codex. However, these latter results are unreliable as the preliminary robustness checks indicate that both models are inconsistent and thus could not be relied on.

The insignificant result as shown by the MPML model is indicative of the fact that EU fish standards in relation to the ones imposed by Codex Alimentarious are not protectionist in nature. Although, the EU have been constantly inhibiting some non-complying African fish exports from entering its borders, the insignificant coefficient indicates that EU regulation is in line with those specified by Codex, such that we can conclude that EU standards have no protectionist intent. This indicates that these regulations are aimed solely to address legitimate concerns for human health and safety and does not necessarily address protectionist concerns. Thus, the inability of African fish exporters to comply with EU standards and the consequent rejection of their exports product might instead indicate the inadequacy of domestic standards regulations and the scientific and technology ability to ensure compliance. This results tallies with Henson and Jaffee (2004) who acclaim that standard is not always problematic and it is less pessimistic than widely portrayed by the widely held view of the mainstream ‘standard as a barrier’ perspective. They argued that standard does not necessarily hurt African exports as in some export sectors, some African countries are successfully responding to stringent food safety standard by making the necessary investments in operations to meet importing countries requirements and proliferate developed countries markets.

Regarding the other costs variables, the results show geographical distance as having negative effects on exports for all the models which is in line with our apriori expectation, but all models are statistically insignificant with the exception of FGLS model which produce a significant trade effect. With respect to the common language variable, for all estimators with the exception of the FGLS, having a common language between the two trading partners do not significantly impact on African fish trade, negating our aprior expectation of significant positive trade effect. These results indicate that sharing similar language with the EU is not a stimulating factor for African fish exporters in establishing possible new trade relationship and

**Table 3 Results from the Various Estimators**

| | TrunOLS lexport (b/se) | FGLS Lexport b/se | Fixed lexport b/se | Random Lexport b/se | ET Tobit lexport b/se | EK Tobit Lexport b/se | PPML Export b/se | MPML Export share b/se |
|---|---|---|---|---|---|---|---|---|
| Log of Exporter GDP | 0.528*** | 0.634*** | -0.075 | 0.498*** | 1.027*** | 1.501*** | 0.139 | 0.469*** |
| | (0.104) | (0.035 | (0.210) | (0.080) | (0.131) | (0.179) | (0.161) | (0.072) |
| Log of Importer GDP | 0.734*** | 0.669*** | 0.136 | 0.792*** | 1.745*** | 2.440*** | 0.143 | 0.189** |
| | (0.107) | (0.037) | (0.178) | (0.083) | (0.138) | (0.176) | (0.367) | (0.080) |
| Fish Standard | -0.007 | -0.001 | 0.002 | 0.001 | 0.004* | 0.005* | 0.001 | 0.000 |
| | (0.005) | (0.001) | (0.002) | (0.002) | (0.002) | (0.003) | (0.001) | (0.001) |
| Log of Distance | -0.813 | -1.098*** | | -0.811 | -1.526 | -1.782 | -1.111 | -0.235 |
| | (1.000) | (0.384) | | (0.871) | 1.874) | (2.545) | (1.176) | (0.552) |
| Com Language | -0.277 | -0.578** | | -0.442 | (0.888 | 1.758 | -1.541* | -0.426 |
| | (0.745) | (0.232) | | (0.608) | 1.071) | (1.583) | (0.931) | (0.670) |
| Colony | 0.497 | 0.846*** | | 1.307* | 3.082** | 3.703** | 2.454** | 2.285** |
| | (0.854) | (0.269) | | (0.761) | (1.346) | (1.855) | (0.990) | (0.914) |
| Landlocked | -6.437*** | -5.331*** | | -3.129*** | -1.982 | -1.489 | -10.023*** | -2.516*** |
| | (1.756) | (0.520) | | (1.001) | (1.208) | (1.906) | (2.558) | (0.881) |
| RTA | 0.535 | 0.433*** | -0.021 | 0.268 | 0.339 | 0.393 | 0.009 | -0.010 |
| | (0.503) | (0.142) | (0.396) | (0.283) | 0.431) | (0.687) | (0.276) | (0.354) |
| Constant | -18.467*** | -18.824*** | 3.739*** | -19.860*** | -55.303*** | -77.820*** | 2.274 | -13.910*** |
| | (2.938) | (1.004) | (0.536) | (2.188) | (3.493) | (4.325) | (7.432) | (2.061) |
| Observations | 2188 | 2345 | 1870 | 2412 | 6480 | 6480 | 6480 | 6480 |
| *AIC* | 10551.544 | . | 5433.016 | . | 12595.81 | 16010.19 | 2.09e+06 | 2709.765 |
| *BIC* | 10608.451l | . | 5460.685 | . | 12670.35 | 16084.73 | 2.09e+06 | 2777.530 |
| *Ramsey Test* | 0.646 | 0.152 | 0.2819 | 0.014 | 0.012 | 0.033 | 0.222 | 0.137 |

Note: the dependent variable is the logarithm of exports for all models except for the Poisson and Multinomial Poisson models whose dependent variables are respectively exports and export share in levels. All models control for multilateral trade resistance using Baier and Bergstrand (2010) approximation. Clustered robust standard errors are in bracket and * $p<0.10$; ** $p<0.05$; *** $p<0.01$

expanding existing ones. Furthermore, in conformity with our aprior expectation, all estimates model predicts negative and statistically significant effects of being landlocked on exports, except the ET and EK Tobit models which produced insignificant effect.

Contrary to our expectations, regional trade agreements between country-pairs does not have any effect on trade for all models except for the FGLS models where it has a positive and large significant effect on fish exports. Similar results were found by Gradeva and Martinez-Zarzoso (2015) who find RTAs is not effective in increasing export to the EU for many participating developing countries. In the case of many African countries, many of the RTAs between Africa and the EU have been non-reciprocal with the exception of the ongoing negotiation known as economic partnership agreement (EPA). Major reasons adduced for this is their lack constraints in terms of the lack of well wither, corruption, their lack of sophisticated science and technology to improve their export products to the EU, all of which deter Africa's ability to penetrate EU market. This result thus signifies that deeper agreements are needed to deeply integrate African countries and ensure their market access to the EU.

In general, from Table 3 the differences in the techniques is mostly seen in the magnitude of the standard errors and coefficient predicted and in seldom cases, in the signs of the parameters of the gravity variables. However, the main difference between them lies in the standard error - the measure of precision. Table 4 summarizes the top two consecutive estimators with the lowest standard errors and the estimator with the highest standard error.

**Table 4 Top Three Estimators with the Low and High Standard Errors**

| Variable | (1)<br>Lower | (2)<br>Lowest | (3)<br>Highest |
|---|---|---|---|
| Log of Exporter GDP | FGLS | MPML | Random Effect |
| Log of Importer GDP | FGLS | MPML | PPML |
| Fish Standard | PPML | MPML | Truncated OLS |
| Log of Distance | FGLS | MPML | EK Tobit |
| Common Language | FGLS | MPML | EK Tobit |
| Colony | FGLS | Random Effects | EK Tobit |
| Landlocked | FGLS | MPML | PPML |
| RTA | FGLS | ET Tobit | PPML |

Calculated based on estimates in Table 3

We could see that FGLS and MPML in most cases exhibit the least standard errors depending on the variable considered, indicating more precision. However EK Tobit and PPML models mostly exhibit the highest standard errors.

## 7.0 CONCLUSION

The issues of zero trade observations and the potential departure from the usual homoscedasticity assumption when using the log linearized gravity equation have generated a number of debates in the literature with differing claims about the most suitable estimation technique.This necessitates a careful consideration of the methods in order to produce reliable policy estimates. Our aim is to consistently investigate if EU food safety standards are overprotective in nature using African dataset on fish exports to the EU. We provide an in-depth review of methods that have been employed in solving these problems. Our survey of studies at the forefront of the current debate show that each estimator is not without its pros and cons. To produce unbiased and consistent estimates for policy making, we undertake a careful consideration of the robustness of a number of widely used estimators - to validate the claims that EU fish standards are protectionist in nature given the high level of African fish exports rejected since 2008 at the EU border, primarily due to the inability to comply with the stringent EU standards.

As an empirical analysis, we adapted the Anderson and van Wincoop (2003) specification of the gravity equation and control for multilateral trade using Baier and Bergstrand (2009) approximation. Given our dataset and the gravity equation specified, we assess the performance of the log linear and generalized linear models in a dataset whose independent variable contains about 63% zero trade flows observations. Our results point out that most of the estimators shows that EU fish standard is not protectionist when compared to the international benchmark recommended by the FAO and WHO. Notwithstanding, the results of the different robustness checks are evidently in favour of only the MPML technique as the most consistent estimator in relation to the impacts of standards and other explanatory variables, and its results are to be relied upon for more efficient and reliable policy outcome. In other words, given this particular African dataset and the resulting data generating process underlying the structure of the error term, gives strong evidence that the data generating process follows a constant variance mean ratio type of heteroscedasticity, which indicate a strong support for the MPML.

Conclusively, the choice of the most appropriate estimator is contingent on the process generating the error term and the dataset (Martinez Zarzoso 2013; Head and Mayer 2014). In addition, in recent time, it has also been acclaimed that "deciding which of the models is more appropriate is an empirical question that has to be answered for each specific dataset the researcher is considering" (Santos Silva et al., 2015, p.2).Thus, a caveat is worth mentioning: though we found that all the estimators give similar results in regards to the impact of standards, however, we are not excluding the fact that this might be different using different dataset, for instance, those of Asia and Latin America. The interesting thing however is that we have used a dataset of poor and small countries which is characterised by many zeros and little trade values, so we believe that this finding can be generalized to other similar datasets with similar characteristics.

Our results thus have several policy implications for achieving increased African export penetration to the EU markets. Although our results point out that EU standards are not overly protectionist in nature, however, the persistent high number of fish exports rejected at the EU border indicates the need of assistance in order to comply with such standards. Thus, engaging in sophisticated scientific and technology transfer and the provision of financial assistance to farmers and exporters are important policy imprint needed to be implemented to ensure positive change. For instance, trade agreement with the EU should include the provision of technological and scientific assistance to the agricultural sector, particularly small scale producers who dominates the scene in order to assist them in complying with EU food safety standards. At the home front, the issue of export rejection at the border can also be addressed through comprehensive reforms in the area of trade facilitations. Good customs and border management and the improvement of transit regimes would minimise delays that cause food contamination and border rejections, and would help move fish exports and other perishables more efficiently to the EU markets.

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**APPENDIX**

**Table A1: The Zero Trade and Logarithmic Transformation in Gravity Modeling – A Summary of the Debate**

| Model/Estimator | Scholar | Characteristics/Merit | Criticism/Demerit | Response to Critics |
|---|---|---|---|---|
| Tobit | Anderson and Marcoiller (2002), Rose (2004), Martin and Pham (2008). | - To deal with the zero trade problem due to unobservable trade flows or measurement error from rounding up.<br>- Applied to fit dataset that is only observable over some range.<br>- Applicable there is difference between actual outcomes and desired outcomes. | - Linder and de Groot (2006) opined that zero trade occur due to binary decision making on the profitability of trade and not from censoring that the model posited, which makes it inappropriate to take care of the zero trade.<br>- Frankel (1979) argued that the estimator is liable to measurement errors, which will impact on the result due to the artificial censoring of positive small trade values.<br>- In response to the position of Martin and Pham (2008), Santoa Silva and Tenreyro (2011) find the threshold Tobit model to have large bias that rise with sample size, which makes it an inconsistence estimator in a simulation exercise. | - Martin and Pham (2008) suggested the use of Eaton and Tamura (1994) threshold Tobit model that gives the lowest bias and outperform all other estimators in a simulation exercise. |

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| Poisson Pseudo Maximum Likelihood (PPML) | Santos Silva and Tenreyro (2006, 2008, 2009, 2011), Staub and Winkelmann (2012). | - It is used to deal with the zero trade and logarithm transformation.<br>- The gravity equation is specified at levels in order to avoid the problem that arose using OLS under logarithm transformation.<br>- It takes into consideration observed heterogeneity; zero trade dealt with through the multiplicative form of the fixed effects in PPML and avoid under-prediction of large trade volume by generating estimates of trade flows rather than the log of trade flows.<br>- Gives the lowest bias among estimators.<br>- Proponents suggest the estimator as the workhorse for the gravity model. | - Burger et al. (2009) argued that the model is vulnerable to over-dispersion in the dependent variable and excess zero flows. This only takes care of observed heterogeneity and unobserved ones.<br>- The assumption of equidispersion in the dependent variable leads to overdispersion due to unobserved heterogeneity.<br>- The overdispersion generates consistent but inefficient estimates of trade flows (Burger, et al. 2009; Turkson, 2010)<br>- Martinez-Zarzoso (2013) opined that PPML is not always the best estimator as its estimates are outperformed by both OLS and FGLS estimates in out of sample forecast, so, it is not always the best estimator.<br>- The PPML assumption regarding the pattern of heteroscedasticity is rejected by the data in | - Santo Silva and Tenreyro (2011) opined that despite the identified overdispersion and excessive zero trade problems, PPML is consistent and generally well-behaved in the presence of overdispersion in the dependent variable and large zero trade will not affect its performance.<br>- Soren and Bruemmer (2012) argued that PPML performs quite well under overdispersion, and show that the PPML is well-behaved under bimodal distributed trade data.<br>- Santo Silva and Tenreyro (2008) responded by justifying the use of PPML as the best estimator in gravity model, but acknowledged that PPML estimator can be outperformed by other estimators in some cases. |

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| | | | most cases (Martinez-Zarzoso, 2013).<br>- Martin and Pham (2008) argue that PPML is not robust to the joint problems of zero trade and heteroscedasticity. | - PPML consistent in the presence of excessive trade zero (Staub and Winkelman, 2012).<br>- Santo Silva and Tenreyro (2011) responded to the critics of PPML arguing that the studies of the critics of PPML did not generate its data through a constant elasticity model, with which their study did.<br>- Also, Santo Silva and Tenreyro (2011) re-investigate the performance of PPML in the presence of large zero trade data in a constant elasticity model. The results show that PPML estimator is consistent, well-behaved with large zero trade and not affected by overdispersion in the dependent variable. |
| Negative Binomial Pseudo Maximum Likelihood | Burger et al. (2009) | - To correct for the overdispersion in the dependent variable and the vulnerability of the | - One of the drawbacks of NBPML and PPML is the excessive number of zero | - Burger et al. (2009) opined that even though the Poisson model and NBPML |

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|---|---|---|---|---|
| (NBPML) and Zero Inflated Models e.g. Zero Inflated Pseudo Maximum Likelihood (ZIPML) technique, Zero Inflated Binomial Pseudo Maximum Likelihood (ZINBPML). | | PPML to excessive trade zero.<br>- It incorporates unobserved heterogeneity into the condition mean and thus, takes care of unobserved heterogeneity. | trade that is derived from non-Poissoness of the model (Johnson and Kotz, 1969).<br>- Turkson (2011) argued that these estimation techniques cannot handle excessive zero.<br>- Staub and Winkelmann (2012) posit that both ZIPML and ZINBPML are inconsistent if the models are misspecified. | model can technically handle zero trade, however, both are not well positioned in the case where the number of observed zeros trade value is greater than the number of zero predicted by the model.<br>- The Zero Inflated Models perform better as they corrected excessive zeros and overdispersion in the dependent variables. The models theoretically well situated in Poisson and non-Poisson estimation. |
| Zero Inflated Poisson Quasi Likelihood (ZINPQL) | Staub and Winelmann (2012) | - Consistent in the presence of excessive zero trade.<br>- Unaffected by unobserved heterogeneity.<br>- It is robust to misspecification as it consistently estimate the regression coefficients irrespective of the true distribution of the counts, while ZIPML and ZINBPML demonstrate | - ZINPQL can be less efficient compared to zero inflated estimators when the zero inflated models are correctly specified. | |

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| | | considerable bias in the medium sample. | | |
| FGLS and other generalized least square (GLM) e.g. Gamma Pseudo Maximum Likelihood (GPML), Non-Linear Least Square (NLS). | Martinez-Zarzoso et al (2007), Martinez-Zarzoso (2013) -FGLS,<br><br>Manny and Mullay (2001) – GPML,<br><br>Frankel and Wei (1993) –NLS. | - FGLS can be applied in the presence of unknown form of heteroscedasticity.<br>- It is an efficient estimator among the class of least square estimators.<br>- Variance of the disturbances needs to be re-estimated to correct for heteroscedasticity errors.<br>- The comparison of the best estimators should be between FGLS and other generalized least models (GLMs) such as; Non-linear least square (NLS), Gamma Poisson Maximum Likelihood (GPML) and PPML.<br>- Gamma Psuedo Maximum Likelihood (GPML) techniques is more efficient under the assumption that the conditional variance depends on higher power | - Santos Silva and Tenreyro (2008) debunked the claim of FGLS proponents and provided justification for the PPML estimator in the context of log-linear gravity model.<br>- Santos Silva and Tenreyro (2011) found GMPL to be consistent and well-behaved under Monte Carlo simulation with excessive zero trade values in a constant elasticity model, but has a larger bias than the PPML.<br>- Martine-Zarzoso (2013) argued that the GMPL may suffer from substantial loss of precision whenever the variance function is misspecified or when the log-scale residuals have high kurtosis.<br>- NLS efficiency is reduced due to its allocation of more | Martinez-Zarzoso (2013) argued that the choice of the best estimator is a function of the dataset and there is no absolute best estimator for all typology of dataset. Thus, the most appropriate estimator is data specific and could be determined by model selection tests. |

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| | | of the conditional mean, thus, given more weight to conditional mean.<br>- NLS assigns more weight to noisier observations.<br>- NLS consistent in the modeling of zero.<br>- NLS gives more weight to observations with large vaeiance. | weight to noisier observation (Santos Silva and Tenreyro, 2006). Also, NLS is inefficient because it generally ignores heteroscedasticity in the data. | |
| Heckman Selection Model | Heckman (1979), Linder and de Groot (2006), Munasib and Roy (2011). | - This model corrects for sample selection bias and specification error when zero trade do not occur randomly.<br>- It is a two-step approach under the normality assumption: first, estimation of the probability of trade at the firm levels (probit regression), finally, using the first approach to estimate the volume of trade.<br>- It has theoretically sound method and offers econometrically elegant solution.<br>- Providing avenue of using information from zero trade | - Burger et al. (2009) argued that in both Heckman and HMR models, it is difficult to satisfy the exclusion restriction because the instrumental variable is often difficult to find.<br>- The transformation of these models into logarithmic form before estimation might cause biased coefficient (Haworth and Vincent, 1979; Santos Silva and Tenreyro, 2006).<br>- Flam and Nordstrom (2011) and Santos Silva and Tenreyro (2009) posited that these models did not control for heteroscedasticity that are pervasive in trade | |

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|---|---|---|---|---|
| | | observation. | data. | |
| Extensive and Intensive Trade Margins Model | Helpman, Melitz and Rubinstein – HMR (2008) | - It extended the Heckman model by controlling for both sample selection bias and firm heteroscedasticity.<br>- It solves the zero trade problem with a two-step estimation procedure.<br>- It measures the effects of the number of exporting firms and volume of trade.<br>- First, it estimates the probit regression for probability of trading at the firm's levels (extensive margin).<br>- Using the first stage estimation result to estimate the intensive trade margin.<br>- It assumes homoscedasticity. | | Linder and de Groot (2006) and Heqetal (2010) included the excluded variables and imposed the normality of the error term. |

***Culled from Kareem and Kareem (2014) RSCAS2014/74.***

**Table A2: List of Countries in the Dataset**

| Country Groups | Members |
|---|---|
| Importers (EU27) | Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuanian, Luxembourg, Malta, Netherlands, Poland, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom |
| Exporters | Algeria, Angola, Benin, Burundi, Cameroon, Cape Verde, Central African Republic, Democratic Republic of Congo, Republic of Congo, Côte d'Ivoire, Egypt, Eritrea, Gabon, The Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Madagascar, Mali, Mauritania, Mauritius, Morocco, Mozambique, Namibia, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, South Africa, Swaziland, Tanzania, Togo, Tunisia Uganda, Zambia, Zimbabwe. |

**Table A3: Summary Statistics**

| Variables | Untransformed | | Demeaned as in Baier and Bergstrand (2010) | |
|---|---|---|---|---|
| | Mean | Std. Dev. | Mean | Std. Dev. |
| Export | 3054.829 | 20937.11 | | |
| Log of Export | 4.902 | 3.648 | | |
| Export Share | 0.104 | 0.449 | | |
| Log of Exporter's GDP | 16.161 | 1.536 | | |
| Log of Importer's GDP | 19.271 | 1.674 | | |
| Fish Standard | -5.541 | 18.725 | -3.53e-08 | 16.213 |
| Log of Distance | 8.582 | 0.439 | 1.20e-07 | 0.132 |
| Language Dummy | 0.106 | 0.308 | 4.71e-09 | 0.238 |
| Colonial Links Dummy | 0.040 | 0.196 | -1.40e-09 | 0.161 |
| Landlocked Variable | 0.389 | 0.488 | 1.12e-08 | 0.168 |
| Trade Agreement Dummy | 0.276 | 0.447 | -3.27e-09 | 0.247 |