The Impact of EU Pesticide Residue standards on African Fresh Produce Exports to the UK

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This paper estimates the impacts of pesticide maximum residue level (MRL) standards imposed by the European Union (EU) on trade-flows from African exporting countries to the United Kingdom (UK) using a fixed-effects gravity model specification with corrections for the zero trade-flows. We employ the Poison Pseudo Maximum Likelihood (PPML) estimation method to estimate the gravity model. Most variables have the expected signs and were statistically significant, consistent with the trade literature. The volume of trade increases with the GDP of the exporting countries and the UK. The volume of trade decreases with geographical distance. The variables describing cultural and economic proximity of countries, such as colonial relationships positively affect the volume of trade. Regarding the impact of MLRs on trade flows, the results were not completely consistent between the product groups. However, some commodities do exhibit sensitivity to changes in pesticide MRL standards imposed by the EU and hence applied in the UK.

Acknowledegment: The authors acknowledge Defra SeedCorn for funding this study

JEL Codes: Q18, F18

#2252

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Key words: *Pesticides, maximum residue limits, trade-flows, gravity model*

1. INTRODUCTION

Since 1993, the EU has been implementing a program to harmonise the maximum residue levels (MRL) of pesticides in food. In July 2000, the EU established MRLs for specific crops and pesticide combinations for 102 active substances. All the EU MRL positions established in July 2000 were approved and implemented as national legislation (Directive 2000/42/EC) by all EU member countries in July 2001 (Chan, 2001). In September 2008, there was a further harmonisation of national legislation with the EU single MRL list (Directive 2005/396/EC). These changes caused serious concern among importers and retailers of imported fresh produce in EU countries, and among exporters and producers in developing countries (Chan, 2001; Garcia-Martinez & Poole, 2004), where trade has generally been on a rising trend (Figure 1).

There have been conflicting reports on how the EU regulations will affect producers in developing countries. A study by Otsuki et al. (2001) predicted that the new EU's Aflatoxin B1 standard would reduce health risk by about 1.4 EU deaths per billion persons per year, but would reduce African exports of cereals, dried fruits and nuts to Europe by US$670 million, compared with the MRL set by international standards. Xiong and Beghin (2012) conducted a study to re-examine the tightening of the EU's MRL on aflatoxins in 2002, and to confirm its impact on African exports of groundnut products. They found no evidence of the MRL standard having a statistically negative trade impact on groundnut exports from Africa across various methods of estimation. Wilson and Otsuki (2004) found that a more restrictive MRL standard would decrease EU banana imports from developing countries by 1.63% per year. Drogue and DeMaria (2012) assess the impact of the differences in MRL of pesticides on the global trade of apples and pears. They showed that the differences between regulations may hinder trade. This contentious debate over food safety standards and their effects highlights the need for more robust economic analysis of standards on trade-flows.

The objective of this paper is thus to assess the impacts of pesticide MRL standards on fresh produce trade-flows from emerging and existing African exporting countries to the UK.[1] We specifically examine exports of fresh fruit and vegetables. Exports to the UK from Egypt, Morocco, Cameroon, Cote d'Ivoire, Ghana, Gambia, Nigeria, Senegal, Ethiopia, Kenya, Uganda, Zambia, Zimbabwe and S. Africa formed the basis of the analysis which is conducted at an aggregated level of exporter nations and with either aggregated commodity groupings or specific selected product exports. The rationale for selecting the sample countries is their presumed non-stringency in MRL regulations (Drogue and DeMaria, 2012). A gravity model approach is one of the more appropriate methods to test the hypotheses that more restrictive pesticide MRL standards could limit trade-flows. Within this modelling framework, our analysis focuses on chlorpyrifos pesticide as an example, with regulatory data from the UK showing it to be one of the most frequently detected residues on fresh produce imports.

The remainder of the paper is structured as follows:-Section 2 describes the UK's sources of fresh fruit and vegetable supply; section 3 outlines the methodology of the study; Section 4 reports and discusses the results of the gravity model estimation and the conclusion considers the policy implications that arise from changes in pesticide MRLs.

[1] The term 'emerging African exporting countries' is used throughout this paper to refer to African exporting countries with low but increasing export volumes of fresh produce to the EU/UK market (Hallam et., 2004).

2. Overview of the UK's sources of fresh fruit and vegetable supply

3 METHODS

3.1 The Gravity Model

One specific modelling approach to specifying and estimating bi-lateral trade-flow relationships is through gravity modelling. Tinbergen (1962) pioneered its use in a study of the levels of bilateral trade-flows and Linneman (1966) extended the model. A number of investigations have provided theoretical support for the gravity model.[2] The gravity equation is routinely used to explain trade-flow effects of distance (Disdier & Head, 2008), currency union (Rose & van Wincoop, 2001), common borders (McCallum, 1995), tariffs (Baier & Bergstrand, 2001), technical bariers to trade (Maskus & Wilson, 2001) and fixed trade costs (Helpman et al., 2008).

There is a proliferating number of studies that use this approach to estimate the trade effects of food safety standards (e.g. Otsuki et al., 2001; Ganslandt & Markusen, 2001; Fontagne et al., 2005; Disdier et al., 2008; Kim & Reinert, 2009; Vigani et al., 2009; Disdier & Marette, 2012; Li & Beghin, 2012; Drogue & DeMaria, 2012; Xiong & Beghin, 2012). Otsuki et al. (2001) estimated a gravity model to examine the impact of the new EU Aflatoxin B1 standard on food imports from Africa. Wilson and Otsuki (2004) extended this study to examine whether regulations on pesticide residues in food could have an effect on banana exports from developing countries. The study by Xiong

[2] Studies have shown that the gravity equation is consistent with both the Heckscher-Ohlin models and models of imperfect competition and trade (Anderson, 1979; Helpman & Krugman, 1985; Bergstrand, 1985, 1989; Feenstra et al. 2001; Deardorff, 1998; Eaton & Kortum, 2002; Evenett & Keller, 2002; Harrigan, 2002).

and Beghin (2012) revisited the study of Otsuki *et al*. (2001) to confirm if European aflatoxin regulations hurt groundnut exports from Africa. Drogue and DeMaria (2012) also used a gravity model to study the impact of MRLs of pesticides on the global trade of apples and pears, with the aim of understanding how their similarity or dissimilarity affect trade. Hence the gravity equation has become an accepted basis on which to conduct economic analyses of the effects of standards on bilateral trade between different geographic entities.

The basic principle behind the gravity model is the simple gravity equation borrowed from Newtonian physics. This states that attraction is greater between larger mass and more closely positioned objects. When applied by analogy to trade between countries, the model postulates that trade increases with the size and proximity of the trading partners. The gravity equation stipulates *a priori* that the value of trade-flows between two countries is positively related to their economic sizes and inversely to the geographical distance between them. In its most simplified form, the gravity equation can be expressed as follows:

$$T_{ij} = R\frac{Y_i^{\beta_1} Y_j^{\beta_2}}{D_{ij}^{\beta_3}} \quad (1)$$

where: T_{ij} is the trade-flow (normally measured as either the value of exports or imports) from country i to country j; R is a constant of proportionality; Y_i and Y_j are the economic sizes of the two countries usually represented by their gross domestic product (GDP), with parameters β_1 and β_2 respectively; and D_{ij} measures the geographical distance between the economic capitals of the trading partners and is often used as a proxy for trade costs.

The multiplicative form of the gravity equation means that it lends itself readily to being estimated by ordinary least squares (OLS) linear regression in the natural logarithms of the variables in Eq.(1) and can be expressed more generally as:-

$$\ln T_{ij} = \beta_0 + \beta_1 \ln Y_i + \beta_2 \ln Y_j + \beta_3 \ln D_{ij} + \varepsilon_{ij} \qquad (2)$$

where: $\beta_0 = \ln R$, $\beta_1, \beta_2 \geq 0$ $\beta_3 \leq 0$, and ε_{ijt} is the error term that is assumed to be normally distributed with mean zero and constant variance. In Eq.(2), the parameters $\beta_1..\beta_3$ represent respectively the GDP elasticities of exports for the exporting (Y_i) and importing country (Y_j), and the distance between countries *i* and *j*. From Newtonian theory, one would expect $\beta_1 = \beta_2 = 1$. However, there is no *a priori* reason from the perspective of economic theory why they should be equal and unity (Head, 2003).

The augmented gravity model for commodity *k* can be generalised as in Eq.(3) (Baltagi et al., 2003; Anderson & Van Wincoop, 2003; Vigani et al., 2009):

$$\begin{aligned} \ln(T_{ij}{}^{k}) &= \gamma_i + \eta_j + \beta_1 \ln(GDP_i) + \beta_2 \ln(GDP_j) + \beta_3 \ln(N_i) \\ &\quad + \beta_4 \ln(N_j) + \beta_5 \ln(D_{ij}) + \sum_{z=1}^{n} \beta_{6n} Z_{ij}^{k} + \varepsilon_{ij}^{k} \end{aligned} \qquad (3)$$

where: γ_i is the fixed effect of the country of origin (exporter), and η_j is an effect specific to the country of destination (importer). The fixed effect model controls for country specific effects related to importers and exporters. The variables N_i and N_j denote the populations of exporting and importing countries respectively, Z_{ij}^{k} is a vector of *n* dummy variables that are used as proxies for trade policy measures such as trade agreements and tariffs, the sharing of a common border (adjacency), common language or the presence of former and historical colonial links.

Recent theoretical developments in the applied trade literature have identified a number of econometric problems associated with the traditional gravity equation in Eq. (3) that are pertinent to this analysis. These issues *inter alia* include the following:-(1) bias generated by the logarithmic transformation, (2) the validity of the assumption that all error terms have equal variance, and (3) the robustness of the results to zero value trade-flows (Silva & Tenreyro, 2006; Burger et al., 2009; Drogue & DeMaria, 2012; Xiong & Beghin, 2012; Head and Mayer, 2014). This paper accounts for the problem of zero values in the log-normal gravity fixed effects model.

A common pattern in bilateral trade data is that zero trade flows may be frequent across country pairs and products, and zero valued trade-flows could exceed positive trade-flows when disaggregate trade data are used. The most obvious reason for the occurrence of zero trade-flows between countries is the lack of trade between small and distant countries, which can be explained by the large variable costs of transportation and fixed costs relating to firm heterogeneity (Frankel, 1997; Helpman et al., 2008; Halak, 2006).[3] Zeros may also simply be the result of rounding errors or missing observations. By convention, the most common strategy to deal with the 'zero problem' in the analysis of trade-flows is to exclude all zero trade- flows (Burger et al., 2009). Statistically, the exclusion of zero trade-flows could lead to a standard sample selection bias (Heckman, 1979). Additionally, deleting all zero trade-flows means that important information on low levels of trade is taken out of the model. This can lead to biased estimates when the zero trade-flows are non-randomly distributed (Burger et al., 2009). Hence a truncation of the sample should be avoided.

[3] Other factors such as the low levels of GDP per capita, the lack of cultural and historical links and the influence of policies are also possible reasons for the absence of trade between countries (Rauch, 1999).

To address these problems, Silva and Tenreyro (2006) proposed estimating the gravity equation in its original non-logarithmically transformed multiplicative form using a Poisson regression model. Burger et al. (2009) showed that some variants of the basic Poisson model can accommodate greater dispersion of the data than the Poisson distribution. Hence the choice of a preferred estimator to address the existence of excessive zero trade-flows and heteroskedasticity issue arising from the log-linearisation of the original multiplicative gravity equation is an important empirical question. In this paper, we apply the Poison Pseudo Maximum Likelihood (PPML) estimation method, developed by Silva and Tenreyro (2006). We describe the data next and then proceed into model specification and estimation.

3.2 Model Specification and Data

Our overall objective was thus to measure the effect of pesticide residue standards and other factors on trade-flows of fresh produce from selected African exporting countries to the UK using the fixed effects form of the gravity model in Eq.(3). The dependent variable (T_{ij}^{k}) for all the models is the export value of a product or commodity group k from the selected exporting countries i to the UK, j, expressed in £ million at constant prices. The classification of commodities is based on the 1992 Harmonised System (HS) of the World Customs Organisation at 2 and 4 digit levels.

Data on the bilateral trade-flows were provided by the Department for the Environment, Food and Rural Affairs (Defra) Statistics Trade Unit. The specific aggregate commodity groups included in the study were fruit (HS 08) and vegetables (HS 07). The specific 4 digit HS code products or product groups included were legumes (HS 0708), onions (HS 0703), tomatoes (HS 0702), potatoes (HS 0701) and other vegetables

(HS 0709), and citrus (HS 0805), melons (HS 0807) and miscellaneous fruit (HS 0804). The availability of MRL data is the underlying reason for choosing these specific fruit and vegetable products. In practice, two aggregate commodity group models (fruit, vegetables) and the seven individual commodity-specific models (legumes, tomatoes, onions, potatoes, citrus, melons and miscellaneous fruit) were estimated. Annual data for the time period 1988-2012 were used in the analysis. Figure 2 clearly shows that the frequency distribution of the volume of trade across trade-flows strongly deviates from a normal distribution (skewness = 3.31, kurtosis = 14.29).

GDP in both importing and exporting countries reflects economic size, and is expected to be positively related to trade, as it can be an indicator of the developed state of the country market and its infrastructure to support production and trade. On the supply (exporter) side, an increase in GDP may signal greater domestic production being available for export especially if the production of the export commodity contributes significantly to the GDP (Papazoglou, 2007). On the demand (importer) side, it would reflect aggregate purchasing power and absorptive capacity (market size) of the trading countries. Data for both the UK and exporting country GDPs for the period 1988-2007 were obtained from the World Economic Outlook (WEO) Database of the International Monetary Fund (IMF). This enables a comparable data source for all countries to be used based on Purchasing Power Parity GDP.

The variables N_i and N_j denote populations of exporting country *i* and the UK, respectively. They were also taken from the WEO Database of the IMF for the same period (1988-2012). In a standard economic interpretation of the gravity model, both population variables would be expected to have a negative sign, with larger countries being more self-sufficient, according to Kim and Reinert (2009). However, one can argue that larger populations in exporting countries might also give rise to scale economies in production and hence with increased exports, thereby having a positive impact. Furthermore, a larger population or market in an importing country may give rise to greater import substitution again potentially exerting a positive impact on trade flows. Hence, *a priori*, the expected sign on population is indeterminate.

Bilateral distance D_{ij} between the UK and each exporting country was employed as a resistance factor in the model, and measured as the geographical distance between the capital cities of the two countries, with the data obtained from CEPII geo-database.[4] This is a proxy for a range of possible transaction-cost related variables such as transport, delivery time, cultural unfamiliarity and market access problems. It is expected that longer distances between trading countries will lead to higher costs and lower profits (Hummels, 2001; Egger, 2008). However, this will depend on the mode of transport used and the nature of the product (Martínez-Zarzoso & Suárez-Burguet, 2005). Longer distances are expected to reduce trade-flows, and whilst, *a priori*, the sign of the distance coefficient should be negative, its magnitude matters more.

An ad valorem import tariff TR^k_{ij} applied to the exports was initially tested as another resistance factor in the model and included to control for the variation of the dependent variable that is not captured by the EU tariff-quota policy dummy variable D_{iACP} which applied to those African, Caribbean and Pacific country signatories of the Lomé Convention with the EU. The expected sign of the coefficient on TR^k_{ij} is negative.

[4] Distance was measured using the 'great circle' formula (Head, 2003). This formula approximates the shape of the earth as a sphere and calculates the minimum distance along the surface. Great circle distances between the capital cities of the exporting countries and the UK were drawn from CEPII database (http://www.cepii.fr/).

Import tariff rates imposed by the EU on each commodity were taken from the trade database of the United Nations Conference on Trade and Development Trade Analysis and Information System (TRAINS) within the World Integrated Trade Solution (WITS) provided by the World Bank (UNCTAD, 2010).

However, whilst the tariff quota (TQ) system of the EU might exert a significant impact on trade-flows and interact with the tariff variable, for the products in this study it was not precisely clear whether the TQs in place were binding or not, making it difficult to pre-judge how the EU tariff-quota policies might be expected to affect trade-flows. Dummy variables for the EU tariff-quota have been employed for example by Wilson and Otsuki (2004) to control for the effect of the tariff quota system. *A priori* if $D_{iACP} = 1$, we would expect its coefficient to be positive and the coefficient on TR^k_{ij} to be zero for trade up to the TRQ level. If trade were to exceed the TRQ, then we would expect the TR^k_{ij} coefficient to be negative and the coefficient on D_{iACP} to be zero.

A further dummy variable D_{iCOL} was also included to control for the omitted variable effect on trade-flows of former colonial ties between the UK and certain exporting countries, as exemplified by some studies cited above. It was expected to have a positively signed coefficient.

Table 1 presents the evolution of the EU MRLs expressed in parts per million (ppm) for selected pesticide-commodity combinations used in the regression models. To observe the effects of the EU MRLs, it was necessary first to examine compliance data. Data on pesticide residue monitoring of imports crossing the UK border from the selected exporting countries are given in Table 2. Some 297,300 samples were analysed for approximately 102 substances. A total of 17 pesticides on imported fruit and vegetables were found to have occurred with frequencies greater than 1. In all, only 1% had residues above the reporting limit, and only 0.03% had residues exceeding the EU MRL, whilst residues were not detected in 98.9% of the samples. There is some variation in residue levels amongst the exporting countries under study but the overall distribution through the years follows a similar pattern with 98-99% of samples without residues:, 0.2-1.5% with residues above reporting limit but not exceeding MRLs and only: 0.01-0.35% with residues above the MRLs. In summary, there has been a low number of MRL violations from the selected exporting countries.

In order to test for the effects on trade of pesticide standards, variables for the MRL of two specific pesticides were included, namely chlorpyrifos for vegetables and dimethoate for fruit. Both are highly toxic insecticides that are effective in controlling a wide range of insect pests. Humans exposed to high levels of these pesticides exhibit poisoning related symptoms. Another rationale for selecting these particular pesticides was the availability of MRL data. MRL values for selected pesticide-commodity combinations were taken from the EU MRL database, MRL databases of the UK's Chemicals Regulatory Directorate (CRD), and Codex Alimentarius of the FAO and WHO. Data were taken from the websites of these organisations. [5,6] Ganslandt and Markusen (2001) explain how standards and technical regulations can have both trade-impeding effects and demand-enhancing effects. The latter possibly reflecting consumer preferences to purchase safer products. However, the maintained hypothesis

[5] Available at: http://ec.europa.eu/sanco_pesticides/public/index.cfm/
[6] Available at: http://www.codexalimentarius.net/mrls/pestdes/jsp/pest_q-e.jsp/

is that the coefficient of the MRL of pesticides is positive, since a lower value of MRL implies a more restrictive standard acting as a disincentive and barrier to trade.

Anderson and Van Wincoop (2003) showed that trade can depend on both the exporting and importing country price levels, which can be related to the existence of trade barriers. This paper does not include relative prices and hence the estimated gravity equation might lead to biased estimates. However, this potential problem can be avoided by including importer and exporter country-specific fixed effects into the model (Hummels, 2001; Rose & Van Wincoop, 2001; Chen et al., 2008; Vigani et al., 2009). Hence, the gravity model specified for initial estimation was as follows:

$$\begin{aligned}\ln(T_{ij}^{k}) = \gamma_i + \eta_i + \beta_1 \ln(GDP_{it}) + \beta_2 \ln(GDP_{jt}) + \beta_3 \ln(N_{it}) \\ + \beta_4 \ln(N_{jt}) + \beta_5 \ln(D_{it}) + \beta_6 \ln(TR_{ijt}^{k}) + \beta_7 \ln(MRL_t^{k}) \\ + \beta_8 D_{iACP} + \beta_9 D_{iCOL} + \varepsilon_i^{k}\end{aligned} \quad (4)$$

where: β_0-β_9 are coefficients to be estimated; and ε_i is the error term that is assumed to be normally distributed with mean zero and constant variance, γ_i is exporting country-specific effects. T_{ij}^{k} is the value of exports of commodity *k* from country *i* to the UK in year *t*. GDP_i and GDP_j are the real GDP (in constant US$) of the exporting country *i* and the UK, respectively, as typically included in a gravity model. The variables N_i and N_j denote populations of exporting country *i* and the UK, respectively. D_{ij} is geographic distance from exporting country to the UK. Di_{COL} and Di_{ACP} are dummy variables for colonial ties and regional trade agreements, respectively. *A priori* we expect that:-

$\beta_1.,...\beta_4, \beta_7, \beta_9 > 0$; $\beta_5<0$; $\beta_6 <0$: $D_{ACP}= 0$; $\beta_6=0$, $\beta_8>0$: $D_{ACP}=1$ and $X^k_{ij}<TQ$; $\beta_6<0$, $\beta_8=0$: $D_{ACP}=1$ and $X^k_{ij}>TQ$.

Our dataset contains 1,380 observations, of which 1310 (95%) are non-zero and only 70 (5%) are zero observations. Thus the zero observations clearly do not dominate the trade records in the data. There are no zero trade-flows in the product lines for potatoes, other vegetables, citrus and miscellaneous fruit. Note that some of these zero values may simply be due to rounding errors or incompleteness of the available trade data but others might reflect the absence of trade between the selected African exporting countries and the UK. Hence it is necessary to explicitly account for this limited dependency of the trade data to control for the lack of trade.

3.3 Model Estimation

Following the recent gravity literature (Silva and Tenreyro, 2006; Burger et al., 2009; Xiong and Beghin, 2012; Drogue and DeMaria, 2012), we apply the Poisson Pseudo Maximum Likelihood (PPML) estimation. The model estimated by the PPML is robust to heteroskedasticity and can deal with the excessive zero observations. The specification of the model for PPML regression is given as follows:

$$
\begin{aligned}
E(Y_{ij}^{k} / X_{ijt}^{k}) = \exp[\gamma_i + \eta_j &+ \beta_1 \ln(GDP_{it}) + \beta_2 \ln(GDP_{jt}) + \beta_3 \ln(N_{it}) \\
&+ \beta_4 \ln(N_{jt}) + \beta_5 \ln(D_{it}) + \beta_6 \ln(TR_{ijt}^{k}) + \beta_7 \ln(MRL_{t}^{k}) \\
&+ \beta_8 D_{ACP} + \beta_9 D_{COL} + \varepsilon_i^{k}]
\end{aligned}
\qquad (5)
$$

where X_{ijt}^{k} is the matrix of explanatory variables under study. The consistency of the Poisson estimator is achieved if we assume that $Var[Y_{ijt}^{k} / X_{ijt}^{k}] \infty E[Y_{ijt}^{k} / X_{ijt}^{k}]$. A detailed description of the PPML specifications of the gravity equation can be found in Silva and Tenreyro (2006), Burger et al. (2009), Drogue and DeMaria (2012), and Xiong and Beghin (2012).

4.0 RESULTS AND DISCUSSION

4.1 Gravity Model Estimation

Results of the gravity model estimations are reported in Tables 3 and 4. Note that the tariff variable was dropped from the final model estimation because most of the exporting countries and product groups included in the regression are exempted from paying tariffs (with zero tariff values recorded in most of the TRAINS data from 1995 onwards).[7]

We start by examining the PPML regression results for vegetables and for the individual commodity of legumes, tomatoes, onions, potatoes and other vegetables with respect to chlorpyrifos (Table 3). The models for each of the products performed relatively well. The GDP, population and geographical distance variables have the expected signs and are statistically significant in most cases under the PPML regressions. The coefficients for UK GDP were positive and highly statistically significant in all individual commodity groups, reflecting the wealth effect of buyers. The coefficients for the UK population were also positive and statistically significant for legumes, tomatoes, onions, other vegetables and the aggregate group of vegetables. The positive signs on the GDP and population coefficients indicate that a larger market size and higher purchasing power in the UK will significantly increase the demand for fresh vegetable imports. However the negative sign on the UK population coefficient in the potato equation may suggest a greater self-sufficiency effect as population and market size increases.

[7] The effect of tariffs is absorbed into the time fixed effects.

The coefficient of the exporting countries' GDP was positive and statistically significant across most individual products. This positive relationship between an increase in exporter country income and exports may be indicative of domestic economic growth stimulating both greater production to meet increased domestic demand and improved marketing infrastructures which can facilitate exporting. This is supported by the coefficients for population of exporting country, which were positive and statistically significant for legumes and other vegetables and reflects economies of scale effects. Under the PPML regressions, the coefficients of geographic distance were negative and statistically significant, confirming distance as an important resistance factor in the fresh produce trade between African exporting countries and the UK. PPML regressions show that colonial ties with the UK can have a positive and significant influence on its fresh vegetable imports (with a large enhancement effect).

Focussing on the primary variable of interest in this study, the coefficients of the chlorpyrifos MRL standard were positive and statistically significant for total vegetables, legumes and onions, but did not appear to significantly affect imports of Other Vegetables, implying that trade in vegetables will tend to be greater, the less stringent the standards on pesticide residues, and conversely, that lower MRLs will depress trade. The elasticity with respect to chlorpyrifos standards range from 0.4 to 0.7, and reveal that the trade response to MRL can be relatively high, and this is consistent with other studies (e.g. Otsuki et al., 2001; Chen et al., 2008).

Table 4 presents the PPML regression results for the aggregate commodity group of fruit and for the individual products of citrus, melons and miscellaneous fruit in relation to dimethoate MRLs. The explanatory power of the regression equations was adequate in all cases. The coefficients of GDP in the exporting countries were positive and statistically significant in all equations, again suggesting supply-side income increases may in some way be reflecting a greater level of domestic production and supply chain infrastructure development stimulating exports. The coefficients for the exporting counties' populations were also positive and statistically significant for all the fruit products showing the likely positive contribution from economies of scale effects on trade. The coefficient for the UK GDP and population variables were also positive and highly statistically significant in most of the cases, and again. Colonial ties have a significantly positive impact for trade in fresh fruit, underlining the importance of language, cultural similarities and historical trading links. Coefficients for geographic distance were of the expected negative sign and significant for all of the commodity groups. The coefficient of dimethoate MRL standards was positive and statistically significant in the miscellaneous fruit model and weakly significant for citrus. The MRL coefficient was not significant for the aggregate group of fruit. To sum up the discussion, our results thus far indicate that pesticide residue standards could have a trade limiting effect, although not for all of the commodities examined.

CONCLUSIONS

This study estimated a fixed effects gravity model for fresh fruit and vegetable product exports from emerging and existing African exporting countries to the UK in order to estimate the effects of pesticide MRL standards on trade. However, the way in which zero trade-flows are treated in the conventional log-normal specification of the gravity trade model can result in biased and inefficient estimates. This paper applied a gravity model specification with corrections for the zero trade-flows, the multilateral resistance terms and heterogeneity across terms. In the analysis, the PPML estimation method was used to estimate the fixed effects gravity model using the trade data between the selected African exporting countries and the UK.

Most variables have the expected signs and were statistically significant, consistent with the trade literature. The volume of trade increases with the GDP of the exporting countries and the UK. The volume of trade decreases with geographical distance. The variables describing cultural and economic proximity of countries, such as having ever been in a colonial relationship positively affect the volume of trade. Regarding the impact of MLRs on trade flows, the results were not completely consistent between the commodity groups. However, some commodities do exhibit sensitivity to changes in pesticide MRL standards, with African exports of Legumes, Onions and Total Vegetables and Miscellaneous Fruits likely to be most affected by any alterations in EU MRL standards for chlorpyrifos and dimethoate pesticides. There is clearly still a need for a further and more extensive EU multi member states analysis in order to establish whether there is indeed more widespread and greater responsiveness of developing country exports to maximum pesticide residue limits within the EU than this study was able to identify.

REFERENCES

Anderson, J, 1979. A theoretical foundation for the gravity equation. *American Economic Review* 61(9), 106-116.

Anderson, J. E., E. Van Wincoop, 2003. Gravity with gravitas: a solution to the border puzzle. *American Economic Review* 93(1), 170–192.

Baier, S. L., Bergstrand, J. H., 2001. The growth of world trade: tariffs, transport costs and income similarity. *Journal of International Economics* 53(1), 1–27.

Baltagi, B.H., Egger, P., Pfaffermayr, M., 2003. A generalised design for bilateral trade flow models. *Economics Letters* 80, 391-397.

Bergstrand, J. H., 1985. The gravity equation in international trade: some microeconomic foundations and empirical evidence. *Review of Economics and Statistics* 67 (3), 474–481.

Bergstrand, J. H., 1989. The generalized gravity equation, monopolistic competition and the factor proportions theory in international trade. *Review of Economics and Statistics* 71 (1), 143–153.

Burger, M., Van Oort, F., Linders, G.J., 2009. On the specification of the gravity model of trade: zeros, excessive zeros and zero-inflated estimations. *Spatial Economic Analysis* 4(2), 167-190.

Cameron, A.C., Trivedi, P.K., 1986. Econometric models based on count data: comparisons and applications of some estimators and tests. *Journal of Applied Econometrics* 1, 29-53.

Cameron, A.C., Trivedi, P.K., 1998. *Regression Analysis of Count Data*. Cambridge University Press, Cambridge.

Chan, M. K., 2001. EU pesticide legislation: friend or foe of developing countries? *Pesticide News* 50, 12-13.

Chen, C., Yang, J., Findlay, C., 2008. Measuring the effect of food safety standards on China's agricultural exports. *Review of World Economics* 144 (1), 83-106.

Codex Alimentarius (2012). Accessed October 2012, available at http://www.codexalimentarius.org/codex-home/en/

Crissman, C.C., Cole, D.C., Carpio, F., 1994. Pesticide use and farm worker health in Ecuadorian potato production. *American Journal of Agricultural Economics* 76(3), 593-597.

Deardorff, A.V., 1998. Determinants of Bilateral Trade: Does Gravity Work in a Neoclassical World? In J. A. Frankel, ed., *The Regionalization of the World Economy*. Chicago: University of Chicago Press, pp. 7-22.

Dinham, B., 2003. Growing vegetables in developing countries for local urban populations and export markets: problems confronting small-scale producers. *Pesticide Management Science* 59,575-582.

Disdier, A.C., Head, K. 2008. The puzzling persistence of the distance effect on bilateral trade. *The Review of Economics and Statistics* 90(1), 37-48.

Disdier, A.-C., Marette, S., 2010. The combination of gravity and welfare approaches for evaluating non-tariff measures. *American Journal of Agricultural Economics* 92(3), 713-726.

Disdier, A.-C., Fontagné, L., Mimouni, M., 2008. The impact of regulations on agricultural trade: evidence from the SPS and TBT Agreements. *American Journal of Agricultural Economics* 90(2), 336-350.

Drogue, S., DeMaria, F., 2012. Pesticide residues and trade, the apple of discord? *Food Policy* 37 (6), 641-649.

Eaton, J., Kortum S., 2002. technology, geography and trade. *Econometrica* 70 (5), 1741–1779.

Ecobichon, D.J., 2000. Our changing perspectives on benefit and risks of pesticides: An historical overview. *Neurotoxicology* 21 (1/2), 211-218.

Ecobichon, D.J. 2001. Pesticide use in developing countries. *Toxicology* 160 (1), 27-33.

Egger, E., 2008. On the role of distance for bilateral trade. *World Economy* 31(5), 653-662

Evenett, S. J., W. Keller, 2002: On theories explaining the success of the gravity equation. *Journal of Political Economy* 110, 281–316.

FAO, 1995. Worldwide regulations for mycotoxins 1995: a compendium. Rome, FAO.

Feenstra, R. C., J. A. Markusen, A. K. Rose, 2001. Using the gravity equation to differentiate among alternative theories of trade. *Canadian Journal of Economics* 34 (2), 430–442.

Fontagné, L., Mayer, T., Zignago, S., 2005. Trade in the triad: how easy is the access to large markets? *Canadian Journal of Economics* 38(4), 1401-1430.

Frankel, J.A., 1997. *Regional Trading Blocs in the World Economic System*. Institute for International Economics, Washington, DC.

Ganslandt, M., Markusen, J. R., 2001. Standards and Related Regulations in International Trade: A Modeling Approach, NBER Working Papers 8346.

Garcia-Martinez, M., Poole, N., 2004.The development of private fresh produce safety standards: Implications for developing Mediterranean-exporting countries. *Food Policy* 29 (1), 229–255.

Hallak, J.C., 2006. Product quality and the direction of trade. *Journal of International Economics* 68, 238-265.

Hallam, D., Liu, P., Lavers, G., Pilkauskas, P., Rapsomanikis, G., Claro, J., 2004). The market for non-traditional agricultural exports. Commodities and Trade Technical Paper. Food and Agriculture Organisation of the United Nations, Rome.

Harrigan, J., 2002. Specialization and the Volume of Trade: Do the Data Obey the Laws, in K. Choi and J. Harrigan, eds., *The Handbook of International Trade*. London: Basil Blackwell.

Head, K., 2003. Gravity for beginners. Working Paper, University of British Columbia. Assessed December 2012, available at https://www.nd.edu/~agervais/documents/Gravity.pdf/

Heckman, J., 1979. Sample selection bias as a specification error. *Econometrica* 47(1), 153-161.

Helpman, E., Krugman, P., 1985. *Market structure and foreign trade*. The MIT Press, Cambridge, Massachusetts.

Helpman, E., Melitz, M., Rubinstein, Y., 2008. estimating trade flows: trading partners and trading volumes. *Quarterly Journal of Economics* 73(2), 441-486.

Hummels, D., 2001. *Towards a Geography of Trade Costs.* West Lafayette, indianna: Purdue University.

Kim, S.J., Reinert, K.A., 2009. Standards and institutional capacity: An examination of trade in food and agricultural products. *The International Trade Journal* 23 (1), 54-77.

Li, Y., Beghin, J., 2012. A meta-analysis of estimates of the impact of technical barriers to trade. *Journal of Policy Modeling* 34 (3), 497-511.

Linnemann, H., 1966. *An Econometric Study of World Trade Flows*. North Holland, Amsterdam.

Martinez-Zarzoso, I., Garcia-Menendez, L., Suarez-Burguet, C., 2003. Impact of transport costs on international trade: the case of spanish ceramic exports. *Maritime Economics and Logistics* 5(2), 179–198.

Martínez-Zarzoso, I., Suárez-Burguet, C., 2005. Transport costs and trade: empirical evidence for Latin American imports from the European Union. *Journal of International Trade and Economic Development* 14(3), 353-371.

Maskus, K.. Wilson, J. 2001. *Quantifying the Impact of Technical Barriers to Trade: Can It Be Done?* Ann Arbor, MI*:* University of Michigan Press.

Matyas, L., 1997. Proper econometric specification of the gravity model. *The World Economy* 20(3), 363-368.

McCallum, J., 1995. National borders matter: Canada–US regional trade patterns. *American Economic Review* 85(3), 615–623.

Okello, J.J., Okello, R.M., 2010. Do EU pesticide standards promote environmentally friendly production of fresh export vegetables in developing countries? The evidence from Kenyan green bean industry. *Environment, Development and Sustainability* 12, 341-355.

Otsuki, T., Wilson, J.S., Sewadeh, M., 2001. Saving two in a billion: quantifying the trade effect of European food safety standards on African exports. *Food Policy* 26(5), 495-514.

Owens, E.W., 1986. Social control of pesticides: some health effects. *International Journal of Social Economics* 13(1-2), 93-97.

Paarlberg, R.L., 1993. Managing pesticide use in developing countries, in Haas, P.M., Keohane, R.O. and Levy, M.A., eds.), *Institutions for the Earth: Promoting International Environmental Protection*. Global Environmental Accords Series. MIT press, Cambridge, London, pp.309-350.

Papazoglou, C. ,2007. Greece's potential trade-flows: a gravity model approach. *International Advanced Economic Research* 13, 403-414.

Pimentel, D., Lehman, H., 1993. *The Pesticide Question: Environment, Economics and Ethics*. New York, Chapman and Hall.

Pingali, P.L., Marquez, C.B., Palis, F.G., 1994. Pesticide and Philippine rice farmer health: a medical and economic analysis. *American Journal of Agricultural Economics* 76(3), 587-592.

Rauch, J.E., 1999. Networks versus markets in international trade. *Journal of International Economics* 48, 7-35.

Rose, A., Van Wincoop, E., 2001. National money as a barrier to international trade: the real case for currency union. *The American Economic Review* 91(2), 386-390.

Silva, S., Tenreyro, S., 2006. The log of gravity. *The Review of Economics and Statistics* 88(4), 641-658.

Tinbergen, J., 1962. *Shaping the World Economy.Suggestions for an International Economic Policy*. New York, Twentieth Century Fund.

Trefler, D., 1995. The case of the missing trade and other mysteries. *American Economic Review* 85, 1029–1046.

United Nations Conference on Trade and Development (UNCTAD), 2010. Trade Analysis Information System (TRAINS) within the World Integrated Trade

Solution (WITS). Accessed October 2012, Available at: http://r0.unctad.org/trains_new/prod.shtm/

Vuong, Q.H., 1989. Likelihood ratio tests for model selection and non-nested hypotheses. *Econometrica* 57, 307-333.

Wilson, J.S., Otsuki, T., 2004. To spray or not to spray: pesticides, banana exports and food safety. *Food Policy* 29(2), 131-146.

Wilson, J.S., V.O. Abiola, 2003. *Standards and Global Trade: A voice for Africa.* Washington, DC: The World Bank.

World Health Organisation (WHO), 1990. Public health impact of pesticides used in Agriculture. Geneva, WHO.

Xiong, B., Beghin, J., 2012. Does European aflatoxin regulation hurt groundnut exporters from Africa? *European Review of Agricultural Economics* 39 (4), 589-609.

Table 1: UK (EU) MRLs for selected pesticide standards in fruit and vegetables (in ppm).

	MRL					
Substance	**Vegetables**	**Onions**	**Tomatoes**	**Legumes**	**Citrus**	**Misc. fruit**
Chlorpyrifos	0.52 (1992-2001)	0.2 0 (1992-2005)	0.50 (1992-2005)	0.05 (1992-2005)	0.30 (1992-2005)	0.05 (1992-2005)
	0.10 (2002-2008)	0.05 (2008)	0.5 (2008)	0.05 (2008)-	0.3 (2008)	0.05 (2008)
CODEX	*0.52*	*0.20*	*0.50*	*0.01*	*1.00*	-
Dimethoate	-	-	-		2.00 (1992-2002)	1.00 (1992-2002)
	-	0.02 (2008)	0.02 (2008)	-	0.02 (2003-2008)	0.02 (2003-2008)
CODEX					*5.00*	-

Notes: Codex standard is presented in the table in italics for reference. Missing values indicate there is no standard set.

Table 2: Incidence of residues in UK imports from selected exporting countries 2000-2008.

Exporting Country	Samples analysed	Samples without detected residues	Samples with residues above reporting limit	Samples with residues above MRL
S. Africa	148,171	146,537 (98.9)	1,620 (1.1)	14 (0.01)
Turkey	16,756	16,502 (98.5)	246(1.5)	8 (0.05)
Kenya	22,157	21,962 (99.1)	166 (0.7)	29 (0.13)
Ghana	2,879	2,856 (99.2)	13 (0.5)	10 (0.35)
Morocco	33,006	32,646 (98.9)	356 (1.1)	4 (0.01)
Zambia	8,251	8,237 (99.8)	14(0.2)	0 (0.00)
Zimbabwe	4,256	4,247 (99.8)	8(0.2)	1 (0.02)
Egypt	47,386	46,976 (99.1)	393 (0.8)	17 (0.04)
Cameroon	9,822	9,691 (98.7)	131 (1.3)	0 (0.00)
Cote d'Ivoire	3,515	3,499 (99.5)	15 (0.4)	1 (0.03)
Senegal	1,101	1,092 (99.2)	9 (0.8)	0 (0.00)
Total	297,300	294,245 (98.9)	2,971 (1.0)	84(0.03)

Notes: Number of samples. Values in brackets are percent of samples with the same origin.
Source: Defra: UK residue monitoring programme

Table 3: PPML results for vegetable exports with chlorpyrifos MRL standard.

Parameter	Legumes	Tomatoes	Onions	Potatoes	Other Vegetables	Vegetables (Total)
GDP exporter	0.57 (7.03)***	0.83 (2.28)**	0.10 (2.19)**	0.50 (2.66)**	0.57 (3.34)***	0.36 (2.60)**
GDP importer	1.01 (7.66)***	2.17 (4.28)***	2.59 (6.64)***	0.99 (3.42)***	1.91 (3.08)***	1.19 (2.66)**
Population exporter	4.91 (5.06)***	0.63 (0.82)	2.82 (2.79)**	0.81 (0.23)	8.40 (6.75)***	-0.40 (-1.08)
Population importer	-2.37 (-1.21)	5.36 (2.66)**	8.83 (1.49)	-2.62 (-1.01)	3.23 (0.23)	5.60 (3.90)***
Geographical distance	-0.73 (-2.67)**	-0.65 (-2.06)**	-1.21 (-2.01)**	-1.71 (-2.32)	-2.12 (-5.79)***	-2.30 (2.76)**
MRL standard	0.83 (5.66)***	-	0.51 (2.28)**	-	1.05 (2.50)**	1.01 (2.09)**
Colonial tie	4.44 (8.21)***	0.11 (0.24)	4.48 (6.93)***	1.69 (3.46)***	0.78 (2.46)***	1.94 (2.60)
Constant	-8.89 (-2.42)**	-16.76 (-3.52)**	-19.68 (-4.22)**	13.58 (3.99)**	-40.58 (-0.81)	-27.62 (-4.03)**
Log-likelihood	-1454.47	-425.19	-415.37	-336.13	-1389.68	-430.97
Chi-2 value	431.85	34.63	175.84	19.34	338.28	147.60
Zero obs.	22	16	18	0	0	4
Non-zero obs.	198	64	62	40	180	216
Tot. Obs.	220	80	80	40	180	220

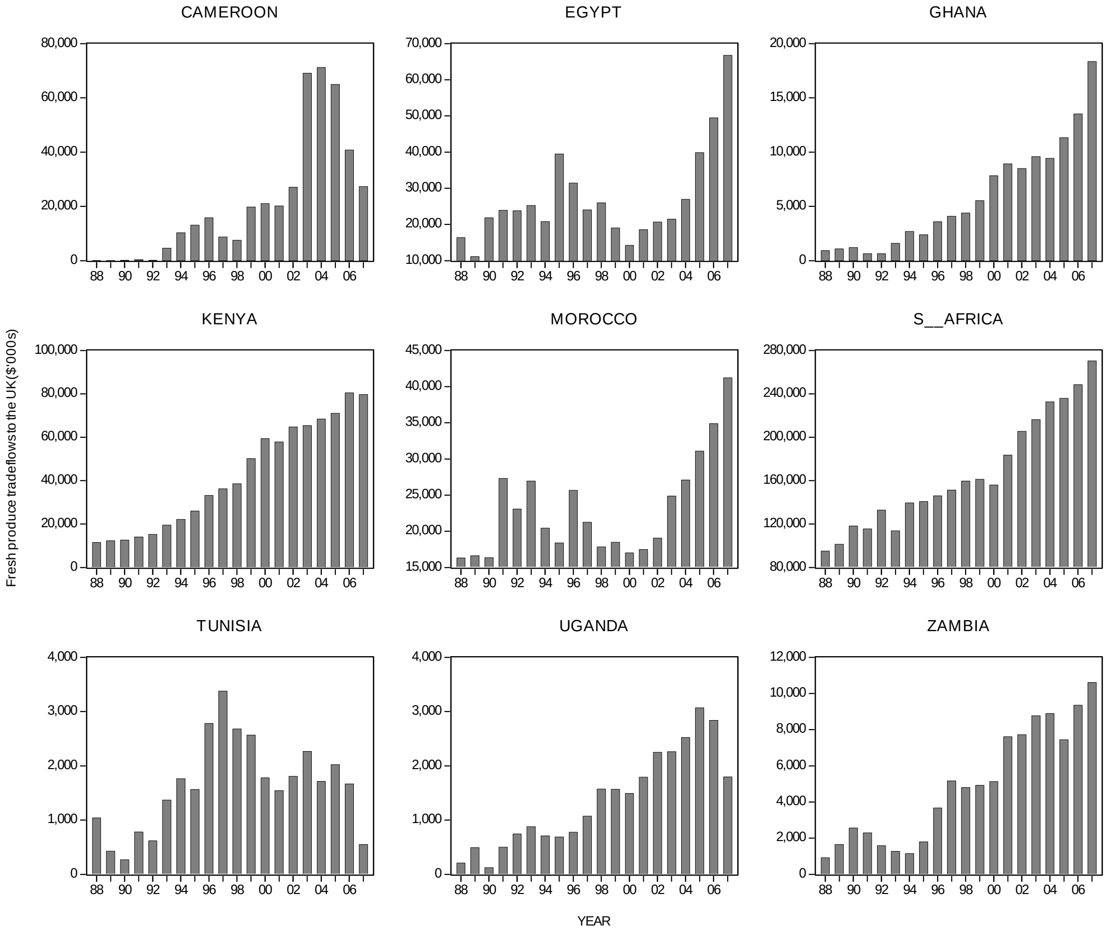
Notes: Fixed effects models used with exporting countries as cross-sections. *, ** and *** imply significance at the 10, 5 and 1 per cent probability level under the two tail test respectively. *t*-statistics are given in brackets. In the aggregate commodity models, the values of the MRLs of pesticides are the simple average values of the MRLs in the individual categories of fruit and vegetable commodities imposed by the UK (EU). Exporting countries in the regression of vegetables include Kenya, Gambia, Zambia, Egypt, S. Africa, Morocco, Uganda, Nigeria, Senegal, Ethiopia and Zimbabwe. Country specific dummies are not reported for brevity purposes.

Table 4: PPML results for fruit exports with dimethoate MRL standard

Parameter	Citrus	Melons	Misc. fruit	Fruit (total)
GDP exporter	1.02	0.84	1.15	0.23
	(3.93)***	(2.46)**	(3.41)***	(2.24)**
GDP importer	0.67	1.24	1.32	0.89
	(3.23)***	(2.66)**	(4.16)***	(8.50)***
Population exporter	1.02	-2.05	4.16	2.02
	(3.93)***	(-1.17)	(4.18)***	(3.53)***
Population importer	4.21	5.02	0.69	-1.61
	(0.47)	(0.47)	(0.04)	(-0.26)**
Geographical distance	-2.57	-0.23	-1.16	-2.89
	(-3.37)***	(-2.19)	(-2.89)	(-2.74)***
MRL standard	0.11	-	0.29	0.28
	(0.90)		(2.33)**	(3.51)***
Colonial tie	3.73	1.30	5.85	4.94
	(3.60)**	(2.76)	(3.57)***	(2.55)**
Constant	13.40	24.18	5.68	17.38
	(0.02)	(3.91)**	(0.49)	(1.61)
Log-likelihood	-227.41	-63.34	-269.51	-534.48
Chi-2 value	111.65	53.32	125.14	406.72
Zero Obs.	-	3	-	7
Non-zero obs.	100	77	140	233
Total obs.	100	80	140	240

Notes: Fixed effects models were used with exporting countries as cross-sections. *, ** and *** imply significance at the 10, 5 and 1 per cent level under the two tail test respectively. t-statistics are given in brackets. Exporting countries in the regression of fruit include S. Africa, Cameroon, Cote d'Ivoire, Kenya, Egypt, Morocco, Ghana, Uganda, Senegal, Tunisia and Zimbabwe. Exporting country specific dummies are not reported.

Figure 1: Exports of fresh fruit and vegetables from selected African exporting countries to the UK (in £'000s).



607