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European's RASFF Border Rejections, African Countries's Reputation and Exports of Edible Vegetables and Fruits

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Abstract

The low level and frequent occurrences of zero trade flows observed between African and European countries are attributable to the increasing number of import refusals in the context of the constraint imposed by the requirement to comply with the food safety standards of the countries of the Rapid Alert System for Food and Feed (RASFF). In this paper, we assess the effects of European countries' import refusals on African exports of edible vegetables and fruits from 2008 to 2018. We specifically estimate the average effects of the RASFF countries' border rejections on the extensive and intensive margins of African countries exports of edible vegetables and fruits. We use the border rejections data from the RASFF online database and export data on 45 African countries from the UN WITS database. We estimate the canonical version of the sectoral gravity equation of Anderson and Van Wincoop (2004) using the Poisson pseudo maximum likelihood (PPML) estimator of Silva and Tenreyro (2006) in association with the robust two-stage residual inclusion (2SRI) approach of Terza et al. (2008). We find that a single increase in the number of import refusals by a RASFF country in the current year leads to a decrease in the number of trade partners in Europe for African countries by 0.018 percent for edible vegetables and 0.143 percent for edible fruits. In addition, our results show that one additional import refusal decreases the export value of African countries' edible vegetables by 0.045 percent. However, we find that RASFF countries' refusal to import once in the current year leads to an increase in the export value of African countries' edible fruit by 0.126 percent. Furthermore, our results explicitly validate the hypothesis of the endogeneity of the number of import refusals and highlight both the direct and spillover effects of border rejections. The latter result means that an increase in the number of border rejections for a given product (for instance, a fresh fruit) in a given year leads to an increase in the number of border rejections for a product and its neighboring products (for instance, a fresh vegetable) in the next year.

Keywords: Africa, Border Rejections, Edible Vegetables and Fruits, Rapid Alert System for Food and Feed, Trade

Classification JE : Q17, Q18, F13, F14.

1 Introduction

Trade between African and European countries in fruit, vegetable and nut products increased from 2008 through 2018. However, over this period, many zero trade flows were observed between African countries and European member countries of the Rapid Alert System for Food and Feed (RASFF) [4]. For instance, during the period 2008-2018, the zero trade flows were 63.68% for edible vegetables and 52.56% for edible fruits (United Nations World Integrated Trade Solutions, UN WITS database [5]). Indeed, in recent years, the use by European Union (EU) member countries of stricter non-tariff measures (NTMs), such as measures related to sanitary and phytosanitary standards (SPSs) and technical barriers to trade (TBTs), has grown in the agrifood and agricultural sectors in an effort to reduce uncertainty over product quality and safety. Although these measures have explicitly no trade objective and are designed to avert sanitary and phytosanitary risks [6], they remain substantial barriers for many African countries in exporting into the

[4] The RASFF network includes 32 member states, which are the 28 EU member states, Switzerland, Norway, Liechtenstein and Iceland.

[5] https://wits.worldbank.org

[6] Sanitary risk refers to food-borne human illness and animal diseases, and phytosanitary risk refers to risks from plant pests and the transmission of disease.

EU market (Kareem et al., 2017; Otsuki et al., 2001; Shepherd and Wilson, 2013). Noncompliance with food quality and safety standards in force in the EU represents the main reason for the refusal of African countries' exports at the borders of European RASFF network countries and the main reason for numerous product recalls (alerts) in these markets. For example, RASFF (2014) reported that violations of maximum residue limits (MRLs) for pesticides, a particular SPS measure, constituted approximately 70% of EU border rejections of all African fruit and vegetable exports between 2008 and 2013. Because of noncompliance with EU food standards, Baylis et al. (2011) have also provided evidence that noncompliance with EU food standards were responsible for several bans on the importation of fish and fish products from Kenya and, by extension, Lake Victoria in the EU market in the late 1990s. In addition, we found from the RASFF database [7] that the number of products recalls from RASFF network countries' markets and the number of border rejections affecting African exports grew rapidly between 2008 and 2019. For example, we found persistent border rejections for some African countries' exports, with a notable example being Sudanese exports to Greece, from 2018 to 2019. Greece rejected 368 times the products classified in harmonized system (HS) category 1207 (other oil seeds and oleaginous fruits) exported by Sudan in 2018 and did so for 650 times in 2019.

The RASFF 2018 annual report (p.37) [8] shows that the majority of EU border rejections are related to mycotoxins (508 records), followed by pathogenic microorganisms (302 records), pesticide residues (154 records), and poor or insufficient controls (104 records). In the same report, it appears that the products more affected by EU border rejections are nuts, nut products and seeds (553 records), followed by fruits and vegetables (237 records), and fish and fish products (107 records). These data imply that EU border rejections are related to technical NTM conformity issues, and they concern products exported by African countries more than other countries. For example, in appendix A, figure 1 shows that the most commonly traded agricultural products between African and RASFF member countries are those classified in harmonized system (HS) category HS08 (fresh, chilled or frozen fruits), followed by HS03 (fresh, chilled or frozen fish and crustaceans), HS07 (fresh, chilled or frozen vegetables), and HS20 (preparations of vegetables, fruit and nuts). Figure 2 in appendix A indicates that these products are more affected by RASFF border rejections than other product groups for African countries, except for preparations of vegetables, fruit and nuts (HS20), which are less affected. This may be because the products classified in category HS20 are more processed, so they are less perishable and less likely to be rejected. In addition, figure 3 in appendix A shows that the trend in RASFF border rejections for products from African countries increased from 2008 to 2018. Figure 4 shows that the African country most affected by RASFF border rejections is Egypt, followed by Morocco, Nigeria, Sudan, Ghana, Mauritania, Tunisia, South Africa, Kenya, Ethiopia, Namibia and Gambia. Figure 5 indicates that these countries trade with RASFF member countries more than other African countries, with Morocco, South Africa, Kenya, Cote d'Ivoire and Egypt being the five largest African exporters. The noncompliance of African exporters with technical NTMs in force in RASFF member countries, resulting in border rejections of export shipments, may be due, on the one hand, to the higher compliance costs for African countries because they have deficient infrastructures and insufficient technical and storage capacities (Beestermöller et al., 2018; Kareem et al., 2017; Xiong and Beghin, 2012), and they often have limited access to certification bodies (Essaji, 2008). On the other hand, the border rejections or alert

[7]The RASFF Database is available at https://webgate.ec.europa.eu/rasff-window/portal
[8]The RASFF 2018 annual report is available at https://ec.europa.eu/food/safety/rasff_en

cases may also be due to the stringent quality and safety standards set by RASFF member countries, accompanied by stricter border inspections for countries with a lower probability of conforming with these standards. As a result, many African countries may fail to export to the RASFF market, and one may find a larger proportion of zeros in trade flows between African countries and these developed countries. In fact, complying with stringent EU standards entails higher compliance costs for African countries, which may discourage potential exporters in Africa from penetrating EU markets, drive away less productive exporters, and decrease both the probability of exporting and trade volume (Bao and Chen, 2013). Thus, the lower observed trade volume and the excessive zeros in trade flows between African and RASFF member countries may be attributed to stringent EU quality and safety standards and the EU's stricter border inspections for countries with less stringent standards and to the higher fixed and variable compliance costs for African exporters. However, this may also be due to data censoring issues.

The objective of this paper is to assess the effects of EU border rejections on African exports of edible vegetables and fruits during the period from 2008 through 2018. In particular, we estimate the average effects of the European RASFF network countries' border rejections on the extensive margin (number of trade partners) and intensive margin (trade value) of African exports of the two plant product categories by controlling for the possible endogeneity of the current number of border rejections and addressing the issue of zero trade flows. The choice of edible vegetables and fruits and European RASFF countries as partners is motivated by four main reasons. First, fruit and vegetable products play a significant role in export earnings and economic growth for many African countries. Indeed, these products constitute the main agricultural products traded between African and RASFF member countries. Second, the RASFF member countries are the largest importers of tropical fresh fruits and vegetables in which African countries have comparative advantages. Third, fresh fruit and vegetable products are more often subject to RASFF country border rejections than other product groups. Finally, these products attract stringent border controls due to their perishable nature and susceptibility to food safety risks. Hence, since African countries' exports of fruit and vegetable products depend heavily on RASFF member countries, it is important to determine the extent to which border rejections by the latter affect the exports of the former. Using border rejection data for European countries obtained from the RASFF online database and export data on 45 African countries from the UN WITS database for the period 2008-2018, we estimate the canonical version of the sectoral gravity equation of Anderson and Van Wincoop (2004) using the Poisson pseudo maximum likelihood (PPML) estimator of Silva and Tenreyro (2006) in association with the robust two-stage residual inclusion (2SRI) approach of Terza et al. (2008).

We depart from the literature in estimating the effects of border rejections on bilateral trade by explicitly validating and correctly addressing the issues of the *endogeneity* of border rejections and *zero trade flows* by jointly employing the 2SRI robust approach and the unbiased and consistent PPML estimator. Indeed, many previous studies (Baylis et al., 2011; Beestermöller et al., 2018; Grant and Anders, 2011; Kareem et al., 2017) have investigated the effects of border rejections on the exports of third countries without explicitly addressing the concern of the *endogeneity* of border rejections and appropriately addressing the issue of *zero trade flows*. The endogeneity of border rejections may arise from omitted variable bias that influences trade value and is correlated with the number of border rejections. For example, one might find that the unobserved quality of a product in the data can affect both the value of trade and the number of border rejections affecting this product. In addition, the endogeneity of border rejections arises as result of their simultaneity with trade value because we find that the number of import refusals is highly and positively correlated with trade value. For instance, figure 3 in appendix A shows that African countries that are more affected by RASFF border rejections trade more with RASFF member countries than do other countries. To address the issues of endogeneity and zero trade flows, previous studies have generally adopted traditional instrumental variable (IV)-based approaches with a simple ordinary least squares (OLS) method. Terza et al. (2008) show that the use of the two well-known traditional IV-based approaches, two-stage least squares (2SLS) and two-stage predictor substitution (2SPS), may sometimes be appropriate for addressing the concern of endogeneity in linear regression models, but 2SLS and 2SPS are both inconsistent in the case of nonlinear regression models, such as a structural gravity trade model. Furthermore, the use of OLS is problematic because this approach requires log-transforming the dependent trade variable and dropping the zero trade flows. Hence, the clear drawback of OLS is that this approach cannot take into account the information contained in the zero trade flows. The problem with zero trade flows becomes especially pronounced in the context of border rejections. Following our empirical strategy, we explicitly validate the hypothesis of the endogeneity of the number of import refusals and highlight both the direct and spillover effects of border rejections. The latter result means that an increase in the number of border rejections for a given product (for instance, a fresh fruit) in a given year leads to an increase in the number of border rejections for a product and its neighboring products (for instance, a fresh vegetable) in the next year. We also find that a single increase in the number of import refusals by an RASFF country in the current year leads to a decrease in the number of trade partners in Europe for African countries by 0.018 percent for edible vegetables and 0.143 percent for edible fruits. In addition, our results show that one additional import refusal decreases the export value of African countries' edible vegetables by 0.045 percent. However, we find that a single import refusal by RASFF countries in the current year leads to an increase in the export value of African countries' edible fruits by 0.126 percent.

The estimation strategy deployed in the literature to estimate the effects of border rejections on the exports of third countries is, in general, the standard inconsistent and biased OLS method. For example, Beestermöller et al. (2018) used a two-step procedure and an OLS method at each step to assess both the direct and spillover effects of RASFF border rejections on Chinese exporters. They did not take into account the endogeneity of border rejections. Baylis et al. (2011) deployed an OLS method to estimate a gravity equation to assess the trade diversion and deflection effects of EU import refusals of fishery and seafood products. Although they seem to find unbiased and consistent estimates with this approach by deleting zero trade values, there is a potential for selection bias, and there remains the issue of controlling for possible spillover effects between related fishery and seafood products classified in different HS 6-digit product categories in their database. Grant and Anders (2011) followed the same approach and method as Baylis et al. (2011) to estimate the magnitudes of trade deflection resulting from United States Food and Drug Administration (US FDA) import refusals of fishery and seafood products. Although these authors seem to obtain unbiased and consistent estimates by segmenting their data into four cross-sections, there remains the issue of controlling for possible spillover effects between related fish and seafood products classified in different HS 4-digit product categories in their database.

The remainder of this paper is organized as follows. In section 2, we define and explain what drives a country's reputation for a product and the spillover effects of reputation. Section 3 presents our theoretical trade models and estimation strategy. In section 4, we describe our data. We present and discuss the empirical results in section 5. In the final section, we draw conclusions.

2 A Country's Reputation for a Product and the Spillover Effects of Reputation

The reputation of a country for a particular product is defined as its ability to produce and export this product in conformity with the quality and safety standards of the country in which that reputation is held (Dimitrova et al., 2017). The quality and safety standards include sanitary and phytosanitary risk mitigation measures, such as TBT and SPS measures. Hence, the reputation of a country for a particular exported product may depend not only on the investments the country has made to meet SPS and TBT requirements related to this product but also on the likelihood that this country will successfully pass through strict border controls. An exporting country may be considered to exhibit a good/bad reputation for a specific product in a given importing country if this country succeeds/fails one or several times to pass this product through the border of the importing country. The highlighted main reason for noncompliance by developing countries is the higher investment cost required to meet the stringent standards set by developed countries because developing countries face deficient infrastructures and insufficient technical and storage capacities (Beestermöller et al., 2018). However, several recent studies (Baylis et al., 2009, 2011; Jouanjean et al., 2015; Beestermöller et al., 2018) on import refusals indicate that inspections at the borders by customs officers are not random, and hence neither is the decision to reject a product. Indeed, identifying unsafe products may be too costly (in terms of money and time), so customs officers focus their controls on a particular country, firm or product to minimize the probability of a noncompliant good entering the importing country or to maximize the likelihood of identifying a fraudulent shipment. The particularity is related to the higher sanitary and/or phytosanitary risks that may be intrinsically associated with specific products (e.g., perishable products) or related to certain countries or firms that have frequently experienced border rejections. In general, this risk is established on the basis of a preexisting alert, information from other countries' inspections, or past refusals affecting that country, firm or product. For example, (Baylis et al., 2009; Jouanjean et al., 2015) show that the probability of rejecting a given product depends on the past reputation of this product, the past reputation of similar products and the past reputation of neighboring countries that export the same product. This mechanism is known in the literature as the *"direct reputation for a product and reputation spillover effect of related products"*. The implication of this mechanism is that the exporting country's reputation for a particular exported product (measured by the number of its shipments rejected at the border) in a given importing country is endogenous. Hence, to estimate an unbiased and consistent effect of an exporting country's reputation for a particular product on bilateral trade, we must account for such endogeneity. We do so by instrumenting the number of current import refusals affecting a particular exporting country i and product k using the lagged border rejection of this product ($\text{Refusal}^{k}_{\text{ijt}-1}$) and the lagged border rejection of related products r ($\text{Refusal}^{r}_{\text{ijt}-1}$). The econometric model is defined as follows:

$$\text{Refusal}^{k}_{\text{ijt}} = \theta_0 + \underbrace{\theta_1 \text{Refusal}^{k}_{\text{ijt}-1}}_{\text{Rejection History}} + \underbrace{\theta_2 \text{Refusal}^{r}_{\text{ijt-1}}}_{\text{Rejection History in Related Products}} + \underbrace{\theta_3 \omega^{\text{k}}_{\text{ijt-1}}}_{\text{Lagged Market Share}} + \theta_4 \ln DIST_{ijt} + \theta_5 \text{CINY}_{ij} + \varepsilon^{k}_{ijt} \tag{1}$$

where i, j, k and t indicate exporter, importer, product, and year, respectively. $Refusal^{k}_{ijt}(Refusal^{k}_{ijt-1})$ denotes the number of import refusals affecting product k exporting from origin country i to importing country j in year t(*t-1*). $Refusal^{r}_{ijt-1}$ denotes the number of import refusals affecting related product r other than product k exporting from origin country i to importing country j in year *t-1*. ω^{k}_{ijt-1} measures the market share of exporting country i over the total imports of importing country j of product k from the world in year *t-1*. $\ln D\text{IST}_{ijt}$ is the logarithm of the distance between the origin country i and the importing country j at time t. CINY_{ij} is a dummy variable taking value 1 if origin country i and importing country j have been in colonial relationship and 0 otherwise. As the number of import refusals is a count model, we use the Poisson model to estimate equation (1) and compute Anscombe (1948)'s residuals that will be included in the trade model as an additional variable to control for endogeneity.

3 The Trade Models

In this section, we present the theoretical frameworks that we follow to analyze the effects of the European RASFF network countries' border rejections on the extensive and intensive margins of African exports of edible fruits and vegetables.

3.1 Intensive margin

As a foundation for our analysis of the intensive margin, we use the gravity model of trade that predicts that the international trade between two countries is directly proportional to the product of their sizes and inversely proportional to the trade frictions between them. We use the canonical version of the Anderson and Van Wincoop (2004) sectoral gravity equation:

$$X^{k}_{ijt} = \frac{Q^{k}_{it} E^{k}_{jt}}{Q^{k}_{t}} \left(\frac{\tau^{k}_{ijt}}{P^{k}_{it} \Pi^{k}_{jt}} \right)^{1-\sigma^{k}} \tag{2}$$

where X^{k}_{ijt} is the export value of product k from origin country i to importing country j at time t. Q^{k}_{t} is the value of global production of product k at time t. τ^{k}_{ijt} is the iceberg bilateral trade cost between origin country i and importing country j at time t. E^{k}_{jt} is the amount of income allocated to the consumption of product k in importing country j at time t. Q^{k}_{it} is the production value of product k in origin country i at time t. Π^{k}_{jt} and P^{k}_{it} are the unobservable inward and outward multilateral resistance terms, respectively. These terms are theoretically constructed, and they capture the incidence of trade costs on the consumers in importing country j and on the producers in origin country i. $\sigma^{k} > 1$ is a parameter capturing the elasticity of substitution between varieties (origins) of product k.

To capture the effect of reputation for a particular plant product on African exports of this product to European RASFF network countries, we extend the standard specification of the bilateral trade cost by including an additional variable ($Refusal^k_{ijt}$) that measures the number of import refusals affecting product k exporting from origin country i to importing country j in year t. Specifically, we specify the iceberg bilateral trade costs (τ^k_{ijt}) as follows:

$$(\tau^k_{ijt})^{1-\sigma^k} = \exp\left(^{\gamma_d \ln DIST_{ijt} + \gamma_c \text{CINY}_{ij} + \gamma_{br} \text{Refusal}^k_{ijt}}\right) \tag{3}$$

where $\ln DIST_{ijt}$ is the logarithm of the distance between origin country i and importing country j at time t. CINY_{ij} is a dummy variable taking value 1 if origin country i and importing country j have been in colonial relationship and 0 otherwise. We do not take into account the tariffs and the contiguity variables because, on the one hand, EU tariffs do not vary across EU member countries and, on the other hand, African countries do not share a common border with EU countries. In addition, we do not include the variable common language LANG_{ij} because it appears to be collinear with the colonial relationship variable CINY_{ij} in our data set. As defined above, for an exporting country i, a specific product k and a given importing country j at time t, the variable ($Refusal^k_{ijt}$) measures the number of import refusals affecting product k, which indicates the reputation for this specific product k at time t.

We obtain the econometric model for the intensive margin by plugging equation (3) into the structural sectoral gravity equation (equation (2)) and then augmenting this equation with an error term as follows:

$$\begin{aligned} X^k_{ijt} = \quad & \exp\Bigg(ln(Q^k_{jt}) + ln(E^k_{it}) - ln(Q^k_t) - (1-\sigma^k) ln(P^k_{it}) - (1-\sigma^k) ln(\Pi^k_{jt}) \\ & + \gamma_d \ln DIST_{ijt} + \gamma_c \text{CINY}_{ij} + \gamma_{br} \text{Refusal}^k_{ijt} \Bigg) \times \vartheta^k_{ijt} \end{aligned} \tag{4}$$

where ϑ^k_{ijt} is a random error term. To control for the unobservable multilateral resistance terms, we follow Anderson and Yotov (2010) and Yotov et al. (2016) by using importer-time and exporter-time fixed effects to account for country-time-specific effects. Specifically, we use fe^k_{jt} to denote the set of importer-time fixed effects that will account for the inward multilateral resistance term Π^k_{jt} and fe^k_{it} to denote the set of exporter-time fixed effects that will control for the outward multilateral resistance term P^k_{it}. In addition, the exporter-time and importer-time fixed effects will absorb the exporter's output (Q^k_{it}) and importer's expenditure (E^k_{jt}) and all other possible observable and unobservable importer-time- or exporter-time-specific characteristics. The final econometric model is now completed by substituting the multilateral resistance terms (Π^k_{jt} and P^k_{it}) for the importer-time and exporter-time fixed effects (fe^k_{jt} and fe^k_{it}).

$$X^k_{ijt} = \exp\left(\alpha_0 + \gamma_d \ln \text{DIST}_{ji} + \gamma_c \text{CINY}_{ij} + \gamma_{br} \text{Refusal}^k_{ijt} + fe^k_{it} + fe^k_{jt}\right) \times \vartheta^k_{ijt} \tag{5}$$

Consistent with the structural gravity equation (2), the parameters of equation (5) are defined as follows: $\alpha_0 = Q^k_t$. Since we use the number of import refusals as the measure of a country's reputation for a product, *we expect that* γ_{br} *should be negative*. It captures the average effect of reputation for a particular product on African exports of this product to the RASFF market.

3.2 Extensive margin

Beyond the intensive margin, we pay particular attention to the extensive margin in explaining the observed trade patterns between African and RASFF member countries. Indeed, because of the information shared through the RASFF tool, one import refusal in a given European country will affect the reputation of the rejected country and then clearly decrease the probability that this exporting country will enter into the other RASFF countries. As a result, both the trade volume and the number of trade partners in Europe for African countries will be affected after a border rejection. A wide variety of definitions have been proposed for the extensive margin in theoretical (Melitz, 2003; Chaney, 2008; Helpman et al., 2008) and empirical (Hillberry and Hummels (2008); Eaton et al. (2004); Berthou and Fontagné (2008); Hillberry and McDaniel (2002); Hummels and Klenow (2005); Dennis and Shepherd (2007) and Helpman et al. (2008)) frameworks. According to these frameworks, among the universe (N_i^k) of firms operating in a given sector k and exporting country i, only firms that exhibit a productivity level greater than a threshold value can export into a given importing country j. Firms with a low productivity level will not be able to sell in foreign markets, while firms that reach the threshold productivity will be indifferent between selling in domestic and foreign markets. The threshold productivity is the one that equalizes the variable export profits to the fixed export costs.

Given that we are interested in capturing the spillover effect of reputation, it follows that we are interested not only in the probability of an exporting country entering a market but also in its ability to expand the market. Therefore, we define our extensive margin as the number of trade partners in Europe for African countries. We begin with the ratio (D_{ijt}^k) of Helpman et al. (2008) defined as the variable export profits over the fixed export costs, expressed as follows:

$$D_{ijt}^k = \frac{(1-\alpha^k)(\Pi_{jt}^k \frac{\alpha^k}{c_i^k \tau_{ijt}^k})^{\sigma^k - 1} E_{jt}^k a_L^{1-\sigma^k}}{c_i^k f_{ij}^k} \tag{6}$$

where D_{ijt}^k is greater than one for all of the exporting firms that will find it profitable to export to country j. This ratio is lower than one for firms that will not earn enough from exporting to country j to cover the fixed export costs ($c_i^k f_{ij}^k$). The indifferent firms will have a ratio equal to one. α^k is a parameter that determines the elasticity of substitution ($\sigma^k > 1$) across varieties of product k, with $\sigma^k = \frac{1}{1-\alpha^k}$. Π_{jt}^k is the unobservable inward multilateral resistance term. E_{jt}^k is the amount of income allocated to the consumption of product k in importing country j at time t. τ_{ijt}^k is the iceberg bilateral trade cost between origin country i and importing country j at time t. c_i^k measures the marginal cost in exporting country i, and f_{ij}^k indicates the fixed export cost coefficient. a_L is the lower bound of the distribution of productivity across firms in exporting country i.

As in Helpman et al. (2008), we define the fixed export costs (f_{ij}^k) as a function of the fixed trade barriers imposed by the importing country on all exporters ($\phi_{IM,j}^k$), the fixed export costs common across all export destinations ($\phi_{EX,i}^k$), and any observed additional country-pair-specific fixed trade costs (ϕ_{ij}^k). Given these factors, the fixed export costs (f_{ij}^k) can be expressed as follows:

$$f_{ij}^k = \exp\left(\phi_{EX,i}^k + \phi_{IM,j}^k + \zeta \phi_{ij}^k - \bar{\eta}_{ij}^k\right) \tag{7}$$

Using the specification of the iceberg bilateral trade costs (τ_{ijt}^{k}) in equation (3) together with the fixed export costs (equation (7)), we define a latent variable $T_{ijt}^{k} \equiv ln(D_{ijt}^{k})$ as follows:

$$T_{ijt}^{k} = \gamma_0 + fe_{it}^{k} + fe_{jt}^{k} + \gamma_d \ln \text{DIST}_{ijt} + \gamma_c \text{CINY}_{ij} + \gamma_{br} \text{Refusal}_{ijt}^{k} + \eta_{ijt}^{k} = \psi\gamma + \eta_{ijt}^{k} \quad (8)$$

where $\eta_{ijt}^{k} \sim \mathcal{N}(0,1)$. $fe_{it}^{k} = -\sigma^k ln(c_i^k) - \phi_{EX,i}^{k}$ represents exporter-product fixed effects and $fe_{jt}^{k} = (\sigma^k - 1)ln(\Pi_{jt}^{k}) + ln(E_j^k) - \phi_{IM,j}^{k}$ indicates importer-product fixed effects. ψ is the set of explanatory variables that determines the latent variable T_{ijt}^{k} and γ, the associated parameters to be estimated.

To obtain the number of trade partners, we define an indicator variable $d_{ijt}^{k} = 1$ if $D_{ijt}^{k} > 1$ or $T_{ijt}^{k} > 0$, with $d_{ijt}^{k} \sim \mathscr{B}\Big(p = Pr(d_{ijt}^{k} = 1) \equiv Pr(T_{ijt}^{k} > 0)\Big)$

Next, let Ω_i^k be the universe of possible importing countries of product k originating from country i. Then, let us define $EM_{it}^{k} \leq \Omega_i^k$ as the observed number of trade partners of exporting country i at time t. It follows that these observed trade partners (j) are those for which the latent variable (T_{ijt}^{k}) is greater than zero ($T_{ijt}^{k} > 0$ or $D_{ijt}^{k} > 1$) or the indicator variable (d_{ijt}^{k}) is equal to one ($d_{ijt}^{k} = 1$). For the remaining number ($\Omega_i^k - EM_i^k$) of trade partners, the latent variable will be lower than zero ($T_{ijt}^{k} < 0$ or $D_{ijt}^{k} < 1$), and then the indicator variable (d_{ijt}^{k}) will be equal to zero ($d_{ijt}^{k} = 0$).

Given the definitions and assumptions on the indicator variable d_{ijt}^{k} and the latent variable T_{ijt}^{k}, we now define the extensive margin as follows:

$$\begin{aligned} EM_{it}^{k} = \quad & \textstyle\sum_{j=1}^{\Omega_i^k} (d_{ijt}^{k} | D_{ijt}^{k} > 1) \equiv \sum_{j=1}^{\Omega_i^k} (d_{ijt}^{k} | T_{ijt}^{k} > 0) \\ & = \Omega_i^k \times \left[1 - \textstyle\prod_{j=1}^{\Omega_i^k} \Big(1 - \Phi(\psi\gamma)\Big)\right] \end{aligned} \quad (9)$$

where $\prod$ is the product operator and $\Phi(.)$ is the normal cumulative density function (cdf). Given that our extensive margin EM_{it}^{k} is a count variable by definition, we specify equation (9) as a Poisson model.

3.3 Estimation Strategy

To estimate equation (5) for the intensive margin and equation (9) for the extensive margin, we first control for the endogeneity of the number of import refusals and then address the issue of zero trade flows. We follow the 2SRI approach of Terza et al. (2008) to address the issue of the *endogeneity* of border rejections (Refusal_{ijt}^{k}) and take into account the *zero trade flows* by using the PPML estimator of Silva and Tenreyro (2006). Indeed, Terza et al. (2008) show that the use of the two well-known traditional IV-based approaches, 2SLS and 2SPS, may sometimes be appropriate to address the concern of endogeneity in linear regression models, but these two methods are both inconsistent in the case of nonlinear regression models, such as a structural gravity trade model. Silva and Tenreyro (2006) propose the PPML estimator to estimate the structural gravity equation in levels rather than translating it into a logarithmic form that requires dropping the zero trade observations. The PPML estimator is more robust than standard OLS because it controls for heteroskedasticity and exploits the information contained in zero trade flows.

As suggested by Terza et al. (2008), to implement the 2SRI estimation procedure, in the first stage, we estimate the reduced-form equation, which is the number of import refusals defined by equation (1), with a Poisson model and then compute the residuals. In the second stage, we include the computed residuals of border rejections as additional regressors in the trade equations (5) and (9). We use the residuals of Anscombe (1948) because the normality assumption for the use of the control function method is not satisfied. Indeed, the number of import refusals is a count variable that follows a Poisson distribution instead of a normal distribution. The Anscombe approach transforms a non-normally distributed variable into one that follows a Gaussian distribution (Anscombe, 1948).

4 Data

We combine 32 European individual country' border rejection data from the RASFF online database [9] with country-level HS 2-digit product export data on 45 African countries from the UN WITS database [10] for the period 2008–2018. The RASFF, initiated by the European Commission in 1979, is a tool that enables its 32 member countries (28 EU Member States, Norway, Liechtenstein, Iceland and Switzerland) to share information related to food safety risks and actions that have been taken to avert these risks. When a member country detects a food safety risk with a given import shipment at its border, the following possible actions are taken and shared in terms of notification with other members through the RASFF platform: *detain, return, reject or destroy the product, etc*. A notification shared through the RASFF provides details on the hazard type, name, category and origin of products, date (daily), action taken, etc. However, the description and classification of products in the RASFF database are not the same as described and classified in the HS product description and classification.

One of our contributions in this paper is that we developed a replicable program in the Stata software[11], which is available upon request, to match the RASFF data with the UN WITS HS 6-digit trade data. Indeed, to identify and classify a product in the RASFF border rejection database into an HS 6-digit product category, we need to treat verbal description records in a variable named *subject* (e.g., "*pyridalyl (0.05 mg/kg - ppm) in chilled strawberries from Egypt*") and aggregated information contained in a variable named *product category* (e.g., "*fruits and vegetables*"). Our Stata program uses the *split* function to split (separators are commas and space)s the variable *subject* and applies the looping commands (*foreach and forvalues loops*) with the *regexm* function to search for key words related to *product name* (e.g., strawberries) and *product state* (e.g., fresh, chilled, frozen, dried, powder, juice, cooked, preserved, or desiccated) to obtain an HS description (e.g., chilled strawberries) of products targeted by a notification. For each notification, the program assigns an HS 6-digit product code by exploiting the information related to the *name* and *state* of the product identified through the variable *subject* and the information from *product category*. For the assignment, we used the 1992 version of the HS product description and classification. We identified an HS 6-digit product code for 99.97% of notifications. We then matched the codified notification data with our UN WITS HS 6-digit trade data. Due to the frequent occurrences of zero trade flows and border rejections at disaggregated level, we aggregate all border rejections

[9] https://webgate.ec.europa.eu/rasff-window/portal
[10] https://wits.worldbank.org
[11] We thank Ms. Cécile Le-Roy, a data management officer at the French National Institute of Research for Agriculture (INRA) in Nantes, for her helpful contributions in elaborating the replicable program in Stata.

and exports by exporter-importer-year at the HS 2-digit level. We used the export data between African and RASFF countries in edible fruits (HS 08) and vegetables (HS 07) for the period 2008-2018.

Table 1 provides summary statistics for trade, border rejections and some gravity variables. The table shows that the annual average bilateral trade value is higher for edible fruits (4.304 million US dollars with a standard deviation of 32.818), followed by edible vegetables (1.818 million US dollars with a standard deviation of 19.949). Figure 6 shows that the trend in trade between African and RASFF countries increased from 2008 to 2018. However, in table 1, we find that there are still many zero trade flows between them. For instance, the zero trade observations represent 63.68% for edible vegetables and 52.56% for edible fruits and nuts. The average market share of African countries over the total imports of European countries is very low, 0.1% for edible vegetables and 0.2% for edible fruits and nuts.

Table 1: Summary statistics

Continous variables	Obs	Mean	Std. Dev.	Min	Max
Trade value of edible vegetables (in 1000 USD)	11842	1817.872	19949.256	0	685725.33
Trade value of edible fruits and nuts (in 1000 USD)	11563	4303.946	32817.669	0	850877.71
Number of trade partners in Europe for edible vegetables (in number)	11842	11.259	8.486	0	31
Number of trade partners in Europe for fruits and nuts (in number)	11563	14.705	8.797	0	31
Number of border rejections of edible vegetables (in number)	11842	.032	1.241	0	123
Number of border rejections of edible fruits and nuts (in number)	11563	.013	.199	0	11
Market share for edible vegetables (in percent)	11842	.001	.009	0	.243
Market share for edible fruits and nuts (in percent)	11563	.002	.008	0	.157
Log of Distance	11842	8.604	0.463	5.993	9.353
Binary variables	Obs	Dummy	Frequency (%)		
Binary trade of edible vegetables	11842	0 1	63.68 36.32		
Binary trade of edible fruits and nuts	11563	0 1	52.56 47.44		
Pair in colonial relationship post 1945	11842	0 1	97.15 2.85		

Table 1 shows that the edible vegetables are more affected by RASFF border rejections than other product categories. On average, edible vegetables originating from African countries have been rejected by RASFF member countries more than once (1.241 times) per year, and edible fruits and nuts have been refused more than once (0.199 times) per year. Figure 3 in appendix A shows that the trend in RASFF border rejections affecting African countries increased from 2008 to 2018. Figure 4 in appendix A shows that the African country that is most affected by RASFF border rejections is Egypt, followed by Morocco, Nigeria, Sudan, Ghana, Mauritania, Tunisia, South Africa, Kenya, Ethiopia, Namibia and Gambia. Figure 5 in appendix A indicates that these countries trade more with RASFF member countries than other countries, with Morocco, South Africa, Kenya, Cote d'Ivoire and Egypt being the five largest African exporters.

Finally, we use two traditional gravity variables from the CEPII database [12] as control variables for the other trade costs. These variables include the population-weighted distance between exporting and importing countries and

[12]CEPII is the Centre d'Etudes Prospectives et d'Informations Internationales. The CEPII database is available at http://www.cepii.fr.

a dummy variable indicating a past colonial relationship between exporting and importing countries. The weighted distance between African and European countries is, on average, 5,453.430 km. The pairs of countries that had a colonial relationship after 1945 represent 2.85%.

5 Results and Discussions

This section presents the results of the effects of European RASFF border rejections on the exports of edible vegetables and fruits from African countries. As we instrument the number of current import refusals affecting a particular exporting country *i* and product *k*, we first present these results in table 2. Our results highlight both the direct and spillover effects of border rejections. Indeed, we find that the border rejections of one of the two plant product categories (edible vegetables (HS 07) and edible fruits and nuts (HS 08)) one year before positively and significantly affect the current number of import refusals of both categories. Specifically, table 2 shows that an increase in import refusals affecting edible vegetables once in the previous year increases the number of current import refusals of edible vegetables and edible fruits and nuts by 0.033 and 0.062 percent, respectively. Similarly, we find that an increase in import refusals affecting edible fruits once in the previous year increases the number of current import refusals of edible fruits and nuts and edible vegetables by 0.356 and 0.452 percent, respectively. Our results show that an increase in African countries' export shares of edible vegetables and fruits over the total imports of the RASFF countries in the previous year substantially increases the number of current import refusals of these products, by 5.620 and 30.24 percent, respectively. As expected, we find that the distance between the African and RASFF member countries decreases the number of current import refusals for both plant product categories. African countries that had previously been in colonial relationships with RASFF member countries are more likely to experience import refusals for edible vegetables.

Table 2: Border Rejection Estimation Results

	Poisson model	
	HS 07: Edible vegetables	HS 08: Edible fruits and nut
Constant	3.642*** (0.785)	5.603*** (0.045)
Log distance (lnDIST_ijt)	-0.947*** (0.094)	-1.534*** (0.099)
Colony (CINY_ij)	3.628*** (0.123)	-3.028 (1.985)
Lagged Border rejections for product HS07	*0.033**** *(0.002)*	*0.062**** *(0.018)*
Lagged Border rejections for product HS08	*0.452**** *(0.029)*	*0.356**** *(0.029)*
Lagged Market share for product HS07	5.620*** (1.179)	
Lagged Market share for product HS08		30.24*** (3.153)
Observations	11842	11563

Standard errors in parentheses: * p<.10; ** p<.05; *** p<.01

Next, we present in table 3 the results of the average effects of European RASFF border rejections on the two export margins of African countries of edible vegetables and fruits. First, our results explicitly validate the hypothesis of the endogeneity of the number of import refusals. However, we do not find evidence for such endogeneity in the intensive margin for edible fruits and nuts. Indeed, we find that the computed Anscombe residuals of border rejections significantly and positively affect the extensive margins of both edible vegetables and fruits and the intensive margins of edible vegetables. The effect is not significant for the intensive margin for edible fruits and nuts.

Table 3: Effects of RASFF Border Rejections on African Exports of Edible Fruits and Vegetables

	Number of trade partners in Europe (in number)		Trade value (in 1000 USD)	
	Poisson model		PPML	
	HS 07: Edible vegetables	HS 08: Edible fruits and nut	HS 07: Edible vegetables	HS 08: Edible fruits and nut
Constant	5.254***	5.603***	19.230***	18.710***
	(0.049)	(0.045)	(1.201)	(0.937)
Log distance (lnDIST_ijt)	-0.326***	-0.338***	-1.223***	-0.961***
	(0.006)	(0.006)	(0.152)	(0.106)
Colony (CINY_ij)	-0.147***	-0.168***	1.334***	0.881***
	(0.021)	(0.017)	(0.104)	(0.069)
Border rejection for product HS07	*-0.0183****		*-0.045****	
	(0.004)		*(0.017)*	
Border rejection for product HS08		*-0.143****		*0.126****
		(0.019)		*(0.042)*
Lagged Market share for product HS07	5.474***		11.690***	
	(0.178)		(0.705)	
Lagged Market share for product HS08		14.290***		17.310***
		(0.195)		(1.011)
Ansombe Residuals of Border rejection for product HS07	0.069***		0.122***	
	(0.007)		(0.028)	
Ansombe Residuals of Border rejection for product HS08		0.160***		-0.018
		(0.012)		(0.040)
Observations	11842	11563	11842	11563
Adjusted R-squared			0.966	0.952
Exporter-Year fixed effects	-	-	YES	YES
Importer-Year fixed effects	-	-	YES	YES

Standard errors in parentheses: * p<.10; ** p<.05; *** p<.01

Note: We combine 32 European individual country' border rejection data from the RASFF online database with country-level HS 2-digit product export data on 45 African countries from the UN WITS database. We first codified the RASFF countries' border rejection notifications at HS 6-digit level, and then matched the codified notification data with African country-level export data. Due to the frequent occurrences of zero trade flows and border rejections at disaggregated level, we aggregate all border rejections and exports by exporter-importer-year at the HS 2-digit level. We used the export data between African and RASFF countries in edible fruits (HS 08) and vegetables (HS 07) for the period 2008-2018.

As expected, we find that the current number of border rejections significantly and negatively affects the extensive margins of both edible vegetables and fruits and the intensive margin of edible vegetables. These results signify that an increase in the number of current RASFF country border rejections affecting edible vegetables and fruits decreases the number of trade partners in Europe for African exporting countries and decreases their export value of edible vegetables. For example, the average effect of border rejections on the extensive margin is - 0.018 (p-value < 0.01) for edible vegetables and - 0.143 (p-value < 0.01) for edible fruits and nuts. These results mean that an increase in import refusals once in the current year decreases the number of trade partners in Europe for African exporting countries by 0.018 percent for edible vegetables and 0.143 percent for edible fruits and nuts. Similarly, an increase in import refusals once in the current year decreases the export value of edible vegetables in African countries by 0.045 percent. In contrast, we find an unexpected effect for edible fruits and nuts. Indeed, we find that an increase in import refusals once in the current year increases the export value of edible fruits and nuts by African countries by 0.126 percent. One possible explanation for this result may be that African exporters tend to concentrate their exports to some EU importing countries when they experience border rejections in other EU countries. This hypothesis is supported by the higher negative effect of edible fruit and nut import refusals on the number of trade partners in Europe for African exporting countries. Although our results are quantitatively different from those found in previous studies (Baylis et al., 2011; Beestermöller et al., 2018; Grant and Anders, 2011) because of the products considered for analysis, they remain qualitatively identical. Indeed, similar to our results, Beestermöller et al. (2018) find that the RASFF countries' border rejections decrease the exports of Chinese exporters. Baylis et al. (2011) indicate that EU import refusals decrease the imports of fishery and seafood products into EU member countries. Grant and Anders (2011) find that US FDA import refusals decrease the imports of fishery and seafood products into the US.

Consistent with the standard estimates of the gravity model, we find that the distance between the exporter and importer significantly decreases the two export margins of African countries in both of the plant product categories. Specifically, a one percent increase in bilateral distance decreases the number of trade partners in Europe for African exporting countries by 0.326 percent for edible vegetables and by 0.338 percent for edible fruits and nuts. The effect of distance on the export value of edible vegetables and edible fruits is -1.223 and -0.961 percent, respectively. As expected, we also find that African countries that had previously been in a colonial relationship with RASFF member countries export more than those that had not. However, the existence of a past colonial relationship does not favor partner diversification.

6 Conclusion

The increasing number of import refusals and the high number of zero trade flows observed between African countries and European member states, which are the largest world importers of tropical edible fruits and vegetables, both highlight the issue of compliance with EU food quality and safety regulations for many African countries. In this paper, we assessed the effects of EU import refusals on the exports by African countries of edible vegetables and fruits during the period from 2008 through 2018. In particular, we estimate the average effects of the RASFF countries' border rejections on the extensive and intensive margins of African countries' exports of edible fruits and vegetables.

Using European countries' border rejection data from the RASFF online database and country-level export data for 45 African countries from UN WITS database, we found that an increase in the number of import refusals in the RASFF countries once in the current year leads to a decrease in the number of trade partners in Europe for African countries by 0.018 percent for edible vegetables and by 0.143 percent for edible fruits and nuts. In addition, our results show that import refusals decrease the export value of African countries' edible vegetables by 0.045 percent. However, we found that the RASFF countries' refusal to import once in the current year leads to an increase in the export value of African countries' edible fruits by 0.126 percent. Furthermore, our results explicitly validated the endogeneity of the number of import refusals and highlighted both the direct and spillover effects of border rejections, which means that an increase in the number of border rejections for a given product (for instance, a fresh fruit) in the previous year leads to an increase in the number of border rejections for a product and related products (for instance, a fresh vegetable) in the current year.

When we consider the main reasons (the presence of mycotoxins and pesticide residues, the poor or insufficient controls, etc.) for EU border rejections, which are mentioned in the RASFF annual reports for 2014 and 2018, our results imply that African countries must invest in improving their infrastructure and technical and storage capacities. These investments may help to reduce the cost of complying with quality and safety standards in force in EU member countries and improve the quality of African countries' exports. Efforts may also be made to improve African exporters' access to mutual certification bodies for edible vegetables and fruits and nuts. There is also a need to harmonize the EU quality and safety standards with those set in international frameworks, such as the CODEX Alimentarius.

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Appendix

Appendix A: Additional figures

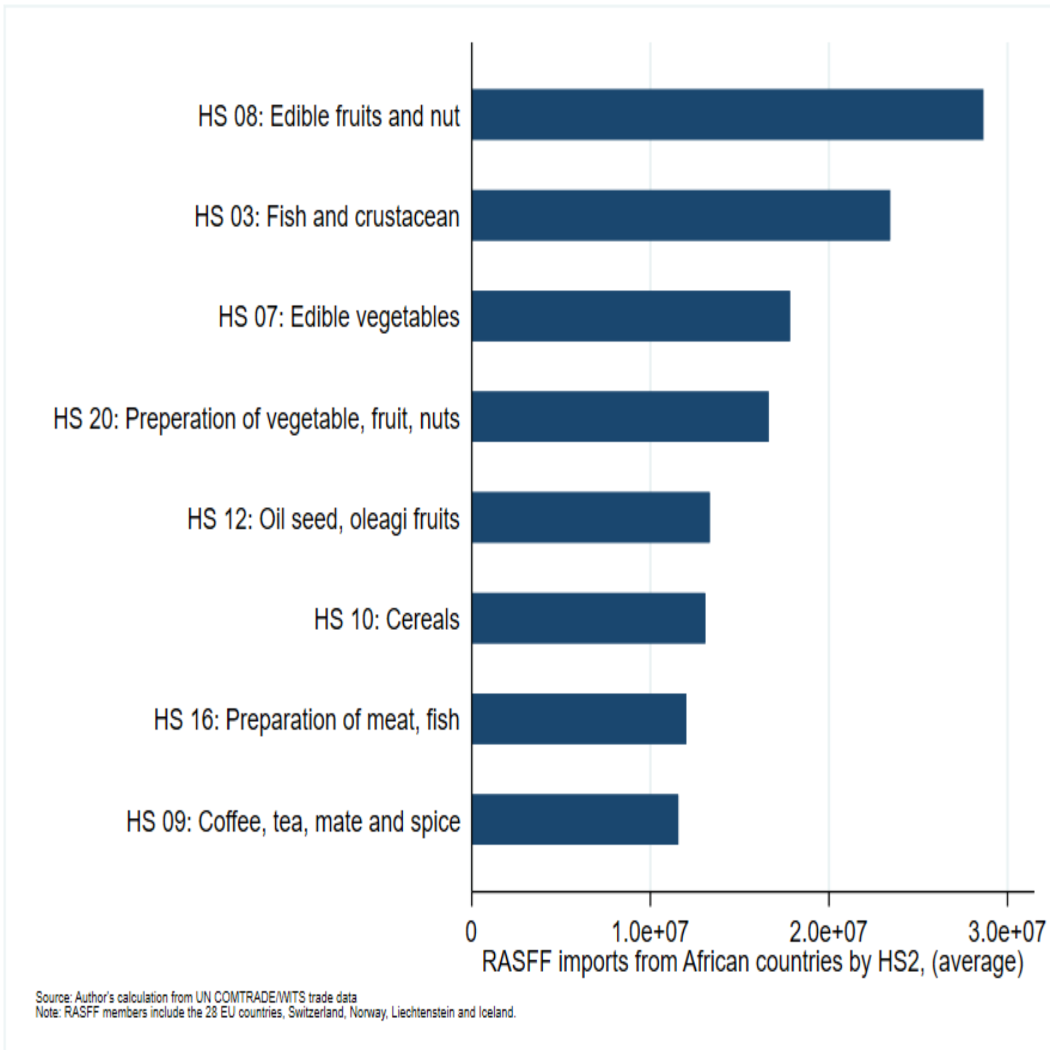

Figure 1: RASFF imports from Africa by HS2, 2008-18

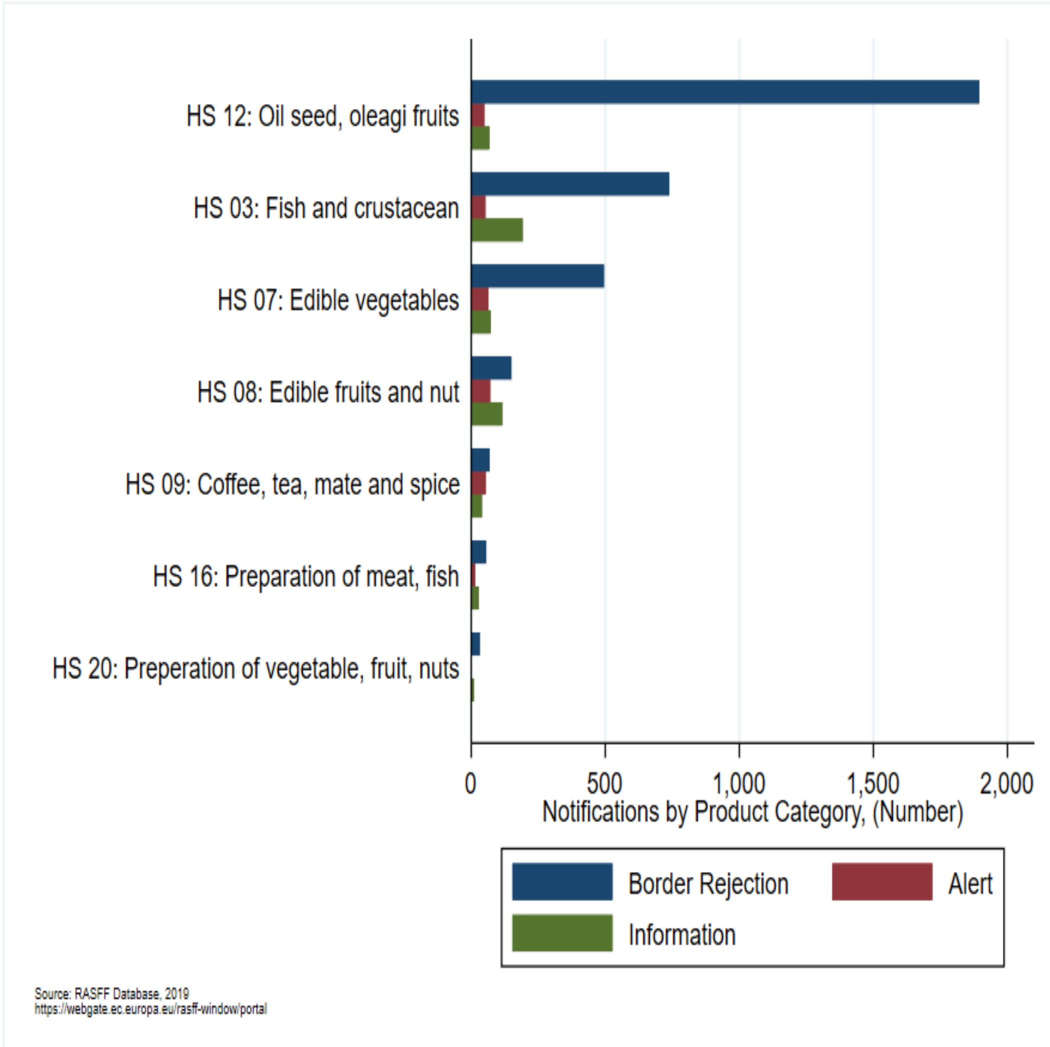

Figure 2: Notifications by Product Category, 2008-2019

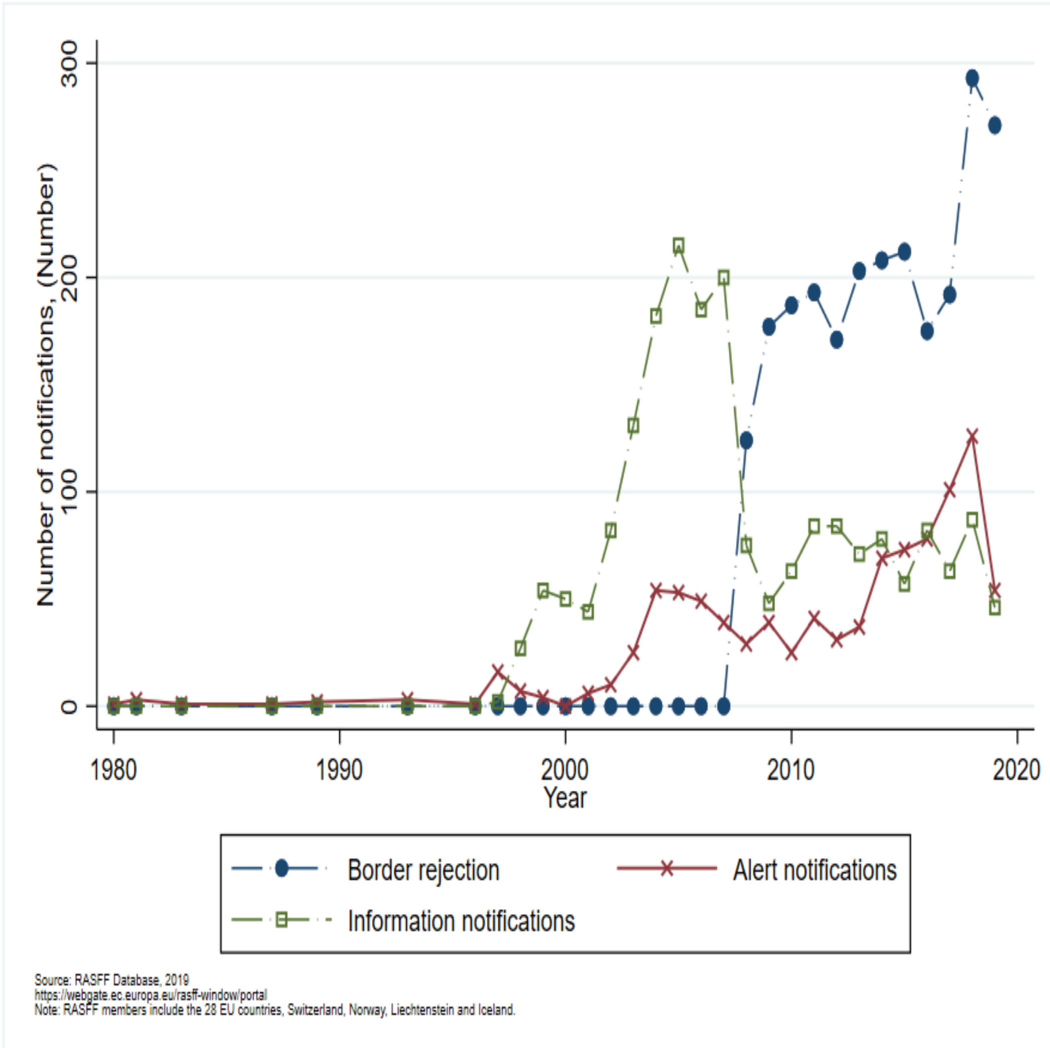

Figure 3: Evolution of RASFF notifications affecting Africa

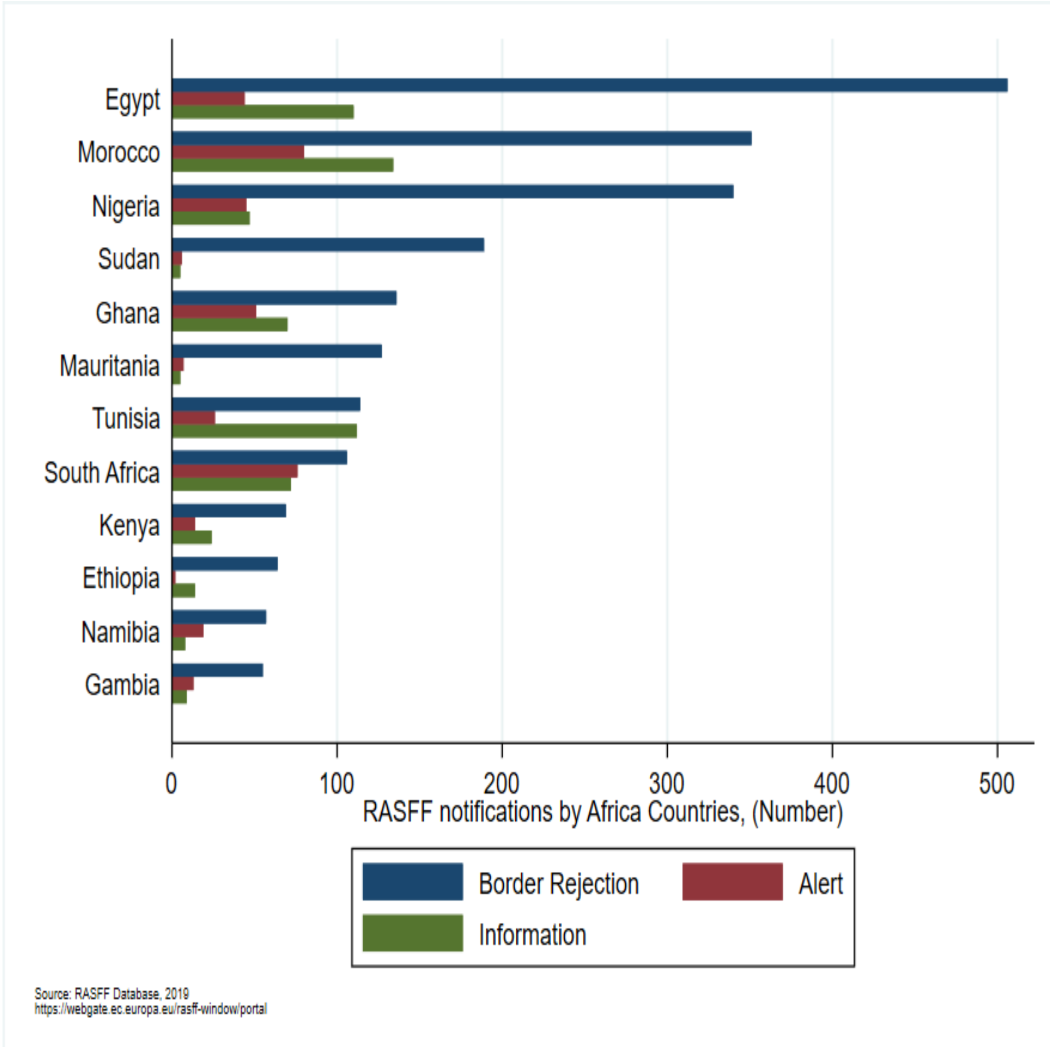

Figure 4: RASFF notifications by African Countries, 2008-2019

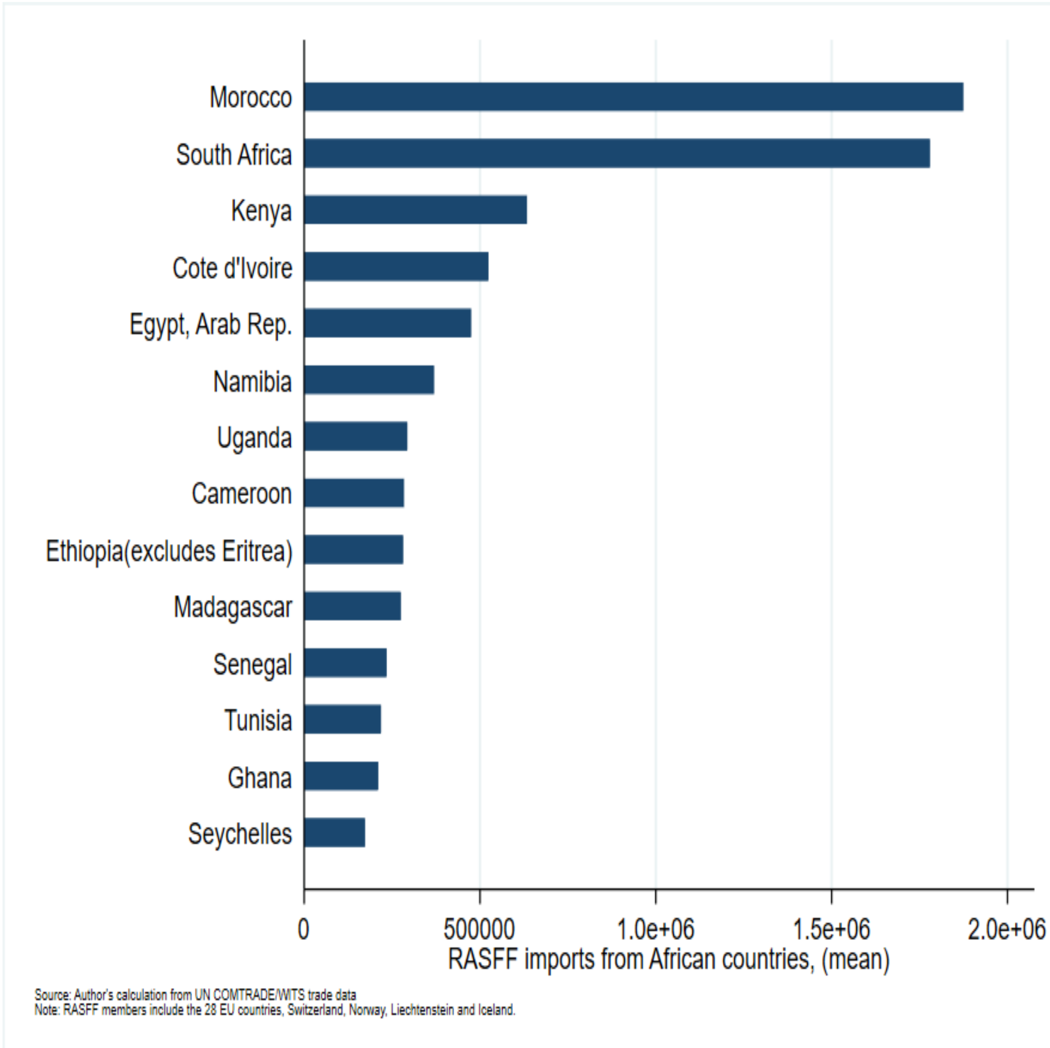

Figure 5: RASFF imports by African country, 2008-18

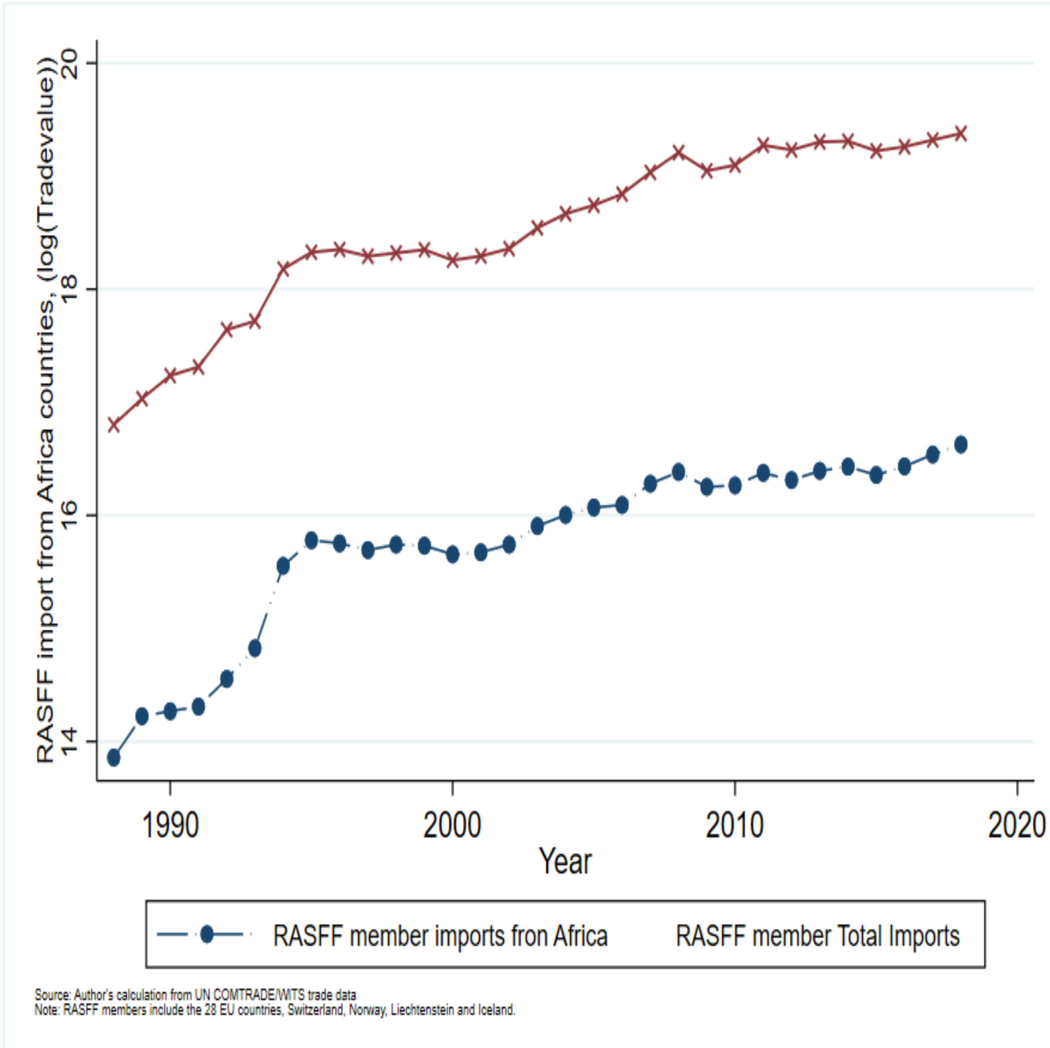

Figure 6: Evolution of RASFF imports from African countries

Appendix B: Additional tables

Table 4: List of exporting and importing countries

Exporters		Importers	
Algeria	Madagascar	Austria	Slovak Republic
Angola	Malawi	Belgium	Slovenia
Benin	Mali	Bulgaria	Spain
Botswana	Mauritania	Croatia	Sweden
Burkina Faso	Mauritius	Cyprus	Switzerland
Burundi	Morocco	Czech Republic	United Kingdom
Cameroon	Mozambique	Denmark	
Cape Verde	Namibia	Estonia	
Central African Republic	Niger	Finland	
Comoros	Nigeria	France	
Congo, Rep.	Rwanda	Germany	
Cote d'Ivoire	Sao Tome and Principe	Greece	
Djibouti	Senegal	Hungary	
Egypt, Arab Rep.	Seychelles	Iceland	
Ethiopia(excludes Eritrea)	Sierra Leone	Ireland	
Gabon	South Africa	Italy	
Gambia, The	Sudan	Latvia	
Ghana	Swaziland	Lithuania	
Guinea	Tanzania	Luxembourg	
Kenya	Togo	Malta	
Lesotho	Tunisia	Netherlands	
Uganda	Zambia	Norway	
Zimbabwe		Poland	
		Portugal	
		Romania	
		Slovak Republic	

Table 5: List of products

HS Code	Description	Number
	HS-07: Edible vegetables	
HS0701	Potato	-
HS0702	Tomato	-
HS0703	Bulb onion; green onion; bulb shallot, garlic; leek,	-
HS0704	Cabblage; cauliflower; kohlrabi; kale	-
HS0705	Lettuce(head); lettuce(leaf); chicory(tops); chicory(root);	-
HS0706	Carrot; turnip(top); turnip(root),	-
HS0707	Cucumber; gerkhin(west indian)	-
HS0708	Bean(haricot)	-
HS0709	Artichoke(globe); asparagus; celery; mushrooms; truffles; spinach	-
HS0714	Casava(manioc); arrowroot; artichoke; sweet potato;	-
	HS-08: Edible fruits and nut; peel of citrus fruit or melon	
HS0801	Coconuts; brazilnut; cashewnut;	-
HS0802	Almond; hazelnut; walnut; chestnut; pistachio;	-
HS0803	Banana; plantain;	-
HS0804	Avocado; date; fig; guava; pineapples; mango; mangosteen	-
HS0805	Orange; mandarin; clementine; lemon; lime; grapefruit;	-
HS0806	Grape	-
HS0807	Watermelon; papaya	-
HS0808	Apple; pears; quince	-
HS0809	Appricot; cherry(black); peach; nectarine; plum prune;	-
HS0810	Strawberry; raspberry; blackberry; mulberry; loganberry; currant (black); currant (red/white); gooseberry; cranberry	-
Total		**-**

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