A tariff equivalent of non-tariff barriers on European horticultural and fish imports from African countries

Nicodème Nimenya[1], Bruno Henry de Frahan[2] and Pascal-Firmin Ndimira[3] *

[1,2] Université catholique de Louvain, Place de la Croix du Sud, 2/15 B-1348 Louvain-la-Neuve, Belgium. E-mail corresponding address: nicodeme.nimenya@student.uclouvain.be,

[3] Université du Burundi, Bujumbura, Burundi C/O GECAD, P.O Box: 6659 Kigali, Rwanda

Abstract

Despite the preferential market access granted to ACP countries by the European Union in the context of the EU-ACP partnership agreement, African exports of agricultural and food products to EU face some trade barriers. Evidence from the available literature shows that food safety standards and other non-tariff measures can act as trade barriers. Using an extension of the price-wedge method that takes into account imperfect substitution and factor endowment in monopolistic competition, this study provides ad valorem tariff equivalent of several international food safety standards. We apply this method to panel data of European imports of fruit, vegetables and fish from Kenya, Tanzania, Uganda, and Zambia. Empirical results show that the tariff equivalent is about 36 per cent for avocados, ranges from 40 to 92 per cent for fresh peas and green beans and goes from 12 to 190 per cent for frozen fish fillet. In addition, we observe a strong home-good preference of more than 99 per cent for frozen fish fillet and an important variation of the tariff equivalent for all the products among the EU importing countries and over time.

JEL Classification: D11, D18, F11, Q13, O32

Key words: *import elasticity of substitution, price wedge method, tariff equivalent, East Africa, European Union.*

1. Introduction

The African, Caribbean and Pacific (ACP) countries benefit from preferential market access to the European Union (EU) through the EU-ACP partnership agreement. Like other developing countries, these countries are also eligible to the Generalized System of Preferences (GSP) of the EU and the least developed of them are eligible to the European Everything But Arms (EBA) initiative. Despite these tariff preferences, ACP countries did not improve their trade performance accordingly. Their share in EU total imports declined from 7 per cent in 1976 to 3.5 per cent in 2008 while that of the Brazil-Russia-India-China (BRIC) group increased from 18 to 30 per cent in the last 15 years. Despite this overall decreasing share of the ACP in EU total trade, some ACP countries such as Ethiopia, Gambia, Kenya, Senegal, Tanzania, Uganda, and Zambia have been particularly successful in exporting high-value agro-food products into the EU over the last two decades. For instance, based on their share in total exports, the main Kenyan exports to the EU nowadays consist of flowers and vegetables instead of tea and coffee. Kenya supplies actually nearly 25 per cent of EU-15 total imports of green beans corresponding to 34 per cent of extra-EU imports of green beans (Eurostat, 2009). However, there is a concern that non-tariff barriers (NTB) have become the main obstacles to the development of these exports from developing countries. Indeed, following the food scandals of the last two decades in industrialized countries EU countries

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have set increasingly stringent food safety standards and other non-tariff barriers that pose major challenges for the development of high-value fresh food exports from developing countries (World Bank, 2005; Bureau *et al.,* 2005; Gioè, 2008;).

Hillman (1996) defines NTB as all government measures, other than tariffs or customs taxes, which restrict or distort international commerce between domestic and imported goods and services. Non-tariff barriers or measures can be classified into technical NTB when they relate to quality product attributes and non-technical NTB otherwise (Nardella and Bocaletti, 2004).[1] Technical requirements are governed by the technical barriers to trade (TBT) agreement. A well-known category of TBT consists of the sanitary and phytosanitary (SPS) measures. SPS measures received from protagonists at the World Trade Organisation (WTO) trade negotiations a specific set of rules due to the political importance of health and sanitary issues (Gaisford and Kerr, 2001). International agricultural markets are more complex and changing as standards are promulgated in multiple spheres at national and international levels as well as public and private levels. Private standards undermine the transparency provided through notification process under the SPS agreement as they fall beyond the scope of the WTO (Jaffee and Henson, 2004).

The double facet of technical requirements makes them more challenging. On the one hand, their *prima facie* objective is to correct for market inefficiencies stemming from externalities associated with the production, distribution and consumption of agro-food products (Roberts and DeKremer, 1997). Hence, NTB act as trade catalysts by reducing the asymmetry of information in the markets by allowing, for instance, easier comparison of quality attributes and turn food credence attributes into search attributes (Marette *et al.,* 2000). On the other hand, NTB can distort trade and be used for protectionist purposes when they diverge from the general WTO principles of non-discrimination, scientific evidence and risk assessment and least-trade-restrictive alternatives. For instance, a lack of adequate scientific evidence and differing interpretations have led to disputes about public SPS regulations applied by particular countries (Colyer, 2006). NTB are also likely to restrict the number of varieties available in a market and hence limit the consumer choice and welfare (Tothova and Oehmke, 2008).

NTB are particularly challenging for developing countries. These countries lack administrative, technical and scientific capacity required to participate effectively in the TBT and SPS agreements (Henson and Loader, 2001) on the one hand, and to comply with emerging and stringent standards in developed countries exports markets on the other hand (Otsuki *et al.*, 2001). There is a growing concern that institutional weakness coupled with rising compliance costs contribute to further marginalization of developing countries in trade of high-value exports (Jaffee and Henson, 2004).

The general objective of this study is stemming from the need to quantify these international food safety standards in the trade of agricultural and food products from developing countries. Alternatively, this measurement provides a reliable representation of NTB that can be used to assess their trade impact. The central research question investigated in this study is the following: what is the *ad valorem* tariff rate *versus* export-subsidy that could have the same trade effect as the set of NTB considered?

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[1] The Trains database of the United Nations Conference on Trade and Development (UNCTAD) provides a detailed coding system of trade control measures.

Among the methods of modelling NTB (see Beghin and Bureau, 2001), we choose the price wedge method which is commonly used to provide the tariff equivalent of a set of NTB observed on a market. Indeed, there is a perception that NTB originate from differences between trading partners. Henson *et al.* (1999) and Lacovone (2005) argue that the heterogeneity of NTB is rooted in legitimate determinants of comparative advantage such as endowment, technology and preferences. Chand (2003) underlines that compliance and certification with technical standards are capital intensive processes and, therefore, place labour intensive products such as those from developing countries at a disadvantageous position. Despite the assumed symmetric treatment of standards between foreign and domestic suppliers, trade impact can be highly asymmetric because the costs of compliance differ among countries (Wilson, 2008).[2] Roberts *et al.* (1999) emphasize that when a SPS measure asymmetrically increases the compliance costs of foreign producers, it has a "tariffication" effect.

This study addresses two main limitations of the price-wedge method. First, the price-wedge method generally provides a tariff equivalent of a set of NTB without, however, being able to identify what those NTB precisely are (Beghin and Bureau, 2001). In this study, these NTB are specified from our investigations in some key African exporting countries. Furthermore, Okello *et al.* (2007) list the common standards set in developed countries markets. The most important are the Global Good Agricultural Practises (GAP) that cover food safety, environment hygiene and social protocols, the British Retail Consortium (BRC) technical food standards, the SPS and TBT public standards, the Hazard Analysis Critical Control Points (HACCP) standards, the farm to fork standards and the Ethical Trading Initiative (ETI) standards. FAO (2007) mentions other voluntary standards such as those of Social Accountability (SA) of the International Labour Organisation (ILO), the International Organization for Standardization (ISO) and the Fair Trade Labelling Organization (FLO). Second, the price-wedge method does not consider the substitution between imports and domestic goods. To deal with this limitation, we follow Yue *et al.* (2006a) to include quality differences in the method. We consider the Armington (1969) assumption where imported and domestic products are distinguished by the place of production. In addition, we make an extension of the price-wedge approach by including in the method both demand and supply conditions.

We measure the trade effect NTB using data on EU imports of fish, fruits and vegetables from specific African countries. Unlike traditional exports whose international trade is still largely governed by price, basic quality requirements and common forms of trade protection and preference (Jaffee and Henson, 2004), exports of high-value food products face stringent safety standards in developed countries markets (Unnevehr, 2000; World Bank, 2005) even though they meet few tariff barriers because of preferential trade agreements.

The next section surveys the use of the price wedge method to quantify food safety standards in international agricultural trade. The third section describes the data. The fourth section provides the econometric method and interprets the empirical results. The last section gives the concluding remarks.

[2] Non-tariff barriers are not always used in a symmetric way among trading countries. Maertens and Swinnen (2009) report three cases in which food standards are used in a discriminatory way at the advantage of domestic or selected foreign suppliers.

2. Tariff equivalence of non-tariff barriers

In this section, we provide the principle of the price wedge method and examples of its application in empirical studies. In addition, we present the analytical framework involving both demand and supply conditions.

2.1. The price-wedge method: principle and applications

The price wedge method consists in providing an implicit tariff or tariff equivalent of trade restrictions that result from NTB (Beghin and Bureau, 2001), that is the tariff rate that would have the same effect on trade as the set of NTB. The method assumes that NTB can alter relative prices between world and domestic markets, thus creating a price wedge between potential traders. This method estimates the level to which NTB raise domestic prices above international reference prices in countries using them (Ferrantino, 2006). A more appropriate measure would be to compare the domestic price that would prevail without the NTB to the domestic price that would prevail in presence of NTB, *ceteris paribus* (Deardorff and Stern, 1998 in Beghin and Bureau, 2001). However, because these prices are usually unobservable, actual measures of NTB focus on a comparison of the domestic and foreign costs, insurance and freight (c.i.f) prices in the presence of the NTB instead. Hence, the tariff rate of NTB is measured as a residue when the price wedge is corrected for tariff, transaction and transport costs (Beghin and Bureau, 2001).

Calvin and Krissoff (1998) use the price wedge method to calculate the tariff equivalent of Japanese phytosanitary protocol on United States (U.S.)-Japan apple trade between 1994-95 and 1996-97. In their calculation, the price wedge is the difference between the domestic price of Japanese apples and the price of similar U.S. apples that is taken as the proxy for the world price. This price wedge includes *ad valorem* tariff rate and the *ad valorem* tariff-rate equivalent of technical barriers to trade, which is the residual. Calvin and Krissoff (2005) add the transaction and international transport costs in the price wedge to calculate tariff equivalent of fire blight and codling-moth technical requirements for the period between 1998-99 and 2003-04. Calvin and Krissoff (1998) find that the tariff equivalent of Japanese technical requirements is 27 per cent compared to an *ad valorem* tariff rate of 19 per cent. The tariff equivalent found by Calvin and Krissoff (2005) varies substantially over time from 2 to 113 per cent with an average of 43 per cent for the Fuji variety. For other apple varieties, the tariff equivalent is far higher ranging between 57 and 503 per cent with an average value of 222 per cent. Krissoff *et al.* (1997) compute the tariff equivalent of phytosanitary requirements related to fire blight, codling moth, apple maggot, and other pests on Japanese, South Korean and Mexican apple imports from the U.S. using monthly c.i.f. and wholesale prices. Assuming that the price gap consists of the tariff and tariff equivalent of the technical barriers, the authors find the latter varies between 0 and 58 per cent depending on apple variety and importing country. Japan and Mexico show the highest tariff equivalent while the least trade distorting requirements are observed in South Korea. All these studies assume that the domestic and imported goods are homogenous.

Yue *et al.* (2006a) drop the law of one price under homogeneous traded commodities to address quality differences in the calculation of the tariff equivalent of Japanese phytosanitary requirements in the U.S.-Japan apple trade during the period 2001-03. The authors use a constant elasticity of substitution (CES) consumer utility function to account for imperfect substitution between domestic and imported apples. Transaction costs from the harbour to the internal wholesale market are also included in the price wedge. They find an *ad valorem* tariff equivalent of 60 per cent.

Instead of using the price wedge method, Henry de Frahan and Vancauteren (2006) use a gravity model of international trade to estimate the tariff equivalent of costs stemming from the unharmonised EU food regulations. The authors model these unharmonised food regulations as one of the variables of the trade cost factor of the gravity model. Their results show that the *ad valorem* tariff equivalent varies significantly across food sub-sectors, from about 10 per cent for meat and dairy sub-sectors to more than 224 per cent for fruit and vegetables. Given that their trade costs are very sensitive to assumptions on the elasticity of substitution, these authors suggest calculating the CES that emerges from the theoretically based gravity equation.

This paper uses the price-wedge approach as in Yue *et al.* (2006a) but introduces two extensions. First, we differentiate imports by origin. Second, following Ferrantino' (2006) suggestion, we include the marginal costs of production in the price gap between domestic and c.i.f. import prices using input prices.

2.2. The analytical framework

The analytical framework used in this study accounts for both demand and supply conditions. On the demand side, this study relies on the Armington (1969) model where goods are differentiated by their place of origin and the number of varieties supplied by each country is fixed to one. This means that countries trade simply because goods are imperfectly substitutable. We consider imperfection substitution to model NTB because quality standards that increase elasticity of substitution between similar products (English *et al.,* 2004) and emerge from country differences in technology, tastes and preferences (Nardella and Bocaletti, 2004; Henson *et al.,* 1999, Lacovone, 2005). Even under similar standards, European consumers can consider domestic products as safer than imported products from developing countries because of a perception of a greater potential of compliance.

Adopting the Armington (1969) assumptions of weak separability among import sources and homotheticity of utility function, we follow Yue *et al.* (2006a) to specify a CES utility function for a representative consumer located in an importing country j. This consumer allocates his expenditures between quantity q_{jj} of domestic product and quantities q_{ij} of foreign imperfect substitutes originating from source $i = 1,....,M$ with $i \neq j$. Let p_{jj} and p_{ij} be respectively the domestic and parity import prices while α_{jj} and α_{ij} represent the parameters of consumer preferences and σ the elasticity of substitution between local product and imported imperfect substitutes. Instead of adopting total imports $\sum_{i=1, i \neq j}^{M} q_{ij}$ in the CES utility function as in Yue *et al.* (2006a), we use a CES aggregator of imports $\sum_{i=1, i \neq j}^{M} \alpha_{ij} q_{ij}^{\frac{\sigma-1}{\sigma}}$.[3] For simplicity, we assume that the elasticity of substitution remains the

[3] According to Davis and Kruse (1993), the adoption of total instead of CES imports is equivalent to restricting $\alpha_{ij} = 1 \;\; \forall (i, j)$ and $\sigma = \infty$ in problem (1). Considering total imports assumes that the elasticity of substitution and the parameter of preference are already known. Further, such assumptions imply that domestic and imported goods are perfect

same in the nested CES utility function according to Armington's (1969) assumptions. This utility function is to be maximized under budget constraint R_j as follows:

$$\text{Max } U_j = \left[\alpha_{jj} q_{jj}^{\frac{\sigma-1}{\sigma}} + (1-\alpha_{jj}) \left(\sum_{i=1, i\neq j}^{M} \alpha_{ij} q_{ij}^{\frac{\sigma-1}{\sigma}} \right) \right]^{\frac{\sigma}{\sigma-1}} \quad s.t.\, p_{jj} q_{jj} + \sum_{i=1, i\neq j}^{M} p_{ij} q_{ij} = R_j \quad \forall i \neq j \tag{1}$$

Solution to the problem (1) leads to the Marshallian demands for both domestic good and each of its imported imperfect substitutes whose ratio is expressed as follows:

$$\frac{q_{jj}}{q_{ij}} = \left[\frac{\alpha_{jj}}{(1-\alpha_{jj})\alpha_{ij}} \frac{p_{ij}}{p_{jj}} \right]^{\sigma} \tag{2}$$

The import price p_{ij} can be decomposed into the world price p_w, the insurance and freight costs IFC_{ij}, the per-unit internal transport costs IT_j from the harbour to an internal wholesale market, the custom tax CT_{ij} and the tariff equivalent TE_{ij} of NTB as follows:

$$p_{ij} = p_w + IFC_{ij} + IT_j + CT_{ij} + TE_{ij} \tag{3}$$

The substitution of relation (3) into expression (2) yields a solution for the tariff equivalent of NTB that is:

$$TE_{ij} = p_{jj} \frac{(1-\alpha_{jj})\alpha_{ij}}{\alpha_{jj}} \left(\frac{q_{jj}}{q_{ij}} \right)^{\frac{1}{\sigma}} - \left(p_w + IFC_{ij} + IT_j + CT_{ij} \right) \tag{4}$$

On the supply side, we also consider product differentiation as in Krugman (1990) based on monopolistic competition and increasing returns to scale as a source of trade. We account for supply conditions because trade effects are sensitive to the incidence of the relative costs of compliance with regulations among trading countries (Roberts *et al.,* 1999). The supply elasticity is a key element in determining tariff equivalent of food quality standards (Nolte and Rau, 2006) and marginal costs of production can not be discounted from the gap between import and domestic prices (Ferrantino, 2006).

We follow Krugman (1990) and Chand (2003) to specify a profit function for an exporting country i and an importing country j. We adopt three inputs that represent key resources, i.e., agricultural land, capital and labour frequently used to produce agricultural and food products instead of the solely labour adopted by Krugman (1990) and Chand (2003). The analytical development relates to exporting country i. The corresponding expressions for importing country j are obtained by replacing the subscript i by j in the expressions below. The profit function Φ_i is specified as follows:

$$\Phi_i (q_{ij}, p_{ij}, f_i, w_i, r_i) = p_{ij} q_{ij} - \psi (f_i, w_i, r_i, q_{ij}) \tag{5}$$

substitutes and violate the underlying assumption of the Armington model that products are distinguished by their place of production.

where Φ_i is the profit function of producer located in country i, q_{ij} and p_{ij} are quantities and prices as previously defined, f_i is the land rental rate, w_i is the agricultural wage and r_i is the interest rate.

Assuming a constant marginal cost with respect to quantity supplied, the first-order condition of profit maximization is written as follows:

$$\partial\Phi_i / \partial q_{ij} = p_{ij} + q_{ij}\partial p_{ij} / \partial q_{ij} - \zeta(f_i, w_i, r_i) = 0 \quad (6i)$$

$$\Rightarrow p_{ij} = \frac{\varepsilon_i}{\varepsilon_i + 1}\zeta(f_i, w_i, r_i) = \xi(f_i, w_i, r_i) \quad (6ii)$$

where ε_i is the own-price elasticity of demand in country i.

We assume asymmetric trade effects of NTB implying costs of compliance that differ between trading countries. As highlighted by Roberts *et al.* (1999), the difference in these compliance and transaction costs is represented by the tariff equivalent TE_{ij}. If foreign suppliers bear higher compliance costs relative to agro food standards, we follow Chand (2003) to specify their profit function as follows:

$$\Phi_i(q_{ij}, p_{ij}, f_i, w_i, r_i, TE_{ij}) = p_{ij}q_{ij} - (1 + TE_{ij})\varphi(f_i, w_i, r_i, q_{ij}) \quad (7)$$

The expression (7) assumes that tariff equivalent of technical regulations raises all inputs required for production by $(1 + TE_{ij})$. From profit maximization, we derive the unitary price as follows:

$$p_{ij} = \nu(f_i, w_i, r_i, TE_{ij}) \quad (8)$$

Finally, the unitary import price is a function of the price of agricultural inputs and the ad valorem tariff equivalent of NTB. Likewise, similar expression holds for the price of domestic good.

3. Data description and preliminary analysis

We apply the price wedge method to EU imports of horticultural and fish products from African countries during the last two decades. Based on data availability, we consider trade of green beans and fresh peas between 1988 and 2008 and trade of frozen fish fillet between 1995 and 2006. Green beans are imported in Belgium-Luxembourg, France, Germany, the Netherlands, and the United Kingdom (UK) from Kenya; fresh peas are imported in Germany, the Netherlands, and the UK from Kenya; fresh peas are imported in the Netherlands and the UK from Zambia avocados are imported in France from Kenya.

It is worthy to note that Kenya is a leader in non-traditional exports while Zambia is showing a recent growth in such exports (Okello *et al*., 2007). In addition, Kenya began exporting to the EU markets and developing the infrastructure and institution involving smallholders before the inception of private food safety standards and traceability guidelines. In contrast, Zambia entered the non-traditional export markets when the regulatory system was already in place. On the basis of this observation from Okello *et al.* (2007), Kenyan growers comply proactively with non-tariff requirements while Zambian growers do so reactively.

Frozen fish fillets are imported in Belgium, France, Germany, Italy, the Netherlands, Portugal, and Spain from Kenya, Tanzania, Uganda taken together to obtain continuous series of imports and prices. We name this source of imports East African Community (EAC) as these countries are the three founding states of this regional trade agreement. In addition to these African sources of imports, we consider imports from the first fifteen Member States of the EU (EU-15) and the rest of the world (ROW).

In this section, we first describe the time series with a focus on trends and data sources. Second, we make a preliminary panel data analysis using unit root and endogeneity tests.

3.1. Data description

We start this data description with trade flows and unit value of flows and continue with input prices. For the last two decades, Kenya is one of the leading exporters of green beans to the EU. About 90 per cent of the Kenyan exports of green beans into the EU-15 are concentrated in the five selected EU Member states. Figure 1 shows that Kenya is the most important import source of green beans in the UK accounting for 60 to 70 per cent of the UK total imports of this commodity. Imports of green beans in France and Belgium-Luxembourg (Bel-Lux) from Kenya represent about 30 per cent in earlier 1990 but are continuously decreasing over time while imports in the Netherlands and Germany expand from less than 5 per cent in 1988 to more than 20 per cent 20 years later.

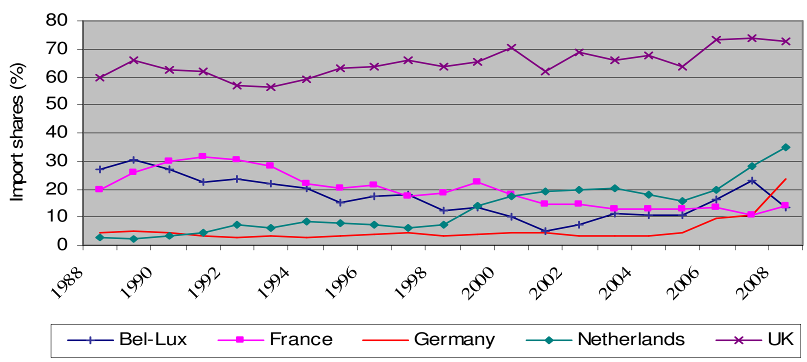

Figure 1. Import shares of green beans from Kenya in total green beans imports of each of the five selected EU countries, 1988-2008 (Source: Eurostat).

Kenya and Zambia are among the leading African exporters of fresh peas to the EU. Kenya was a pioneer in exports of high-value fresh horticultural products that date back to the mid-to-late 1950 during the colonial era while Zambia became an exporter in the last two decades when stringent standards were already in place (Okello *et al.,* 2007). EU-15 imports of fresh peas from Kenya and Zambia are concentrated in the UK, the Netherlands and Germany. Kenya is the largest import source of fresh peas for the UK.

Figure 2 shows that Kenya accounts for a major source of fresh peas of the UK increasing from near 1 per cent in 1988 to more than 50 per cent of the total imports of this commodity 20 years later. This share decreases to 23 per cent between 2000 and 2003 and increased again between 2004 and 2008. Kenya accounts for less than 1 per cent in 1988 to more than 50 per cent in 2008 of the total imports of fresh peas of the Netherlands 20 years later. Its share in imports of fresh peas of Germany increases from less than 1 per cent in 1988 to 30 per cent in 2008. The share of Zambia in total imports of fresh peas of the Netherlands and the UK fluctuates over time between less than 1 per cent and nearly 10 and 20 per cent respectively.

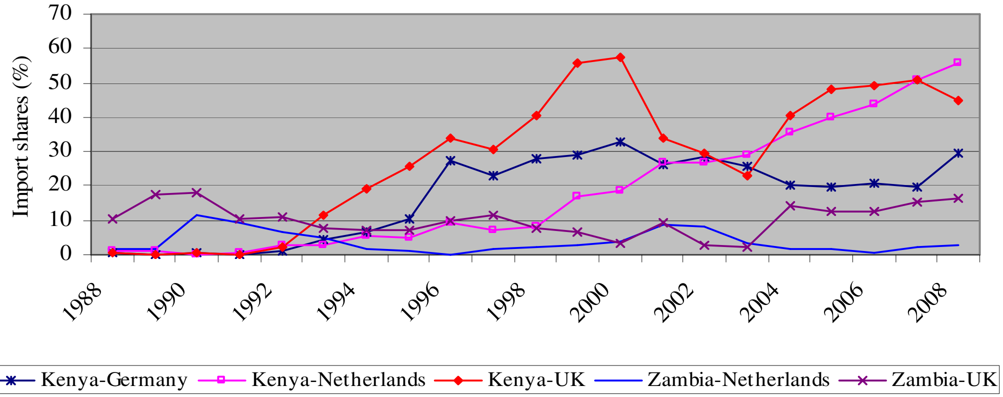

Figure 2. Import shares of fresh peas from Kenya and Zambia in total imports of fresh peas of each of the selected EU countries, 1988-2008 (Source: Eurostat).

Kenya is one of the leading African sources of French imports of avocados. France is also an important destination of Kenyan avocados. According to the commodity trade (Comtrade) database of the United Nations Conference for Trade and Development (UNCTAD), Kenya exports about 50 to 80 per cent of its total exports of avocados to France. Figure 3 shows that the share of Kenya in total imports of avocados of France is increasing over time from less than 3 per cent in 1988 to 14 per cent in 2001 and then decreasing to 8 per cent in 2006.

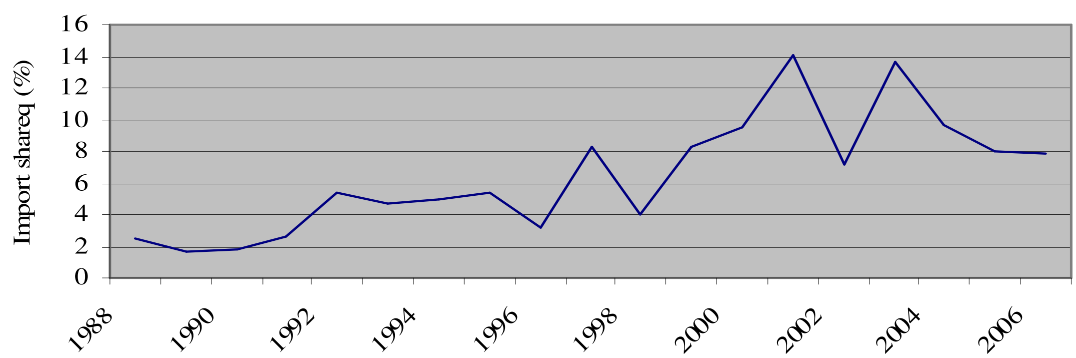

Figure 3. Import shares of avocados from Kenya in total imports of avocados of France, 1988-2006 (Source: Eurostat).

The EU-15 fish imports from EAC area are dominated by the Nile perch (*Lates ninoticus*) from Lake Victoria accounting for more than 80 per cent of exports. The EU accounts for more nearly 60 per cent of total exports of frozen fish fillet from Kenya, Tanzania and Uganda prior to the introduction of food safety restrictions in 1997. After this period, there is an important trade diversion effect whereby exporters pursue alternative markets such as Israel, Japan, Singapore, and the United Arab Emirates (Henson *et al.,* 2000). The share of frozen fish fillet from these three African countries in total imports of this commodity in the selected EU countries shows a decline over time especially between 1997 and 1999. Abila (2003) finds that the ban of April 1999 has been the most damageable for Kenyan fish exports with a decrease of 62 per cent in foreign exchange earnings compared to those of November 1997 and January 1998 which generate a decrease in exports value of 13 and 32 percent respectively. These losses were due to the cases of salmonella and fish poisoning with pesticides reported in the Lake Victoria. According to some estimates, the consumption of unwholesome fish and fishery products account for about 30 per cent of the total food-borne illnesses in the world (Abila, 2003).

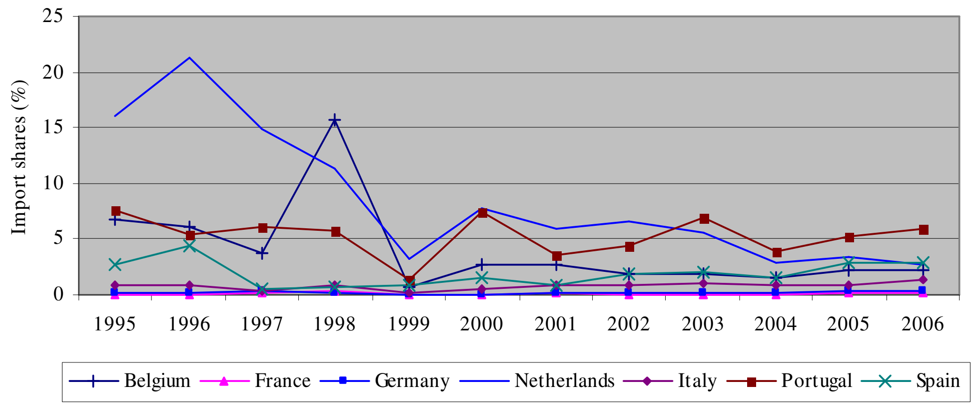

Figure 4. Import shares of frozen fish fillets from EAC in total imports of frozen fish fillets of selected EU countries, 1995-2006 (Source: Eurostat).

Data of Kenyan, Tanzanian and Ugandan exports in volume and current f.o.b. value from 1994 to 2005 are taken from the Kenya Revenue Authority (K.R.A), the Tanzania Revenue Authority (T.R.A) and the Uganda Revenue Authority (U.R.A) respectively. Data from 2006 to 2008 are taken from the Comtrade database. Data of Zambian exports in volume and in f.o.b. value taken from the Comtrade database are available from 1997 to 2008. We use the unit free on board (f.o.b.) value to proxy the exports prices.

Data on EU-15 external trade come from the Comext database of Eurostat. Data on imports in EU selected countries from the rest of the world are calculated from the difference between extra-EU imports and imports from the selected African countries. Data of domestic production and prices between 1988 and 2008 are taken from the New Cronos database of Eurostat for green beans (C1910), fresh peas (C1890) and avocados (C2253). Data of domestic production of frozen fish fillet (PRCCODE: 15201270) between 1995 and 2006 are taken from the Europroms database of Eurostat. Domestic sales of horticultural and fish imports in the EU countries are derived from the difference between the domestic production and total exports. The consumer price index from the World Development Indicators (WDI) of the World Bank (WB) is used to derive the real value of trade flows presented above.

World prices are determined from export unit values of the world leading exporters: Turkey and Morocco for green beans, France for fresh peas, Mexico for avocados and China for frozen fish fillets. International transport costs are calculated by the difference between the c.i.f. and f.o.b. prices. Nominal exchange rates taken from the WDI are used to convert f.o.b. value of African exports in local currency unity into the U.S. dollars (US$). The nominal exchange rate provided by the New Cronos database of Eurostat is used to convert data expressed in US$ into Euro. Data on custom tariffs at the Harmonised System (HS) at 6 digits are obtained from the on-line custom tariffs database *"The common customs tariff and integrated tariff of the European communities"* (Taric).

Per capita gross national income (pcGNI) adjusted by the purchasing power parity (PPP) provided by WDI database is used as an indicator of the agricultural wage in importing and exporting countries. The real interest rate obtained from WDI database is used as an indicator of the cost of capital. Land rent provided by the New Cronos database is only available for the EU countries.

3.2. Preliminary data analysis

3.2.1. Stationarity tests of the panel data

Importing countries are taken as cross-section units to construct panel data over the same product and origin. We follow Maddala (1994) and Wu (1996) in Banerjee (1999) to test the stationarity of the relative quantities and prices derived from the log-linearization of relation (2). These two authors propose a test combining the p-values π_j obtained from the Dickey-Fuller (DF) and Augmented-Dickey-Fuller (ADF) unit root tests in each cross-sectional unit $j = 1,...,N$ as follows:

$$t_{Maddala\ \&Wu} = -2\sum_{j=1}^{N} \ln(\pi_j) \rightarrow \chi^2_{2N} \qquad (9)$$

The Maddala (1994) and Wu (1996) test is a Chi-square distributed test with $2N$ degrees of freedom under the assumption of cross-sectional independence, N being the number of cross-sectional units, i.e., the number of EU importing countries. For trade in avocados we use the usual unit root tests of DF and ADF.

Table A.1.in the Appendix gives the Chi-square statistics of the unit root tests. We find that 15 ratios out of 18 are integrated of order 0. We fail to reject the null hypothesis of non-stationarity for relative quantities of imports of green beans from EU-15, relative prices of imports of fresh peas from Zambia and relative prices of imports of frozen fish fillets from EU-15.

3.2.2. Individual effect tests from panel data

We test the random *versus* the fixed individual effects using panel data. The majority of the relative quantities and prices series derived from relation (2) are log-level stationary. Posing $y_{jt} = \ln\left(\frac{q_{jjt}}{q_{ijt}}\right)$ and $x_{jt} = \ln\left(\frac{p_{ijt}}{p_{jjt}}\right)$ for each commodity and each of the three sources of imports (African country, EU-15 and the ROW), we follow Gallaway *et al.* (2003) to specify a parsimonious geometric lag model as follows:

$$y_{j,t} = a_{0,j} + a_{1,j}x_{j,t} + a_{2,j}y_{j,t-1} + \varepsilon_{j,t} \qquad (10)$$

where $a_{0j} = \sigma \ln\left[\frac{\alpha_{jj}}{(1-\alpha_{jj})\alpha_{ij}}\right]$. The model (10) enables to obtain both short-run and long-run estimates of the Armington elasticities. The short-run elasticity is $\hat{a}_{1j}$ while the long-run elasticity can be estimated as: $\hat{a}_{1,j}/(1-\hat{a}_{2,j})$ if $0 < \hat{a}_{2,j} < 1$. If $\hat{a}_{2,j} \notin]0,1[$ only the short-run elasticity is reported.

Table A.2 in the Appendix synthesizes the sequence of the Chi-square and Fisher tests on panel data analysis. We follow Hurlin (1999) to test the presence of individual effects using a Fisher test. In eight cases out of twelve, we reject the null hypothesis of absence of individual effects. In other words, we reject the equality of N constants a_{1j} given the homogeneity of the other parameters. When the homogeneity of the constants a_{0j} is not rejected, we use the Hausman test to discriminate fixed and random individual effects. This test compares two kinds of estimators: the generalized least square (GLS) from random effects and the least square dummy variable (LSDV) from fixed effects. In the absence of endogeneity bias, GLS is used because it is the best unbiased estimator. Otherwise, the LSDV estimator which is always unbiased even though not best is used. The Hausman test is a Chi-square distributed test with a degree of freedom equalling the number of regressors.

Table A.3 in the Appendix shows that whenever the individual effects are not rejected, these effects are always fixed. This means that there is a correlation between the right-hand side variables and the disturbance. As a result, we use instrumental variables to yield unbiased and consistent estimates (Thomas, 1997; Castiñeira and Nunes, 1999).

4. Econometric estimation of tariff equivalence

We first estimate the Armington elasticities from the maximization of the nested CES utility function under budget constraint using the seemingly unrelated regressions (SUR) on the geometric lag model. The SUR method provides estimates of a set of non-linear equations with cross-equations constraints imposed. SUR yields consistent and asymptotically consistent and more efficient estimates than the single equation (Cheng, 2001). Each of the set of equations in the SUR estimation is a panel fixed effects. It is possible to obtain the panel fixed effects using ordinary least squares (OLS) on series deviated from their respective mean values (Hurlin, 1999; Sevestre, 2003). We use this method to define a set of three equations in the SUR corresponding to the three import sources. This means that the constants $a_{0,j}$ have to be calculated because they drop with the data transformation. Finally, we use the consumer preferences from the fixed effects and Armington elasticities to compute the tariff equivalent of non-tariff barriers.

However, the Hausman test on the geometric lag model detects an endogeneity bias to be addressed using instruments. The use of the same instruments across equations in the SUR yields the three-stage least square (3-SLS). However, there is no reason why instruments should remain the same across equations corresponding to the three import sources where the supply constraints and opportunities may differ. We use instruments that differ from one equation to another instead. This approach requires the use of generalized method of moments (GMM) estimation. For the horticultural products, the use of equation-specific instruments on the set of equations of the SUR method yields the GMM estimates. For frozen fish fillets, we have poor instruments because we aggregate imports from Kenya, Tanzania and Uganda. We do not have valid wage, real interest rate and nominal exchange rates for these countries considered together. We consider then the elasticities derived from the SUR estimation.

4.1. The Armington elasticities

We estimate the Armington elasticities using the seemingly unrelated regressions (SUR) method on equation (10). The Armington (1969) model assumes the same elasticity of substitution between any pair of products competing in a market. To do so, we impose cross-equations constraints on parameters $a_{1,j}$ and $a_{2,j}$. We use instruments from supply conditions in the SUR estimation to address the endogeneity bias detected by the Hausman test (Table A.2. in the Appendix). The instruments include the prices of inputs commonly used in agriculture (real interest rate, wage and land rent) following the optimality condition (8), the nominal exchange rate and the lag of relative prices.

A suitable set of instrumental variables are both sufficiently uncorrelated with the stochastic disturbance terms and sufficiently correlated with relevant explanatory variables (Castiñeira and Nunes, 1999). To select orthogonal instruments, we pursue an iterative process. From a SUR or GMM estimation using all the available instruments, we extract the residuals. The latter are thereafter regressed on the selected instruments and the significant instruments at 10 per cent level of probability are dropped. The process is iteratively repeated until no significant instruments are left.

Table 1 gives the estimates of the short-run and long-run Armington elasticities with starting values via 3-SLS. Fresh peas from Kenya, EU-15 and ROW are withdrawn from the analysis because the corresponding relative quantities and prices are not stationary. We follow Casella and Berger (2002) to establish the sampling distribution of the long-run elasticities using the Delta method that is based on Taylor series approximation.

Table 1
Estimates of short-run and long-run Armington elasticities of EU imports of green beans, fresh peas, avocados and frozen fish fillets from different sources

Product	Import source	Estimates				R^2	DW test
		a_1	a_2	$a_1/(1-a_2)$	Adjustment rate		
Green beans[a]	Kenya EU-15 ROW	0.15* (1.68)	0,98*** (27.99)	8.9*** (4.05)	0.02	0.74 0.40 0.81	2.14 2.14 2.16
Fresh peas[a]	Zambia EU-15 ROW	0,25 (1.34)	0.96*** (36.34)	5.8 (1.24)	0.04	0.18 0.27 0.94	2.44 2.72 2.12
Avocados[a]	Kenya EU-15 ROW	2.68 (1.28)	0.50** (2.48)	5.4* (1.60)	0.50	0.40 0.72 0.16	2.74 1.40 1.96
Frozen fish fillet[b]	EAC EU-15 ROW	0.31** (2.01)	0.49*** (8.56)	0.6*** (2.69)	0.52	0.60 0.41 0.58	2.61 1.60 1.18

Legend: (a) and (b) denote GMM and SUR estimates respectively; EU: European Union, ROW: Rest of the World, EAC: East African Community; *, ** and *** denote statistical significance at 0.10, 0.05 and 0.01 probability level respectively; the t-statistic is indicated in parentheses beneath the estimated coefficient

Using the GMM estimators, we obtain a short-run elasticity of 0.15 and a long-run elasticity of 8.9 for green beans. The long-run elasticity is 5.4 for avocados. The short-run and long-run Armington elasticities are not statistically different from zero for fresh peas. The use of the SUR method on frozen fish fillet yields short-run and long-run Armington elasticities that are both lesser than one. The values of long-run Armington elasticities found for horticultural products are roughly comparable to those commonly found in similar applied studies. Yue *et al.* (2006a, 2006b) find an elasticity of substitution of 7.1 between total imports of apple and domestic supply in the Japanese market using a two-stage least square (2-SLS) to address endogeneity bias. Our SUR estimates of Armington elasticities for frozen fish fillets are of lesser extent compared to the values of 1.3 and 2.0 found by Cheng (2001) for short-run and long-run elasticity respectively using SUR estimation on U.S. scallops imports from Canada, Japan and China.

The adjustment rates that are calculated as the ratio of short-run to the long-run elasticity, however, differ from those of similar applied studies. We find an adjustment rate equalling 0.02 for green beans, 0.04 for fresh peas and 0.50 for avocados and frozen fish fillet. The values especially for the frozen fish fillets are of the same magnitude as 0.67 of Cheng (2001) while the adjustment rate found for the vegetables group are of a lesser extent. According to Thomas (1997), the adjustment rate measures the proportion of any discrepancy between the desired and previous relative quantities that is eliminated in the current period. The adjustment rate lies between 0 and 1. If the adjustment rate tends to zero, no adjustment takes place while the latter becomes total when the adjustment rate becomes closer to 1.

These small adjustment rates for green beans and peas could be explained by the fact that high-value horticultural fresh exports from African countries to the European markets begun as off-season export crops during winter season between 1950 and 1960.[4] Nowadays, these exports are year-around exports. Off-season imports do not compete with domestic products because they are not sold at the same moment. They are rather considered as complementary to the domestic supply with an elasticity of substitution close to 0. However, year-round imports from Africa compete with their imperfect substitutes produced in EU importing countries with an elasticity of substitution ranging between 0 and infinity.

As we use these Armington elasticities to calculate the tariff equivalent of NTB, we can compare these coefficients to the values used in similar studies. Olper and Raimondi (2005) use an import substitution elasticity provided by the Global Trade Analysis Project (GTAP) database and ranging from 3 to 7 and to derive the tariff equivalent of border effects on agricultural trade in OECD countries. According to Hummels (2001) and Head and Ries (2001), the estimated substitution elasticity increases from around 4 to around 8 when the disaggregation passes from 1 to 3 digits industry level respectively. As we use disaggregated data at HS-6 digits industry level, our long-run elasticities ranging from 5.4 to 8.9 are in the same range. Because, the long-run elasticities are more appropriate for most trade-policy analysis (Gallaway *et al.,* 2003), we use them to compute the *ad-valorem* tariff equivalent of non-tariff barriers in the EU imports of horticultural and fish products.

4.2. The consumer preferences

Because of the data transformation into deviations from the individual means used in OLS estimation to provide panel fixed effects estimates, the constants $a_{0,j}$ of relation (10) have to be calculated. These constants are used to provide the parameters of consumer preferences affected to local and imported products. Let $\overline{y_{i,j,t}}$, $\overline{x_{i,j,t}}$ and $\overline{y_{i,j,t-1}}$ be the mean values of relative quantities, relative prices and the lag of relative quantities respectively in

[4] Okello and Sindi (2006) highlight this feature for green beans in Kenya.

each cross-sectional unit, that is, importing country. We follow Thomas (1997) and Hurlin (1999) to compute the constants $\hat{a}_{0,j}$ as follows:

$$\hat{a}_{0,j} = \overline{y_{j,t}} - \hat{a}_1 \overline{x_{j,t}} - \hat{a}_2 \overline{y_{j,t-1}} \qquad j = 1,....,N \tag{11}$$

where $\hat{a}_1$ and $\hat{a}_2$ are the GMM and SUR estimates of Table 1.

We use the computed constant $\hat{\sigma}_{0,j}$ for each cross-section unit j and for each import source i to solve for the parameters of consumer preferences $\hat{\alpha}_{jj}$ and $\hat{\alpha}_{ij}$. We have a system of three equations with three parameters to be calculated. In the case of avocados, data are not transformed because we use standard OLS estimation of equation (10) with time series data. Hence, the constant is still estimated in SUR output. Because we use long-run Armington elasticities to compute the tariff equivalent of NTB, it is relevant to use also long-run values of the parameters of preference in this computation.

Table 2 lists the short-run and long-run values of the parameters of preferences that are derived from the $\hat{a}_{0,j}$ terms of equation (11). In the short term, we observe high values of parameters of preference for imports from the ROW except for frozen fish fillets. In the long-run, European consumers are indifferent to purchase local varieties of horticultural products or their imperfect substitutes imported from Africa, EU-15 and the ROW. In the trade of frozen fish fillets, we observe a high preference for domestic and imports from EAC area.

Table 2
Short-run and long-run values of parameters of consumer preferences in the trade of horticultural and fish products

Product	Importing countries	Consumer preferences							
		Short-run parameters $\hat{\alpha}_{ij}$				Long-run parameters $\hat{\alpha}_{ij}$			
		Domestic	Africa[a]	EU-15	ROW	Domestic	Africa[a]	EU-15	ROW
Green beans	Belgium	0.05	0.07	0.17	0.76	0.25	0.33	0.33	0.34
	France	0.03	0.08	0.20	0.72	0.24	0.33	0.33	0.34
	Germany	0.09	0.35	0.35	0.30	0.25	0.33	0.33	0.33
	Netherlands	0.03	0.12	0.40	0.48	0.24	0.33	0.33	0.34
	UK	0.00	0.09	0.29	0.62	0.24	0.33	0.33	0.34
Fresh peas	Netherlands	0.00	0.00	0.00	0.99	0.10	0.11	0.26	0.63
	UK	0.00	0.00	0.01	0.99	0.21	0.27	0.33	0.40
Avocados	France	0.12	0.39	0.28	0.33	0.18	0.36	0.31	0.33
Frozen fish fillet	Belgium	1.00	0.98	0.01	0.01	0.99	0.84	0.08	0.07
	France	1.00	1.00	0.00	0.00	0.99	1.00	0.00	0.00
	Germany	1.00	1.00	0.00	0.00	1.00	0.92	0.02	0.06
	Italy	1.00	1.00	0.00	0.00	1.00	0.95	0.03	0.02
	Netherlands	1.00	0.29	0.05	0.67	1.00	0.34	0.14	0.52
	Portugal	1.00	0.99	0.01	0.00	1.00	0.88	0.09	0.04
	Spain	1.00	0.89	0.01	0.10	1.00	0.69	0.08	0.23

Note. The reported values of 0 and 1 are in this case meaningless and are not computed. They are only used for rounded values for purpose of presentation; (a)**:** the African source is Kenya for green beans, Zambia for fresh peas and Kenya, Tanzania and Uganda taken together for frozen fish fillet.

4.3. The tariff equivalent of non-tariff barriers

4.3.1. The analytical expression of the tariff equivalent

We include the parameters of consumer preferences and the estimated Armington elasticties in the expression (12) to compute *ad valorem* the tariff equivalent of NTB. Expression (12) is an adaptation of the relation (4) that is valid for the specific tariff equivalent. Letting p_{CIFit} be the cost insurance freight unit value of imports from African country i at time t, the *ad valorem* tariff equivalent TE_{ijt} of the set of NTB prevailing in export markets becomes:

$$TE_{ijt} = \frac{1}{p_{CIFit}} \left[p_{jjt} \frac{(1-\hat{\alpha}_{jj})\hat{\alpha}_{ij}}{\hat{\alpha}_{jj}} \left(\frac{q_{jjt}}{q_{ijt}} \right)^{\frac{1-\hat{a}_2}{\hat{a}_1}} - \left(p_{w,t} + IFC_{j,t} \right) \right] \qquad (12)$$

Unlike Yue *et al*. (2006a) who use prices in an internal wholesale market, we do not consider internal transports costs but the c.i.f. prices. In addition, relation (12) does not account for the custom tariff in the discrepancy between domestic and world prices because the custom tariff is zero for EU imports of horticultural and fish products from ACP countries.

4.3.2. The results on ad valorem tariff equivalent

Table 3 gives the values of *ad valorem* tariff equivalent of non-tariff requirements of EU importing countries. The mean tariff equivalent ranges between 36 and 92 per cent for trade in green beans, peas and avocados. For trade in green beans, there is no sharp difference in the tariff equivalents across importing countries. However, for trade in fresh peas, the UK imports of fresh peas from Zambia face more trade-distorting requirements with an *ad valorem* tariff equivalent that is almost the double of the tariff equivalent for the Netherlands imports. This difference could be due to the incidence of private standards such as the British Retail Consortium. Jaffee (2003) highlights for instance UK supermarket pressures for HACCP and BRC certification on African suppliers of fresh food products. The difference in tariff equivalents between Zambian peas and Kenyan green beans could be due to the experience of these two countries in growing high-value horticultural products for exports. Kenya is a pioneer in these exports and its exports begin in the colonial era before the inception of stringent food standards. Zambia however entered the non-traditional export markets more recently when the regulatory system was already in place. On the basis of this observation from Okello *et al.* (2007), the Kenyan growers of green beans are more likely to comply proactively with food standards while Zambian growers of fresh peas do so reactively. Furthermore, extra-EU15 supplies more than 56 per cent of the total EU15 imports of green beans. For peas however, extra-EU15 represents less than 20 per cent of the EU15 total imports of peas. Due to this important internal EU15 supply of peas, non-tariff barriers should then be more stringent for this commodity to protect domestic suppliers.

Trade lowest value of tariff-equivalent is observed for French imports of avocados from Kenya. This low value is likely due to very low domestic supply of avocados in France. that is far lower than imports. This could explain why France remains the first leading destination of Kenyan exports.

Larger differences in the values of tariff equivalence are observed trade in frozen fish fillets across EU importing countries. Imports in France, Spain and, to a lesser extent, Italy show the highest levels of tariff equivalence with a mean value of 190, 186 and 88 per cent respectively. Compared to these three countries, the Netherlands, Belgium and Portugal adopt the least-trade-restrictive requirements *vis-à-vis* imports of frozen fish fillets from EAC area.

Across years, the global trend of *ad valorem* tariff equivalent corroborates the pressure from the external regulatory environment in the period between 2001 and 2003 in the form of maximum residue limit of pesticides, requests for HACCP, GlobalGAP and BRC certification, ethical audits for selected clients (Jaffee, 2003). The stringency of the regulatory environment is depicted in the Figure 5 where the tariff equivalent of NTB on both fresh peas and green beans imports has a parabolic shape with a maximum value reached in the period between 2001 and 2003. However, the tariff equivalent for imports of avocados is continuously decreasing over time.

Exports of frozen fish fillets face the most trade-distorting NTB with a corresponding tariff equivalent greater than 200 per cent during the EU fish ban period. Figure 5 shows that from 1995 to 2006, the tariff equivalent increases, reach a peak in 1999 and decreases over time thereafter. This trend could reflect the modernization of fish export supply that occurred after the EU ban on fish imports from Kenya and its neighbours (Henson *et al.,* 2000; Okello, 2006). For Italy and Spain, the tariff equivalent is still high during the whole 1997-1999 ban period. The EU adopts a ban on fish imports from Kenya and its neighbours following the claims on the presence of salmonellae, reports of a cholera outbreak and fish poisoning with pesticides in the Lac Victoria during respectively in November 1997, January 1998 and April 1999. However, the EU does not adopt a common trade policy *vis-à-vis* imports from EAC area. According to Abila (2003), when Spain and Italy banned fish imports from Kenya, claiming the presence of salmonellae in November 1997, other EU countries continued to import fish from Kenya and its neighbours on bilateral agreements.

Globally, the tariff equivalent strongly varies over time with an increasing trend for vegetables and a decreasing trend for avocados and frozen fish fillet. These changing values over time reflect either the change in regulatory environment as highlighted by Jaffee (2003) or a possible rigorous implementation of the regulations at the border for standards that remain unchanged on paper (Otsuki *et al.,* 2001).

The values on the tariff equivalent calculated in this study are comparable to the findings of other empirical applied studies. Our values of tariff equivalent are higher than the values of 27 per cent found by Calvin and Krissoff (1998). However, they are of the same magnitude as the *ad valorem* tariff equivalent ranging between 39 and 60 per cent in Yue *et al.* (2006a) in the U.S.-Japan apple trade. The extent to which our tariff equivalent varies across commodities is comparable to the finding of Henry de Frahan and Vancauteren (2006) where the tariff equivalent is ranging from 10 per cent for meat and dairy sub-sectors to more than 180 per cent for food industry and fruit and vegetables. Finally, our results are lower than those of Olper and Raimondi (2005) who find an *ad valorem* tariff equivalent of border effects on agricultural markets in the OECD countries ranging from 17 per cent to 889 per cent.

Table 3

Ad valorem tariff-equivalent (%) of non-tariff barriers on EU fish and horticultural imports from Africa

Products	Green beans					Fresh peas		Avocados	Frozen fish fillet						
Origin	Kenya					Zambia		Kenya	East African Community (EAC)[5]						
Destination	BE	FR	DE	NL	UK	NL	UK	FR	BE	FR	DE	NL	IT	PT	ES
1990	9	23	13	8	19	-	-	-	-	-	-	-	-	-	-
1991	14	36	20	20	29	-	-	-	-	-	-	-	-	-	-
1992	32	40	27	30	35	-	-	-	-	-	-	-	-	-	-
1993	25	35	24	17	31	-	-	-	-	-	-	-	-	-	-
1994	35	50	32	31	41	-	-	68	-	-	-	-	-	-	-
1995	33	47	39	50	41	-	-	70	3	56	29	8	8	69	12
1996	29	59	30	49	44	-	-	81	5	1162	21	5	12	124	11
1997	37	59	51	47	40	22	75	28	13	21	15	6	139	47	382
1998	40	63	57	48	38	41	107	51	1	4	9	7	26	9	302
1999	43	61	53	39	23	70	123	11	236	127	558	52	725	243	634
2000	67	83	80	53	49	69	138	16	23	304	119	11	43	11	228
2001	61	81	85	61	53	52	100	10	2	47	23	12	17	46	375
2002	61	74	97	58	37	84	94	33	23	263	29	13	25	29	173
2003	47	63	92	51	46	81	124	7	31	105	9	6	15	5	59
2004	52	66	113	73	37	59	107	17	33	107	25	8	21	21	53
2005	54	68	90	77	41	49	101	35	26	16	9	7	14	14	32
2006	66	42	91	62	47	49	76	34	-	14	7	9	13	8	21
2007	56	39	71	71	39	26	35	-	-	-	-	-	-	-	-
2008	35	35	79	71	55	52	29	-	-	-	-	-	-	-	-
Mean	**42**	**54**	**60**	**45**	**39**	**55**	**92**	**36**	**38**	**186**	**71**	**12**	**88**	**52**	**190**

Legend: BE: Belgium-Luxembourg, FR: France, DE: Germany, NL: The Netherlands, UK: The United Kingdom; IT: Italy; PT: Portugal; ES: Spain

[5] It includes only the three founding states of EAC: Kenya, Uganda and United Republic of Tanzania

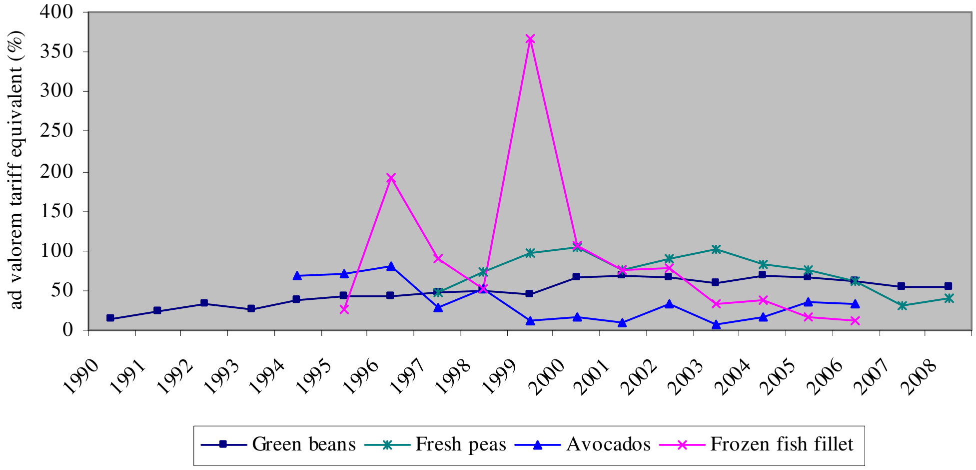

Figure 5. Evolution of annual mean values of *ad valorem* tariff equivalent of NTB between 1990 and 2008

5. Concluding remarks

The main objective of our analysis is to quantify the tariff equivalent of a set of food safety standards and other non-tariff barriers prevailing in the destinations of African high-value exports. We provide the measurement of the NTB using the price wedge method and taking into account differences in factor endowment and technology between trading partners. We consider that local and imported products are imperfect substitutes distinguished by their place of production according to the Armington (1969) hypothesis. Past empirical studies have also attempted to correct the difference between domestic and import prices for tariffs, international and internal transports and more recently for quality differences but few of them have accounted for differences in supply conditions among trading countries and separability between import sources. From the results of this empirical investigation, we draw the following conclusions.

First, on the basis of the magnitudes of estimated tariff equivalents of NTB on African exports to selected EU countries, our empirical results show that these NTB act asymmetrically among trading countries. African growers face higher costs of compliance with non-tariff requirements compared to the European suppliers. As a result, these non-tariff barriers have a tariffication effect as suggested by Roberts *et al.* (1999). The level of these tariff equivalents is higher than the current tariff rate of the agricultural trade liberalization and is comparable to the tariff rate of the Uruguay round era.

Second, despite the expansion of high-value exports from selected African countries to the main European markets, our results confirm that non-tariff barriers limit their market access as they act as *ad valorem* customs taxes. Consequently, complete trade liberalization between ACP and EU countries in the framework of the Economic Partnership Agreements (EPA) has to account for trade effects from non-tariff barriers.

Third, our results reveal strong differences in the *ad valorem* tariff equivalence among EU importing countries, especially for peas and frozen fish fillets despite the functioning of a single EU market. Hence, ACP countries would need to focus on the origins of these differences in discussing trade issues with their EU partners. Nardella and Bocaletti (2004) reach a similar concluding remark following an assessment of trade impact of EU and U.S. agro-food non tariff measures on exports from developing countries. Increasing foreign aid to help alleviate compliance costs through capacity building in African countries should for instance stimulate trade in high-value products.

Fourth, superposing the time trends of flows with those of the tariff equivalents, we realize that the latter are more likely to affect negatively the trade. In our work in progress on gravity equation, we provide an empirical investigation on this perception.

These empirical results are, however, very sensitive to three parameters: the ratio of domestic supply to imports, the domestic price and the estimated elasticity of substitution. We should then analyze the sensitivity of the *ad valorem* tariff equivalents to changes in the levels of elasticity of substitution and data disaggregation on commodity trade. The empirical analysis includes supply conditions in the form of instruments. Data on compliance costs should also improve our estimates of tariff equivalents of NTB using the price wedge method. Comparison of compliance costs with non-tariff requirements between African and European countries should be sufficient to provide a reliable estimation of their tariff equivalent.

Other useful data to integrate into the empirical specification would be domestic support for the fish and horticultural products involved in this study in EU countries. As suggested by Fukao *et al*. (2003), their use is more likely to increase the tariff equivalent. Indeed, subsidies or internal support to domestic producers is another kind of non-tariff barriers that can accentuate the gap between domestic and import prices.

This study did not examine the trade and welfare effects of the public and private food standards. Despite considerable compliance costs as reported to us by the plant health inspection service in Kenya, exports of horticultural products from Kenya and Zambia have expanded over the last two decades. To test to what extent these NTB are actually trade distorting, we suggest using a gravity model that includes our estimates of tariff equivalents to NTB. To estimate the full welfare effects, we would need to discuss the more intangible positive effects from these public and private food standards that include health and ethical effects from the compliance to food safety standards for the benefit of workers and consumers in developing countries.

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Appendix

Table A.1

Unit root test statistics on relative quantities and prices (in logarithms) for imports of green beans, fresh peas and frozen fish fillets in selected EU countries

Product	Importing country	Import source[a]	Variable	χ^2_{2N} test statistic
Green beans	Belgium-Luxembourg France Germany Netherlands United Kingdom	Kenya	Relative quantities	23.43***
			Relative prices	8.92**
		EU-15	Relative quantities	14.81
			Relative prices	19.13**
		ROW	Relative quantities	27.12***
			Relative prices	31.64***
Fresh peas	Netherlands United Kingdom	Zambia	Relative quantities	7.74*
			Relative prices	7.13
		EU-15	Relative quantities	13.78***
			Relative prices	9.72**
		ROW	Relative quantities	15.54***
			Relative prices	7.65*
Frozen fish fillets	Belgium France Germany Italy Netherlands Portugal Spain	EAC	Relative quantities	52.17***
			Relative prices	43.65***
		EU-15	Relative quantities	20.64
			Relative prices	38.61***
		ROW	Relative quantities	27.59**
			Relative prices	41.18***

(a): EU-15: European Union of the fifteen, ROW: rest of the world; EAC: East African Community

The symbols ***, **** and ******* denote statistical significance at 0.10, 0.05 and 0.01 probability level respectively. The corresponding p-value (upper tail area) is indicated beneath the test statistic

Table A.2

Sequence of Chi-square and Fisher tests on panel data analysis using the geometric lag model (10)

Hypothesis	Chi-square and F-statistical tests[a]	Testing rules
1. Global homogeneity test: $H_0^1 \equiv a_{1,j} = a_1; a_{2,j} = a_2; a_{0,j} = a_0 \ \forall j \in [1,N]$ $H_a^1 \equiv \exists (j,l) \in [1,N] / a_{1,j} \neq a_{1,l}, a_{2,j} \neq a_{2,l} \ or \ a_{0,j} \neq a_{0,l}$	$F_1 = \dfrac{(SSRR_1 - SSRU_1)/[(N-1)(K+1)]}{SSRU_1/[NT - N(K+1)]}$	Reject H_0^1 if: $F_1 > F_{\alpha\%}[(N-1)(K+1), [NT - N(K+1)]]$ If not, the panel is homogenous in all the parameters
If hypothesis H_0^1 is rejected, we perform the following tests		
2. Homogeneity test on the slopes $a_{1,j}$ and $a_{2,j}$: $H_0^2 \equiv a_{1,j} = a_1; a_{2,j} = a_2 \ \forall j \in [1,N]$ $H_a^2 \equiv \exists (j,l) \in [1,N] : a_{1,j} \neq a_{1,l} \ or \ a_{2,j} \neq a_{2,l}$	$F_2 = \dfrac{(SSRR_2 - SSRU_2)/[(N-1)K]}{SSRU_2/[NT - N(K+1)]}$	If $F_2 < F_{\alpha\%}[(N-1)K, [NT - N(K+1)]]$, do not reject H_0^2 If not, we reject H_0^2. Thus, there is no panel structure. It is then better to specify different equation for each individual
If hypothesis H_0^2 is not rejected, we pass to the tests listed below		
3. Homogeneity test on constants $a_{0,j}$: $H_0^3 \equiv a_{0,j} = a_0 \ \forall j \in [1,N]$ $H_a^3 \equiv \exists (j,l) \in [1,N] : a_{0,j} \neq a_{0,l}$	$F_3 = \dfrac{(SSRR_3 - SSRU_3)/(N-1)}{SSRU_3/[N(T-1) - K]}$	Reject H_0^3 if $F_3 > F_{\alpha\%}[(N-1), [N(T-1) - K]]$ If H_0^3 is not rejected, there are individual effects
If hypothesis H_0^3 is rejected, we pass to the Hausman test to discriminate fixed and random effects		
4. Hausman test on individuals effects: $H_0^4 \equiv \chi_K^2$ where K is the number of explanatory variables	$F_4 = (\hat{\beta}_{GLS} - \hat{\beta}_{LSDV})' [\mathrm{var}(\hat{\beta}_{GLS} - \hat{\beta}_{LSDV})]^{-1} (\hat{\beta}_{GLS} - \hat{\beta}_{LSDV})$	If $F_4 > \chi^2(df = K)$, we reject H_0^4 and there is a misspecification. We prefer fixed to random effects specification. If not, the model is well specified, random effects are then adopted.

(a): $SSRR$ and $SSRU$ are residual sum of squares in the restricted and unrestricted models respectively; N is the number of cross-sectional units in the panel structure; K is the number of regressors while T is the time dimension and $\alpha\%$ a probability threshold, generally 10 per cent.

Table A.3

Fisher and Hausman tests from the geometric lag model (10) applied to panel data in trade of green beans, fresh peas and frozen fish fillets in selected EU countries

Product	Import source[a]	Test on individual effects $F[(N-1),(NT-K-N)]$	Hausman test (χ_2^2)	Conclusion
Green beans	Kenya	F(4,93) = 2.87 (0.028)	7.29 (0.026)	Fixed effects
	EU-15	F(4,93) = 4.76 (0.002)	9.97 (0.007)	Fixed effects
	ROW	F(4,93) = 1.56 (0.193)	3.08 (0.214)	No individual effects
Fresh peas	Zambia	F(1,36) = 0.03 (0.869)	0.02 (0.988)	No individual effects
	EU-15	F(1,36) = 5.23 (0.029)	4.42 (0.035)	Fixed effects
	ROW	F(1,36) = 1.74 (0.196)	1.45 (0.228)	No individual effects
Frozen fish fillets	EAC	F(6,67) = 7.34 (0.000)	19.52 (0.000)	Fixed effects
	EU-15	F(6,67) = 3.78 (0.003)	14.66 (0.000)	Fixed effects
	ROW	F(6,67) = 1.39 (0.231)	5.35 (0.069)	Fixed effects

(a): EU-15: European Union of the fifteen, ROW: rest of the world; EAC: East African Community.
The p-value is indicated in parentheses beside the value of the Fisher and Chi-square test statistics