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RESEARCH ARTICLE

Effect of Standards on Sub-Saharan African Countries' Agricultural Exports

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ABSTRACT

The aim of this paper is to investigate the impact of public standards (SPS, TBT) on Sub-Saharan Africa's exports of food, which represent less than 3% of world food exports. This situation is accentuated by the standards on agricultural goods. A modest contribution has been made both theoretically and empirically. Theoretically, the basic model has been criticized and subsequently reformulated by incorporating the cost function of food production in the exporting country. This reformulation made it possible to build a model, the methodology of which was developed by several authors. Empirical analysis shows that SPS and TBT standards have a negative impact on agricultural exports of the Sub-Saharan African (SSA) countries.
Keywords: Subsaharian Africa; Exports; Agricultural products; Standards; Border rejections

1. Introduction

To participate in global trade and access markets for valuable agricultural products, African producers must nowadays, be able to comply with agricultural standards, which designate a required or agreed level of quality or functionality [1]. Quality represents "all the properties and characteristics of a product or service aimed at satisfying the explicit or implicit needs of consumers. In the agri-food sector, quality includes many

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factors, such as health safety, organoleptic characteristics (taste, aroma, color, texture), functionality, cost and environmental, as well as socio-economic and cultural impact" [2].

Beyond the great diversity of standards, the WTO has defined two main categories of standards through two Agreements which entered into force on January 1, 1995. These are the "Sanitary and Phytosanitary" Agreement (SPS) and the "Technical Barriers to Trade" (TBT) Agreement. SPS standards refer to measures aimed at protecting the health and life of humans and animals; while TBT standards refer to requirements for packaging, labeling and sizing of products.

Through these two Agreements, the WTO recognizes the right of member countries to adopt the standards they deem appropriate, protect the health and life of people and animals, preserve plants, protect the environment or defend other consumer interests. Member countries have the duty, for the sake of transparency, to notify in advance to the WTO, new or modified SPS and TBT standards. They must also create a national information point. These public standards are by nature mandatory and they are supplemented by a multitude of private standards generally developed by civil society organizations. Private standards refer to codes of good practice; therefore, they are not obligatory.

In this study, we are interested in public standards, particularly SPS and TBT standards. We can cite for example Regulation 1881/2006 and its amendments which set in the European Union (EU) the maximum threshold of presence for aflatoxins and other contaminants in foodstuffs consumed as well as the ban on pesticides and heavy metals in products. The number of notifications of SPS and TBT standards by WTO member countries has also experienced rapid expansion, going from 400 to 3,600 between 1995 and 2020 [3].

Since this implementation of SPS and TBT standards in international trade, agricultural exports have generally stagnated in SSA with the exception of the period 2000–2011. Based on UNCTAD statistics [4], for example, they increased from 36.26 billion in 2011 to around 40 billion USD in 2020. Thus, Sub-Saharan Africa represents 2.8% of global agricultural exports in 2020 compared to 3.1% in 1998. This proportion was already very low as we can see. However, agriculture absorbs more than 60% of the active population and constitutes more than 20% of the export earnings of SSA countries.

Several authors have examined the effect of standards on international trade in goods and services in general [5–10] and in particular world trade in agricultural products [11–15]. These studies produce contradictory results. Since in fact, some analyzers come to the conclusion that standards have a positive impact on exports [16]. Others, on the other hand, find a negative effect of standards on exports [11–13, 15, 17]. Finally, a third group of authors show that the effect is not significant [18, 19].

The objective of this article is to assess the impact of public standards on African agricultural exports, hence the following research question: What are the effects of public standards on agricultural exports from SSA countries?

In addition to focusing on Sub-Saharan Africa, whose particularities in terms of agricultural practices, climate and transport infrastructure can amplify the effect of standards on agricultural exports, the importance of this study lies in the fact that it focuses, unlike most existing work, on the development of a theoretical model highlighting the impact of standards on agricultural exports. It is thus a modest attempt to fill in the literature by formulating a model of international trade in agricultural products which takes into account the incompleteness of markets. This model will also constitute the basis of the empirical analysis.

The rest of the article is organized as follows. It will begin by an inventory of agricultural standards and exports in SSA. A review of the literature will then allow us to revisit existing work on the issue with a view to making our modest contribution. This contribution will be useful in defining the methodology adopted. The interpretation and discussion of the results followed by economic policy recommendations will conclude the analysis.

2. Agricultural Standards and Exports in SSA Countries: The Stylized Facts

We present the standards applied to agricultural exports first, and then attempt to compare the evolution of standards with the evolution of agricultural exports of SSA countries over time in order to perceive the effects of standards on international trade.

2.1. Evolution of Standards Applicable to Agricultural Products

The export of agricultural products is subject to standards set by the generally industrialised importing countries. This is because the consumption of agricultural goods of bad quality can can have negative effects on human health. For example, the presence of aflatoxin in peanuts makes this food carcinogenic. Agricultural exports suffer either rejections (volume effect) or discounts on selling prices (value effect).

Agricultural standards generally cover food additives, pesticide residues, heavy metals, moulds, microbiological contamination, organoleptic aspects, packaging and labelling. They also define maximum residue limits (MRLs) for toxic elements that may be present in exported agricultural products. In other words, an MRL is a maximum tolerable concentration of residues of pesticides, heavy metals, or any other pathogenic organism in foodstuffs.

Most countries have a health risk analysis system in place to inspect agricultural goods at the point of entry to ensure that they are safe. Agricultural standards are more of the SPS and TBT type. They have grown rapidly over the past 25 years (**Figure 1**).

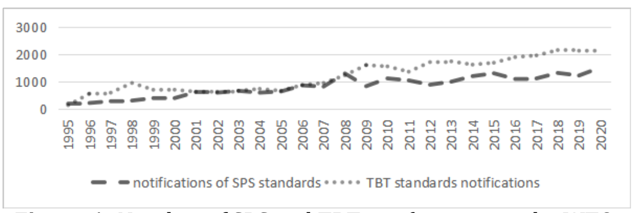

Figure 1. Number of SPS and TBT notifications to the WTO.

Source: Adapted from OMC [20].

Figure 1 shows that :

- The number of notifications of SPS standards increased significantly between 1995 and 2020 (from 200 standards in 1995 to more than 1500 in 2020). The number of reporting countries also increased from 40 to 80 between 1995 and 2010 [21].
- The evolution of TBT standards has been even more exponential than SPS standards (from 200 standards in 1995 to 2133 in 2020). Likewise, the number of reporting countries increased from less than 20 in 1995 to 50 in 2010 [21].

Furthermore, a comparative analysis of the standards concerning MRLs on agricultural goods for 40 pesticide-food combinations shows that they are relatively restrictive in developed countries [22]. The EU has the lowest MRLs in almost 75% of cases. In general, EU lists have around 100 to 150 pesticides per product; while those of the Codex Alimentarius Commission, which is the international body responsible for developing food standards at the global level, are frequently limited to a few dozen [23]. (CODEX alimentarius is a joint program of the Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO) consisting of a collection of standards, codes of practice, guidelines and other recommendations relating to food production and processing worldwide.)

Particularly with regard to Sub-Saharan Africa, practically all exported agricultural products are subject to foreign standards. These include fruits, vegetables, flowers, cereals, cocoa and coffee. Sanitary quality standards are integrated into regulations and constitute mandatory standards (traceability, hygiene control, maximum residue limits). If we take the case of pineapple for example, according to the UNECE-49 standard of 2017, this fruit must be: (i) whole; (ii) free from rot, deterioration and any visible foreign matter; (iii) free from foreign odor and/ or taste; (iv) free from parasites; (v) fresh and mature. The same applies to cocoa for which the European Commission stipulates that the beans must be free of heavy metals, pesticide residues, mycotoxins (notably aflatoxin), polycyclic aromatic hydrocarbons, microbes and foreign bodies. This significant presence of standards in the exports of African agricultural products is also illustrated by the rejections of agricultural products that SSA countries experience at the borders of developed countries.

2.2. Effect of Standards on Agricultural Exports from SSA Countries

In order to analyze the effect of standards on agricultural exports of SSA countries, we plotted the **Figure 2** and **Figure 3** below, using 2021 statistics from

UNCTAD, WTO and the RASFF portal (for border rejection).

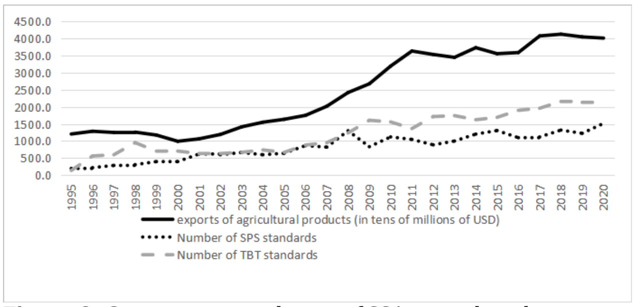

Figure 2. Comparative evolution of SSA agricultural exports and the number of SPS and TBT notifications.

Sources: Adapted from CNUCED [4] and OMC [20].

Figure 2 shows that the value of agricultural exports from SSA countries has roughly the same evolution as the number of SPS and TBT standards. But a comprehensive analysis shows that in the case of TBT standards, the periods 1995–2008 and 2010–2012 are the ones in which the value of exports and the number of standards have moved in opposite directions. In the case of SPS, its negative effect on agricultural exports was most pronounced at the beginning, between 1995–2001 and 2009–2011.

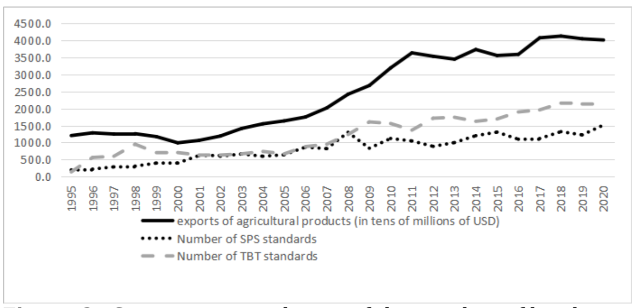

Figure 3. Comparative evolution of the number of border rejections of agricultural foods from Africa and the number of SPS and TBT standards.

Source: Number of SPS, TBT [20].; Number of releases [24].

Figure 3 shows that the curve for the number of border rejections has almost the same shape as the curves for standards. In particular, the TBT standards curve is closely merged with the border rejections curve.

Thus, it can be concluded that standards can exert a significant impact on agricultural exports from SSA countries. Econometric analysis will undoubtedly provide a better understanding of this effect.

3. Literature Review

The effect of standards on world trade has been analysed by several authors both theoretically and empirically.

3.1. Theoretical Analysis

On a theoretical view, the relationship between standards and exports has been controversial.

- For some authors, standards improve exports by solving the problem of asymmetric information and ensuring compatibility [6–9]. On the one hand, they signal the quality of goods, thus reducing transaction costs. On the other hand, they allow goods from different horizons to be brought together. This view seems to be valid in the case of manufactured goods, but relatively less for agricultural goods which not only do not have spare parts, but also, above all, pose harmful side effects on the health of the consumer when they are of poor quality.
- For other authors, on the other hand, standards are a brake on exports because they generate compliance costs (adaptation, certification and inspection costs) and are used as an instrument of disguised protectionism [17, 25, 26].
- To our knowledge, most studies on the effect of standards on international trade have not been formalized. Consequently, there are very few theoretical models on the issue. However, we can note the presence of formalised models with Casella [27], Chen, Otsuki and Wilson [17], Cheldon [28], Baltzer [29], Birg and Voßwinkel [10], and Ganslandt and Markusen [5].

However, almost all of these models are suitable for studying trade in manufactured goods. The standard is often taken into account by the compliance costs that exporting firms face.

The model chosen in this work as the basic model is based on that of Ganslandt and Markusen [5] due to its hypotheses. Indeed, the hypothesis that considers two countries, one poor and one rich, corresponds well to the case of SSA (developing countries) facing its importers (developed countries). Similarly, the assumption of 2 goods is also relevant because we consider the agricultural good and the industrial good. Their assumptions are as follows :

- Two-country model (one rich country and one poor country).
- Two goods model, one tradable and one non-tradable.
- Two-factor model (capital and labour).

The Ganslandt and Markusen model, which we will modify later, is as follows :

The authors consider a tradable good X produced in the domestic country (*h*) and the foreign country (*f)* , and a non-tradable good Y produced in the foreign country only. They define :

- A utility function U_{fi} of the representative individual in the foreign country:

$$U_{fi} = Y_{fi}^{1/2}\left(A\left[nX_i^{\beta_i} + n_f X_{fi}^{\beta_i}\right]^{1/\beta_i}\right)^{1/2} \tag{1}$$

  Where: n and n_f are the number of local and foreign varieties respectively.
  $\beta_i = \frac{s_i - 1}{s_i}$, s_i being the coefficient of elasticity of substitution.
  This is a Cobb-Douglas utility function whose second argument is of the form CES function.

- An identical production function for both goods and having the Cobb-Douglas form. The production function of the tradable good in country *h* is written :

$$X = L^{\delta} K^{1-\delta} \tag{2}$$

  Where: L_h and K_h are the quantities of labour and capital respectively; δ is the coefficient of elasticity of the production factor.

- A price function based on the assumption that the market for the non-tradable good is in a situation of pure and perfect competition and the market for the tradable good is in imperfect competition. With these assumptions, in equilibrium, the price function is given by the following expressions:

$$P_{fy} = mc_{fy}\left(w_f, r_f\right) \tag{3}$$

$$P_x(1 - m_x) = mc_x\left(w, r\right) \tag{4}$$

$$P_{fx}(1 - m_{fx}) = mc_{fx}\left(w_f, r_f\right) \tag{5}$$

$$P_{fx}(1 - m_x) = \left(1 + S_f\right) mc_x\left(w, r\right) \tag{6}$$

P_{fx} is the price of the tradable good produced in the poor country and sold abroad. It is a function of the trade margin (m_x), the marginal cost of production (mc_x) and the costs of compliance with foreign standards. These include the costs of adapting the production unit, inspection and certification of products. For the authors, these costs represent a proportion S_f of the marginal cost.

Ganslandt and Markusen have used this formulation to run simulations using a computable general equilibrium model and find that the standards penalise the poor country's exports.

Thus presented, their model would have resulted in the formation of the foreign sales price of goods produced in a poor country and exported to a rich country. It had the advantage of integrating into this price a parameter S_f which represents the cost linked to standards.

We can make some criticisms of the Ganslandt and Markusen model:

- The model does not explain why only the poor country exports the tradable good to the rich country. It may be limited to the case of similarity trade where both countries import and export goods of the same kind (the case of automobiles); but traditional theories of international trade are based on the case where each co-trader imports a single good and exports another good different from the first to the partner country.
- The consumer utility function has two different arguments for the consumption of the same good, namely the tradable good. It is as if in the foreign country market the two goods will be differentiable, which implies that the interchangeability assumption is no longer verified.
- As a corollary to the above criticism, the price of the tradable good on the foreign market is different depending on whether it is produced in the domestic or foreign country.

- This model only introduces the costs of compliance with standards, which assumes that countries have the human and financial capacity to do so. This is not the case for African farmers, who suffer not only from rejections and discounts for non-compliant products, but also from external constraints such as climate and the quality of infrastructure.
- The hypotheses on goods markets seem unrealistic, particularly for agricultural products, whose prices are formed on international markets, leaving no possibility for the producer (price-taker) to set a margin.

In view of the above, this paper attempts to formulate a theoretical model for agricultural exports from SSA to developed countries, based on the Ganslandt and Markusen model.

In contrast to Ganslandt and Markusen, we consider a world consisting of 2 countries (1 rich and 1 poor country) and 2 tradable goods (1 agricultural and 1 industrial good). The poor country is SSA and the rich country is the importer of agricultural products (notably the EU countries). The agricultural good is produced by the poor country and exchanged for the industrial good produced by the rich country. Each good has only one variety.

We consider that the agricultural good is produced using very little capital but a lot of land (T) and labour (L) whose unit prices are ***g*** and ***w*** respectively. Similarly, agricultural goods not only incur compliance costs. They have to bear several other direct and indirect costs that can be easily assimilated to the cost of production. These are:

- The climate, which is becoming increasingly unpredictable with global warming. For example, too little or too much rainfall can considerably reduce production, thus increasing the unit cost of production, all other things being equal. In addition to this, the climate also affects the quality of the agricultural product, some or all of which may be rejected at the time of export. For example, in case of high rainfall, cocoa beans can contract mould which turns into aflatoxin. Similarly, if there is insufficient rainfall, fresh fruit and vegetables will not have the required organoleptic properties (colour, shape) to be exported. In all these cases, the rejected or discounted products would constitute, in the eyes of the producer, a production cost whose unit price is ***c***.
- The cost of transporting agricultural goods from the field to the export port, which is significant in Africa, given the poor state of transport infrastructure. It has been shown that African farmers pay 2 to 6 times the world price for fertiliser when they are able to obtain it [30]. It would also be more expensive to transport fertiliser from an African port to a plantation 100 km inland than it would be to transport it from an American factory to the port of Douala [30]. Since the agricultural commodity is essentially perishable, the shaking and the very long time for this transport damages part of the product that can no longer be exported or that will suffer the discount. Let us call ***m***, the unit cost of this constraint suffered by farmers.
- The standards themselves: even if the climate and infrastructure are favourable to production, agricultural production is still subject to standards related, for example, to the use of pesticides. Let us note s and **θ** the respective unit costs of SPS and TBT standards.

In total, the average cost (CM) of production will depend on several factors of production and not on 2 factors. It will therefore be written as:

$$CM = f(T, L, C, I, N) \quad (7)$$

Where: T, L, C, I and N are respectively land, labour, climate, quality of communication infrastructure and standards.

Furthermore, agricultural goods are priced on the international market in USD. An appreciation of the USD against the Euro would make the prices of agricultural goods more expensive in the EU and, in turn, reduce the demand for these goods. In contrast to the work done so far, we assume in this paper that the producer of the agricultural good in the poor country, the price taker for his exported product, can only minimise his cost of production to maximise his profit. We also assume that he is a buyer of the quantity produced. This quantity is imposed on it by the prices on the market of the importing country. Consumers in the latter country maximise their utility under the constraint of their income. In view of the above, we need to define the cost function in the country exporting the agricultural product and the utility function in the importing country.

Let us start with the maximisation of utility in the importing country. We write this utility U_f in the form CES, as follows:

$$U_f = (X^{\frac{1}{2}} + Y_f^{\frac{1}{2}})^{1/2} \tag{8}$$

X_h is the quantity of the agricultural good consumed by the consumer in the importing country and Y_f is the quantity of the industrial good produced by the importing country and consumed by the economic agent in that country. The problem of the consumer in the importing country seeking to maximise his utility under the constraint of his income is written as follows:

$$\begin{cases} Max\, U_f \\ S/C \quad R_f - \frac{P_x}{t}X + P_y Y = 0 \end{cases} \tag{9}$$

Solving this problem by the Lagrange method allows us to find the corresponding optimal quantity X_h. It is written as follows:

$$X = \frac{R_f P_y t}{P_x(P_x + P_y)} \tag{10}$$

Where:

- X_h is the optimal quantity demanded of the agricultural good by the consumer in the importing country which must correspond to the supply of the exporting country of this good.
- Y_f is the optimal quantity manufactured of the industrial good in the importing country and demanded by the consumer in that country.
- P_x is the world price of the agricultural good charged to the producer of that good (in USD).
- P_Y is the domestic price of the industrial good in the country producing the good.
- t is the exchange rate between the partner country's currency and the USD (quoted on the spot in the partner country).

In the country producing the agricultural good, the production function is assumed to be of the Cobb-Douglas type. It is written on the basis of Equation (2), but takes into account the factors of production that we have defined above. It is therefore as follows :

$$X = N^{\alpha} L^{\beta} C^{\gamma} I^{\rho} S^{\mu} O^{\delta} \tag{11}$$

Where: N, L, C, I, S and O are respectively the quantities of land, labour, climate, transport infrastructure, SPS and TBT standards.

The total cost function of the producer of the agricultural good is written as follows:

$$T = gN + wL + aC + mI + sS + \theta O \tag{12}$$

Where: g, w, a, m, s and θ are respectively the unit prices of land, labour, climate, transport infrastructure, SPS and TBT standards.

If the producer of the agricultural good is a price taker on the factor market (which is generally the case because there are several producers demanding these factors), he can only minimise the total cost under the sole constraint of the quantity X_h imposed on him by the outside. This quantity is defined by Equation (10). The producer's problem is therefore written as:

$$\begin{cases} Min\, CT \\ S/C \quad X - \frac{R_f P_y t}{P_x(P_x + P_y)} = 0 \end{cases} \tag{13}$$

Solving this problem by the Lagrangian method allows us to find the optimal values of the production factors N, L, C, I, S and O that allow the producer of the agricultural good to minimise his production cost (and therefore to maximise his profit), given the double constraint of prices and quantity imposed on him by the world market for agricultural goods.

Replacing the values of N, L, C, I, S and O in the production function gives the following result:

$$X = \frac{R_f P_y t}{P_x(P_x + P_y)} \Big[\Big(\frac{g^{1-\alpha}\beta^{\beta}\gamma^{\gamma}\rho^{\rho}\mu^{\mu}\delta^{\delta}}{\alpha^{1-\alpha}w^{\beta}a^{\gamma}m^{\rho}s^{\mu}\theta^{\delta}} \Big)^{\alpha} \Big(\frac{w^{1-\beta}\alpha^{\alpha}\gamma^{\gamma}\rho^{\rho}\mu^{\mu}\delta^{\delta}}{\beta^{1-\beta}g^{\alpha}a^{\gamma}m^{\rho}s^{\mu}\theta^{\delta}} \Big)^{\beta} \Big(\frac{a^{1-\gamma}\alpha^{\alpha}\beta^{\beta}\rho^{\rho}\mu^{\mu}\delta^{\delta}}{\gamma^{1-\gamma}g^{\alpha}w^{\beta}m^{\rho}s^{\mu}\theta^{\delta}} \Big)^{\gamma} \Big] \Big[\Big(\frac{m^{1-\rho}\alpha^{\alpha}\beta^{\beta}\rho^{\rho}\mu^{\mu}\delta^{\delta}}{\rho^{1-\rho}g^{\alpha}w^{\beta}a^{\gamma}s^{\mu}\theta^{\delta}} \Big)^{\rho} \Big(\frac{s^{1-\mu}\alpha^{\alpha}\beta^{\beta}\gamma^{\gamma}\rho^{\rho}\delta^{\delta}}{\mu^{1-\mu}g^{\alpha}w^{\beta}a^{\gamma}m^{\rho}\theta^{\delta}} \Big)^{\mu} \Big(\frac{\theta^{1-\delta}\alpha^{\alpha}\beta^{\beta}\gamma^{\gamma}\rho^{\rho}\mu^{\mu}}{\delta^{1-\delta}g^{\alpha}w^{\beta}a^{\gamma}m^{\rho}s^{\mu}} \Big)^{\delta} \Big] \tag{14}$$

Equation (14) can serve as a basis for the empirical analysis.

3.2. Empirical Analysis

The link between standards and exports has been empirically verified by several authors. These analyses have been carried out mostly using the gravity model. Some authors have found that standards negatively impact exports [12, 15, 17, 31, 32]. This impact is also significant when the standards: (i) are not harmonized [6, 31–34]; (ii) generate significant compliance costs [12, 17] and border rejections [35, 36]; (iii) are SPS [11] or TBT [14]. Other authors, on the other hand, will show that the impact of standards is insignificant [18, 19] or even positive [14] on agricultural exports, particularly with regard to SPS standards. This contradiction in the empirical results is linked to the sample of countries and the variables considered in the studies cited. The choices made by the authors are questionable and open the way to possible empirical work. This is how we can formulate some critical remarks about the empirical work briefly presented above:

- Even if it is true that gravity models nowadays take into account several variables explaining multilateral resistance, their basic specification which integrates the geographical distance between the main capitals, seems less relevant for analyzing the structure of exports of the countries of Sub-Saharan Africa. For example, Cameroon and Ivory Coast all have access to the sea and almost the same distances between their respective capitals and those of EU countries and yet, Ivorian agricultural exports are every year, almost twice as high as those of Cameroon [4].
- Studies dealing with the impact of standards on exports of agricultural products most often use the basic gravity model and include very few SSA countries. Some studies like Kalaba, Kristen and Sacolo [13] as well as Liu et al. [15] also tend to confuse standards with non-tariff measures. Note that standards are only one component of non-tariff measures among many others.
- To our knowledge, very few empirical studies have had theoretical underpinnings; most have arbitrarily chosen variables on which coefficients have been assigned to obtain the empirical model.
- Analyses to date have taken into account the number of standards notified to the WTO, although not all of these are in force. The impact of standards on exports should instead take into account existing standards that already apply to exports. Our analyses will be made in this way.
- Finally, existing empirical studies do not take into account factors that have a direct impact on standards such as climate and transport infrastructure. Indeed, the tropical climate of the SSA region is conducive to the existence of aflatoxin. Similarly, the quality of agricultural products is negatively impacted by the poor state of the transport infrastructure between the plantation and the port of shipment.

In total, the review of the literature has enabled us to make some criticisms of the theoretical and empirical work on the subject. In particular, the inadequacies of the Ganslandt and Markusen model, which we considered as the basic model, led us to reformulate the analysis by starting from the production cost in the exporting country. From this reformulation, we built a theoretical model whose refinement led to our methodology. Thus, unlike many authors, the theoretical and empirical analyses are linked.

4. Methodology and Data

4.1. Methodology

Taking Equation (14) obtained in the theoretical analysis and try to simplify and linearize using the logarithm, we obtain the following Equation:

$$\text{Log}X = A + \beta_1 Logg + \beta_2 Logw + \beta_3 Loga + \beta_4 Logm + \beta_5 Logs + \beta_6 Log\theta + \beta_7 Logt \tag{15}$$

This Equation (15) must be put into estimable form. However, this study is an estimation using panel data based on pairs of countries. In other words, we determine the agricultural exports of each Sub-Saharan African country (i) to each trading partner (j) for each year (t). We also introduce the error term (Ɛ) as well as the specific effects and obtain the following mathematical expression:

$$\text{Log}X_{ijt} = A + \beta_1 Logg_{ijt} + \beta_2 Logw_{ijt} + \beta_3 Loga_{ijt} + \beta_4 Logm_{ijt} + \beta_5 Logs_{ijt} + \beta_6 Log\theta_{ijt} + \beta_7 Logt_{ijt} + \mu_i + \mu_j + \gamma_t + \epsilon_{ijt} \tag{16}$$

Where:

- A is the constant of the model to be estimated. It replaces all the constant parameters of Equation (14).
- $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6$ and β_7 are coefficients associated with the explanatory variables.
- μ_i is the fixed effect associated with the countries of Sub-Saharan Africa. It takes into account the unobservable heterogeneity of the countries in this region of the world.μ_i
- μ_j is the fixed effect of the partner countries taking into account the unobservable characteristics specific to each of them.
- γ_t is the effect which takes into account the temporal dimension, in other words, the variations linked to time.

The explained variable is agricultural exports from SSA countries. The explanatory variables are contained in Equation (14), which results from the theoretical model that we proposed. These are unit prices of land (g), labor (w), climate (a), transport infrastructure (m), SPS standards (s), TBT standards (θ) and the exchange rate (t). Since statistics on unit prices of factors of production are not available and since these unit prices are a function of their more or less abundance and are more or less proportional to factor endowments, we can validly replace them with the stock of factors available to each SSA country. In the model to be estimated represented by Equation (17):

- X is the value of agricultural exports from SSA countries to partner countries.
- T is the amount of arable land valued in ha.
- L is the labour force, i.e. the size of the working population.
- C is the average rainfall (climate).
- I represents the stock of transport infrastructure.
- S is the number of SPS standards in force.
- O is the number of TBT standards in force.
- t is the nominal exchange rate between the partner country's currency and the USD.
- $\varepsilon_{ijt}$is the error term.

Thus we have:

$$\text{Log}X_{ijt} = A + \beta_1 LogT_{ijt} + \beta_2 LogL_{ijt} + \beta_3 LogC_{ijt} + \beta_4 LogI_{ijt} + \beta_5 LogS_{ijt} + \beta_6 LogO_{ijt} + \beta_7 Logt_{ijt} + \mu_i + \mu_j + \gamma_t \quad (17)$$

4.2. Data

The statistics used to measure the variables of the model (Equation (16)) are taken from different sources such as the World Bank ($T,\ L,\ C$), UNCTAD ($X,\ I,\ t$) and the WTO ($S,\ O$). The three dimensions i, j and t are taken into account in the sample in order to remain faithful to our econometric specification. Thus, we considered 44 countries in Sub-Saharan Africa whose agricultural exports go to 13 main developed countries (**Table 1**). The observation period is from 2000 to 2016. There are a total of 9724 (44 × 13 × 17) observations.

The description of the variables is as follows:

- Agricultural exports from each SSA country to each partner country include all agricultural products exported. This variable can be evaluated in volume or in value. Even if it is preferable to take it in volume in order to cancel out the effect of inflation and to assess the real export capacity of the country, the constraint of having the data for all the countries in the sample forces us to choose the value evaluation. The estimation of agricultural exports in value also makes it possible not to penalize African countries which export agricultural goods with high added value such as horticultural products. Agricultural exports are thus evaluated in thousands of USD.
- The quantity of land: this is the surface area of Arab land, which can easily be cultivated. We assume that the more arable land a country has, the higher its agricultural production, and, consequently, the more its exports. The evaluation is made in hectares.
- Labor force: this is the workforce devoted to agricultural activities. We evaluate it using the active population because a very significant part of the active population in Sub-Saharan Africa works in agriculture. We assume that exports are an increasing function of the labor force. The evaluation is made in number of people.
- Climate: this is the average height of precipitation in the year. We could have used indicators that are more relevant such as the variability of precipitation or drought. However, to our knowledge, the only data available on precipitation for the major-

Table 1. Sample countries.

SSA countries	Partner countries
Angola, Benin, Burundi, Burkina Faso, Cameroon, Chad, Guinea, Guinea-Bissau, Senegal, Botswana, Kenya, Lesotho, Liberia, Madagascar, Malawi, Congo, Mali, Côte d'Ivoire, Mauritania, South Africa, Djibouti, Mauritius, Equatorial Guinea, Mozambique, Eritrea, Namibia, Ethiopia, Niger, Gabon, Nigeria, Gambia, Rwanda, Ghana, Sao Tome and Principe, Sierra Leone, Togo, Uganda, Tanzania, Zambia	Belgium, Canada, China, France, Germany, Italy, Japan, Netherlands, Poland, Portugal, Spain, UK, USA

ity of countries in the sample are constant from year to year, which does not allow us to calculate their variability. The evaluation is made in millimeters.

- The stock of transport infrastructure: several indicators are used in the literature to measure transport infrastructure (synthetic indices, density of paved roads, length of the railway, air traffic). In order to avoid multicollinearity problems, we use the synthetic transport infrastructure index which measures the ability of a system to transport people or goods from one place to another. It is defined by UNCTAD [4] as the capillarity of the road and rail network and air connectivity. The higher the value of this index, the more transport-related infrastructure there is.
- The number of SPS standards: unlike other studies which choose the total number of standards, the percentage of exports affected by non-tariff measures or the number of specific trade problems, we consider the number of standards in force declared each year to the WTO by the trading partner country. These are indeed the standards applied because countries can declare certain standards without immediately applying them. We assume that the more standards a partner country declares, the more restrictive access to its market is for Sub-Saharan Africa.
- The number of OTC standards: the description is identical to that made previously concerning the SPS standards.
- The exchange rate: this is the nominal exchange rate between the currency of the partner country in the exchange and the US dollar given that goods are generally sold on the international market in US dollars.

5. Results and Discussion

5.1. Descriptive Statistics

The following **Table 2** shows the descriptive statistics of the variables presented above:

Table 2 shows that there is a high dispersion between countries in the value of agricultural exports. The value of bilateral agricultural exports would also be zero in certain cases. The dispersion is also important for the variables number of SPS standards and number of TBT standards. In other words, there are partner countries that apply relatively more SPS and TBT standards than others.

Table 3 below presents the correlation matrix between the model variables.

We find that the correlation is particularly negative between agricultural exports and the number of SPS standards and TBT standards. These results seem to confirm the analyses we conducted above. The correlation is, however, positive with the variables stock of arable land, average rainfall, size of the active population and nominal exchange rate.

5.2. Econometric Results

This is a pseudo-gravity model taking into account the spatial dimension and the temporal dimension. This model should in principle be subject to a basic evaluation through statistical tests carried out on panel data. However, based on the developments proposed by Yotov et al. [37], we directly used the Poisson Pseudo Maximum

Table 2. Descriptive statistics of model variables.

Variable	Obs	Mean	Std. Dev.	Min	Max
lnExports	9724	6.160489	3.925275	0	14.09236
lnTerres_Arabes	9724	13.83701	2.286426	4.941642	17.42643
lnInfrastructures	9646	2.397606	0.3806557	1.386896	3.897383
lnPrecipitation	9724	6.761253	0.8022988	4.521789	8.070906
lnOTC	6688	2.154632	1.509146	0	6.261492
lnSPS	6072	2.297526	1.324226	0	6.493754
lnForce_Work	9438	14.7773	1.481258	10.70831	17.86503
Exchange rate	9724	0.959117	0.4965084	0.0079752	2.000914

Source: Obtained from estimation.

Table 3. Correlation matrix between model variables.

	1	2	3	4	5	6	7	8
1	1							
2	0.3911	1						
3	−0.0878	−0.5363	1					
4	0.1210	0.0115	0.2926	1				
5	−0.0543	−0.0179	−0.0374	−0.0022	1			
6	−0.0100	−0.0149	−0.0255	0.0005	0.5607	1		
7	0.4663	0.9046	−0.4238	0.0137	−0.0480	−0.0376	1	
8	0.1314	0.0004	−0.0047	−0.0003	−0.0143	0.0520	0.0008	1

Note: 1 = log of exports; 2 = log of arable land; 3 = log infrastructures; 4 = log precipitation; 5 = log OTC; 6 = log SPS 7 = log of labor force; 8 = Exchange rate.
Source: Obtained from estimates made.

Likelihood (PPML) estimator with fixed effects. This estimator allows us to correct, if necessary, biases linked to the endogeneity of the explanatory variables, to the zero values taken by the explained variable and to heteroskedasticity. It is, according to Correia, Guimaraes and Zylkin [38], an estimator robust to heterogeneity and convergence problems.

The robustness of our results was also verified by carrying out several estimations. The first estimate (column 2 in **Table 4**) includes the total number of TBT standards applied. The second estimate (column 3) takes into account the number of SPS standards applied. The third estimate (column 4) on the other hand considers the total number of standards applied regardless of whether they are SPS or TBT. The results of the three estimations are summarized in **Table 4** below:

According to **Table 4**, the standards negatively and significantly impact agricultural exports from SSA countries in all the estimations carried out. Thus, a 10% increase in the number of SPS and OTC leads to a drop in the value of exports of −0.23 and −0.07 percentage points respectively. We also see that SPS standards have a higher impact than TBT standards. These results are consistent with the studies of Otsuki, Wilson and Sewadeh [11], Fontagné, Mimouni and Pasteels [39] and Chen, Otsuki and Wilson [17]. They are contrary to those of Swann [7], Moenius [8], Mangelsdorf [16], Birg and Voßwinkel [10], and Da Silva-Glasgow and Hosein [14]. Several explanations can be given to our results. First of all, SSA countries are located in the tropical zone which is an area where agricultural products rapidly develop fungi and mycotoxins (notably aflatoxin), substances that are almost banned in international trade in agricultural goods. Then, agriculture is generally practiced in Africa south of the Sahara by the rural population who adopt agricultural practices (for example drying cocoa beans on asphalt road or using wood fire) amplifying contamination or even modification of the organoleptic properties of agricultural goods. Then, most of the partner countries present in the sample are developed countries which apply agricultural standards which are most often stricter than the CODEX Alimentarius standards [40]. Finally, the inadequate institutional environment (for example the quality of infrastructure) in SSA constitutes a factor in amplifying the risk of non-compliance with standards by agricultural products, particularly horticul-

Table 4. Results of the estimation of the global export model.

	(1)	(2)	(3)
Variables	LogX	LogX	LogX
LogT	−0.0012	−0.0123	0.0148
LogI	0.1557***	0.1354**	0.2272***
LogC	0.0854***	0.0928***	0.0718**
LogO	−0.0072*		
LogS		−0.0233***	
Log(O+S)			−0.0122***
t	0.0330***	0.0385***	0.0340***
LogL	0.2326***	0.2433***	0.2298***
A	−2.4331***	−2.3922***	−2.6890***
Sample	7214	6928	11005

tural products. However, the magnitude of the effect of the standards taken separately or together is relatively small (less than 2.25%). This would, for example, be due to failure to take into account borders rejections and price discounts in the estimates for lack of data.

The other variables in the model have the expected signs and are statistically significant with the exception of the Arab land stock variable. Thus, an increase in the workforce, the quality of infrastructure, the exchange rate (therefore a depreciation of USD) and the average height of precipitation by 10% leads to an increase in the value of agricultural exports from the SSA countries by 2.29, 2.27, 0.3 and 0.71 percentage points respectively. These results are consistent with those obtained by Fontagné, Mimouni and Pasteels [39], Dontsi [40], FANDC [41] and Djontu [42]. The somewhat surprising result of the effect of arable land stock could be explained by the low agricultural productivity in Sub-Saharan African countries. Indeed, faced with a quasi-static evolution of the stock of Arab land, the increase in national food demand due to demographic growth leads to a drop in the exported part of agricultural production in favor of satisfying this internal demand additional.

6. Conclusions and Recommendations

The objective of this paper was to analyse the effect of public standards on exports from SSA countries. This is a poor region of the world whose agricultural exports are not only weak but suffer from rejections and price discounts due to the presence of standards on the international market. Our modest contribution is at two levels:

In the theoretical analysis, we revisited the model of Ganslandt and Markusen (2001). The criticisms of this basic model have made it possible to integrate into the analysis the factors that influence both agricultural production and compliance with standards (climate, quality of infrastructure, arable land, exchange rate). In this way, we have built an analytical model that takes into account the specificities of agricultural production in SSA. This model shows that standards theoretically have a significant negative effect on agricultural exports from Southern countries.

In terms of empirical analysis, the theoretical model we developed allowed us to estimate using the PPML estimator with fixed effects on a sample of 44 SSA countries and 13 partner countries covering the period from 2000 to 2016. We find that the standards have a negative and significant impact on agricultural exports from sub-Saharan African countries. An increase in SPS and TBT standards of 10% overall leads to a drop in agricultural exports of 0.12 percentage points. The effect is greater for SPS standards compared to that of TBT standards.

These results allow us to formulate some elements of economic policy. On the one hand, States must supervise farmers on the methods of growing and preserving agricultural products so that they comply with international standards. They must also subsidize local companies producing organic fertilizers to replace chemical fertilizers. We will thus use the rejects and waste from agriculture (excrement, dead leaves, domestic waste) to feed it. On the other hand, developing countries, particularly African countries, must lobby to push developed countries to reduce their standards to the levels recommended by the CODEX Alimentarius Commission. This lobbying must also be active in the international standards elaboration bodies so that their specificities are taken into account. Furthermore, it is necessary to take actions to increase the price paid to the farmer (main link in the chain), to mitigate climate change (tax on pollution) and improve the institutional environment.

Several lines of research open up following this study. These include: (i) the introduction of border rejections and price discounts; (ii) empirical evaluation of the interaction between standards and climate and transport infrastructure variables; (iii) the introduction of the quadratic form of the climatic variable; (iv) taking into account the content of the standards, in other words their degree of restriction; (v) the introduction of national food demand and (vi) the analysis from the perspective of exported volumes.

Author Contributions

All co-authors actively contributed to the writing of this article. The first author notably developed the problematic and the theoretical model, interpreted the results and supervised the writing. The second, under the supervision of the first author, wrote the article and carried out the econometric analysis.

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Data Availability

The data used in this study exist and can be made available if necessary.

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Conflict of Interest

There is no conflict of interest of any nature whatsoever in the context of this article.

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