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Trade Determinants and Export Potential of Senegalese Vegetable Products

Déterminants et Potentiel d'Exportation en Produits Maraichers du Sénégal

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Abstract

This paper aims to identify the key factors and export potential of Senegalese vegetables to 33 partners for the period 2000-2021. We apply the Poisson pseudo-maximum likelihood method (PPML) to the structural gravity model using WITS, CEPII, WDI and WDG databases. The results suggest that Senegalese exports of horticultural products can be boosted both by strengthening macroeconomic competitiveness and by targeting importers with high GDP, strong institutional robustness, a shared colonial past, and preferential trade agreements. Conversely, administrative costs and procedures, as well as the language barrier, considerably reduce trade flows. The assessment of export potential revealed substantial untapped commercial potential. Indeed, all of Senegal's partners represent only the tip of the iceberg (0 to 30%). It also highlights a high concentration of trade flows towards a few European partners, while African partner countries remain marginal in the export structure.

Keywords : Vegetable products; structural gravity model; trade potential; ppml.

JEL Classification: F14, Q17, O13, Q13, L66

Résumé

L'article vise à identifier les facteurs déterminants et le potentiel d'exportation des légumes sénégalais vers 33 partenaires, sur la période 2000-2021. Nous appliquons la méthode du pseudo-maximum de vraisemblance de Poisson à un modèle de gravité structurel, en utilisant les bases de données WITS, CEPII, WDI et WDG. Les résultats suggèrent que les exportations sénégalaises de produits horticoles pourraient être stimulées, d'une part, par le renforcement de la compétitivité macroéconomique et, d'autre part, en ciblant des pays importateurs caractérisés par un PIB élevé, des institutions solides, un passé colonial commun et l'existence d'accords commerciaux préférentiels. À l'inverse, les coûts et procédures administratifs, ainsi que la barrière linguistique, réduisent considérablement les flux commerciaux. L'évaluation du potentiel d'exportation révèle un potentiel commercial substantiel encore inexploité ; en effet, l'ensemble des partenaires actuels du Sénégal ne représente que la partie émergée de l'iceberg (0 à 30 %). L'étude met également en évidence une forte concentration des flux commerciaux vers quelques partenaires européens, tandis que les pays partenaires africains demeurent marginaux dans la structure des exportations.

Mots-clés : Produits maraîchers ; modèle de gravité structurel ; potentiel commercial ; PPML.

Classification JEL : F14, Q17, O13, Q13, L66

Introduction

Recent studies on international trade highlight the growing importance of agricultural products within the global economy (Gaigne & Gouel, 2022). To take full advantage of this trend, Senegal has implemented numerous strategies and policies, the most recent of which is the National Food Sovereignty Strategy 2024–2028. Agriculture plays a central role in the Senegalese economy, contributing approximately 16.6% of GDP in 2023, according to the World Bank[1]. With regard to agricultural production, the horticulture sub-sector occupies a very important place. In 2023, Senegal (182.88) ranked first among the countries of the West African Economic and Monetary Union (WAEMU) in terms of the primary production index for fruits and vegetables (Faostats, 2026). At the same time, the production of fruits and vegetables stands at approximately 1.6 million tonnes (ANSD, 2024), while domestic consumption is estimated at 1.3[2] million tonnes (ANSD, 2024). Consequently, Senegal is not only self-sufficient but also a net exporter. According to the World Integrated Trade Solution (WITS), in 2023, Senegalese exports are mainly destined for China (29%), India (18%), Vietnam (17%), the United Kingdom (14%), Mali (12%) and Spain (12%).

Despite meeting most domestic needs, horticultural exports remain relatively low. In 2023, horticultural exports accounted only 2.7% of Gross Domestic Product (GDP) compare to 13.2% in Ivory coast (Faostats, 2026). In particular, exports are largely dominated by vegetables, which account for around 70%. This highlights a largely untapped export potential, which could be exploited through both tariff and non-tariff measures (Arata et al., 2025; Disdier et al., 2023; Disdier, 2025). Theoretically, tariff and non-tariff measures help reduce costs (Ricardo, 1817; Smith, 1776; Tinbergen, 1962), favor sectors intensive in abundant factors (Ohlin, 1933), extend product life cycles (Vernon, 2015), confer technological advantages (Posner, 1961), and enable returns of scale as well as product differentiation (Krugman, 1980). They also reassure foreign consumers by limiting information asymmetry (Akerlof, 1978) and mitigate contractual uncertainties (Coase, 1937; Williamson, 2007).

However, although tariff and non-tariff measures theoretically confer advantages, empirical studies remain divided as to which measures are most likely to foster better utilization of agricultural potential. Studies particularly highlight geographical constraints (Kerrouch, 2025

[1] https://donnees.banquemondiale.org/indicateur/NV.AGR.TOTL.ZS?locations=SN&utm_source=copilot.com
[2] According to the Directorate of Agricultural Analysis, Forecasting and Statistics, fruit and vegetable consumption is 70–75 kg per capita per year, or approximately 1,300,000 tonnes for a population of over 18 million inhabitants.

and Vincent, 2024), issues of competitiveness (Danon et al., 2024 and Neville-Rolfe, 2025), comparative advantages and logistical factors (Bott et al., 2024 and Boudifa, 2024), administrative standards (Calvo, 2024 and Touré et al., 2024), as well as institutional quality (Essaadi, 2022 and Lin et al., 2020). Given that, it is relevant to ask the following question: how can Senegal exploit its export potential in vegetable products?

Understanding the trade determinant of Senegalese vegetable export is important for several reasons. First, it helps identify the channels through which Senegal should leverage its vegetable potential. Furthermore, it takes into account aspects of international trade that have been largely unexplored in previous research on Senegal (Ndao, 2024; Touré et al., 2024), such as non-tariffs barriers. Then, it contributes to reduce post-harvest losses accounted in Senegal 40% of total fruit and vegetable production (Faye, 2025). Secondly, developing this untapped potential can significantly increase public revenue for the government and improve the income of horticultural producers. Thirdly, research on the existence of commercial potential in developing countries remains controversial. While some studies highlight the weakness, or even the exhaustion, of the commercial potential of African countries (Amadji & Gervais, 2024 and Avom & Mignamissi, 2017), others point to a largely unexplored trade potential (Atif et al., 2017; Hajivand et al., 2020; Lin, 2020).

This papier analyses the export potential of Senegal's vegetable products. Specifically, it seeks, firstly to identify the determinants of Senegal's vegetable exports, secondly determine the trading partners with whom Senegal has the greatest potential for vegetable trade. It differs from the work carried out so far in Senegal in uses most recent data and the most recent gravity model estimation techniques such as the PPML.

The article is organized into three sections. Firstly, the context is presented, followed by a review of the literature. Next, the methodological approach is outlined. Finally, the results obtained are discussed.

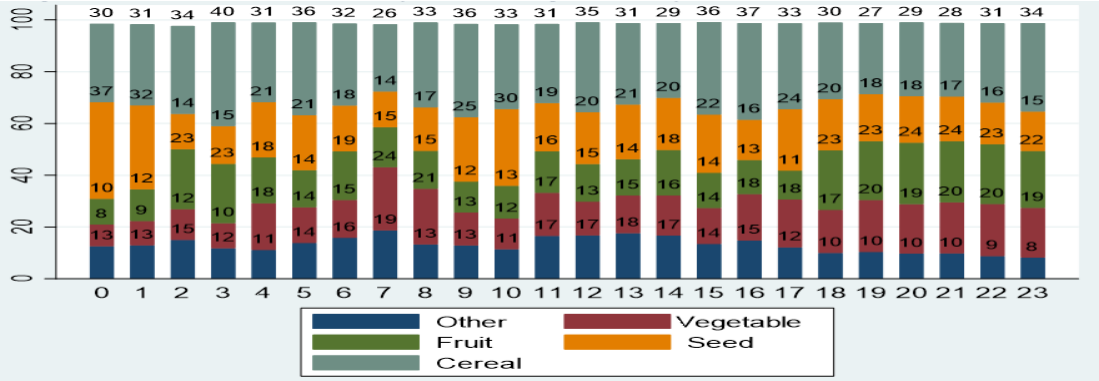
1. Stylized facts of Senegal's vegetable production and export Sector

In Senegal, the horticulture sub-sector presents numerous opportunities for both the government and the private sector. It plays a vital role in wealth creation and distribution. It also helps to mitigate the country's trade deficit. Indeed, horticultural production, particularly of fruits and vegetables, is one of the most successful components of the agricultural sector in Senegal.

Figure 1 illustrates the evolution of the structure of agricultural production between 2000 and 2023 across five product categories: cereals, fruits, vegetables, seeds, and other products. It

reveals a limited structural transformation of the agricultural system toward higher value-added horticultural sectors, which are nonetheless often linked to greater opportunities for income generation, productive diversification, and job creation. The relative shares of fruits and vegetables fluctuate moderately over time, without showing a clear or sustained upward trend. This variability may reflect the vulnerability of horticultural production to climate risks, constraints in access to water, storage, and marketing infrastructure, as well as challenges in market integration.

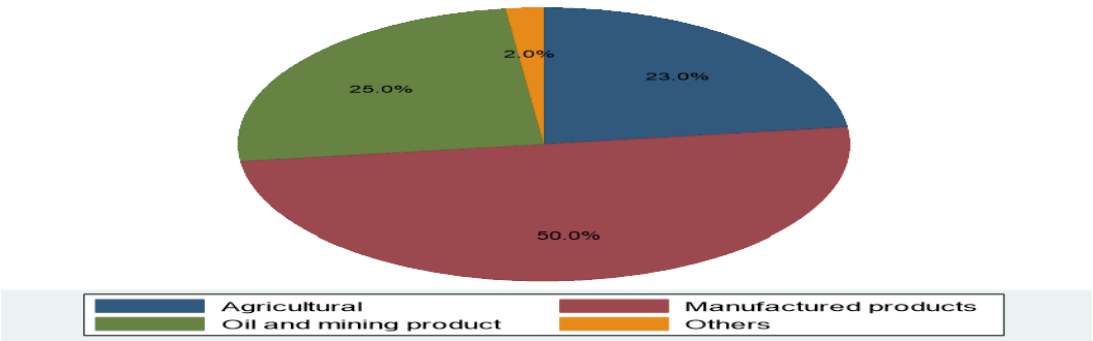
Figure N°1: Share of horticultural product in agricultural production 2000-2023



Source: Author's based on FAO database

Figure 2 highlights the dominance of manufactured goods in Senegal's export structure, representing 50% of the total, reflecting a marked focus on processed goods. Petroleum and mining products occupy second place with 25%, confirming the still significant weight of extractive resources in export performance. Agricultural products account for 23%, underscoring the significant, though not dominant, role of the primary sector.

Figure N°2: Structure of exports by product type (%) in 2023



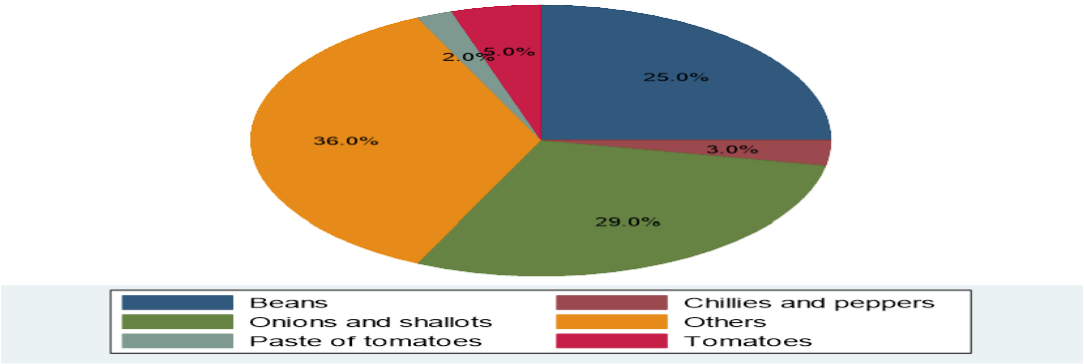
Source: Author's based on WITS database

The horticultural exports are largely dominated by vegetables (70%), compared to 30% for fruit[3] as shown by figure N°3. Vegetable exports are more concentrated on a few products,

[3] Calculated by the author

including onions and shallots (29%), and beans (25%), while tomatoes (2%) and dried chilies/peppers (8%) remain underrepresented. Overall, this highlights a predominance of exports of minimally processed fresh produce, some diversification within the sector, but also potential for moving upmarket through food processing.

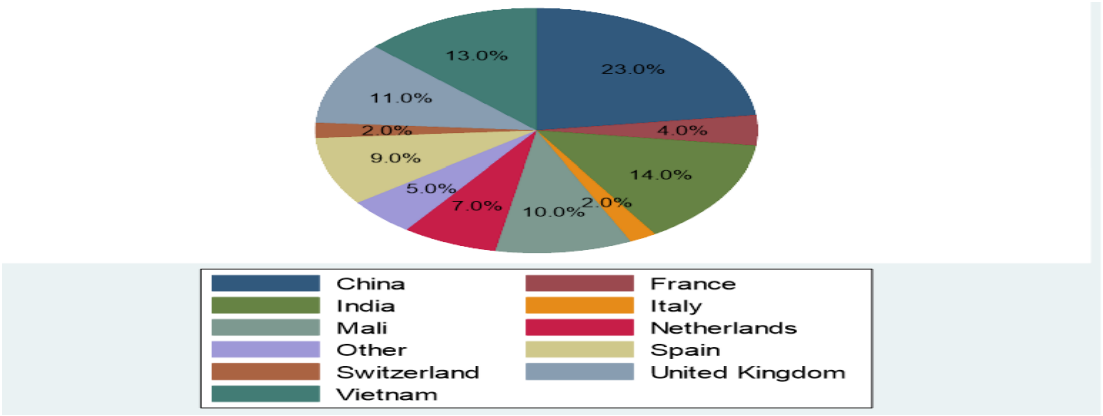
Figure N°3: Structure of vegetable exports (%) in 2023



Source: Author's based on FAO database

Figure 4 highlights a strong concentration of vegetable product market share among a few major partners. China clearly dominates with 23% of the share, followed by India (14%) and Vietnam (13%), underscoring the significant presence of Asian countries in this sector. The United Kingdom (11%) and Mali (10%) occupy an intermediate position, while Spain stands at 9%. The more modest shares of the Netherlands (7%) and France (4%) reflect a relatively limited European presence. Overall, the structure reveals a marked hierarchy, with Asian players leading the way.

Figure N°4: Share partners in vegetable products in 2023



Source: Author's based on WITS database

2. Literature review: toward a framework for Senegalese vegetable trade

The determinant of trade refers to the key explanatory factors that influence the exchange of goods and services. It is customary to distinguish between "tariff" (fiscal tools) and "non-tariff" components (regulatory and administrative tools). Empirically, Head & Mayer (2014),

using the gravity equation, identify economic, geographical and various structural factors as the key determinants of international trade. Indeed, economic factors measured by tariff barriers such as customs duties, gross domestic product, the bilateral exchange rate, and the inflation rate affect trade between partner countries (Avom & Mignamissi, 2017; Nguyen, 2010). While geographical factors, including distance, landlockedness, and proximity, also play a crucial role. For example, geographical remoteness and landlockedness reduce exports, whereas sharing a border fosters them (Atif et al., 2017; Abdullahi et al., 2022). However, the new evidence identity cultural and institutional factors including cultural proximity, a shared historical past, institutional quality, and trade partnership agreements are positively affect trade (Atif et al., 2017; Obeng, 2021). Similarly, non-tariff barriers factors play a key role in international trade (Lengai et al., 2022). Also, these findings found an untapped potential in most developing countries, particularly those that focus on agricultural.

Most studies highlight the existence of untapped potential for agricultural exports in developing countries, shaped by factors such as tariff and non-tariff barriers (Abdullahi et al., 2021; Hajivand et al., 2020; Verter et al., 2020). Conversely, some research concludes that the trade potential of African countries is weak, or even exhausted (Amadji & Gervais, 2024; Avom & Mignamissi, 2017;Kouassi, 2024). To reach these conclusions, researcher have employed a variety of methodological approaches.

Early studies conducted across different regions and products employed the traditional gravity model, originally introduced by Tinbergen (1962). While intuitive and useful, this model primarily relies on basic variables such as economic size (GDP) and geographical distance, thereby oversimplifying the complex reality of international trade. To address these limitations, subsequent research has incorporated additional dimensions like economic, social, linguistic, and historical (Anderson & Van Wincoop, 2003; Braha et al., 2017; Head & Mayer, 2014; Mao et al., 2019). However, much of this work remains confined to examining the determinants of product exports without explicitly assessing export potential. In this context, numerous studies have adopted varied approaches to estimate countries' export potential (Abdullahi et al., 2021; Avom & Mignamissi, 2017; Hajivand et al., 2020).

To address this issue, Atif et al. (2017) applied a stochastic frontier gravity model to data covering the period 1995-2014 in order to assess untapped export potential between Pakistan and its 63 trading partners in the agricultural sector. Their estimation of technical efficiency scores revealed that Pakistan possesses significant export potential, particularly with neighboring countries in the Middle East and Europe. Similarly, Hajivand et al. (2020)

analyzed Iranian agricultural exports using a stochastic frontier gravity model with data from 38 countries spanning 1982-2017. Their findings indicated an average agricultural export potential of 69%. However, when trade flows are zero for a large number of observations, the stochastic frontier model becomes unsuitable, as it fails to account for censoring in the data. To address this issue, Lin et al. (2020) investigate the role of institutional quality in shaping bilateral coconut trade. Employing a structural gravity model, they apply the PPML approach developed by Baier & Bergstrand (2009) to examine trade flow between 26 major producing counties and 15 large importing economies over the period 1996 and 2016. Their findings highlight untapped trade potential among the producing countries, which can be realized through improvement in institutional quality.

Extensive literature in Senegal highlights multiple determinants influencing international trade. These include price competitiveness and quality standards (Kouadio & Camara, 2019), trade policies and market access (Sarr & Ndiaye, 2021), infrastructure and logistics (Ndiaye et al., 2020), production capacity and technology (Faye et al., 2019), institutional and financial support (Mbaye, 2017), and exchange rate volatility (Fall et al., 2018). Also, those of the most recent and focus in agricultural product was carried out about the potential of mango sector (Mbodj, 2024) and the impact of the taxation on cashew nut exports (Coly et al., 2021). Therefore, we did not find any work analyzing the determinant of horticultural exports, focusing on vegetable. A critical analysis of this literature suggests that for analyzing the determinant of Senegalese vegetable products to set the cursor the diversity of factors influencing trade costs and the existence of untapped horticultural potential. Indeed, existing studies present certain limitations as to take account the cultural and institutional variables and then administrative issue such as phytosanitary measure. Moreover, they do not adequately propose improvement strategies or trade policies specifically aimed at enhancing vegetable exports. These gap, underscore the need for further studies on agricultural export potential, employing innovative approach.

3. Methodology and data

In this section, we present the econometric specification, estimation strategy, data sources, and descriptive statistics.

3.1. Econometric specification and strategy estimation

Traditionally, the gravity approach distinguishes between two types of gravity equations: an intuitive formulation (Tinbergen, 1962) and a structural specification (Anderson & Van Wincoop, 2003). The former relies on an a priori selection of factors that influence trade

flows, whereas the latter is grounded in microeconomic foundations (Arthur et al., 2020). It also allows consideration of multilateral resistance terms, unlike the first one. For these reasons, the structural gravity model is used to identify the determinants and then calculate the horticultural potential of Senegal. After processing the Anderson & Van Wincoop (2003) model, the multiplicative form is given by:

$$exp_{ijt} = \exp\left[\alpha_0 + \alpha_1 \ln(gdp_{it}) + \alpha_2 \ln\left(gdp_{jt}\right) - \alpha_3 \ln\left(dist_{ij}\right) + \tau_{ij} + \Phi_j + \Phi_i\right] + \varepsilon_{ijt} \quad (1)$$

where exp_{ijt} represents trade flow from country i to country j; gdp_{it} Gross Domestic Product of country i; $dist_{ij}$ distance between countries $i$and j; τ_{ij} denotes bilateral resistance terms represented by dummy variables such as common language, common currency; ε_{ijt} the error term; α_i parameters of interest; Φ_i exporter's multilateral resistance term; and Φ_j importer-specific effect (the destination country's multilateral resistance). Therefore, taking into account geographical, commercial and administrative cost (Atif et al., 2017; Avom & Mignamissi, 2017; Abdullahi et al., 2022; Nguyen, 2010), the equation 3 became:

$$\begin{aligned} vegexp_{ijt} = \exp\big[&\alpha_0 + \alpha_1 \ln(gdp)_{it} + \alpha_2 \ln(gdp)_{jt} - \alpha_3 \ln\left(dist_{ij}\right) \\ &+ \alpha_4 \ln(change\ rate)_{ijt} + \alpha_5 \ln(costums\ duties)_{it} + \alpha_5 \ln(population)_{jt} \\ &+ \alpha_6 \ln(entry\ cost)_{jt} + \alpha_7 \ln(entry\ procedure)_{it} \\ &+ \alpha_8 institutional\ quality_{it} + \alpha_9 institutional\ quality_{jt} \\ &+ \alpha_{10} common\ language_{ij} + \alpha_{11} common\ colonizer_{ij} \\ &+ \alpha_{12} free\ trade\ agrement_{ij} + \alpha_{13} common\ border_{ij} + \alpha_{14} landlocked_{ij} \\ &+ \Phi_j + \Phi_i\big] + \varepsilon_{ijt} \quad (2) \end{aligned}$$

To asses trade potential, we adopt the approach proposed by Fontagné et al. (2002). It suggests that the trade flows simulated by the model reflect a theoretical structure (factor endowments, transaction costs and preferences), but they must be calibrated to incorporate the real constraints observed in practice. The procedure consists of two steps.

Step 1: Adjustments to the simulated trade flows as follows

$$trade_{ij}^{*} = \frac{\widehat{trade}_{ij}(\sum_j trade_{ij} - trade_{ij})}{\sum_j \widehat{trade}_{ij} - \widehat{trade}_{ij}} \quad (3)$$

$\widehat{com_{ij}}$ represents the gross simulated bilateral trade flows, i.e. those directly obtained from the model estimation; Comij the observed level of bilateral trade; and com_{ij}^{*} the adjusted simulated trade flows.

Step 2: calculation of trade potential (TP)

The second step consists of computing the trade potential for a given period as the arithmetic mean of the gross simulated cash flows and the adjusted simulated cash flows:

$$TP_{ijt} = \frac{1}{2}(\widehat{trade}_{ijt} + trade^{*}_{ij}) \quad (4)$$

Three main concerns arize when estimating the gravity model. Firstly, we should perform a multicollinearity check[4] to verify if certain explanatory variables in the model are strongly correlated with each other. This test indicates there is no problem of multicollinearity between the variables. Secondly, we must control for unobserved heterogeneity associated with partners. Thirdly, we need to account for time varying country effects. To address these concerns, one solution is to avoid linearization and estimate the gravity model in its multiplicative form using a nonlinear estimator.

A Widely adopted nonlinear approach is the poisson pseudo maximum likelihood estimator (PPML). It offers two key advantages over OLS: it produces consistent estimates even in the presence of heteroscedasticity, and it allows the inclusion of zero trade flows without bias. Several strategies exist to control both for heterogeneity across trading partners and time but also as a robustness check. In our analysis, we take account the country-product-year and country pair fixed effects by using PPML HDFE estimation like Wassie et al. (2025). Ultimately, the preferred specification used as the basis for projections and results employs the PPML HDFE estimation. This approach captures within sample changes in macroeconomic conditions or trade policies that may drive observed variations in trade flows beyond what can be explained by cost differentials or GDP growth.

Furthermore, since this is a single exporting country, its GDP and institutional quality are removed because there is no within-sample variation. They are absorbed by the fixed effects, creating collinearity with these fixed effects and providing no additional information. They also risk generating convergence or multicollinearity problems in the estimates, especially when using the PPML command. Similarly, sharing a common border can be used as a cluster variable. Indeed, there is often a certain degree of economic, institutional, and cultural similarity between neighboring countries. Thus, by grouping observations according to the criterion of a common border, we can capture structural heterogeneities in the impact of trade policies. We conducted a sensitivity analysis for the PPML and the PPML HDFE estimator by excluding the observations assumed to be zero trade (Larson et al., 2018). The ultimate econometric model to estimate is follow:

[4] See append 1

$$vegexp_{ijt} = \exp\big[\alpha_0 + \alpha_1 \ln(gdp)_{jt} - \alpha_2 \ln(dist_{ij}) + \alpha_3 \ln(exchange\ rate)_{ijt} + \alpha_4 \ln(costums\ duties)_{it} + \alpha_5 \ln(population)_{jt} + \alpha_6 \ln(entry\ cost)_{jt} + \alpha_7 \ln(entry\ procedure)_{jt} + \alpha_8 institutional\ quality_{jt} + \alpha_9 common\ language_{ij} + \alpha_{10} common\ colonizer_{ij} + \alpha_{11} free\ trade\ agrement_{ij} + \alpha_{12} landlocked_{ij} + \Phi_j + \Phi_i\big] + \varepsilon_{ijt} \quad (5)$$

3.2. Data and descriptive statistics

The data used covers 33 partners[5] over the period 2000 to 2021, due to their availability. They come from three sources, which are the World Integrated Trade Solution (WITS) of the United Nations Conference on Trade and Development (UNCTAD), the World Governance Indicators (WGI) and the World Development Indicators (WDI) of the World Bank (WB) and the Centre for International Prospective Studies and Information (CEPII). Definition and measurement of variables in the table 1 shows that the gravity model combines economic variables (vegetable exports, GDP, population, exchange rates, customs duties) with geographical factors (distance, shared borders, access to the sea) and institutional dimensions (free trade agreements, institutional quality, entry procedures). It reflects the fact that Senegal's trade flows are explained not only by the size and wealth of its partners, but also by historical and cultural ties (language, common colonizer), market access costs (entry cost, entry procedure), and political and regulatory conditions.

[5] See append 1

Table N°1 : Definition, measurement of variables and data sources

Variables	Unit	Sources
Vegetable exports[6]	Vegetable exports from Senegal to its various partners in US dollars	WITS
Common border	Sharing a common border: It takes the value 1 if yes and 0 if no	CEPII
Distance	It measures the distance in km between the capital of Senegal, Dakar, and that of the partner country.	CEPII
Common language	Sharing a common language, which is French. It takes the value 1 if yes and 0 if no	CEPII
Commun colonizer	The sharing of a common colonizer, the common France. It takes the value 1 if yes and 0 if no	CEPII
Free trade agrement	A binary variable that captures the existence of a preferential trade agreement between Senegal and partner countries.	CEPII
Groos domestic product (gdp)	This refers to the total value of goods and services produced in an economy over a given period in current thousands of US$	CEPII
Entry cost	Destination Cost of business start-up procedures (% of GNI per capita)	CEPII
Entry procedure	Origin Start-up procedures to register a business (number)	CEPII
Population	It represents the number of people residing in the national territory	CEPII
Landlocked	A country is considered landlocked if it has no access to the sea. The variable takes 1 if the country is landlocked and 0 otherwize.	Google Earth
Real exchange rate	The exchange rate is the cost of one currency relative to another. It is obtained by dividing the CFA franc of the WAEMU (in US dollars) by the national currency in US dollars of the importing country for each year.	WDI
Customs duty rate	It represents the rate applied to primary products entering the importing country. It is expressed as a percentage.	WDI
Institutional quality	It measures the quality of institutions in importing countries. It is calculated as the arithmetic mean of Kaufmann's six indicators (freedom of expression, political stability and absence of violence, government effectiveness, quality of regulation, rule of law and control of corruption).	WGI

[6] Potatoes, onions, green beans, chili peppers, peas, lentils, tomatoes and other vegetables

Table 2 of the descriptive statistics highlights the significant dispersion of variables. The average vegetable export, estimated at USD 1.05 million, is relatively low compared to the maximum observed amount of USD 53.2 million, reflecting a high degree of heterogeneity in trade flows. The average GDP of importing countries, at USD 1.02 billion, reveals the diversity of trading partners, ranging from small economies to very large markets. The average distance of 3,619 km underscores a primarily extra-regional trade integration, while the real exchange rate and customs duties exhibit high variability, reflecting heterogeneous access conditions. Institutional variables and importers' entry costs show marked disparities, with a slightly positive but highly dispersed average institutional quality and sometimes prohibitive entry costs.

Table N°2: Descriptive statistics

Variables	Obs	Mean	Std. dev.	Min	Max
Vegetable	726	1049615	4089405	0	5.32e+07
Importer Gross domestic product	725	1.02e+09	2.84e+09	370173.9	2.30e+10
Distance	726	3619.28	2160.362	160	8632
Real exchange rate	726	480.2013	1111.187	0.499	9565.082
Customs duty rate	726	11.759	7.316211	2.12	99.502
Population importer	726	32918.18	56442	442.426	331893.7
Importer Institutional quality	726	0.154	0.790	-1.278	1.509
Entry cost importer	726	63.222	158.0257	0	1540.2
Entry proceure importer	726	7.597	2.991	2	17
Variable	Obs	Percent		Min	Max
Common language	726	0.42		0	1
Common colonizer	726	0.30		0	1
Free trade agrement	726	0.27		0	1
Landlockess	726	0.09		0	1
Common border	726	0.15		0	1

Source : Author using WITS, CEPII, WDI and WDG databases

Furthermore, the analysis of categorical variables shows that, on average, 42% of observations concern countries sharing a common language (French), reflecting significant cultural proximity. The proportion of partners with a common colonizer (30%) and those linked by a free trade agreement (27%) demonstrate the importance of historical legacies and institutional arrangements in trade. Landlocked countries represent only 9%, highlighting the predominance of maritime partners. Finally, the share of countries sharing a direct border with Senegal remains limited (15%), suggesting that trade flows extend well beyond the immediate regional context. Overall, these averages reflect a trade environment characterized by a high degree of structural and institutional diversity among partners. Also, historical and

institutional factors play a more significant role than mere geographical proximity in structuring trade.

4. Result and discussions

In this section, we will first present the determinants of vegetable product exports from Senegal, before presenting the results of the calculation of the commercial potential.

4.1. Trade determinants of Senegal vegetable's product

Analysis of the results in Table 3 shows that estimation using the ppml hdfe method (2) refines the coefficients of the ppml estimation by better controlling for unobserved heterogeneity thanks to the absorbed fixed effects

Table N°3: The determinants of vegetable international products

VARIABLES	(1) ppml	(2) ppml hdfe
GDP j	1.768***	1.188***
	(0.521)	(0.249)
Distance	-2.490***	-2.159***
	(0.888)	(0.571)
Exchange rate	0.321***	0.302***
	(0.002)	(0.019)
Costums rate j	-0.196	0.051
	(0.182)	(0.345)
Population j	-1.258***	-0.608***
	(0.384)	(0.091)
Entry cost j	-0.213***	-0.165***
	(0.028)	(0.062)
Entry procedure j	-2.076***	-1.882***
	(0.503)	(0.543)
Instutional quality j	0.934***	1.447***
	(0.063)	(0.031)
Common language	-0.862***	-0.776**
	(0.289)	(0.362)
Common colonizer	0.529***	0.625**
	(0.009)	(0.262)
Free trade agrement	1.631***	0.829***
	(0.261)	(0.246)
Landlocked	2.510***	1.716***
	(0.671)	(0.240)
Constant	13.523***	14.979***
	(1.171)	(0.848)
Observations	708	708
R-2/Pseudo R2	0.555	0.5956

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

A general reduction in the magnitude of the coefficients is observed, suggesting that the specification of the estimates is more robust. Some variables become statistically stronger, notably the quality of institutions. Finally, the R^2 improves from 0.555 to 0.596, indicating a better explanatory power of the hdfe model. In summary, method (2) confirms the basic relationships but refines them, reducing biases and strengthening the reliability of the results. The sensitivity test (append 3) shows that the main determinants of Senegalese vegetable trade remain robust, even when accounting for trade zeros. Indeed, fundamental variables such as the importing country's GDP, distance, exchange rate, population, entry costs and procedures, and institutional quality retain consistent signs and statistical significance. However, a weakening of the coefficients is observed when only positive trade flows are considered. These results suggest a source of bias in the removal of zero trade observations but confirm the stability of the major determinants of vegetable exports from Senegal.

The positive relationship between importer GDP and Senegalese's exportation vegetable aligns with the gravity model's core premize: larger economies with higher purchasing power trend to import more goods (vegetable). Indeed, a 1% increase in the gross domestic product of importing countries leads to a 1.888% increase in vegetable exports from Senegal (Table 3, column 2). This result is corroborated by Abdullahi et al. (2022), who show that a 1% increase in the GDP of Nigeria's partner countries increases agri-food exports by 1.97%. In practice, Senegalese vegetable exports to high-income economies, such as the United States and France, benefit from the strength of their consumer markets. The strategic implication is clear: directing trade flows toward countries with sustained GDP per capita growth should be a priority for Senegalese exporters. Furthermore, this observation reinforces the export-led growth hypothesis, suggesting that external demand from the most prosperous economies can act as a driver of national industrial expansion (Fan et al., 2023).

The negative relationship between distance and Senegal's vegetable exports is consistent with the prediction of the gravity model which states that trade flows decrease with increasing distance due to higher transport costs, longer delivery times, and logistical complexities (Anderson & Van Wincoop, 2003). Indeed, an increase in distance significantly reduces Senegal's vegetable exports by a factor of 2.19 (Table 3, column 2). For Senegal, the cost of transporting goods to distant markets is significantly higher than that to neighboring countries. These logistical difficulties reduce the competitiveness of vegetable products in distant markets. This observation underscores the need to improve infrastructure to mitigate the

negative effects of distance on export performance. This finding is corroborated by data showing that distance reduces the efficiency of Malaysian palm oil exports by 1.234%.

The positive and significant effect of the foreign real exchange rate on vegetable exports confirms the theoretical hypothesis that currency depreciation enhances export competitiveness by making domestic products more competitive in foreign markets. Indeed, the depreciation of the foreign exchange rate led to a 0.302% increase in Senegalese vegetable exports (Table 3, column 2). This result is consistent with studies by showing that a 1% increase in the foreign exchange rate causes a 0.122% increase in palm oil export revenue in Malaysia. In the Senegalese context, a depreciation of the foreign exchange rate increases the attractiveness of its vegetable products on international markets. However, the benefits of a depreciating exchange rate depend on the stability of macroeconomic conditions and the elasticity of demand in the destination countries. Excessive volatility or significant inflation can negate the gains associated with a weaker currency, highlighting the importance of a prudent monetary policy. Furthermore, customs duties have no significant effect on Senegal's vegetable exports. A similar result is corroborated by Amin et al. (2024) showing that customs duties have no effect on Malaysia's palm oil exports. This result can be attributed to Senegal's comparative advantages in vegetable exports, such as abundant production. It can also be explained by regional trade agreements and the good trade relations between Senegal and its trading partners.

The significant negative relationship between population and vegetable exports from Senegal suggests that population growth in destination countries contributes to decreased demand for these products. Indeed, an increase in importer population lead 0.608% decrease of Senegalease's vegetable export (Table 3, column 2). This finding can be explained in two different ways. First, a larger population implies a more diversified consumption pattern, where vegetables imported from Senegal may represent a marginal share compared to other sources of supply. Second, densely populated markets may be more difficult to penetrate due to regulatory barriers, high entry costs, or protectionist policies aimed at safeguarding domestic production. However, this finding is not supported by the work of Rambe et al. (2025), who argue that population growth in partner countries stimulates commodity exports from Indonesia.

The significant negative relationship between export costs and procedures and international trade in Senegalese vegetables suggests that administrative constraints and costs in destination countries contribute to decreased demand for these products. The costs and delays associated

with export procedures significantly reduce vegetable exports by 0.165% and 1.882%, respectively. This finding is not corroborated by Seck (2017), who demonstrates that regulation reduces the likelihood of firms from sub-Saharan African countries participating in international trade.

The positive and significant relationship between the quality of institutions in importing countries and Senegal's vegetable exports suggests that good institutional quality in destination countries promotes Senegal's vegetable exports. Improving the quality of institutions in importing countries increases Senegal's vegetable exports by 1.447% (Table 3, column 2). t also promotes economic stability and provides a better framework to support agricultural exports (Lin, 2020; Lin et al., 2020). This result is corroborated by Akpa et al. (2026), who show that a certain level of institutional quality improves agricultural exports in sub-Saharan African countries.

Sharing a common language with Senegal (French) significantly reduces vegetable exports by 0.776%. This counterintuitive result can be explained by the fact that a shared language can create trade diversion effects towards other Francophone supplier partners such as Morocco, Côte d'Ivoire, etc., which increases competition and reduces the share of Senegalese exports. Furthermore, this result contradicts that of Abdullahi et al. (2022) who found that sharing a common language with China (Mandarin) increases Chinese agricultural export flows by 1.02%. Furthermore, sharing a common colonizer with Senegal (France) significantly increases vegetable exports by 0.625%. This result can be explained by the fact that sharing a common colonizer generally leads to a similar legal system and administrative procedures, facilitating and reducing the costs associated with international trade. Moreover, this result contradicts that of Santos Silva & Tenreyro (2022), who found that sharing a common colonizer has no significant effect on international trade.

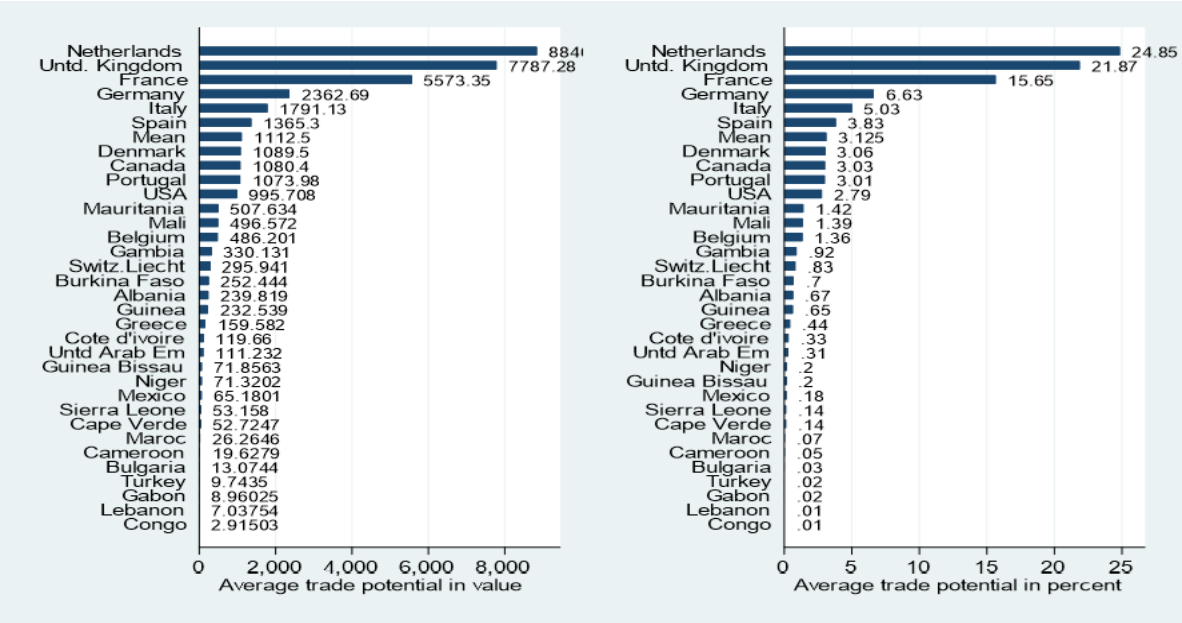
Preferential trade agreements have a significant and positive impact on Senegal's vegetable exports, increasing them by 0.829%. This finding aligns with that of Romyen et al. (2023), who assessed the trade effects of free trade agreements between Thailand and its trading partners for agricultural products. Their results demonstrate that Thailand exhibited high export efficiency due to these trade agreements. Also, we found a positive and significant relationship between landlocked countries and the Senegal's vegetable exports. Landlocked status increases these exports by 1.716%. This result can be explained by structural mechanisms: landlocked West African countries are heavily dependent on Senegalese ports, particularly the Port of Dakar, to access international markets. The positive correlation thus

reflects a "logistics hub" effect where Senegal acts as both a supplier and a transit point. However, this result contradicts those found in the literature. For example, Fan et al. (2023) show that landlocked countries have a negative correlation with Chinese agricultural exports to ASEAN countries.

4.2. Trade potential in vegetable's export products

Figure 5 reveals that Senegal has an average trade potential of 32 988. 3075 millions us dollars from 2000 to 2021. Shi et al. (2025) classify market depend on their potential in four types the saturated (90% to 100%), Expansion (60% to 90%), Development (30% to 60%), and Iceberg (0 to 30%). According to the figure 7, all countries partner's of Senegal are iceberg Markets (Netherlands 24.85%, United Kingdom 21.87%, France 15.65%, Germany 6.63%, Italy 5.03%, Spain 3.83%, etc. down to Congo 0.01%). Senegalese's vegetable product export trade to these countries is yet to be developed and it should focus on encouraging trade liberalization and advocating for the elimination of trade barriers.

Figure N°5: Average trade potential of Senegalese's vegetable 2000-2021



Source: Author

The vegetable export potential of Senegal towards these countries has been continuously increasing. Individually, there are significant differences in the export potential. Figure 5 reveals a strong concentration of trade flows towards a few European partners. The Netherlands (24.85%), the United Kingdom (21.87%), and France (15.65%) alone absorb more than 62% of total exports. This dominance reflects a structural dependence on Northern and Western Europe, where port infrastructure and demand for tropical products foster trade integration.

Beyond the top three, countries like Germany (6.63%), Italy (5.03%), and Spain (3.83%) reinforce the European Union's position as the primary market. Even though their shares are smaller, they confirm a concentration around developed markets, where demand is stable and solvent. The United States (2.79%) and Canada (3.03%) also appear as significant partners, illustrating a transatlantic openness. However, these results demonstrate limited regional diversification towards African countries.

African partner countries remain marginal in the export structure. Mauritania (1.42%), Mali (1.39%), Gambia (0.93%), and Burkina Faso (0.71%) are among the top performers, but their shares remain small. This weak regional integration underscores the logistical, tariff, and institutional constraints that hinder intra-African trade, despite geographical proximity.

At the bottom of the ranking, we observe shares of less than 0.5% for countries such as Greece (0.45%), Côte d'Ivoire (0.33%), the United Arab Emirates (0.31%), and emerging markets like Mexico (0.18%) and Morocco (0.07%). These destinations reflect embryonic diversification, but without any real weight in the overall structure.

Furthermore, the results found are consistent with studies that highlight a largely untapped commercial potential in developing countries(Achy, 2007; Avom & Mignamissi, 2013; Fotso, 2014; Geda & Seid, 2015).

Conclusion

Horticulture sector plays a strategic role in Senegalese agricultural export, particularly the vegetable sub-sector, which presents a promising vegetable market for its partners. It allows government to generate resources for financing its development and contributes greatly to food security. Therefore, this study used a structural gravity model to analyze potential and determining factors of Senegalese exports of vegetable products in 33 partners for the period 2000-2021. To answer the research question, we used two estimation methods (the ppml and ppml hdfe) and to support the robustness check we use the same estimators by excluding the observations assumed to be zero trade.

Senegal's vegetable exports are boosted by economic and institutional factors such as the GDP of importing countries, the depreciation of the real exchange rate, the institutional strength of partner countries, a shared colonial past, the existence of preferential trade agreements, and the country's landlocked status, all of which have a significant positive impact. Conversely, geographical and demographic constraints such as distance, the population size of importing countries, administrative costs and procedures, and the shared

language significantly reduce trade flows. Finally, customs duties appear to have no significant effect on Senegalese vegetable exports. Export potential evaluation showed a large untapped potential trade. Indeed, all countries' partners of Senegal are the iceberg (0 to 30%) markets. It also reveals a strong concentration of trade flows towards a few European partners, but African partner countries remain marginal in the export structure.

Several recommendations should be put forward by Senegalese government to fully exploit its commercial potential:

- direct its vegetable exports toward large markets with high GDP and simultaneously strengthening its macroeconomic competitiveness by ensuring monetary stability;
- give priority to partners with strong institutional frameworks and to leveraging preferential agreements to reduce trade barriers;
- capitalize on its historical ties with certain European markets;
- mitigate geographical constraints by developing trade with its African neighbors;
- adapt its demographic strategy by targeting specific consumer niches rather than mass markets;
- simplify administrative procedures to streamline trade flows;
- diversifying its partners to include Africa, Asia, and the Americas is essential to exploit the untapped potential of "iceberg markets.";

This work offers a new perspective by evaluating the potential and determinants of Senegal's vegetable exports, an aspect that has received little attention until now. However, future research avenues include examining the influence of other horticultural products such as fruits, as well as specific products like mangoes.

Appendix

Append 1 : Correlation matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1) gdp	1.000												
(2) dist	0.763	1.000											
(3) ER	-0.348	-0.263	1.000										
(4) dd	-0.626	-0.459	0.235	1.000									
(5) pop	0.798	0.539	-0.191	-0.405	1.000								
(6) entry cost	-0.758	-0.563	0.461	0.583	-0.441	1.000							
(7) entry proc	-0.362	-0.235	0.309	0.311	-0.269	0.569	1.000						
(8) inst quali	0.756	0.520	-0.418	-0.609	0.349	-0.775	-0.342	1.000					
(9) comlang	-0.158	0.041	0.243	0.403	0.002	0.115	-0.118	-0.274	1.000				
(10) comcol	-0.465	-0.302	0.411	0.501	-0.100	0.439	0.084	-0.635	0.634	1.000			
(11) fta	-0.660	-0.781	0.279	0.393	-0.255	0.600	0.112	-0.607	0.166	0.489	1.000		
(12) contig	-0.528	-0.779	0.230	0.259	-0.324	0.448	0.199	-0.436	-0.018	0.276	0.690	1.000	
(13) landlocked	-0.274	-0.171	0.253	0.166	0.042	0.295	-0.059	-0.254	0.370	0.483	0.516	0.160	1.000

Append 2 : Average Trade potential of Senegalese's vegetable product from 2000 to 2021

Ranking	Countries	Mean in millions	Percent	Ranking	Countries	Mean in millions	Percent
1	Netherlands	8846899	24.85	18	Guinea	232539.2	0.65
2	Untd. Kingdom	7787276	21.87	19	Greece	159581.7	0.45
3	France	5573346	15.65	20	Cote d'ivoire	119660.2	0.33
4	Germany	2362688	6.63	21	Untd Arab. Em.	111232.3	0.31
5	Italy	1791127	5.03	22	Guinea Bissau	71856.32	0.2
6	Spain	1365301	3.83	23	Niger	71320.22	0.2
7	Denmark	1089500	3.06	24	Mexico	65180.07	0.18
8	Canada	1080404	3.03	25	Sierra Leone	53158.01	0.15
9	Portugal	1073985	3.01	26	Cape Verde	52724.68	0.15
10	USA.	995708.1	2.79	27	Maroc	26264.59	0.07
11	Mauritania	507634.3	1.42	28	Cameroon	19627.92	0.07
12	Mali	496571.6	1.39	29	Bulgaria	13074.45	0.05
13	Belgium	486201.4	1.36	30	Turkey	9743.499	0.04
14	Gambia	330131.2	0.93	31	Gabon	8960.255	0.04
15	Switz.Liecht	295940.9	0.83	32	Lebanon	7037.538	0.03
16	Burkina Faso	252443.8	0.71	33	Congo	2915.026	0.02
17	Albania	239818.6	0.67		Total	32 988. 3075	100

Append 3: Sensitivity of PPML and PPML HDFE to zero-trade observations

VARIABLES	(1)ppml	(2)ppml hdfe
Gdp j	1.388***	1.043***
	(0.524)	(0.342)
distance	-1.917**	-1.657***
	(0.746)	(0.487)
Exchange rate	0.318***	0.307***
	(0.001)	(0.010)
Costums rate j	-0.087	0.096
	(0.144)	(0.211)
Population j	-1.070**	-0.695***
	(0.434)	(0.257)
Entry cost j	-0.335***	-0.305***
	(0.026)	(0.053)
Entry procedure j	-1.952***	-1.734***
	(0.393)	(0.412)
Institutional quality j	0.652***	0.987***
	(0.142)	(0.137)
Common language	-1.051***	-0.960***
	(0.230)	(0.279)
Common colonizer	0.402**	0.413
	(0.200)	(0.414)
Free trade agrement	1.142***	0.837***
	(0.032)	(0.095)
Landlocked	2.292***	1.721***
	(0.722)	(0.415)
Constant	14.926***	15.143***
	(0.392)	(0.090)
Observations	462	462
R-squared	0.540	0.5621

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Reference

Abdullahi, N. M., Aluko, O. A., & Huo, X. (2021). Determinants, efficiency and potential of agri-food exports from Nigeria to the EU : Evidence from the stochastic frontier gravity model. *Agricultural Economics/Zemedelska Ekonomika*, *67*(8).

Abdullahi, N. M., Zhang, Q., Shahriar, S., Irshad, M. S., Ado, A. B., & Huo, X. (2022). Examining the determinants and efficiency of China's agricultural exports using a stochastic frontier gravity model. *PLoS One*, *17*(9), e0274187.

Achy, L. (2007). Le commerce intra-régional : L'Afrique du Nord est-elle une exception? *L'année du Maghreb*, (III), 501-520.

Akpa, A. F., Edewor, S. E., & Zogbassè, S. (2026). The effect of foreign direct investment on agricultural export in sub-Saharan Africa : Does institutional quality matter? *The Journal of International Trade & Economic Development*, *35*(3), 720-747. https://doi.org/10.1080/09638199.2025.2606670

Amadji, F. M., & GERVAIS, A. (2024). *Potentiel commercial du TOGO*. Mémoire en vue de l'obtention du grade de Maîtrise en économique, Université ….

Amin, A. A. (1996). *The effects of exchange rate policy on Cameroon's agricultural competitiveness*.

Amin, S. I. M., Shukor, M. S., & Abdul-Rahman, A. (2024). Determinants of Malaysian palm oil export efficiency : A gravity stochastic frontier model. *Geografia*, *20*(2), 145-155.

Anderson, J. E., & Van Wincoop, E. (2003). Gravity with gravitas : A solution to the border puzzle. *American economic review*, *93*(1), 170-192.

ANSD. (2024). *Bulletin mensuel des statistiques économiques et financières*.

Arata, L., Chakrabarti, A., Coderoni, S., Disdier, A.-C., Krisztin, T., Meinhart, B., Kuhn, T., Muzzillo, M., Sanjuán, A. I., & Sckokai, P. (2025). A scoping review of the impact of agricultural, food, and environmental policies on the transition towards a safe and just operating space for EU agri-food systems. *Q Open*, qoaf011.

Arthur, J., Dray, A., & Puppetto, L. (2020). *Estimation de potentiels de commerce par un modèle de gravité*. Trésor Direction Générale.

Atif, R. M., Haiyun, L., & Mahmood, H. (2017). Pakistan's agricultural exports, determinants and its potential : An application of stochastic frontier gravity model. *The Journal of International Trade & Economic Development*, *26*(3), 257-276.

Atif, R. M., Mahmood, H., Haiyun, L., & Mao, H. (2019). Determinants and efficiency of Pakistan's chemical products' exports : An application of stochastic frontier gravity model. *PloS one*, *14*(5), e0217210.

Avom, D., & Mignamissi, D. (2013). Évaluation et analyse du potentiel commercial dans la Communauté économique et monétaire de l'Afrique centrale (CEMAC). *L'Actualité économique*, *89*(2), 115-145.

Avom, D., & Mignamissi, D. (2017). Pourquoi le commerce intra-CEEAC est-il si faible? *Revue française d'économie*, *32*(3), 136-170.

Baier, S. L., & Bergstrand, J. H. (2009). Bonus vetus OLS : A simple method for approximating international trade-cost effects using the gravity equation. *Journal of International Economics*, *77*(1), 77-85.

Beke, T. E. (2022). Effets des coûts de commerce sur les échanges agricoles dans l'espace CEDEAO. *Économie rurale*, *380*(2), 41-67.

Bergstrand, J. H. (1989). The generalized gravity equation, monopolistic competition, and the factor-proportions theory in international trade. *The review of economics and statistics*, 143-153.

Bott, A., Meddour, A., & Benaissa, M. L. (2024). *Logistique internationale dans le contexte du commerce d'exportation* [PhD Thesis, ENSTA].

Boudifa, H. (2024). Opportunités et contraintes pour les exportations algeriennes intra AFRICAINES. *La Revue des Sciences Commerciales*, *22*(2), 54-75.

Braha, K., Qineti, A., Cupák, A., & Lazorčáková, E. (2017). Determinants of Albanian agricultural export : The gravity model approach. *AGRIS on-line Papers in Economics and Informatics*, *9*(665-2017-1574), 3-21.

Calvo, F. (2024). *Comment les règles et les flexibilités de l'Organisation mondiale du commerce peuvent-elles promouvoir la sécurité alimentaire des pays les moins avancés?*

Chauvin, S., & Gaulier, G. (2002). *Regional trade integration in Southern Africa*. CEPII. https://www.cepii.fr/PDF_PUB/wp/2002/wp2002-12.pdf

Coase, R. H. (1937). The nature of the firm (1937). *The nature of the firm: origins, evolution, and development*, 18-33.

Coly, S. M., Diallo, M. A., & Weibigue, A. G. (2021). Impact d'une taxation à l'exportation de noix de cajou sur les revenus des ménages et de l'État au Sénégal : Une application à l'aide d'un modèle d'équilibre général calculable. *Repères et Perspectives économiques*, *5*(2).

Crescimanno, M., Galati, A., & Yahiaoui, D. (2013). Determinants of Italian agri-food exports in non-EU Mediterranean Partner Countries : An empirical investigation through a gravity model approach. *New Medit*, *12*(4), 46-54.

Danon, B. R. N., Yedji, P. D., & Glidja, J. B. (2024). Facilitation des échanges et compétitivité des entreprises agréées au Schéma de Libéralisation des Echanges (SLE) de la CEDEAO : Une analyse en contexte Bénin. *Journal of Economy & International Finance (EIF)*, *3*(2), pp-118.

Désiré, A., & NJIKAM, M. M. (2014). *Intégration par le marché cas des pays de la CEEAC*.

Disdier, A., Gaigné, C., & Herghelegiu, C. (2023). Do standards improve the quality of traded products? *Canadian Journal of Economics/Revue Canadienne d'économique*, *56*(4), 1238-1290. https://doi.org/10.1111/caje.12678

Disdier, A.-C. (2025). Normes internationales et compétitivité des filières agroalimentaires. *INRAE Sciences Sociales*, *2025*, 1-2.

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

Djimasra, N. (2009). *Efficacité technique, productivité et compétitivité des principaux pays producteurs de coton* [Phdthesis, Université d'Orléans]. https://theses.hal.science/tel-00482828

Dreyer, H. (2014). *Misaligned distance : Why distance can have a positive effect on trade in agricultural*.

Erdem, E., & Nazlioglu, S. (2008). Gravity Model of Turkish agricultural exports to the European Union. *International Trade and Finance Association Conference Papers*, 21.

Essaadi, H. (2022). Les facteurs clés de la performance à l'exportation Une revue de littérature systématique. *Revue Française d'Economie et de Gestion*, *3*(11).

Fan, H., Trinh Thi, V. H., Zhang, W., & Li, S. (2023). The influence of trade facilitation on agricultural product exports of China : Empirical evidence from ASEAN countries. *Economic research-Ekonomska istraživanja*, *36*(2). https://hrcak.srce.hr/file/442863

Faostats. (2024). *Indice de production horticole*.

Faye, V. (2025). Stockage des produits horticoles au Sénégal : Défis. *HortiConnect*.

Fontagné, L., Pajot, M., & Pasteels, J.-M. (2002). Potentiels de commerce entre économies hétérogènes : Un petit mode d'emploi des modèles de gravité. *Economie prevision*, *152153*(1), 115-139.

Fotso, A. D. (2014). The potential effects of the ECCAS Free Trade Area on Trade Flows. *Munich Personal RePEc Archive*, *2*. https://core.ac.uk/download/pdf/213965135.pdf

Gaigne, C., & Gouel, C. C. (2022). Trade in agricultural and food products [Commerce des produits agricoles et alimentaires]. *HAL Post-Print*, (hal-03707237).

Geda, A., & Seid, E. H. (2015). The potential for internal trade and regional integration in Africa. *Journal of African Trade*, *2*(1-2), 19. https://doi.org/10.1016/j.joat.2015.04.001

Hajivand, S., Moghaddasi, R., Zeraatkish, Y., & Mohammadinejad, A. (2020). An application of stochastic frontier gravity approach (the case of Iran's potential agricultural exports). *International Journal of Analysis and Applications*, *18*(3), 482-492.

Hatab, A. A., Romstad, E., & Huo, X. (2010). Determinants of Egyptian agricultural exports : A gravity model approach. *Modern Economy*, *1*(03), 134.

Head, K., & Mayer, T. (2014). Gravity equations : Workhorse, toolkit, and cookbook. In *Handbook of international economics* (Vol. 4, p. 131-195). Elsevier.

Helliwell, J. F., & Schembri, L. L. (2005). Frontières, monnaies communes, commerce et bien-être : Que pouvons-nous déduire de l'observation des faits? *Revue de la Banque du Canada*, 21-37.

Kerrouch, M. (2025). Analyse des Relations Commerciales entre le Maroc et l'Afrique Anglophone : Perspectives et Dynamique Économique. *International Journal of Accounting, Finance, Auditing, Management and Economics*, *6*(1), 572-589.

Kouassi, D. S. E. (2024). *Analysis of the trade potential of ECOWAS countries | International Journal of Accounting, Finance, Auditing, Management and Economics*.

Larson, J., Baker, J., Latta, G., Ohrel, S., & Wade, C. (2018). Modeling international trade of forest products : Application of PPML to a gravity model of trade. *Forest Products Journal*, *68*(3), 303-316.

Lengai, G. M., Fulano, A. M., & Muthomi, J. W. (2022). Improving access to export market for fresh vegetables through reduction of phytosanitary and pesticide residue constraints. *Sustainability*, *14*(13), 8183.

Lin, J. (2020). *The role of institutions on modern agricultural value chains* [PhD Thesis, Dissertation, Göttingen, Georg-August Universität, 2020].

Lin, J., Flachsbarth, I., & Von Cramon-Taubadel, S. (2020). The role of institutional quality on the performance in the export of coconut products. *Agricultural Economics*, *51*(2), 237-258. https://doi.org/10.1111/agec.12552

Linnemann, H. (1966). *An econometric study of international trade flows*. North-Holland.

Mao, H., Liu, G., Zhang, C., & Muhammad Atif, R. (2019). Does Belt and Road Initiative Hurt Node Countries? A Study from Export Perspective. *Emerging Markets Finance and Trade*, *55*(7), 1472-1485. https://doi.org/10.1080/1540496X.2018.1553711

Mbodj, B. (2024). Potentiel de commerce de la filière mangue au Sénégal : Truchement d'un modèle de gravité par approche sectorielle. *Revue Française d'Economie et de Gestion*, *5*(6).

Ndao, M. S. (2024). Analyse de l'évolution des échanges commerciaux intra zone en Afrique de l'Ouest. *Revue Française d'Economie et de Gestion*, *5*(2).

Neville-Rolfe, E. (2025). Compétitivité de l'agriculture et des industries agricoles et alimentaires britanniques par rapport à celles du continent. *Économie rurale*, *92*, 13-26.

Nguyen, B. X. (2010). The determinants of Vietnamese export flows : Static and dynamic panel gravity approaches. *International Journal of Economics and Finance*, *2*(4), 122-129.

Pöyhönen, P. (1963). A tentative model for the volume of trade between countries. *Weltwirtschaftliches archiv*, 93-100.

Rambe, K. R., Suharno, S., Malau, L. R. E., Intan, D. R., Purba, K. F., Khaliqi, M., & Ginting, L. N. (2025). Examining the Determinants, Efficiency, and Potential Export of Indonesia's Plantation Commodities to G-20 Countries. *Iranian Economic Review*, *29*(2), 475-498.

Romyen, A., Nunti, C., & Neranon, P. (2023). Trade efficiency under FTA for Thailand's agricultural exports : Copula-based gravity stochastic frontier model. *Journal of Economic Structures*, *12*(1), 9. https://doi.org/10.1186/s40008-023-00303-0

Safia, K. (2024). *La conciliation entre les impératifs de la sécurité des aliments et la liberté de commerce dans l'accord SPS* [PhD Thesis, Université Mouloud Mammeri de Tizi Ouzou].

Santos Silva, J. M. C., & Tenreyro, S. (2022). The Log of Gravity at 15. *Portuguese Economic Journal*, *21*(3), 423-437. https://doi.org/10.1007/s10258-021-00203-w

Sapa, A., & Droždz, J. (2019). Polish agri-food trade with non-EU countries–a gravity model analysis. *Roczniki (Annals)*, *2019*(1230-2020-825).

Seck, A. (2017). Trade facilitation and trade participation : Are sub-Saharan African firms different?☆. *Journal of African Trade*, *3*(1-2), 23. https://doi.org/10.1016/j.joat.2017.05.002

Ševela, M. (2002). Gravity-type model of Czech agricultural export. *Agricultural economics*, *48*(10), 463-466.

Shi, L., Zhang, S., & Hashmi, S. M. (2025). Study on the export pattern and export potential of agricultural products from China to RCEP countries—An empirical study based on gravity model. *Frontiers in Sustainable Food Systems*, *9*, 1492812.

Tinbergen, J. (1962). Shaping the World Economy : Suggestions for an International Economic Policy. *The Twentieth Century Fund*. https://repub.eur.nl/pub/16826/Appendices.pdf

Touré, M., Agbahoungba, L. S., Wade, I., & Thiam, I. (2024). Analyse de la perception des PME sénégalaises sur l'application des Mesures Non Tarifaires dans les exportations de fruits frais et légumes. *International Journal of Innovation and Applied Studies*, *44*(1), 162-174.

Verter, N., Zdráhal, I., Bečvářová, V., & Grega, L. (2020). 'Products mapping'and trade in agri-food products between Nigeria and the EU28. *Agricultural Economics*, *66*(1), 34-45.

Vincent, Z. (2024). Transport, commerce et développement territorial : Le cas de Dakola à la frontière Burkina Faso-Ghana. *Espace Géographique et Société Marocaine*, *1*(93).

Wassie, M. A., Kornher, L., & Zaki, C. (2025). Revisiting the impact of trade facilitation measures in Africa : A structural gravity approach. *The Journal of International Trade & Economic Development*, *34*(7), 1604-1634. https://doi.org/10.1080/09638199.2025.2519105

Contracting. In C. Boersch & R. Elschen (Éds.), *Das Summa Summarum des Management* (p. 61-75). Gabler. https://doi.org/10.1007/978-3-8349-9320-5_6

Zhang, G., Wu, X., & Wang, K. (2022). Research on the impact and mechanism of internet use on the poverty vulnerability of farmers in China. *Sustainability*, *14*(9), 5216.