Iranian Economic Review, 2025, 29(1), 288-310
DOI: 10.22059/ier.2025.349965.1007563

RESEARCH PAPER

The Potential of Iran's Agricultural Exports: Evidence from a Stochastic Frontier Gravity Model

Turaj Alizadeh[a], Reza Shakeri Bostanabad[a,*], Negin Keshvarz[a]

a. Department of Agricultural Economics, Faculty of Agricultural and Development Economics, University of Tehran, Tehran, Iran.
* Corresponding author, E-mail: reza.shakeri@ut.ac.ir

Article History: Received 15 October 2022, Revised 26 May 2023, Accepted 13 June 2023, Published 01 April 2025
Publisher: University of Tehran Press.

Abstract

The evidence shows that the lack of comprehensive trade policies in Iran's agricultural sector has caused the growth of this sector to be unstable and limited to a few countries. Experts and economists also claim that Iran's capacity to achieve higher export figures and expansion of target markets is higher. Therefore, this paper aims to quantify the export capacity of Iranian agricultural products to trading partners using a stochastic frontier gravity model during 1997-2021. The results indicated that Iran has the export efficiency above 50% with only six countries including Germany, Russia, Vietnam, Spain, India, and the UAE, which represent the high capacity of Iran's export potential in many trading partners in agricultural products. In addition, except for Russia and the UAE, other neighboring countries have a high potential for accepting agricultural products. On the other hand, regarding the estimation of the average export potential and its gap from the actual export based on the estimated stochastic frontier gravity model, the results indicated that the highest potential agricultural exports are related to Turkey, Egypt, Libya, Croatia, and Uzbekistan, respectively. The export gap is negative for all trading partners, which indicates that Iran has agricultural exports less than the maximum possible limit to all trading countries. The results confirmed that economic size and geographical distances have a positive and negative effect on Iran's agricultural exports, respectively.

Keywords: Agriculture Exports, Export Potential, Gravity Model, International Trade, Stochastic Frontier Model.
JEL Classification: C23, F17, G14, Q17.

1. Introduction

International trade is recognized as a tool and a driver for economic development, and classical and neoclassical economists consider foreign trade as the engine of economic growth (Frankel and Romer 1999). International trade is considered as one of the factors for strengthening GDP as a source of foreign exchange, which increases economic growth, reduces poverty, and increases employment (Mohammadi et al., 2019). In addition, we can benefit from economies of scale with the development of trade (Helpman and Krugman, 1985). Export efficiency is considered as one of the most important concepts of trade which has been less considered. Export efficiency is defined as the ratio of the actual exports of a country to its maximum export potential (Doan and Xing, 2018).

The efficiency and performance of different countries in global markets are not the same, and the heterogeneity of countries in terms of economic development, trade relations, and border policies may be considered as the cause of inefficiency in realizing trade potential. Some of these factors are related to the exporting country (domestic factors) and others are related to the destination countries (foreign factors) (Hajivand et al., 2020). Therefore, focusing on export efficiency and its evaluation in different countries is important since it allows policymakers to identify suitable export markets and minimize or eliminate trade constraints and barriers to achieving full export potentials (Mohammadi et al., 2019).

High fluctuations in oil prices and economic sanctions against Iran have forced politicians and economic planners to free the country from a single-product economy and promote non-oil exports such as agricultural exports. Agriculture is recognized as one of the key sectors of Iran's economy, which accounted for about 12.2% of GDP in 2019, while its share of total labor, non-oil exports, and food supply was 23, 21, and 80%, respectively (Central Bank of Iran, 2019). In the sixth five-year development plan, Iran's agricultural sector is expected to grow by 8% annually. Therefore, this sector as a source of non-oil revenues has a high priority in the five-year national development plans.

The value of Iran's agricultural exports has significantly increased during 1997-2021 from 768 million$ to 2.64 billion$ (244% growth) (Chamber of Commerce, Industry, Mines, and Agriculture of Iran, 2021). Despite the significant growth, the instability of the value of Iran's agricultural exports during the mentioned period (Figure 1) and the limited target countries of Iran's exports (Figure 2)[1] are considered as the weaknesses of exports in this sector. The fact is that the lack of comprehensive policies regarding trade in the agricultural sector has caused the growth of this sector to be unstable and limited to a few countries. Experts and economists claim that Iran's capacity to achieve higher export figures

[1]. The share of trading partners in exporting Iran's agricultural products in 2021, which is obtained by dividing the value of Iran's exports to the target countries by the total value of agricultural exports in Iran, 2021.

and expansion of target markets is higher (Roosta et al., 2017). Thus, the following questions were raised in this study.

Q1. What is the potential of Iran's agricultural exports?

Q2. Has Iran been able to be effective in exporting agricultural products?

Q3. Which countries have more capacity to export Iranian agricultural products?

The answer to these questions can be a comprehensive guide for policy makers and Iranian businessmen in the development of export markets of agricultural products.

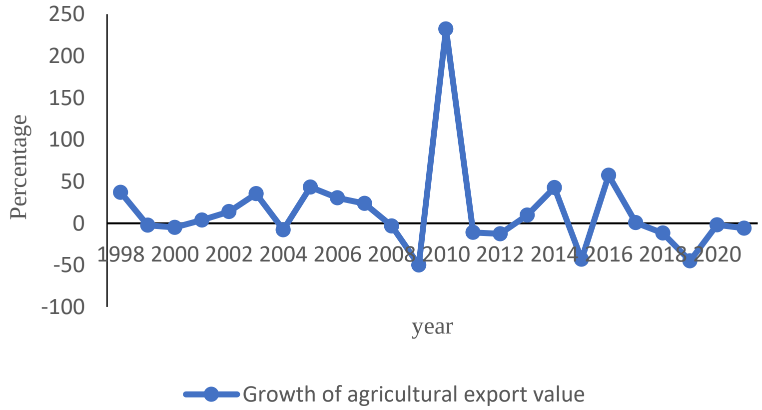

Figure 1. Growth of Iran's Agricultural Exports during 1998-2021
Source: Research finding.

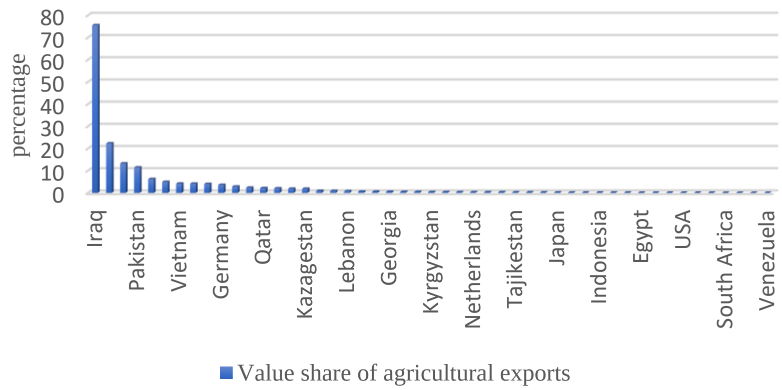

Figure 2. The Share of Trading Partners in Agricultural Exports in Iran
Source: Research finding.

2. Literature Review

Few researchers have addressed the evaluation of export efficiency. Deluna and Cruz (2013) examined the export performance of Philippine goods in 69 trading partner countries by using a frontier gravity model. The results of the estimated coefficients of the gravity equation indicated that the flow of exporting goods from the Philippines to trading partners is significantly affected by the income and market size of the importing partner.

Tamini et al. (2016) analyzed the export potential versus real trade among trading partners in North Africa during 2001-2012 based on a stochastic frontier gravity model. The results indicated that commercial efficiency for agricultural products is relatively low. In addition, there was a weak and inverse regulatory environment, which highlighted the importance of improving domestic policies to encourage the development of entrepreneurship and business facilities.

Noviyani et al. (2019) analyzed the efficiency of Indonesian exports and their influential factors by applying a stochastic frontier gravity model. The results indicated that the flow of Indonesian exports is significantly affected by gross domestic product (GDP) and population. In addition, the efficiency of average export to 62 trading partners in Indonesia was 51.35 and 49.69% in 2012 and 2016, respectively. The highest and lowest value of export efficiency is related to Singapore and Portugal, respectively.

Atif et al. (2019) assessed the main determinants of Pakistani agricultural exports by using a frontier gravity model during 1995-2014 among 63 countries and the results indicated bilateral exchanges and tariff rates in agricultural exports. In addition, ` the impact of common borders, common culture, colonial history, and preferential trade agreements was evaluated by considering dummy variables. Further, based on technical efficiency, Pakistan has a great export potential with neighboring countries, the Middle East, and Europe.

Mohammadi et al. (2020) efficiency of Iran's pistachio exports to the target markets in the time period of 2001-2016 have been investigated. For this purpose, they have used the random boundary gravity model. The efficiency results indicated that the efficiency of Iran's pistachio exports in all markets and European markets has decreased. While, this trend is increasing for Asian markets and has reached from 0.412 to 0.567.

In another study, Abdullahi et al. (2021) discussed the determinants of efficiency and export potential of agricultural products from Nigeria to the European Union during 1995-2019 by using a stochastic frontier gravity model and the results indicated that the economic size (GDP) and bilateral distance between Nigeria and the EU countries could positively determine the export of agricultural products from Nigeria to the EU. In addition, Nigeria has a relatively low score in terms of export efficiency of its agricultural products to EU countries. Nguyen (2022) estimated the factors affecting Vietnam rice and coffee exports by applying a stochastic frontier gravity model. Technical efficiency and potential exports indicated that Vietnam can play a significant role in increasing rice and coffee exports with its main trading partners. The Association of Southeast Asian Nations is still considered as the major market for Vietnamese rice and coffee.

Abdullahi et al. (2022) examine the key determinants and efficiency of China's agricultural exports with its 114 importing countries by applying the Stochastic Frontier Analysis (SFA) on an augmented gravity model for the period of 2000–2019. The results reveal that China's economic size (GDP) and its importing countries, the Belt and Road Initiative (BRI), common border, and the Chinese language positively determine China's agricultural export flows. The results, on the other hand, also reveal that China's agricultural export is adversely influenced by the income (per capita GDP) of China and its trade partners, currency depreciation, distance, and land-locked. Suroso and Tandra (2022) investigate the determinants, efficiency, and potential of Indonesian palm oil downstream exports to the global market using stochastic frontier gravity model (SFGM) during 2012–2020. The determinants show that the gross domestic product (GDP) importer, Indonesia's GDP per capita, the bilateral exchange rate, colonialization, and World Trade Organization (WTO) membership have a positive and significant impact on Indonesia's palm oil downstream exports. Nevertheless, there are negative and significant effects from Indonesia's GDP, geographical distance between Indonesia and trading partners, the importer's GDP per capita, and landlocked countries. Romyen et al. (2023) assessed the trade effects of free trade agreements (FTA) between Thailand and its trading partners using a copula-based stochastic frontier gravity model for important agricultural commodities such as: silk, cassava, fruits, vegetables and medicinal plants from 1998 to 2019. The results showed that China and Japan have the highest export efficiency (0.48), followed by India (0.41), New Zealand (0.39) and Australia (0.33), respectively. Hence, Thailand should pursue more FTA negotiations with the trading partners. Moreover, they should promote miscellaneously behind-the-border barriers to stimulate flows of goods to enhance the country's trade efficiency substantially.

Helian Xu et al. (2023) investigate the determinants of Vietnamese agricultural exports to APEC using a stochastic frontier gravity model and determine the export gap between Vietnam and each APEC trading partner in the period 1998-2018. The empirical results confirm the suitability of the gravity model for Vietnamese agricultural exports. The new findings suggest that the government should focus on designing a policy framework to encourage export companies to invest more in technology, especially for large and demanding markets such as the United States, Japan, and Korea. On the other hand, research should be conducted to create competitive strategic products that can be exported to potential new markets such as Russia, Australia, and Malaysia.

Based on the above literature, few researchers have addressed the evaluation of export efficiency in agriculture sector, especially in domestic studies. Therefore, this study aims to examine the efficiency and export potential of agricultural sector in Iran during 1997-2021.

3. Methodology

There are many theoretical and empirical studies on the relationship between trade and development. Various aspects of trading have been explored by researchers. But the most interesting question is to find the determinants of trade and future prospected development of a country's trade. Empirically, the gravity model has not only been employed to estimate exports, imports, and bilateral trade but it has also been applied to explain trade factors of production (Atif et al., 2019).

The difference between actual exports (observed) and predictive quantities (appropriate) is usually defined as potential exports. Estimating the potential export or export between two countries using the ordinary least squares (OLS) equation leads to an estimation error due to the estimation of the conditional average of the data and the failure to calculate the high data constraints (Baldwin, 1994). Therefore, it is necessary to make an estimate that shows the high range of data (Kalirajan, 2008). To address this issue, Kalirajan (2008) proposed the concept of the Stochastic Frontier Gravity Model (SFGM) to make the model estimation more meaningful.

4. Stochastic Frontier Gravity Model (SFGM)

Aigner et al. (1977) and Meeusen and Van Den Broeck (1977) individually develop the gravity equation using SFA in production economics. This method suggests that the estimations of the maximum level of output and a production possibility frontier (PPF) can be reached from a given level of inputs. A firm/industry operating below the frontier output is considered a technically inefficient firm, indicating a shortfall between the observed and the maximum possible output levels. In contrast, technically efficient operates on the PPF such that observed and frontier levels of output correspond. Hence, the former refers to the opportunity for additional expansion of output. Thus, the technically inefficient production function refers to the degree to which actual output falls short of potential output. Similarly, in the case of exports, SFA can be used to define export frontier whereby inefficient export performance refers to the degree to which actual export falls short of the maximal potential export. Kalirajan (2007) introduces the SFA in the gravity equation to explain trade partners' variations in trade. The trade frontiers estimated through this approach give liberty in taking the optimal trade level among the countries in the analysis. These bilateral trade frontiers are influenced by positive or negative error terms formed within the model. This allows the randomly created trade frontier to differ according to the given deterministic part of the gravity model. The observed magnitude of trade afterwards can be matched against the predicted frontier values of trading nation partners to analyze the maximum size of the trade.

Belotti et al. (2013) and Kalirajan (2007) suggest the significance of applying the SFGM in international trade analysis as follows. First, it can offer information on exports' efficiency and potential. Second, it can be applied even if a model has not adequate information about the omitted variables. Third, it separates the analysis from the white noise term, and it estimates the effect of the economic distance term, which may cause non-normality and heteroskedasticity. The inclusion of SFA in the gravity model permits estimation of exports potential at a bilateral level. These export frontier quantities are influenced by a random error that may either be positive or negative and, consequently, permit stochastic frontier exports to fluctuate around the model's deterministic part (Ravishankar and Stack, 2014; Atif et al., 2016). Therefore, the strong theoretical and policy relevance of SFA results provide a decent justification for its use.

At first, Tinbergen (1966) used the gravity model to find the determinants of trade. In this model, trade is directly proportion to the income of trading countries and inversely proportion to the distance between these two. Therefore, the basic form of gravity model can be presented for our agriculture export model as follows:

$$AGXP_{jt} = \frac{GDP_t , GDP_{jt}}{DIST_j} \tag{1}$$

where $AGXP_{jt}$ is agriculture export flow from Iran to importing country 'j' (j =1,2,3, …...,63) in period 't' (t = 1995,1996, …,2021). $DIST_j$ is the geographical distance between Iran and importer 'j.' Following the gravity theory, agricultural exports are supposed to be positively influenced by both countries' GDP. Iran's GDP_t is representing the supply-sided output capacity. On the other hand, the importer's GDP_{jt} is a demand-sided phenomenon and is representing the demand capacity of the importer's country for Iranian products. Distance is a proxy for transport cost and it is assumed that it has a negative influence on trade. Equation (1) is non-linear in nature and has estimation problems. Therefore, it is generally estimated by taking log of both sides to make it linear.

$$\ln AGXP_{jt} = \beta_0 + \beta_1 \ln GDP_t + \beta_2 \ln GDP_{jt} + \beta_3 \ln DIST_j + \varepsilon_{jt} \quad (2)$$

In Equation (2), ln is natural log and βs are elasticity parameters to capture the impact of GDP of Iran and importer and distance on exports.

The gravity equation, revealing the significance of geographical dynamics in international trade theory, created a reawakening interest among researchers to establish theoretical foundation of gravity model. For instance, Anderson (1979), first, derived gravity equation through product differentiation model. Bergstrand (1989) investigated the theoretical base of bilateral trade through monopolistic competition models. Helpman and Krugman (1985) justified gravity model by assuming increasing returns to scale and differentiated product market. Deardorff (1995) establishes that gravity model characterizes many models and can be validated through standard trade theories.

Along with the theoretical explanations, gravity model has been enriched by various scholars by introducing different time variant and invariant explanatory variables. For example, Frankel (1992) augments Equation (2) by incorporating the product of GNP and GNP per capita as proxies for economy size and level of development, respectively. Similarly, Wall (1999) introduces trade policy index as a measure to estimate the trade protection level of US with the trading partners. Nguyen (2010) extends gravity model by including lagged volume of trade, regional trade agreements and exchange rate to explain Vietnam's exports flows with ASEAN[1] countries.

The gravity model is widely estimated to project the determinants of trade for the trading nations. However, there is a weakness in the estimation methodology. Exports or imports are generally taken as average of sample instead of optimum feasible values for the trading countries. This may be problematic in estimation gravity model in the presence of highly diverging values in the sample (Ravishankar and Stack, 2014). Therefore, stochastic frontier methodology stands better in estimation of gravity model.

[1]. The Free Trade Agreement, signed between Malaysia, Indonesia, Singapore, Thailand, Brunei Darussalam, Vietnam, Myanmar, Laos, and Cambodia on January 28, 1992, in Singapore to reduce trade and customs tariffs, was signed by member states.

The stochastic frontier technique was developed by Aigner, Lovell, and Schmidt (1977). Since the conception of this idea, this methodology has widely been used to assess firm performance. Typically, the stochastic frontier model (SFM) postulates a production possibility frontier representing the optimal level of production obtained from fixed available inputs. The efficient firms operate on production possibility boundaries whereas technically inefficient firms operate inside the given frontier level and also it is representing production loss equal to difference between actual and potential output. Hence, it implies that the latter can further expand its output from given level of inputs. Thus, stating in the context, the firm operating below optimal level of production commits technical inefficiency.

Similarly, SFM is a better methodology in dealing with the trade below than optimal level. In this connection we can modify gravity model as follows:

$$ln\,A\,GXP_{jt} = \beta_0 + \beta_1\, ln\,G\,DP_t + \beta_2\, ln\,G\,DP_{jt} + \beta_3\, ln\,D\,IST_j + \sum_{g=1}^{G} \gamma_g Z_j + \sum_{k=1}^{K} \alpha_k X_{jt} + \nu_{jt} - \mu_{jt} \tag{3}$$

In Equation (3), all the trade determinants are same like Equation (2). However, the error term ε_{jt} has been segregated into two parts. That is ν_{jt}, a double-sided error term that assumes N (0 ~ σ2v) and it explains statistical noise caused by estimation error. And a single side error term u_{jt}, that is supposed to be normally distributed, N (0 ~ σ2v), and it stands for a measure of trade performance. The term u_{jt} represents technical efficiency[1] and can be used to identify the extent to which the actual trade level strays from the maximum possible/potential trade. According to Anderson and Wincoop (2003), these deviations happen due to multilateral trade resistances. These resistances are difficult to quantify and lead to inefficient trade performances in the bilateral and multilateral trade settings.

Following the Aigner, Lovell, and Schmidt (1977) methodology, we are using maximum likelihood estimation technique in Equation (4). In this methodology, SFM is an appropriate methodology if inefficiency is proved as significant. Furthermore, we would test the existence of technical efficiency through single-sided likelihood ratio test. For example, H0: $\sigma^2u = 0$ is null hypothesis against the alternative H1: $\sigma^2u > 0$. Acceptance of null hypothesis indicates that SFM is reduced to ordinary least square estimates. Following the

[1]. Technical efficiency is the ability of a firm to produce as much output as possible with a specified level of inputs, given the existing technology. It can also be a situation wherein it is impossible, with current technical knowledge, to increase output from given inputs or produce a given output using less than one input without using more of another input (Erena et al., 2021).

estimation of gravity parameters, the point estimates for technical efficiency can be calculated by following equation suggested by Battese and Coelli (1988):

$$E\left[exp(-\mu_{jt})|\nu_{jt}+\mu_{jt}\right] = \left[\frac{1-\phi\left[\sigma_\alpha+\gamma\left(\nu_{jt}+\mu_{jt}\right)/\sigma_\alpha\right]}{1-\phi\gamma\left(\nu_{jt}+\mu_{jt}\right)/\sigma_\alpha}\right] \times exp\left[\gamma\left(\nu_{jt}+\mu_{jt}\right)+\frac{\sigma_u^2}{2}\right] \quad (4)$$

where ϕ (0) denotes the density function for standard normal random variables. If the value of γ is equal to 0 then it means that there is no deviation due to inefficiency. Whereas, if $\gamma = 1$ then it indicates that there is no deviation in export-caused variance in 'u'. The technical efficiency can be estimated for each country-pair ranging from 0 to 1. A value equal to 1 indicates that the potential and actual trade coincides whereas value near to 0 implies that the actual trade is below the potential trade and there are possibilities for the further trade.

To analyze the determinants of agricultural exports of Iran, this study uses SFM gravity approach to estimate bilateral trade potential. This technique enables us to get consistent estimates from gravity model what Concretely, Baier and Bergstrand (2009) show that the following model produces similar estimates from those obtained by fixed effect method but without taking into account of dummy variables. Further, we have replaced the X_{jt} and Z_t from Equation (3) with tariff, bilateral exchange rate, border, language and preferential trade agreements in Equation (5).

$$ln\,AGXP_{jt} = \beta_0 + \beta_1\,ln\,GDP_t + \beta_2\,ln\,GDP_{jt} + \beta_3\,ln\,DIST_j + \beta_4\,ln(1 + ATAR_{jt}) + \beta_5\,ln\,BEXR_{jt} + \beta_6\,ln\,BORD_j + \beta_7\,ln\,LANG_j + \beta_8\,ln\,PTA_j + \beta_9 Sanction_j + \nu_{jt} - \mu_{jt} \quad (5)$$

where $ATAR_{jt}$ = Average tariff imposed by country 'j' on agriculture exports from Iran, $BEXR_{jt}$ =Bilateral exchange rate between Iran and importer. $BORD_{ij}$, $LANG_{ij}$, $SANCTION_j$ and PTA_{ij} = border, language, sanction and preferential trade agreements dummies.

Table 1 shows a summary of the variables used in the model, as well as the expected sign and information sources of the variables.

Table 1. Expected Sign and Sources of Data

Variables	expected sign	Previous studies	Data resources	Details
Iran's agricultural export to partners			UN Comtrade Database	Aggregate of HS.01-24
Iran's GDP per capita	+	Koochakzadeh and Karbasi: (+)	World bank	GDP per capita (constant 2015 US$)
GDP per capita in trading partner	+	Hendizadeh et al.: (+) Toossi et l.: (+)	World bank	GDP per capita (constant 2015 US$)
Geographical distance	-	Karbasi and Aminizadeh: (-)	Centre d'Etudes Prospective et d'Informations Internationales (CEPII)	Distance between the capital of importing and exporting countries
Tariff rate	-	Atif, Haiyun and Haider Mahmood (-)	World bank	Tariff rate, applied, weighted mean, primary products(%)
Real exchange rate	(+/-)	Atif, Haiyun and Haider Mahmood (+)	World bank	Real effective exchange rate index (2010 = 100)
Trade agreement	+	Dourandish et al.: (+) Aminizadeh et al.: (-) Shepherd and Wilson: (-/+)	Centre d'Etudes Prospective et d'Informations Internationales (CEPII)	Dummy variable value "1" Existence of agreement with business partner and "0" Absence of agreement.
Common border	+	Shepherd and Wilson: (-/+) Toossi et l.: (+)	Centre d'Etudes Prospective et d'Informations Internationales (CEPII)	The dummy variable is a value of "1" for a business partner with a common border and "0" for a non-common border.
Common language	+	Atif, Haiyun and Haider Mahmood (+)	Centre d'Etudes Prospective et d'Informations Internationales (CEPII)	The dummy variable is "1" for a business partner with a common language and "0" for a non-common language.
Economic sanction	(-/+)	Karbasi and Aminizadeh: (-)	Samur (2015)	the dummy variable is "1" for the years 2010 onwards and "0" for the years before 2010.

Source: Research finding.

5. Results

As shown in Table 2, the high coefficient of variation (cv) in the value of agricultural exports in Iran (3.57) indicates that Iran's exports are very scattered. Further, the cv of GDP per capita among importing countries indicates the diversity of market size in Iran's target countries. The minimum and maximum range for the import per capita GDP of the importer and bilateral exchange rate is considerably wide, which means that Iran's partners are heterogeneous in many respects.

Table 2. A Summary of Statistics in Model Variables

Variables	Mean	Standard deviation	coefficient of variation	Minimum	Maximum
Agriculture exports	63.5	227	3.57	852	2610
Exporter -GDP per capita	4717	609.5	0.13	3703	5664
Importer-GDP per capita	42310	180803	4.27	332.7	1593917
Distance	3461	2623	0.76	540	12916
Tariff rates	5.07	5.39	1.06	0	62
Bilateral exchange rate	5299	13699	2.58	0.11	135921

Source: Research finding.

Note: ∗indicates the variables adjusted for MR term.

Before estimating the gravity model, it is necessary to check the stationary of the variables. The results Fisher and Im-Pesaran-Shin tests showed that all variables are stationary (Table 3).

Table 3. Results of Unit Root Test

Variable	**Fisher**		**Im-Pesaran-Shin**	
	Statistics	**Significance level**	**Statistics**	**Significance level**
Iran’s agricultural export to trading partners	4.71	0.00	-2.16	0.01
Exporter -GDP per capita	9.12	0.00	-4.10	0.00
Importer-GDP per capita	29.93	0.00	-7.21	0.00
Tariff rates	1.51	0.08	-1.59	0.05

Bilateral exchange rate	13.73	0.00	-2.39	0.00

Source: Research finding.

In addition, based on the results in Table 4, no perfect collinearity is observed between the independent variables of the model.

Table 4. Results of Covariance Matrix Test

	lex	lgdpci	lgdpcj	latr	lbi	ldist1
lex	1					
lgdpci	0.346	1				
lgdpcj	0.0490	0.0723	1			
latr	-0.0371	-0.312	-0.319	1		
lbi	0.0629	0.220	0.222	-0.175	1	
ldist1	-0.286	-0.0865	0.220	-0.183	-0.218	1

Source: Research finding.

Table 5 indicates the results of panel diagnostic tests. The result of Chow's test indicated that the structured data used to estimate the gravity model is in the form of a panel. Further, the result of Hausman test showed that the null hypothesis of the effect of the random effects method is rejected and the fixed effect method has better results.

Table 5. Results of Panel Diagnostic Tests

Test	Statistic	p-value
Chow test	29.26	0.00
Hausman test	19.02	0.00

Source: Research finding.

Table 6 shows the factors affecting Iran's agricultural exports by using a stochastic frontier gravity model. The coefficients of the explanatory variables are in accordance with the expected economic theories. The model fits well based on the high value of gamma (γ) which is 0.75. The value (μ) is significant at 1%, which confirms the inefficiency of the model. In addition, the value of $\sigma2$ is significant, which measures the average of total changes over time. In fact, the flows of Iran's agricultural export are different over time. However, (η) is not statistically significant at the level of 10%, which indicates a lack of significant changes in export inefficiency during the study period.

Based on the results, the value of agricultural exports is positively determined by supply capacity (Iran's GDP), as well as partner demand capacity (GDP of importing countries), while geographical distances are considered as the main barriers. The coefficient of domestic supply capacity indicated that a 1% increase in GDP leads to an increase in the value of agricultural exports by 2.38%, while a 1% increase in importer revenue (importer GDP) results in increasing the demand for agricultural exports by 0.29%. Similarly, regarding the negative distance coefficient, a 1% increase in distance prevents from exporting agricultural products by 0.7%. Both predictions theoretically are consistent with the gravity model hypothesis upon which Iran's agricultural exports are positively related to economic volume and inversely related to the distance between trading partners. The results are in line with those of Raimondi and Olper (2008) and Atif et al. (2016) in which agricultural trade has a positive and negative relationship with market size and distance, respectively.

In addition to the base gravity model estimates, the average tariff rate was added as an explicit measure of trade costs. Regarding the negative coefficient of 0.18, the export of agricultural products has a negative relationship with the tariff rate and the export of agricultural products decreases by 0.18% and vice versa by a 1% increase in the tariff rate by the importing country. In addition, a negative relationship between tariff rates and exports of agricultural products was confirmed by Raimondi and Olper (2008) and Ghazalian et al. (2012).

Further, the positive and significant coefficient of the bilateral exchange rate shows that an increase in the bilateral exchange rate (devaluation of the rial based on the definition) results in increasing the income of agricultural exports by 0.13%. Therefore, the demand for exporting Iranian agricultural products is elastic and its devaluation plays a significant effect on the earnings of agricultural exports. The finding is consistent with that of Erdal et al. (2012) which focused on agricultural exports.

Along with other independent variables, four dummy variables were added to examine the effect of a common border, common language, trade agreements, and economic sanctions on Iran's agricultural exports. The common border coefficient for exporting Iranian agricultural products was significant. In other words, the existence of a common border led to an increase in agricultural exports of Iran, which may be related to lower shipping costs and easier access to the market. Common border markets have a more similar food taste due to cultural similarities and tastes, which leads to more exports to the neighboring countries.

Common language (CL) failed to have a significant effect on the value of exports, which is in line with the study of Herath et al. (2014).

Given that Iran has not adopted any trade agreements in the agricultural sector except for Pakistan and Turkey, and these agreements have failed to create any significant change in Iran's agricultural exports to these countries, the trade agreement variable failed to play any significant role on the value of Iran's agricultural exports. Furthermore, the lack of significant effect of economic sanctions on the value of Iran's agricultural exports may be related to the fact that US and EU multilateral sanctions have not had any effect on agricultural products due to food security reasons, and accordingly failed to decrease Iran's exports.

Table 6. Maximum Likelihood Estimates of the Stochastic Frontier Gravity Equation for Iran’s Agriculture Exports

Variable	Coefficient	Standard error	P-Value
Exporter -GDP per capita	2.38	0.67	0.00
Importer-GDP per capita	0.29	0.13	0.04
Distance	-0.70	0.36	0.05
Tariff rates	-0.18	0.10	0.07
Bilateral exchange rate	0.13	0.06	0.04
Language	0.27	1.21	0.82
Regional trade agreements	1.27	1.80	0.48
Common border	1.28	0.6	0.05
Sanction	-0.20	0.15	0.19
Year	0.01	0.01	0.53
Constant	2.29	7.19	0.76
(γ)	0.75	0.06	0.86
(η)	0.00	0.01	0.40
(μ)	2.88	0.47	0.00
$\sigma 2$	3.38	0.85	0.00
Log-likelihood	-919.64	X2	83.16

Source: Research finding.

6. Technical Efficiency and Export Potential

6.1 Export Efficiency

Table 7 indicates the estimation of the average export technical efficiency based on the stochastic frontier gravity model for major trading partners in Iran. Based on the results, none of the countries indicated 100% technical efficiency. In other words, regarding the factors playing a role in the gravity model, Iran has failed to do maximum exports with its trading partners and a lot of potentials are available for increasing the trade with these countries. As shown in Table 7, Iran has had export efficiency above 50% with only 6 countries including Germany, Russia, Vietnam, Spain, India, and UAE, which represents the high export potential of many trading partners in agricultural products. In addition, except for Russia and the UAE, other neighboring countries have high potentials for accepting agricultural products.

Table 7. The Efficiency of Iranian Exporting Target Markets

Partner country	Technical efficiency (%)	Partner country	Technical efficiency (%)
Germany	76	Yemen	5
Russia	64	United Kingdom	4
Vietnam	61	Thailand	4
Spain	60	Belgium	3
India	59	Syria	3
United Arab Emirates	57	Indonesia	3
Afganistan	34	Greece	3
Italy	24	Hungary	3
Kazagestan	23	Egypt	3
China	19	Turkey	3
Lebanon	14	Azerbaijan	3
Uzbekistan	14	Algeria	3
Tajikestan	12	Morocco	2
Japan	11	Georgia	2
Turkmenistan	10	Armenia	2
France	9	Qatar	2
Pakistan	8	South Africa	1
Australia	6	Jordon	1
Republic of Korea	6	USA	1
Kyrgyzstan	5	Bahrein	1
Kuwait	5	Oman	1
Iraq	5	Singapore	1
Poland	5	Libya	0
Netherlands	5	Croatia	0

Source: Research finding.

6.3 Export Potential

Table 8 estimates the average export potential and its gap from actual exports based on estimated stochastic frontier gravity model. The results indicated that there is a significant potential for Iranian agricultural exports with all of the trading partners. The highest potential agricultural exports in Iran, which is about US 32,273 million dollar, belong to Iraq, followed by Turkey, Oman, Qatar and Pakistan. In fact, the highest export potential is related to the neighboring country, common border, large population, and informal Arabic and Turkish language common in most parts of Iraq and Turkey.

Table 8. Agriculture Export Gap in Iran: An Average of US Million Dollars (1997-2021)

Partner country	Actual exports	Potential exports	Exports gap	Partner country	Actual exports	Potential exports	Exports gap
Iraq	1584.7	32273.1	-30688.4	Poland	9.9	206.6	-196.6
Turkey	191.0	6938.8	-6747.8	Russia	316.5	496.9	-180.4
Oman	59.0	5929.6	-5870.6	Uzbekistan	28.4	206.4	-177.9
Qatar	68.4	4176.0	-4107.7	United Kingdom	7.5	178.6	-171.1
Pakistan	298.2	3610.5	-3312.4	India	200.9	339.5	-138.7
Azerbaijan	70.9	2761.2	-2690.3	Australia	8.6	143.9	-135.3
Armenia	27.1	1462.9	-1435.7	Morocco	2.8	120.1	-117.4
Kuwait	70.7	1413.3	-1342.5	Italy	37.0	153.2	-116.2
China	285.4	1514.4	-1229.0	Belgium	4.2	120.2	-116.0
Libya	3.6	1178.1	-1174.5	Egypt	3.1	108.6	-105.5
Syria	34.4	1061.1	-1026.7	Lebanon	17.3	121.1	-103.7
Afghanistan	507.9	1505.4	-997.5	France	9.7	106.5	-96.8
Jordon	10.5	999.6	-989.0	USA	1.0	91.8	-90.8
Kyrgyzstan	34.4	642.5	-608.1	Indonesia	2.9	91.5	-88.6
Bahrein	5.4	529.5	-524.2	Greece	2.3	74.3	-72.0
Turkmenistan	58.5	579.9	-521.4	Tajikestan	9.8	79.3	-69.4
Georgia	10.9	511.2	-500.3	Hungary	1.8	60.9	-59.2
Singapore	3.6	418.9	-415.3	South Africa	0.8	56.9	-56.0
Thailand	16.5	409.9	-393.3	Germany	155.4	203.5	-48.1
United Arab Emirates	464.7	808.4	-343.7	Japan	5.4	49.3	-43.9
Croatia	0.5	292.5	-292.0	Vietnam	58.2	94.6	-36.4
Kazakhstan	77.8	343.2	-265.4	Republic of Korea	2.2	38.0	-35.8
Netherlands	11.2	238.3	-227.0	Spain	53.8	89.5	-35.7
Algeria	5.6	224.1	-218.5	Yemen	1.3	29.0	-27.7

Source: Research finding.

7. Conclusion and Policy Implication

The results indicated a significant growth in the export value of Iran's agricultural products in the studied period, although the lack of stability in the value of Iran's agricultural exports and the limitation of Iran's export target countries during the studied period are considered as the main weaknesses of exports in this sector. It is believed that the capacity of Iran to achieve higher figures is very high. Therefore, in this study, the gravity model was estimated for Iran's agricultural exports to its 48 main trading partners during 1997-2021 by using the stochastic frontier gravity model technique. Further, the factors related to Iran's agricultural export potential were assessed with its major trading partners. The results confirmed that economic size and geographical distances have a positive and negative effect on Iran's agricultural exports, respectively. Additionally, the real exchange rate (devaluation of the domestic currency) has had a positive and significant effect on the export income of the agricultural sector. However, implementing such a policy successfully necessitates the adoption of correct financial and monetary policies (Karimzadeh et al., 2014). Furthermore, common borders have positive and significant effects on agricultural exports, while common language, trade agreements, and sanctions failed to help us analyze the agricultural exports in Iran.

In addition, the stochastic frontier gravity model technique quantifies the values of export potentials by estimating technical efficiency. The average technical efficiency of agricultural exports in most trading partners was less than 10%. Further, actual agricultural exports have been considerably lower than potential exports. As a result, the export gap was negative for all trading partners. The results of this study for GDP per capita of the exporting country and importing countries, geographical distance, common border, bilateral exchange rate and tariff with the studies of Delona et al. (2014), Atif et al. (2016), Noviani et al. colleagues (2017), Hajivand et al. (2020) is consistent. For Iran's export potential in the agricultural sector, it is consistent with the studies of Hajivand et al. (2020) and Mohammadi et al. (2017). Based on the model findings, the following suggestions are mentioned.

First, the business partners with the highest export potential were Iraq, Turkey, Oman, Qatar and Pakistan. In the meantime, considering the impact of the common border and geographical distance on exports, it is recommended that Iraq, Turkey and Pakistan should be prioritized for Iran's exports due to their short distance. However, this variable has not had a significant effect on improving agricultural exports because of the lack of attention to trade agreements in Iran's agricultural sector, especially with neighboring countries. Second, participation in regional trade agreements can help strengthen the political bond between Iran and its trading partners while developing Iran's bilateral trade. Accordingly, given that geographical distance affects transportation and the volume of bilateral trade, it is recommended that the government plan should expand trade with the neighboring countries which have high economic, cultural, and social similarities with Iran. Finally, considering that the agricultural sector has never been included in the list of sanctions imposed on Iran due to the provision of food to the people and the demonstration of human rights by the sanctions (Faraji et al., 2018), this variable failed to have a significant effect on the export value of agricultural products. Thus, politicians can compensate a part of the currency shortage by the agricultural sector by boosting agricultural trade.

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Cite this article: Alizadeh, T., Shakeri Bostanabad, R., & Keshvarz, N. (2025). The Potential of Iran's Agricultural Exports: Evidence from a Stochastic Frontier Gravity Model. *Iranian Economic Review*, *29*(1), 288-310.