academicJournals

Vol. 8(43), pp. 5320-5326, 7 Number, 2013
DOI: 10.5897/AJAR11.1952
ISSN 1991-637X ©2013 Academic Journals
http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

Evaluating the effect of aflatoxin food safety concerns on Iran's pistachio trade with gravity model

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Accepted 30 October, 2013

How food safety affects international trade is an important factor to be studied for low-income countries which continue to rely on agricultural exports. Iran, as the greatest pistachio exporter in the world, encounters a serious problem of aflatoxin contamination. This food safety shocks affected Iran's income which has caused a lot of damages to the country's economy. The paper estimates the effect of food safety concerns on Iran's pistachio export during 1997 to 2006. Using a generalized gravity model, we find that food safety has significant effect on Iran's pistachio export, beside other factors that have effect on pistachio trade. Based on our analysis, food safety regulations have a greater effect in the long run as against the short run. Programs aimed at reducing aflatoxin contamination of pistachio is a key recommendation for policy makers. The results of this study suggest that Iran pistachio growers would benefit from better marketing and increased food safety regulations to maintain its export market share in the world

Key words: pistachio, food safety, panel data, generalized gravity model, Iran.

INTRODUCTION

Agriculture is known to be the largest source of employment of labour, GDP growth, and a source of exports and foreign exchange revenue in many low-income countries. Agriculture has the highest levels of trade capacity in these countries. Thus, the export of agricultural commodities plays a predominant role in the economy of developing countries. For this reason, many countries have redesigned their foreign trade programs in order to develop more viable opportunities.

Food safety regulations are mandatory controls over the quality attributes of a final product, based on the potential effects on human health from food handling, preparation, or consumption (Hooker, 1999). Some advantages of food safety regulation are decreasing the risks of morbidity and mortality related to the consumption of unhealthy food. Food safety and agricultural health risks can cause market failure in international trade like the famous alar scare in apples in 1989. Consequently, both public and private sectors play important roles in the management of food safety shocks and other risks. Food safety is one of the important factors effecting consumers health and their belief about a product

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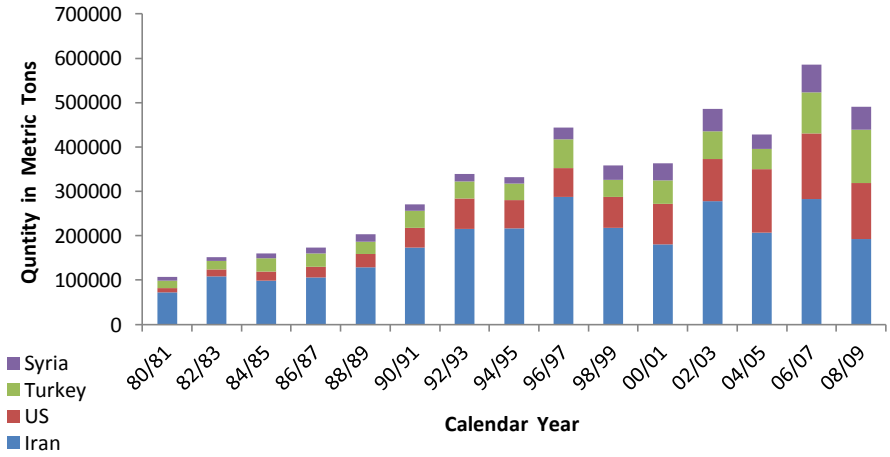

Figure 1. Major World Pistachio Producers' Production Quantity in Metric Tons,1980-2009. (Data Source: FAO Production Indices).

which can cause a decrease in demand (Brunke et al., 2004). Iran's economy largely depends on oil exports but the country has a diverse range of products in its agricultural sector. Iran's exports are dominated by three agriculture commodities: pistachio, raisins and shrimp. Iran is the largest producer and exporter of pistachios in the world as seen in Figure 1.

In recent years, the value of pistachio exports has been the same as oil exports. During the 1997 to 2000 time period, Iran's pistachio industry encountered some challenges including aflatoxin contamination and emergence of new competitors including USA and China. However, the discovery of high aflatoxin levels in pistachios, a major food safety concern, is the leading cause of the declining trend in terms of value, (both nominal and real prices) and volume since 1990 according to FAO (2007). During this time, pistachio export expansion was supported by the government.

Aflatoxin is a kind of toxin produced by certain strains of the fungi *Aspergillus flavus* and *A. parasiticus*. Most tree nuts have encountered aflatoxin contamination. This kind of toxin causes problems to the liver. Excess consumption of this toxin can lead to liver failure and death. Government often attempt to aid food safety by mandating standards and evaluation of food products to expand the efforts by private firms and industries. Following a brief 1997 ban on exports to the EU, efforts have been made to improve the screening of export shipments to the EU by the Iranian government. However, it appears that aflatoxin infection levels increased during shipment, and a particularly alarming number of containers have been rejected since 2003. Another part of this declining trend in Iranian pistachio exports is attributed to the emergence of new producers and exporters. The emergence of the US and China in pistachio world trade, for instance, resulted in the lowering of Iran's market share of world exports. The US joined the exporter countries in 1982 and has since become Iran's major rival and competitor in the international markets.

The objective of this research is to analyze how global trade patterns in pistachio exports change when food safety as an indicator of aflatoxin contamination is parameterized in a gravity trade model.

Literature review

Gravity models are a well-known technique for analyzing welfare effects in international trade. Wilson and Otsuki (2001) examined the impact of adopting international food safety standards on global food trade patterns by using panel data method. They estimated the effect of aflatoxin standards on some developing and developed countries. They found that total world exports would increase by $38.8 billion if international standards (Codex) were adopted, compared to the current divergent national standards in place. Okubo (2003) used a Gravity Model by using ols method for each year to analyze the border effect in the Japanese market. The results suggest that the border effect in Japan is much lower than in the United States and Canada, and has declined year by year between 1960 and 1990. Emlinger et al. (2006) focused on the difficulties faced by the Mediterranean countries to enter the EU market. They used gravity equation by collecting annual data to evaluate the change in tariff sensitivity and its "non-tariff" trade resistance according to the exporting countries. Results illustrate that the higher the tariff sensitivity the higher the

impact of liberalization on trade and this impact can be limited by a high trade resistance.

Lueth and Ruiz-Arranz (2006) estimated the gravity model by using panel data method for workers' remittances. They found that most of the variation in bilateral remittance flows can be explained by a few gravity variables. Results indicated that remittances do not seem to increase in the wake of a natural disaster and appear aligned with the business cycle in the home country. Simwaka (2006) examined Malawi's trade with her major trading partners using an econometric gravity model. Its results showed that transportation cost and distance have a negative influence on Malawi's trade; and positively determined the size of the economies (GDP of the importing country) and similar membership to regional integration agreement.

Ardakani et al. (2009) used a gravity model with panel data to estimate the trade effect of non-tariff barriers imposed by importer countries on pistachios, raisins and shrimp exported by Iran. The results showed that NTBs had a negative impact on pistachio and shrimp exports and their effect was greater than that of tariffs; raisin exports were unaffected by NTBs. Nguyen and Wilson (2009) estimated a theoretically-consistent gravity model with both panel data method and traditional models for changing food safety regulations in the EU, the US, and Japan. The results show that different food safety regulations have differential effects on aggregated sea food and different effects across sea food products.

Thus, gravity models are widely used to measure the impact of a displacement in trade caused by a change in an important variable such as food safety. This research contributes to this literature by examining a food safety measure. By reviewing these previous studies which used gravity model, some hypotheses were derived which are mentioned below:

(1) Food safety concerns such as aflatoxin contamination in pistachio is the most important factor for expanding the pistachio export.
(2) GDP and common border have positive effect on the export of most commodities such as pistachio.
(3) Transportation costs and distances have negative effects on exportation.

METHODOLOGY

The empirical structure in this paper is based on a gravity model. The gravity model can accurately explain the bilateral trade flows. It is used for various purposes especially to assess market access, trade resistance and impacts of regional agreements. In fact, it permits estimation of trade creation or diversion in case of a regional agreement (Nahuis, 2004; Soloaga and Winter, 1999). The originality of gravity model came back to the Newton's law of gravitation in the seventeenth century. The gravity model is a function of attraction factors such as 'economic mass' (GDP) and resistance factors such as distance ' economic centers of gravity', population and trade preference factors like common language, common borders and others which can effect international trade.

In our empirical model, we assume that intercept for all trading partners are homogeneous, as such, there is a bias in the estimation process (Egger, 2006). In the other words, the individual units that can include consumers and producers are heterogeneous in many kinds of features that have many conflicts with each other which affected the level of trade and are correlated with principal variables of the model.

One way to overcome the effects of heterogeneity is to use panel data in which case, each country is considered as a distinct intercept. The application of panel data has several advantages over cross sectional analysis.

Generalized gravity model

The model used in this study is a generalized gravity model. This model is used to analyze trade flows and bilateral trade potential for the countries which import pistachios from Iran. Here, we have added a variable for food safety concern to the gravity model to evaluate its effect on Iran's pistachio exportation. Food safety is an indicator of Iran's pistachio export ban due to aflatoxin contamination. This variable is different from previous studies using a gravity model.

In constructing the empirical model, a sample of nine countries were considered: Australia, France, Italy, India, Japan, Canada, Spain, Russia and Germany. These countries were chosen because they imported the largest volume of pistachios from Iran during the time period under study according to availability of data, which is 1997 to 2006.

In most studies, a gravity model is estimated for exports and imports. But Kao et al. (1994) and Wang et al. (2000) did not use bilateral trade equations. Iran does not import pistachios from other countries, so the gravity model for pistachio export was treat as a function of gross domestic production of each country and Iran's gross domestic production; exchange rates of all destinations; population of all countries and Iran's distance between the capital of each country with and their common border and food safety as dummy variables. These are common variables identified from the literature review:

$$EX_{it}=f(POP_{ijt},\ GDP_{ijt},\ EXR_{it},\ FS,\ Dis_{ij},\ Border) \quad (1)$$

Where EX_{it} is real pistachio imports of each country from Iran, GDP_{it} is the real GDP of a country *i,* EXR_{it} is the exchange rate at the U.S. dollar and Dis_{ij} is the geographical distance between the country *i* and country *j* (measured in kilometers as the direct line distance between the capital cities of the two countries). FS is food safety as a binary variable which is set to 1 for the years that Iran's pistachios have high aflatoxin levels (Codex set 15 pbb for the amount of aflatoxin in exported pistachio, the higher level of aflatoxin is banned) that other countries didn't import pistachio from Iran and 0 was used for the years that Iran's pistachio didn't have high aflatoxin, and Border is a binary for common border. If the two trading partner countries share a border, the value of this variable is 1, and it is 0 otherwise; also POP is the population of Iran and other countries which import pistachio from Iran, α_t stands for the individual effects. Since individual effects are included in the regressions, we have to decide whether they are treated as fixed or as random. Subscripts *i* and *t* indicate the country of the destination and time, respectively.

The source of data for pistachio volume of trade is Food and Agriculture Organization (FAO); data for population, exchange rate and gross domestic production were obtained from World Development Indicators (World Bank). For the estimation of geographical distance between Iran and the capital city of other countries, city distance tool which is an internet software was used.

For our empirical study, we specify the gravity model of Iran's pistachio export function as follows:

$$\ln(EX_{it}) = \alpha_t + \alpha_1 \ln(GDP_{ijt}) + \alpha_2 \ln(EXR_{it}) + \alpha_3 \ln(pop_{ijt}) + \alpha_4 FS + \alpha_5 \ln(Dis_{ij}) + \alpha_6 border + \ln(\varepsilon_{it}) \quad (2)$$

The panel method was used for estimating generalized gravity model for Iran's pistachio exportation. Panel data estimation is often considered to be an efficient analytical method in handling econometric data. Panel data analysis became popular among social scientist because it allows the inclusion of data for N cross-sections (e.g., countries, households, firms, individuals etc.) and T time periods (e.g., years, quarters, months etc.) the combined panel data matrix set consist of a time series for each cross-sectional member in the dataset, and offers a variety of estimation methods. In this case the number of observations available increased by including developments over time.

Both DF and ADF unit root tests are extended to panel data estimations, to consider cases that possibly exhibit the presence of unit roots. Most of the panel unit root tests are based on an extension of the ADF test by incorporating it as a component in regression equations. However, when dealing with panel data, the estimation procedure is more complex than that used in time series. There are a variety of panel unit root tests which includes those used in Breitung (2000), Hadri (2000), Choi (2001), Levin et al. (2002) and Im et al. (2003) among others[1].

Model estimation procedures

The Hausman test is formulated to assist in making a choice between the fixed effects and random effects approaches. Hausman (1978) adapted a test based on the hypothesis of no correlation. For the panel data the appropriate choice between the fixed effects and the random effects methods investigates whether the regressors are correlated with the individual (unobserved in most cases) effects.

If the value of the statistics is large, then the difference between the estimates is significant and we reject the null hypothesis that the random effects model is consistent and use the fixed effects estimators. With our data set, the resulting Hausman test statistics is 12.59, which is significant at the 1% level and we reject the null hypothesis of no correlation between the individual effects and the X_{it}. For testing panel with fixed effects, we estimate the model with fixed effects and then test redundancy of fixed effects. The F statistics was significant with 0.002 probability value.

RESULTS

Table 1 shows the results of the gravity model for Iran's pistachio export. Impact of food safety on Iran's pistachio exportation and trade relations with countries of destination is analyzed. Most of the variables have high significant effect with the appropriate hypothesized sign on Iran's pistachio export. The results generally support the conclusion that the gravity model is well suited to examine all product groups in the analysis. The expected sign for GDP in the model is positive. When income and national product of countries increase, their demand for imports of goods and services would increase as well. As depicted in Table 1, Iran's GDP has a negative sign. This could be due to the high aflatoxin level in Iran's pistachio during years 1997 to 2006. Therefore, due to the reduction of importers demand, pistachio exports declined while GDP experienced an increasing trend in Iran. Results show that one percent increase in GDP of Iran's partners cause an increase of about 1.34% in their pistachio import.

The coefficient of Iran's GDP has a negative sign; it means that a percentage increase in Iran's GDP can reduce Iran pistachio export to its destination to about 2.08%. Note that the largest share of GDP depends on oil revenue; it could be argued that the increase in GDP was associated with increase in oil prices during this study as intended. It means that if the GDP of trade partners of Iran increases, they tended to spend more of their income to import pistachio which is a luxury commodity for most of these countries. It is anticipated that increase in the population of importer countries lead to an increase in the overall import volume, but the effect of this increasing trend on the exporter country is not clear. Thus, the coefficient sign for importer country is positive but the sign for exporter is undetermined. Table 1 illustrates that the coefficient for importers is negative. Pistachio is a luxury good; as a result, with increasing population of importer countries, they need their foreign exchange in the purchase of essential goods. However, this variable for importer countries is not significant. The coefficient is negative for Iran's populations, by the increase in Iran's population, Iranians would consume more pistachio and less would remain for exportation. Iran's population has a negative coefficient sign that states a percentage increase in its population, Iranian pistachio export will decline as much as 238% and it could be related to the increase in the demand for domestic products such as pistachio that is due to Iranian cultural behaviors.

The exchange rate has a positive relationship with export and a negative one with import. Increase in the value of exchange rate may cause a decrease in the import of the destination countries as is shown in Table 1. Results indicate that one percent increase in Iran's partners' exchange rates causes 0.87% reduction in their pistachio import. The geographical distance is considered as transportation cost which has a negative sign in our model (Table 1). This is expected as trade

[1]For our empirical model we find that the null hypothesis of a unit root is rejected for the level of each variable with most of the tests such as Levin, Lin and Chow, Im, Pesaran and Shin and ADF-Fisher chi square tests (related table in the Appendix Table 1)

Table 1. Parameter estimates and Hypothesis Test Results for the Fixed Effects Model.

Variable	Coefficient	Std. Error	t- Statistic	Prob.
C	4284.89	565.15	7.58	0.00
GDP_i	1.34	0.12	11.09	0.00
EXR_i	-0.87	0.38	-2.28	0.03
POP_i	-0.01	0.18	-0.07	0.94
POP_{Iran}	-237.59	31.22	-7.61	0.00
GDP_{Iran}	-2.08	0.35	-5.99	0.00
FS	-0.15	0.03	-4.98	0.00
DIS	-0.01	0.01	-2.12	0.09
BORDER	119.71	75.18	1.59	0.17
Weighted statistics				
R- squared	0.95	Mean dependent var	10.95	
Adjusted R-squared	0.94	S.D. dependent var	7.76	
S.E.of regression	0.66	Sum squared resid	24.04	
F- statistic	74.09	Durbin- Watson stat	1.68	
Prob (F-statistic)	0.00			
Unweighted statistics				
R- squared	0.86	Mean dependent var	7.42	
Sum squared resid	27.69	Durbin- Watson stat	1.55	

between more distant countries imposes a higher transportation cost which in turn reduces the international trade revenue.

A food safety shock is found negative and significant. The Food and Agricultural Organization (FAO) illustrates data showing that the pistachio imports in to the European Union dropped to 42% in 1998, and since 1997, Japan had been reducing Iranian Pistachios imports, ending import completely in 2006. Thus, Japan was one of Iran's pistachio markets that was lost.

Finally, as would be expected, a common border has positive and significant effect on Iran's pistachio export. It means that the countries which have common border with Iran, import pistachio more than other countries and it is according to low transportation costs for both importer and exporter.

IMPLICATIONS

This study analyses the factors that affect the gravity model of Iran's pistachio export. The empirical results show that the parameters of the gravity model are statistically significant at high significant levels and have good explanatory power. The main goal of this study is to evaluate the effect of food safety on gravity model of pistachio export. We find that aflatoxin contamination have different impacts on Iran's pistachio export. First, it causes a decrease in importation of some countries which pay attention to the food quality. Second, emersion of new markets for pistachio which looks for low price pistachio. This finding can be partly explained by the deep concern among consumers when facing this serious neurological threat as well as the disruption to production, trade, and other sectors of the economy.

The implications include a recommendation for allocating appropriate financial support to research, considering the rapid growth of competing products and their quality, using new technology to accelerate the international trade, learning ways to reduce aflatoxin contamination of pistachio which other producers run, paying more attention to the customers' requirements and recognizing competitors' pricing methods in foreign markets. The policies should be concentrated to increase yields and to achieve higher quality standards which are essential to sustain a suitable profitability level of production on one side and to maintain the country's share in the international markets on the other side. Policy makers and private sectors need to perform strategic perspective on standards, particularly in developing countries which are standards takers. To maintain Iran's export share in global market and achieve new markets, the following measures should be done:

(1) One of the proposed debates in food safety of pistachio is packaging. By packing this product we could have a higher control on safety and maintaining the standards of pistachio.

(2) Government should regulate investment in packaging and also other requirements of pistachio Orchardists, in order to provide financial credits for banks.
(3) To ensure food safety in pistachio some rules should be imposed in line with international laws and regulations. These rules must be informed to the production units permanently and systematically.
(4) For observing pistachio production standards such as their healthiness, some research centers and NGOs should be formed.
(5) According to the negative relation between export and the distance between countries, government should investigate on strengthening the transport infrastructure for international markets to compensate this effect.
(6) The positive relation between common border and Iran's pistachio export quantity in gravity model shows that, focusing on neighboring countries is important. Therefore, it is suggested that with the proper marketing techniques, more pistachio can be exported to these countries.

Poor food safety standards can strictly limit developing countries exports. Food safety regulations have greater effects in the long run versus the short run. Government should consider programs to reduce aflatoxin contamination of pistachio. Governments could regulate food production and marketing by imposing standards and inspection requirements. An aflatoxin-related food safety event could impose serious costs on the pistachio industry. Based on the results, Iran needs to have a more certain and clearer planning in production, marketing, and more importantly observation of health principles in order to maintain its export market shares in the world. Industries should undertake voluntary actions, which determine standards or similar measures for a product because the conditions of Iran and the market facts call for such a move.

ACKNOWLEDGMENTS

The authors wish to thank Dr. Michael Boland for his helpful comments and suggestions. The authors would also like to thank the editor and referees for the insightful comments.

Abbreviations: GDP, Gross domestic product; **EU,** European Union; **FS,** food safety; **EXR,** exchange rate; **POP,** population; **DIS,** distance.

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APPENDIX

Table 1. Hypothesis test results for panel unit root test.

Variable	Log(EX_{it})	Log(pop_{ijt})	Log(GDP_{ijt})	Log(EXR_{ijt})
Differences	**Level**	**Level**	**Level**	**Level**
Levin, Lin and Chow	-5.88	-4.63	-4.78	19.83
P- value	0.00	0.00	0.00	0.00
Breitungt- stat	-0.45	4.06	3.58	0.61
P- value	0.32	1.00	0.99	0.73
Im, Pesaran and Shinw- stat	-1.38	-3.12	-0.17	-3.23
P- value	0.08	0.001	0.63	0.00
ADF- Fisherchi-square	35.31	47.98	23.83	45.31
P- value	0.01	0.00	0.16	0.00
PP-Fisherchi-square	58.50	25.98	27.16	23.82
P- value	0.00	0.10	0.076	0.16

Panel unit root test

Consider the following autoregressive specification:

$$Y_{it}=\rho_i y_{it-1}+\delta_i X_{it}+\varepsilon_{it} \quad (1)$$

Where i=1,…, N for each country in the panel; t=1,…,T refers to the time period; X_{it} represents the exogenous variables in the model including fixed effects or individual time trend; ρ_i are the autoregressive coefficients; and ε_{it} are the stationary error terms. If $\rho_i<1$, y_{it} is considered weakly trend stationary where $\rho_i=1$, then y_{it} contains a unit root.

$$Y_{it}=\rho_{it} y_{it-1}+\sum_{j=1}^{p_i} u_{ij}\, e_{it-j}+\delta_i X_{it}+u_{it} \quad (2)$$

Where p_i represents the number of lags in the ADF regression. The null hypothesis is that each series in the panel contains a unit root (H0: $\rho_i=1$). The alternative hypothesis is that at least one of the individual series in the panel is stationary (H0: $\rho_i<1$).

The fixed and random effects method

In general, linear panel data models can be estimated using three different methods:

(a) With a common constant as in equation,
(b) Allowing for fixed effects, and
(c) Allowing for random effects.

In the fixed effects method the constant is treated as group (section)-specific. This means that the model allows different constants for each group (section). The fixed effects estimator is also known as the least-squares dummy variables (LSDV) estimator because in order to allow for different constants for each group, it includes a dummy variable for each group. To understand this better consider the following model:

$$Y_{it}=\alpha_i+\beta_1 X_{1it}+\beta_2 X_{2it}+\ldots\ldots\ldots+\beta_k X_{kit}+u_{it} \quad (3)$$

An alternative method of estimating a model is the random effects model. The difference between the fixed effects and the random effects method is that the latter handles the constants for each section not as fixed, but as random parameters. The random effects model therefore takes the following form:

$$Y_{it}=(\alpha+v_i)+\beta_1 X_{1it}+\beta_2 X_{2it}+\ldots\ldots\ldots+\beta_k X_{kit}+u_{it} \quad (4)$$

$$Y_{it}=\alpha+\beta_1 X_{1it}+\beta_2 X_{2it}+\ldots\ldots\ldots+\beta_k X_{kit}+(v_i+u_{it}) \quad (5)$$

One obvious disadvantage of the random effects approach is that we need to make specific assumptions about the distribution of the random component. Also, if the unobserved group specific effects are correlated with the explanatory variables, then the estimates will be biased and inconsistent.