Food Distribution Research Society

Journal of Food Distribution Research
Volume 53, Issue 1, pp. 33–40

Research Report: A Gravity Model of Central American Organic Coffee Trade with the United States

Lauren Benavidez[a] and Tian Xia[b]Ⓘ

[a]*Graduate Research and Teaching Assistant, Department of Agricultural Economics, 342 Waters Hall, 1603 Old Claflin Place, Kansas State University, Manhattan, Kansas 66506, USA*

[b]*Professor, Department of Agricultural Economics, 313 Waters Hall, 1603 Old Claflin Place, Kansas State University, Manhattan, Kansas 66506, USA*

Abstract

This research analyzes the effects of economic and regulatory factors on the trade volume of organic Arabica green coffee from Central America to the United States. A gravity model with a panel data set is estimated using data from 2011 to 2020. We found that the major factors affecting the organic coffee trade were the organic price paid to exporters, U.S. per capita GDP, and the number of organic certified USDA-NOP organizations in the exporting countries. Central America can continue diversifying its production by adopting more organic certification schemes and expanding its market share in international markets.

Keywords: coffee, gravity model, organic certification, trade

Ⓘ Corresponding author: Tel: (785) 532-1512
Email: tianxia@k-state.edu

Introduction

Green coffee is among the top five exported agricultural products of Central America (CA): Guatemala, Nicaragua, Honduras, Costa Rica, El Salvador, and Panama, and the United States was the principal market for the 2019-2020 season. In 2020, 34.41% of total U.S. imports of organic Arabica green coffee came from Central America, and 40.93% of U.S. imports came from South America (U.S. Department of Agriculture, Global Agricultural Trade System, 2021).

Coffee is the most imported organic product by the United States. U.S. organic product sales have been increasing in the past several years and their value reached $55.1 billion in 2019 (Organic Trade Association (OTA), 2020). Furthermore, 82% of U.S. households had experience buying organic products in 2016 (OTA, 2016).

Coffee farmers in Central America have been slowly adapting operations and transitioning to an organic-certified production to receive better prices. Mendez et al. (2010) found that farmers selling organic-certified products were more likely to sell 100% of their products at the certified prices, while farmers selling fair-trade-certified products sold only 60% at the certified prices.

Given the importance of organic coffee trade to CA producers and the U.S. markets, this paper uses a gravity trade model to estimate the effects of economic and regulatory factors on the trade of organic Arabica green coffee between Central America and the United States.

Literature Review

Gravity models were first proposed by Linnemann (1967), who created a model for trade flow of goods with variables that affect trade. In the first version of the model, the trade flow from country *i* to country *j* (*X*) is specified as a function of gross domestic product (GDP) of both nations (*Y*), population (*N*), distance (*D*), and preferential trade factors (*P*):

$$X_{ij} = \sigma_0 Y_i^{\alpha_1} N_i^{-\alpha_2} Y_j^{-\alpha_4} D_{ij}^{-\alpha_5} P_{ij}^{\alpha_6} . \quad (1)$$

Gravity models include the incomes/GDPs of importing and exporting countries. This type of model can also include variables such as distance, exchange rates, adjacency, and GDP deflators (Bergstrand, 1985). Researchers have adapted gravity models accordingly to fit their main objectives or opted for other types of models (Egger and Nigai, 2015).

There have been debates on applying random (Cardoso et al, 2016; Zhou, Li, and Lei, 2018) or fixed effects (Gopinath and Echeverria, 2004; Tamini, Doyon, and Simon, 2016; Osabuohien et al., 2019) in a gravity model. Osabuohien et al. (2019) applied a Hausman test to choose between a random effects model and a fixed effects model for the study. A fixed effects model was chosen. However, as proven by Zhou, Li, and Lei (2018), the fixed effects approach eliminates time-invariant variables such as the distance variable in gravity models.

Some research has been done on coffee trade and organic standards. Cardoso et al. (2016) estimated gravity models with GLS random effects to measure the most influential factors in coffee trade between Italy and 11 trading partners. Canavari and Cantore (2010) used gravity models to evaluate the equivalence of organic standards among Italy and its trading partners.

Methods

In the gravity model for the organic coffee trade between Central America and the United States, we include regulatory variables of organic certification and adoption, in addition to macroeconomic variables (Cardoso et al., 2016) and market determinants (Koo, Karemera, and Taylor, 1994).

The volume (Q_{jt}) of U.S. imports of organic Arabica green coffee from a Central American country *j* at time *t* is specified as:

$$Q_{jt} = f\left(OP_{jt}, CP_{jt}, GDPUS_t, GDPCA_{jt}, OrgC_{jt}, FC_t, Dist_j\right), \quad (2)$$

where OP_{jt} and CP_{jt} are the prices paid to the organic and conventional coffee exporters (US$/Kg), respectively; $GDPUS_t$ and $GDPCA_{jt}$ are the per capita gross domestic product in U.S. dollars in the United States and Central America country *j*, respectively; $OrgC_{jt}$ is the quantity of organic certified organizations in the exporting country *j*; FC_t is the quantity of fraudulent organic certificates reported by the USDA; and $Dist_j$ is the physical distance between the exporting country *j* and the United States. The organic (OP_{jt}) and conventional (CP_{jt}) coffee prices are expected to have a negative and positive effect, respectively, on the trade volume. Conventional coffee is considered as a substitute for organic coffee in this study. Both GDP variables are expected to have positive effects on the quantity traded. More organic certified organizations ($OrgC_{jt}$) should result in larger trade volume. The number of fraudulent organic certificates (FC_t) can reduce U.S. import demand for organic coffee. A longer distance ($Dist_j$) is expected to decrease the trade volume.

Data was grouped by country and by year in a panel-type database with 60 observations (10 years for six Central American countries). A log transformation was applied to the data for quantity, prices, and per capita GDP. The final econometric equation is

$$lnQ_{jt} = \beta_0 + \beta_1 lnOP_{jt} + \beta_2 lnCP_{jt} + \beta_3 lnGDPUS_t + \beta_4 lnGDPCA_{jt} + \beta_5 OrgC_{jt} + \beta_6 FC_t + \beta_7 Dist_j + \varepsilon_{jt}. \quad (3)$$

The model was estimated as a panel regression with random effects using the software STATA.

The data of quantity, organic, and conventional coffee prices were collected from the Global Agricultural Trade System of the USDA (USDA-GATS, 2021).[1] Per capita GDP data were obtained from the International Monetary Fund (IMF, 2021), and the data of distance between the

[1] Values of Panama organic coffee exports for 2018 and 2019 were missing, an average from 2017 and 2020 data was used for both observations on quantity and price.

exporting countries and the United States were obtained from Mayer and Zignago (2011). Data from organic certified organizations and fraudulent organic certificates were obtained through the USDA's Organic Integrity database (USDA, 2021a, b). Around 40% of organic certified operations produce coffee, making coffee one of the most important organic crops produced in Central America.

Results

Table 1 displays the estimation results of the gravity model in equation (2). All the coefficient estimates have the expected sign except the ones for *GDPUS* and *GDPCA*.[2] The coefficient estimates of three major explanatory variables are statistically significant. The effects in percentage of regulatory variables (*OrgC* and *FC*) on trade are presented in Table 2.[3] In the following subsections, we discuss the major results of the estimation in detail.

Table 1. Estimation Results of the Gravity Model

Coefficients	Estimate	Std. Error	Z
Intercept	121.891**	26.43	4.61
LnOP	-1.899*	0.85	-2.23
LnCP	0.602	1.38	0.44
LnGDPCA	-0.242	0.43	-0.57
LnGDPUS	-8.932**	2.41	-3.71
OrgC	0.024**	0.003	7.45
FC	-0.013	0.01	-0.96
Dist	-0.002	0.002	-1.03
R^2 = 0.2504 (within) 0.8915 (between)	0.7567 (overall)		
Observations = 60			

Notes: Double and single asterisk (**, *) indicate significance at the 5% and 10% levels, respectively.

Table 2. The Effects in Percentage of Regulatory Variables

Variable	Coefficient	Effects in Percentage
OrgC	0.024	2.429%
FC	-0.013	-1.292%

Organic Coffee Price (OP)

The green organic coffee import price has a negative impact on the import volume, as expected. For a 1% increase in the import price, the import quantity would be reduced by 1.899%. It can be

[2] The coefficient estimate of *GDPCA* was not statistically significant from zero. The coefficient estimate for *GDPUS* is significant and negative, which implies that increases in *GDPUS* will cause a smaller trade flow (Jaenicke and Demko, 2015). Possible implications on the negative relationship between *GDPUS* and coffee trade will be discussed further in a subsequent subsection of the paper.

[3] The data of the regulatory variables are, by their nature, in levels, while other trade variables in the model are in logarithm to facilitate estimation and analysis. Thus, the effects in percentage of the regulatory variables on trade were calculated using their coefficient estimates and included in Table 2 to facilitate an easier discussion of their trade effects.

inferred by economic reasoning that organic coffee has an elastic import demand by the United States. This result is consistent with other findings in literature on the demand for organic products. In previous research on the organic fresh fruits demand in the U.S. markets, both conventional and organic products were analyzed, and findings showed negative coefficients on the own-price elasticities in all cases. Based on those findings, researchers concluded that consumers of organic products were more likely to switch to conventional products if the organic prices increased (Lin et al., 2009).

Organic Fraudulent Certificates (FC)

As expected, the variable measuring the quantity of fraudulent organic certificates in the USDA organic database has a negative coefficient estimate, which implies that a 1% increase in the number of fraudulent organic certificates will lead to a 1.292% reduction in U.S. import volume. This shows that trust reduction on organic certificates does cause an adverse effect for the trade of organic products.

GDP Per Capita in the United States (GDPUS)

This coefficient estimate of *GDPUS* shows a somewhat surprising result of the impact of U.S. per capita GDP. When U.S. per capita GDP increased by 1%, the import volume of organic green coffee from Central America declined by 8.93%. Jaenicke and Demko (2015) assumed that GDP is proportional to trade so that it leads to a positive impact, as was expected. However, opposite results can be justified by analyzing the specific product demand and its purchasing behavior. By evaluating coffee demand in the United States and costumer quality perception by product origin, Houston, Santillan, and Marlowe (2003) analyzed the effects of income, consumption habits, prices, and trade agreements on mild coffee trade. They found that higher U.S. income leads to more imports of mild coffee from Kenya, Tanzania, and Colombia.

Other research measured the effect of country-of-origin labeling on coffee prices using hedonic models. The research found that Latin American coffee prices ranged between $9-$10 per pound (retail level), whereas East African and Indonesian coffees ranged at higher levels, $11-$12 per pound (Teuber, 2010). It can be inferred that with an increase in per capita GDP, U.S. consumers could switch to perceived high-quality coffee, such as East African and Indonesian coffees, so organic coffee imports from Central American countries may be reduced.

Organic Certified Organizations (OrgC)

Finally, the variable for the number of USDA organic-certified organizations in Central America has a positive coefficient estimate, indicating that when there is a 1% increase in the number of organic-certified organization, U.S. imports will be 2.429% larger. As the adoption of organic agriculture in a Central American country increases, the number of suppliers of organic products becomes larger, and the organic certifier entities and agricultural organic techniques used are more trusted. As a result, U.S. demand for this Central American country's organic products will increase.

Conclusions

The findings in this paper have important contributions to the economic literature on the organic coffee trade, especially regarding regulatory factors. It is essential to note that as Central American countries adopt more organic agricultural practices, the volume of the organic coffee trade will be higher. An increase in U.S. per capita GDP may cause U.S. consumers to switch to higher-quality coffee products, causing a decrease in organic coffee imports from Central America.

Previous research has focused primarily on the trade of conventional coffee in other regions (Cardoso et al., 2016; Abafita and Tadesse, 2021). This research has built on those studies by highlighting the importance of certifications and organic coffee in international trade. The findings in this study improve the understanding on organic coffee trade between the United States and Central America and provide essential information for producers on the benefits of entering the international markets, as well as on the importance of transitioning to organic-certified production.

References

Abafita, J., and T. Tadesse. 2021. "Determinants of Global Coffee Trade: Does RTAs Matter? Gravity Model Analysis." *Cogent Economics & Finance* 9(1):1–22.

Bergstrand, J. 1985. "The Gravity Equation in International Trade: Some Microeconomic Foundations and Empirical Evidence." *The Review of Economics and Statistics* 67(3):474–481.

Canavari, M., and N. Cantore. 2010. "Equivalence of Organic Standards As a Signal of Affinity: A Gravity Model of Italian Agricultural Trade." *Journal of International Food & Agribusiness Marketing* 22:314–327.

Cardoso, B.F., D. Bentivoglio, E. Giampietri, A. Finco, and P.F. Assis Shikida. 2016. "The Italian Coffee Import: A Gravity Model Analysis." *Rivista di Economia Agraria*, Anno LXXI, n.1.

Egger, P.H., and S. Nigai. 2015. "Structural Gravity with Dummies Only: Constrained ANOVA-Type Estimation of Gravity Models." *Journal of International Economics* 97:86–99.

Gopinath M., and R. Echeverria. 2004. "Does Economic Development Impact the Foreign Direct Investment-Trade relationship? A Gravity-Model approach." *American Journal of Agricultural Economics* 86(3):782–787.

Houston, J.E., M. Santillan, and J. Marlowe. 2003. "U.S. Demand for Mild Coffees: Implications for Mexican Coffee." *Journal of Food Distribution Research* 34(1):92–98.

International Monetary Fund. 2021. *World Economic Outlook Database*. Available online: https://www.imf.org/en/Publications/WEO/weo-database/2021/April

Jaenicke, E.C., and I. Demko. 2015. *Impacts from Organic Equivalency Policies: A Gravity Trade Model Analysis*. Washington, DC: Organic Trade Association. Available online: https://www.ota.com/sites/default/files/indexed_files/OTAOrganicTradeReport2015.pdf.

Koo, W.W., D. Karemera, and R. Taylor. 1994. "A Gravity Model Analysis of Meat Trade Policies." *Agricultural Economics: The Journal of the International Association of Agricultural Economists* 10(1):81–88.

Lin, B-H., S.T. Ten, C.L. Huang, and T.A. Smith. 2009. "U.S. Demand for Organic and Conventional Fresh Fruits: The Roles of Income and Price." *Sustainability* 1:464–478.

Linnemann, H. 1967. "An Econometric Study of International Trade Flows." *The Economic Journal* 77(306):366–368.

Mayer, T., and S. Zignago. 2011. *Notes on CEPII's Distances Measures: The GeoDist Database*. Paris, France: Centre d'Etudes Prospectives et d'Informations Internationales. Available online: http://www.cepii.fr/PDF_PUB/wp/2011/wp2011-25.pdf.

Mendez, E., C.M. Bacon, M. Olson, S. Petchers, D. Herrador, C. Carranz, L. Trujillo, C. Guadarrama-Zugasti, A. Cordon, and A. Mendoza. 2010. "Effects of Fair Trade and Organic Certifications on Small-Scale Coffee Farmer Households in Central America and Mexico." *Renewable Agriculture and Food Systems* 25(3):236–251.

Osabuohien, E.S., U.R. Efobi, J.T Obediyi, O.O. Fayomi, and A.O. Salami. 2019. "Bilateral Trade Performance in West Africa: A Gravity Model Estimation." *African Development Review* 31(1):1–14.

Organic Trade Association. 2016. *U.S. Households Purchasing Organic Products*. Washington, DC: Organic Trade Association. Available online: https://ota.com/sites/default/files/indexed_files/HouseholdPurchasing_USOperations_500.pdf.

Organic Trade Association. 2020. *U.S. Organic Industry Survey 2020*. Washington, DC: Organic Trade Association. Available online: https://ota.com/organic-market-overview/organic-industry-survey.

Tamini, L.D., M. Doyon, and R. Simon. 2016. "Analyzing Trade Liberalization Effects in the Egg Sector Using a Dynamic Gravity Model." *Canadian Journal of Agricultural Economics* 64:383–411.

Teuber, R. 2010. "Geographical Indications of Origin As a Tool of Product Differentiation: The Case of Coffee." *Journal of International Food & Agribusiness Marketing* 22:277–298.

U.S. Department of Agriculture. 2021a. "Organic Integrity Database." Available online: https://organic.ams.usda.gov/Integrity/Reports/DataHistory.aspx.

U.S. Department of Agriculture. 2021b. *Reported Fraudulent Organic Certificates by National Organic Program (NOP)*. Washington, DC: U.S. Department of Agriculture, Agricultural Marketing Service. Available online: https://www.ams.usda.gov/services/enforcement/organic/fraudulent-certificates.

U.S. Department of Agriculture. 2021c. "Trade Data." Washington, DC: U.S. Department of Agriculture, Foreign Agricultural Service. Available online: https://apps.fas.usda.gov/gats/ExpressQuery1.aspx.

Zhou, L., L. Li, and L. Lei. 2018. "Avian Influenza, Non-Tariff Measures and the Poultry Exports of China." *Australian Journal of Agricultural and Resource Economics* 63:72–94.