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## **Assessing the Intensity of Market Competition in the US Papaya Import Market**

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### **Abstract**

Most of the empirical work addressing imperfect competition in international agricultural trade has focused on grains and meats. The present study is an attempt to help fill the gap by assessing market competitiveness in the US fresh papaya market, which can be characterized as oligopolistic whereby Mexico, Belize, and Brazil are the main suppliers. In order to assess the intensity of competition among fresh papaya exporters in the US market, an inverse residual demand model is specified and estimated. The findings suggest that Mexico, Belize, and Brazil are completely constrained in exercising market power in the US fresh papaya market.

**Keywords:** Papayas, market power, residual demand, imperfect competition

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## **Introduction**

Papaya is the third most traded tropical fruit after pineapples and mangoes, respectively. World imports of fresh papayas exceeded 261,000 metric tonnes (MT) in 2011, with an import value of \$250.82 million. Globally, the United States is the number one papaya importer, and in 2011, accounted for 53.43 percent of the trade valued at around \$79.82 million (FAOSTAT 2013).

The US fresh papaya import market may be characterized as oligopolistic (imperfect competition), with Mexico, Belize, and Brazil being the main import suppliers. Mexico plays a dominant role in the US papaya import market; however, market share per se does not necessarily prove Mexican papaya exporters exercise market power for papaya exports in the United States. For instance, Brazil which exports the Solo cultivar, considered to be of higher quality and a slightly differentiated product, commands a higher price for its produce and could in fact be the one exercising market power.

The United States, although not currently a major player in the market, is considering becoming more active with an anticipated increase in supplies coming mainly from Florida. This potential development stems from ongoing research nearing completion, which could circumvent the major production constraint having to do with the presence of papaya ringspot virus (PRSV) that to-date has severely curtailed production supplies coming from this source. Since success in the market will depend on the extent to which US growers can compete in the market, an understanding of the level of competition that exists in the market is of paramount importance. Hence, the primary objective of this study is to investigate the intensity of the competition that currently exists in this market among the major players.

A secondary objective of the study is to fill the gap that currently exists in the literature with respect to the scarcity of studies investigating the competitiveness of tropical fruits in international markets within the context of imperfect, rather than perfect, competition. While international agricultural markets are often characterized by oligopoly (Reimer and Stiegert, 2006), most studies that tend to assume perfect completion and those that have studied the existence and nature of imperfect competition in international agricultural markets have focused mainly on commodities such as grains and meats.

Among the studies focusing on international competition of fruit is a study conducted by Arnade and Pick (2000). Their paper focused attention on deciduous fruits and proposed a method for estimating and testing for seasonal changes in the degree of oligopoly power in the US pear and grape markets. While the model tests for the seasonal nature of market conduct, it is not designed to identify the sources of market imperfections. Arnade and Pick found a small but significant degree of oligopoly power in the US pear market when domestic supply of the fruit declines. In the US grape market, it was found that oligopoly power measures tend to be higher when foreign grape supplies dominate the market.

Winfree et al (2004) estimated a seasonal oligopoly power model for the US D'Anjou pear market. It was found that the Northwest D'Anjou pear industry has some degree of oligopoly power when the new crop enters the market at a time that supplies of imported or other pears

varieties are low. Market power of the Northwest D'Anjou pear industry wanes as the marketing year progresses and becomes small following the arrival of imported pear supplies.

To our knowledge, there has not been any empirical work addressing imperfect competition in the international trade of tropical fruits. Our study is the first attempt to assess market competitiveness in the US fresh papaya import market. Specifically, we investigate the intensity of competition among the main US fresh papaya import suppliers. We adopted the general framework developed by Goldberg and Knetter (1999) and estimate an inverse residual demand model by country for the main US papaya suppliers—Mexico, Belize, and Brazil. In particular, we estimate the residual demand elasticity that each exporter faces in the US market. Results provide an estimate of the degree of market power, pricing, and competitive behavior of Mexico, Belize, and Brazil in the US fresh papaya import market.

The paper is organized into six sections. Section 2 presents a brief overview of the US papaya import market. Section 3 discusses the conceptual framework. In section 4, the empirical model is presented together with the data estimation procedures. The results are presented and discussed in section 5. The paper concludes with a brief summary and a few remarks in section 6.

## **Overview of the US Papaya Market (Main Features)**

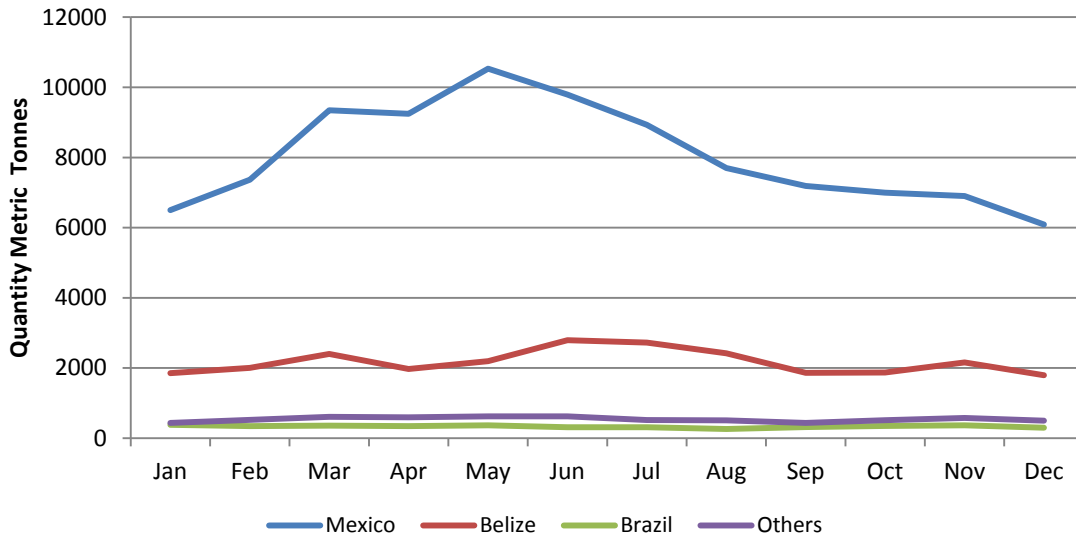
As mentioned earlier, the United States is the largest single-country importer of papayas. Imports of US fresh papaya have grown 39.58 percent, from 101,875 MT in 2003 to 142,199 MT in 2012. During this period, Mexico has been the leading supplier of fresh papaya to the United States, dominating the import market with a share of 72.57 percent, followed by Belize (19.56 percent) and Brazil (3.01 percent). Reflecting the increase in volume of papaya imported by the United States, the value of trade rose by 41.10 percent over the same period, from \$60.80 million in 2003 to \$85.79 million in 2012 (USDA/FAS 2013).

The noticeable increase in the volume of papaya imported by the United States is attributed to increased supplies in the main papaya-producing countries and the rising consumer interest in functional food products. Papaya is a rich source of biologically-active compounds such as antioxidants (carotenes, vitamin C, and flavonoids), B vitamins (folate and pantothenic acid), minerals (potassium and magnesium), and fiber (Mahattanatawee et al. 2006) that play a significant role in promoting a healthy cardiovascular system and preventing colon and prostate cancers. Another factor contributing to the rise in US fresh papaya imports is the national increase in ethnic populations, especially Hispanics and Asians who have familiarity with the fruit.

The two main papaya cultivars marketed in the United States are Maradol, and Solo. Maradol is by far the dominant cultivar consumed in the United States. The main suppliers of this cultivar to the United States are Mexico, Belize, Guatemala, and the Dominican Republic, respectively. The Solo cultivar, best known as Hawaiian papaya, is supplied by Brazil and the Dominican Republic, respectively.

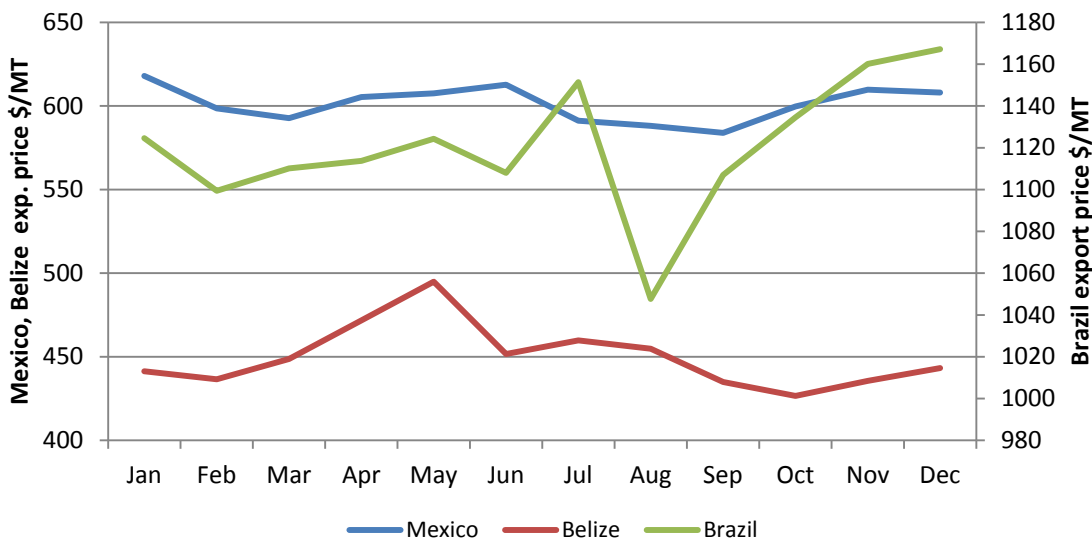
Fresh papayas from the top three suppliers are available in the US market all year round. The US average monthly fresh papaya import quantities for the ten-year period 2003:01 to 2012:12 are shown in Figure 1. Mexico is by far the main supplier of the fruit. As shown in Figure 1, imports of Mexican papaya increased from January, reaching a peak in May, followed by a steady

decline until December. In contrast, papaya imports from other sources tend to remain relatively flat throughout the year, with a slight uptick in quantities imported from Belize during the period from May to August when the Mexican volume of the fruit decreases substantially.



**Figure 1.** Average monthly US fresh papaya imports by origin, January 2003 to December 2012

Fresh papaya average monthly export prices for the January 2003 to December 2012 period are presented in Figure 2. Mexico papaya export prices decrease from January to March, when the export price reaches a low of \$593/MT; then prices rise to a maximum of \$612/MT in June. From June to September, export prices decrease because of summer competition from other fruits. Finally, prices start to recover from September to December due to a combination of reduced shipments from Mexico and the end of the season for several domestic fruit crops.



**Figure 2.** Average monthly US fresh papaya export prices by origin, January 2003 to December 2012

Belizean export prices increase from January to reach a peak of about \$500/MT in May, followed by a downward trend until October due to competition from other types of fresh fruits in the market.

The main papaya cultivar exported by Brazil is Solo, which commands higher market prices, compared to the Maradol cultivar. Brazilian export prices oscillate around \$1,120/MT during the first half of the year, reaching a peak of about \$1,160/MT in July. Prices then drop from July to August, averaging \$1,045/MT. In September, export prices begin increasing rapidly, reaching a maximum of about \$1,167/MT during December.

## Conceptual Framework

As pointed by Pick and Park (1991), despite its popularity in the literature, the perfect competition model has limited use to analyze agricultural trade and trade policies. This is so since, in most cases, international agricultural markets deviate from the perfect competition model due to the existence of firms large enough to exercise market power.

In antitrust cases, the method used to prove market power involves calculating the defendant's market share; a larger market share is considered evidence of market power. However, as pointed out by Goldberg and Knetter (1999), this method may be inadequate. A firm with a significant market share may still be constrained in its ability to exercise market power if it faces an elastic demand curve or if the supply of competing firms is elastic.

Historically, the Lerner index has been the customary measurement of market power. Defined as  $L = (P - MC) / P$ , the Lerner index measures the difference between price and marginal cost as a fraction of the price of the product. The index provides information about market power, defined as the ability of a firm to price above its marginal cost.

However, calculation of the Lerner's index is not a simple task since marginal costs are unknown and the lack of relevant data complicates the empirical estimation. Estimation of market power of a single firm requires the estimation of a full oligopoly model and data about competitors selling in a particular market may not be readily available. Data constraints in international markets are even more evident, as an exporter may face different demand conditions and different competitors in each destination market. To calculate the Lerner index for each destination market, it is necessary to have data about prices and quantities for every firm selling in a particular destination, which may be unavailable, as this information is subject to confidentiality. This has prompted researchers to consider alternative ways of estimating the degree of market power a firm has in a given market. Research in the new empirical industrial organization (NEIO) has come up with some methods to estimate market power without requiring information about marginal costs.

For instance, Goldberg and Knetter (1999) proposed a simpler method to estimate the market power a group of exporters may have in any destination market. This method uses the elasticity of the residual demand curve to measure the intensity of competition. The residual demand curve is derived as the difference between the market demand and the competitive fringe's supply curves. Therefore, properties of the residual demand schedule, such as elasticity, will depend on

properties of the market demand schedule, as well as the supply schedules of other firms in the market. As pointed out by the authors, competitor's products may or may not be perfect substitutes. Because this method is not based on particular assumptions about the shape of the cost function, marginal cost can be constant or a function of the quantity produced (for more details about the method, see Goldberg and Knetter (1999)). While estimation of market power of an exporter group in a particular destination market usually requires simultaneous equation techniques to estimate the demand, cost, and conduct parameters, the Goldberg and Knetter (1999) method estimates only one equation (the exporter's residual demand curve). Although this method cannot separately estimate own- and cross-price elasticities of demand, and conduct parameters, it captures their joint impact on market power through the elasticity of the residual demand curve. Moreover, as the authors point out, it can be shown that the residual demand elasticity coincides with the Lerner index in the following cases: Stackelberg leader, the dominant firm model with a competitive fringe, perfect competition, and extensive product differentiation.

In the present study, Mexico plays the role of the dominant firm, compared to Belize and Brazil, respectively. The estimating equation of the inverse residual demand function developed by Goldberg and Knetter (1999) takes the following general form:

$$(1) \ln P_m^{ex} = \lambda_m + \eta_m \ln Q_m^{ex} + \alpha'_m \ln Z_m + \beta'_m \ln W_m^N + \varepsilon_m$$

where  $\alpha'$  and  $\beta'$  are vectors of parameters to be estimated, the subscript  $m$  indexes a specific market. The vectors  $Z_m$  and  $W_m^N$  denote the demand shifters for destination  $m$ , and the cost shifters for the  $n$  competitors the export group faces in a specific destination market, respectively; and  $\varepsilon_m$  is the error term which is assumed to be independently and identically distributed. This specification implies that separate equations will be specified for each product and destination; the price  $P_m^{ex}$  that the export group charges and the demand shifters are expressed in destination currency units. The coefficient of  $\eta_m$  can be interpreted as the residual demand elasticity, given the logarithmic specification of the model. If the estimated value of  $\eta_m$  is zero, the exporter operates in a perfectly competitive market and faces a perfectly elastic curve in the destination market; therefore, the export price is determined by the costs of other competitors in that market. The larger the absolute value of the residual demand elasticity, the larger the markup over marginal cost, and the more power the exporter has over price. The variable  $Q_m^{ex}$  refers to the quantity exported for the respective country.

The demand shifters  $Z_m$  consist of a combination of a time trend, real income, and the price level for the destination market. The cost shifters  $W_m^N$  for the  $n$  competitors include measures of input prices. These costs can be divided into two parts: (1) the part expressed in the competitor's currency that is not destination specific and (2) the part that varies with destination, specifically the exchange rate of the competitor country vis-a-vis the destination market. As stated by the authors, exchange rate movements are ideal cost shifters in international trade because they move the relative costs for the exporting countries.

The Goldberg and Knetter (1999) method has been used in the past to investigate competitive behavior in the Japanese meat import markets (Reed and Saghalian 2004; Poosiripinyo and Reed 2005) and in the Chinese soybean import market (Song et al. 2009). Reed and Saghalian (2004)

investigated the competitive behavior of the United States, Canada, Australia, and New Zealand in the Japanese import meat market. Results indicate that exporter's market power in the Japanese market varies by beef type.

Other application of the residual demand elasticity involved the competitive structure analysis of the Chinese soybean import market (Song et al. 2009). It was found that US soybean exporters were able to price their exports above their marginal cost; results indicate that the marketing margin of US soybean exporters in the Chinese soybean market is about four percent of the US farm-level price plus transactions costs.

## Empirical Model and Data

We follow the framework developed by Goldberg and Knetter (1999) to measure exporter power in the US fresh papaya market. Mexico, Belize, and Brazil are considered the main competitive countries in the US market. The empirical model consists of two countries as competitors against one exporter; the inverse demand equation is specified as follows:

$$(2) \quad \ln p_{US_t}^{ex} = \lambda_{US} + \eta \ln Q_{US_t}^{ex} + \beta_1 \ln DPI_{US} + \beta_2 \ln ER_{US}^{c1} + \beta_3 \ln ER_{US}^{c2} + \beta_4 \ln PPI^{c1} + \beta_5 \ln PPI^{c2}$$

where  $\ln p_{US_t}^{ex}$  represents the logarithm of the exporters' papaya prices in US dollars;  $\ln DPI_{US}$  represents the logarithm of the US real disposable income;  $\ln ER_{US}^{c1}$  and  $\ln ER_{US}^{c2}$  stand for the logarithm of the real exchange rate of competitors 1 and 2, respectively;  $\ln PPI^{c1}$  and  $\ln PPI^{c2}$  represent the producer price index (PPI) for competitors 1 and 2, respectively. Both exchange rates and producer price indices of the competitors are used as cost shifters.

The quantity exported,  $Q_{US_t}^{ex}$ , is endogenous and has to be instrumented if there is simultaneity between quantity and prices; exchange rate and producer costs of the exporter are the natural instruments. In the first equation Mexico is the exporting country and Belize and Brazil are the two competitors. In the second equation Belize is the exporting country and Mexico and Brazil are the two competitors. Finally in the third equation Brazil is the exporting country and Mexico and Belize are the two competitors.

Monthly data for the period January 2003 to December 2012 were used for the empirical model. Average monthly export prices (\$/MT) and quantities (MT) of fresh papaya exports from the top three import sources, Mexico, Belize, and Brazil, were obtained from the USDA/FAS Global Agricultural Trade System.

Real exchange rates for Mexico and Brazil were drawn from the USDA Economic Research Service (USDA/ERS 2013); the real exchange rate for Belize is calculated using the US–Belize nominal exchange rate (OANDA.COM), the monthly US Consumer Price Index for fresh fruits and vegetables (US BLS) and the quarterly Belize CPI (Belize Stats). Annual US disposable personal income data from FRED were converted to monthly data for the purpose of this analysis and used to represent the income variable. Owing to the general unavailability of international data on production costs, such as labor and energy, we used the monthly Mexican producer price



index (PPIMX) from INEGI and the monthly Brazilian producer price index (PPIBR) from IBRE as proxies of production costs for competitors; data about producer price index for Belize were unavailable.

A potential problem in estimating equation (2) above is the fact that quantity exported is likely to be endogenous. Several procedures are available to test for simultaneity, namely the Hausman (1978) specification test and the Spencer and Berk (1981) simultaneity test. The Spencer and Berk test can test the specification of a single equation system, while the Hausman test tests the specification of a single equation in a system of simultaneous equations. In this study, we apply the Spencer and Berk test. This test was completed as a two-step procedure. For the first step, it was necessary to obtain a reduced form equation using a set of instrument variables for each one of the three exporting countries.

$$(3) \quad \ln Q^{ex} = \beta'_{us} \ln IV_{us} + \xi_{us}$$

where IV represents instrumental variables—a vector of exogenous or predicted variables that are strongly correlated with  $Q^{ex}$  and uncorrelated with the disturbances;  $\beta'_{us}$  represents the vector of coefficients to be estimated; and  $\xi_{us}$  is an error term. For instance, IV variables correlated with quantity exported for the Mexican exporters' equation were the US–Mexico exchange rate and the Mexican producers' price index. Because the choice of instrumental variables affects the final estimation results, the instruments were chosen based on their statistical significance (Cho et al. 2002); therefore, variables were eliminated if they were not statistically significant at the 5 percent level.

The second step consisted of estimating equation (2) by OLS using the residual  $\xi_{us}$  obtained in equation 3 as an independent variable. Under the null hypothesis of no simultaneity, the coefficient of  $\xi_{us}$  must not be statistically different from zero. A *t* test on the coefficient of  $\xi_{us}$  is the appropriate specification test. Table 1 shows the results of the simultaneity test.

Based on the results of the test, the estimated coefficients of the  $\xi_{us}$  residual in the equations of each of the three main papaya suppliers to the US market are not statistically different from zero; there is no simultaneity between own prices and own quantities. Therefore, there was no need to use the instrumental variable method to conduct the empirical estimation.

**Table 1.** Spencer and Berk Simultaneity Test Results

Country	Residual estimate	t value	P-value	Simultaneity
Mexico	0.5821	1.36	0.1753	No
Belize	0.0702	0.88	0.3789	No
Brazil	0.3721	-1.52	0.1311	No

The null hypothesis of the Spencer and Berk test has no simultaneity between  $p^{ex}$  and  $Q^{ex}$ . The null hypothesis is not rejected at the 10% level.

## Estimation Results and Discussion

The customary diagnostic tests were performed for the model; multicollinearity was detected in the equation in which Belize is the exporting country. In order to address the multicollinearity issue, the Brazilian producer price index was dropped from this equation.

Results of the Durbin Watson test for autocorrelation indicated that first-order positive autocorrelation existed. In order to correct for autocorrelation, equation 2 was estimated by Generalized Least Squares (GLS) using the Cochrane-Orcutt iterative procedure.

Table 2 summarizes the estimation results for the residual inverse demand elasticities for the three main fresh papaya exporters to the US market. The R-square values are high, ranging from 0.70 for Brazil to 0.89 for Mexico, indicating that the empirical model explains most of the variation in the export prices. Autocorrelation is not an issue as the Durbin-Watson statistics were close to 2.

**Table 2.** Estimation results for the market power of Mexico, Belize, and Brazil in the US papaya import market, 2003–2012.

	Mexico	Belize	Brazil
Intercept	4.8189 (1.82)	2.0645 (0.96)	8.1654 (2.19)
<b>LQMEX</b>	-0.0447 (-1.11)		
<b>LQBEL</b>		-0.0291 (-1.23)	
<b>LQBRA</b>			0.0532 (1.40)
LUSDPI	<b>0.9999**</b> (2.19)	<b>1.1757***</b> (2.67)	0.1053 (0.14)
LERUS-MEX		<b>-1.0349***</b> (3.45)	-0.5326 (-1.20)
LERUS-BEL	-1.3628 (-1.05)		<b>-4.7467**</b> (-2.15)
LERUS-BR	0.2433 (1.60)	<b>0.3457**</b> (2.54)	
LPPIBR	<b>-0.6808**</b> (-2.05)		
LPPIMEX		-0.2014 (-0.95)	0.3448 (1.27)
R-Square	89.18	71.10	70.95
DW	1.856	1.995	2.336

t statistics are in parentheses.

\*\*Significant at the 5% level.

\*\*\*Significant at the 1% level.

The estimated inverse residual demand elasticity of Mexican papaya has the expected negative sign but was not statistically different from zero. This suggests that although Mexico has a significant share in the US fresh papaya market, they behave competitively and do not exercise market power. In other words, the price they obtained for their papayas is largely determined by

market conditions of supply and demand. One possible explanation is that given the increased availability of papayas in Mexico, the US market is seen more as an outlet market to reduce pressure on prices in the Mexican domestic market. Were it not for the US market, prices in Mexico would plummet given the level of supply. Papaya exporting firms operate on both sides of the US-Mexico border. This is also true in the case of Belize and Brazil. In this regard, Mexican producers/exporters are more concerned with maximizing overall profit through a strategy of increased export volume despite relatively small profit margins. A further incentive could be the prices in the US market are much higher than those in the Mexican domestic market. The results could also be explained in terms of a desire by Mexican exporters to dominate the US papaya import market and compete with other fruits, mainly on the basis of low commodity prices. It is also possible that given the highly perishable nature of the produce and volume to be marketed, that there could be a level of cut-throat competition among exporters, with the result that prices are kept close to the marginal cost of production.

The coefficient for the income variable had the expected sign and magnitude, as tropical fruits are beyond basic food necessities; therefore, increases in income may lead to a higher consumption of fresh papayas. The coefficients of the US–Belize and US–Brazil exchange rates were not significantly different from zero. The exchange rate of the two main competitors did not have a significant impact in the pricing of Mexican papaya exports to the US market. The coefficient for the Brazilian producer price index was statistically significant at the five percent level; the negative sign indicates that a decrease in Brazil production costs has a negative effect in the papaya export prices Mexico exporters receive.

With respect to Belizean exports of fresh papaya, the results indicate that the estimated coefficient of the inverse residual demand elasticity had the expected negative sign; however, it was not statistically different from zero. This implies a zero markup of export prices over marginal cost, suggesting that the exporters were not exercising market power. Again, prices in international markets are higher than in domestic markets, making it more profitable to export the fruit. Results indicate that Belizean fresh papaya exporters face an elastic demand curve; Belize papaya export prices are determined by the prices charged by the competitors.

The income elasticity coefficient had the right sign and magnitude; changes in income have a significant effect on the prices receive by Belizean exporters. Consumers with higher disposable income tend to include more fruits as part of their diets. The coefficient of the US–Brazil exchange rate is positive and significant at the five percent level. An appreciation of Brazil's currency increases its cost of selling the fruit to the US market, allowing Belize exporters to charge higher prices.

The estimated inverse residual demand elasticity for Brazilian fresh papaya exports to the United States had a positive sign; however, it is not statistically significant, meaning that Brazilian exporters of fresh papayas do not charge an export price above their marginal cost. One of the interesting features of the Goldberg and Knetter (1999) model is that it may be used in cases involving product differentiation. Solo-type papayas are considered sweeter than Maradol papayas and of excellent quality (California Rare Fruit Growers 1997). Results therefore suggest that the Solo papaya cultivar exported by Brazil is not sufficiently differentiated in the market to enable the exporters to exert market power.

## Summary and Conclusions

In the present paper, we assessed the intensity of competition among fresh papaya exporters in the US market. An inverse residual demand model for the three main competitors (Mexico, Belize and Brazil) is specified and estimated. Results of this analysis offer an interesting insight into the competitive behavior of the three main fresh papaya exporters in the US market. The empirical estimates indicate that over the sample period, imperfect competition was not an issue for the three main fresh papaya exporters to the US market.

Mexico, Belize, and Brazil are completely constrained in the exercise of market power in the US fresh papaya market as they were unable to price their exports above the marginal cost. Mexico and Belize face relatively flat residual demand curves for their papaya exports to the United States as the estimated parameters were not statistically different from zero. Costs shifters of the competitors have a significant effect on the export prices charged by each of the three main papaya exporters in the US market.

In the case of Brazil, despite some claims that Solo-type papayas are of better quality, compared to Maradol papayas, there was no evidence that this particular cultivar had a competitive advantage on the US market. In fact, Brazilian papaya exporters have gradually experienced a decrease in their market share, signaling an intense competitive pressure on the US fresh papaya import market.

One of the interesting features of the Goldberg and Knetter approach is that it incorporates the role of competition through competitors' exchange rates. For Belizean papaya exporters, a change in the US–Brazil exchange rate, particularly with an appreciation of Brazil's currency, gives them the opportunity to obtain higher export prices.

Our findings suggest that from 2003:01 to 2012:12, the three main fresh papaya exporters behaved in a competitive way; however, this does not necessarily mean that during certain months, they are unable to price above their marginal costs, although that is a topic for further research. The present study addressed the issue of imperfect competition only from the exporter's side and found no evidence of it. However, for the United States as the largest fresh papaya importer, the opportunity to exercise market power in the form of oligopsony exists.

The findings of this study imply that the US papaya market is very competitive and is driven mainly by price competition and to a lesser extent by cultivar/quality characteristics. It therefore suggests that Florida growers can do reasonably well in the market as long as they can compete on a price basis since there are no major barriers to entry. The shorter distance to the market should aid Florida producers in this regards.

Market power in international agricultural markets remains a topic for future research to address trade inequality, particularly in the tropical fruit trade as many of these products come from developing countries. The Goldberg and Knetter approach is a simpler methodology to investigate concerns of intensity of competition in international markets using publicly available data.

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