The Economic Potential of the Lime-Oil Industry in Mexico

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Lime oil, as a by-product of lime processing, has a variety of food and industrial uses. Mexico is currently the world's leading producer of lime oil, and has an interest in possible expansion of the industry. The primary market is the U.S., with lesser potential in the EU based on past trends. Expansion of this industry, if feasible, would increase producer revenue and add jobs in lime processing and allied and secondary sectors of the economy, spurring economic development in affected rural areas of Mexico. Juice for human consumption and pulp for animal feed are also products of lime processing but are fraught with commodity characteristics. Lime oil, on the other hand, is an ingredient in differentiated food and cosmetic products and appears to be associated with fairly stable prices over time even in the face of competition from Brazil and Peru. This study determines the economic feasibility and potential extent of expanding lime-oil production in Mexico.

About 60 percent of citrus production in Mexico is on the west coast, largely the states of Colima, Michoacan, Jalisco, Guerrero, and Oaxaca. The other 40 percent is produced on the Gulf coast, in the states of Veracruz, Tabasco, and Yucatan (SAGARPA 2005)

Mexico is the world's leading producer of limes, a major citrus crop, with a farm-gate value of $20 million. Limes are grown largely in tropical climates around the world (USDA-ERS 2006). Among citrus crops, limes are second in economic importance to Mexico because of their high value in both fresh and processed forms (SAGARPA 2007). In recent decades the limes sector of Mexican agriculture, which involves exports mainly to the U.S. and a few countries in the European Union, has experienced an increase in demand for limes and lime by-products (Consultores 2002).

The main importers of lime oil are the U.S, the UK, Japan, Ireland, and Belgium (FAOSTAT 2007). The food industry uses around 60 percent of essential oils production, and the cosmetics and fine-fragrances industry uses the remaining 40 percent (Venkataraman 2006). U.S. lime-oil imports have been increasing by average of 4.9 percent per year since 1989 as the U.S. does not have a limes industry. In 2006 U.S. lime-oil imports amounted to more than $25 million (USDA-FAS 2007). As a result, the U.S. is a principal target market for lime-oil producers. Mexico's main competitors in the U.S. market are Peru and Brazil. However, Mexico is the principal exporting country to the U.S., with 1,078.1 metric tons in 2006. Peru is second with 209.8 metric tons, followed by Brazil with 94.2 metric tons. Mexico accounts for 70 percent of all U.S. lime-oil imports. The peak season for U.S. lime-oil imports is from May through July (USDA-FAS 2007).

There are three principal techniques for manufacturing lime oil (White Lotus Aromatics 2005). The first method is labor intensive, requiring extraction of the oil by pressing the limes by hand against a spike-studded copper bowl. The benefit of this method is that it yields the highest-quality oil, which is used primarily as candy flavoring. In the second technique, a machine is used to press the oil from the lime peels. The oil extracted via this process is generally used in beverages and perfume. A process of distillation is used for the final method. Washed, crushed limes are stored in tanks for at least two weeks before the desired oil is extracted from the pulp at the top of the tank. Most lime oil is produced by this method, for use in soft drinks, ice cream, and other lime-flavored food products (White Lotus Aromatics 2005). Increased lime-oil production in Mexico with high availability of raw materials, technology, and quality would seem to have great potential for the export market.

Model Specification

For competitive markets the market clearing price is determined where demand and supply are equal. The U.S. quantity demanded is

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(1) Q_D = f (U.S. price, U.S. per-capita income, CPI, U.S. population).

Quantity supplied (Q_S) in this case is predetermined. Because lime oil is a by-product of the production of limes, a highly perishable commodity with quantities that cannot be adjusted in the short run, lime-oil quantities are treated as being predetermined with price adjusting to clear the market (Matsuda 2004).

Thus the market clearing price for $Q_D = Q_S$ is

(2) U.S. price = f (Q_S, U.S. per-capita income, CPI, U.S. population).

After specifying Q_S by source, combining per-capita income and population, and adjusting price and income for inflation, the estimating equation becomes

(3) real U.S. price = f (Q_i, real U.S. income),

where Q_i is quantity supplied from source *i*.

Data and Empirical Procedure

The primary suppliers of lime oil to the U.S. are Mexico, Brazil, and Peru. Thus the data are grouped accordingly, i.e., Mexico, Brazil, Peru, and the rest of the world. Annual data for 1989 to 2006 were obtained from the U.S. trade statistics database provided by the Foreign Agricultural Service (USDA-FAS 2007). The Harmonized Trade System (HTS), which classifies products traded internationally, indicates that lime oil is in the category of "essential citrus fruit oils of lime" with code 330114 (USITC 2007). The HTS data are given by quantity and value. Thus the U.S. price of lime oil is imputed. The price variable in the model is the real weighted-average U.S. import price of lime oil. U.S. disposable personal income is taken from the U.S. Bureau of Economic Analysis. The price and income variables are deflated by the CPI in 1982–84 dollars (USDC-BEA 2007). The simple statistics and definitions for the variables are in Table 1.

The linear-regression model incorporating competition among source countries is specified as

(4) USP = f(MXQ, PRQ, BRQ, RWQ, USDPI),

where the variables are defined in Table 1.

Results and Implications

Model estimation results are presented in Table 2. The coefficients for Mexican lime-oil quantity (MXQ) and rest of the world quantity (RWQ) are negative, as expected. The MXQ coefficient is significant at the 0.20 level, while that for RWQ is significant at the 0.01 level. The coefficients for Peruvian (PRQ) and Brazilian (BRQ) quantities are positive. The coefficient for PRQ is significant at the 0.20 level, while that for BRQ is not significantly different from zero. The positive coefficient for PRQ is associated with a decline in Peru's market share of U.S. lime-oil imports from 44 percent to 14 percent over the study period. Moreover, real U.S. lime-oil prices (USP) were generally higher dur-

Table 1. Simple Statistics for Variables in the U.S. Lime-Oil Import-Price Model, 1989–2006.

Variable[a]	Mean	Std. Dev.	Min.	Max.
USP	10.13	1.87	7.88	14.54
MXQ	0.70	0.29	0.23	1.20
PRQ	0.19	0.06	0.10	0.28
BRQ	0.08	0.05	0.02	0.19
RWQ	0.12	0.05	0.05	0.25
USDPI	3.88	0.52	3.23	4.71

[a] USP is U.S. Import Price in thousand 1982–1984 dollars, MXQ is Mexican Quantity in thousand metric tons, PRQ is Peruvian Quantity in thousand metric tons, BRQ is Brazilian Quantity in thousand metric tons, RWQ is Rest of the World Quantity in thousand metric tons and USDPI is U.S. disposable personal income in trillion 1982–1984 dollars.

ing the first part of the study period. The generally higher real prices during the first part of the study period versus generally lower real prices later is also associated with rising real U.S. disposable personal income (USDPI), thus the negative and significant (0.10 level) coefficient for USDPI.

Price flexibilities are computed from the significant (0.20 level) coefficients given in Table 2 and mean values of the variables (Table 3). Flexibility coefficients are the percentage change in price for a one-percent change in quantity or income (Houston and Nieto 1988). The quantity and income impacts on price appear to be limited at mean levels. The greatest impact on price is shown to be with respect to income (USDPI)—a ten-percent increase in income is associated with a 6.9-percent decrease in price. Such limited relationships with price suggest considerable growth potential for lime-oil exports to the U.S.

Optimum Mexican Lime Oil Exports to the U.S.

Using trend values for the variables and model coefficients from Table 3, a price-dependent demand curve for U.S. lime-oil imports from Mexico is isolated for 2008. The quantity necessary to maximize Mexican total revenue is computed from the demand curve. The resulting optimum quantity is 2.1 thousand metric tons, which compares to a 2008 trend value of 1.2 thousand metric tons for Mexico. Clearly, the growth potential for Mexican lime-oil exports to the U.S. for 2008 is almost double the trend value.

Conclusion

Given the expected growth in demand for lime oil and tremendous potential for revenue growth for Mexico as shown in this analysis, the future would

Table 2. U.S. Lime-Oil Import-Price Model Parameter Estimates, 1989–2006.

Variable	Parameter estimate	Standard error	t Value	Pr > |t|
Intercept	19.28	3.83	5.03	0.00
MXQ	−2.50	1.74	−1.44	0.18
PRQ	7.07	5.19	1.36	0.20
BRQ	4.44	4.89	0.91	0.38
RWQ	−17.64	5.29	−3.34	0.00
USDPI	−1.81	0.98	−1.85	0.09

N = 18.

Table 3. Estimated Lime-Oil Price Flexibility Coefficients,[a] 1989–2006.

Variable	Coefficient
MXQ	−0.17
PRQ	0.13
RWQ	−0.21
USDPI	−0.69

[a] Price flexibility coefficients, (dP/dQ)(Q/P) and (dP/dY)(Y/P), are calculated from estimated parameters at mean values (Houston and Nieto 1988).

seem to be bright for the Mexican limes industry and for rural development in affected states. However, recall that lime oil is a by-product, so other considerations are in order—specifically, the economic feasibility of increasing the production of fresh limes and juice and of finding more uses for pulp, such as in animal feed.

This analysis was limited to a portion of the overall question regarding the feasibility of expanding the Mexican limes industry. Clearly, the lime-oil segment shows great promise. Future research will address the remaining questions. It is important to note that producing Mexican lime oil is a much more encompassing process than finding alternative enterprises for farm producers. The means of developing and expanding this processing industry involve limes production, assembly, processing, marketing, distribution, and financing—all of which affect the rural economies of Mexico in complicated ways. Of prime importance are the opportunities for producers and labor at all skill levels.

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