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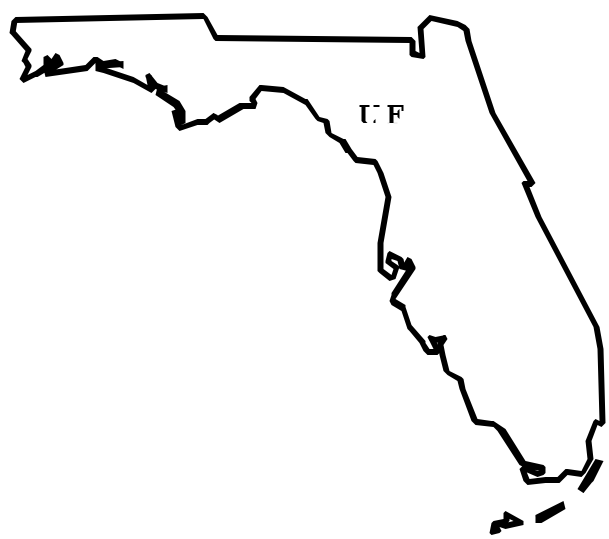

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# Quality Differentiation and Market Power in the Mexican Coffee Market: Theory and Evidence[†]

by Charles B. Moss and Gustavo A. Guerra Galindo

## Abstract

The effect of market power in the processing sector of the Mexican coffee industry is examined in this study. Mexican coffee producers are experiencing financial difficulties related to lower world prices for coffee and lower quality coffee produced by many small farmers. The small producers sell to a few larger processors. A series of models to analyze the effect of the market channel in pricing the quality of Mexican coffee are developed in this paper. A restricted form of channel analysis is used to analyze the potential for rent extraction through quality differentiation in the Mexican coffee market.

*Keywords*: coffee quality, market power, institutions, game theory

## 1. Introduction

Economic analysis of agricultural systems has typically emphasized the market for agricultural commodities at the farm gate. This emphasis could be justified on several grounds such as the existence of agricultural policies like price supports, which insulated producers from competitive pressures, or the existence of competitive markets in the processing sector. However, dramatic changes in the closing decade of the twentieth century negated these assumptions. Governments have significantly reduced their involvement in the agricultural sector. In the United States, the passage of the Federal Agricultural Improvement and Reform Act of 1996 (FAIR) signaled a clear change in philosophy, from one that directly supported agriculture and rural communities to one that relies on efficiently operating markets to reallocate resources. Internationally, the Uruguay Round Agreement implies a decreasing acceptability of agricultural protection. At the same time, competition in the processing sector has declined dramatically. Several markets for agricultural output are dominated by small numbers of firms. One possible effect of these changes has been a growing emphasis on vertical integration in U.S. agriculture. These moves toward integration raise significant questions about the allocation of economic rents in vertical channels. This paper builds on previous work by Guerra Galindo (2000) to analyze the effect of the market channel in the pricing of quality in the Mexican coffee market.

Coffee production in Mexico represents a significant agricultural enterprise. Mexico is the fifth largest exporter of coffee in the world and coffee represents 84 percent of Mexico's agricultural exports. However, the industry is currently experiencing financial difficulties. These difficulties are the result of external pressures through low world prices for coffee and internal pressures that lower the overall quality of coffee produced in Mexico. While the genesis of the internal problem is structural, low external prices for coffee aggravate the problem. Specifically, the low world coffee price coupled with the continued decline in average farm size in Mexico have led to a general de-

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cline in the quality of coffee. The details of this model can be found in Guerra Galindo.

To analyze the coffee market, we begin by constructing a somewhat oversimplified model of the market channel for coffee in Mexico. This simple model defines the potential effect of market power in the processing sector of the Mexican coffee industry. After developing this simplified model, the question of quality differentiation at the processor level is examined. The econometric results of a model focusing on market power and changes in quality are then presented. Finally, turning to the new theory of the firm, long-run implications of the quality game in the Mexican coffee market are further developed.

## 2. Modeling the Vertical Channel

As previously stated, the competitive model of a single market interaction has been the dominant model used in the analysis of economic questions in the farm sector. Specifically, most analysts have assumed that many farmers interact with numerous consumers to determine a market price and quantity for agricultural output at the farm gate. While this abstraction is clearly an oversimplification, one could argue that the simplification implied little cost to the analysis. However, certain policy issues have arisen over the past decade that necessitate analysis of more complete marketing channels. In this study, a restricted form of channel analysis is used to analyze the potential for rent extraction through quality differentiation in the Mexican coffee market.

As a point of reference, consider the agricultural market in figure 1 where producers sell output to a processor who repackages it for sale to consumers. $D$ is the consumer level demand curve, $S$ is the farm level supply curve, $MC_P$ is the marginal cost to the processor. $S+MC_P$ is the effective supply curve to the consumer. Assuming that each player behaves competitively, the market channel produces a consumer price of $P_C$, a farm level price of $P_F$, and a quantity supplied in the market channel of $Q$. This equilibrium yields a consumer surplus of $CS$, processor profit of $p_P$, and a farmer profit of $p_F$.

Historically, agricultural markets have been held up as an obvious case of perfect competition. Specifically, numerous farmers produce food for numerous producers. The weak link, of course, is the number of processors. Figure 2 presents the same market channel presented in figure 1, but assumes that the

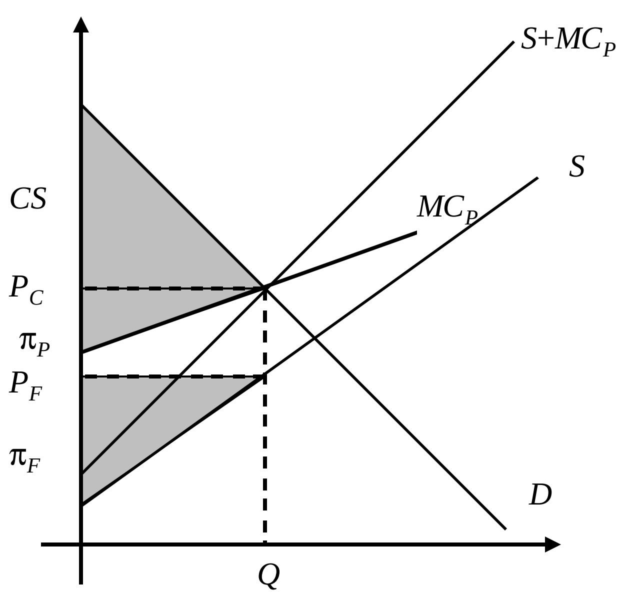


*Figure 1. Economic Rents in a Competitive Market Channel*

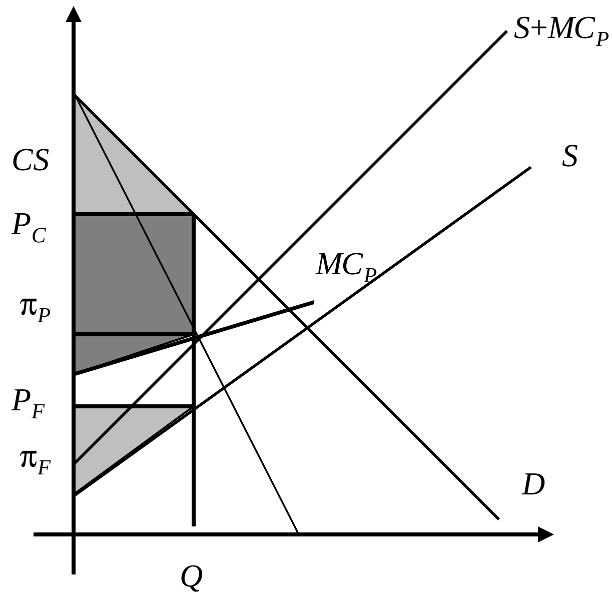


*Figure 2. Economic Rents in the Marketing Channel with Monopolistic Processor*

processor behaves as a monopolist. Specifically, the processor now prices into the consumer market based on the marginal revenue (*MR*). Monopolistic behavior by the processor generates a higher consumer price and lower consumer surplus, a lower producer price and lower producer profit, and a higher economic rent to the processing sector.

The economic distortions presented in figure 2 are fairly straightforward, but not exactly relevant for our analysis of coffee markets in Mexico. Specifically, figures 1 and 2 assume that the agricultural sector faces a downward sloping demand for output. In the case of coffee, however, it is more appropriate to model Mexico as a price taker on the international market. In this case, the channel is modeled not by adding the marginal cost of transformation onto the supply function to obtain the supply curve facing the consumer, but by subtracting the marginal cost of the processor from the international price to generate the derived demand curve at the farm gate. This relationship is presented in figure 3. As before, $P_F$ denotes the price at the farm level, $p_F$ denotes the profit at the farm level, and $p_p$ denotes profit at the processor level. However, the existence of the world market price reduces the consumer price and consumer surplus from the model.

Modifying the channel in figure 4, we allow for imperfect competition in the form of monopsonistic behavior by the processors. Specifically, we allow the processors to set the farm level price in a way that maximizes processor income. In the monopsonistic case, processors choose the quantity in the domestic market such that the marginal input cost (*MIC*) equals the derived demand for coffee. The figure indicates that monopsonist process less coffee at a lower farm price. The net effect of this choice is to increase the economic rents to the processor and decrease the economic rents to the farmer.

Figure 4 provides a starting place to discuss the potential role of market differentiation and price discrimination in the Mexican coffee market. Mathematically, the farm level price can be derived as

$$S_F\left(Q\right) = P_W - \left(1 - q\right) MC_P\left(Q\right) \quad (1)$$

where $S_F(Q)$ is the supply curve for coffee at the farm level, $P_W$ is the world price of coffee, $MC_p(Q)$ is the marginal cost of coffee processors at quantity $Q$, and q is a parameter measuring market power. If q=0, then the market is competitive and processors do not extract monopsonistic rents. However, if q>0 processors exhibit some degree of price discrimination.

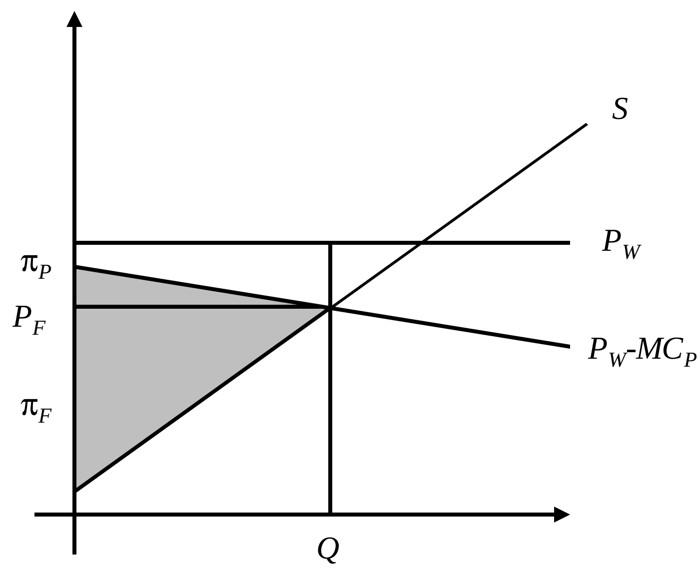


*Figure 3. World Price Taker with Perfect Competition*

This model follows the Appelbaum (1982) approach to measuring market power.

## 3. Pricing Differential Quality in the Coffee Market

A major part of the equilibrium in equation (1) is the world market price for coffee. However, as in many agricultural markets, there exists several world market prices dependent on quality. One approach would be to differentiate each quality and estimate (1) for each. However, this approach ignores the possibility of mixing differing qualities of coffee. Specifically, we will assume that Mexican coffee comes in two qualities, but the world market admits an intermediate quality. The processor then faces the decision to sell the individual qualities or to mix the coffees to produce an average quality coffee. The question of the "effective price" for Mexican coffee on the world market then has direct implications for the test of market power postulated in equation (1). Specifically, the market power parameter in equation (1) may actually capture changes in the relative quality of coffee.

In general terms, we can formulate the processor's problem as

$$\max_{x_1, x_2, x_3, z_1, z_2, z_3} p_1 x_1 + p_2 x_2 + p_3 x_3 - w_1 z_1 - w_2 z_2 - w_3 z_3$$
$$st \quad F\left(x_1, x_2, x_3, z_1, z_2, z_3\right) = 0 \qquad (2)$$

where $p_1$ is the price of high quality coffee, $p_2$ is the price of medium quality coffee and $p_3$ is the price of low quality coffee, each on the world market, and $x_1$, $x_2$, and $x_3$ are the respective quantities of each produced in Mexico. These three quantities are produced from three inputs: $z_1$ the quantity of high quality coffee produced by Mexican producers, $z_2$ is the quantity of low quality coffee produced by Mexican producers and $z_3$ other inputs used in the production process. Each input has the respective price $w_1$, $w_2$, and $w_3$. $F(.)$ is the technology function mapping the relationship between the inputs and outputs.

Focusing on the production system, we assume that the quantity of each variety of coffee produced can be represented by three equations

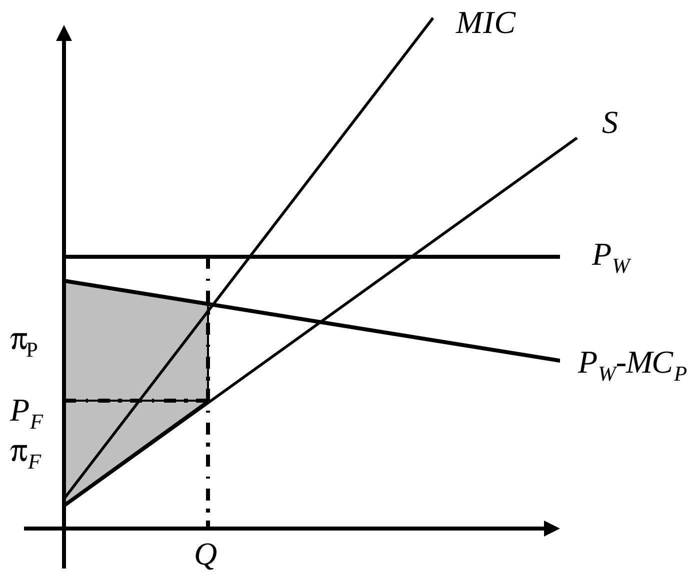


*Figure 4. World Price Taker with Monopsonistic Processor*

$$\begin{aligned} x_1 &= A_{11} z_{11} F_1(z_{31}) \\ x_2 &= (A_{21} z_{12} + A_{22} z_{22}) F_2(z_{32}) \\ x_3 &= A_{32} z_{23} F_3(z_{33}) \end{aligned} \quad (3)$$

where $z_{11}$ denotes the high quality coffee used by the processor to produce in the high quality export market, $z_{12}$ denotes the high quality coffee used by the processor to produce medium quality coffee for the export market, $z_{22}$ denotes the low quality coffee used to produce medium quality coffee for the export market, and $z_{23}$ represents the low quality coffee used to produce low quality coffee in the export market. Each production process is linear in the coffee input. $A_{11}$ is the quantity of high quality coffee used to produce a single unit of high quality coffee in the export market. Assuming some cleaning operation, $A_{11} < 1$. The second operation equation states that $A_{21}$ units of high quality coffee can be mixed with $A_{22}$ units of low quality coffee to produce a single unit of medium quality export coffee. Extending the results of the high quality, $A_{21}+A_{22} < 1$. Similarly for the low quality coffee $A_{32} < 1$. It could be argued that $1>A_{11}>A_{21}+A_{22}>A_{32}$ or that lower quality coffee is also less efficient, but this result will not be necessary for the following model.

In each case $F_i(z_{3i})$ is the transformation function that allows for the interaction with other inputs.

Substituting the production relationships from equation (2) into equation (3) yields an unrestricted profit function

$$\begin{aligned} p = {} & p_1 A_{11} z_{11} F_1(z_{31}) + p_2 (A_{21} z_{12} + A_{22} z_{22}) F_2(z_{32}) + \\ & p_3 A_{32} z_{32} F_3(z_{33}) - w_1 (z_{11} + z_{12}) - w_2 (z_{22} + z_{23}) - \\ & w_3 (z_{31} + z_{32} + z_{33}) \end{aligned} \quad (4)$$

The formulation of the profit maximization problem in equation (4) is a variant of a linear programming model. Within this framework, the solution to the maximization problem will be a corner solution where all the inputs are completely exhausted (in the case of the coffee inputs). In order to visualize the solution, we totally differentiate equation (4) with respect to each coffee input variable yielding

$$\begin{aligned} dp = {} & \left[p_1 A_{11} F_1(z_{31}) - w_1\right] dz_{11} + \left[p_2 A_{21} F_2(z_{32}) - w_1\right] dz_{12} + \\ & \left[p_2 A_{22} F_2(z_{32}) - w_2\right] dz_{22} + \left[p_3 A_{32} F_3(z_{33}) - w_2\right] dz_{23} \end{aligned} \quad (5)$$

Formulating the change in profit for a one-unit change in high quality coffee marketed as high quality coffee on the international market

$$\frac{dp}{dz_{11}} = \left[p_1 A_{11} F_1(z_{31}) - w_1\right] + \left[p_2 A_{21} F_2(z_{32}) - w_1\right]\frac{dz_{12}}{dz_{11}} + \left[p_2 A_{22} F_2(z_{32}) - w_2\right]\frac{dz_{22}}{dz_{11}} + \left[p_3 A_{32} F_3(z_{33}) - w_2\right]\frac{dz_{23}}{dz_{11}} \quad (6)$$

Assuming that all the constraints are binding $dz_{12}/dz_{11}$=-1,$dz_{22}/dz_{11}$=-1, and $dz_{23}/dz_{11}$=1. Therefore,

$$\begin{aligned} \frac{dp}{dz_{11}} \geq 0 \Leftrightarrow\ & p_1 A_{11} F_1(z_{31}) - p_2 A_{21} F_2(z_{32}) - p_2 A_{22} F_2(z_{32}) + p_3 A_{32} F_3(z_{33}) \geq 0 \\ \Leftrightarrow\ & p_1 A_{11} F_1(z_{31}) - p_2 A_{21} F_2(z_{32}) \geq p_2 A_{22} F_2(z_{32}) + p_3 A_{32} F_3(z_{33}) \end{aligned} \quad (7)$$

Given that the prices and technical coefficients in equation (7) hold, the processor maximizes profit by selling two different qualities of coffee. If the sign on the inequality in equation (7) is reversed, then the processor maximizes profit by blending coffees to sell the medium quality coffee.

The results from equation (7) represent the flip side of the results from Guerra Galindo. Specifically, the results from equation (7) imply that different qualities are marketed if the gain to marketing high quality coffee exceeds the loss from selling low quality coffee as low quality coffee. The results in Guerra Galindo state that producers will separate coffee into different qualities if the gain to the separation exceeds the loss in price due to selling undifferentiated quality plus the cost of grading.

To more fully develop the market for each quality of coffee, we need to consider three cases. In the first case, the value to blending is less than the value of marketing differential qualities of coffee. In this case the market price paid to producers is simply

$$\begin{aligned} w_1 &= p_1 A_{11} F_1(z_{31}) \\ w_2 &= p_3 A_{32} F_3(z_{33}) \end{aligned} \quad (8)$$

In the second case, the optimum solution is to blend the coffee, but there is relatively more high quality coffee than low quality coffee. In this case, the market for high quality coffee is set in the differentiated market, but the price of low quality coffee is set in the blended market

$$\begin{aligned} w_1 &= p_1 A_{11} F_1(z_{31}) \\ w_2 &= p_2 A_{23} F_2(z_{32}) \end{aligned} \quad (9)$$

In the third scenario, the excess quantity is in the low quality market

$$\begin{aligned} w_1 &= p_2 A_{21} F_2(z_{32}) \\ w_2 &= p_3 A_{32} F_3(z_{33}) \end{aligned} \quad (10)$$

In order to compare these solutions, note that in the case of excess high quality coffee

$$p_2 A_{21} F_2(z_{32}) \geq p_1 A_{11} F_1(z_{31}) \quad (11)$$

so that the producer does not get the blending premium. Similarly, in the case of excess supply in the low quality coffee market

$$p_2 A_{22} F_2(z_{32}) \geq p_3 A_{32} F_3(z_{33}) \quad (12)$$

In each case, the processor keeps the blending premium on the excess variety.

In general, the results indicate that producers may gain from the blending of the qualities of coffee. This gain is dependent on the quality constraint. The quality that is the most constrained gains while the quality in relative abundance earns the same return as the differentiated market. Several factors currently observed in the Mexican coffee industry support the abundance of low quality coffee. Specifically, as developed by Guerra Galindo, the general reduction in the size of coffee producers over the past 20 years has reduced the average size of producers below the level necessary to effectively capture the quality premium at the farm level. Thus, at the margin producers are not rewarded for quality and the average quality of Mexican coffee has declined. These results suggest that the overall decline in quality may make the sale of blended coffee relatively more profitable, but any gains to blending are likely captured by the processors and the suppliers of high quality coffee and not passed to the average producer.

Finally, this model is highly stylistic. The relative margin is driven by other variable factors ($z_3$). Additional insights may be gained by postulating a capacity constraint in the processing sector. Given that the capacity constraint is binding, processors will allocate available capacity in a way that maximizes their relative margin. The net effect of that rule in this model is uncertain since the margin is completely exhausted by payments to each input.

## 4. Testing for Market Power with Different Qualities

Given the forgoing discussion of the economics of different qualities, a reformulation of the testable hypothesis in equation (1) would appear appropriate. Specifically, the price of coffee is now a function of at least two prices. For example, the price of high quality coffee in Mexico is a function of the price of high quality coffee on the international market and the price of blended coffee. In addition, the price of low quality coffee could be a function of blended quality or low quality.

One direct formulation of the processor allocation problem would be

$$\begin{aligned} w_1 &= \max\left(A_{11} p_1, A_{21} p_2\right) - \left(1-q\right) MC_P\left(z_1\right) \\ w_2 &= \max\left(A_{22} p_2, A_{23} p_3\right) - \left(1-q\right) MC_P\left(z_2\right) \end{aligned} \quad (13)$$

However, this formulation raises several empirical problems. First, the coefficients $A_{11}$, $A_{21}$, $A_{22}$, and $A_{32}$ are unobserved and may change over time. More problematic is the definition of the marginal cost functions for the processor. In some cases simple models similar to equation (1) have been estimated using a procedure suggested by Appelbaum, but the data requirements are significant.

An alternative approach suggested by the Structure-Conduct-Performance paradigm involves estimating the effect of concentration on the price spread

$$\frac{p_M}{p_W} = a_0 + a_1 H + e \quad (14)$$

where $p_M$ is the price in the Mexican market, $p_W$ is the price in the world market, and $H$ is a measure of concentration among processors. In this study, we use the entropy measure suggested by Horowitz and Horowitz to measure concentration. Based on the results of the quality measurement model, the price ratio may also be affected by the relative quality of coffee produced in Mexico. So a measure of relative quality is appended to equation (14) yielding

$$\frac{p_M}{p_W} = a_0 + a_1 H + a_2 \frac{Q_H}{Q_L} + a_3 M + e \quad (15)$$

where $Q_H$ is the quantity of high quality coffee marketed, $Q_L$ is the quantity of low quality coffee marketed and $M$ is the total quantity of coffee exported from Mexico. The last term allows us to test whether Mexico is a price taker in the international coffee market.

The data used to estimate for market power or quality differentiation in the Mexican coffee market are taken from Guerra Galindo and presented in table 1. The second column presents the quantity of coffee exported from Mexico in metric tones. The third and fourth columns are coffee prices in dollars per pound. The third column gives the price of Mexican coffee in dollars while the fourth gives the average price of coffee in the United States. The fifth column presents the entropy measure of concentration for coffee exporters in Mexico, based on the relative shares of the twenty largest coffee exporters. The final two columns present the relative quantities of high quality coffee (altura) and low quality coffee (prima).

The ordinary least squares estimates for equation (15) are presented in table 2. In general, the coefficient on concentration is not statistically significant, so the evidence does not support market power among processors. However, the coefficient on relative quality is statistically significant suggesting that the price deviations that have occurred can be largely explained by differences in quality over time. In addition, the statistical coefficient on Mexican exports confirms our hypothesis that Mexico is a price taker in the international market.

## 5. The New Theory of the Firm and the Market for Coffee Quality

Given the absence of aggregate monopsonistic power, we turn briefly to some recent advances in industrial organization theory proposed in the new institutional economic paradigm. These paradigms tend to be based on transaction costs attributable to asymmetric or impacted information that gives rise to mar-

Table 1. Data for Empirical Analysis of Mexican Coffee Industry.

| Year | Mexican Exports (tones) | Mexican Price ($s/pound) | U.S. Price ($s/pound) | Entropy | Share Altura | Share of Prima |
|---|---|---|---|---|---|---|
| 1980 | 117120 | 3.01 | 5.51 | 1.911 | 15.8 | 65.2 |
| 1981 | 110760 | 3.58 | 4.44 | 1.900 | 14.3 | 65.7 |
| 1982 | 186540 | 2.66 | 4.55 | 1.911 | 15.9 | 65.1 |
| 1983 | 174180 | 2.97 | 4.49 | 1.917 | 16.1 | 64.6 |
| 1984 | 178920 | 2.79 | 4.68 | 1.922 | 15.9 | 64.9 |
| 1985 | 221580 | 2.95 | 4.73 | 1.966 | 16.2 | 64.1 |
| 1986 | 230580 | 2.98 | 6.11 | 1.934 | 15.7 | 65.3 |
| 1987 | 152940 | 3.48 | 5.20 | 1.940 | 14.2 | 67.8 |
| 1988 | 224340 | 2.94 | 5.04 | 1.935 | 12.9 | 70.1 |
| 1989 | 261540 | 2.89 | 5.45 | 1.935 | 14.7 | 67.4 |
| 1990 | 210360 | 2.42 | 5.26 | 1.908 | 12.2 | 69.8 |
| 1991 | 187360 | 1.74 | 4.98 | 1.928 | 12.7 | 69.3 |
| 1992 | 183600 | 1.81 | 4.57 | 1.951 | 12.3 | 69.8 |
| 1993 | 189000 | 2.35 | 4.79 | 1.927 | 11.9 | 70.2 |
| 1994 | 195420 | 3.91 | 6.33 | 1.947 | 12.7 | 70.5 |
| 1995 | 274740 | 2.96 | 4.87 | 1.944 | 12.6 | 73.4 |
| 1996 | 262860 | 3.29 | 6.08 | 1.925 | 15.9 | 65.0 |
| 1997 | 232920 | 3.63 | 6.45 | 2.067 | 15.1 | 60.7 |
| 1998 | 245100 | 3.66 | 5.41 | 2.007 | 18.1 | 61.7 |
| 1999 | 315507 | 2.97 | 6.56 | 1.922 | 15.2 | 68.9 |

Table 2. Regression Estimates

| Coefficient | Estimate | Std Err. |
|---|---|---|
| Constant | 2.264 | 0.170 |
| Concentration | -0.237 | 0.267 |
| Quality Ratio | 0.482 | 0.235 |
| Mexican Exports | 0.402 | 2.650 |

ket power for one or both agents. The most common result is called the hold-up problem where one or both agents can use impacted information and imperfect competition to extract rents from the other participant.

Moss and Schmitz (1999) describe one such hold-up problem in sugar production in the United States. Given the bulky and time dependent nature of sugarcane, processing must occur soon and close to the point of harvest. Thus, once harvested, processors could exert additional market power over producers. However, in Florida, processors also faced relatively few producers enabling the producers to exert hold-up pressure on the processors. The two-sided hold-up in Florida led to increased vertical integration through direct ownership. In other areas, such as Louisiana, a relatively larger number of producers led to vertical integration through formal and informal contracts, as predicted by Grossman and Hart (1986). In both cases, the nature of the industry is profoundly affected by the hold-up problem.

In discussing the potential role of the new theory of the firm as developed in Coase (1937), Williamson (1985) and Grossman and Hart, integration in the sugarcane market can be contrasted with the lack of hold-up in grain production. Grains such as wheat are typically fairly storable when harvested. Standard practice among farmers in the United States is the construction of on-farm storage for small grains. In addition, grains are relatively easy to transport. Hence, local elevators can exercise little market power and little integration has been observed.

The implications of this theory for coffee production are similar to the case of sugarcane. Cherry coffee is relatively bulky and must be processed quickly. In addition, the quality of coffee is not easily discernable in its cherry form. Coupling this with the presence of many small sellers and relatively few buyers, conditions are ripe for a one-sided hold-up problem. However, the nature of the hold-up problem is dependent on the size of the firm. As in the case of sugarcane, larger farmers can exert countervailing market power or choose to integrate into the next level of production. This division of the industry is observed around Coatapec, Veracruz. Larger farmers sell their coffee in pergimino form instead of cherry coffee, integrating into the first stage of processing. This reduces the hold-up problem.

Several questions regarding the implications of the new theory of the firm remain in the Mexican coffee sector. Specifically, the formulation of the hold-up problem works best if the game is a single event. However, the annual coffee cycle implies that the game is played several times. In game theory, repeated or sequential games are sufficient to eliminate the prisoner's dilemma. If the prisoner's dilemma is no longer valid, then the hold-up problem may decline.

However, the repeated nature of the game may also have implications for the coffee industry as a whole. Specifically, the long-term well being of the industry is linked to the profitability of at least some farm level production of coffee in Mexico. However, the continued slide in the quality of coffee threatens the existence of a large portion of the sector. Thus, processors may have a vested interest in creating the channels to provide quality incentives to smaller producers.

## 6. Conclusions

Recently agricultural marketing channels have undergone significant changes. Agricultural policies have become less generous in the United States and abroad while international trade agreements have become increasingly focused on the elimination of trade barriers. Concomitantly the processing sector of agribusiness in the United States and around the world appears to be increasingly concentrated. Both of these characteristics raise the potential for monopsonistic power in the agricultural sector. However, market power alone may not describe the changes in market price relationships at the industry level. Specifically, changes in relative quality may change the average price received by farmers. This study examines the possibility of market power and quality changes in the Mexican coffee industry. The results indicate that changes in quality have significantly affected the average price of Mexican coffee over time. In addition, the results do not support the increase in market power.

Turning from the traditional monopsonist model, we then focus on the possibility of institutional failure in the market channel using the new institutional economics paradigm. In general, the structure of the industry, especially for smaller producers, appears consistent with the hold-up problem developed by Williamson. Thus, while market power may not be traced directly to rent extraction, the decline in quality may be directly attributed to transaction costs in the marketing channel.

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