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COULD FUTURES MARKETS HELP GROWERS BETTER MANAGE COFFEE PRICE RISKS IN COSTA RICA?

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ABSTRACT

Costa Rican coffee farmers are almost fully exposed to world price variability. Yet, despite small farm sizes, specialization in coffee, and a marketing system that prolongs uncertainty and aggravates cash flow problems, this study finds that most farmers still manage their price risks surprisingly well. Farmers are able to forecast prices with comparable accuracy to the New York futures market. They have a favorable seasonal cash flow, ready access to credit, and are willing and able to bear risk. Within this context, the potential gains from using the New York futures market to provide forward price contracts at harvest are found to be modest.

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COULD FUTURES MARKETS HELP GROWERS BETTER MANAGE COFFEE PRICE RISKS IN COSTA RICA?

Peter Hazell[*]

1. INTRODUCTION

Many developing countries depend heavily on agricultural exports yet face high levels of instability in their export prices. Price variability can be detrimental to the stability of export earnings, and hence to the ability of developing countries to grow and to service debt. Moreover, if export price risks are transmitted to producers, they may act as an impediment to the expansion of agricultural exports.

To buffer producers from the full force of world price movements, many governments have intervened with buffer stock or variable export levy schemes. The experience with these schemes has not been particularly encouraging, not least because they can easily be politicized by producer or urban consumer interests to distort the average prices that farmers receive (Knudsen and Nash, 1990). Moreover, the implementation of these schemes requires a public agency or marketing board with sufficient power to prevent or neutralize cross-border trade at unauthorized prices. This is

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[*] Peter Hazell is Director of the Environment and Production Technology Division at the International Food Policy Research Institute. Much of the research reported in this paper was undertaken while the author was with the Agriculture and Rural Development Department of the World Bank. This study would not have been possible without the contributions of Mario Vedova, who directed the farm survey; of Rigoberto Stewart and Mauricio Jaramillo, who helped design the survey and contributed to the analysis; and of Apparao Katikeni, who undertook most of the computer work.

unlikely to be consistent with the full privatization of market functions, and may be used to rationalize the existence of monopolistic marketing boards that is otherwise undesirable.

A better approach is to seek ways of strengthening the ability of the private sector to offer more risk management options to farmers. A promising prospect is the development of appropriate institutional mechanisms whereby a broader range of private agents in developing countries can gain access to international futures and options markets for agricultural commodities. At present developing countries are minor participants in these markets, even though they are sometimes the major suppliers of the underlying commodities (for example, coffee, cocoa, and tea).

Several studies have shown how international futures and options markets can be used by government agencies in developing countries to manage the effects of world price risks on a country's trade balance, on government revenue, or on the earnings of public marketing agencies (for example, Gemmill (1985), Glaessens and Varangis (1991), Overdahl (1986), and Meyers (1991)). But very little work has been undertaken on how international futures and options markets might be harnessed through appropriate trade and marketing institutions for the benefit of developing country farmers. This paper analyzes the feasibility and potential economic benefits of using the New York futures market to hedge forward price contracts for smallholder coffee growers in Costa Rica.

BACKGROUND

Costa Rica is typical of many small developing countries in that the economy depends heavily on a handful of agricultural export commodities. The most important export is coffee, which, despite a declining trend in relative economic importance, accounts for some 30 percent of total export earnings, 25 percent of agricultural GDP, and 5 percent of national GDP. Yet the world coffee price is notoriously unstable; during 1961-97, the coefficient of variation (CV) around trend of Costa Rica's export price was 38 percent. There is no program to stabilize coffee prices in Costa Rica, hence nearly all the variation in the export price is transmitted to producers; the CV of the average producer price exceeded 30 percent in recent decades and was almost perfectly correlated with the world price (Hazell, Jaramillo, and Williamson, 1990).

As Table 1 shows, most of the coffee farmers are small-scale farmers. The average grower has 6.3 ha of coffee, and 90 percent of the growers have less than 10 ha of coffee. Most producers are also specialized, obtaining at lest two thirds of their total household income from coffee. These characteristics suggest that many growers may be vulnerable to price risks, possibly facing severe financial difficulties when coffee prices are low.

The present marketing arrangements aggravate the consequences of price risks for Costa Rica's coffee growers. Coffee is harvested and delivered to the mills between November and January each year. At the time of delivery, the farmer receives an initial advance payment from the mill (usually between 25-50 percent of the expected market

Table 1: Characteristics of Costa Rican coffee farms by coffee-farm size group, 1989

	Coffee (ha)						
	0-1.5	1.5-3.0	3.0-5.0	5.0-10.0	10.00-25.00	>25.00	All
% Farms in sample	23.4	32.9	21.0	11.5	7.5	3.7	100.0
Coffee as % of total household income	62.7	71.9	73.7	68.6	76.3	60.0	69.7
% Farms selling mainly to cooperatives	54.0	55.0	61.0	53.0	32.0	-	52.0
Average coffee area (ha)	1.0	2.3	4.0	7.3	16.2	63.3	6.3

Source: Survey of 295 randomly selected coffee farms (from ICAFE's national registar) undertaken by PRODESARROLLO and the World Bank in June-August, 1989

price), and this is followed by additional advances of 10-20 percent at two to three month intervals. But the final price is not known or fully paid until each mill has calculated a liquidation price for the entire season's sales. This liquidation price is traditionally announced in November, nearly twelve months after the coffee has been harvested, and some 20 months after the beginning of the growing season which begins in March.

The combination of price uncertainty and delayed payments could adversely affect producers' welfare in three ways. First, since decisions about input use, pruning and cash flow management must be made each growing season, price forecasting errors may lead to inappropriate decisions. Second, price risks lead to income variability which, if farmers are risk averse and do not have access to adequate off-farm risk management aids, may lead to under investment in coffee bushes and a reduced willingness to replant with modern varieties or to use recommended levels of fertilizers and other inputs. This in turn would lead to reduced coffee output and income. Third, delayed payments for harvested coffee may increase the need to borrow credit to purchase inputs for the next growing season. This would lead to higher interest payments and hence lower farm incomes on average.

In the next three sections, farm survey data are used to examine the empirical significance of each of these potential welfare losses. Subsequently, we suggest how futures trading might be used to reform the current marketing system, and then evaluate the potential gains to farmers with the aid of a mathematical programming model.

The survey data used here were collected jointly by the World Bank and the Center for the Promotion of Sciences and Socioeconomic Development (PRODESARROLLO) in San Jose. The survey covered a nationally representative

sample of about 300 coffee farms, drawn on a regionally stratified basis from a national registrar of coffee farms maintained by the Costa Rican Coffee Institute (ICAFE), a governmental regulatory agency. The main fieldwork was carried out in June/July 1989, but a follow-up survey of farmers' price expectations was conducted in October 1989.

2. PRICE FORECASTING ERRORS

Investment decisions about the number and varieties of coffee bushes to grow depend on long-term expectations about the profitability of coffee farming. Since coffee bushes take at least four years to mature, these longer-term price risks cannot be hedged in the futures market, and are not analyzed in this paper.

Of greater relevance are short-term decisions about the use of fertilizer, weeding, the timing of pruning and stumping decisions, and the management of seasonal cash flow. These decisions affect coffee production and income within single growing seasons, and may be related to farmer's short-term price expectations. Fertilizer use and weeding can have direct effects on yields within a season.

Pruning and stumping (an extreme form of pruning in which the bush is virtually cut off at the ground) must be undertaken regularly to maintain the vigor and longer-term productivity of the bushes, but there is some flexibility in advancing or delaying these decisions to influence short-term yields. The management of seasonal cash flow, which involves decisions about when and how much to borrow or to spend on farm costs and household consumption, is complicated by uncertainty in coffee revenue, yet helps determine borrowing costs, income and family welfare.

If a farmer can accurately predict harvest prices each year, then he/she could optimally adjust growing and financial practices within seasons. More accurate price forecasts should therefore lead to higher profits and welfare on average, as well as help reduce the size of income losses in low price years. As part of the June/July 1989 survey, the sampled farms were questioned about their expectations for the 11/89 and 11/90 liquidation prices. In addition to forecasting 'most likely' (or modal) prices, they were also asked to state the lowest and highest prices that could conceivably occur. The same questions were asked again three months later when a sub-sample of 80 farmers was resurveyed. Subsequently, the actual liquidation prices paid for 11/89 and 11/90 were collected from the mills, and this information was used to calculate forecast errors.

The timing of the initial survey coincided with the breakdown of the International Coffee Agreement (ICA), and farmers faced considerable uncertainty about future price movements. Since they were being asked to predict a domestic price in their national currency (colones), their forecasts necessarily embodied perceptions about changes in the currency exchange rate as well as movements in world coffee prices.

As a simple measure of forecast error, the absolute value of the price error is expressed as a percent of the actual price. That is, $e_t = |p_t - p^*_t|/p_t \times 100\%$, where p_t is the actual price and p^*_t is the forecasted price. Pertinent results are to be found in Table 2 for both the June/July and October 1989 surveys.

The June/July forecasts of the 11/89 price had an average error of 8 percent, with 71 percent of the farmers having errors of less than 10 percent, and nearly half having errors of less than 5 percent of their actual prices. By way of comparison, the average

Table 2: Farmer's Price Forecasting Performance, 11/89 and 11/90 Liquidation Prices

	June/July 1989 Survey				October 1989 Survey	
	11/89 Price		11/90 Price		11/89 Price	11/90 Price
Forecast error (%)[a]	8	(8)[b]	22	(26)[b]	4	13
Minimum error (%)	0	(0)	0	(1)	0	0
Maximum error (%)	43	(23)	69	(69)	13	55
Percent farmers with forecast errors less:						
1%	13	20	4	(5)	27	10
5%	46	(45)	20	(20)	68	37
10%	71	(70)	30	(25)	93	44
Forecasted range (as % of modal price)	16	(14)	25	(23)	7	23
Forecasted skewness[c] (as % of modal price)	1	(-1)	-1	(-9)	0	-4
Sample size	265	(41)	176	(41)	41	41

[a] Calculated as $|p_t - p^*_t|/p_t$ where p_t is actual price and p^*_t is the forecasted most likely price.

[b] Figures in parentheses are the June/July means for the subsample of farms re-interviewed in October.

[c] Calculated as [(max–mode) + (min -mode)] / mode x 100%, (see Heady and Kaldor, 1954). The index is zero when the distribution is symmetric and negative (positive) when the distribution is skewed to the left (right).

price for 12/89 contracts in the New York futures market at the time of the June/July survey turned out to overestimate the realized 12/89 spot price by 40 percent. This forecast error was almost as large as the maximum forecast error observed in the June/July farm survey.

The average error for the 11/89 forecast was only half as large in the October survey (4 percent) and nearly all the farmers came within 10 percent of their actual prices. This increased accuracy is to be expected given that the forecast period was reduced from 4-5 months to a single month. The New York futures market also improved its predictive performance during this period. The average price of 12/89 contracts quoted during October came to within 0.1 percent of the average 12/89 spot price.

Not surprisingly, farmers did less well in forecasting the 11/90 liquidation price. The average error for the June/July survey (a 16- 17-month forecast) was 22 percent, and only 30 percent of the farmers came within 10 percent of their realized prices. Because the 11/90 liquidation price would be an average of the seasonal prices prevailing between the 1989 harvest and the November liquidation, the appropriate New York comparator is the average error in the futures market between the prices quoted in June/July 1989 for 12/89, 3/90, 5/90, 7/90, and 9/90 contracts, and the spot prices that were realized in each of those months. On this basis, the comparable error in the NY futures market for the 11/90 liquidation was 15.4 percent.

Farmers greatly improved their information about the 11/90 price between the June/July and October surveys, even though the forecast period was still about one year. The average error fell from 22 to 13 percent, with 37 percent of the farmers having errors

of less than 5 percent. There was a little change in the forecast errors of the New York futures market over the same period; the error between the October 1989 quotes for 12/89, 3/90, 5/90, 7/90 and 9/90 contracts and the realized spot prices was 12.5 percent, down from a 15.4 percent error in the July 1989 quotes.

Farmers were reasonably confident of their price forecasts. During the June/July survey, they gave price ranges of 16 and 25 percent, respectively, of their most likely prices for the 11/89 and 11/90 liquidations. The range for the 11/89 price was smaller in the October survey, but it remained unchanged for the 11/90 price, indicating continuing levels of uncertainty. The 11/90 forecasts were also more negatively skewed, indicating higher levels of pessimism than for the 11/89 price.

These results show that Costa Rican coffee farmers are generally well informed about the international coffee market, and that their price forecasts were about as accurate as the New York futures market. However, the size of the errors, especially for 16- 17-month price forecasts --almost the length of time between allocating inputs at the beginning of the growing season and the realization of the final liquidation price for the resultant harvest --leaves considerable scope for error in making short-term resource allocation and financial management decisions.

Given the sample variation in forecasting errors, it is possible to identify factors that distinguish the more successful farmers. Regressions of the forecast errors against an array of household characteristic variables showed few to be statistically significant. Separate regressions were estimated for the 11/89 and 11/90 forecast errors, as well as for a pooled regression that controlled for unobserved household effects through a random

components specification. Three variables proved to be consistently significant. Farmers belonging to a milling cooperative made smaller forecast errors on average than nonmembers. Similarly, farmers who had completed secondary education were also more accurate on average than those with a lesser education. However, the size of the initial advances paid by the mills at harvest apparently misled farmers. The larger the advance, the greater the tendency to over-estimate the eventual liquidation price.

RISK AVERSION

The volatility in coffee prices inevitably translates into significant risk in coffee farm incomes. If farmers are risk averse and do not have access to adequate on- or off-farm risk management aids, then they may under invest in coffee bushes and be reluctant to replant with modern varieties or to adopt recommended levels of fertilizers and other inputs.

As a direct measure of the degree of risk aversion, several 'typical' farmers were selected from the June/July 1981 survey and asked to participate in a carefully designed lottery game. The basis for the game is described in Anderson and Dillon (1992). It involves establishing the certainty equivalents of a series of two-outcome gambles, and then combining this information with an assumed constant absolute risk-aversion utility function to estimate the degree of risk aversion. In all cases, the results showed that the farmers were either risk-neutral or even mildly risk-loving in their behavior. These results are less surprising when placed in the context of the relatively high wealth levels of most coffee farmers. At 1989 prices, a typical 3-hectare coffee farm in the Central Valley was worth about US $60,000.

In an attempt to assess farmer's attitudes to coffee price risks, questions were included in the June/July 1989 survey about the value of forward price contracts. As discussed in the previous section, farmers were asked to forecast most likely (modal) prices for the 11/89 and 11/90 liquidations. They were also asked the minimum cash prices they would accept at the time of the survey so as not to have to wait for the unknown liquidation prices. For the 11/89 liquidation, the cash price was stated as payable immediately (since the coffee for that harvest had already been delivered to the mills), whereas the cash price for the 11/90 liquidation was to be agreed at the time of the survey but only paid in full when the coffee was delivered to the mill at harvest later in the year. In establishing these minimum forward prices, the enumerators were encouraged to negotiate with the farmers as if they were representing a miller who was actually prepared to enter into forward contracts. But since the contracts remained hypothetical, we cannot be sure that the farmers reacted with full sincerity.

In Table 3, the minimum cash, or forward, prices are expressed as ratios of the most likely liquidation prices forecasted by the farmers. These ratios summarize the price discounts that farmers were willing to accept to lock in cash prices at the time of the June/July survey. They represent the combined benefits from removing further price risk and the time value of money from receiving earlier payments. For the 11/89 price, the forward contract would have advanced all remaining payments by 4-5 months. For the 11/90 price, the forward contract would have paid in full at harvest, thereby accelerating the entire liquidation process by one year.

Given the presumed benefits of the forward contracts, the resulting discounts are small. On average, farmers were only willing to sacrifice 2 percent of their expected 11/89-liquidation price to obtain a full cash price at the time of the survey. The discount is larger for the 11/90-liquidation price, but at 3 percent, it is still less than the time value of money. Small-scale farmers would have been willing to accept discounts of up to 5 percent for the 11/90-liquidation price, but large-scale farmers actually wanted to be compensated for accepting forward contracts. They preferred to continue to gamble on the liquidation price.

Regression analysis of the determinants of the discount ratio across farms identified wealth as the only consistently significant variable. Total farm wealth (land, trees and livestock) was negatively related to the size of the discount.

CASH FLOW

The low discounts for forward price contacts are consistent with low levels of risk aversion. They also suggest that farmers are not unduly troubled by cash flow problems, despite the delayed payments inherent in the current coffee liquidation scheme.

Tables 4 and 5 summarize the seasonal cash flows for a representative small (3.2 ha) coffee farm and a large (14 ha) coffee farm chosen from the 1989 survey. The cash flows were calculated on a 4-month basis, and are reported for an average and a low coffee price. The average coffee price is the mean for the period 1979/80 to 1987/88. The low price is the one that occurred in 1982/83.

Table 3: Risk Discounts for Forward Price Contracts as Elicited from Farmers in June/July 1989

	Coffee farm size group (ha)						
	0-1.5	1.5-3.0	3.0-5.0	5.0-10.0	10.0-25.0	>25.0	All
11/89 Liquidation							
Expected liquidation price[a] (colones/fanega)	5408	5448	5441	5476	5533	5673	5458
Acceptable forward price[b] (colones/fanega)	5300	5273	5332	5307	5583	5691	5339
Discount ratio	0.98	0.	0.9	0.9	1.(	1.(	0.
Sample size	50	7	51	27	18	1	235
11/90 Liquidation							
Expected liquidation price (colones/fanega)	5822	5732	5876	5711	5874	5421	5779
Acceptable forward price[c] (colones/fanega)	5494	5380	5635	5498	5792	6010	5535
Discount ratio	0.95	0.	0.9	0.9	0.9	1.	0.
Sample size	54	7	55	28	19	1	246

[a] Price that farmers said they were most likely to receive.

[b] Minimum price that farmers were willing to accept in cash at time of interview.

[c] Minimum contract price that farmers were willing to sell their 1989/90 crop at the time of interview for cash payment at time of delivery of coffee to the mill.

Note: A fanega is a bag of milled 'gold' beans, and weighs 46 kg.

Both farms have positive cumulative cash flows throughout the year for the average and low coffee prices. Despite the delayed payments under the current coffee marketing system, it seems that farmers do receive adequate liquidity to cover production costs each season without any real need for credit. This is possible because the initial harvest advance of up to 50 percent of the expected price is paid about the same time that the final liquidation payment from the previous year's crop is paid. Since the latter is usually about 20 percent of the liquidation price, farmers actually receive a combined payment of about 70 percent of the value of their crop each harvest period (November-January). This is apparently adequate to cover the growing costs incurred from March onwards for the next season's crop.

Even though there is no apparent need for credit, farmers do in fact borrow quite heavily from the mills. Part of this borrowing may be related to lumpy investments in replanting coffee bushes (the calculations in Table 4 assume that a constant proportion of the farm is replanted each year, whereas many farmers tend to replant whole fields at a time). But part may be related to farm household consumer needs.

Since credit is fungible, farmers may borrow from the mills to cover coffee costs, but then use their own money to help stabilize consumption expenditures in low coffee price years. This could, in fact, be quite an efficient way of managing coffee price risks. Analysis of these relationships requires a more formal household modeling approach.

Table 4: Four monthly cash flows for small and large coffee farms[a] (10^3 colones in 1987/88 prices)

	Small Farm			Large Farm		
	Nov-Feb.	March-June	July-Oct.	Nov.-Feb.	March-June	July-Oct
Cash Payments						
Inputs[b]	18	111	97	80	383	552
Hired labor[b]	51	6	3	564	12	-
Overhead costs	34	34	33	138	138	138
Total payments	103	151	133	782	533	690
Coffee Receipts						
Average price[c]	460	131	66	2,017	576	288
Low price[d]	353	101	50	1,548	442	222
Cash Balance						
Average price	357	-20	-67	1,235	43	-402
Low price	250	-50	-83	766	-91	-468
Cumulative Cash Balance						
Average price	357	337	270	1,235	1,278	876
Low price	250	200	117	766	675	207

[a] The small farm has a total coffee area of 3.2 ha, including 2.67 ha of productive trees, 0. 13 ha of young trees, and 0.4 ha of stumped trees. The large farm has a total coffee area of 14.0 ha, including 10.52 ha of productive trees, 0.74 ha of young trees, and 2.74 ha of stumped trees.

[b] Includes costs for young trees and stumped trees.

[c] 5475 colones/fanega.

[d] 4202 colones/fanega.

3. POTENTIAL ROLE OF FUTURES TRADING

The results reported so far suggest that Costa Rican coffee farmers are managing their price risks quite efficiently, despite the delayed payments that characterize the current marketing system. Nevertheless, the facts that price-forecasting errors are not trivial and that farmers do borrow credit from the mills, suggest that there is scope for improving the marketing system.

Forecast errors could be considerably reduced if farmers were to receive a full cash price at harvest. This would reduce the forecast period at the beginning of each coffee growing season from about 20 to 8 months. The earlier payment would also increase the cash flow available for family consumption and farm expenditures during the growing season.

There are two ways in which full cash pricing at harvest might be achieved. The first is for the mill to process and export the coffee as soon as it is received. But this may not be possible within the capacity constraints of existing marketing infrastructure. An alternative approach is for the mills to pay a full cash price before the coffee has been exported, and then to hedge the price risks they assume in the New York futures market. The cash price could be based on any of the futures contracts quoted in New York at the time the coffee is delivered to the mill. However, to conform to current exporting practices, the cash price could be based on an average of the quarterly futures contracts quoted at harvest for December through September. The mills would need access to increased credit to finance the cash payments, at least for the first year of implementation of a cash price system. But judging from the amount of credit they currently obtain from

the international coffee houses through their ties to Costa Rican exporters, the additional credit might not be difficult to arrange. The cash price would, of course, have to be discounted to cover all relevant financing and transactions costs.

Using the futures market in this way provides an interesting example of how these markets might be harnessed to benefit developing country small holders without the latter being involved, or perhaps even knowing about, the transactions that are conducted on their behalf. Moreover, if the mills were empowered to offer farmers a choice between cash prices and the current liquidation system, this would increase their ability to compete with each other in attracting customers. To measure the potential value to farmers of a cash price system at harvest, a dynamic linear programming model of some typical farmers' decision problems were constructed.

THE FARM MODEL

The model depicts a specialized coffee farm in which the area of productive coffee bushes is constrained by land and labor, and by the need to stump and replant parts of the coffee area each year. However, these decisions are largely predetermined by the absence of viable cropping alternatives and by the available technology. The financial structure of the model is more important in influencing the optimal choice of marketing strategy.

In order to track seasonal cash flow, the year is divided into 4-month periods in the model, beginning with the harvest period through February 28. There are nine periods in the model to span a three-year planning horizon. Extending the model beyond one year

is necessary because the current marketing strategy has a payments scheme that extends over four periods. Inclusion of additional years also reduces the influence of the model's terminal conditions on the solution for the initial periods.

Cash flow constraints are defined for each 4-month period, and take the form:

- [Opening cash balance] + [Coffee receipts] + [Borrowing]

- [Production costs] - [Fixed costs] - [Consumption]

- [Debt repayment] = [Closing cash balance]

Production costs include hired labor costs, and the cost of all variable inputs used on productive coffee bushes and on stumped and young replacement bushes. Per hectare production inputs are predetermined at estimated 1988 levels. This precludes the possibility of adjusting inputs (e.g., fertilizer) and pruning decisions each year in response to anticipated movements in coffee prices. It was not possible to include these options in the model in the absence of suitable data about their effects on yields.

Coffee receipts each period include cash-on-delivery payments for any coffee sold during the period, together with any delayed payments due that period from coffee sold in previous periods. For example, coffee sold under the existing marketing system generates receipts in four consecutive 4-month periods. To simplify the model, it is assumed that whatever marketing strategy is chosen for the first season harvest is also adopted for the following two seasons.

Only short-term credit is considered in the model and, following actual practice, is assumed to be repaid to the mills at harvest time. Credit can be borrowed in any period, so the longest duration of any one loan is 12 months. However, since loans can be rolled

over from one year to the next simply by borrowing anew, then longer-term borrowing is effectively possible.

Fixed costs include taxes, rents, and depreciation of farm buildings and equipment. While the farmer has some flexibility in choosing when to pay these costs, the model includes constraints on the minimum mounts that must be paid each period.

If there were no price uncertainty in the model, then only a single cash flow equation would be required for each 4-monthly period. However, since coffee prices are uncertain, it is necessary to keep track of the cash balances available at the end of each period for each possible sequence of coffee prices. To facilitate this objective, we approximate the probability distribution of prices for each marketing strategy with five discrete price outcomes, and use a discrete stochastic programming approach (Cocks, 1968; Rae, 1971a; Rae, 1971b; Turvey and Baker, 1990).

For the first period in the model, there is no uncertainty about coffee revenue. The mills would already have announced their initial advance payable on delivery of the coffee. Moreover, if a cash price system were in place, this price would also be known. Only one cash balance equation is therefore required for this period, and this determines the cash balance available at the beginning of period 2.

For periods 2 and 3 of the first year, a cash flow equation is required for each of the five possible price outcomes that year. At the end of the year, there are five possible cash balances to carry over to the next year. The cash flows in year 2 must also allow for five possible price outcomes. However, since there are five possible cash balances

available at the beginning of the year, it is necessary to specify 5 x 5 = 25 equations for each period. This leads to 25 possible cash balances available at the beginning of year 3.

Year 3 also has five possible price outcomes for each marketing strategy, but since there are 25 possible cash balances available at the beginning of the year, it is necessary to track 25 x 5 = 125 cash flows for each period

The key decision variables in the model are the choice of marketing strategy, and the amount of cash to borrow, consume, save or to allocate to fixed costs in each 4-month period. Given a set of values for these choice variables, the model generates a series of nine 4-month consumption values corresponding to each of the 125 possible price sequences. Assuming an annual discount rate of 10 percent, these consumption streams are discounted to the beginning of the planning horizon, and provide the basis for defining the model's objective function.

If farmers are assumed to be risk neutral, then an appropriate objective function is the expected value of discounted consumption. Two modifications are required to deal with terminal conditions in the model. Since consumption could be arbitrarily increased in the model by borrowing heavily towards the end of the planning horizon, it is necessary to deduct the discounted value of any debt still outstanding at the end of year 3. Moreover, so as not to penalize the current marketing strategy, the discounted value of the final liquidation payment from the year 3 harvest is also added to the objective function.

An alternative objective function is also used that assumes farmers are risk averse and that their behavior conforms to the axioms of expected utility theory. The specific function chosen is:

$$\mu = \sum_i p_i \ln (V_i)$$

where V_i denotes the discounted value of consumption corresponding to the i^{th} the random price sequence over the three years, and the p_i is the probability of that sequence. This function assumes a constant absolute risk aversion coefficient equal to unity (see Newbery and Stiglitz, 1981, page 74).

THE MARKETING OPTIONS

Two alternative marketing strategies are evaluated with the model. The first is the current marketing system with its series of quarterly advances and a final liquidation payment in November of the year following harvest. This will be called the "November liquidation" option.

The second marketing strategy to be considered involves payment of a full "cash price at harvest". It is assumed that the mills would continue to export coffee from harvest until the following September, but they would hedge the price risks assumed from farmers in the New York futures market. The cash price paid for farmers would, therefore, be based on the average quotation at harvest time for December through September futures contracts in New York. The New York spot price and Costa Rica export price are sufficiently related that only a small basis risk would be involved (Claessens and Varangis, 1993).

The model was initialized to early November 1998. To estimate a discrete probability distribution of prices for the November liquidation scheme, the liquidation prices paid by a representative mill during 1979/80 to 1988/89 were obtained. These

prices were adjusted to constant 1987/88 prices and, based on a regression analysis, were found to be free of trend. The cumulative distribution of the prices was then plotted and divided into five equal intervals. The prices and associated probabilities at the midpoints of these intervals provided a 5-outcome approximation to the price distribution. The same price distribution was used for each of the three liquidations in the model's planning horizon. This assumes that price shocks are statistically independent over time, and this was confirmed by statistical tests.[1]

Advance payments were assumed to be directly proportional to the liquidation price for each of the five possible price outcomes. The advances are distributed as follows: 50 percent in the harvest period, 20 percent in the second period, 10 percent in the third period, and a 20 percent liquidation payment in the harvest period of the following year. The harvest advance for 1988, which is nonstochastic in the model, was

[1] Based on an ARIMA analysis of world coffee prices from 1900 to 1988, Wil Martin (personal communication) found a significant second-order lag term of the form:

$$\Delta \ln p_t = \delta + \beta \Delta \ln P_{t-2} + e_t$$

where $\beta = 0.238$ and has a t value of 2.13. However, when this relationship is fitted to Costa Rican export prices for 1975/76-1988/89, the results are insignificant. A nonparametric runs test also supported the hypothesis that Costa Rican mill prices are randomly distributed across years.

set at half the 1979/80-1988/89 average liquidation price and the second advance was adjusted to bring the total of the two advances to 70 percent for each of the five possible price outcomes. Basing the harvest advance on 1979/80-1988/89 prices was deemed more appropriate than using the actual 1988 harvest advance, since this would have implied considerable prior information for the first year in the model.

To estimate the price distribution for a cash price scheme, data were obtained for 1979 to 1988 on the price of New York futures contracts for December, March, June and September deliveries as quoted in the first week of December each year. Assuming a linear sales strategy from December to September, an average contract price was calculated for each year. This was then converted into a local mill price in Costa Rica.[2] The price series used does not allow for transaction costs or for the cost of credit that the mills would have to borrow to pay the full cash price. However, once the farm model has been used to calculate the value of a cash price system to farmers, we can determine whether the gain would be large enough to exceed a reasonable level of transaction costs.

Once the 'cash price at harvest' series was obtained for 1979/80-1988/89, the cumulative distribution was plotted and used to estimate a 5-outcome approximation to the price distribution. This was used to quantify the possible cash price outcomes for

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[2] The necessary data to directly transform these average New York contract prices into local mill prices in Costa Rica did not exist; hence, the following procedure was adopted. First, the average contract price for each year was expressed as a ration (c_t) of the 1979-88 mean contract price. Second, each of these ratios was multiplied by the average 1979/80-1988-89 November liquidation price from the representative mill (x_t). This gave a cash price series ($z_t = c_t x_t$) for the mill that has the same mean as the November liquidation price series (since $\sum c_t = 1$), but which is perfectly (and positively)

years 2 and 3 in the model. Since the cash price for the 1988 harvest would have been announced by early December 1988, a single outcome is appropriate for that year in the model. This price was set at the 1979/80-1988/89 mean.

MODEL RESULTS

The model was calibrated to two representative farm situations, and all the technical coefficients and resource constraints in the model were calibrated to these two farm situations. One is a typical small family farm in a high-altitude coffee growing area of the Central Valley with 3.2 ha of coffee land. The coffee farm provides about 50 percent of family income; the farmer also works part time as a real estate agent and co-owns a livestock ranch on the Atlantic coast. The farmer has few financial reserves, belongs to a milling cooperative, and borrows regularly against his coffee crop. The farm is planted entirely to modern varieties, and employs two regular workers in addition to seasonally hired labor.

The second farm is larger (14.0 ha of coffee land) but is located in a lower altitude area. The family is part owner of a second coffee farm, but is entirely dependent on coffee income. The coffee is sold to a private mill, and the mill provides a regular source of seasonal credit. Most of the bushes have been replanted with modern varieties, and the farm employs 3 regular workers in addition to seasonal help.

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correlated with, and has the same coefficient of variation, as the average New York futures price series.

The results from the two farm models are summarized in Tables 5 and 6. The model solutions give the optimal cash management decisions by 4-month periods for

Table 5: Model results for alternative marketing strategies, small coffee farm[a]

Marketing Strategy	Discounted Consumption		Average Consumption			Average Borrowing		
	Expected Value	Standard Deviation	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3
			(Thousands Colones)					
Risk Neutral Behavior								
A. *Interest Rate 12%*								
November Liquidation	700	167	299	238	246	161	138	119
Cash at Harvest	743	97	588	255	132	318	320	200
B. *Interest Rate 50%*								
November Liquidation	683	168	138	269	269	-	-	-
Cash at Harvest	714	97	269	269	269	-	-	-
Risk Averse Behavior[b]								
C. *Interest Rate 12%*								
November Liquidation	699	166	299	384	91	161	283	119
Cash at Harvest	741	97	588	351	29	318	417	200

[a] The farm has 3.2 ha. of coffee land, of which 2.67 ha. are productive trees.
[b] Relative risk aversion parameter equals unity.

Table 6: Model results for alternative marketing strategies, large coffee farm [a]

Marketing Strategy	Discounted Consumption		Average Consumption			Average Borrowing		
	Expected Value	Standard Deviation	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3
Risk Neutral Behavior			(Thousand Colones)					
A. *Interest Rate 12%*								
November Liquidation	2,273	732	1,030	799	669	727	677	493
Cash at Harvest	2,463	427	2,238	816	404	1,359	1,364	957
B. *Interest Rate 50%*								
November Liquidation	2,194	738	310	870	879	8		-
Cash at Harvest	2,329	427	879	879	879	-		-
Risk Averse Behavior[b]								
C. *Interest Rate 12%*								
November Liquidation	2,262	722	1,078	1,033	349	775	96[illegible]	493
Cash at Harvest	2,450	418	2,819	457	135	1,941	1,615	957

[a] The farm has 14.0 ha. of coffee land, of which 10.52 ha. are productive trees.

[b] Relative risk aversion parameter equals unity.

each of 125 possible sequences of price outcomes. These results have been averaged over the possible price outcomes for each year in the tables. The standard deviation of discounted consumption summarizes the variability in discounted consumption over the 125 possible price sequences.

With risk neutral behavior and a 12 percent interest rate (panel A in Tables 5 and 6), the 'cash at harvest' marketing option is marginally superior to the November liquidation strategy. The expected value of discounted consumption is 6.1 percent greater for the small farm and 8.3 percent greater for the large farm. It is doubtful, though, whether these gains are sufficiently large to offset the commissions and interest charges that mills would have to charge in order to offer cash prices at harvest.

Introducing risk averse behavior leads to little change in coffee growing decisions, or to the expected value of discounted consumption (panel C in Tables 5 and 6). Risk aversion does change the yearly amounts of credit and consumption used, but this simply demonstrates some degeneracy in the model for many of the financial decisions. More importantly, the 'cash at harvest' marketing strategy has a much lower standard deviation of discounted consumption (42 percent lower for both the small and large farm). Hence, if coffee farmers were risk averse, then the 'cash at harvest' marketing option should be much more attractive than the current November liquidation system. For example, assuming a linear E,σ approximation to the utility function of the form $U = E - 1.5\sigma$, then the expected utility of discounted consumption for the 'cash at harvest' option would be 32 percent greater than the November liquidation option for the small farm (450 verses 596 colones), and 55 percent greater for the large farm (1179 versus 1823 colones).

Differences of these magnitudes would warrant attempts to implement the proposed 'cash at harvest' marketing strategy. But as we have already seen, the available evidence does not support the hypothesis that Costa Rican coffee farmers are risk averse.

Both farm models consistently borrow credit in all three years of the planning horizon when the interest rate is 12 percent. However, credit is not really required to cover seasonal farm costs and borrowing is driven by desired patterns of consumption including income smoothing over years. This is shown in the panel B results where an interest charge of 50 percent leads to virtually no borrowing but without leading to much change in discounted consumption. Despite the loss of credit to smooth consumption, the benefit of the 'cash at harvest' strategy does not improve over the November liquidation strategy. In fact, the gain in the expected value of discounted consumption declines slightly for both the small and large farm.

4. CONCLUSIONS

Costa Rican coffee farmers are almost fully exposed to the volatility in world prices. Yet, despite small farm sizes, a high degree of specialization in coffee, and a current marketing system that prolongs uncertainty and aggravates cash flow problems, most farmers still seem to manage their price risks surprisingly well. Farmers are well informed about the international coffee market, and are able to forecast prices up to 16-17 months ahead with a degree of accuracy that is comparable to the New York futures market. They have a favorable seasonal cash flow as well as good access to production credit from the coffee mills and which, because money is fungible, is used to achieve

desired patterns of household consumption over time. Farmers are also relatively wealthy and are willing and able to bear risk. Within this context, the potential gains from using the New York futures market to provide a full cash price at harvest are relatively modest; about 6 percent and 8 percent of the expected value of discounted consumption for small and large farms, respectively. The size of these gains would increase, however, if coffee farmers were to become more risk averse, but this seems unlikely unless there is a sharp decline in their wealth levels.

The size of the potential gains to growers from moving to a full 'cash price at harvest' marketing scheme is probably too small to warrant the additional costs that the mills would incur in implementing the scheme. These costs would include commissions on futures trading, interest charges on loans that the mills would have to borrow in order to pay cash on delivery, and the basis risk that the mills would bear because the Costa Rican and NY prices are not perfectly correlated. The mills would also have to be convinced that such a marketing scheme would serve their own interests, and as Claessens and Varangis (1993) have suggested, this may require several institutional changes to bring about a greater congruence of interest between mills and growers.

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