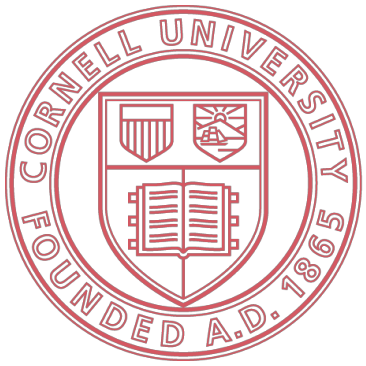
Staff Paper

Small Farmers and Big Retail: trade-offs of supplying supermarkets in Nicaragua

Hope Michelson, Thomas Reardon, Francisco Perez

Staff Paper 2010-02 **April, 2010**



MICHIGAN STATE UNIVERSITY

Department of Agricultural, Food, and Resource Economics
Michigan State University
East Lansing, Michigan 48824

Small Farmers and Big Retail: trade-offs of supplying supermarkets in Nicaragua

Hope Michelson, Francisco Perez and Thomas Reardon [*†]

May 4, 2010

Abstract

In Nicaragua and elsewhere in Central America, small-scale farmers are weighing the risks of entering into contracts with supermarket chains. We use unique data on negotiated prices from Nicaraguan farm cooperatives supplying supermarkets to study the impact of supply agreements on producers' mean output prices and price stability. We find that prices paid by the domestic retail chain approximate the traditional market in mean and variance. In contrast, we find that mean prices paid by Wal-mart are significantly lower than the traditional market but that Wal-Mart systematically reduces price volatility compared with the traditional market. We find some evidence, however, that farmers may be paying too much for this contractual insurance against price variation.

keywords: small farmers, supermarkets, contracts, Wal-Mart, Latin America, Nicaragua

[*]The data and qualitative details in this analysis were gathered in Nicaragua between September 2007 and July 2008 in collaboration with the Nitlapan Institute at the Universidad Centro Americana. Producer cooperatives with ongoing supply relationships with the two major food retail groups operating in Nicaragua provided data on prices received and quantities sold over time and traditional market data was accessed through Nicaragua's governmental statistical agency. Veronica Palladino helped gather data on supermarket retail outlet growth. This material is based upon work supported by the United States Agency for International Development via the Assets and Markets the BASIS Assets and Market Access Collaborative Research Suport Program and the Social Science Research Council.

1 Introduction

Supply relationships between supermarket chains and small farmers in the developing world represent a key intersection of current critical dimensions of economic theory and policy: participation of the rural poor in regional and global markets; possibilities for rural entrepreneurship in developing world contexts; and contract negotiation between small, constrained growers and large, well-capitalized buyers to resolve idiosyncratic market failures.

This paper uses data from Nicaraguan supermarket contracts to analyze market relationships emerging between farmers and supermarkets. The contracts we examine are negotiated by three Nicaraguan farmer-cooperatives and vary both over supermarket chains and over time. Using these data we can establish for the first time how supply agreements impact farmers' output price distributions compared with the traditional market and how contract terms change over time. The resulting analysis offers a new perspective on potential payoffs to participation in supermarket supply chains for farmers.

Research has focused both on understanding whether and why supermarkets source from small farmers and on establishing welfare impacts of supply relationships on small farmers. Considerable research has anticipated (Barrett and Reardon, 2000; Blandon *et al.*, 2009; Key and Runsten, 1999; Kirsten and Sartorius, 2002; Gibbon, 2003) and identified (Dolan and Humphrey, 2000; Boselie *et al.*, 2003; Reardon *et al.*, 2003) the exclusion of small farmers from supermarket supply chains. Other findings suggest that small farmers are included (Maertens and Swinnen, 2009) or find that inclusion is confined to those small farmers who are relatively well-capitalized with non-land capital such as irrigation (Hernández *et al.*, 2007), or who gain access through established producer associations (Balsevich *et al.*, 2005).

Most of the research analyzing participation in supermarket supply chains also considers the impacts of that participation. There has been less rigorous analysis as yet of the way that supermarket supply relationships impact participants' mean output prices and price stability. Typically, the approach has been to compare average returns per kilogram, perhaps controlling for quality, between farmers supplying to supermarkets and those not. The extant literature does not empirically test for increased farmer mean profit or decreased marketing risk under contractual relationship with a supermarket. For example, in their study of supermarket suppliers in Senegal, Maertens *et al* (2008) write "small farmers...reduced production and marketing risks" (p.5). Similar assumptions can be found in Swinnen (2007), Boselie *et al* (2003), Kirsten and Sartorius (2002), Neven and Reardon (2008), and Swinnen and Maertens (2007).

Two important gaps thus exist in the literature. First, no paper has addressed whether the terms of exchange for small farmers – both level and variance – are better or worse

with modern versus traditional retail. Second, while there has been measurement of the average payoff over channels using farm data, the robustness of these findings has not been validated over time, over contract types, or chains. Moreover, the analysis has been confined to study of the average payoff, with little attention to variability in payoff. A number of works have posited that supermarkets reduce output price variability but have lacked data to test whether variability is reduced and by how much.

Building on the insights of existing research, we use historical prices negotiated between supermarkets and farmers to analyze for the first time the average payoff and payoff variability of supermarket channels compared with the traditional market. We find that prices in La Colonia, the domestic chain, approximate the traditional market in mean and variance. In contrast, we find that mean prices paid to suppliers of Wal-mart supermarkets are significantly lower than the traditional market. Instead, we find that Wal-Mart supply agreements represent significant reductions in price risk to farmers over the traditional market. Deriving farmers' implied relative risk aversion from these contracts, we find some evidence that farmers may be paying too much for this implicit insurance against price variation. Our findings, which support the extant hypothesis in the literature that supermarkets decrease output price variability, add new evidence to the current debate regarding supermarkets in the developing world as agents of change and economic stimulus.

This study uses data collected from two primary sources. First, we gathered from three farmer cooperatives detailed records of the historical prices negotiated with supermarkets. Figure 1 presents the sequence and coverage of the price data from cooperatives. Second, we use historical (January 2001–June 2008) traditional market weekly price data from the Nicaraguan government Ministry of Agriculture and Forestry (MAGFOR) office.

Because our analysis compares crop prices across marketing channels, we have given careful consideration to possible quality differences between markets. Based on interviews with supermarket buyers and traditional market wholesalers as well as considerable time spent observing transactions in wholesale markets and supermarkets, we have found that supermarkets in Nicaragua purchase the premium share of a farmers' production for the horticultural crops studied here. Our results indicate that the mean supermarket purchase share of farmers' total production is close to 70 percent. The 70 percent supermarkets purchase is carefully culled: for example, Wal-Mart follows a tightly-guarded manual of product-specific quality standards, codifying required attributes such as variety, size, coloration, cleanliness, damage, and weight. La Colonia follows a similar quality selection process. In contrast, traditional market wholesalers purchase nearly 100 percent of a seller's production, buying all size grades, discarding only damaged or extremely small vegetables or fruits.

Because supermarkets purchase less than 100 percent of the farmers' production and because that share is carefully edited to meet chain-specific standards, our analysis assumes that mean product quality in the supermarket channel is at least as high as the traditional

channel. Because we compare a product in the supermarket chain with quality at least as high as the traditional market, our finding that mean prices in the supermarket chain are not significantly higher than in the traditional market is made even stronger.

[Figure 1 about here.]

The next section provides context: critical features of the Nicaraguan traditional and modern horticulture markets, the population of horticulture producers, and the operations of the two primary supermarket chains operating in the country. The third section analyzes the mean and variance in output price, comparing supply agreements between farmers and supermarkets in Nicaragua to the traditional wholesale market. A fourth section derives coefficients of farmer relative risk aversion to evaluate the mean/variance trade-off for a producers' cooperative in the Wal-Mart supply chain. The final section concludes.

2 Fresh fruit and vegetable production in Nicaragua

Nicaragua's population of horticulture producers constitutes a tiny share of total farmers. According to the country's 2001 agricultural census, while 76 percent of landholding farmers grew basic grains including maize, beans, and sorghum, only 2.14 percent cultivated tomatoes, 1.23 percent green peppers, and 0.25 percent cabbage (MAGFOR, 2001).

Statistics on irrigation suggest the existence of dual production structures in Nicaragua's tiny horticulture sector; approximately one-third of 2001 horticulturalists were equipped with production and price risk-mitigating irrigation. Moreover, the population of irrigated horticulturists in the 2001 agricultural census was split between large growers (19.6 percent) and small and medium growers with less than seven hectares (17.2 percent).

This production dualism defined by irrigation is critical to producers' experience in seasonally volatile horticulture output markets. Rainfed Nicaraguan horticulture farmers generally produce one or two seasons of crops each year and sell their harvest in a regional spot market or to a buyer at the farmgate. Nicaraguan small farmers without irrigation describe a volatile boom-bust cycle of fresh fruit and vegetable farming driven primarily by output swings in the market. The farmer without irrigation, cold storage, or means to move perishable product quickly to another zone must sell when there is a local glut and suffer the price drop. Thus, farmers without irrigation are likely to be more concerned about price variability than those with irrigation who can sell in times of high prices and benefit from price variation.

Dualism in the Nicaraguan horticulture production sector therefore suggests a potential tension in supermarket contract adoption. While the supermarket is likely to prefer irrigated farmers who can offer the retailer steady supply streams throughout the year, those with irrigation and capacity have less incentive to adopt the contract given that they are

already playing the market, riding out the ups and down of the output price. Conversely, rainfed horticulture farmers struggling to manage high price volatility will have more incentive to adopt the supply contract but are likely to be hindered by a lack of productive capacity.

A third-party program funded by the United States Agency for International Development (USAID) has emerged in Nicaragua to equip small farmers with the liquidity and irrigation systems to permit an intensive farming schedule and to begin to resolve this contracting asymmetry. In June, 2006 USAID contracted with four multinational NGOs to begin working with farmers on a three-year, $20 million project (USAID and Nicaragua, 2006) designed to meet the needs of supplying supermarkets in Nicaragua.

These intermediary NGO programs seem to have obviated supermarkets' distinction between farmers with irrigation and without. We observe that farmers adopting supply contracts in this analysis are largely those likely to value the price stability associated with the contract and the capacity building facilitated by the NGO: small farmers without irrigation before the program. The 54 suppliers who are members of the three cooperatives included in this analysis are overwhelmingly drawn from the rainfed horticulture sector. Table 1 disaggregates supplier farmers according to their 2001 landholdings and irrigation in the year before supply chain entry; mostly small farmers (77.8 percent) and mostly without irrigation (88.9 percent).

[Table 1 about here.]

2.1 Supermarkets in Nicaragua

Two companies dominate Nicaragua's supermarket retail: La Colonia is a 10-store (2008) family-owned national chain that has operated in Nicaragua since the late 1960s; and Wal-Mart Central America, which acquired a controlling stake in Corporacion de Supermercados Unidos' (CSU) 380 Central American retail outlets in April 2006. As of May 2009, Wal-Mart had expanded CSU's 33 retail stores in Nicaragua to 52 Nicaraguan outlets.

The two retail groups have developed distinct procurement strategies. La Colonia relies heavily on a network of traditional wholesalers as well as approximately 50 preferred small farmers working alone or in one of two producer cooperatives. Because La Colonia has no warehouse, the company holds minimal inventory between purchases and suppliers daily transport fresh produce to the chain's headquarters in Managua.

Wal-Mart has taken a different approach to developing a domestic supply chain in Nicaragua, using buyers to source products in rural areas rather than relying on farmers to manage transport. Wal-Mart's procurement division picks up production from supplier farmers in the farmers' field or community. As Wal-Mart has extended procurement and retail into

more remote regions, the company has kept transport costs down by using supply trucks to backhaul agricultural production to the central warehouses.

3 Small farmer outcomes: price mean and volatility

Taking the contract choice as given, in this section we use data from traditional markets and producer cooperatives to study how supply agreements between small farmers and supermarkets impact mean price and price stability.

Units of analysis: per kilogram prices at farmgate

Our analysis uses per kilogram farmgate prices to compare the traditional and supermarket channels. Transaction sites vary by supply chain, so we equalize prices at the farmgate by subtracting transport costs to comparison markets. We describe briefly how the farmgate price series are constructed.

Because Wal-Mart picks up products sourced from farmers in farmer communities well outside the capital city, we equalize transport costs between the Wal-Mart farmgate prices and the Managua-sited transactions of La Colonia and the traditional wholesale market. We subtract cooperative-specific transport costs from the La Colonia and Managua traditional market prices.[1] Once we equalize transport costs, we can compare farmgate prices between our three price series: traditional (Managua), Wal-Mart (farmgate), and La Colonia (Managua).

Unless otherwise noted, prices are compared between supermarket and traditional market channels over equivalent time periods. That is, if a contract relationship between a supermarket and a cooperative lasted between April 2005 and November 2006, the comparison traditional market price series is considered for the same period. Also unless otherwise specified, all prices in the paper have been adjusted to July 1999 Cordobas. One January 2008 US$= 14.53 July 1999 Cordobas ($C). Computed farmgate prices are gross per kilo; we do not subtract production costs of the farm.

Non-transport related transactions costs

We have observed that farmers selling to supermarkets generally incur the standard transactions costs of the traditional market in addition to the costs of sorting, grading, cleaning, and packing production to meet supermarkets' specific quality criteria. We therefore assume that non-transport related transactions costs are at least as high in the supermarket channel as in the traditional wholesale market. Significant qualitative and survey evidence motivates our assumption. To begin with, both La Colonia and Wal-Mart demand significant cleaning, selecting, and sorting of the product to meet stipulated quality standards. These costs are not incurred in the traditional channel. Moreover, as discussed in the intro-

duction, while farmers can sell all of their production in traditional markets with minimal loss due to quality grading, our data indicate that farmers supplying supermarkets sell approximately 70 percent of their production.[2] Because the supermarket does not purchase all of a farmers' production, farmers and cooperatives are generally in multiple markets, selling product rejected by the supermarket to a broker at farmgate or to a wholesaler in a local or regional market. This means that participant farmers generally incur the transactions costs of two markets instead of one.

3.1 Supermarkets do not increase mean prices

Because supermarkets purchase a premium share of the farmers' production and require post-harvest processing beyond the demands of the traditional market, we expect farmers selling to supermarkets to receive higher mean output prices for their production. We can test whether mean per kilo prices in the supermarket channel are significantly higher than in the traditional market by matching data collected from cooperatives with traditional market prices over corresponding periods. Because the two retail chains' distinct procurement strategies have important implications for the analysis, we evaluate the chains' contract prices in turn.

Wal-Mart

The timing of the contract observations is valuable to understanding the sequence of Wal-Mart supply agreements. We observe two epochs of Wal-Mart supplier relations: the Sébaco cooperative is an example of first-generation Wal-Mart supply agreements and Ocotal a second-generation contract. The Sébaco cooperative sold to Wal-Mart between April 2005 and November 2006 but left the Wal-Mart relationship to supply La Colonia, providing us with an observation of a cooperative that operated in both supermarket channels and demonstrated a preference for La Colonia over Wal-Mart. The Ocotal cooperative contracted with Wal-Mart as the Sébaco cooperative left the supermarket in mid-2006.

In the top half of Table 2 we compare mean per kilo farmgate prices between Wal-Mart and the traditional market using a standard ttest to test for equivalence in means between the traditional market and supermarket farmgate price distributions.

We find that, for both first and second-generation contracts, mean per kilo prices for both salad and roma tomatoes are significantly lower selling to Wal-Mart than the traditional channel for both cooperatives. The gap in mean prices across the channels is striking and economically significant; the difference between Wal-Mart and the traditional market price (as a percent of the Wal-Mart price) is between 34 and 54 percent.

Note that farmgate prices in Table 2 were negotiated and reported by cooperatives assisted and at least partially financed by NGOs. These cooperatives sell in bulk quantities via one

group transaction to the supermarkets, reducing buyer coordination, quality assessment, and transport costs. Because of the convenience, quality, and bulk quantity attributes they offer the supermarkets, these suppliers are positioned to negotiate relatively a high price with supermarkets. Yet here we find the opposite.

La Colonia

In the bottom half of Table 2 we compare the La Colonia price series against their traditional market counterparts for the Sébaco and Tomatoya cooperatives.

We find that La Colonia's mean farmgate prices compare somewhat more favorably to the traditional market than Wal-Mart. La Colonia represents a mix of both higher and lower mean farmgate prices than the traditional market. Over the specified time periods[3] we find: La Colonia's mean lettuce farmgate prices are significantly lower than traditional market sales; La Colonia's mean salad tomato and cabbage prices are significantly higher than the traditional market channel; and we fail to reject the hypothesis of the equivalence of mean farmgate prices between the La Colonia channel and the traditional market for per kilo roma tomato and small green peppers.

[Table 2 about here.]

Results in Table 2 demonstrate two general results. First, prices in the supermarket supply channel are not always significantly higher than the traditional market. Second, La Colonia offers a mean price that is a much closer approximation to the traditional market while Wal-Mart compares relatively poorly with the traditional market, paying suppliers significantly below parity.

These results are even more surprising given that prices in Table 2 are gross of post-harvest production costs specific to the supermarket chain including cleaning, selection, and packing. For example, Sébaco cooperative farmers who sell to La Colonia contribute three percent of their sales proceeds for administrative services and weekly pay a team of ten women who select and clean produce $C 100 apiece (2008 Cordobas). So the net supermarket farmgate price is even lower than reported above. Again, because of the post-harvest processing and selection costs incurred by the farmer cooperative we would expect a significantly higher mean price. Yet this is not what we find.

Our analysis of supermarkets' relative mean price raises two interesting questions. Why might farmers accept a low price for a quality product if a higher traditional market price was available? And why are mean farmgate prices with Wal-Mart systematically lower than the traditional market relative to La Colonia?

One explanation for the differences between the chains in Table 2 is the difference in procurement structures distinguishing the Wal-Mart supply network from the La Colonia system: Wal-Mart sends its trucks to the farmers' community to source production while La Colonia suppliers make the trip to the supermarket's Managua headquarters themselves.

Wal-Mart, therefore, can exploit the existence of regional spatial market segmentation in horticulture by assuming the transportation costs and logistical risks of sourcing the crop in the field.

Evidence that field brokers at farmgate pay a price below the extant wholesale market price less transport costs would suggest the presence of market segmentation; an opportunity for Wal-Mart's procurement and contracting. Table 3, which compares per kilo mean prices farmers reported receiving at farmgate from traditional wholesalers, presents evidence to this effect. Surveyed farmers were asked maximum, minimum, and most common (modal) price observed for their most remunerative crop. A triangle distribution was used to infer the mean of the regional farmgate wholesale price paid by field brokers. For comparison, we include corresponding Wal-Mart, La Colonia, and Managua mean per kilo farmgate prices.

[Table 3 about here.]

Evidence in Table 3 suggests the existence of asymmetries in Nicaraguan horticulture markets in which local brokers sourcing at farmgate can pay a price below the extant wholesale market price less transport costs. Significant margins in Table 3 separate the per kilo prices farmers report receiving from traditional wholesalers at the farmgate and documented farmgate per kilo prices (price less transport) in the Managua market. Wal-Mart mean farmgate prices most closely approximate prices reported by farmers transacting with traditional buyers at the farmgate in Table 3. Note that we cannot use this data to actually test for the presence of supernumerary profits and thus local market power for either field brokers or Wal-Mart.

Evidence in Table 3 suggests the existence of spatial market segmentation that might result from a lack of public or private transport to take crops to market, credit to finance transport, or coordination failures to bulk production with other farmers. The assumption that Managua per kilo wholesale prices less transport costs should equal farmgate prices is based on a further assumption: that farmers can transport the crop to Managua themselves or that competition among farmgate traders bids away supernumerary-profit. A failure in the capital markets for small farmers, however, increases the price of transporting the crop if farmers cannot secure funds to purchase or rent transportation. A second problem could stem from limited competition among farmgate wholesalers in rural output markets; regional wholesaler monopsonies preserve trader marketing margins. Simultaneous failures in these two markets, high opportunity costs of farmer time, or coordination failures among farmers leave resource-poor small farmers to accept the low price offered by traders at the farmgate.

Evidence of supernumerary marketing margins separating farmgate prices from central markets in an environment of capital constrained farmers suggests an opportunity for arbitrage by a well-capitalized intermediary like Wal-Mart. Reaching deep into the country-

side, Wal-Mart's supply network facilitates participation by farmers who would otherwise lack the capital to transport product to the central market in Managua. The company can therefore take advantage of the significant price margins separating the city from the countryside, negotiating a per kilo farmgate price better than what traditional farmgate wholesale buyers offer rural farmers yet still significantly below the Managua price (less transport costs). Of course, it may be that Wal-Mart assumes significant procurement costs and earns no profit on the provision of procurement in farmers' communities. However, Wal-Mart's scale and efficiency imply bulk transport costs significantly less than the cooperatives' transport costs. These are possibilities that we cannot test using our current data.

La Colonia's transaction proximity to the Managua market explains why the domestic chain's prices tend to approximate or exceed the per kilo farmgate prices estimated from the Managua market prices (Table 2). La Colonia cannot take advantage of the spatial arbitrage opportunity because its suppliers come to Managua to make semi-weekly deliveries. La Colonia suppliers are equipped with trucks; they make habitual stops to sell excess supply at the Managua markets after delivering product to the supermarket.

3.2 Supermarkets stabilize output price

We examine in this section how per kilo farmgate price volatility differs across supermarket and traditional channels. Our analysis of whether supermarkets decrease output price volatility relative to the traditional market begins with a comparison across channels using statistics on channel variances and coefficients of variation. We then use first order stochastic dominance tests to more systematically study the producer's mean-variance tradeoff across traditional and supermarket channels.

Significant price volatility is a serious concern for farm households. When firms profit maximize, the convexity of the profit function implies a firm prefers price volatility. But if household production and consumption decisions are nonseparable and the household is income risk averse then the household is also price risk averse. Residual uninsured risk exposure can lead to inefficient production and investment as households routinely undertake costly measures to reduce exposure. A decrease in output price risk can be expected to lead to improved efficiency in production and investment.

Data from farmer cooperatives and the traditional market support the hypothesis that supermarkets reduce price volatility over the traditional market. Table 4 reports the first and second moments of producer cooperative and traditional market price distributions using the price data analyzed in Table 2. As in the analysis of mean prices across channels, we consider relative price variance by supermarket chain in turn.

[Table 4 about here.]

Wal-Mart

The first and second moments of the price distributions reported in Table 4 suggest that Wal-Mart's suppliers negotiate a mean/variance tradeoff; a lower mean per kilo farmgate price is paired with less volatile price for all Wal-Mart crops and both first and second-generation contracts. Initial comparisons across moments of distributions in Table 4 suggest that the Wal-Mart relationship systematically dampens the volatility in farmgate per kilo prices compared with the traditional channel, but the exchange for this tempering may be a reduction in mean price. Coefficients of variation in the Wal-Mart channel are uniformly lower than the traditional market.

La Colonia

As we found in our comparison of mean prices across channels (Table 2), La Colonia exhibits trends that are both distinct from Wal-Mart and distinct across crops. For example, the traditional lettuce market offers a more stable, higher mean per kilo farmgate price; La Colonia exhibits a higher mean and lower variance price for salad tomatoes; but cabbage prices are characterized by a higher mean with the supermarket and slightly higher variance.

We can more systematically study the producer's mean-variance tradeoff across channel-specific price distributions by testing the stochastic dominance of supermarket price distributions against the traditional market farmgate price distribution. Each crop-specific pair of price distributions is characterized by cumulative distribution functions F_T and F_S for the traditional and supermarket channels, respectively. For all monotonically increasing utility functions, distribution F_S first-order stochastically dominates (FOSD) distribution F_T if $F_S(x) \geq F_T(x)$ for all farmgate price levels, x. Using first order stochastic dominance tests, distributions can be ranked according to their returns. The weakness of the first order stochastic dominance test is that it is a partial ordering, unable to rank distributions whose cumulative distribution functions cross.

For the stochastic dominance tests, we use all dates for which we have price information for the traditional market. We include prices for all recorded dates for the traditional market under the assumption that the full 2001-2008 series better reflects the true intertemporal distribution of per kilo prices in the marketplace. To compare 2001-2008 prices with the period of the supply relationship we must assume both that the underlying price generating process is unchanged and that farmers perceive the 2001-2008 distribution as a consistent representation of the distribution of farmgate prices that they face.

Note that the comparison of per kilo prices below using stochastic dominance tests (Table 5) should be treated as a best-case scenario in a comparison of expected revenues across traditional and supermarket channels. The reason: our analysis compares per kilo farmgate prices while a comparison of total revenues would interact the price distribution under the supermarket with quantities sold. Evidence from our household survey data and farmer

interviews suggest that supermarket relationships can introduce new areas of uncertainty into the producer portfolio of marketing risks. We have discussed supermarkets' tendency to purchase less than a farmer's total production. Moreover, supermarket agreements can increase a farmer's risk of total loss should the supermarket renege on the sales agreement at the time of harvest through failure to purchase or failure to pay. For example, our data suggests that the likelihood of loss due to supermarket failure to make payment is significantly higher than the traditional market; the reported annual incidence of supermarket payment default is 1.3 percent, nearly double the traditional market incidence rate at the farmgate and 14 times the payment default rate reported in regional markets.

Given that the supermarket represents an increase in both the probability of buyer default and of rejections resulting from standards enforcement, the supermarket per kilo revenue distribution will always have a higher mass at zero than the traditional markets. Therefore a dominance test comparing total revenue distributions between the traditional market and the supermarket channel, the distribution of possible total revenue outcomes under the supermarket can never first order dominate the traditional market.

La Colonia

Table 5 presents a summary of the results of stochastic dominance tests. Figure 2 plots the cumulative distribution functions (CDFs) for both salad and roma tomatoes for La Colonia and the first and second-generation Wal-Mart contracts, illustrating the first order stochastic dominance tests in Table 5. As expected from results in Tables 2 and 4 La Colonia price CDFs in some cases dominate and in others are dominated by the traditional channel.

[Table 5 about here.]

[Figure 2 about here.]

Wal-Mart

As with the mean price comparisons, the sequence of Wal-Mart supply agreements is critical to interpreting the FOSD tests. Results in Table 5 and the second row of Figure 2 indicate that traditional market first order dominates the supermarket for Wal-Mart's early first-generation contracts for roma and salad tomatoes from Sébaco.

In the FOSD joint analysis of the first and the second moment of the price distribution we see evidence of Wal-Mart's contractual evolution with its suppliers. In a departure from the earlier contracts, Table 5 and the bottom row of Figure 2 demonstrate that the second-generation contracts for tomatoes from Ocotal were not strictly dominated by the traditional markets; a cross in the CDFs renders the test inconclusive.

In fact, the dominated nature of Wal-Mart's first generation contracts may explain the introduction of the second-generation agreements. Early Wal-Mart supply agreements did

not increase mean farmgate prices for the farmer relative to the traditional market – indeed, our data indicates that these contracts were stochastically dominated by the traditional market.

The second-generation of Wal-Mart contracts codified what had previously been an implicit price insurance of the contract. Beginning in 2007, Wal-Mart introduced supply agreements that explicitly provide farmers insurance against price risks of the traditional market. The company also began moving NGO-backed farmers and farmer cooperatives to year-round production agreements featuring seasonal planting plans. In early 2008, farmers described three distinct contract types, all contracts pegged to a reference traditional market price, an average at the time of sale of the prices in two Managua wholesale markets and a regional market close to the farmer. The three contract types were: an average-price contract in which Wal-Mart pays the average traditional market price; a price-band contract in which Wal-Mart and the farmers fix an upper and lower bound on the average traditional market price and Wal-Mart pays the farmer the lower bound if the average falls below the lower bound and the upper bound if the average market price exceeds the upper bound; and a price-floor contract (introduced in 2008) in which Walmart and farmers fix a lower bound on the average traditional market price and Wal-Mart pays the average traditional market price less 15 percent or the floor price.

Wal-Mart and the Ocotal cooperative negotiated a price band contract in 2007. The mininmum negotiated price for roma tomatoes was 3.50 C$/kilo and the maximum 6.20 C$/kilo. The comparison means from the Managua wholesale market during this period was 5.02 C$/kilo and the reported mean farmgate price for roma tomaoes 4.43 C$/kilo (Table 3). Salad tomatoes had a negotiated minimum price of 5.52 C$/kilo, and maximum at 8.27 C$/kilo; the Managua comparison mean for salad tomatoes was 6.34 C$/kilo. The 2007 contract also set minimum and maximum prices for sweet bell pepper, small green pepper, jalapeno pepper, cucumber, and baby corn.

Both the price-band contract and the price-floor contract embed an insurance contract; the supermarket eliminates some share of traditional market downside price risk, truncating the lower tail of the traditional market price distribution. Producers pay for the insurance in the form of a reduced mean price. The bottom row of Figure 2 plots the CDFs for roma and salad tomatoes for the Ocotal cooperative for the tenure of their relationship with Wal-Mart through May 2008. The two figures in the bottom row clearly illustrate the critical difference between the banded Ocotal contracts and Wal-Mart's supply relationships with the Sébaco cooperative: the truncation of the bottom of the traditional market distribution. Ocotal cooperative farmers reported in March 2008 that they preferred these insurance contracts to the traditional market.[4]

A critical question we address to in the next section is how much farmers are willing to lower their expected mean price with the supermarket in order to truncate their distribution of possible per kilo prices. Do farmers pay too much?

4 Estimates of relative risk aversion coefficients

We have established that a primary impact of a supply agreement for small farmers is a reduction in price volatility. The contract reduces uninsured risk exposure that can discourage investment and innovation and risk averse households are expected to be willing to pay a premium to reduce risk exposure. Households have heterogeneous risk preferences; in general, poorer households are more risk averse and are willing to pay more than wealthy households to avoid a monetarily equivalent risk. In the context of our analysis, a higher willingness of poor households to pay to avoid price risk could provide another explanation for the willingness of supermarkets to work with small farmers.

We can determine whether farmers adopting Wal-Mart supply contracts are paying too much for the price risk insurance by using our data to compute the farmers' minimum relative risk coefficients that rationalize acceptance of the contract. By comparing derived relative risk coefficients with coefficients that have been estimated in the empirical risk literature we can assess the degree of risk aversion implied by preference for the contracts over the wholesale markets. Derived coefficients that significantly exceed ranges in the literature would imply that farmers are accepting a reduction in mean price which is too high.

Greater risk aversion is associated with a more curved utility function. The coefficient of relative risk aversion, R at income Y, is the elasticity of marginal utility at income Y. The dimensionless measure is defined as:

$$R(Y) = \frac{-YU''(Y)}{U'(Y)} \tag{1}$$

Newbery and Stiglitz' (1981) Taylor series approximation of certainty equivalent income gives an approximate definition of relative risk aversion: individual i's relative risk aversion is equal to income times two times the risk premium divided by the income variance.

$$R_i(\bar{Y_i}) = \frac{\bar{Y_i} 2\rho_i}{\sigma^2_{\bar{Y_i}}} \tag{2}$$

We assume that the traditional market price p_t is characterized by variance σ_t^2 and the Wal-Mart supply channel price is characterized by σ_s^2, with $\bar{p_t} > \bar{p_s}$ and $\sigma_t^2 > \sigma_s^2$. The risk premium, ρ_i, is equal to farmers' annual quantity of tomatoes transacted, Q_i, times the difference in mean per kilo farmgate prices between the traditional and supermarket channels. Thus ρ_i is the mean revenue increment the farmer foregoes for the stability of the supermarket channel. We use predicted 2007 household income for $\bar{Y}$, regressing measured 2007 income on the household's vector of assets, geographic controls, and demographic characteristics to generate predicted income $\hat{Y}$. The variance $\sigma^2_{\hat{Y}}$ is the variance in income

attributable to accepting the bet, the price variance in the higher-mean traditional market, var(Qp_t) Equation 2 can be rewritten:

$$R_i(\hat{Y}_i) \geq \frac{\hat{Y}_i 2 Q_i(\bar{p_t} - \bar{p_s})}{Q_i^2 \sigma_t^2} = \frac{\hat{Y}_i 2(\bar{p_t} - \bar{p_s})}{Q_i \sigma_t^2} \tag{3}$$

Equation 3 has an intuitive interpretation. The minimum relative risk aversion rationalizing the investment in the supermarket supply chain is increasing in the difference between mean prices and decreasing in the variance of the traditional market and the quantity transacted.

We use household survey data from Ocotal cooperative members who sell to Wal-mart to compute farmer-specific coefficients of relative risk aversion. A second estimate uses farmers who quit supplying supermarkets but continued to grow roma tomatoes.

Table 6 presents computed ranges of coefficients of relative risk aversion for farmers with positive 2007 predicted incomes for current suppliers and farmers who left the supply chain (non-suppliers). Coefficient means are somewhat high given estimated coefficients generally range between one and three (Saha *et al.*, 1994; Chavas and Holt, 1996). The distributions of estimated coefficients suggest that some farmers' adoption of supply agreements implies implausibly large coefficients of relative risk aversion.

A second method to assess suppliers' revealed relative risk preferences is to fix R in Equation 3 and derive farmers' implied willingness to pay for the new distribution, given R. We assume $R(\hat{Y})$ to be equal to a range of values and estimate the maximum per kilo risk premium $(\bar{p_t} - \bar{p_s})$, the maximum mean price difference between the traditional and supermarket channels that rationalizes the adoption of the Wal-Mart contract. This per kilo risk premium can be thought of as the farmer's willingness to pay for the insurance against price volatility in the supply contract. We set $R(\hat{Y}) = 1, 2, 3$ – values that have been estimated in the literature using a range of utility functions and specifications (Saha *et al.*, 1994; Chavas and Holt, 1996). Bellemare *et al.* (2009) adopt a similar approach, pegging relative risk aversions coeffients in estimations of crop cross-price risk aversion coefficients.

The bottom section of Table 6 presents results from the second, willingness to pay method, in which we set values of relative risk aversion R and compute farmer-specific limits on the per kilo mean price reduction between the traditional and supermarket channel. The true observed per kilo difference in mean price between the traditional and supermarket channels is 2.03 C$/kilo. Therefore, a computed maximum willingness to pay less than 2.03 C$/kilo suggests that farmers at the assumed level of relative risk aversion should reject the contract, given their risk preferences and the price mean implied by the contract. The third and fifth columns of Table 6 indicate the percent of farmers (suppliers and non-suppliers) for

whom, given the assumed level of risk aversion, the supermarket mean/variance reduction, represents an economically reasonable choice over the traditional market.

Results in the lower half of Table 6 suggest that, over an established range of farmer risk aversion, most current supplier farmers' willingness to pay for the price insurance is less than the contract's 2.03 C$/kilo mean price reduction. That is, established levels of relative risk aversion cannot explain the adoption levels that we see.

As expected, as assumed coefficients of relative risk aversion increase in Table 6, the terms of the supermarket price distribution (specifically the reduction in mean price given the reduction in price variance) are attractive to a larger share of both current participants and non-suppliers. Notice comparing columns three and five that the terms of the supply contract are relatively more suited to the non-suppliers – that is, a larger share of non-suppliers at all levels of assumed relative risk aversion would accept the reduction in mean price for the reduction in volatility it implied. Part of what drives the higher relative suitability of the contract terms to the non-suppliers is that the derived maximum mean price reduction ($\bar{p_t} - \bar{p_s}$) is decreasing in income. As a group, the supermarket suppliers have significantly higher incomes than those not supplying supermarkets in Table 6 and thus their maximum acceptable reduction in mean price given an assumed level of risk aversion is relatively lower.

[Table 6 about here.]

Evidence in Table 6 suggests some farmers pay a high price for price volatility insurance in the Wal-Mart contract. Two possible explanations might account for participant farmers' apparent high willingness to pay for reductions in price volatility. First, our analysis may be picking up the difference between risk and loss aversion. If farmers are loss averse, with a strong preference to avoid sharp seasonal price drops, they might have a higher value for the insurance of the contract than our analysis can assess.

A second possibility is that farmers perceive the probability of an extremely low price in traditional markets to be significantly higher than reflected in the year-round data collected by the Nicaraguan government. We have shown that farmers adopting supermarket contracts are generally without irrigation at the time of adoption; their experience of horticulture markets prior to the supermarket is seasonal. When farmers adopt supermarket contracts, they are generally moving into year-round production and marketing for the first time.

Producers may base risk assessments on prior marketing experience, likely limited to brief periods of seasonal production characterized by high price volatility. Because traditional seasonal non-irrigated producers of horticultural crops tend to harvest and plant within the same narrow window as one another, they tend to be in the markets when prices are most volatile. If producers remember these market gluts acutely, they may be willing to accept from the supermarket contract a decrease in mean price in order to insure them-

selves against what is, in fact, a relatively rare event, a price crash in a local or regional market.

If this explanation holds, it would carry implications for the sustainability of Wal-Mart's contract structures and pricing over time. Farmers will update their beliefs about the underlying price distributions over time, learning the true annual price distribution as they switch to year-round cultivation, and their valuation of the contract may change. Moreover, we find that by 2008, 83.3 percent of the 54 supplier farmers in this analysis were equipped with some irrigation. Given supermarkets serve as the spur to move to a more intensive production calendar and investment in irrigation, and given that irrigation systems provide farmers with the capacity to ride out seasonal price fluctuations, it is not clear if, once equipped with irrigation, farmers will continue to value the supermarket contract.

5 Conclusions

Research into the consequences and possibilities of the expansion of supermarket operations in Africa, Asia, and Latin America has centered around establishing the economic and institutional conditions under which supply relationships between small farmers and supermarkets take place and documenting the impacts of the inclusion and exclusion of smallholders. Research has not yet addressed the mean and variance of the net price paid by supermarkets and traditional markets nor examined the variation in price mean and stability over different contract designs. Finally, no work has examined the cost of reduction of risk in reduced means. Addressing these questions for the first time, our analysis offers a new perspective on the payoffs to participation in supermarket supply channels for farmers.

We find that La Colonia, Nicaragua's domestic supermarket chain offers farmers a market option similar to the traditional market in mean price and price variability. Wal-Mart has pursued a different strategy. To draw in suppliers, Wal-Mart initially employed a pricing method similar to field brokers' prices, which were less than the wholesale market less transport and suggest the existence of supernumerary profits. Wal-Mart took advantage of credit and transport failures that led to this spatial market segmentation, offering terms similar to traditional farmgate buyers. Early Wal-Mart supply agreements were not welfare-improving for the farmer relative to the traditional market – indeed, they were often stochastically dominated by the traditional market.

Beginning in 2007, Wal-Mart changed its supply agreements to provide farmers insurance against the price risks of the traditional market. Farmers prefer these insurance contracts to the traditional market, and the supply agreements now both provide access to those who did not have market access previously and address the price risk problem in traditional

spot markets. However, our analysis suggests that some farmers may be paying too much for this insurance against traditional market price volatility.

Finally, our findings demonstrate that features of the traditional market including spatial segmentation, output price variability, and competition among regional wholesalers impact private contract outcomes. Improved understanding of supply relationships between smallholders and supermarkets can bring new insight into constraints in traditional agricultural markets and contribute to our knowledge of the causes and persistence of rural poverty.

Notes

[1]We have good comprehensive estimates for transportation costs that include the per mile cost of the truck, gasoline, and driver generated using the Sébaco cooperative's round-trip cost for the trip between Managua and Sébaco (50 miles oneway) and the truck's capacity. The Sébaco cooperative rents the truck from a member of the cooperative and pays the cost of the gasoline and the driver. All three cooperatives are located on a good road network, at varying distances from Managua. We applied the per-pound/per-mile transport cost to each cooperative's mileage from Managua to generate cooperative-specific transport costs. The cooperatives are at varying distances from Managua: Tomatoya is 70 miles away, Ocotal is 103 miles distant. Roads between cooperatives and Managua are of consistent and decent quality.

[2]This rate includes product rejection quantities; both La Colonia and Wal-Mart reject produce that does not meet specifications and supplier farmers in our household survey reported per transaction crop rejection rates between 0 and 80 percent with an average per transaction rejection percent over the 2000-2008 period of 5.8 percent.

[3]If we test farmgate prices received by cooperatives from supermarkets against farmgate prices in traditional markets for all dates between 2000-2007, and not merely for restricted dates over which the cooperatives sold to supermarkets, our results do not change significantly. Using the full series, we reject the hypothesis that traditional and supermarket means are equal for green peppers (traditional market significantly higher for the full series) and salad tomatoes (La Colonia significantly higher). All other results are consistent whether we use the full or reduced series for the traditional market.

[4]NGOs assist the cooperatives of this analysis with credit, irrigation, and technical assistance. It could be that the value of such subsidies exceeds the loss of direct mean price difference, creating an artificial net profit not visible to our analysis. This is an interesting critical area for further study.

References

Balsevich, F., Reardon, T., and Berdegue, J. A. (2005). Access of small tomato growers to supermarket and traditional markets in nicaragua. pages 1–41.

Barrett, C. and Reardon, T. (2000). Agroindustrialization, globalization, and international development: An overview of issues, patterns, and determinants. *Agricultural Economics*, **23**(3), 195 – 205.

Bellemare, M., Barrett, C., Brown, Z. S., and Just, D. R. (2009). Working paper: The welfare impacts of price stabilization: Evidence from rural ethiopian households. pages 1–37.

Blandon, J., Henson, S., and Islam, T. (2009). Marketing preferences of small-scale farmers in the context of new agrifood systems: a stated choice model. *Agribusiness*, **25**(2), 251–267.

Boselie, D., Henson, S., and Weatherspoon, D. (2003). Supermarket procurement practices in developing countries: Redefining the roles of the public and private sectors. *American Journal of Agricultural Economics*, pages 1155–1161.

Chavas, J. and Holt, M. (1996). Economic behavior under uncertainty: A joint analysis of risk preferences and technology. *the Review of Economics and Statistics*.

Dolan, C. and Humphrey, J. (2000). Governance and trade in fresh vegetables: the impact of uk supermarkets on the african horticulture industry. *Journal of Development Studies*, **37**(2), 147–176.

Gibbon, P. (2003). Value-chain governance, public regulation and entry barriers in the global fresh fruit and vegetable chain into the eu. *Development Policy Review*, **21**, 615–625.

Hernández, R., Reardon, T., and Berdegué, J. (2007). Supermarkets, wholesalers, and tomato growers in guatemala. *Agricultural Economics*, **36**(3), 281–290.

Key, N. and Runsten, D. (1999). Contract farming, smallholders, and rural development in latin america: the organization of agroprocessing firms and the scale of outgrower production. *World Development*.

Kirsten, J. and Sartorius, K. (2002). Linking agribusiness and small-scale farmers in developing countries: is there a new role for contract farming? *Development Southern Africa*, **19**(4), 503–529.

Maertens, M. and Swinnen, J. (2009). Trade, standards, and poverty: Evidence from senegal. *World Development*, **37**(1), 161–178.

Maertens, M., Colen, L., and Swinnen, J. (2008). Globalization and poverty in senegal: A worst case scenario? pages 1–45.

MAGFOR (2001). Cenagro: Nicaraguan agricultural census.

Neven, D. and Reardon, T. (2008). The rapid rise of kenyan supermarkets: Impacts on the fruit and vegetable supply system. *The Transformation of Agri-Food Systems: Globalization, Supply Chains and Smallholder Farmers*, page 189.

Reardon, T., Timmer, C., Barrett, C., and Berdegue, J. (2003). The rise of supermarkets in africa, asia, and latin america. *American Journal of Agricultural Economics*, pages 1140–1146.

Saha, A., Shumway, C., and Talpaz, H. (1994). Joint estimation of risk preference structure and technology using expo-power utility. *American Journal of Agricultural Economics*.

Stiglitz, J. and Newbery, D. M. (1981). The theory of commodity price stabilzation.

Swinnen, J. (2007). Global supply chains, standards and the poor: some empirical and theoretical insights. *Farrell Lecture. University of Guelph*.

Swinnen, J. and Maertens, M. (2007). Globalization, privatization, and vertical coordination in food value chains in developing and transition countries. *Agricultural Economics*, **37**(s1), 89–102.

USAID and Nicaragua (2006). Usaid and wal-mart sign agreement. *http://nicaragua.usaid.gov/bulletinjuly06*$_1$*.html*.

List of Figures

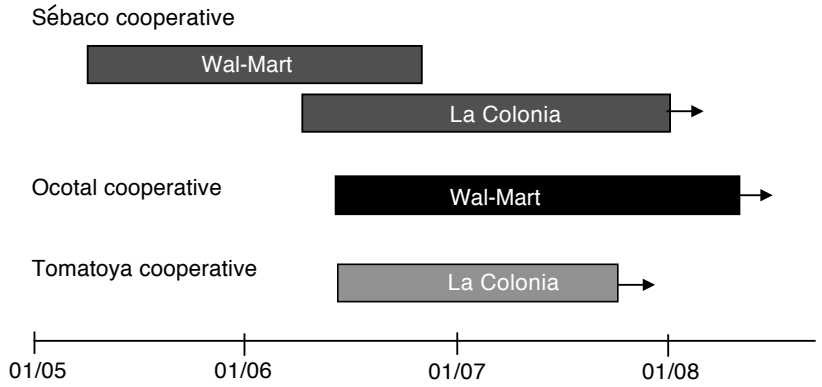


Figure 1: Cooperative suppliers data coverage. Arrows indicate supply relationships that continue past the period of data coverage.

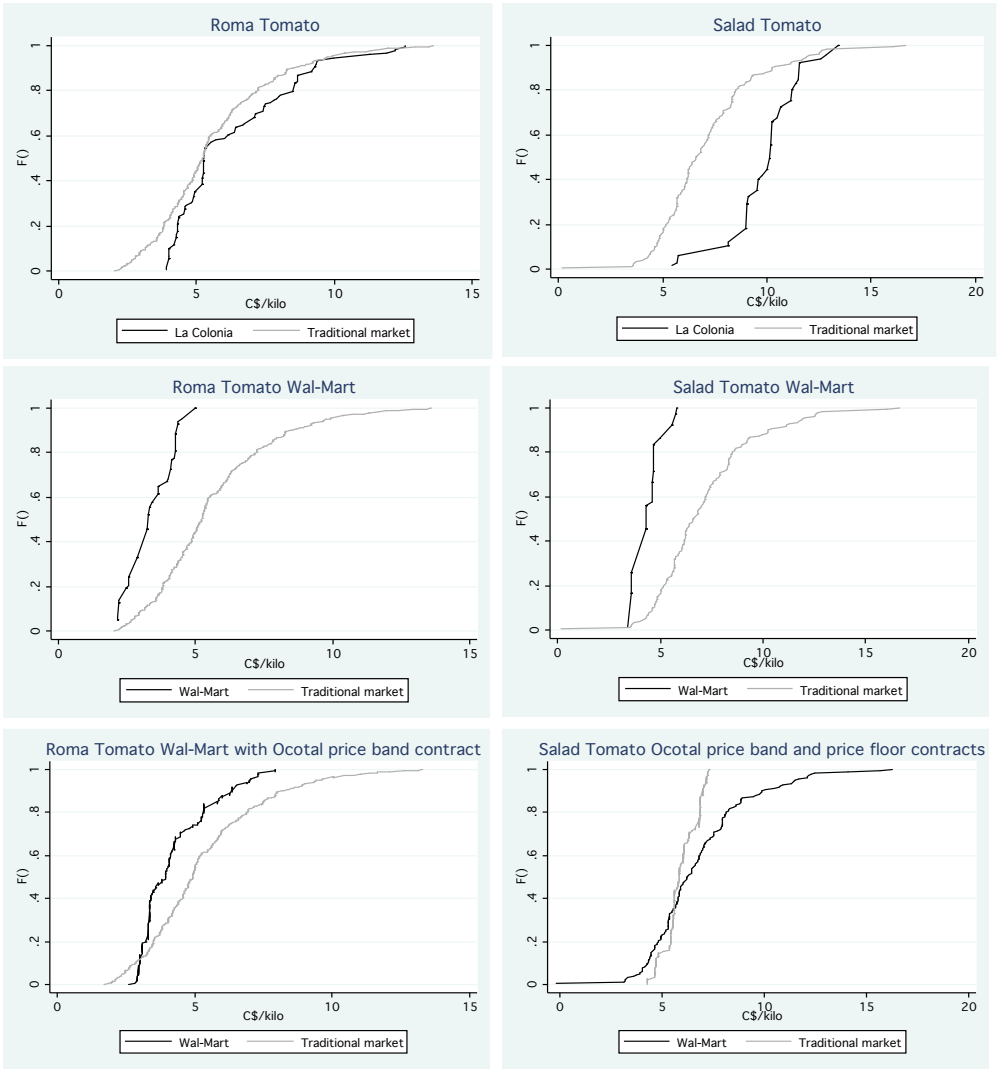


Figure 2: First order stochastic dominance tests for roma tomato and salad tomato in La Colonia (top row), Wal-Mart first-generation (second row), and Wal-Mart second-generation (bottom row). All price CDFs are plotted against corresponding traditional market CDFs.

List of Tables

	Without irrigation	With irrigation	Total
Small farmer (0-3.5 hectares)	36	5	41
Medium farmer (3.5-7)	4	0	4
Large farmer (> 7 hectares)	5	4	9
Total	45	9	54

Table 1: Supply cooperative farmers' landholdings and irrigation in the year before joining the supermarket supply chain.

Crop	Dates (mm/yy)	($C/kilo)	($C/kilo)	p-value
Wal-Mart		Traditional	Wal-Mart	
Sébaco co-op				
Roma tomatoes	04/05-11/06	**5.23**	3.40	$< 10^{-4}$
Salad tomatoes	04/05-11/06	**6.68**	4.41	$< 10^{-4}$
Ocotal co-op				
Roma tomatoes	06/06-05/08	**6.33**	4.24	$< 10^{-4}$
Salad tomatoes	06/06-05/08	**7.94**	5.92	$< 10^{-4}$
La Colonia		Traditional	La Colonia	
Sébaco co-op				
Roma tomatoes	04/06-12/07	**6.40**	**6.30**	$p = 0.77$
Salad tomatoes	04/06-12/07	7.88	**9.99**	$< 10^{-4}$
Tomatoya co-op				
Small green peppers	06/06-10/07	**7.51**	**6.71**	$p = 0.09$
Cabbage	06/06-10/07	1.57	**2.60**	$< 10^{-4}$
Lettuce	06/06-10/07	**5.57**	4.85	$< 10^{-4}$

Table 2: Mean farmgate prices in Wal-Mart and La Colonia compared with the traditional market.

Crop ($C)/kilo)	n	Farmgate* min	max	mode	mean (est.)	Managua mean	LC mean	WM mean
Sébaco co-op								
Indust. tomatoes	28	0.71	9.41	2.34	2.84	6.40/5.23	6.30	3.40
Tomatoya co-op								
cabbage	32	0.20	3.17	1.10	1.16	1.57	2.60	-
lettuce	52	0.29	9.80	1.70	1.76	5.57	4.85	-
Ocotal co-op								
indust. tomatoes	19	1.18	14.12	4.02	4.43	6.33	-	4.24

Table 3: Farmgate broker, Managua, La Colonia (LC), and Wal-Mart (WM) price means. *farmgate min/max/mode reported by farmers in the 2008 household survey; n refers to the number of regional observations for each crop

Crop (units)	Mean ($C/kilo)	Variance	CV (σ/μ)
Wal-Mart (WM)			
WM Sébaco co-op roma tomatoes	3.40	**0.66**	0.24
Managua roma tomatoes	**5.23**	2.68	0.31
WM Sébaco co-op salad tomatoes	4.41	**0.44**	0.15
Managua salad tomatoes	**6.68**	5.82	0.36
WM Ocotal co-op roma tomatoes	4.24	**1.68**	0.31
Managua roma tomatoes	**6.33**	7.51	0.43
WM Ocotal co-op salad tomatoes	5.92	**0.64**	0.14
Managua salad tomatoes	**7.95**	7.94	0.35
La Colonia (LC)			
LC roma tomatoes	6.30	**4.96**	0.35
Managua roma tomatoes	6.40	7.06	0.42
LC salad tomatoes	**9.99**	**2.81**	0.17
Managua salad tomatoes	7.88	8.94	0.38
LC peppers	6.71	7.25	0.40
Managua peppers	7.51	**6.47**	0.34
LC cabbage	**2.60**	0.27	0.20
Managua cabbage	1.57	**0.14**	0.24
LC lettuce	4.85	2.59	0.33
Managua lettuce	**5.57**	**1.59**	0.23

Table 4: Per kilo farmgate price mean and variance in supermarket and traditional market channels.

	Traditional Market	Supermarket
La Colonia contracts		
La Colonia roma tomatoes (Sébaco)		FOSD
La Colonia salad tomatoes (Sébaco)		FOSD
La Colonia peppers (Tomatoya)	FOSD	
La Colonia cabbage (Tomatoya)		FOSD
La Colonia lettuce (Tomatoya)	no first order dominance	no first order dominance
Wal-Mart first-generation contracts		
Wal-Mart roma tomatoes (Sébaco)	FOSD	
Wal-Mart salad tomatoes (Sébaco)	FOSD	
Wal-Mart second-generation contracts		
Wal-Mart roma tomatoes (Ocotal)	no first order dominance	no first order dominance
Wal-Mart salad tomatoes (Ocotal)	no first order dominance	no first order dominance

Table 5: Stochastic dominance tests comparing supermarket and traditional per kilo farmgate CDFs.

Method 1	Ocotal Suppliers n=20	% with $R < 3$	Non-suppliers n=30	% with $R < 3$
Relative risk coefficient (R), mean	4.85		5.39	
Range	0.14–20.09	20%	0.13–29.33	56.67%

Method 2	(C$/kilo)	% rational adopters (wtp>2.03)	(C$/kilo)	% rational adopters (wtp>2.03)
Assuming R=1				
Max mean price reduction, mean	2.23	60%	1.68	50%
Range	0.10–14.62		0.07–16.09	
Assuming R=2				
Max mean price reduction, mean	4.46	60%	3.36	66.6%
Range	0.21-29.24		0.14–32.18	
Assuming R=3				
Max mean price reduction, mean	6.70	70%	5.05	76.6%
Range	0.31–43.86		0.21–48.27	

Table 6: Computed levels of relative risk aversion (Method 1) and willingness to pay (Method 2). Observed difference ($\bar{p_t} - \bar{p_s}$) is 2.03 $C/kilo.