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Abstract. Based on a survey of 145 tomato farmers and interviews with supermarket chains, NGOs, wholesalers, and farmer organizations in 2004, this paper examines the determinants and effects of farmers' participation in supermarket channels, with and without assistance from NGOs in "business linkage" programs. It finds that absent that assistance, the farmers that work with supermarket chains tend to be the "upper tier" of small farmers, better capitalized with various assets. The smaller and less-capitalized farmers that work with supermarkets tend to do so in association with NGO assistance. Despite higher input expenditures and entry requirements, farmers in the supermarket chain earn more. The paper discusses the issue of whether this development program approach is sustainable and can be upscaled, and wrestles with the tradeoff of helping poor farmers gain access to dynamic markets, of making it affordable at a larger scale by national governments with tight budgets, and at the same time field programs that are market-sustainable and market-responsive.

Key words — Markets, supermarkets, Central America, Nicaragua, tomato farmers, NGOs.

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1. INTRODUCTION

Driven by rising incomes and urbanization, as well as foreign investment and procurement technology change, the share of supermarkets in food retail in Latin America rose from a mere 10-20% in 1990 to 50-60% by the early 2000s, displacing small shops and open-air markets (Reardon and Berdegué, 2002). That trend started somewhat later in Central America and has gone less far, reaching 20-40% (depending on the country) of food retail by the early 2000s, and rising. One of the poorest in the region, Nicaragua, has shared that trend, with the share reaching 15-20% today, and rising (Berdegué et al., 2005).

Such change downstream in the agrifood system can be hypothesized to be changing market conditions facing farmers. Generally, compared to traditional retailers, supermarkets have different and more demanding product and transaction requirements. However, despite the increasing importance of the rise of supermarkets, there has been little empirical research on the determinants of channel choice of farmers (between supermarket and traditional market channels) and the effects of those choices on net incomes and technologies. This paper aims at those issues, taking as a case that of tomatoes growers and supermarkets in Nicaragua. It is based on field interviews with supermarkets, wholesalers, and NGOs, and a representative survey of farmers.

2. The Context

Food retailing in general, and tomato retailing in particular, have, until very recently, been undertaken exclusively in the "traditional retail sector" in Nicaragua. That sector is composed of many small grocery stores, local wet-markets, street vendors and retail sections of large central markets. These traditional retailers procure their produce directly from farms (when the retailers are in small towns and villages) and from the traditional wholesale markets in the main and secondary cities (Leiva, 2004).

A new set of actors in food retail in Nicaragua is at an early stage of emergence – supermarkets. In the early 1990s, supermarkets had the tiniest of niches, with only 5% of food retail; that has increased to 15 to 20% in 2003, still an early stage but the beginning of a factor affecting food markets (Berdegué et al. 2005). The supermarket sector "took off" after the end of the revolutionary period and the liberalization of foreign direct investment (FDI). As is typical in supermarket market penetration, their penetration of the overall food market exceeds that of their share in fresh produce retail where they now have only about a 10% share. It is thus particularly interesting to understand the effect of the new retail channels on food markets and farmers at this early stage, for its own sake, and to form a base for observation as it grows over time.

Today the supermarket sector is made up of two supermarket chains (with 37 stores) with about two-thirds of the market, and 23 independent supermarkets. The supermarket sector's leader is *Corporación de Supermercados Unidos* (CSU) chain – of Costa Rican capital, which entered Nicaragua in 1994 with 3 stores. Now the chain has 30 stores targeting high end consumers under the label "La Union" and low end consumer segments under the

label “Pali” (80% of stores, and the fastest growing segment as CSU expands into lower-middle and working poor consumer segments and secondary and tertiary cities in the provinces). CSU is part of the Central American Retail Holding Company (CARHCO), which through August 2005 (hence during our study period) was a joint venture among CSU, La Fragua (the leading chain in Guatemala) and Ahold (the third largest food retail chain in the world, based in the Netherlands), with 1.5 billion US dollars in sales and 363 stores in Guatemala, El Salvador, Honduras, Costa Rica, and Nicaragua. [1]

The second-place supermarket chain is La Colonia, the largest locally owned chain. This chain grew much more slowly than CSU (the difference between a large chain in an established market vigorously investing, versus a local chain growing from the local base) although it started about the same time, went from three stores in 1990 to seven stores in 2004, and has focused only on Managua, the capital city.

The two supermarket chains used to (during all the 1990s), and the independents continue to, procure produce in the same way as the traditional retailers, mainly from the traditional wholesale markets. Around 2000 the chains initiated several fundamental changes in their procurement systems for produce.

First, as recently as 2000, the chains began sourcing in long-term relationships from large, specialized wholesalers. We call them “new-generation wholesalers” because they differ from the traditional wholesalers in their contractual or semi-contractual relations with their clients, in their degree of dedication to the supermarket sector and other modern food industry

[1] Note that in September 2005 Ahold sold its stake to Wal-mart.

clients such as fast food chains, and their tendency to go beyond mere spot market relations with farmers. The new-generation wholesalers procure, select and sort, and pack for the supermarkets, and deliver to the recently started distribution centers of the chains. For CSU, the new-generation wholesaler is the local Nicaraguan subsidiary of Hortifruti (that started in Nicaragua in the mid 1990s), a firm in the same holding company as CSU in Costa Rica. Hortifruti is itself a multinational operating in the same countries as CSU (hence Costa Rica, Nicaragua, and Honduras). CSU sources all its produce via Hortifruti. For La Colonia, for tomatoes, the wholesalers are two large wholesalers chosen by the chain; these wholesalers are somewhere between traditional wholesalers (as most of their business is still with and in the traditional wholesale market) and new-generation. La Colonia has several such wholesalers per main product, with some wholesalers purveying several products.

Why did the chains shift from sourcing on the traditional wholesale market, with its large volumes, plentiful intermediaries, geographic ubiquity, and variety of produce grades? While supermarket chains could get sufficient volumes at the "high season" from the traditional wholesale markets, the seasonality was too sharp, and the quality (commercial grade quality based on cosmetic attributes) too inconsistent, for their needs. Moreover, while individual small wholesalers and brokers are plentiful and relatively cheap, as the produce section of the supermarkets expanded, they started to incur diseconomies of congestion and coordination using many intermediaries, according to our interviews with Hortifruti. This new organization of the supply chain allows supermarkets to exert a higher degree of control over and monitoring of suppliers, and to consolidate its "channel captain" role in the governance of the supply chain, that is, the capacity to define and enforce product standards and transaction conditions. Finally, the new organizational arrangement allows supermarket chains to

'externalize' (i.e., transfer to the supplier and/or the public/NGO sector) different risk factors as well as different costs, both direct and transactional. This is of course the common trend internationally in the relation between supermarket chains and their suppliers.

Second, both supermarket chains have centralized their produce procurement and logistics. Hortifruti has made investments in two distribution centers, one in Managua and one in the northern city of Sebaco, where most produce is bought and delivered. La Colonia has a mixed system of produce procurement, partly centralized, partly decentralized. The chain centralizes purchases of higher value and volume products, and leaves the minor products in the hands of each store. Tomatoes are delivered on a centralized basis.

Third, the two supermarket chains have implemented a set of private standards (written in manuals) concerning product quality and transaction attributes for produce that the new-generation wholesalers must apply. The chains have similar standards for tomatoes; CSU implemented them first and La Colonia emulated these for competitive reasons. The standards treat produce quality/appearance (minimum size, form, ripeness, insect and mechanical damage, color, and firmness) and transaction requirements (packing, volumes, and consistency).

In contrast with traditional wholesalers (focused exclusively on the traditional retailers) who do not require standards of farmers, the new-generation wholesalers implement the retailers standards in their requirements of the farmers. There are important differences however between the two sets of wholesalers.

On the one hand, Hortifruti only accepts tomatoes that meet CSU's standards; farmers have to grade their tomatoes, and deliver top grade to Hortifruti and sell the "seconds" to the wholesale market. Hortifruti pays a price some 10% above the wholesale market price, and also

arranges with the donor-funded NGOs the various implicit subsidies to its preferred suppliers, in particular the smaller ones who we show receive the assistance. Those implicit subsidies include subsidized credit, technical assistance (not available at affordable cost on the market or from extension services) and equipment, to small farmers selling (at the time of our research) only to CSU-Hortifruti and a few other selected buyers. Continued access to these substantial subsidies must have had an important effect of influencing farmers' market channels choices; that of course can only be verified with the counterfactual of what these farmers would do in the absence of these implicit and explicit subsidies from donors/NGOs, but it is reasonable to hypothesize that their channel choice was influenced by these conditions.

On the other hand, La Colonia's wholesalers accept all tomatoes from the farmers on their lists, and then grade them and sell La Colonia the firsts (at a 20-30% higher price than they get for the seconds in the wholesale market) the firsts and sell themselves the seconds on the wholesale market. That means the requirements of the farmers are less difficult in the "hybrid" wholesale channel still used by La Colonia, compared to CSU's. Yet, the much better price that La Colonia's wholesalers get for "firsts" drive them to pick the better farmers, and to push those farmers to better quality.

The centralization of procurement and use of new-generation wholesalers have made practicable the enforcement of private quality standards by the chains, not practicable by mere use of spot markets from traditional wholesale markets, whose inconsistency translates into high costs of sorting and selecting; we do not have quantitative data on this, but do have the qualitative assessment from the interviews with the chains; it is necessary in future to do quantitative survey analysis of these cost differences. This centralization of monitoring allows

enforcement by the retailer of the wholesalers. If produce delivered by Hortifruti to CSU does not meet the standards, Hortifruti bears the costs of the rejects.

The strategy is driven by the need to reduce enforcement and congestion costs, waste, and coordination failures, and to increase the relative power of the supermarkets to impose and enforce standards and conditions in the supply chain. For example, La Colonia used to monitor quality of the produce as it entered each store; that became costly as stores were added, and monitoring levels varied over stores leading to differential quality and thus reputation issues. The recent move to centralization and use of only two wholesalers allowed La Colonia to have a narrow, and cost-effective, "funnel" through which tomatoes passed to their stores, from preferred suppliers, through the two wholesalers, to the distribution center, to the stores, monitored all the way. This also allows the chains to shift the monitoring cost burden from the retailer to the wholesaler. Such a 'funnel' also allows the supermarket and its agents to continuously monitor the behavior of farmers and to easily detect those that should be 'delisted' for quality or contractual reasons. In practice this has occurred seldom.

Fourth, the interface of the procurement system, new wholesale system, and the farmers is the use, by the wholesalers of "preferred suppliers lists." The wholesalers have basically informal, but still effective contracts in the sense of Hueth et al. (1999), with the farmers. In general, they assist the farmers with some credit and technical assistance. The wholesalers working for La Colonia facilitate the provision of input credit to the farmers via market-based deals with the input suppliers. Hortifruti (for CSU) provides little technical assistance and credit directly, but it entered a relationship with non-governmental organizations (NGOs) wherein its growers receive assistance as part of the latter's "market linkage" programs.

Specifically for tomatoes, Hortifruti has developed gradually in the past five years a working relation with a list of 43 preferred producers who supply all of their "roma" (basic, commodity) tomatoes. This is a small group, but supermarket produce retailing is just in incipience in Nicaragua. This supplanted their former practice of buying tomatoes when available in the local wholesale markets, and importing from Costa Rica and Guatemala. Replacing imports with domestic tomatoes allowed transport cost savings, a key driver in developing the local supply chains. Hortifruti pays a small premium over the price in the wholesale market, controlling for quality. Hortifruti sends trucks to the farms (some are close to its distribution center, some far) to pick up the produce, but encourages (through price disincentives) the farmers to move their own product.

Hortifruti's agronomists, along with those of the NGOs with whom they are in alliances, provide training, and some input credit, for farmers to meet their standards; they visit the farms to see the crops and make recommendations to improve product quality such as regarding the amount and type of fertilizer and non-organic inputs to apply, the tomato variety, pest control techniques, irrigation systems and water source (for safety as well as crop calendar), and use of stakes and strings (important for color), and crop planning; the latter plus irrigation help Hortifruti to have tomatoes locally through the year, instead of a "glut and then dearth" cycle from the spot market. This is an interesting example of "tied" credit based on delivering output to Hortifruti, and is thus an inter-linkage of technical assistance and credit markets, the output market, and the wholesale sector, addressing idiosyncratic market constraints facing the farmers[2]. However, and we discuss this more in depth in the implications section, the method of addressing market failures for this specific group of farmers is based essentially on donor

[2] See Bardhan (1981) and Eswaran and Kotwal (1985) for theoretical treatment of these phenomena, and Swinnen (2004) for comparative illustrations of similar inter-linkages in Central and Eastern Europe.

funding, external to the resources of the firms and farms involved. In other situations where this occurs (outside projects) it is often the client firm with "deep pockets" that finances the same sort of actions.[3] But having it externally (donor or government) based means that the continuity and sustainability of this temporary solution depends on two things: (1) continued donor or government funding of the projects, which could come and go; (2) the growth of the chains and the suppliers themselves inducing the hoped-for emergence of private service providers (credit, technical assistance, inputs) to the farmers that sell inputs and services at affordable rates. Only time will tell whether the second occurs, and the choice of how projects are undertaken, as well as government and private sector association policies and programs, will affect that path.

La Colonia's tomato wholesalers have developed a preferred producer system that includes 26 producers. The two dedicated wholesalers have worked for 7 and 13 years (respectively) with La Colonia, but they have moved from buying in the public wholesale markets for La Colonia to buying from the preferred producer systems in only the past half decade. The two wholesalers have alliances with input firms; they have a credit line with the firms who in turn provide inputs to the farmers; the wholesalers guarantee payment (hence the wholesale contract is the "collateral substitute" for the input credit of the input firm to the farmer). The arrangement is that of "tied credit" in that the farmers have then to deliver their tomatoes only to the wholesalers. This is an interesting example of inter-linked credit-input-wholesale markets to overcome idiosyncratic market constraints for the farmers (who lack collateral to get the inputs). In this case, as compared to the HORTIFRUTI-NGO arrangement, the scheme is more 'market-based' and less dependent on external grants or subsidies, hence, it may end up being more sustainable over the medium and long run. Yet, as will be shown later, it

[3] Such as in the case of Lyle-Tate global sugar company providing similar assistance to its farmers in Slovakia to resolve "idiosyncratically" (for its specific group of suppliers) the market failures those farmers faced in the technical assistance and credit and input markets; see Gow and Swinnen (2001)

is significantly less inclusive of small, poorer farmers. This is an important dilemma that needs to be addressed in policy and program debate.

3. Data

The data are from a farm survey conducted June-July 2004. The sample consists of 145 tomato growers selling to the supermarket and traditional channels. There are three sub-samples: (1) the full set of all 43 producers selling tomatoes to CSU/Hortifruti; (2) the full set of all 26 growers selling to the two wholesalers working for La Colonia; (3) a random sample of 76 growers chosen from the growing areas where the first two sub-samples are. The universe from which these were sampled came from information supplied by the 10 spot-market wholesalers in Managua (capital city) wholesale market.

4. Grower Characteristics

Table 1 shows characteristics of farms, Table 2.1 the structure of gross income, costs, and profits, and Table 2.2 details concerning technology used. Several salient points emerge.

First, the sample is composed of from very small to small farms, ranging from 0.5 to 1 ha per capita of cultivated land, 2 to 5 ha of cultivated land per farm. (The rest of the farm is pastures and fallow.)

Second, the great majority of growers for CSU-Hortifruti are assisted by NGOs (although half of the tomato volume comes from those growers not assisted). The NGO-assisted growers tend to be in cooperatives (while the non-assisted are not) and an average grower is four times smaller (and produces 13 times less volume of tomato) than the average non-assisted grower. The NGOs thus work with the smaller and poorer producers, via assisting their coops with substantial credit and technical assistance, to raise incomes and help them diversify away from basic grains.

Third, by contrast, very few growers for La Colonia are assisted by NGOs, and where they are, the assistance is not an alliance relationship to help farmers enter the supermarket-market per se.

Fourth, a crucial point is that the non-assisted growers for La Colonia are in many ways similar to the non-assisted growers for CSU. The non-assisted growers for both supermarket chains tend to be in the upper tier of the small farmer category (by Nicaraguan standards) rather than very small farmers who are the NGO-assisted supermarket-channel growers. The non-assisted growers also tend to be more specialized, as they produce much higher volumes on a much higher share of an average farm, compared to the NGO-assisted newcomers in the CSU/Hortifruti channel or the traditional channel growers. Growers for La Colonia also tend to be more experienced in tomatoes. They tend to have tractors and vehicles and other indices of capitalization, relative to the very small poor NGO-assisted growers in the CSU channel. This is a key result: without the subsidy to the smallest farmers provided by the NGOs (who are spending some 4-5 times more per farmer than the average Nicaraguan's share of the government budget for agriculture) supermarkets tend to source from the upper tier of small farmers who have more capital, experience, and are more specialized in commercial horticulture.

Fifth, Table 2.1. shows that growers for supermarkets have 30% higher production costs than those selling to traditional channels only. Table 2.2. breaks that down into prices and quantities. The CSU channel growers have higher fertilizer use (quantities) but lower use (from 1/3 to 2/3 less) of quantities of other toxic chemicals (insecticides, fungicides, herbicides) than the other supermarket channel - but both chains' growers have higher than the traditional channel, thus confirming Thrupp et al.'s (1995) argument about modern retail (in her work it is developed country retailers importing fruit from Central America) driving higher pesticide use in countries with a limited regulatory and almost non-existent enforcement capacity, such as Nicaragua. The fact that the cash outlays are higher is explained by Hortifruti's requiring the farmers to use certain kinds of chemicals, and those kinds have higher prices, reflected in the higher outlay than the other channels.

Sixth, however, within the CSU/Hortifruti channel, it is interesting that the non-NGO-assisted growers have 30% lower production costs than do the NGO-assisted producers, who have the highest fertilizer, seed, irrigation energy, and labor costs of any producer group. Given that we control for channel in making this comparison, it appears due to the NGOs' technological package recommendations, geared to minimizing risk of not meeting standards. We know of no evidence that such expenditure in excess of the non-assisted farmers is grounded on any sort of agronomic experimentation that shows the effect on risk reduction.

Seventh, profit per hectare is substantially higher for both supermarket channels compared to the traditional channel; using a sample-weighted average, supermarket-channel farmers earn 65% more profit per hectare. A small advantage in prices paid by supermarkets, and a large advantage in average yields, compensates for the higher outlays for inputs.

Finally, La Colonia suppliers earn 56% more profit per ha than those supplying CSU. However, comparing non-NGO-assisted growers in each, one finds only a 12% difference. What drives the difference between these results? Non-NGO farmers, chosen for their prowess and capital, have much higher yields than the small NGO-assisted farmers. However, even the small, NGO-assisted farmers earn 14% higher profits than the traditional growers, but doing so depends on the general assistance and credit they receive from NGOs (hence an implicit subsidy) plus their ability to pay 36% higher input costs up front, a significant capital entry barrier.

5. Regression Model to Determine Farmer Channel Choice

We use a two stage model in which the first stage is market channel choice and the second stage is production technology choice.

The market channel choice of farmer i in channel j is specified as follows:

$$\begin{aligned} MARKETCH_j &= \alpha_{jo} + \alpha_{j1} FARMSIZE_{ij} + \alpha_{j2} LIV_{ij} + \alpha_{j3} TRUCK_{ij} \\ &+ \alpha_{j4} ROAD_{ij} + \alpha_{j5} ELECT_{ij} + \alpha_{j6} HOUSEHSIZ_{ij} + \alpha_{j7} DEPENDR_{ij} \\ &+ \alpha_{j8} FEM_{ij} + \alpha_{j9} AGE_{ij} + \alpha_{j10} EDUC_{ij} + \alpha_{j11} EXPE_{ij} + \varepsilon_{ij} \end{aligned} \quad (3)$$

MARKETCH is the producer's market channel *(j)* defined as (1) CSU channel, (2) La Colonia channel, and (3) traditional markets.

The producer's market channel decision is hypothesized to be affected by the following variables: FARMSIZE, the overall farm size in hectares; LIV is the quantity of livestock owned by the producer; TRUCK is a dummy variable; ROAD is the distance to an asphalt road; ELECT is access to electricity; HOUSEHSIZ is the number of members in the household; DEPENDR is the dependency ratio; FEM is one if the producer is a female; AGE, EDUC and EXPE are the

age (years), education (years of schooling) and experience in tomato production (years) of the producer.

Our second stage specifies, conditional on market channel choice, the producer's production function and output and input system as follows:

$$\begin{aligned}\ln OUTPUT_j &= \beta_{jo} + \beta_{j1}\ln LABOR_{ij} + \beta_{j2}\ln FERTI_{ij} + \beta_{j3}\ln FOL_{ij} \\ &+ \beta_{j4}\ln INSECT_{ij} + \beta_{j5}\ln FUNG_{ij} + \beta_{j6}\ln HERB_{ij} + \beta_{j7}\ln SEED_{ij} \\ &+ \beta_{j8}\ln LAND_{ij} + \beta_{j9}\ln IRRIG_{ij} + \beta_{j10}AGMACH_{ij} + \beta_{j11}REG1_{ij} \\ &+ \beta_{j12}REG2_{ij} + \beta_{j13}\lambda_{1i} + \beta_{j14}\lambda_{2i} + \eta_{ij}\end{aligned} \tag{4}$$

$$\begin{aligned}OUTPUT_j &= \chi_{jo} + \chi_{j1}PRIT + \chi_{j2}WAGE_{ij} + \chi_{j3}FERP_{ij} + \chi_{j4}LAND_{ij} + \chi_{j5}IRRIG_{ij} \\ &+ \chi_{j6}AGMACH_{ij} + \chi_{j7}REG1_{ij} + \chi_{j8}REG2_{ij} + \chi_{j9}\lambda_{1i} + \chi_{j10}\lambda_{2i} + \eta_{ij}\end{aligned} \tag{5}$$

$$\begin{aligned}INPUT_{jk} &= \delta^k_{jo} + \delta^k_{j1}PRIT + \delta^k_{j2}WAGE_{ij} + \delta^k_{j3}FERP_{ij} + \delta^k_{j4}LAND_{ij} + \delta^k_{j5}IRRIG_{ij} \\ &+ \delta^k_{j6}AGMACH_{ij} + \delta^k_{j7}REG1_{ij} + \delta^k_{j8}REG2_{ij} + \delta^k_{j9}\lambda_{1i} + \delta^k_{j10_o}\lambda_{2i} + \eta_{ij}\end{aligned}$$

In the production function: OUTPUT represents the farm's tomato production in kilograms (i = 1… 145); LABOR is total labor days in tomato cropping (family and hired labor). Variable non-labor inputs include: FERTI, organic input costs of fertilizers; FOL, INSECT, FUNG, HERB, SEED, the non-organic total input costs of foliar chemicals, insecticides, fungicides, herbicides and seed.

LAND is tomato area measured in hectares. IRRIG is the percentage of tomato land that is irrigated. AGMACH is a dummy variable, one for use of tractor, zero for animal traction. REG1 and REG2 are dummy variables for regions. $\lambda_{1i}, \lambda_{2i}$ are the inverse mills ratio (IMR) to control for endogenous stratification in the first stage, calculated from the first stage used to control the producers' conditional probability of being in a channel. η_{ij} is the error term.

In the output and input structural system, PRIT is the price of tomato (US$/kg), WAGE is the salary per day, FERP is the average price of non-labor variable inputs (US$/Kg). INPUT is the vector of three *k* input demand functions for labor (total labor days), non-labor variable inputs (Kg).

The estimation method is as follows. Market channel choice is determined in the first stage, and in the second stage the production function and output supply and input demand functions are estimated jointly. As we estimate the structural equations based on sub-samples of producers selling to each market channel, potential sample selection bias arises as a consequence of the conditional probability of producers being in a market channel. Vella (1998) presents options (following Heckman 1979) when there is sample selection bias in the case of a dichotomous outcome. Two alternatives are presented for multiple outcomes when ordering on the outcomes is not possible: (1) one by Lee (1983) and the other by (2) Hay (1980) and Dubin and McFadden (1984). Bourguignon et al. (2004) note that the Dubin-McFadden method is preferable to Lee's under most circumstances, and conclude that selection bias correction based on the multinomial logit model provides a good correction for the outcome equation even when the independence of irrelevant alternatives hypothesis is violated. Based on these considerations, we use a multinomial logit regression for the first stage and Zellner's seeming unrelated regression estimator (SURE) in the second stage for those three equations. The model's first stage is estimated using the weights suggested by Manski and Lerman (1977) and Coslett (1981) and applied for example in Pitt and Khandker (1998) under similar sampling situation, when the sample has been endogenously stratified. In the second stage we estimate production functions using a Cobb Douglas function using the standard log-linear transformation.

6. Regression Results

Table 3 shows market channel participation estimation results. Choosing the supermarket channels is correlated with more education. Interestingly, overall farm size was not a significant determinant, but one can see from Table 1 that the farm sizes over the strata are not markedly different, but the area to tomato is, hence specialization rather than overall farm size varies over channels.

Table 4 presents the estimation results for the input demand and output supply regressions. These results, combined with average sample variable values, are used to calculate the absolute marginal response of price and non-price factors of producers selling to the three market channels.

First, output price elasticities are higher for producers selling to supermarket chains than those of producers selling to the traditional channel, reflecting a commercial orientation. Supply response to increases in intermediate input prices exhibit the labor-bias technology used by producers selling to CSU and the capital-bias technology used by producers selling to La Colonia as compared to producers selling to traditional markets.

Second, La Colonia producers' capital-factor bias technology is exhibited (showing the curvature of the isoquant) by their inelastic supply with respect to non-labor input prices and its higher supply elasticity with respect to wages. Their non-labor input demand is elastic with respect to both non-labor prices and wages. La Colonia producers' combination of supply and input demand elasticities, factor prices combined with their buyers' credit availability imply the use of a more capital-using technology, corroborating the descriptive results.

Third, producers' non-price elasticities are somewhat similar for producers selling to the three market channels. However the marginal response is higher for producers selling to supermarkets as compared to traditional markets. As producers that sell to CSU and La Colonia add one hectare they grow 10% and 30% respectively more tomatoes compared to suppliers of traditional markets. This is a reflection of a more productive technological package.

7. Allocative Efficiency and Factor Constraints

Following Carter and Wiebe (1990) and Lau and Yotopolous (1971), we compare in Table 5 marginal value products (MVP) with factor prices to test for allocative efficiency and factor use constraints. Allocative efficiency is the point at which the MVP of a factor equals the factor's price. If the MVP exceeds the factor price, more of the factor could be profitably used and this reflects a constraint to access of the factor, and the opposite, an overuse of the factor perhaps because of inability to sell the factor; Carter and Wiebe (1990) illustrate this by showing that smaller farmers in Kenya have a constraint in access to capital (such as fertilizer) but an overuse of labor (indicating a constraint to selling labor in other markets).

Table 5 shows that producers selling to CSU-Hortifruti are close to their non-variable inputs allocation efficiency and producers may not intensify the use of foliars, fungicides and seeds. However, MVP exceeds factor prices for labor, fertilizers and herbicides. The MVP of land and insecticides are below their prices, indicating inefficient allocation of one and possibly overuse of the latter (in an allocative efficiency sense). The large difference between marginal and average product value of land is somewhat unclear but may be due to the input mix or limited agriculture frontier in areas where they are located.

Second, producers selling to La Colonia and traditional markets will benefit from marginal additions of land, labor, seeds and fertilizers but may no longer benefit from additions of non-labor variable inputs as their marginal product value is already under the market factor prices.

Third, producers selling to La Colonia supermarket chain may benefit the most by adding land and labor because they show the highest marginal product value for these two inputs. However, they are somewhat limited because they face labor factor scarcity, possibly because they are located in remote areas. Also, addition of more land has been undertaken (most important among all three marketing channels) by La Colonia producers which reflect their economic behavior response to these economic incentives.

Lastly, producers selling to La Colonia and traditional markets in economic terms are over-applying non-labor inorganic variable inputs because their MPV is already way bellow factor prices, that is, an inefficient technical allocation of productive resources. Answering this question need additional research in areas such as: (1) risks associated with crop losses where over application of inorganic inputs shield the producers against pest infestations; (2) low quality of inorganic inputs (illegitimate or adulterated products, expired products, etc.); (3) production area high incidence of pests, fungus and others diseases; (4) insufficient producer's knowledge to apply these inputs correctly among other reasons.

8. Implications Discussion, Focused on the Role of Business-Linkage Projects via NGO Assistance to Farmers to Enter Supermarket-Markets

There are substantial requirements and significant payoffs to entering the supermarket channel as compared to the traditional market channel. Farmers that can participate, absent

assistance hence implicit subsidy from NGOs, are the “upper tier” of small farmers, more capitalized, commercially oriented, and specialized. The volume of produce sold by supermarkets in Nicaragua is still small, and requires relatively few farmers, even the very-small to medium-small farmers that dominate the ranks of tomato suppliers to supermarkets.

These findings indicate the challenge to development programs to upgrade small farmers to have the capacity to participate in restructuring market channels, and to find alternatives for the majority who are unable to make the grade to participate in the new markets. The very small farmers able to sell to the CSU-Hortifruti channel work with substantial NGO “subsidies” mainly in the form of organizational capital, technical assistance and quasi-fixed assets such as post-harvest collection facilities and irrigation systems. It is uncertain if the smaller producers would sell to this channel if these subsidies were not present. This points to a more general and crucial issue related to “business linkage” models that are now in vogue, driven mainly by donor funds and implemented mainly by NGOs and private consulting companies. Those issues are as follows.

Some international and Nicaraguan NGOs, funded by international aid agencies, are acting as agents in this supply chain with the objective of increasing access to the supermarket market for small scale and resource poor farmers. In contrast with the old forms of agricultural extension work, these NGOs are very much demand-driven and market-oriented.

Typically, they engage with one or a few firms (either supermarkets directly and/or new-generation wholesalers) which require products that can be (potentially at least) produced by small scale farmers. In very close coordination with these firms, they: (1) define the technological, management and organizational changes that farmers need to implement in order to be able to consistently produce and deliver a product which meets the supermarket standards,

(2) secure a quota from the supermarket for such product and at least an understanding that the quota will expand if the farmers are successful, (3) put in place a strategy and a program of quite intensive support to small scale farmers to implement the changes agreed upon in (1). The technical staff hired by these NGOs tends to be much better paid in comparison with 'regular' NGOs, and they are well equipped and funded to carry out their support activities.

Such activities usually include: (1) supporting the formation or strengthening of a farmers' economic organization such as a cooperative, (2) designing a 'technological package' (farm and off farm) and providing the training and technical assistance to implement it, (3) building the necessary farm and off farm infrastructure (e.g., irrigation wells; grading and packaging facilities; cold storage facilities) and introducing new equipment (e.g., greenhouses, trucks), (4) providing brokerage and market information services, including very close liaison with the representatives of the supermarkets to monitor changes in demands, standards and conditions and also compliance of agreements by both supermarkets and farmers, and, (5) last but not least, funding all of the above with substantial grants or soft loans.

Because of the relative good quality of the staff and of the project budgets at their command, they provide services to farmers, wholesalers and supermarkets that are more intensive, of better quality and (very likely) more effective than those that a 'regular' NGO or the government's extension system can provide. At the same time, such service is very expensive compared to the alternatives in Nicaragua; we estimate that the direct costs are approximately USD 850 per farmer per year, compared to something in the order of USD 100 for a more 'normal' service by a more typical NGO and to perhaps less than that in the case of the government's extension systems. This cost is about 40% higher than what Chile has invested on small scale farmers between 1990 and 2004, although Chile's GDP is 4.6 times higher than that

of Nicaragua (Berdegué et al., 2005). Because of its cost and its intensity, this service can only be provided to small numbers of well selected small scale, resource poor farmers, typically a few dozen or at best a few hundred per project.

There is very little doubt that the serviced farmers receive a high quality and very effective service. They gain access to markets that otherwise would be outside their reach. They also gain access to technical and financial services in a country were there are substantial market failures and large anti-poor biases in these markets. As was shown above, their total income and net asset positions increase. Their human and social capital expands because of the training and organizational support they receive from the NGO.

Yet, there are some important outstanding issues with this type of NGO strategy and project. First, the model, as it is, is financially unsustainable beyond the end of the project, as its cost is well beyond the means of the Nicaraguan government or the Nicaraguan private sector; if it were to be financed by the beneficiary small farmers themselves after a period of subsidized support, to do so would take the increase in profits per hectare from all of their tomato land area and more. Second, for the same reason, the model as it is cannot be expected to be upscaled to a degree sufficient enough to make a difference at a national level. Third, as a consequence of the financial unsustainabilty and non-replicability of the model as it is, what is being funded with public moneys are private goods for a handful of lucky farmers; few public goods are being created by these public projects. Fourth, that because of the demand-orientation and the strong voice of the supermarket and/or the wholesaler in setting out key parameters of the NGOs strategy and project, the model as it is, is transferring onto the farmers (actually, onto the NGO that bears the cost, but onto the farmers when the NGO is no longer present) risks and costs that

in the traditional market supply chain are paid for by the wholesaler, the retailer, and the consumer.

The dilemma is that the positive effects are due to exactly the same factors that cause the problems outlined above. How to have a support model for resource-poor farmers in poor countries like Nicaragua, that is effective in gaining market access and increasing income, while also being more financially realistic and sustainable, more replicable and less risky to the farmers? This topic is beyond the scope of this paper, but the answer probably has to do with placing these services within a more comprehensive national agricultural development strategy that today is absent in Nicaragua. Such a strategy would have to address the development of markets for rural financial and non-financial services, seek across-the-board improvements in quality and productivity, modernize and improve traditional markets, and modernize contract institutions and regulations between supermarkets and suppliers, such as the establishment of commercial practices laws such as PACA in the US, or the private code of commercial conduct established in Argentina in 2001 (Brom 2004), which helped supplier and retailer alike.

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Table 1: ***Overall farm characteristics***

	CSU-Hortifruti			La Colonia			Traditional			Significance	
	NGO	Non-NGO	Total	NGO	Non-NGO	Total	NGO	Non-NGO	Total	sub-channels (6)	Totals (7)
Overall farm size (ha) (1)	6.3	5.5	6.2	5.0	11.3	10.1	15.9	4.4	9.8	c,e	
Total area cropped in 2004 (ha)	2.3	2.1	2.3	3.9	6.0	5.6	2.7	4.2	3.5		
Area total of tomato (ha)	0.4	1.3	0.6	1.6	3.7	3.3	1.0	1.8	1.4		
Area total of other vegetables (ha)	0.4	0.3	0.4	1.5	1.0	1.1	0.5	0.9	0.7		
Area total of grains (ha)	1.5	0.4	1.3	0.8	1.3	1.2	1.2	1.5	1.4		
Household size (Members)	5.1	2.7	4.7	6.8	4.1	4.6	4.7	4.8	4.7	a,b,f,g,h	
…Adults	3.6	2.1	3.4	4.6	2.6	3.0	3.7	3.1	3.4	a,b	
Land-Labor ratio (Overall farm size/Adults)	1.75	2.55	1.84	1.09	4.33	3.38	4.34	1.40	2.91		a,c
Age of producer (years)	47	52	47	44	37	39	46	44	45	b,g,h,i	a,c
Experience with tomatoes (years)	9	2	8	18	13	14	10	13	12	a,d,f,g,h	a,b
Producer education (years of schooling)	6	12	7	4	6	5	5	6	5	a,g,h	
Female producer (%)	8	14	9	0	5	4	22	0	11	c,e,f	
Dependency ratio (%)	29	23	28	31	33	32	24	33	29	c	
House made with construction material (%)	97	100	98	80	76	77	58	90	75	c,e,h	a,b
Household has off farm income (%)	14	0	12	20	29	27	28	23	25	a,g,h	b
Household members with off farm income	0.14	0.00	0.12	0.20	0.52	0.46	0.33	0.30	0.32	a,g,h	a,b
Has means of transport (%)	14	71	23	20	29	27	22	18	20	a,f,g	
Cattle Stock (Heads)	4	0	4	1	6	5	6	2	4	c,g,h	
Distance to asphalted road (kms)	11	1	10	3	18	15	6	5	5	a,b,d,e,f,g,h,i	a,b,c
Has electricity (%)	83	100	86	100	95	96	83	95	89		
Has greenhouse (%)	11	-	9	60	-	12	3	-	1	b,f	b
Use tractor (%)	25	100	37	60	81	77	56	73	64	a,e,g,h	a,b
Use animal traction (%)	72	-	60	20	62	54	67	48	57	a,c,d,f,g,h	
Use manual traction (%)	-	-	-	60	-	12	3	-	1	b,d,f	a
Irrigation											
Number of producers with irrigation system (%)	100	100	100	100	90	92	100	88	94		
Share of area of tomato with irrigation (%)	71	98	76	93	60	66	87	81	84	a,b,d,e,g,i	c
Receives credit (%)	97	14	84	80	81	81	89	50	68	a,b,c,e,h,i	b
Receives technical assistance (%)	100	29	88	80	33	42	69	30	49	a,c,g,i	a,b

Notes: (1) Overall farm size is the addition of land owned plus land obtained for usufruct plus rented in plus sharecropped in less the summation of land rented out and land sharecropped out (year cropping season 2004); (2) Household size is the total number of family members living in the producer's household (during the last 6 months).; (3) Adults is the number of household members with 15 or more years.; (4) Dependency ratio is the number of members in the household with less than 15 years or older than 65 years over total household size times 100.; (5) Household has off farm income has been defined as any member (or the number of members) with employment outside the farm.; (6) T-test at 10% significance between NGO Vs Non-NGO sub-channels: a = between CSU-Hortifruti NGO & CSU-Hortifruti Non-NGO, b = between La Colonia NGO & La Colonia Non-NGO, c = between Traditional NGO & Traditional Non-NGO, d = between CSU-Hortifruti NGO & La Colonia NGO, e = between CSU-Hortifruti NGO & Traditional NGO, f = between La Colonia NGO & Traditional NGO, g = between CSU-Hortifruti Non-NGO & La Colonia Non-NGO, h = between CSU-Hortifruti Non-NGO & Traditional Non-NGO, and i = between La Colonia Non-NGO & Traditional Non-NGO. (7) T-test at 10% significance between marketing chains totals: a = between CSU-Hortifruti & La Colonia, b = between CSU-Hortifruti & Traditional, and c = between La Colonia & Traditional.

Table 2.1: ***Tomato production characteristics***

	CSU-Hortifruti			La Colonia			Traditional			Significance	
	NGO	**Non-NGO**	**Total**	**NGO**	**Non-NGO**	**Total**	**NGO**	**Non-NGO**	**Total**	**(8)**	**(9)**
Number of Producers (counts) (1)	36	7	43	5	21	26	36	40	76		
Share of sub-channel by number of producers **(%)**	84	16	100	19	81	100	47	53	100		
Share of sub-channel by tomato production **(%)**	55	45	100	11	89	100	28	72	100		
Gross Income-sales of tomato (US$/ha)	6,561	7,871	6,967	5,622	9,646	8,993	4,943	5,459	5,243	e	a,b
Price of tomato (US$/Kg) **(2)**	0.23	0.2	0.23	0.18	0.26	0.25	0.23	0.21	0.22	b,d,g,i	c
Yield (Kg/ha)	28,527	39,355	30,290	31,236	37,100	35,972	21,491	25,997	23,834	a,e	a
Transport cost (US$/ha) (3)	142	54	129	312	484	445	296	213	253	e,g,h,i	a,b,c
Non-labor variable inputs expenditures (4)	2,285	1,579	2,175	1,371	2,139	1,972	1,233	1,591	1,423	c,d,e	b,c
Cost of Fertilizers (US$/Ha)	357	196	332	211	289	271	219	303	262		
Cost of Foliars (US$/Ha)	173	116	164	156	178	179	129	208	171		
Cost of Insecticides(US$/Ha)	660	331	607	287	752	648	334	380	359		
Cost of Herbicides(US$/Ha)	39	11	35	49	92	82	27	44	38		
Cost of Fungicides(US$/Ha)	184	261	195	308	469	432	141	281	214		
Cost of Stakes and string materials (US$/Ha)	240	219	237	291	317	311	251	233	241		
Cost of seeds, others (US$/Ha)	633	444	605	69	43	49	133	142	137		
Tilling cost (US$/ha) (5)	25	23	25	53	52	52	29	22	25		
Irrigation energy costs (US$/ha)	156	81	144	121	119	119	154	100	125		
Labor cost (US$/ha) (6)	815	671	792	702	706	705	793	626	705	i	
Family labor cost (US$/ha)	378	107	334	200	48	77	192	138	164	a,e,i	a,b,c
Hired labor cost (US$/ha)	437	563	458	502	658	628	600	488	541	i	a
Total Cost (US$/ha)	3,525	2,379	3,346	2,652	3,488	3,352	2,574	2,601	2,590	a,e,g,i	b,c
Net Income (US$/ha) (7)	3,036	5,492	3,620	2,970	6,158	5,641	2,369	2,858	2,654	a,b,g	a,b

Table 2.2: ***Tomato production characteristics (Continuation)***

	CSU-Hortifruti			La Colonia			Traditional			Significance	
	NGO	Non-NGO	Total	NGO	Non-NGO	Total	NGO	Non-NGO	Total	(8)	(9)
Average Price of non-labor inputs (US$/Kg)											
Price of Fertilizers (US$/Kg)	0.28	0.27	0.28	0.22	0.30	0.28	0.29	0.31	0.30		
Price of Foliars (US$/Kg)	14	10	13	4	6	6	8	7	8		
Price of Insecticides(US$/Kg)	45	39	44	16	43	37	34	31	32		
Price of Herbicides(US$/Kg)	15	13	15	19	18	18	9	16	13		
Price of Fungicide (US$/Kg)	13	20	14	11	13	13	9	11	11		
Average physical quantity of non-labor inputs											
Fertilizers (Kg/Ha)	1288	740	1208	967	968	968	754	963	863		
Foliars (Kg/Ha)	13	11	12	37	28	30	17	28	23		
Insecticides (Kg/Ha)	15	8	14	18	18	18	10	12	11		
Herbicides (Kg/Ha)	3	1	2	3	5	5	3	3	3		
Fungicides (Kg/Ha)	14	13	14	27	35	33	15	25	20		
Average total farm production (Kg)	12,278	52,419	18,813	72,096	137,068	124,574	25,096	50,138	38,118	a,c,e,g,i	a,b,c
Cycles of tomato production	2.5	1.9	2.4	1.6	2.1	2.0	1.4	1.5	1.4	a,d,e,g,h,i	a,b,c
Total area of tomato (ha)	0.4	1.3	0.6	1.6	3.7	3.3	1.0	1.8	1.4	a,b,c,e,g,i	a,b,c
Labor (days/ha)	426	351	414	281	286	285	333	289	310	a,d,e,g	a,b
Family labor (days/ha)	204	59	180	80	19	31	99	67	82	a,e,i	a,b,c
Hired labor (days/ha)	223	292	234	201	267	254	234	222	228	i	
Input-Labor ratio (Kg/labor days)	3.13	2.20	3.02	3.74	3.68	3.70	2.85	3.60	3.22	c,g,h	

Notes: (1) Share of sub-channel by number of producers % is the total number of producers in a given marketing chain assisted or not assisted by NGOs over the total number of producers in that marketing channel times 100; Share of sub-channel by tomato production is the share measured by the total tomato production of all producers in a given marketing chain either assisted or not by NGOs over the total production of all producers in that marketing chain times 100; (2) Price is the average price for all markets, all seasons weighted by volume; Gross income is quantity of tomato sold times price (for all markets, all seasons) divided by total tomato land cropped (US$/ha).; '(3) Transport cost is the summation of all transport costs per ha incurred in delivering the tomatoes to the buyer.; (4) Non-labor variable input is the summation of all quantities*prices of fertilizers, foliars, insecticides, herbicides, fungicides, tutoring materials and others (seeds) per ha; (5) Tilling cost is the price of renting a tractor and/or animal plus tilling equipment to till an ha plus any additional cost paid for labor need to operate the equipment.; (6) Labor costs is the summation of all hired and family labor days times hired wage (imputing this cost to family labor). Labor days spent in production activities such as land cleaning, planting, fertilization, irrigation, fumigation, weed control, tutoring, harvesting, classification, marketing; (7) Net income is the

proxy for restricted profit, that is, the gross income less the summation of transport costs, tilling costs, non-labor input costs and total labor costs (per ha).; (8) Share of total area of tomato with irrigation is total area of tomato with irrigation over the total area of tomato cropped times 100 (details in Balsevich, 2005); (9) & (10) See table 1.

Table 3: ***Marketing Chain Selection Estimation Results (WESML)***

	Number of obs = 145	
Wald chi2 (28) = 7724.76	Prob > chi2 = 0.0000	
Log pseudo-likelihood = -51.928071	Pseudo R2 = 0.6061	
Covariate	**CSU-Hortifruti**	**La Colonia**
Producer is female	-0.155	1.662
	(0.88)	(1.59)
Age of farmer (years)	0.037	-0.078*
	(0.03)	(0.06)
Experience in tomato production (years)	-0.093**	0.097
	(0.04)	(0.06)
Producer education (years of schooling)	0.155*	-0.027
	(0.09)	(0.15)
Household size (members)	0.183	0.057
	(0.24)	(0.18)
Dependency ratio	0.362	0.758
	(1.26)	(1.93)
Producers has means of transport (dummy)	0.626	-1.069
	(0.71)	(1.13)
Livestock (heads)	0.009	0.035
	(0.10)	(0.04)
Producer has electricity (dummy)	-0.67	1.929
	(0.99)	(1.91)
Distance to asphalted road (kms)	0.129***	0.080*
	(0.04)	(0.04)
Overall farm size (ha)	-0.064	0.044
	(0.05)	(0.04)

Notes: 1. Robust standard errors in parentheses. 2. Parameter * significant at 10%; ** significant at 5%; *** significant at 1%. 3. Base Category is traditional marketing chain.

Table 4: ***Output Supply and Intermediate Input demand Function Estimation Results (Zellners)***

Parameter Estimates	Hortifruti			La Colonia			Traditional		
	Tomato Output Supply	Labor Demand	Non-labor input demand	Tomato Output Supply	Labor Demand	Non-labor input demand	Tomato Output Supply	Labor Demand	Non-labor input demand
Price tomato (US$/Kg)	33810*	185	1109	77892*	644	3341	18207	199	1296
	(14639)	(220)	(739)	(19910)	(1076)	(5079)	(30562)	(213)	(989)
Wage (US$/day)	-8687***	-101*	21	-34847	-204	1728	-757	-44*	202
	(4262)	(64)	(215)	(65966)	(356)	(1683)	(6622)	(26)	(206)
Non-labor inputs (US$/Kg)	-5093**	52**	-82**	-3394	114	-2647***	-2541	58**	273
	(1493)	(22)	(35)	(2578)	(138)	(652)	(1924)	(27)	(122)
Tomato area (ha)	32294*	502	562***	38194**	247***	547***	29393***	256***	706***
	(1534)	(23)	(77)	(4071)	(22)	(104)	(1993)	(14)	(62)
Tomato irrigated area (%)	7458**	-11	177	21589**	2	-333	9631	34	65
	(3178)	(48)	(160)	(9069)	(103)	(486)	(6941)	(48)	(216)
AGMACH	4500**	(32)	-266**	5198***	227	122	1676	45	91
	(2195)	(33)	(111)	(1536)	(191)	(902)	(5083)	(35)	(128)
millsp1	-214	-17*	3	-634	-15	-134	-2144	16*	-66*
	(595)	(8)	(30)	(4083)	(22)	(104)	(2288)	(9)	(40)
millsp2	206	4	-32	2272	-31	69	469	-9	8
	(273)	(4)	(35)	(4290)	(23)	(109)	(742)	(5)	(23)
Constant	11819**	173	-394	-73789	130	-8464	-8002	-229	-729
	(4057)	(121)	(407)	(183262)	(990)	(4675)	(20939)	(146)	(650)
R2	0.85	0.84	0.65	0.81	0.82	0.78	0.74	0.78	0.66
Observations		43			26			76	
Price elasticities									
Price tomato	0.42	0.18	0.55	0.16	0.17	0.29	0.11	0.11	0.37
Wage	-0.88	-0.80	0.08	-0.69	-0.54	1.48	-0.05	-0.26	0.60
Non-labor inputs	-0.51	0.41	-0.32	-0.04	0.20	-1.49	-0.10	0.22	0.52
Non-price elasticities									
Tomato area	0.99	1.22	0.69	1.01	0.88	0.62	1.10	0.94	1.30
Tomato irrigated area	0.11	-0.01	0.10	0.09	0.00	-0.06	0.10	0.04	0.03
AGMACH	0.09	-0.05	-0.21	0.03	0.19	0.03	0.03	0.08	0.08

Notes: Standard errors in parentheses. * significant at 10%, ** significant at 5%, ***significant at 1%

Table 5: ***Marginal Product Value (MPV) and Average Product Value (APV) by Marketing Chain (calculated from second stage Cobb Douglas production function).***

Input variable	CSU-Hortifruti			La Colonia			Traditional		
	MPV	**APV**	**Factor Price**	**MPV**	**APV**	**Factor Price**	**MPV**	**APV**	**Factor Price**
Labor: family & hired (labor day)	10	18	1.9	70	33	2.5	13	22	2.3
Organic non labor variable inputs									
Fertilizers (Kg)	6	30	0.3	14	32	0.3	1	26	0.3
Inorganic non-labor variable inputs									
Foliars (Kg)	11	85	13	8	53	6	-3	38	8
Insecticides (Kg)	15	22	73	7	22	37	3	25	35
Herbicides (Kg)	41	307	15	2	127	18	7	161	13
Fungicides (Kg)	17	39	18	6	18	14	1	27	14
Seeds (Cost in US$)	1.1	12	1	18	220	1	6	89	1
Land (ha)	6,012	7,549	1,489	11,198	9,418	1,325	2,616	5,918	1,658

Notes: (1) The input's marketing chain average marginal physical productivity (MP) is equal to the input's marketing chain production function Cobb-Douglas regression parameter estimate times the marketing chain sample average output (tomato production) divided by the marketing chain input value sample average; (2) Input's marginal product value (MPV) equals the marketing chain input's average marginal physical productivity (MP) times the marketing chain sample average tomato price; (3) Input's average product value (APV) is tomato production times tomato price divided by input; and (4) Factor price is the sample average by channel: Labor is wage per day (US$/labor day); Organic & inorganic variable inputs is US$/Kg; Seeds: its price is measured as the cost of 1 additional US$ spent in seeds; and Land is the value (US$) of acquiring one hectare.