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Small Farmers, NGOs, and a Walmart World: Welfare Effects of Supermarkets Operating in Nicaragua — Source link

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Abstract

Despite more than a decade of NGO and government activities promoting developing world farmer participation in high-value agricultural markets, evidence regarding the household welfare effects of such initiatives is limited. This paper analyzes the geographic placement of supermarket supply chains in Nicaragua between 2000 and 2008 and uses a difference-in-difference specification on measures of supplier and non-supplier assets to estimate the welfare effects of small farmer participation. Though results indicate that selling to supermarkets increases household productive asset holdings, they also suggest that only farmers with advantageous endowments of geography and water are likely to participate.

Key words: agricultural markets, contract farming, development, Latin America, Nicaragua, supermarkets, Walmart

JEL classification: L23, O12, O13, O14, Q12, Q18

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Multinational and domestic supermarkets increasingly source fruits and vegetables in the developing world for sale in the developing world. As these markets expand, an intermediate quality-differentiated market is emerging for labor-intensive crops in whose production small farmers might compete. These domestic supermarkets offer an option for farmers with more rigorous requirements than traditional spot markets but with fewer risks and strict standards than export. Large international companies like the Walmart corporation are beginning to interact with and possibly transform horticulture marketing in the developing world. What are the forseeable consequences for poverty and agricultural development?

In several nations, such as Nicaragua, with significant small-scale farming economies, the public and private sectors are seeking to understand the impact of Walmart-dominated supermarket systems as the retail giant builds purchasing relationships with hundreds of individual farmers. Similarly, in the People's Republic of China, Walmart will soon contract with hundreds of thousands of farmers and it is imperative that the impact of such contracts on participant smallholders is clearly understood.

The question in the foreground is straightforward: with such arrangements undergoing dramatic expansion in many regions, are these relationships providing economic benefit for participating farmers, or not? There is some precedent for concern. Research on the effects on small farmers of the growth of the agricultural exports sector in Latin America in the 1980s and 1990s suggests that growth tended to be exclusionary and that structural changes in the agricultural sector generally benefited small farmers as laborers rather than as independent growers (Carter, Barham, and Mesbah 1996; Barham et al. 1992).

Two critical questions have engaged researchers studying the emergence of new food supply chains in the developing world and similarly motivate this paper: first, how will small farmers be included in these structural transformations and second, what welfare effects can be attributed to that inclusion.

The bulk of the recent literature analyzing small farmer participation in supply relationships has focused on the correlates of participation at the household level, and on whether

there has been exclusion based on farm size or non-land assets (Barrett and Reardon 2000; Blandon, Henson, and Islam 2009; Key and Runsten 1999; Kirsten and Sartorius 2002; Gibbon 2003; Dolan and Humphrey 2000; Boselie, Henson, and Weatherspoon 2003; Reardon et al. 2003). Some research now suggests that small farmers can be included (Maertens and Swinnen 2009; Bellemare 2012; Wang et al. 2009; Miyata, Minot, and Hu 2009) though evidence is mounting that participation may be available largely to those who are already equipped with irrigation or cooperative membership (Hernández, Reardon, and Berdegué 2007; Neven et al. 2009; Balsevich, Reardon, and Berdegue 2005).

One dimension of the supermarkets and small farmer participation story that has received little attention is the way in which geography and access to water and infrastructure may influence farmer participation in supply chains. Yet these characteristics may be at least as important as farmer wealth or irrigation in influencing entry and outcomes. Our analysis uses panel community-level data on Nicaraguan small farmers' relationships with Walmart and a Nicaraguan supermarket chain to analyze how observable community and household characteristics are related to the evolution of new supermarket supply chains.

Regarding the welfare effects of new supermarket supply channels, a primary empirical challenge has been the the potential endogeneity of the observed outcomes. Welfare outcomes measured as effects of participation may be jointly determined by observables influencing placement of the supply chain such as access to water and infrastructure, or unobservables influencing household participation such as entrepreneurial or management ability. Most studies have used cross-sections, matching a group of farmers supplying a particular horticulture crop to a supermarket with a group of similar farmers selling the same crop into the traditional market system and relying on Heckman two-step selection corrections to estimate welfare effects. We are aware of only two cross-sectional studies that control for lagged asset stocks or landholdings in studies of small farmer supermarket supply chain participation: both Hernández, Reardon, and Berdegué (2007) and Neven et al. (2009) control in their analyses of participation for landholdings, share of land owned,

and whether the household had an irrigation system five years prior to their survey. Results from both studies indicate the critical importance of controlling for participant asset stocks and landholdings at the time the farmer entered the supply relationship.

Therefore, though early evidence suggests that farmers who participate in supermarket supply chains experience higher, more stable incomes (Neven et al. 2009; Minten, Randrianarison, and Swinnen 2009; Key and Runsten 1999; Miyata, Minot, and Hu 2009; Bellemare 2012), persistent identification challenges mean that significant debate continues over whether developing world small farmers benefit. Moreover, few studies have looked beyond income to study effects on other critical dimensions of household welfare such as assets.

In 2012, Walmart was the world's third largest public corporation, with 8,500 retail stores in fifteen countries. Their operations in the developing world increasingly are designed to source directly from small and medium farmers; in 2010 the company announced a "global commitment to sustainable agriculture" that set forth the goal that by 2015 the company would sell $1 billion in food sourced from 1 million small and medium farmers worldwide. Nicaragua is an important site for study because, as a part of Walmart's Central American Direct Farm initiative, it serves as a model program for Walmart's operations with small farmers around the world including much larger operations in India and China. Therefore, findings on participation and effects can provide insight into much larger programs just beginning elsewhere. Also, the Nicaraguan supermarket sector is in an early stage; the population of small farmers directly supplying supermarkets with fresh fruits and vegetables (FFV) was around 350 in 2008, and the ongoing transition to supermarket dominance should offer valuable insights into economic and social welfare impacts in their early phase. Moreover, the dramatic discrepancies in the Nicaraguan rural sector, with regard to arable land, resources, family assets, and income, all give this work a particular urgency. Research distinguishing populations of likely beneficiaries from groups expected to require

assistance will be invaluable to policymakers designing and targeting interventions. This is a primary objective of the paper.

This article makes four primary contributions to the empirical literature on developing world small farmers' adaptation to new agricultural market structures. First, we demonstrate that geographic and natural resource endowments are strong predictors of community and individual inclusion in a supermarket procurement basin. To our knowledge, our data is the first to characterize a national population of supermarket small farmer suppliers over time. These unique data allow us, for the first time, to characterize the geographic correlates of supply chains and the way that site characteristics interact with household asset endowments to influence participation over time.

Moreover, our analysis, which analyzes the placement and effects of supermarket supply chains in Nicaragua over the eight years in which the sector experienced significant growth in the number of retail outlets, provides some insight into a major question in the development literature: the consequences of the transformation of supply chains for nonparticipant farmers. Given that the population of supermarket horticulture suppliers in Nicaragua with regular direct relationships with companies in 2008 was approximately 350, our analysis casts some doubt on speculation that supermarkets will have a major impact on nonparticipant farmers in the developing world, at least in the near term. The small participant numbers we identify also suggest that changes in regional rural poverty and growth related to supermarket expansion will be modest, again, at least in the near term.

The second contribution of this paper is to estimate the effect of supermarket supply chain participation on asset stocks: investments likely to change future household incomes and income dynamics. To date, most studies of supermarket supply chains have used cross-sectional data on farmer revenues or incomes and have struggled to identify cleanly the effects of participation. We use a difference-in-difference specification on data on durable household assets and landholdings before and after participation in domestic supermarket supply chains to estimate the effects of participation on farmers' welfare. A combination

of panel and cross-section data allow us to validate the quality of the recall data collected. We find a significant effect of participation on farmers' productive assets, an increase of approximately 16% of suppliers' mean pre-participation holdings but no effect on households' consumer durables or landholdings.

Difference-in-differences exploits the time series strength of our data and offers a more tractable and transparent method to assess impact than existing cross-sectional analyses. A critical assumption that must hold is that, in the absence of participation in a supply chain, the control and supplier farmer groups would have experienced similar trends. We establish that mean asset holdings before entering the supply chain were the same for suppliers and the control group of non-suppliers. We do this for multiple waves of supplier entry.

Third, we test for NGO impact: whether NGO-assisted suppliers are different at entry into the supply chain from suppliers that participate independent of NGOs and whether they exhibit different asset outcomes from non-NGO assisted suppliers. We find no significant difference in wealth or landholdings among NGO-assisted farmers. Moreover, despite the considerable per-farmer investment made by these programs, we see no evidence that NGO farmers have specially accrued assets or landholdings. It appears, however, that the NGO activities may help overcome knowledge and experience-related barriers that farmers face as they enter the supply chain. For example, the share of exits from the supply chain by farmers with no horticulture experience prior to the supermarket relationship is significantly less among farmers who are assisted by NGOs.

Finally, we test for significant investment by producers in relevant assets, landholdings or irrigation in advance of their entry into the supply chain. The possibility of such pre-participation investment by suppliers has been a matter of concern in the empirical literature because it can complicate the analysis of household characteristics correlated with entry. Researchers have worried that farmers' characteristics such as baseline assets or landholdings themselves might be endogenous to selection into the supply chain (Barrett et al. 2011). We find no evidence to support these concerns.

Data

Two retail groups dominate Nicaragua's domestic supermarket sector, the ten-store national chain La Colonia and Walmart, with 46 Nicaraguan outlets (2011). Michelson, Reardon, and Perez (2012) and Balsevich, Reardon, and Berdegué (2005) describe the sector, the evolution of respective procurement structures and the rapid growth in retail and sourcing in the Nicaraguan supermarket sector since 2000. Figure 1 presents the growth in retail outlets in Nicaragua since 2000.

This research is designed to characterize and estimate supply chain placement and welfare effects of supply chain participation at a national level. To draw a supplier sample, we designed and implemented a strategy to locate and survey all Nicaraguan small farmers who had sold fresh vegetables[1] directly to La Colonia or Walmart between the beginning of the sector's growth in 2000 and the time of the survey in 2008. The relatively small number of farmers that have had direct sales relationships with supermarkets in Nicaragua made this a feasible task. The head of fresh fruit and vegetables purchasing for Walmart's dedicated wholesaler Hortifruti in 2007 reported that the maximum number of small farmers with a direct relationship with the chain in that year was around 350, roughly split between fruits and vegetables suppliers. The head of purchasing for La Colonia reported that the chain only bought directly and regularly from one or two small cooperatives of farmers working with an NGO.

Interviews with current and former buyers for La Colonia and Walmart established three important facts. First, compared with Walmart, La Colonia sources only a small share of its fresh fruits and vegetables directly from small farmers. Second, the number of supplier farmers between 2000 and 2008 was relatively small. Third, supermarkets highly concentrated horticulture purchasing among small groups of farmers who produce large quantities of vegetables and fruits year-round. Within the range of products sourced from small farmers, purchasing is further concentrated. For example, Hortifruti's purchasing

manger explained that 95% of Walmart's tomato sold in Nicaragua in 2007 came from two cooperatives of small farmers.

While La Colonia provided lists of current and former suppliers and supplier cooperatives, Walmart was unwilling to disclose the locations or identities of their current or former small farmer suppliers. Using interviews with buyers, NGOs working in agriculture, and farmers' organizations, we compiled lists of communities and municipalities in Nicaragua defining supermarket procurement basins. Nicaragua is a relatively small country, with horticulture production largely concentrated in a few primary areas. The NGO community is also relatively small and institutions proved well aware of one anothers activities and projects. Nicaragua is made up of 153 municipalities. Of these, interviews identified that 73 contained communities where farmers either had supplied supermarkets or might plausibly supply supermarkets due to proximity to supplier municipalities or the primary road network. Lists of supplier communities were used to conduct a supplier census, identifying all farmer supermarket suppliers of fresh fruits and vegetables. Census teams used a snowball sampling method. Beginning in communities where interviews had identified that supermarkets had sourced, enumerators compiled names of current and past suppliers and assembled names of additional communities where supermarkets had purchased. If supplier communities named by interviewees were not already included on our list, census teams visited these communities as well. In the census, teams gathered information including supplier name, supermarket(s) supplied, dates of participation in the supermarket supply chain, and crops supplied.

Upon the completion of the supplier census, enumerator teams returned to all farmers located in the supplier census and conducted a detailed household survey with the household head. All supplier farmers were surveyed. We interviewed 425 farmers who had supplied supermarkets in Nicaragua.

Of the 425 surveyed households, 29 interviews were incomplete, leaving us with 396 complete supplier household surveys. As a validation for our final supplier sample, we

compare our totals with Walmart and La Colonia's own numbers. We know from interviews with Walmart that the share of production sourced directly from small farmers has grown over time and that the 2007 number was approximately 350, roughly split between vegetables and fruits, so we expected to find 200-250 current suppliers in 2008 (including the La Colonia suppliers). We found 244. Given the steady growth in retail outlets since 2000 (Figure 1), we expect to see corresponding growth in supplier and exiting supplier numbers over time. Figure 2 plots the suppliers and exits, by year.

As a comparison population for a welfare analysis of supermarket suppliers, we use a representative sample of farmer households in regions of Nicaragua where supermarkets source fresh fruits and vegetables. We resample an existing panel with observations in 1996 and 2000[2].

We revisited an existing panel as a comparison group because interviews with supermarket buyers as well as NGO personnel and suppliers indicated that a representative national sample confined to historically horticulture-producing areas close to roads would offer a good comparison for the supply chain as a whole. Note that like our supplier sample, the non-supplier group is roughly split between basic grains growers and farmers growing some horticulture or cash crop.

Significant qualitative work suggested a range of entry pathways through which small farmers could become suppliers in Nicaragua. For example, buyers indicated that proximity to paved roads was a primary criteria they used to identify prospective suppliers but claimed that there were no asset or land requirements mediating participation[3]. NGOs reported a range of criteria for their project participants; several targeted farmers for inclusion that were formerly subsistence maize growers while others had minimum requirements for landholdings of two hectares. Suppliers therefore represent a range of pre-supermarket farming experience: from those who had moved from subsistence staple grain production to those with prior experience in horticulture for the spot market.

Finally, because the analysis studies the effects of participation in the supply chain on households' assets and landholdings, re-surveying an existing panel as a comparison group provides an excellent check on the accuracy of the recall data used in the empirics. We assess the accuracy of the recall data in Section 3.

We restricted our re-survey of the panel to the same municipalities from the supplier sample, in which interviews indicated that farmers had supplied supermarkets or might plausibly supply supermarkets because of proximity to primary road networks and other supply municipalities. There were 640 farmers in the panel living in established or plausible supply municipalities. We successfully located and interviewed 466 of these farmers. Our attrition rate was 25.9%. An analysis of attrition shows we were were more likely to lose low-wealth farmers that lived further from roads, biasing our comparison group towards a higher-wealth, less isolated sample, strengthening our results in Section 3.[4]

We begin with a description of the starting asset, landholdings and irrigation positions of supplier farmers. Section 2 presents the dynamic analysis of supply chain placement. Section 3 explains the estimation strategy for the welfare effects analysis, validates the asset recall data, and presents the results from the welfare effect estimations related to participation and NGOs. Section 4 examines a candidate mechanisms that might drive welfare effects. The final section concludes.

For the duration of the paper, *suppliers* and/or *participants* will refer to farmers who supplied supermarkets. When referring to data for suppliers before they supplied the supermarket, we will speak of suppliers pre-entry or suppliers before the supermarket. Non-suppliers will exclusively be used to refer to farmers in our data who never supplied supermarkets between the period of 2000 and 2008.

Supplier descriptive statistics

In this section we use descriptives to characterize the production and market behavior of suppliers before they sold to the supermarket and to provide some background on the con-

tract relationship. The exercise builds intuition for the subsequent analyses of participation and effects.

Table 1 disaggregates the 396 suppliers by the supermarket chain supplied and presents the mean relationship tenure, both (1) by retail chain and (2) by whether the farmer had exited the supply chain or was still a supplier in 2008. Across retail chains, the mean supply relationship for suppliers still working with a supermarket in 2008 was a little over two and a half years. Across chains, the mean tenure for discontinued suppliers was approximately one and a half years. Our samples of both current suppliers and discontinued suppliers are dominated by farmers supplying Walmart (or Walmart's predecessor, Ahold).[5] Few farmers supply multiple chains simultaneously, in fact Walmart had policies to actively discourage supplier farmers from working with the company's competition.

Supermarket supply contracts

Supermarket contracts with small farmers in Nicaragua generally consist of verbal agreements specifying quantities of product of a specified quality to be purchased from the farmer at a future date or dates. Prices at the date of the transaction are often set explicitly or set with respect to reference traditional markets; minimum prices are also often set, so the farmer knows the lowest possible price that he will receive for his production.

In June 2006 four multinational NGOs began working with Nicaraguan farmers through a United States Agency for International Development (USAID) program designed to build the capacity of small farmers to participate in modern markets. Supermarkets in Nicaragua did not (as of 2008) offer credit or technical assistance to farmers or farmers' cooperatives. NGOs generally assist with credit, irrigation, information, and technical advice, quality management and contract negotiation between cooperatives and supermarkets. In the case of NGO-organized farmers, a written contract is sometimes negotiated between the supermarket and the NGO for a specified quantity and purchasing schedule.

Suppliers' crop production, pre and post supermarket

Table 3 presents the pre-supermarket production technologies of suppliers. One third of the supplier farmers were growing only basic grains before they became a supplier, 14% were cash crop farmers (mostly coffee), and a little over half had some experience with a horticulture crop. However, even among those with some experience in horticulture, few were growing at the scale or the frequency required by supermarkets. Less than 30% of farmers who grew horticulture before selling to supermarkets were farming with irrigation. In fact, more than three-quarters of all suppliers were without irrigation prior to the supermarket relationship. The distinction is important: for small farmers who farmed basic grains prior to the contract, the move to supplying a supermarket will include both the change attributable to producing a new higher value crop and the change attributable to the supermarket relationship; while for small farmers who farmed horticulture, the supermarket relationship will represent likely changes to production technology and marketing.

Once farmers enter the supply chain, neither their production nor their marketing behavior is exclusively concentrated in the supermarket relationship. Data from suppliers indicate that the majority supplied one crop to the supermarket while selling two crops to non-supermarket buyers and growing a mean of four crops. Table 2 presents the mean total number of crops grown and total number of crops sold by suppliers in 2007, disaggregated by the number of crops the supplier sold to the supermarket in 2007.

The crops gown by suppliers and the transaction frequency described in this section suggest that participating farmers require access to the geographic and household resources to permit year-round production schedules. A plausible empirical strategy therefore must consider place and household characteristics simultaneously, a task to which we now turn.

Supply chain placement

Farmers enter into a supply relationship with a supermarket through a variety of pathways. Some farmers enter through NGOs that prioritize transitioning basic grains subsistence

smallholders into horticulture, some enter through NGOs that set minimum landholding thresholds, others are incorporated when a supermarket buyer driving a supply route extends an invitation to a farmer with a healthy-looking field of tomatoes. Interviews with Walmart supermarket produce buyers charged with meeting weekly regional horticultural supply quotas indicate that buyers value two primary attributes: farmers who are easily accessed by roads and phone and farmers who offer the agro-climatic potential to provide a year-round supply stream.

In this section we identify the factors that correlate with entry into the supply chain at a national level since 2000. We also test to see how the relationships between community and household characteristics and entry into the supply chain have changed over time.

To test whether there has been some change over time in the community and household-level correlates of entry into the supply chain, we use a linear probability model (LPM) with fixed effects and entry into the supply chain as the dependent variable. Because there is some concern in the literature that coefficient estimates may not be consistent in the case in which there are only a few time-series per individual (our data include nine), we also run a conditional logit model (Maddala 1987; Chamberlain et al. 1984). The conditional logit model results are consistent in significance, sign, and relative magnitude with the panel LPM and so we report the easier to interpret LPM coefficients.

Our analysis demonstrates that suppliers are on the whole a group characterized by the agro-ecological resources to permit stable, year-round output, even when contrasted with a comparison group selected to reflect preferential access to paved roads and horticultural growing zones. This has been a hypothesis in the literature (Barrett et al. 2011), but ours is the first analysis to provide evidence on this point.

Note that the bias in the selection of the control households to include higher-wealth and less isolated households colors the interpretation of the participation analysis. Our results suggest households' initial land and wealth have significant but relatively small effects on the likelihood of supplying supermarkets over time. It is probable that the small magnitude

of the effects of productive asset wealth and land that we find are due to the bias in the control sample. That is, compared with more characteristic sample of Nicaraguan farmers (including those living further from roads and in less historically-productive agricultural regions), the wealth and land coefficients might be much larger.

The 862 farmers in our sample are distributed among 496 communities; 356 are non-supplier communities. Based on interviews with supermarket buyers and intuition from the literature suggesting that community characteristics influence supply chain placement through the consequences for fixed and per-unit costs of the transaction for the buyer, we hypothesize that several classes of characteristics may determine a community's inclusion in a supermarket supply basin: altitude, depth of water table, year-round access to water for agricultural production, distance to paved roads, the closest municipal market, and the closest supermarket retail outlet in the year 2000. In communities containing multiple households, responses for community variables were averaged across residents.

First, communities without capacity to supply year-round are regions of high cost contracts because the fixed costs of the contract for the buyer are spread over a smaller number of transactions and growing seasons. We expect supply communities to have higher altitude (reflecting higher historical horticulture production in the country's interior highlands), shallower depth of water table (to permit easy well drilling for irrigation), and greater access to water throughout the year for agricultural production.

In addition, supermarket buyers report a preference for farmers with whom they can maintain a flexible supply relationship – updating quantities, prices, and timing the week before a transaction. We therefore expect that variables capturing the isolation of the community including distance to a paved road and distance to the closest supermarket retail outlet in 2000 (essentially a measure of distance from Managua, as nearly all supermarkets in 2000 were in the capital) should negatively influence inclusion.

Based on findings in the literature (Hernández, Reardon, and Berdegué 2007; Balsevich, Reardon, and Berdegue 2005) and interviews with NGOs, and buyers, several household

characteristics are expected to influence participation in supermarket supply chains. Given the costs associated with transaction requirements and the supermarket payment delays of one to three weeks, it is anticipated that farmer participation is positively associated with wealth. However, the effect of wealth is difficult to predict, given findings elsewhere (Michelson, Reardon, and Perez 2012) that the price risk-mitigating terms of the contract are likely to be more attractive to poorer farmers.

Farm size is expected to be negatively associated with participation because larger farmers in Nicaragua generally work in highly remunerative large scale cash crops. Because supermarket buyers report a strong preference for farmers who can provide steady, year-round supply streams, a farmer's irrigated landholdings are expected to positively influence inclusion. Productive assets and consumer durables are compiled into an index using factor analysis (Sahn and Stifel 2000) and details regarding computation of the asset index are available in the supplementary appendix online. We consider productive assets and consumer durables separately. We also include controls for a farmer's total farming experience. Household demographic characteristics include: age, gender, and education of the household head.

Table 4 reports the results of the linear probability model with fixed effects. As hypothesized, the results demonstrate that community-level characteristics matter a great deal to supply chain placement, even among a sample of households already restricted to regions of higher agricultural potential and access to roads and markets. Community altitude, access to year-round water, and distance to the closest supermarket retail outlet (in 2000) are significant predictors of household inclusion. One might expect that communities with this intersection of favorable supply characteristics also tend to have the kinds of capable suppliers that interest supermarkets, so their robustness to the inclusion of household-level wealth and experience variables is noteworthy.

The importance of many of the household and community characteristics changes over time, suggesting some evolution in the required attributes to gain entry into the supply chain

between 2000 and 2009. At the household level, the small positive relationship between landholdings and entry diminishes significantly over time. However, total irrigation is a significant predictor of entry only in the years 2006 and 2007; this is likely reflecting the post-2005 NGO programs that equipped farmers with irrigation in advance of entry into the supply chain. Finally, note that new entrants into the supply chain are significantly younger and significantly less likely to be female over time.

Community characteristics related to productive capacity and environment are increasingly important over time for supply chain inclusion: altitude and year-round access to water are significant and positive predictors of supply chain participation whose magnitude grow between 2000 and 2009.

Results in Table 4 are noteworthy in two respects. First, we find evidence of the existence of corridors of higher economic potential, areas that, because they are endowed with relative proximity to roads, optimal growing conditions, and year-round access to water are able to participate in new market opportunities. Areas without sufficient water resources are less likely to be included in supermarket supply chains. Second, our results suggest that estimates of household welfare effects due to adoption of new markets should be attentive to possible supply chain placement biases in addition to individual selection biases, controlling for community characteristics relating to isolation, water access, and climate. Our results suggest that, at least in this case, studies assessing effects at regional or national scales would include significant placement bias should they fail to control for community-level water, transport, and isolation variables. Note that because most existing supermarket welfare effects studies are matched cross-sections over relatively small geographic areas, this bias generally is not a problem in the existing literature.

Participation in these opportunities is clearly not equally available to all farmers, even within regions of established supermarket procurement near roads and with water access. The prominence and influence of geography in farmers' productivity and transactions costs

and therefore supply chain placement has been notably absent from most academic work and policy discussions around smallholders and modern market participation.

Welfare effects empirical strategy and estimations

Two issues underlie our estimation and data collection strategies: possible bias in the welfare estimates due to non-random supply chain placement and possible bias from non-random household participation in the supermarket contracts.

Controlling for the potential bias in regional estimates of welfare effects requires that we understand the supermarket site criteria determining which communities lie within supermarket supply basins. The problem for impact evaluation arises if program placement depends on the relevant outcome variable or if placement is not controlled for in the estimation. Pitt, Rosenzweig, and Gibbons (1993) termed the resulting bias "area heterogeneity bias".

Results in Section 2 suggests that supermarket procurement basins are situated based on observable characteristics related to transport and year-round growing potential; our panel data and method allow us to control for potential bias arising from this non-random supply chain placement.

Regarding the household selection effect, the primary empirical challenge is the potential endogeneity of the observed outcomes, that is, that asset outcomes may be jointly determined by unobservables influencing household participation such as ability. Our panel data method will permit us to control for this unobserved household heterogeneity.

This section begins with a validation of the recall data and a presentation of the pre-entry holdings of suppliers and non-suppliers. We then perform a standard difference-in-difference estimation and a version using a method to correct for potential serial autocorrelation from Bertrand, Duflo, and Mullainathan (2004). Finally, we perform a series of robustness checks on the results including the following specifications: omitting suppliers who entered the supply chain with irrigation; controlling for the year of farmer entry; and

estimating separate models for farmers who joined before and after 2006 (when the NGO programs began to play a role). We also test for differences in effect on NGO suppliers and on farmers who reported growing only basic grains before entering the supply chain.

Validation of recall data

We use a difference-in-differences method to compare growth in participant and non-participant household assets and landholdings over time. Our data includes eight years of recall on household assets, landholdings, and irrigation. Difference-in-differences is preferable for reasons related to both data and methodology. First, there is no credible instrument in our data for participation in the supply chain. Difference-in-differences offers a more transparent and appropriate method to asses impact and it allows us to control for unobserved heterogeneity in the data. Moreover, the use of assets is attractive because they reflect a household's productive stock and therefore may better represent a household's likelihood of being poor in the future. In the case of supply chain participants, assets provide information about whether households are making investments in technologies and productive capital that are likely to shift their productive state in the future or whether the supply chain is merely a one or two period change in income with little effect on the households' productive fundamentals. To our knowledge, no recent study of supermarket effects has yet examined impacts on household asset portfolios and land accumulation.

Finally, assets may be preferred given the particular complexity of gathering income data for farmers in the supermarket supply chain. Our data (Table 2) indicate that suppliers in 2007 grew, on average, between four and six crops. Each additional crop is likely to add noise to a total household income calculation because the costs and marketing quantities and prices must be gathered for each crop, often across numerous plantings within a given year. For example, many irrigated vegetable growers in the supply chain plant in three week cycles for a full year, producing more than 50 harvests annually. The quantities and costs of mineral fertilizer and chemical applications for these cropping cycles can vary

throughout the year. In addition, because supplier farmers sell, on average, about 70% of their production to the supermarket, suppliers are often selling in multiple markets and receiving multiple prices for their production, which vary throughout the year. What this means is income measures for suppliers are likely to contain considerable measurement error.

Asset data is often characterized by fewer problems of recall bias, seasonality and measurement error than flow measures of economic wellbeing such as consumption or income and research has demonstrated clear links between household productive asset holdings and future poverty states (Carter and Barrett 2006; Carter and May 2001, 1999; Filmer and Pritchett 2001; Rosenzweig and Wolpin 1993; Barrett et al. 2006).

A concern with using recall data is the accuracy of respondents' recollections. This is often only something a researcher can speculate about. However, for non-suppliers we have both recalled values of 2000 productive assets from the 2008 survey and we have the measured values from the year 2000 survey. We can thus assess the extent of reporting bias associated with our outcome variables for non-suppliers.

We match measured and recalled holdings of 22 productive assets for 459 households in the panel. Table 5 lists these assets and a constructed ratio that measures the accuracy of recall for each asset. The ratio is computed by taking the measured value of the household's asset in the year 2000 over the household's 2008 recall of their 2000 holdings. We add one to both the numerator and the denominator to permit the inclusion of households whose 2008 recall holdings were zero. The ratio is constructed such that a value greater than one indicates that the recall mean is lower than the true mean, so households underreported at recall. A value of less than one indicates that the recall mean is greater than the true mean, so households over reported in 2008 when they recalled their 2000 portfolio.

For nearly all of the assets, households exhibit a tendency to underreport slightly. Overall, Table 5 demonstrates that the mean tendencies are small. The effects seem to be largest for the plow for oxen and the backpack sprayer, two of the lowest value and most widely

held assets. The significance of Table 5 for our asset index makes sense: households seem to remember larger, more valuable assets with a greater degree of accuracy.

We also test the relationship between the recall ratios in Table 5 and households' annual asset index values. We regress annual household asset indices on the household recall ratio for the year 2000. In this way we can test if our productive wealth measures are related to households' tendencies to over or understate their recalled assets.

We find no statistically significant relationship between recall and wealth. We also include in Table 6 results from simple bivariate regressions that regress the households' annual productive asset indices in 2001 through 2008 on recall ratios for each asset. In this way, we can test to see whether higher-wealth households have a tendency to over or underreport holdings of particular productive assets in the recall data. A plus sign in the table indicates that a higher index value in that year relates to a tendency to understate wealth in recall of 2000. A negative sign indicates that a higher index value relates to a tendency to overstate wealth in recall of 2000.

Overall, the results in Table 6 look reasonable, with no relationship between index value and recall ratio for most assets. Two of the productive assets for which there is a relationship between productive wealth and recall over time were held by less than three households. The other two assets for which there is a consistent wealth relationship over time are the backpack sprayer and the tiller. The magnitude of the relationship of productive wealth on tiller recall is quite small, less than 0.04, meaning for every one unit increase in the index the household was four percent less likely to remember having a tiller at baseline. Given that the mean supplier baseline index holdings have a standard deviation of 0.49 (with a mean of 0.37), this is a very small effect. The backpack sprayer is a widely held asset and the effect ranges over time between 0.06 and 0.14, also a small potential effect.

We argue that our results on non-suppliers' recalled asset portfolios also provides evidence that the recall data for the suppliers is reliable. We have no reason to believe that the suppliers would recall differently than non-suppliers.

As a final validation of the asset data's relationship with wealth we study the relationship between 2007 productive assets, households' income in 2007, and households' use of credit in 2007. The correlation between the productive asset index and income in 2008 is 0.32. Regarding credit use, 357 of the 862 households reported using formal credit in 2007. The mean productive asset index for those who used credit was 0.87 and 0.62 for those who did not, a statistically significant difference at the one percent level. So we see good evidence that our final period measure of productive wealth is related to other dimensions of household welfare.

Pre-entry supplier asset holdings

The critical assumption of any difference-in-difference is that the trends, here, of accumulation of productive assets, consumer durables, land, and irrigation, were the same for suppliers and non-suppliers before suppliers joined the supply chain. If the trend was greater among suppliers then the estimate of the effect of participation would be overstated. Similarly, if the trend was less among suppliers then we would understate the impact of participation.

It is of course impossible to test the identifying assumption that suppliers and non-suppliers would have experienced identical asset trends in the absence of participation. However, because we have multiple observations (from recall) of households' portfolios we can test whether the assumption of a common trend holds before farmers join the supply chain. Note that results in the previous section established that there are differences in the agro-climatic endowments of supplier farmer communities. For this reason, we cannot use propensity score matching to match the suppliers with non suppliers. Instead, we test for differences between supplier and non-supplier households' asset and land holdings before suppliers entered the supermarket supply chain. Our argument is that, though supplier and non-supplier households may have been living in areas characterized by different ac-

cess to water, their asset portfolios suggest that they shared a similar productive state before the arrival of the supermarket.

Table 7 compares mean annual supplier holdings of productive assets, consumer durables, land, and irrigation with non-supplier holdings between 2000 and 2007. Because suppliers entered the supply chain at different times, in each year we compare the portfolios of households that had not yet entered the supply chain with non-supplier households. Evidence in table 7 suggests that before entering the supply chain, supplier households are similar to non-supplier households in their productive assets and consumer durables holdings over time. Though supplier households have significantly lower mean landholdings, we test for and find no significant difference in land accumulation trends before entering the supply chain.

The one difference evident in Table 7 is supplier households' irrigation. Supplier households have significantly higher mean irrigation. They are also accumulating irrigation more quickly than non-suppliers before they enter the supply chain. Given that we cannot reject that irrigation trends were different before suppliers entered the supermarket channel, our estimations will not test the effect of the supply chain on farmers' irrigation. Because differences in irrigation holdings between non-suppliers and suppliers before entry could be evidence of endogeneity bias, that some suppliers were on a higher-productivity path before entry, we will run a specification of the impact analysis regression where suppliers who held irrigation before entry in the supply chain are omitted from the set of suppliers.

Because we are also interested in whether there is a special effect on NGO-assisted farmers we also test for common pre-participation trends within suppliers. We find that NGO farmers are indistinguishable from other suppliers in their pre-entry holdings of productive assets, consumer durables, and land. These results can be found in Table 8.

Welfare effects estimation using standard difference-in-differences

We use difference-in-differences to study the effect of the supply chain on participant households' asset stocks and accumulation. The difference-in-difference method will identify the average treatment effects on participants under the assumption that the selection bias based on unobservable household characteristics is constant over time. One type of selection bias might vary over time and affect our estimates: if outcomes in asset portfolios are associated with starting differences between suppliers and non-suppliers. Note that given that the supermarket supply market in Nicaragua remains small relative to the size of the agriculture sector and given the geographic distribution of our non-supplier sample, we are not worried about spillover effects from supermarket affecting the asset accumulation of non-suppliers.

We want to test the effect of participation in the supply chain on asset stocks. Define μ_{it} to be the mean outcome in group i at time t, with $i = 0, 1$ for the non-suppliers and the suppliers, respectively and $t = 0, 1$ for the pre and post participation periods, respectively. Suppliers before entering the supply chain therefore are in μ_{10} and after μ_{11}, The objective is to estimate:

$$(1) \quad \gamma = (\mu_{11} - \mu_{10}) - (\mu_{01} - \mu_{00})$$

where the first difference is the change in outcomes for supermarket suppliers and the second difference is the change in outcomes for non-suppliers. We first estimate γ using an equation similar to the following:

$$(2) \quad A = \beta_0 + \beta_1 T + \beta_2 I + \gamma I * T + \varepsilon$$

Where T is a binary variable capturing differences between periods that would occur in the absence of the participation in the supply chain, A the outcome of interest, I the participation group dummy capturing differences between the supplier and non-supplier groups, the $I * T$ interaction is equivalent to a dummy variable equal to one for households in the supplier group in the second period, and ε the iid error term. The average treatment effect, the coefficient of interest, is γ.

Our data include considerably more information than a two-period panel; we have eight years of recalled data on assets and landholdings for suppliers and non-suppliers. These data including multiple observations for suppliers' asset holdings in the years before entering the supply chain and multiple observations of holdings in the years after.

Because farmers entered the supply chain in different years, the estimation includes a full set of year dummies. We create a participation variable with a lead term to test whether farmers invest in productive assets, consumer durables, or land in advance of entry into the supply chain. The participation variable is interacted with a dummy that indicates whether the farmer was assisted in the supply chain by an NGO (verified using the NGOs' participant rolls). We include regional dummies and cluster standard errors at the level of the household. Results are presented in table 9. See Wooldridge (2001) for details on difference-in-differences with multiple time periods. Results for these uncorrected estimations are presented in Table 9.

It has been pointed out that difference-in-difference estimates that do not account for serial auto-correlation can be plagued by bias in the estimates of the standard errors (Bertrand, Duflo, and Mullainathan 2004) and thus overstate the significance of coefficients. As expected, we find evidence of serial autocorrelation in our time series. We estimate the auto-correlation coefficients for eight time steps by regressing the residuals on lags ranging between one and eight years. Estimated auto-correlations are significant and range between a first order coefficient of 0.89, declining to 0.38 in year eight. This is strong evidence motivating a difference-in-difference estimation with correction for auto-correlation.

As expected, results tend to exhibit a stronger magnitude and a greater level of significance than in the corrected model in the next section. For example, there is evidence in the uncorrected regressions (Table 9) that farmers invest in productive assets before entering the supply chain and that there are strong effects on productive assets, consumer durables assets, and landholdings.

Serial auto-correlation DD correction

We adopt a strategy advocated by Bertrand, Duflo, and Mullainathan (2004) to explicitly account for the serially correlated nature of the outcomes in our time series data. Bertrand, Duflo, and Mullainathan present evidence that most standard multiple period difference-in-difference methods significantly understate the magnitude of standard errors and are therefore more likely to find a treatment effect where there is not one.

The two-stage strategy involves a first stage regressing the asset variable of interest on year and regional dummies and relevant co-variates. Observations on suppliers and non-suppliers are pooled across years. In this first stage, we include the covariates from the placement regressions (Table 4) such as year-round water access, gender, age, and education of the household head, parents' landholdings, distance from closest paved road and supermarket outlet (2000), altitude, year of cell phone access. The first stage regression contains no measure of participation in the supply chain. Results from these first-stage regressions are available in the supplementary appendix online.

In the second stage, residuals from the first stage regression (u_{it}) are split into suppliers' and non-suppliers' residuals. The suppliers' residuals are retained and divided into residuals from years before the farmer entered the supply chain and residuals from years in and after the farmer entered the supply chain. The intuition is that the suppliers' residuals after entry include the effect of participation while the residuals from before entry do not include the effect. The suppliers' residuals are pooled into two groups: pre-entry and post-entry.

The welfare effect and the correct standard error, now adjusted for the serial nature of the data, are estimated using a random effects panel data model on this two-period panel:

$$(3) \quad u_{it} = Y_t + \gamma_1 I_{it} + \gamma_2 I_{it} * NGO_i + \gamma_3 S_{it} + \gamma_4 S_{it} * NGO_i + \beta_3 X_{it} + \varepsilon_{it}$$

Where $I = 1$ for years the farmer was in the supply chain and $I = 0$ for years before entry, S is a lead variable with $S = 1$ for the year immediately preceding entry, and $S = 0$ otherwise, Y_t is a vector of year dummies and X_{it} a vector of household and regional controls. We include S to test whether farmers anticipate entry into the supply chain by investing in productive assets, land, consumer durables, or irrigation before they become suppliers. To test if participant welfare effects vary according to whether the farmer entered the supply relationship through an NGO program, we also include terms interacting whether the farmer was assisted by an NGO with the participation and lead variables. Errors are clustered at the household level and regional dummies are also included in the regression.

Table 10 presents the results from the welfare estimation. The first column presents results from a regression with productive assets as the dependent variable but without the NGO interactions. Because there is little difference between these results and results in column two when the NGO interactions are included, we present the results with the NGO interactions only in columns three and four. The results for all models are different from the regressions without the correction for autocorrelation (Table 9); with the correction, effects on consumer durables and land are no longer significant and the estimate of the effect on productive assets is reduced.

Productive assets and income

We find (Table 10) that for suppliers the mean effect of participation in a supermarket supply chain is an increase in productive assets. The magnitude of this effect is relatively large. Given that the mean productive asset holdings of suppliers before entering the supply

chain was an index value of 0.36, the total effect is equivalent to approximately a 16% increase in the household's productive asset stock. Mean tenure in the supply chain in the sample is 2.5 years, so if the effect is constant over the supply relationship, this would translate into a mean increase of 6.4% annually in the household's productive asset stock.

What might such a productive asset increase mean for income? We can regress productive asset stocks and a vector of household and regional controls on 2007 income to derive a relationship between the productive asset measure and expected income. The results suggest that an increase equal to the estimated magnitude in household's productive asset stock could be expected to translate into an increase in annual household income of approximately US$ 200 (2007 exchange rates).

Note that if we leave out the NGO interactions, the magnitude of the effect does not change but the standard errors decrease such that the significance level goes up.

Consumer durable assets and landholdings

We find no evidence of increases in consumer durables nor in household landholdings attributable to participation in the supply chain. Note that if we run two separate models, splitting the suppliers into those that joined before 2006 and those who joined in and after 2006 (when major NGO efforts got under way) we do find weak evidence of a land effect for participants and that participants are investing in land in advance of entry. The mean land participation effect is approximately 2.14 mz and the pre-entry investment effect is approximately 1.36 mz. Both effects are significant at the ten percent level. These results are available upon request.

Pre-entry investment by farmers

We find no evidence that farmers are investing in productive assets, land, or consumer durables in advance of entry into the supply channel, something that has been a concern in the empirical literature related to small farmer supermarket participation for some time.

NGO effect

Given the investment made by NGOs to build the capacity of farmers to supply supermarkets, we are interested in (1) whether NGOs incorporate farmers who might otherwise not sell to supermarkets and (2) whether NGO-assisted farmers in the supply chain accrue assets or land to greater degree than farmers unassisted by NGOs. To begin with, we test for differences between NGO assisted farmers' productive asset stocks and other suppliers' before entering the supply chain and find no difference (Table 8). However, descriptive statistics on tenure length and pre-supermarket farming experience suggests that NGOs may play a critical role in keeping farmers with little experience in horticulture in the supply chain (Table 3).

We find no special effect of participation on NGO suppliers. Note that no difference in outcomes would be a noteworthy result if farmers entering the channel through NGO programs were found to have less initial access to productive capital. If this were the case, equivalent accumulation rates might indicate that NGO activities had improved the outcomes of farmers formerly on a less-productive trajectory. However, NGO assisted farmers' are found to be equally endowed with productive assets and land before entering the supply chain.

Robustness checks

We perform five robustness checks on the results. First, we run a specification in which we control for the year that the farmer entered the supply chain in case there is some change over time in the farmers who become suppliers. Second, we restrict the control group of non-suppliers to farmers who were growing something besides basic grains (beans and maize) in 2007, omitting 251 non-suppliers. This second check should compare the suppliers with a group of farmers engaged in selling horticulture and/or cash crops and perhaps more likely to invest in productive assets and land over time. In a third check, we we omit the suppliers from the estimation who had irrigation before entering the supply chain (approximately 25% of the supplier sample). Fourth, we remove the non-suppliers

completely from the sample and tests suppliers' accumulation in the years after entry into the supply chain with their accumulation before entry. For all of these specifications, the results are consistent: participation in the supply chain leads to a 16% increase in household productive asset holdings, no effect on consumer durables or landholdings, and no special effect on NGO suppliers. A final check retains only data from the years 2000 and 2008 and runs the two-step difference-in-difference with autocorrelation correction on the reduced two-year panel. The estimated effect on productive assets is twice as strong (0.12) and significant at the 1% level.

Discussion

We have identified a strong, positive effect of participation on suppliers' asset portfolios, suggesting that the supermarket relationship may have lasting effects on the productivity and poverty outcomes of participant farmers. In this section, we interrogate this result, drawing on cross-sectional data comparing participant and non-participant farmers incomes and credit use in 2007.

Several mechanisms, possibly related, could be subtending growth in productive assets. First, the supermarket channel may be increasing incomes of farmers, spurring their investment in productive asset stocks; second, the relationship may directly or indirectly facilitate credit access allowing farmers to build these asset stocks; third, the contract itself may alter risk-reward expectations with regard to investments in productive assets. However, evidence supporting any these mechanisms, or relationships among them, could be compromised by the same challenges referenced earlier, issues of endogeneity and placement and selection bias. For example, one might interpret significantly higher yields (bean and maize per hectare) of supplier farmers as evidence of increased-productivity spillovers in the supply chain. However, innately higher productivity of the farmers is likely correlated with participation in the supermarket supply channel.

The analysis in this section, therefore, is limited to suggestive exploration, in hopes of motivating future research on the mechanisms through which supermarket channel participation increases supplier asset investment.

Our data indicate that suppliers report significantly higher incomes than non-suppliers. Mean supplier income in 2007 was approximately double that of non-suppliers and approximately 25% higher than former suppliers. Of course, these farmers might have been higher earners in the absence of the supermarket supply chain. We include information on supplier incomes because the topic has received so much attention in the literature.

Similarly, suppliers report higher use of credit in 2007 than exited suppliers or non-suppliers. Table contains descriptive statistics for the mean quantity of credit borrowed by households in 2007 and the mean number of credit sources[6]. A much higher share of suppliers used credit in 2007 than did discontinued suppliers or non-suppliers. Moreover, suppliers had higher mean total credit, though not significantly so, and a slightly larger number of credit sources, on average, than non-suppliers.

Numerous suppliers reported that their supply agreement with the supermarket system has proved sufficient, in and of itself, to secure an agricultural loan from regional banks. Conversely, once a farmer leaves the supply chain, he or she may be unable to access the same level of credit. It is also possible that some of the exiting suppliers leave the supply chain because they have not been successful at securing credit for production. Again, causality is not possible here.

Regarding credit: one consistent finding of empirical work estimating effects of residual risk attributable to imperfections in savings, credit, and insurance markets is that residual uninsured risk can lead to inefficient under investment in technology adoption, and also have adverse effects on the household in the form of foregone output (Sandmo 1971).

As previous work on Nicaraguan supermarket supply chains and small farmers has established (Michelson, Reardon, and Perez 2012), although mean output prices paid by supermarkets in Nicaragua are not significantly higher than output prices in the traditional

market, prices paid by supermarkets exhibit significantly less volatility than in the traditional market. In some cases, the supermarkets guarantee (in written contracts or oral agreements) that farmers receive a minimum output price (i.e., a price floor for the contracted quantity of their production). Qualitative interviews with farmers confirmed that this guaranteed minimum output price is a primary attractive feature of supply relationships. The importance of the provision of the minimum price is some measure of insurance against output price volatility in the spot market.

A plausible explanation for the increases in household productive asset holdings is that, protected by the contract from the considerable output price fluctuations of the spot market (Michelson, Reardon, and Perez 2012), farmers are willing to invest in vegetable production, intensifying their farming and in some cases moving from seasonal to year-round cultivation. Moreover, farmers can finance these productive investments through increased, more stable incomes or through new household liquidity from credit made available through NGOs or regional banks willing to accept the supply agreement as a guarantee of a stable income source.

A narrative of increased farm household income resulting from production increases, complemented by a decrease in output price risk reinforces conclusions from other recent studies suggesting that longer or more frequent production cycles are associated with supermarket participation. Balsevich, Reardon, and Berdegué (2005) find that growers accessing supermarkets plant an average of 0.6 more cycles in a year than traditional growers. Neven and Odera (2009) find that supermarket orders for suppliers with long-term supply agreements come in throughout the year. Our contribution is to link findings on increased asset stocks explicitly to the reduction of downside output market risk.

Conclusions

The continuing rapid growth of supermarket systems in developing countries is a phenomenon with critical implications for international development and poverty outcomes.

As the domestic market share of a supermarket system like Walmart in Nicaragua rises, the company interacts with regional farmers to satisfy demand for fresh produce. This expansion of supermarket procurement channels may result in significant opportunity for small farmers; conversely, exclusion could mean economic hardship.

Supermarket buyers generally demand that suppliers satisfy chain-specific transaction requirements; in exchange they offer incentives that might include guaranteed purchase volumes or prices. With regard to household welfare, can it be established that the supermarket results in beneficial outcomes to participant small farmers? Do farmers who participate consistently benefit from such arrangements, either in a single season or over a span of years?

Our research addresses a set of questions related to the large-scale issues summarized above, and relevant for smallholders, policy-makers, and development economists. We offer four contributions to the empirical literature on developing-world small farmer adaptation to new agricultural markets. First, we demonstrate that geographic location and transport options can be decisive with regard to farmer participation in these new market systems. What this means is not only that not all farmers have the endowments to enter new supply chains but that we may be able to foresee the areas and the farmers that will be excluded based on geography as the supermarket sector grows in the developing world.

Second, we demonstrate that participation in supermarket supply chains directly affects the productive asset stocks of participant households. We find a mean increase of about 16% in household productive assets, equivalent to an expected increase in household annual income of $US 200 (about 15% of mean 2007 income in the sample). This is similar to magnitude effects that have been estimated elsewhere (Rao and Qaim 2011; Ashraf, Giné, and Karlan 2009; Bellemare 2012). Because asset stocks directly contribute to future household productivity, our results suggest that the market opportunity could have lasting impacts on participants' household poverty outcomes.

Third, we find no special welfare effect on NGO-assisted farmers, nor do we find that NGOs are drawing from a specially materially disadvantaged class of farmers (in terms of observable characteristics and pre-participation endowments). This is a surprising result, given that these NGO programs can represent substantial per-farmer investment and that NGOs often mediate contract negotiation, broker market information, and provide technical assistance to farmers. Because NGO programs in the region under study started their operations the time-span under scrutiny here, one explanation is that their involvement was as yet too brief to show any measurable special economic effect on the farm households with whom they interacted.

Though we find no differences between NGO suppliers and other suppliers based on their observable wealth characteristics, NGO-assisted farmers have higher levels of education and have more farming experience and are located significantly further from paved roads and with a higher water table. So the NGOs may be facilitating access to areas where the supermarket is less likely to source. NGO suppliers could also be different in unobservable ways from suppliers that are not assisted by NGOs.

Finally, we find no evidence of significant farmer investment productive assets or land in anticipation of entry into the new supply chain. This possibility has been a concern in the literature for some time as researchers have wondered whether small farmers might be making strategic investments in order to attract supply chain contracts. Because evidence of such investments would complicate researchers' understanding of the dynamics of supply-chain entry, as well as of the welfare effects of participation, this finding is also important.

With respect to the development potential of supermarket supply relationships, our findings here offer grounds for optimism, and also for a measure of caution. Pragmatic public policies, when founded on accurate information and solid theory, can go a long way towards assuring that new market configurations will benefit at least a portion of a smallholder farm population in developing countries. In evolving such policies, however, one key issue is the potential for smallholders to operate as entrepreneurs, profiting thereby from new private

initiatives for production and marketing. Our evidence indicates that the contracted farmers evaluated here have experienced significant gains in the acquisition of productive assets. However, it is also clear that the location of supermarket procurement basins and the rate of household participation are strongly impacted by access to roads, markets, and sufficient water for crop production. With regard to projecting long-term sustainability of estimated income and asset returns in these new agricultural market configurations, we need to be careful: given the significant involvement of NGOs in the development of agriculture in Nicaragua, and the fact that the supermarket sector there may still be in an early stage of development, it remains to be seen what the regional equilibrium effects will be for the agricultural sector as more farmers enter these markets.

Notes

[1]We focus on vegetables because fruit crops in Nicaragua are mostly tree crops with one annual harvest and are therefore characterized by different production and marketing dynamics as well as distinct investment times to payoff.

[2]The original 1996 study followed a nationally representative area-based sampling procedure in which every piece of land in Nicaragua was given equal weight in the random selection of 1,450 plots, excluding the departments of the Atlantic Coast and all production units exceeding 500 manzanas (approx. 350 hectares, one Nicaraguan manzana is equal to 0.7 hectares). In 2000, researchers from the World Bank in collaboration with the University of Wisconsin and a Nicaraguan NGO revisited the original 1,450 households. They were able to locate 1,350 of the original households

[3]In fact, Walmart's supply chain structure, in which company buyers travel to farms and communities weekly or semi-weekly to pick up produce, means that entry is not confined to farmers with transport.

[4]We are not concerned about the attrition rate because were most successful locating and interviewing farmers living close to major roads. Because our control group therefore is biased towards farmers living proximate to roads, our sample is likely biased towards farmers with a higher proclivity towards market participation, it is a more suitable comparison for the supplier group. Our results in Section 3 are only strengthened.

[5]The supermarket category Other in table 1 is mostly the retailer PriceSmart, which has one store in Managua. The category Multiple largely consists exclusively of farmers who moved from supplying Walmart to supplying La Colonia.

[6]Respondents were read a list of credit sources and asked whether, in the previous twelve months, any member of the household had received credit from that source. The list of sources included: private bank, credit or savings cooperative, producers' cooperative or association, unconventional bank, rural bank or agricultural lender, NGO or project, government program, commercial trader, buyer, moneylender, other area farmer, family or friend, or other.

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Figures

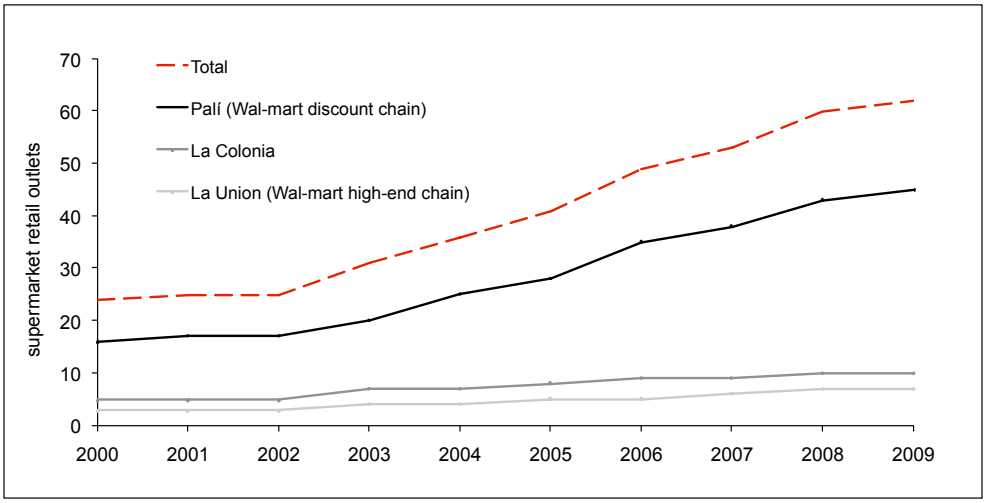

Figure 1. Supermarket retail outlets in Nicaragua, 2000-2009.

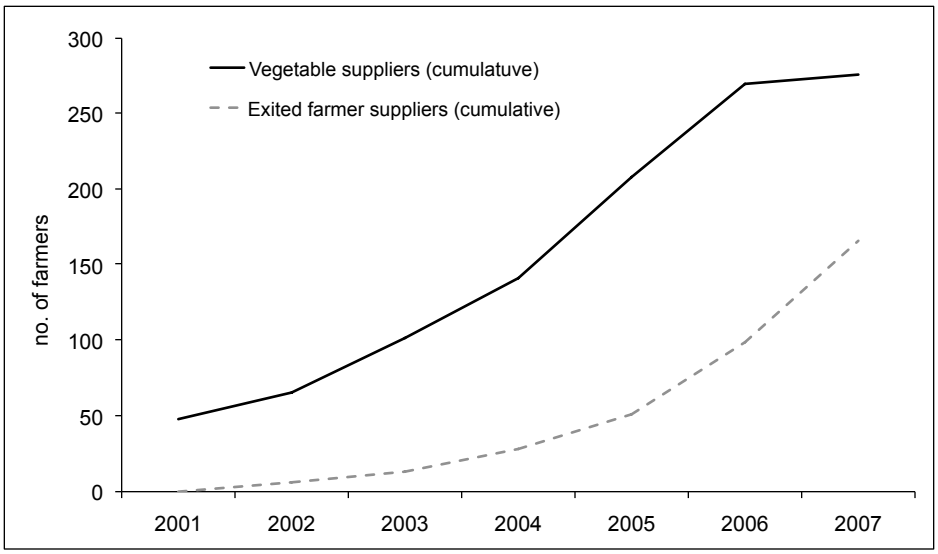

Figure 2. Fresh vegetable suppliers to Nicaraguan supermarket chains, 2001-2007.

Tables

Table 1. Mean Duration of Supply Relationship, by Supplier Status and Supermarket Chain

	n	Mean supply relationship duration (years)	(s.d.)	min	max
Walmart					
Current suppliers	168	2.7	(1.9)	0	7
Discontinued suppliers	144	1.7	(1.3)	1	7
La Colonia					
Current suppliers	34	2.9	(2.0)	0	7
Discontinued suppliers	2	1.0	.	1	1
Other					
Current suppliers	10	1.9	(1.3)	1	4
Discontinued suppliers	6	2.2	(2.4)	1	7
Multiple					
Current suppliers	32	3.7	(2.0)	1	7
Total	396	2.40			

Table 2. Total Crops Grown and Sold by Suppliers in 2007, Disaggregated by Quantity Sold to the Supermarket in 2007.

Crops sold to supermarket	n	Total crops grown (2007 mean)	Total crops sold, all markets (2007 mean)
Supplied 1 crop in 2007	169	4.3	2.3
Supplied 2 crops in 2007	54	4.7	2.8
Supplied 3 crops in 2007	20	6.5	3.7
Supplied 4 crops in 2007	1	14.0	5.0
Non-suppliers	466	2.7	1.4
Discontinued suppliers	152	4.1	2.6
Total farmers	862		

Table 3. Pre-supermarket Production Technologies of Suppliers, Shares

Group	2007 suppliers (share)	Exited suppliers (share)
Basic grains farmers with NGO assistance	0.09	0.11
Basic grains farmers without NGO assistance	0.25	0.42
Horticulture growers with irrigation	0.13	0.09
Horticulture growers without irrigation	0.39	0.23
Cash crop farmers	0.14	0.16
Total	1.00	1.00

Table 4. Relationship Between Household and Geographic Covariates and Supply Chain Participation Over Time, Linear Probability Model with Household Fixed Effects.

	Dependent variable: New supply chain entrants
Productive asset index	0.066**
*2001 dummy	0.021
*2002 dummy	0.008
*2003 dummy	0.032
*2004 dummy	0.037
*2005 dummy	0.009
*2006 dummy	0.022
*2007 dummy	0.078**
*2008 dummy	0.023
Consumer durables asset index	0.007
*2001 dummy	0.008
*2002 dummy	-0.009
*2003 dummy	0.003
*2004 dummy	0.001
*2005 dummy	0.001
*2006 dummy	-0.025
*2007 dummy	-0.061**
*2008 dummy	-0.017
Land (Ha)	0.003***
*2001 dummy	-0.001***
*2002 dummy	0.000
*2003 dummy	0.000
*2004 dummy	-0.002***
*2005 dummy	-0.001*
*2006 dummy	-0.001
*2007 dummy	-0.003***
*2008 dummy	-0.002***
Irrigation (Ha)	0.041
*2001 dummy	0.021
*2002 dummy	0.019
*2003 dummy	0.000
*2004 dummy	0.018
*2005 dummy	0.015
*2006 dummy	0.070**
*2007 dummy	0.063**
*2008 dummy	0.039

Table 4, continued

Age of household head	
*2001 dummy	0.000
*2002 dummy	0.000
*2003 dummy	-0.001**
*2004 dummy	-0.001***
*2005 dummy	-0.002***
*2006 dummy	-0.004***
*2007 dummy	-0.005***
*2008 dummy	-0.004***
Gender of household head (1=F)	
*2001 dummy	-0.009
*2002 dummy	0.001
*2003 dummy	-0.012
*2004 dummy	0.009*
*2005 dummy	-0.045***
*2006 dummy	-0.093***
*2007 dummy	-0.093***
*2008 dummy	-0.057***
Altitude of the farm (log mts)	
*2001 dummy	0.000
*2002 dummy	0.008
*2003 dummy	0.009
*2004 dummy	0.008
*2005 dummy	0.031***
*2006 dummy	0.086***
*2007 dummy	0.085***
*2008 dummy	0.044***
Share of households reporting community has water year round	
*2001 dummy	0.045***
*2002 dummy	0.045***
*2003 dummy	0.087***
*2004 dummy	0.094***
*2005 dummy	0.153***
*2006 dummy	0.286***
*2007 dummy	0.297***
*2008 dummy	0.232***
Distance from closest supermarket in the year 2000 (log mts)	
*2001 dummy	-0.006
*2002 dummy	-0.017***
*2003 dummy	0.006
*2004 dummy	0.011
*2005 dummy	-0.022**
*2006 dummy	-0.034**
*2007 dummy	-0.023
*2008 dummy	-0.023**
n	6397
overall R^2	0.11

Note: Variables in which there was no effect, in any year for either model: depth of water table, distance to paved roads, landholdings farmed by parents, log of farmers' own experience.

Table 5. Recall Data Accuracy Ratios, Productive Assets

	$\frac{\text{True 2000 +1}}{\text{Recall 2000 +1}}$
Tractors	1.031
Plow for tractor	1.034
Plow for oxen	1.374
Tractor harrow	1.015
Oxen harrow	1.005
Sower for tractor	1.007
Sower for oxen	0.997
Rastra for tractor	1.012
Cart for oxen	1.111
Backpack sprayer	1.424
Motorized backpack fumigator	1.021
Grass cutter	1.009
Combine harvester	1.001
Small mill	0.997
Cream separator	0.999
Coffee pulping machine	1.016
Chainsaw	1.003
Milking machine	1.000
Irrigation pump	1.016
Generator	1.000
Light truck	1.045
Truck	1.022
Mean	1.097

Table 6. Relationship Between Productive Asset Index and Recall Ratio, 2001-2008

	Assets 2001	2002	2003	2004	2005	2006	2007	2008
Tractors	-	-	-	-*	-*	-	-	-
Plow for tractor	+	+	+	+	+	+	+	+
Plow for oxen	-	-	-	-	-	-	+	+
Tractor harrow	-	-	-	-	-	-	-	-
Oxen harrow	-	-	-	-	-	-	-	-
Sower for tractor	+	+	+	+	+	-	+	+
Sower for oxen	-**	-**	-*	-	-	-	-	-
Tiller	+**	+**	+**	+**	+**	+**	+*	+*
Cart for oxen	-	-	-	-	-	-	-	-
Backpack sprayer	+	+*	+**	+**	+*	+***	+**	+**
Motorized backpack fumigator	+	+	+	+	+	-	+	+
Grass cutter	+	+	+	+	+	-	+*	+*
Combine harvester	+	+	+	+	+	-	+	+
Small mill	-**	-**	-*	-*	-	-*	-	-
Cream separator[a]	+***	+***	+***	+***	+***	+***	+***	+***
Coffee pulping machine	-	-	-	-	-	-	-	-
Chainsaw	-	-	-	-	-	-	-	-
Irrigation pump	-	-	-	-	-	+	+	+
Generator[a]	-***	-***	-***	-***	-***	-***	-***	-***
Light truck	+	+	+	+	+	+	+	+
Truck	-	-	-	-	-	-	-	-

[a] A small N effect. The asset was held by less than five households in 2000.
Note: *, **, and *** indicate statistical significance at the ten, five, and one percent levels, respectively

Table 7. Annual Mean Asset and Land Holdings for Suppliers Before Joining the Supermarket Channel and Non-suppliers

	n	Productive assets		Consumer durables		Land (mz)		Precision irrigation (mz)		Flood irrigation (mz)	
	Suppliers	Suppliers	Non	Suppliers	Non	Suppliers	Non	Suppliers	Non	Suppliers	Non
2001	400	0.14	0.20*	0.28	0.33	7.6	14.3***	0.06***	0.01	0.20***	0.04
2002	365	0.16	0.22*	0.32	0.37	7.8	14.2***	0.04**	0.01	0.21***	0.04
2003	344	0.21	0.27	0.37	0.41	8.1	14.1***	0.07***	0.01	0.21***	0.05
2004	302	0.25	0.32*	0.43	0.49	7.7	14.1***	0.09***	0.01	0.27***	0.06
2005	256	0.34	0.37	0.50	0.59**	8.5	14.1***	0.11***	0.01	0.30***	0.06
2006	175	0.43	0.47	0.59	0.70**	8.9	14.0***	0.16***	0.02	0.36***	0.06
2007	74	0.62	0.50	0.77	0.80	7.9	14.0***	0.09**	0.02	0.32***	0.06

Note: *, **, and *** indicate statistical significance at the ten, five, and one percent levels, respectively

Table 8. Annual Mean Asset and Land Holdings for NGO-assisted Suppliers and Non-NGO Suppliers Before Joining the Supermarket Channel

	n		Productive		Consumer durables		Land (mz)	
			Non-NGO	NGO	Non-NGO	NGO	Non-NGO	NGO
2001	299	97	0.13	0.18	0.28	0.29	7.10	9.13
2002	269	96	0.15	0.18	0.33	0.29	7.35	9.20
2003	249	95	0.20	0.24	0.40	0.33	7.56	9.55
2004	216	73	0.24	0.30	0.46	0.38	7.48	9.10
2005	184	72	0.31	0.40	0.51	0.46	7.84	10.06
2006	123	52	0.43	0.55	0.62	0.50	8.64	8.79
2007	55	19	0.64	0.56	0.82	0.64	7.58	8.73

Note: *, **, and *** indicate statistical significance at the ten, five, and one percent levels, respectively

Table 9. Standard Difference-in-Differences Estimation: Welfare Effects of Supermarket Supply Chain Participation

	Productive assets	Consumer durables	Land
Supplier control	-0.06	0.04	-9.10***
	(0.05)	(0.04)	(1.60)
Participation effect	0.16***	0.06**	1.42***
	(0.03)	(0.03)	(0.49)
Year before participation	0.07***	0.01	0.56
	(0.02)	(0.03)	(0.43)
NGO assisted suppliers	0.09	-0.02	2.14
	(0.06)	(0.05)	(1.69)
NGO*Participation	0.01	0.03	0.03
	(0.06)	(0.06)	(0.93)
NGO*Year before participation	0.01	0.01	0.42
	(0.04)	(0.05)	(0.84)
Total n	7362	7362	7362
Total clusters	818	818	818

Note: Errors are clustered at the household level and year and regional dummies are also included.
*, **, and *** indicate statistical significance at the ten, five, and one percent levels, respectively

Table 10. Autocorrelation Corrected Difference-in-Difference Estimation: Welfare Effects of Supermarket Supply Chain Participation

	(1) Productive assets	(2) Productive assets	(3) Consumer durables	(4) Land
Participation effect	0.06**	0.06*	-0.01	0.56
	(0.03)	(0.03)	(0.02)	(0.45)
Year before participation	0.02	0.02	0.02	0.08
	(0.02)	(0.02)	(0.03)	(0.44)
NGO assisted suppliers	.	0.03	-0.03	0.97
		(0.05)	(0.05)	(1.54)
NGO*Participation	.	0.01	0.01	0.05
		(0.04)	(0.05)	(0.93)
NGO*Year before participation	.	0.01	0.03	0.36
		(0.05)	(0.06)	(0.84)
Total n	3564	3564	3564	3564
Total clusters	396	396	396	396

Note: Errors are clustered at the household level and year and regional dummies are also included.
*, **, and *** indicate statistical significance at the ten, five, and one percent levels, respectively

Table 11. Descriptive Statistics on Credit, by 2007 Supplier Status

	Current suppliers	Discontinued suppliers	Non-suppliers
Reported credit in 2007 (n)	163	83	111
Share of group	0.65	0.55	0.24
Credit borrowed (USD 2007)	1544.98	1242.88	1013.82
	(1376.16)	(1446.05)	(1462.42)
Credit sources, total	1.08	1.09	1.01
	(0.32)	(0.29)	(0.09)

Note: Standard deviations in parentheses. Sample is sub-sample of farmers who reported using credit in 2007.