Adoption and Accumulation Patterns in Guatemala's Latest Agro-export Boom

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Abstract: This paper examines how the current agro-export boom in Guatemala is affecting small farm households' access to and use of land. Utilizing an agrarian history survey of households in the Central Highlands of Guatemala, the study focuses on the determinants of adoption of the new cash crops, and examines the interlinkage between adoption and land accumulation patterns. Unlike previous agro-expoirt booms in Central America, all but the tiniest of farms are participating in the new cash crops. The positive impact of adoption on land accumulation appears most pronounced among those households that start with the least land.

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1. Introduction

Previous agroexport booms in Central America were dominated by large farm units whose successful adoption of boom products enabled them to expand their farm holdings and displace small farm units. The exclusive nature of these agroexport booms produced increasingly dualistic economic/agrarian structures, rising income disparities, and intense social conflict, contributing to the revolutionary crisis of the 1980s. This paper examines how Central America's current non-traditional export promotion strategy is affecting small farm households' access to and use of land in the Central Highlands of Guatemala, a region which has recently experienced a rapid expansion of vegetable exports. It brings empirical evidence to bear on recent theoretical work concerning the determinants of adoption of agroexports, the patterns of land accumulation, and interactions that arise between these two processes. What makes the work unique is that it is based on an agrarian history survey, in which 318 households in an area of Guatemala's ongoing agroexport push were asked to reconstruct the history of their farm, in terms of land use and land transactions from the household's inception to 1990-1991. The empirical analysis shows that unlike earlier booms while adoption is positively linked to farm size, all but the tiniest farms are likely to allocate some land to the production of the new agroexports. Moreover, while adoption enhances land accumulation, the positive impact of adoption on land accumulation is most pronounced among those households that start with the least amount of land.

The paper is organized as follows. Section 2 places Central America's recent non-traditional agricultural export push in the historical context of previous booms and their effect on peasant access to land. Section 3 summarizes the principal conjectures of what hitherto have been two distinct lines of research, one on the determinants of adoption of new technologies and new crops, and the other on patterns of land accumulation, and highlights interactions between the two phenomena. Sections 4 and 5 use the agrarian history and additional survey data gathered from the farm households in Guatemala to examine the adoption and land accumulation issues raised in Section 3. Section 6 considers the relevance of the findings for non-traditional agricultural export promotion and for further research.

2. Agroexport Booms and Small Farms in Central America

Agroexport booms have shaped Central America's economic development. Coffee, bananas, cotton, sugar, and cattle, the region's leading traditional exports, each went through a boom period, in which their introduction, widespread adoption, and consolidation as profitable export crops transformed the economic organization and basic tenure patterns of major geographic regions along the isthmus.[1/] Coffee came first, in the piedmont regions during the late 19th century, and set the stage for subsequent booms by establishing the preeminence of titled private property rights over communal holdings and traditional land rights, by stimulating the expansion of roads and infrastructure which transformed previously remote areas into commercial export regions, and by favoring those landholders who could mobilize capital. Private enfranchisement and the wealth associated with the expansion of coffee was captured by a favored few, particularly in El Salvador and Guatemala (see Dunkerley (1982) and Moss (1955)), and was accompanied by disenfranchisement for thousands of small farm households and communal farmers. For most peasants, disenfranchisement meant expulsion and a search for access to land in the highlands or on marginal land surrounding the large estates of the Pacific Coast.

Later agroexport booms in Central America followed a pattern similar to coffee generating greater land concentration and, over time, an increasingly dualistic economic structure.[2/] Over the past century of Central America's economic development, adoption and land accumulation trends have been both tightly interwoven and highly exclusionary with respect to small farm households. Initially concentrated land distributions were perhaps the taproot of the process, but scale economies of production and adoption as well as unequal access to credit,

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1/ Bulmer-Thomas (1987) offers a comprehensive review of the evolution of Central American economies and the central importance of agroexport booms for the region's economic development. Brocket (1988) presents a historical account of agrarian evolution and political conflict. Weeks (1985) and Williams (1986) focus on more recent agroexport booms. For specific agroexport booms, see Cambranes (1985) for coffee, Kepner and Soothill (1935) and Ellis (1983) for bananas, and Williams (1986) for cotton and cattle. Sugar has no region-wide account similar to that of other crops, though its location and features were very close to that of cotton.

2/ Dualism generally refers to a "modern, export-oriented, large-scale farm sector juxtaposed with a traditional, subsistence-oriented, small-scale sector" (von Braun et al., (1989:20), in which the two sectors are integrally linked via the rural labor market. Brockett (1988) and Williams (1986) present regional accounts of evolving land tenure patterns in Central America and the rise of dualism. Hintermeister (1984), von Braun et al. (1989), Thery et al. (1988), and Schweigert (1990), explore the evolution of dualism in Guatemalan agriculture.

titling, and government resources appear to have played significant roles in driving the exclusionary cycles of agroexport adoption and land accumulation.

2.1 The Dualistic Structure of Guatemalan Agriculture:

Dualism in Guatemalan agriculture is apparent in the bimodal distribution and use of land. One indicator is the Gini coefficient for land distribution in Guatemala, which was 0.85 in 1979 (Thery *et al.*, 1988:18), and represented one of the most skewed land distribution in all of Latin America. Of more importance to this study is the extensive fragmentation of small farm households. Von Braun *et al.* (1989) report that between 1964 and 1979, farms with less than 1.73 acres almost tripled in number, while their average holding decreased from 0.95 to 0.60 of an acre. As a proportion of total farm households, this same stratum grew from 20% to 40% of the total number of farms. Even more striking is the fact that this fragmentation occurred in an era when total farm area in Guatemala expanded by 20%.

The dualism of Guatemala's agrarian structure is also evident in the type of crops cultivated by different size farms. Small farms allocate more than 85% of their land to basic food crops. Larger farms, especially those over 110 acres, dedicate a similar proportion of their land to cash and export crops, and cattle. This stark disparity in land allocation, combined with the bimodal pattern of land distribution and small farm fragmentation, suggest a reenforcing dynamic between adoption and land accumulation. Adoption of new export crops may be essential to land accumulation, and initial land holdings may be crucial to adoption of new crops.

The income distribution consequences of Guatemala's dualistic agriculture structure have been further exacerbated by the fact that most of the large farm export crops have been characterized by low or seasonal labor use. As argued by Hintermeister (1984), Thery *et al.* (1988), and Schweigert (1990), underemployment and diminishing access to land in the highlands of Guatemala have been primary reasons for declines in both absolute and relative incomes among Guatemala's rural poor over the past 20 years. These findings give added impetus to the need for a better understanding of the interlinked patterns of adoption and land accumulation in Guatemala.

2.2. The Current Promotion of Non-traditional Exports

Promotion of non-traditional exports in Central America follows the region's most severe economic and political crisis of the century. In El Salvador, Guatemala, and Nicaragua, the militarized conflicts of the late 1970s and 1980s revolved, to a significant extent, around the inequities of previous development episodes. Demands for and resistance to substantive land reforms were at the center of these conflicts, which resulted in the deaths of nearly 300,000 Central Americans, wreaked billions of dollars of damage on the wartorn economies, and left all but Costa Rica with standards of living near or below those of the early 1970's (see Fagen, 1987 and Roberto López (1987, 1990). While the extent of subsequent land reform has varied from a major redistribution in Nicaragua and, to a lesser extent, El Salvador to minimal reform in Guatemala, the push for expanding non-traditional agricultural exports (NTAX) extends across the whole region.

For Central American governments seeking economic reactivation without the major inflows of a Marshall Plan, macroeconomic motivations for NTAX promotion are multifold: poor price forecasts for traditional exports, pressing foreign exchange needs, revival of rural economies, modernization of small farm techniques, and employment creation to name but a few (Barham *et al.* (1992) explore the NTAX strategy in Latin America). Because outcomes, such as the volume of NTAX production, the employment and linkage impacts, the equity effects, and the overall political-economic sustainability of the strategy, will depend to a major extent on the adoption patterns and the land accumulation trends that the push generates, it is imperative to have a clear view of how these two processes are likely to work.

NTAX promotion in Central America has advanced furthest in Costa Rica and Guatemala.[3/] In Guatemala, the Central and increasingly the Western Highlands have been a prime locale for NTAX expansion. Winter vegetables (e.g. broccoli, cauliflower, snow peas), berries and melons, and "mini" (gourmet) vegetables have been the main focus of activity, with substantial small farmer participation via cooperatives, contract

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3/ Economic data from the U.S. Department of Commerce, Imports for Consumption, shows that between 1983 and 1989, the growth of non-traditional fruits, vegetables, and plants were as follows in Central America: Costa Rica - $11.9 million to $43.9 million; El Salvador - $ 1.8 million to $5.0 million; Guatemala - $14.0 million to $43.9 million; Honduras - $12.0 million to $23.2 million; and Panama - $1.0 million to $10.4 million (1987 numbers, 1989, the year of the U.S. invasion, NTAX exports were $4.9 million).

farming arrangements, and spot product markets.[4/] The study by von Braun *et al.*, 1989 of the successful, internationally financed, Cuatro Pinos Cooperative has received wide circulation for its account of how small farm households adopted and expanded rapidly their production of snow peas and other winter vegetables in the Central Highlands. As explained by von Braun *et al.*, the competitive advantage of small farms is rooted in their ability to circumvent the labor superivision problems facing large farms which try to grow these products with hired labor.[5/] Moreover, von Braun *et al.* found that the labor-intensive nature of vegetable production was absorbing family labor and generating demand for additional hired labor to work side-by-side with family labor. Household incomes of members were also rising markedly, and higher yields of basic grains were argued to compensate for the reduction in land dedicated to grain production, although the observed yield differences between adopters and non-adopters of NTAX could have been present before the introduction of winter vegetable exports.

The story of Cuatro Pinos suggests a market-driven scenario for reducing Central America's dualistic agricultural structure and stemming the fragmentation of microfundios in the Guatemalan highlands. Our study in the Central Highlands of Guatemala attempts to explore the broader potential for this scenario by examining the agrarian histories of households outside of the Cuatro Pinos Cooperative scheme. As shown in Table 1, the average farm size of the farms adopting NTAX in our sample is 3.56 acres, of which 77% is owned by the household, while for non-adopters the average farm size is 1.92 acres, with 78% owned. As in the Cuatro Pinos study, smallholders are participating in NTAX, though they have more land than non-adopters. Moreover, the average annual increase in landholdings is four times larger for NTAX adopters than for non-adopters. What remains to be explored is the extent to which further adoption by small farm households and the profitable

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4/ In an unpublished survey of seven major broccoli processing firms operating in the Central Highlands of Guatemala, Elizabeth Katz, a co-investigator of the project, found that about 80% of the volume came from farms with less than 17 acres and that individual contract farming arrangements of less than 3.5 acres accounted for 36% of the broccoli production used by the processors.

5/ Von Braun et al. (1989) discuss the transition to contract farming and cooperative organization following initial efforts in the late 1970s by one U.S. based multinational, ALCOSA, to raise the winter vegetables on a large corporate farm and then by contracting with a handful of medium-large domestic farms. The economic logic suggested behind this move is essentially one of diseconomies of scale in labor supervision associated with the labor-intensive nature of the production process and the high quality effort required in the care and harvest of the products.

expansion of this sector could induce the subdivision of some larger tracts of land, perhaps first by rental and then by sale to small farm households, as the competitive advantage of small farm's in the sector raises their shadow value of the land above that of other users. Among other factors, realization of this market-driven land redistribution scenario depends fundamentally on the pace of adoption among small farms and the extent to which they obtain sufficient resources to finance the purchase of additional land. It also hinges on how significant and permanent the supervisory diseconomies of scale are compared to other market features, such as access to credit, new technologies, and information, that may work against these same small farm households, especially where cooperative organizations are not well developed.

It is possible that the observed participation of highland Guatemalan small holders in NTAX production is a special case based on the historic fact that smallholders are the current landholders in the geographic region most suited to the new crops. If market features, in fact, favor medium or larger scale production over time, the leading role of small farm households may give way. In such a case, the spread of NTAX crops is likely to be associated again with increasing concentration of land, via displacement from without or differentiation and consolidation from within the small-farm sector. At this stage, identifying the determinants of adoption and the patterns of land accumulation at work in the Central Highlands are central to evaluating the potential of NTAX crops for breaking down or reenforcing the dualistic structure of Guatemalan agriculture.

3. Prevailing Theories of Adoption Determinants and Land Accumulation Patterns

Economic research on the adoption of technological innovations in LDC agriculture and the patterns of land accumulation has developed along separate paths, with only the former being the subject of much formal analysis. Section 3.1 explores the main determinants of adoption identified in the literature. Section 3.2 considers the market features underlying the competitiveness of different classes of producers and how these might determine patterns of land accumulation. Section 3.3 sketches the possible links between adoption and accumulation patterns.

3.1 Adoption

Analyzing the patterns of substitution of new, high yielding varieties of grains for traditional varieties has been the driving force behind recent research on adoption. Because high yielding varieties and cash crops tend to require substantial increases in the package of purchased inputs, emphasis has been placed on both the share of farm area (or amount of land) allocated to the new technology and the quantity of modern inputs per unit land applied during production. Adoption decisions are thus examined extensively in land allocation and intensively in input use per unit land.

Most theoretical models frame the issue as a static choice between two technologies, the modern, high yielding variety and its key inputs, versus the traditional technology (Feder (1980) and Just and Zilberman (1983)). A stochastic structure of production risk is defined along with the objective function of the farm household and their basic endowments. The household portfolio choice is studied for its sensitivity to the stochastic structure, preferences and endowments, and other market features, such as fixed costs, imperfect credit markets, or tenurial arrangements. Dynamic models of adoption (Jensen (1982), Stoneman (1981), Tsur *et al.* (1990)) mostly explore the effects of learning by doing or "learning by watching" on adoption.

In adoption models, modern technology promises higher average returns. What makes the portfolio choice between modern and traditional technologies nontrivial are the risks involved in production and the potential for reducing risk via diversification. Except in the learning models, the structure of production risk across the two technologies is the same for all farm households. What differs is sensitivity to these risks, which in turn is a function of preferences, endowments, and market features. Typically, the objective function, expected utility of income or wealth, is assumed to be uniform across households; thus, what leads to variation in adoption outcomes is differences in endowments and credit constraints.

3.1.1 Farm Size

Formal models of adoption have highlighted the effects of farm size on the technology choices of households. Three factors make scale of operation or ownership central to adoption decisions. First is the potential for economies of scale in production based on fixed transaction and information acquisition costs associated with many new technologies. Feder and O'Mara (1981) show that fixed costs give a positive relationship between farm size and the extent of adoption of the new technology. Moreover, when combined with stochastic production risk, fixed costs also generate a threshold farm size below which farmers do not adopt the technology at all because of absolute risk aversion.

A second important scale economy affecting adoption decisions may arise in the credit market, if large farms have greater access to credit than small farms and can thus better finance the higher working capital requirements of the new technology (Carter and Weibe (1990) and Eswaran and Kotwal (1986)). Risk is the third broad factor that links farm size with adoption outcomes. Its effects can enter into the household optimization problem both through the stochastic nature of production and through the role of farm size, or household wealth, in determining risk preferences. Just and Zilberman (1983) explore a model with different stochastic structures of production and various assumptions about absolute and relative risk aversion of farm households. Assuming decreasing absolute risk aversion and increasing relative risk aversion, they show that the extent of adoption decreases with farm size, when the variability of the modern technology is sufficiently large relative to the traditional technology. As in Feder and O'Mara (1981), fixed costs again lead to a minimum farm size below which certain households do not adopt. Just and Zilberman (1983) further show that above a certain farm size the extent of adoption declines because of decreasing relative risk aversion and the nature of production risk.

In sum, the effect of farm size on adoption is positive where scale economies in production or credit markets are present but may be negative when certain risk characteristics hold. For empirical analysis, it is worth noting that farm size and adoption decisions might have a spurious positive correlation in cross-sectional data because as fixed costs of information acquisition fall with technological diffusion, small farm households may adopt later. If, in addition, small scale farms end up adopting more extensively because of the nature of risk, then what initially is a technology dominated by larger scale farm participation may, over time, become just the opposite.

3.1.2 Credit and Safety-First Concerns

Credit market features can enter into adoption decisions from the consumption side as well. As Eswaran and Kotwal (1989) demonstrate, consumption credit serves to replace missing insurance markets by helping producers to smooth consumption over time and therefore take on risky endeavors. Indeed, the role this credit plays as a consumption guarantee following a bad realization allows adoption that otherwise might not have occurred, either because the investments might prove difficult to convert into cash or because they might be lost as part of the working capital used by the new technology. Credit is thus essential not only to finance the "ex ante" working capital needs for adoption but also as a source of "ex post" consumption smoothing in the case of bad outcomes. The implication for adoption models is obvious. Farmers who have access to consumption credit or other sources of wealth, e.g. more land, which can serve as insurance will be more likely to adopt new technologies. Roumasset (1976) and Weibe (1992) apply this idea in a "safety-first" modelling context.

3.1.3 Household Labor Resources and Intrahousehold Distribution Issues

Formal models of adoption elaborated by Schultz (1964,1981) and Welch (1978) include household labor resources by considering the role of human capital, especially of the head of household, in technology choice. As suggested above in the discussion of the Cuatro Pinos experience in Guatemala, household labor resources could also be a main determinant of adoption favoring small farm households because of the incentive issues that are overcome when the returns to high quality labor effort are captured by the family unit. Besides reducing supervisory costs, household labor resources could also be used to help finance adoption. Off-farm earnings could be used for working capital or as consumption insurance in the case of low yields.

Off-farm labor efforts of other family members could also discourage adoption, if standard assumptions about unitary household preferences are replaced by ones in which adults have distinct preference orderings and thus intrahousehold income distribution becomes an issue.[6/] In this case, off-farm labor earnings of farm

6/ See Folbre (1984, 1985) for an introduction to intrahousehold distribution issues in development and Katz (1992) for more on the specifics in the Guatemalan context.

members, especially those who are not the farm "head," may be their means of realizing their consumption preferences. Their earnings may not serve to relax credit constraints for adoption of new technologies, and their on-farm labor contribution will be limited as well. These factors could make adoption negatively correlated with off-farm earnings of other family members. However, if food security is a shared concern, the presence of off-farm earnings would help to mitigate this constraint on adoption because the earnings would still provide an insurance mechanism for low yields or returns from the new technology.

3.2 Patterns of Land Accumulation

The literature on agrarian structure centers on what happens to the peasantry or, more generally, the distribution of land across strata over time, particularly as capitalism advances in agriculture. Five evolutionary paths for agrarian structure have been set forth, and are described in detail in Carter and Mesbah (1991) and Carter and Walker (1989). In all of the paths, land transfers between or within strata provide the basis for tracing out the paths or patterns of land accumulation. The direction of land transfers depend on the competitiveness of farms, with production scale economies, the scale sensitivity of key agricultural factor markets, and differences in endowments and preferences lying at the heart of most interstrata competitiveness discussions.

Three of the five paths for agrarian structure predict that small farms will disappear over time. Two of those, what Lenin labelled the Junker Path and the Farmer Path, view the peasantry as fundamentally uncompetitive with larger farms because of scale economies in both production and market access. Along the Junker Path, large feudal manors become the basis for large-scale capitalist farms, with a critical minimum land endowment determining whether farm households get on an accumulation path or deaccumulate and join another strata, presumably the proletariat. Along the Farmer Path, a differentiation process among small farms leads some to accumulate and a less fortunate subset to deaccumulate. Again, the competitive advantages of scale economies push agrarian structure toward a unimodal distribution of large farms. Small farms also disappear in the Family Farm Path of Lehman (1982,1986) and Scott (1985), because they must grow to obtain the scale economies associated with modern production techniques and access to credit. However, the size of holdings is constrained by the supervisory and monitoring costs that arise once farms move beyond the scale of family farm operations. In this third scenario, large farms will tend to sell off lands, while smaller ones accumulate, leading to a unimodal distribution of medium size farms.

The other two paths, Chayanov's view of a stable peasantry and Kautsky's "peasant refuge" depict the likely persistence of small scale farms though for quite distinct reasons. On the Chayanovian path, family labor advantages allow peasant farms to remain competitive with larger farms. Size variations depend on where families happen to be in their life cycles. When households form, both the productive resources and the consumption needs will be less than later when their children are maturing. Late in the lifecycle, they cultivate less land because their children are on farms of their own (starting with inherited land) and because they have lower consumption needs than when the children were at home. The time path of landholdings within peasant households is thus expansion followed by contraction. Apparent differentiation is a result of cross-sectional views of households in varying stages of their lifecycles.

On the final path, small farms are a "poverty refuge" for peasants.[7/] These households are highly resistant to selling off the remaining holdings because the vagaries of the rural wage labor market make for very high reservation prices on land. At the same time, these same households are blocked from significant land accumulation because of scale biases present in production, markets, and government policies related to agriculture. The resulting agrarian structure is bimodal, with a dynamic large farm sector and a stagnant but persistent micro farm sector.

What is missing from the theoretical discussions of agrarian structure is the potential for variation in these paths that arises with different crop possibilities in distinct geographic locations and with changing market and social conditions that can redefine profitable product and technological opportunities. Determining which of the five paths, if any, might best describe the evolution of agrarian structure in a particular locale and time

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7/ De Janvry (1981) offers an alternative explanation for a bimodal distribution of landholdings. The semi-proletariat (smallholders) are part of a structure of functional dualism, in which their access to small amounts of land serves to lower the costs of hired labor for large farms. The persistence of small farms is supported by larger farms as means of preserving access to cheap labor.

depends thus on several factors: the natural production opportunities of distinct geographic areas, the price-cost signals being sent by near and distant markets, and the existing agrarian structure.

3.3 Linking Adoption and Accumulation Patterns

The link between adoption and land accumulation receives cautionary mention in Feder, Just, and Zilberman (1985:294) who conclude their survey article on adoption as follows: "The early adopters (usually the larger and wealthier farms) can accumulate more wealth and use the differential in the subjective value of land to acquire more land from the laggards. The acquisition of new wealth enables further adoption and thus affects the dynamic pattern of aggregate adoption. Thus, special attention to changes in landholding patterns and wealth accumulation... is warranted." Their concern about the interaction of adoption and accumulation processes rests on the potential effect that differential timing of adoption between large and small farmers could have, presumably even if the actual production process of the new crop or technology has no scale economies or is one in which diseconomies of scale exist.

An alternative view of the adoption-accumulation interlinkage is one in which small farm households escape their land-poor state through the adoption of NTAX or other new technologies that, on balance, favor smaller-scale operation. In this scenario, small farms might lag somewhat behind in adoption, but their fundamental competitiveness in new crops or technologies that are particularly well suited to a specific region would allow them, over time, to get on an accumulation trajectory comparable to Lehman and Scott's Family Farm Path. One crucial question in this case would be whether the growth of smaller farms occurs through acquisitions of land from large farms, or from other small farms. Another would be the extent to which land markets were developed enough to allow small farms to take advantage of their competitiveness in a dynamic sector and obtain additional land in small increments, particularly from larger holders. In the end, sorting out the connections between adoption and accumulation requires both formal and empirical analyses that link the determinants of adoption, the bases for inter- and intra-strata competitiveness, and the given agrarian structure.

4. Patterns of Non-Traditional Agricultural Export Adoption in Guatemala

The data used in the current study were collected in five indigenous (Cakchiquel-speaking) villages located in the departments of Sololá and Chimeltenango in Guatemala's Central Highlands.[8/] Four villages were known to be participating to varying degrees in NTAX production of snow peas and broccoli, while the fifth was selected as a "control" or non-adopting village. The rates of participation in the NTAX sector range from 87% in the village where NTAX production is most extensive to 15% in that where it is least. After conducting a census in each village, a stratified (by farm size) random sample of 318 households was drawn and a series of surveys related to agricultural production, labor market participation, household consumption patterns, and the nutritional status of children were conducted in the Fall of 1990 and the Spring and Summer of 1991. In addition, household heads were asked to reconstruct the history of their farm with respect to land accumulation and NTAX production from the initial formation of the household through 1990.

4.1 A Tobit Specification for the Adoption Decision

Two aspects of the NTAX production decision are of interest here: (1) the binary choice of **whether or not** to adopt NTAX and (2) the amount of land to allocate to this production. Let y^* be the unobserved propensity to allocate land to NTAX production and assume that it is linearly related to a vector of exogeneous variables $\underline{z}$ such that:

$$y^* = \underline{\gamma}'\underline{z} + \sigma\varepsilon,$$

where ε is a random variable independent of **x** that has a standard normal distribution. Suppose further that the observable censored variable y is determined as

$$y = y^*, \quad \text{if } y^* > 0,$$

$$y = 0, \quad \text{otherwise.}$$

8/ The five villages incoluded in this study are Las Canaos, El Tablón, Santo Domingo El Rosario, Xejolón and Chirijuyú.

Under this Tobit specification, the expected amount of land allocated to non-traditioanl export crops is:

(1) $E(y \mid \underline{z}) = \Phi(\underline{\gamma}'\underline{z}/\sigma)\underline{\gamma}'\underline{z} + \sigma\Phi(\underline{\gamma}'\underline{z}/\sigma)$,

where Φ and ϕ are, respectively,the cumulative distribution and probability density functions for the standard normal distribution. The probability of adoption is given by:

(2) $Prob(y > 0) = Prob(\varepsilon > (-\underline{\gamma}'\underline{z}/\sigma)) = \Phi(\underline{\gamma}'\underline{z}/\sigma)$.

Considering only those who adopt, equation (1) can be rewritten as:

(3) $E(y \mid \underline{z}, y^* > 0) = \underline{\gamma}'\underline{z} + \sigma[\phi(\underline{\gamma}'\underline{z}/\sigma)/\Phi(\underline{\gamma}'\underline{z}/\sigma)]$.

For the purposes of this analysis, it is hypothesized that the choice of whether to adopt NTAX crops and how much land to devote to such production is determined largely by the expected increase in household income and the risk such production entails relative to other uses. This, in turn, is seen as a function of the household's overall resource endowment (land and its quality, labor stock). Off-farm wage income is not considered as an exogenous variable since the high labor demands of NTAX crops make laboring off-farm one of the endogenous choice variables present in the adoption decision. Since cropping decisions are considered to be principally the domain of the male head of household (or female head of household, if no male head is present) his (or her) age and level of education are included to test their influence on the adoption decision. Female labor as a proportion of total household labor is included since, as discussed earlier, there is some evidence that the gender composition of households may influence their preferences with respect to NTAX production. In addition, Annis suggests that religion has an effect on the preference structure of households as it relates to choice of remunerative activities with Protestant evangelicals being more likely to adopt NTAX than Catholic households. Finally, microclimates, the quality of infrastructure and proximity to processors vary spatially across our sample leading us to include village specific variables in our specification.

4.2 Results and Discussion

The parameter vector $\underline{\gamma}$ is estimated via equation (1) using maximum likelihood procedures. The results are given in Table 2 along with some descriptive statistics for each of the variables.

It seems particularly worthy of note that the coefficients on household labor and its square are both statistically insignificant (at the 5% level) and small in absolute terms. At the mean of our sample, adding two adult workers to the household, a 53% increase in household labor, increases the probability of adoption by 4%. The expected amount of land allocated to NTAX rises by only 0.17 cuerdas for those who adopt. This seems curious, given the importance of family labor in the IFPRI-INCAP analysis of NTAX production patterns in the same region (von Braun, *et al.*, 1989), though it is consistent with the result they obtained in their probit estimation. It may be that for small farms, where family and hired labor work side-by-side, labor-supervision is not the problem that it is for larger farms. In such a case, hired labor, which seems readily available in these communities, is a reasonably good substitute for family labor.

The sample data fails to support the importance of the gender-composition of the household's labor force in making adoption decisions, though the sign on this coefficient is negative as expected. The statistical insignificance of the coefficient on education may be indicative of some countervailing influences. On the one hand, the more educated the household head the more willing and able he (she) might be to experiment with new technologies. On the other hand, higher levels of education are likely to increase the opportunity cost of on-farm labor reducing the willingness of the household to adopt labor-intensive technologies. The positive sign on the coefficient (as well as the lack of statistical significance) of the religion variable contradicts the hypothesis concerning greater innovativeness of evangelicals vís-a-vís Roman Catholics in these communities.

The coefficient on land quality is found to be positive and statistically significant at the 5 % level. All else being equal, a 10% increase in land quality at the mean of the independent variables increases the expected amount of land allocated to NTAX production by 5% overall. This seems straight-forward enough. As land quality improves, so do the expected income increases associated with NTAX production. Producer age is negatively associated with land in NTAX and its coefficient is statistically different from zero. Again, at the mean of the independent variables, a 5 year increase in age results in a 12.5% decrease in land allocated to NTAX crops. This may reflect the more traditional belief structure of older producers or their increased reluctance to adopt new technologies. If we take the accumulation patterns discussed in the next section into account, it may also be be linked with the tendency of older households to begin a process of land deaccumulation via gifts to children and younger relatives.

Village effects were pronounced with all of the village dummies having statistically significant coefficients. An adopter in El Tablón at the mean of the independent variables plants, on average, 60% less land in NTAX than a similar adopter in Xejolón. This points out the importance of spatial variables, whether related to the proximity to processing plants or local diffusion patterns. It should also be remembered that by concentrating on a cross-section of our data, we are capturing each community at a particular moment in time, with respect to its experience with and ability to support NTAX production.

The coefficients on farm size, farm size squared and farm size cubed are all statistically significant (at the 5% level) suggesting a cubic specification for the relationship between farm size and adoption. Figure 1 uses these Table 1 estimates of b and equations (1) and (2) to illustrate the relationship between farm size and, respectively,the probability of adoption (dashed line) and expected quantity of land in NTAX (solid line) at the mean of all the other independent variables. The initially positive relationship between farm size and NTAX adoption and the high degree of participation by even very small producers in this sector are apparent from the figure. At the mean of our sample (10.4 cuerdas = 2.9 acres) fully 73% of producers are expected to adopt NTAX technologies allocating, on average, three tenths of their land to NTAX crops. The adoption probability and land allocation curves level off at just over 22.4 cuerdas, though both again begin to increase with farm size near the upper limit of our sample. If we consider **extent** of adoption (proportion of land cultivated in NTAX), we see that extent **decreases** with farm size until we reach the very largest farms in our sample. A separate, non-random survey of eleven large producers, many of whom are devoting all or nearly all of their cultivated land to NTAX crops, provides some evidence that this upturn is not an artifact of our sample.

Although the relationship between farm size and adoption behavior is obviously complex, these results are not inconsistent with the suggestion by von Braun *et al.* (1989) that diseconomies of scale emerge relatively quickly in the production of broccoli and snowpeas. The extreme labor demands that such production places on households may constrain the overall level of adoption even at very modest farm sizes–though our econometric results do not confirm the importance of labor constraints in reducing overall levels of adoption. It seems more likely that credit constraints inhibit increased NTAX adoption among small scale producers by limiting working-capital and the ability to ensure against poor outcomes. Such constraints may be overcome by only the very largest producers in our sample.

"Safety-first" concerns need to be considered, though it is difficult to know for certain how they might influence the adoption decision overall. On the one hand, care to ensure sufficient food for the household in the coming year may inhibit the production of more profitable, but riskier NTAX crops. These concerns would seem to diminish as farm size increases. On the other hand, if as we argue in the next section, production of NTAX crops represents a viable strategy for acquiring more land, it may be that smaller farmers have a greater incentive to trade increased food insecurity in the near–term for increased overall security in the future. Even the short-term riskiness of NTAX production with respect to household food security is unclear, however, if the pursuit of NTAX strategies is associated with improved productivity on food plots. Such improvements may result if NTAX production lessens the need for seasonal migration or results in the increased knowledge about and ability to obtain inputs, such as fertilizers.

5. Land Accumulation Patterns in the Highlands of Guatemala - Before and After NTAX

Non-traditional agricultural exports can affect land accumulation patterns and agrarian structure by changing the incentives and land acquisition capabilities of both adopters and non-adopters. For adopters, the potential profitability of additional land in NTAX as well as the increased financing provided by profits from current holdings promote land accumulation; whereas for non-adopters, the pecuniary externality of rising land prices can reduce their land accumulation potential. This section develops a simple framework for testing the impact of NTAX adoption on land accumulation, yet one which models the potential heterogeneity of adopters versus non-adopters.

The model estimated is a two equation seemingly unrelated regression (SUR) system, one equation covering land accumulation patterns in the period before the widespread diffusion of NTAX and the other covering accumulation patterns after the diffusion of NTAX. Each equation is itself specified as a switching regression in which those units that eventually adopt NTAX have a different regression function than those that do not.

The data used in the analysis were based on surveys in which households were asked to reconstruct the evolution of their land holdings and usage from the inception of the farm household to 1990. For the original 318 households in the sample, the agrarian history covers an average of 16.5 years per household, though after eliminating households from the sample which originated after the diffusion of NTAX was well under way, the total sample size is 287. All land measures are standardized in cuerdas, where 3.61 cuerdas = 1 acre.

5.1 The Impact of Adoption on Accumulation: A Switching Regressions Framework

As a starting point for the discussion of a household's land accumulation, we define accumulation, DLit, as the change in land owned by farm unit "i" over some period of time:

(4) $\Delta L_{it} = L_{it} - L_{i0}$,

where L_{it}, and L_{i0} are the amounts of farm land owned in time "t" and in time "0," respectively. To enable comparison of accumulation patterns across time periods of unequal length, define the standardized land accumulation measure,

(4') $\overline{\Delta L}_{it} = (\Delta L_{it})/t$,

which is simply the per-annum land accumulation by unit "i" over the "0" to "t" period.

Three major factors specific to the farm households are likely to affect land accumulation patterns: The age or position of the household in the demographic lifecycle; The initial farm size as an indication of its access to markets, labor costs, etc.; and, The relative endowment of skill and other latent attributes which help to determine relative profitabilities and expansion potentials of households.

Denote the age or demographic lifecycle position of the household in period "t" as Ait. According to a Chayanovian view, a peasant farm household in the early stages of its lifecycle would be expected to accumulate land, while one in the later stages would be more likely to sell-off or endow its land to younger farm households. Total land holdings over the family lifecycle would appear as an inverted-U relationship under the Chayanovian view.

As discussed above, a second factor likely to affect land accumulation is the farm's size at the beginning of the period, L_{i0}. In general, structural and economic factors which influence the profitability of different farms will also affect the land accumulation patterns of farm households. Where technology exhibits non-constant returns to scale, or where market access and factor prices differ by farm size, farm size is likely to be an important determinant of land accumulation patterns over time. Decreasing economic returns to scale or size would imply a negative relationship between land accumulation and initial farm size, while scale or size advantages would imply the reverse, a positive relationship between land accumulation and farm size. If middle size farms are the most efficient (perhaps because, as Lehman (1986) and Scott (1985) suggest, they optimally mediate the labor cost advantages of smaller farms and the capital access advantages of larger farms), the size effect could be non-monotonic, increasing then decreasing accumulation as initial farm size increases.

Equation 5 offers a simple expression in which a basic lifecycle accumulation pattern is modified by initial size of farm land (L_{i0}):

$$(5) \qquad \overline{\Delta L}_{it} = \underline{\beta}_0 + \underline{\beta}_1 A_{it}^2 + \underline{\beta}_2 A_{it}^2 + \underline{\beta}_3 L_{i0}^2 + \underline{\beta}_4 L_{i0}^2 + u_{it}$$

Note that using (5), total expected land holdings in time "t," for a household which began its lifecycle at year "0" (such that $A_{it}= t$) will be:

$$(6) \qquad \overline{\Delta L}_{it} = L_{i0} + t[\overline{\Delta L}_{it}] = L_{i0} + \underline{\beta}_0 t + \underline{\beta}_1 t^2 + \underline{\beta}_2 t^3 + \underline{\beta}_3 L_{i0} t + \underline{\beta}_4 L_{i0}^2 t$$

As (6) shows, the specification in equation (5) permits the basic lifecycle trajectory to vary with initial farm size.

Gathering the independent variables into a single matrix $\mathbf{X}_{it}$, (5) can be rewritten as:

$$(7) \qquad \overline{\Delta L}_{it} = \underline{\beta}'\mathbf{X}_{it} + \mu_{it}$$

To study the interaction of NTAX adoption on land accumulation patterns, equation (7) can be respecified as a switching regression:

$$(7') \qquad \overline{\Delta L}_{it} = \underline{\beta}'\mathbf{X}_{it} + D_i(\underline{\delta}'\mathbf{X}_{it}) + \mu_{it},$$

where D_i is a binary variable which takes on the value 1 for adopters and 0 for non-adopters. Under this specification, $\underline{\delta}$ captures the structural effect of NTAX adoption on land accumulation. As discussed above, a positive interaction between adoption and accumulation suggests that $\underline{\delta}'\mathbf{X}_{it} > 0$.

Estimation of $\underline{\delta}$ in (7') is problematic. Latent characteristics, such as farmer skill, are likely to directly enhance differential accumulation and to be systematically correlated with NTAX adoption. Ordinary least squares estimation of 7 could, therefore, confound the structural effect of NTAX adoption on land accumulation with the effect of farmer skill differentials on land accumulation. An OLS estimate of $\underline{\delta}$ could measure the gross differential accumulation effect, but it would not separately identify the structural effect of NTAX on from the effect of farmer characteristics.

Latent variable approaches would be one way of addressing this identification problem. A more straightforward and compelling approach is to take advantage of the historical data to look for "Pre-Boom" and "Boom" patterns of differentiation among adopters and non-adopters of NTAX. Any differentiation in land accumulation patterns "Pre-Boom" cannot be a structural effect of NTAX *per se*, and will be interpreted as an indicator of the preexisting pattern of differentiation driven by latent characteristics. This "Pre-Boom" pattern then stands as a benchmark which can be subtracted from the gross differential accumulation effect in the "Boom" regression to yield an estimate of the structural effect of NTAX on land accumulation.

More formally, the two equation switching regressions system set forth below in equations (8) and (9) puts forward this "Pre-Boom" and "Boom" specification:

$$(8) \qquad \overline{\Delta L}^{P}_{it} = \underline{\beta}^{P\prime}\mathbf{X}^{P}_{it} + D_i(\underline{\delta}^{P\prime}\mathbf{X}^{P}_{it}) + \mu^{P}_{it},$$

$$(9) \qquad \overline{\Delta L}^{B}_{it} = \underline{\beta}^{B\prime}\mathbf{X}^{B}_{it} + D_i(\underline{\delta}^{B\prime}\mathbf{X}^{B}_{it}) + \mu^{B}_{it},$$

where the "P" and "B" superscripts index parameters and variables for the pre-boom and boom periods respectively. The binary variable D_i takes the value of "1" for units which adopt NTAX crops during the boom period. Finally let $\Sigma = \begin{pmatrix} \sigma_P & \sigma_{PB} \\ \sigma_{PB} & \sigma_B \end{pmatrix}$ denote $V(\underline{\mu}_{it})$.

This framework permits an explicit test of the assertion by Maxwell and Fernandez (1989:1683) that the differentiation in land ownership patterns that occurs with the spread of export agriculture often reflects preexisting differentiation patterns. The "Pre-Boom" period offers a test of preexisting heterogeneity in land accumulation patterns and the "Boom" period estimates provide evidence on the acceleration or dampening of this differentiation resulting from the introduction of NTAX. Coefficient estimates of $\underline{\delta}^B$ will offer evidence on the heterogeneity between adopting and non-adopting households by testing for potentially significant differences between the two groups prior to the actual adoption period. The gross effect of adoption in the boom period is estimated by the coefficient estimates of $\underline{\delta}_A$, while the structural effect of NTAX adoption, understood as differentiation that would not otherwise have occurred, will be estimated by $(\underline{\delta}^B-\underline{\delta}^P + \underline{\beta}^P-\underline{\beta}^B)'X$.

The seemingly unrelated regression (SUR) specification of equations (8) and (9) increases the efficiency of the estimates by incorporating the potential correlation in the dependent variables across the two time periods that might result from unmeasured factors affecting accumulation performance in both time periods. The SUR framework allows cross equation restrictions on the coefficients to test whether the coefficients differ significantly across the two time periods. Imposing these restrictions below permits an evaluation of the extent to which land accumulation patterns of the Pre-Boom and Boom eras differ.

5.2 Estimate of the Impact of NTAX on Accumulation

The full switching regression specified in (8) and (9) was estimated first. It proved impossible to precisely estimate the coefficients on many of the quadratic and interaction terms. As a result, a revised, partial switching regressions model was selected for analysis. This alternative model, reported in Table 3, specifies land accumulation per-year as a linear function of initial land endowment, a quadratic function of lifecycle age, and permits only the intercept and land coefficients to switch between adopters and non-adopters.

The first two columns of Table 3 report the SUR estimates for the partial switching regression model with no cross equation restrictions imposed. The notable results for these unconstrained estimates are:

1.) In the Pre-Boom regression, all of the coefficients except for the constant are statistically significant, with the switching parameters NTAX and NTAX*Land being significantly positive, suggesting evidence of heterogeneity in land accumulation patterns in the sample;

2.) In the Boom regression, the coefficient on NTAX*Land is small and statistically insignificant, indicating that initial farm size has the same impact on land accumulation for adopters and non-adopters. However, the coeffficient on the NTAX constant term is quite large and statistically significant, so that regardless of initial farm size adopters are estimated to accumulate almost halfa cuerda of land per year more than non-adopters.

In order to see the interacting effects of the estimated age and initial farm size coefficients, Figures 2 and 3 plot the land accumulation trajectories over the lifecycle of NTAX and non-NTAX households for the Pre-

Boom and Boom periods. The four trajectories are derived using equation (6), assuming initial land endowments of 2 cuerdas in Figure 2 and 30 cuerdas in Figure 3.

Three striking trends emerge. The first is that the Non-Adopter, Pre-Boom trajectories in Figures 2 and 3 are fully consistent with a Chayanovian View of land accumulation over the demographic lifecycle. Those households starting with an initial farm size of 2 cuerdas accumulate land over the first 25 years of their lifecycle, peaking at 7 cuerdas and then begin to deaccumulate. For those starting with 30 cuerdas, deaccumulation occurs over the lifecycle of the household with the most rapid deaccumulation occurring in the period after 25 years. All of these are consistent with a view of peasant farm households where there are both diseconomies of scale and important demographic trends driving land accumulation and deaccumulation.

The second point is the stark difference in land accumulation trajectories between adopting and non-adopting households in the Boom era. In other words, the gross differential accumulation effect of NTAX adoption is evident in both trajectories (broken lines in Figures 2 and 3), irrespective of farm size. Farmers who begin with 2 cuerdas, and adopt NTAX, accumulate 14 cuerdas by year 25, while those that have not adopted slightly deaccumulate to less than 2 cuerdas. The deaccumulation of land among the non-adopters in the larger farm size trajectory of Figure 3 creates a similar accumulation wedge between NTAX adopters and non-adopters. However, a significant portion of the gross differentiation in land accumulation among adopters and non-adopters in the Boom era would have occurred without the NTAX boom. As depicted in Figure 2, the estimated Pre-Boom trajectories show that the 2 cuerda farm which adopted NTAX would have accumulated 5 more cuerdas by year 25 than the non-adopters. For the smaller farm category, therefore, the structural effect of the NTAX boom (represented in the figures by the difference in the spreads between the dashed and solid line curves) accounts for 7 cuerdas of total differentiation. For farms with initial endowments of 30 cuerdas, the estimated structural effect is negligble. The absence of a structural effect, for the larger farmers, suggests that diseconomies of scale in NTAX production may be limiting the accumulation trajectories of larger farms in the Boom era.

Finally, the observation that land accumulation trajectories of non-adopters are lower in the Boom than they were in the Pre-Boom era suggests that additional land accumulation by NTAX adopters in the Boom period may have come partially at the expense of non-adopters. Coupled with the result that the smaller of the initial farm sizes adopting NTAX are projected to be the most significant accumulators, the implication is that land accumulation patterns may be following a Farmer Path, with differentiation occurring among small farmholders on the basis of their adoption decisions.

While provocative, the apparent shift in land accumulation with the NTAX boom is statistically weak. The regression model explains little of the relatively high variability in land accumulation per-year in the Boom period, with an R^2 of only 0.04. The third column in Table 3 reports SUR estimates when the coefficients on the Pre-Boom and Boom equations are restricted to be the same. These constrained coefficients are numerically almost identical to the Pre-Boom coefficients, and the hypothesis that the cross-equation restrictions are true cannot be rejected. The Wald Test Statistic is 6.67 far below the critical chi-squared value at the 95% confidence level. The hypothesis that the NTAX boom had no effect on the pattern of differentiation thus cannot be rejected.

The estimated land accumulation trajectories for the constrained estimation are identical in appearance to the solid curves in Figures 2 and 3. By year 25 in the lifecycle, adopters who begin with 2 cuerdas accumulate 5 cuerdas more than non-adopters and adopting farms which begin with 30 cuerdas have 15 cuerdas more than comparably endowed non-adopters. The NTAX boom, under this interpretation, does not appear to disrupt the Chayanovian logic of non-adopting households.

A closer look at the statistical results warns, however, against too facile an acceptance of the inference that NTAX has not shifted patterns of accumulation and differentiation. The regression model explains little of the relatively high variability in the land accumulation in the Boom period. Given the weakness of the fit in the Boom model, it is not surprising that the cross-equation restrictions were not rejected. Clearly, however, patterns of land accumulation are changing in the Boom period. The unconditional variance of "$\overline{\Delta L}_{it}$," or land accumulation per-year is 2.04 (versus 0.184 in the Pre-Boom era) and the SUR estimate of the constrained variance is 2.09 (versus 0.184 in the Pre-Boom era). It should also be noted that the boom thus far has covered a period of only three years. In sum, while the hypothesis of no structural change in land accumulation periods across the two periods cannot be rejected, further work and a longer history of NTAX production is needed to verify and explain the apparent change in land accumulation patterns.

6. Conclusions

For much of this century, agro-export booms have excluded and displaced small farmers in Central America. The current wave of Central American agro-export promotion appears in many instances to once again be concentrated in the large, or highly capitalized farm sector (Barham *et al.*, 1992). An apparent exception to this observation is the export vegetable (broccoli and snowpeas) production currently being promoted in the highlands of Guatemala. The boom in these crops over the last decade seems to play an optimistic *laissez faire* scenario in which open markets premit small farmers to effectively utilize their cheap labor, participate in remunerative export agriculture, and break out of the dualistic agricultural structure inherited from past episodes of agricultural growth (de Janvry and Sadoulet, forthcoming). The research presented in this paper has examined the highland Guatemala agro-export boom precisely along the two dimensions which have proven so problematic in past Central American agro-export expansions: the participation of small farmers in export production; and, the impact of agro-export growth on the land access and stability of the small farm sector. Using data drawn from a broadly representative sample of highland producers, this study shows that indeed small farms are participating in the production of the new exports. Farms as small as 2.5 acres are estimated to have a 75% probability of growing at least some non-traditionals.

The data demonstrate a pre-existing pattern of modest differentiation within the small farm sector. Efforts to identify whether the NTAX boom has shifted paths of differentiation and accumulation gave mixed results. There is weak evidence that the export boom has heightened the pattern of differentiation among adopters and non-adopters. However, a hypothesis of no structural shift cannot be rejected. Interpretation of this test requires caution, because the data manifest a large increase in the variability of land accumulation across households in the boom period. Clearly, patterns of accumulation have changed, but they cannot be precisely explained at this time.

This uncertainty not withstanding, the agro-export boom in highland Guatemala is taking a different shape than prior booms in cotton, coffee, and cattle, and the current booms in melons, flowers, and pineapple. The microeconomics of size disadvantages (rooted in the supervision costs of these labor-intensive crops) would seem to explain the set of results summarized above. However, the research reported in this paper raises two important concerns which must temper these results. First, the absolute amount of land devoted to NTAX export crops by the surveyed households is estimated to level off very quickly at about 0.8 acres in the non-traditionals, and does not increase at all as total farm size increases from 4 to 11 acres. This limited extent of adoption seems to indicate the presence of constraints to further adoption. One quite logical explanation would be the limited availability of the family labor needed to supersede labor supervision problems and profitably adopt NTAX crop production. Unfortunately, the econometrics do not support his interpretation, and instead provide *prima facie* evidence that capital constraints are the more likely explanation of the phenomenon of limited adoption.

Whatever the rationale for the limited adoption, the data also show a rapid upturn of land devoted to non-traditional production as farm size exceeds 11 acres. Moreover, a separate survey of large farm producers of highland non-traditional crops uncovered a strata (of indeterminate population weight) of producers with more than 25 acres who are accumulating land - largely through rental arrangements - and devoting nearly 100% of their cultivated area to the lucrative non-traditionals. These farm units also appear to be consummately commercial, and it is unlikely that they face the same capital constraints as the small holder sector. Unfortunately, their long-term competitiveness vis-a-vis the small farm sector and their impact on agrarian structure in the region must await future analysis.

Table 1: Characteristics of Adopters versus Non-Adopters of Non-Traditional Agricultural Exports (NTAX)

Variable (No. of Producers)	NTAX Producers (182)	Trad. Producers (136)
Farm Size, cuerdas*	13.0	7.0
Land Owned, cuerdas*	10.1	5.5
Avg. % Land in NTAX	29.4	0
Avg. Annual Increase in Land Holdings, cuerdas per year	0.217	0.051

* in standardized cuerdas
(n.b. 1 acre = 3.61 cuerdas)

Table 2: Land Allocated to Non-traditional Exports Tobit Estimates

Variable	Coefficient	Std. Error	Mean	Std. Dev.
CONSTANT	-2.569	1.483		
Farm Size (cuerdas)	0.9211**	0.1353	10.434	8.887
Farm Size Squared	-3.492E-02**	6.632E-03	187.6	361.2
Farm Size Cubed	4.263E-04**	9.124E-05	4943	15582
Land Owned (Proportion of Total)	-0.6558	0.4972	0.6944	0.3920
Land Quality Index	0.1547**	0.0658	7.408	2.885
Household Labor (Adult Equivalents)	0.1570	0.4521	3.786	1.770
Household Labor Squared	-1.331E.03	0.0467	17.56	16.34
Female Labor (Proportion of Total)	-0.9334	1.188	0.5063	0.1500
Age	-0.0577**	0.0153	41.893	15.446
Education Index*	-0.0142	0.0310	7.421	6.851
Religion (1=Catholic,0=other)	0.4606	0.3545	0.5881	0.4930
Village Dummies:				
Las Canoas*	-0.9244**	0.4022	0.3019	0.4598
El Tablón*	-3.1872**	0.8300	0.1289	0.3357
Santo Domingo*	-2.6477**	1.019	0.0660	0.2487
Xejolón*	1.9137**	0.5849	0.0975	0.2971
Dependent Variable (Land in NTAX-cuerdas)			1.900	2.473
log-likelihood = .495.66				

* The education index is constructed such that the first digit indicates the level and the second digit represents the number of grades completed at that level: Level 0 = none; Level 1 = Primary, Grades = 1-6; Level 2 = Secondary; Grades = 1-6, Level 3 = University; grades = 1-8.

** Significant at the 95% confidence level.

Table 3: Seemingly Unrelated Regressions Estimations of the Impact of the NTAX Boom on Land Accumulation

	Unconstrained		Constrained
	Pre-Boom [Pre 1987]	Boom [Post 1987]	Pre-Boom = Boom
Dependent Variable, Land Accumulation Per Annum			
Mean	0.2203	0.277	xxx
Standard Deviation	0.4692	1.468	xxx
Explanatory Variables			
Constant	-0.1379 [0.0963]	0.0469 [0.0412]	-0.1204 [0.0838]
Age	[0.0122]*	0.0503 [0.0487]	-0.0260.0477 [0.0116]*
Age Squared	-0.0013 [0.0004]*	0.0004 [0.0012]	-0.0012 [0.0003]*
Initial Farm Size	-0.0239 [0.0056]*	-0.0238 [0.0187]	-0.0241 [0.0054]*
NTAX Dummy	0.1412 [0.0500]*	0.4483 [0.2235]*	0.1634 [0.0577]*
NTAX Initial Farm Size Interaction	0.0166 [0.0074]*	0.0039 [0.0021]	0.0151 [0.0068]*
Variance Estimates, Σ			
Pre-Boom, σ_P	0.184		0.184
Boom, σ_B	2.046		2.092
Covariance σ_{PB}	-0.006		-0.028
R Squared			
Pre-Boom	0.16		0.16
Boom	0.04		0.03

Figures in brackets are standard errors.

* Denotes significance at the 95% confidence level.

Figure 1
Farm Size and Adoption of Non-Traditional Exports

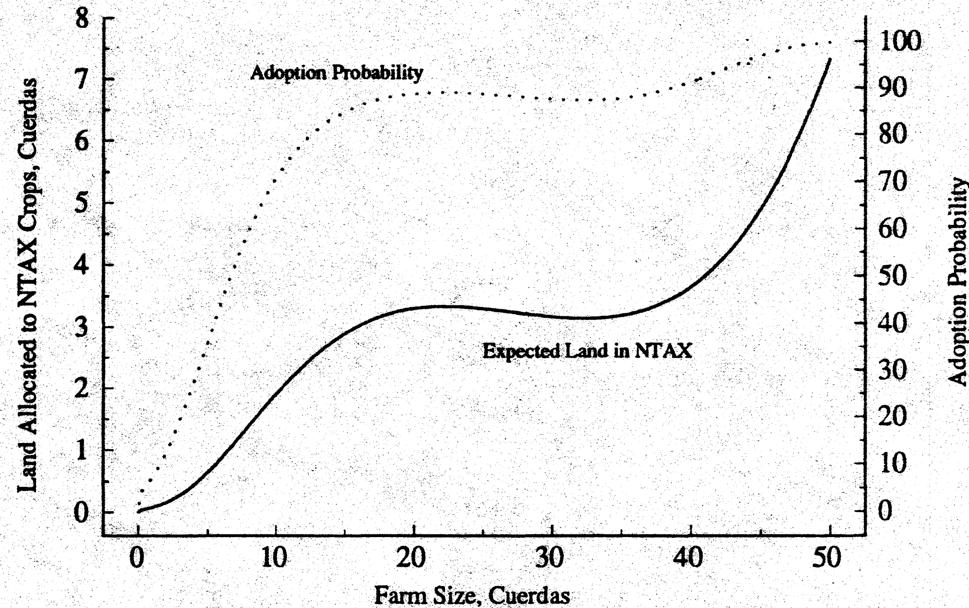


Figure 2
Estimated Land Accumulation Trajectories
Initial Land Endowment 2 Cuerdas (0.5 acres)

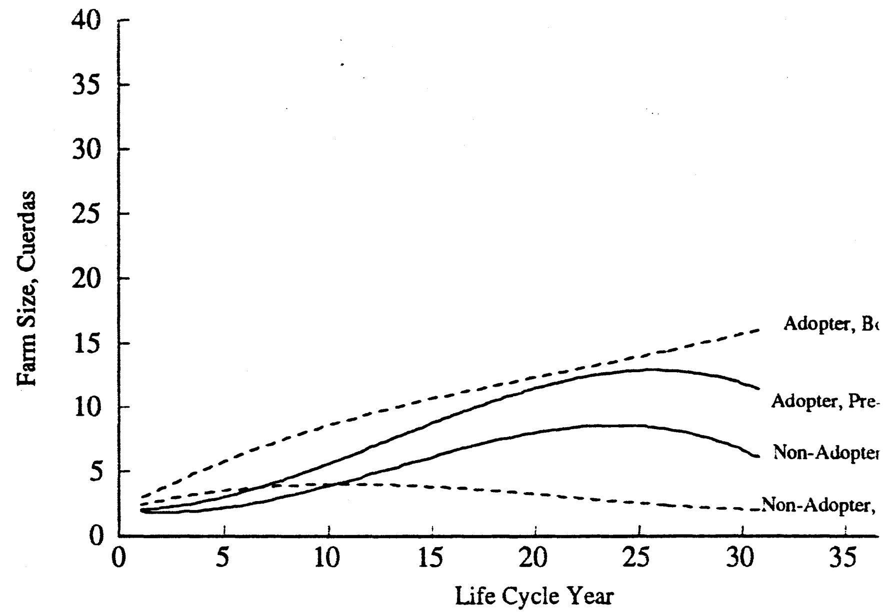
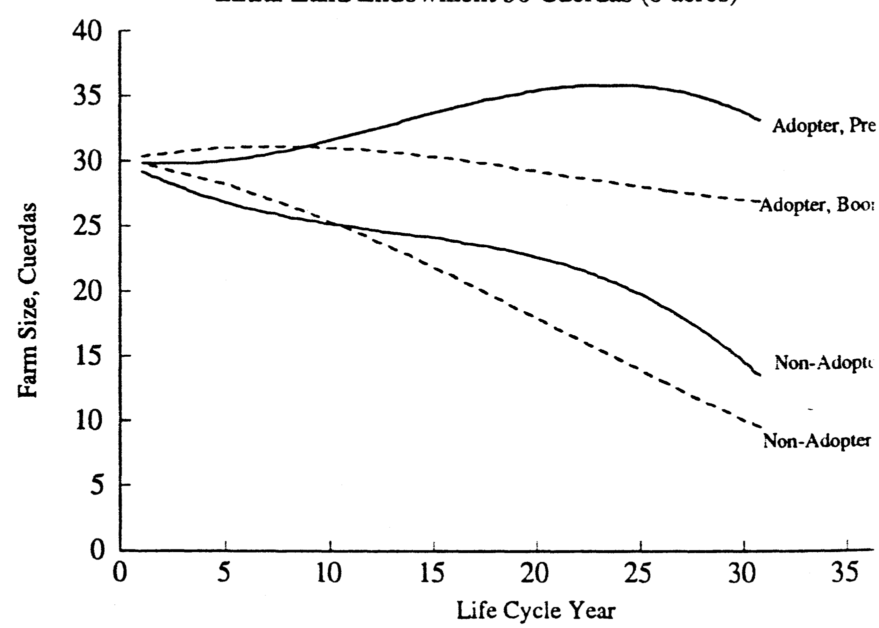


Figure 3
Estimated Land Accumulation Trajectories
Initial Land Endowment 30 Cuerdas (8 acres)



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