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Competing objectives of smallholder producers in developing countries: examining cacao production in Northern Ecuador

Abstract

The use of non-timber forest products (NTFPs) is supported as a solution for sustainable agricultural development. While NTFP advocates claim these resources offer a financial incentive to smallholder households, this incentive is often smaller than the income received in agricultural monoculture systems. Rural households often utilize NTFPs or adopt sustainable methods even though they could adopt more profitable practices. The authors examine the tradeoff between working for cash income and meeting the subsistence needs of smallholder cacao producers in Northern Ecuador. The authors compare the economic and ecological factors to be considered when producing cacao in either a monoculture or agroforestry system. The paper finds that farmers' preference for agroforestry systems is more highly related to environmental benefits than to specialty market access, and that cacao farmers utilizing agroforestry systems are neither the wealthiest nor the most marginalized.

Keywords: agroforestry, biodiversity, cacao production, sustainable economic development.
JEL Classifications: Q13, Q12, Q56, Q57.

Introduction

One of the world's greatest challenges is ending poverty without jeopardizing the environment. Development at the expense of the environment is not sustainable, as short-term income gains threaten future well-being and profitability. This is especially acute in the tropics, which contain some of the world's most environmentally sensitive areas and highest concentration of poverty.

Utilizing non-timber forest products (NTFPs) is supported as a solution to end poverty while protecting the rainforests. NTFPs are agricultural crops such as coffee, cacao, Brazil nuts, and orchids that could provide sustainable incomes for rural communities living in rainforests (Dahlquist et al., 2007; López-Feldman & Wilen, 2008). While agroforestry systems are less profitable than monoculture systems, some communities prefer them. For instance, Indonesian cacao farmers are willing to accept lower prices for smaller yields using agroforestry systems (Steffan-Dewentera et al., 2007).

Indeed, production decisions are varied and intertwined, from which crops to grow to where to market products. These decisions traditionally have been conceptualized in economics as choosing the option that is most profitable, but this is often not the case with smallholder farmers in developing countries. Researchers have noted that smallholder households make production decisions based on interdependent factors rather than simply maximizing profits (Dutilly-Diane, Sadoulet & De Janvry, 2003). Hildebrand (2002) furthered this argument by including leisure needs in livelihood models for smallholder households. Others, such as Chambers (1995), have advanced the sustainable livelihood concept, including importance of the environment and well-being factors in livelihood choices.

Competing objectives may lead households to make production decisions that seemingly contradict the long held theory of rational profit maximization. In fact, research has shown that many smallholder households react in ways that defy profit-maximizing behavior. For instance, higher prices are not the primary motivation for Kenyan smallholder farmers participating in organic markets (Bechetti & Costantino, 2008) or Mexican smallholder farmers preferring traditional maize varieties (Arslan & Taylor, 2009). Research has also found a gap in the economic understanding on the influence of non-market benefits, including biodiversity, on smallholder farmers' production decisions.

Our research examines the cacao production system in Ecuador. Through a review of the literature and statistical analysis of extensive household surveys, we explore how non-market factors related to biodiversity influence smallholder households to use the agroforestry system. Ecuadorian cacao production provides a great example of understanding how biodiversity and other ecological factors influence production decisions in choosing between the traditional, highly diverse, agroforestry system and themodern, highly productive, monoculture system. The following sections are divided into the role of cacao to the economy and environment in Ecuador and throughout the tropics, an explanation of the two agricultural systems used, and the non-market benefits of agroforestry cacao production. Our empirical strategy, data and results are presented in the next two sections. Our final section provides some discussion and conclusions.

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1. Cacao's importance to the tropics and Ecuador

Tropical countries are known for their high levels of poverty and biodiversity. The impact of cacao production in these regions is large, with 7.42 million hectares producing over five metric tons of cacao valued at US$6.75 billion in 2007 (FAO, 2009). Indeed, cacao is the second most important cash crop in the tropics (Steffan-Dewentera et al., 2007), with over 70% of the world's cacao produced by small landholders (Dahlquist et al., 2007).

One tropical country heavily dependent on cacao production is Ecuador. Historically, cacao was Ecuador's most important export, with large expanses of the coastal region devoted to producing this crop (cacao was referred to as "Pepa de Oro" or "Seeds of Gold").

The economic crisis of the 1930s and the land reforms of the 1960s forced the large cacao haciendas to be divided into parcels that were sold to small landholders. Today, Ecuador controls 70% of the cacao market for gourmet, dark chocolates, and is one of only three countries where high-quality cacao can be grown. Twelve percent of the economically active population in Ecuador is involved in cacao production, with 90% of the cacao produced on land holdings less than 50 hectares [over 30% of these are farms smaller than 10 hectares] (CORPEI, 2009).

Cacao production is seen as an avenue to help alleviate poverty in rural communities. The need for economic development in Ecuador is acute, with 29% of Ecuadorians living below the poverty line (CIA, 2012). Because of the importance of cacao to Ecuador's economy, especially to small landholders, the Ecuadorian government, along with local and international development organizations, has begun to advocate cacao Nacional (Nacional) as an economic development strategy (CORPEI, 2009).

2. Cacao production systems

Most of the cacao produced throughout the world is hybrid varieties such as CCN-51 cacao (CCN-51). While the main advantage of CCN-51 over Nacional is that it is more productive, it does not produce as high a quality cacao as Nacional. In the past, CCN-51, which is used in lower quality chocolates at lower prices (El Cacao Volvió Ser la Pepa de Oro, 2007), was promoted to small landholders as a superior option based on its profitability. As farmers have accessed specialty markets where they receive premiums for Nacional and organically produced cacao (Bentley, Boa and Stonehouse, 2004), Nacional has become popular, with price premiumsincreasing over 60% between 2004 and 2007 (El Cacao Volvió Ser la Pepa de Oro, 2007).

In addition to the quality differences, these two cacao varieties are produced using different farming methods. The agroforestry system used to produce Nacional includes a diverse array of crops and retention overstory trees to enhance nutrient cycling, as well as mechanical weeding methods (e.g., pruning), rather than agrochemicals, to control diseases and pests. This production approach varies greatly from the monoculture method used to produce CCN-51, which is less susceptible to sun damage, and is produced in more densely planted parcels using multiple agrochemicals for higher profitability (Bentley, Boa and Stonehouse, 2004).

3. Non-market benefits of agroforestry systems

The agroforestry system better enhances the biodiversity of native plants and animals than the monoculture system but less than primary forests (Reitsma, Parrish & McLarney, 2001; Duguma, 2001). One of the critical objectives of the agroforestry system is to replicate the natural forest environment to mitigate the loss of natural forests. The protection of native plant and animal species is particularly important to Ecuador because its coastal region, where cacao production is concentrated, is included in the world's biodiversity hot spots of threatened and endangered plant and animal species (Myers et al., 2000; Conservation International, 2012). The additional ecological benefits that an agroforestry system provides include pollution and runoff control, improved soil quality through nutrient cycling and organic matter accumulation, and carbon sequestration (Duguma, 2001).

Compared to producing cacao in a monoculture system, the agroforestry system has been shown to help prevent further degradation of water resources. Using an agroforestry system also helps ameliorate soil erosion which is critical in agriculture sustainability. The shade trees of an agroforestry system prevent some of the leaching of pesticides and other chemicals into the groundwater and slow down water runoff so less soil is removed. The dense planting of trees and plants in agroforestry systems provides organic matter to be recycled back into the soil to maintain soil fertility. The tree canopy also protects the soil from the full impact of rainfall by protecting the soil from being loosened and washed away (Beer et al., 1998).

In addition to environmental services, agroforestry systems allow subsistence households to meet their consumption needs by incorporating other products, such as plantains and fruit, which are important to the diet of Ecuadorian farm families. Even if a household were to earn much more cash income for CCN-51, exclusively using monoculture systems may prevent households from meeting their subsistence needs (Bentley, Boa and Stonehouse, 2004). The tradeoff between working for cash income and meeting subsistence needs was also demonstrated in a study of Brazil nut gatherers in the Brazilian Amazon. Household consumption needs were not met as smallholder farmers dedicated their time to collecting Brazil nuts instead of growing subsistence crops (Ros-Tonen et al., 2008).

In sum, producing cacao in a diversified agroforestry system may obtain additional values along with the nonmarket values that could make it the preferred production method for Ecuadorian smallholder producers. We empirically explore this question in the next sections.

4. Empirical analysis

As explained above, Ecuadorian smallholder cacao producers have two production alternatives: agroforestry (Nacional) systems or monoculture (CCN-51) systems. We investigate the different incentives associated with each of these two systems in Northern Ecuador. We start with a standard analysis of production and profitability to confirm whether the monoculture system is more profitable in the Ecuadorian context. We then explore potential liquidity constraints that may limit the adoption of CCN-51. Plain economic rationality suggests that farmers would prefer to plant CCN-51, rather than Nacional, but that has not happened in Ecuador. Thus, we explore whether there exist environmental and other non-market benefits from using the agroforestry system that may justify their choices. We find evidence that this is the case. These additional values provide the economic incentives to use agroforestry systems (this is consistent with the findings of Duguma (2001) for West and Central Africa). After presenting descriptive statistics for these factors we use probit regression to explore the relative importance of these in determining farmers' preference of cacao variety.

4.1. Data. We obtained extensive plot and household information for 50 cacao farmers using 69 farmed plots in the counties of Santo Domingo de los Tsáchilas, Puerto Quito, and Quininde in July and August of 2009. We asked questions about their household and farm characteristics; production methods in different plots; required inputs and outputs; prices; plot characteristics; impressions of the profitability of their operations; access to alternative markets; perceptions of environmental quality; past economic shocks; and well-being satisfaction. Some of the most marginalized in Ecuadorian society, either through ethnic discrimination or poverty, were included in the survey. The sample included mostly small and medium farming operations, with 62% of the farms less than 10 hectares. Within the sample households, 26% were indigenous Tsa'chila, and 8% were Afro-Ecuadorian. These two groups are particularly marginalized in society (Gobierno de la Provincia de Pichincha, 2003).

4.2. Production and profitability values. Our survey results reveal a clear difference between Nacional and CCN-51 production in terms of labor and other inputs, yield, and profits. Nacional farmers are more dependent on family labor and utilize more labor overall. Comparing the two cropping systems on a per hectare basis does not reveal the true difference between the two systems as CCN-51 is planted much more densely than Nacional. In order to make a per tree comparison, the two cacao varieties are compared as if they were planted at the same density of 625 trees per hectare; thus, the comparison for costs and profits between the two varieties are made in terms of hectare equivalent units. A parcel with a tree density of less than 625 cacao trees per hectare would have a hectare equivalent smaller than the actual hectare size while a parcel with more than 625 trees would have a hectare equivalent value larger than the number of hectares in the parcel. Basically, the hectare equivalent designation allows each variety to be compared on a tree for tree basis. Hectare equivalent is utilized throughout this study to reference this conversion.

Table 1. Yield and costs per hectare (parcel level)

	Cacao CCN-51	Cacao Nacional
Total labor (days/ha)	33.62	33.96
Family labor (days/ha)	18.67	22.72
Hired labor (days/ha)	14.95	10.87*
Planting costs with family labor (USD/ha)	55.71	43.00
Planting costs without family labor (USD/ha)	47.65	18.85**
Other input costs (USD/ha)	55.88	21.84***
Total costs with family labor (USD/ha)	355.99	296.91
Yield (quintal/ha)	16.41	8.97**
Number of observations	18	51

Table 2. Farm revenue and profits (USD/ha)

	Cacao CCN-51	Cacao Nacional
Revenue in the standard market	1419.37	648.90**
Revenue in the specialty market	N/A	824.41
Revenue in the organic markets	N/A	562.60
Profit in the standard market with family labor	1066.54	361.31
Profit in the standard market w/o family labor	1233.21	543.34**
Profit in the specialty market with family labor	N/A	644.63
Profit in the specialty market w/o family labor	N/A	762.20

Table 2 (cont.). Farm revenue and profits (USD/ha)

	Cacao CCN-51	Cacao Nacional
Profit in the organic market with family labor	N/A	745.91
Profit in the organic market w/o family labor	N/A	870.87
Number of observations	13	31

Notes: * Significant difference at the 10% level. ** Significant difference at the 5% level. *** Significant difference at the 1% level. N/A – not available.

Tables 1 and 2 list the production cost, yield, revenue, and profit on a per hectare basis while Table 3 lists these variables on a hectare equivalent basis.

Table 3. Yield, costs, revenue and profits per hectare equivalent

	Cacao CCN-51	Cacao Nacional
Total labor (days/hae)[a]	28.75	63.77**
Family labor (days/hae)[a]	16.16	37.72**
Hired labor (days/hae)[a]	12.59	25.01
Labor for weeding (days/hae)[a]	9.24	29.14**
Other labor input costs (USD/hae)[a]	51.50	28.78**
Total costs with family labor (USD/hae)[a]	304.40	564.61*
Total cost without family labor (USD/hae)[a]	165.14	258.40
Revenue in standard market (USD/hae)[a]	1393.97	834.88*
Revenue in specialty market (USD/hae)[a]	N/A	1060.86
Revenue in organic markets (USD/hae)[a]	N/A	1026.95
Profit in standard market with family labor (USD/hae)[a]	1081.10	285.15**
Profit in general market w/o family labor (USD/hae)[a]	1223.84	608.65*
Profit specialty market with family labor (USD/hae)[a]	N/A	677.90
Profit in the specialty market with family labor (USD/hae)[a]	N/A	677.90
Profit in the organic market without family labor (USD/hae)[a]	N/A	-182.32 (median) 288.39
Profit in the organic market without family labor (USD/hae)[a]	N/A	233.57

Notes: [a] hae = hectare equivalent. Each parcel was converted to the amount of hectares it would contain if the trees were planted at a density of 625 trees per hectare. * Significant difference at the 10% level. ** Significant difference at the 5% level. *** Significant difference at the 1% level. N/A – not available.

Nacional production is much more labor intensive, and is less productive and profitable than CCN-51 production. There is no difference in the amount of labor utilized in both systems when compared by labor use per hectare, with an average of 33.96 days per hectare for Nacional and 33.62 days per hectare for CCN-51. However, there is a significant difference in labor use when compared by hectare equivalent, with 63.77 days of labor per hectare equivalent for Nacional and 28.75 days of labor per hectare equivalent for CCN-51. In particular, there is a significant difference between the days of family labor used, with 37.72 days of labor per hectare equivalent for Nacional and 16. 16 days per hectare equivalent for CCN-51. No significant difference was found to exist in the use of hired labor.

A large difference exists in the use of other inputs, such as fertilizers, insecticides, and herbicides, between the two production systems. The monoculture system uses an average of US$51.50 in other inputs per hectare equivalent, compared to US$28.78 per hectare equivalent for the agroforestry system. Households that raise CCN-51 substitute other inputs for labor, especially herbicides. Because weeding is more labor intensive for Nacional, there is a clear difference in the amount of weeding labor, with 29.14 days of labor per 625 trees for Nacional and 9.24 days of labor per 625 trees for CCN-51.

The market price for hired labor does not properly represent the true cost realized for this labor. With few options for employment, the opportunity costs of many household members are much less than the market wage. Since the household is paying itself for labor, the opportunity cost of household members is zero. To examine the differences in the two values for the real cost for family labor, the costs and profits were calculated both as if family labor were valued at the market rate and at zero. When family labor is valued at the market rate, the total cost for raising Nacional is much higher than that for CCN-51. On average, Nacional costs US$564.61 per hectare equivalent to grow while CCN-51 costs US$304.40 per hectare equivalent. When family labor is valued at zero, there is no significant difference in the cost to produce either variety, with average production costs of US$258.40 per hectare equivalent for Nacional and US$165.14 per hectare equivalent for CCN-51.

Based on a per hectare basis, CCN-51 is much more productive than Nacional. In fact, higher yield is the main reason why CCN-51 is touted over Nacional (Melo, 2009). The study confirmed the perception that CCN-51 has significantly higher yields. The farmers participating in our study revealed that the average yield between September 2008 and August 2009 was 16.41 quintals per hectare for CCN-51 and 8.97 quintals per hectare for Nacional. These values are very near the BIOFASCA estimates of annual cacao production (16 quintals per hectare for CCN-51 and 8 quintals per hectare for Nacional). However, this yield measurement masks the differences in tree density for each variety. Comparing yield on a tree by tree basis, average yield during this time period was 14.80 quintals per hectare equivalent for CCN-51 and 11.66 quintals per hectare equivalent for Nacional.

Households receive significantly larger revenues for CCN-51 than for Nacional. In standard markets without premiums for Nacional, the average revenue from September 2008 through August 2009 was US$1,393.97 per hectare equivalent for CCN-51 and US$834.88 per hectare equivalent for Nacional. During this period, the average revenue for Nacional farmers with access to markets paying premiums for this variety was US$1,060.86 per hectare equivalent. CCN-51 was significantly more profitable than Nacional in the standard and specialty markets, even when the value of family labor was discounted. The average profit for CCN-51 was US$1,223.84 per hectare equivalent, compared to US$608.65 per hectare equivalent for Nacional.

Surprisingly, organic cacao production was not profitable, although it has the highest market value (US$90-$110 per quintal). When family labor input is included, the organic farmers had an average loss of US$182.32 per hectare equivalent, and only US$233.57 when family labor is not valued.

4.3. Likelihood to plant cacao. A good indicator of household long-term expectations for cacao is intention to plant cacao. The households participating in our survey were asked if they wanted to plant more cacao trees and which variety they wanted to plant.

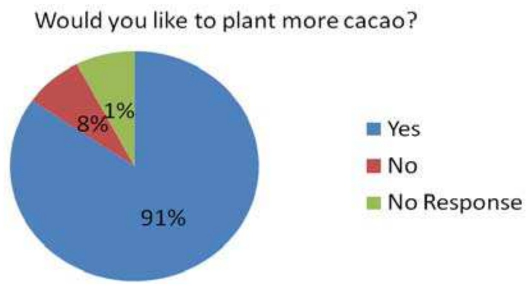

Fig. 1. Likelihood to plant cacao

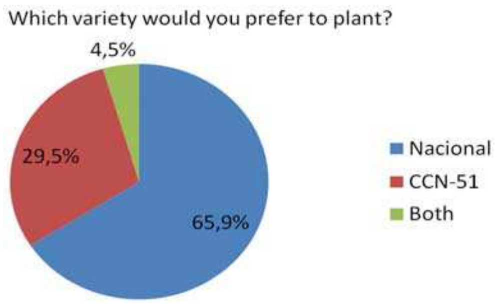

Fig. 2. Cacao variety planting preferences

Overall, they had high expectations for cacao, with 88% of the households wanting to plant cacao, and the majority of those (65.9%) preferring Nacional. This result appears to contradict the theory of profit maximization, as a profit-maximizing household would prefer CCN-51 over Nacional. Our study reveals that smallholder decisions are not based only on profit.

4.4. Perceptions of environmental factors and parcel characteristics. Environmental factor and parcel characteristics perceptions by households over a six-year period were rated on a scale of one to five, with one being very bad and five being very good. The farmers were asked to rate their perceptions of the soil fertility and biodiversity of their entire farms and cacao fields.

Table 4. Environmental perceptions

Variable name	CCN-51 parcels	Nacional parcels	Entire farm
Soil quality 6 years ago[r]	3.00	4.36[aaa]	3.76[***]
Soil quality 3 years ago[r]	3.00	4.25[aaa]	3.45[***]
Biodiversity 6 years ago[r]	2.00	3.95	3.65
Biodiversity 3 years ago[r]	1.67	2.95[aa]	2.64

Notes: [r] Farmers scored the variables on a scale from one to five, with one being very bad and five being very good. [a] Difference between cacao Nacional and CCN-51 is significant at the 10% level. [aa] Difference between cacao nacional and CCN-51 is significant at the 5% level. [aaa] Difference between cacao Nacional and CCN-51 is significant at the 1% level. [*] Difference between cacao Nacional and the entire farm is significant at the 10% level. [**] Difference between cacao Nacional and the entire farm is significant at the 5% level. [***] Difference between cacao nacional and the entire farm is significant at the 1% level.

Farmers clearly perceived Nacional parcels to have better soil quality than either the entire farm or CCN-51 parcels. The farmers also rated the loss of native plant and animal speciesas less for Nacional. These findings support the ecological research claim that agroforestry systems protect and even enhance biodiversity in comparison to monoculture systems. As a result, agroforestry systems may be a second-best solution, compared to native forests in controlling the loss of native plant and animal species.

The Nacional parcels are larger, have older trees, and have more biodiversity than the CCN-15 parcels.

Table 5. Parcel characteristics

	Cacao CCN-51	Cacao Nacional
Parcel area (ha)	2.57	4.50[**]
Tree density (trees/ha)	702.78	502.18[*]
Tree age (years)	3.94	10.49[***]
Slope[a]	1.83	1.82
Number of annual crops per parcel	0	0.25[*]
Number of perennial crops per parcel	1.33	2.65[***]
Number of trees varieties per parcel	0.61	1.08[*]
Number of observations	18	51

Notes: [*] Significant difference at the 10% level. [**] Significant difference at the 5% level. [***] Significant difference at the 1% level. [a] 1: Plain, 2: Hilly, 3: Steep.

Nacional has been produced in Ecuador for over 150 years while CCN-51 has been produced for only 10 years. The average Nacional tree age is 10.94 years old while the average CCN-51 tree is 3.94 years old.

Although households producing CCN-51 have larger farms, these households plant their cacao on smaller plots that are more densely planted. The average parcel size is 2.57 hectares for CCN-51 and 4.50 hectares for Nacional. The average planted tree density is 700 trees per hectare for CCN-51 and 500 trees per hectare for Nacional. Because they use agroforestry systems, Nacional farmers intersperse other crops and trees between their cacao trees.

To study their bioversity, farmers participating in the survey were also asked how many varieties and which varieties of crops and trees they planted in their cacao parcels. Both native and non-native plant species were included in this biodiversity measure for ecological benefits from cacao trees. Nacional farmers were considered more biodiverse because they plant over two varieties of perennial crops and at least one other tree variety with their cacao trees while CCN-51 farmers are more likely to plant only one other perennial crop with their cacao trees.

4.5. Potential liquidity constraints of households that produce each variety of cacao. There are distinct differences between households producing either Nacional or CCN-51.

Table 6. Liquidity constraints of households

	Cacao CCN-51	Cacao Nacional
Total income per month[1]	4.87	3.44*
Farm income per month[1]	3.81	2.85*
Percentage indigenous	31.25	29.41
Family size	4.75	4.09
Farm size (ha)	28.44	13.08**
Percentage that own a car	50.00	15.15***
Percentage with running water	25.00	6.25**
Rooms in the home	4	3.25**
Number of observations	16	34

Notes: * Significant difference at the 10% level. ** Significant difference at the 5% level. *** Significant difference at the 1% level.

CCN-51 farmers are wealthier than Nacional farmers. Household incomes were recorded on a scale of one to nine, with one being less than US$100 per month and nine being over US$800 per month. The average rating of total household income for producing CCN-51 was 4.87 (median of 5), while Nacional averaged 2.44 (median of 3). As households in both categories are statistically similar in size, household incomes can be compared on a one to one basis. There is a difference of at least US$200 between the total incomes of the two groups. This difference is significant in Ecuador, where the minimum wage in 2009 was US$218 per month (the poverty line is US$56 per person, per month). Average farm income is also statistically different for the two groups, although the difference is smaller. CCN-51 farmers earn nearly US$100 more in farm income than Nacional farmers.

Other indicators of household wealth revealed significant differences between the two types of households. CCN-51 farmers have larger homes than Nacional farmers. CCN-51 farms averaged 28.44 hectares, compared to 13.08 hectares for Nacional farms. In addition, CCN-51 farmersare more likely to own a car (50%) and have running water (25%), compared to Nacional farmers (15% and 6.25%, respectively).

4.6. Access to specialty markets. Our survey included questions about farmers' access to specialty cacao markets. The farmers were asked if they had access to markets where they are paid premiums for Nacional or to markets for organic cacao. If they lacked access to these markets, they were then asked if they would like to have access to these markets and what factors inhibited them from having access to the more lucrative markets. Only 26% of households had access to the premium markets for Nacional. Of those households without access to these markets, 42% would like to have access, 22% were unsure if they would like to have access, and only 6% were uninterested in having access. Of those who did not have access to specialty markets, 43% were in the process of trying to gain access, 35% were unaware of how to gain access, 17% claimed they did not produce enough to access the market, and 5% thought there was no market demand. Even fewer households (6%) had access to organic markets. It was noted that 58% of the households would like to have access to organic markets, although 79% of this group stated that cost and lack of market knowledge prohibited their entry into the organic market. These results complement the results of the case study by Nelson and Galvez (2000) which found that many cacao farmers lacked access to fair trade markets, especially the most remote, marginalized households.

5. Regression analysis and results

Our descriptive analysis in the previous section shows that agroforestry benefits, such as enhanced biodiversity and soil quality, as well as liquidity constraints, are potential motives for Ecuadorian farmers to continue growing the variety. The desire to access specialty markets is also a potential reason why farmers prefer producing Nacional in spite of the higher profitability of CCN-51. We explore the relative significance of these determinants through a probit regression where the dependent variable corresponds to responses for preferred variety (Nacional = 1). We use a set of explanatory variables that reflects the identified potential motivations for this preference. The first variable, *Access*, measures whether the farmer has access or would like to have access to specialty markets. Then, the perception of biodiversity in

Nacional parcels is measured on a scale from 1 to 5, where 1 is very bad and 5 is very good. In order to capture liquidity constraints we include the size of the land when they started farming[1]; a dummy to indicate whether they own a car; and another dummy for lack of credit access and safety nets (this information takes the value of one for farmers coping with negative economic shocks by consuming/selling assets or working off-farm, rather than borrowing money/credit or relying on community, family or government help). We also include a measure of perceived health (on a 1 to 5 scale) and the education level of the household head. Other variables include household characteristics, such as ethnicity, age of household head, family size, and number of children less than 5 years old, since they influence household preferences. In particular, the ethnicity variable indicates whether the head of the household is of the Tsa'chila indigenous group, which is distinct from the rest of the population in that they believe all plants and animals need to be protected because they have spirits, and they use medicinal plants grown in their fields. This would suggest that they are more likely to choose agroforestry systems. Also included are price variables that influence demand, such as wages ($ per day of labor) and average price of chemical fertilizers, insecticides, and herbicides.

5.1. Regression results. Our regression analysis confirms that farmers who perceive Nacional as providing more biodiversity in their farm are more likely to prefer this variety to extend their plantings. Interestingly, having or willing to obtain access to specialty markets is not a significant variable for explaining the preference for Nacional. On the other hand, farmers with credit constraints and no safety nets are more likely to prefer CCN-51. Overall, these results show that the current preferences for Nacional are driven by biodiversity benefits, while the preference for CCN-51 is driven by higher cash earnings.

Finally, other significant control variables have the expected signs: Tsa'chila heads are more likely to prefer nacional, households facing high wages are less likely to prefer Nacional (Nacional is more labor intensive), and producers facing high prices of chemical inputs are more likely to prefer Nacional (CCN-51 requires more chemical inputs).

Discussion and conclusions

Our survey of smallholder cacao-producing households in Northern Ecuador reveals differences in the profitably and the environmental impact of both systems. While cacao produced in monoculture systems is much more profitable, cacao produced in agroforestry systems is rated higher in bioversity and ecological benefits. Agroforestry systems, which are planted with wider arrays of other crops, native plants, and trees, maintain better soil quality. There are definite differences between the households producing the two cacao varieties (Nacional and CCN-51). The households utilizing agroforestry production systems are more likely to have less wealth and smaller farms than those households utilizing monoculture production systems.

Even though monoculture production systems are more profitable, the majority of smallholder households prefer agroforestry production systems, which contradicts the classical economic theory about profit maximization. The study reveals that additional factors, such as environmental benefits, access to food and medicinal plants, and cultural beliefs about nature from indigenous groups, influence the desire to use the agroforestry system. The discovery that wealthier households are more likely to produce CCN-51 in monoculture systems provides empirical evidence for the conclusions of Barnum and Squire (1979), Hildebrand (2002), and Chambers (1995) about the production decisions of smallholder producers being more dependent on their farms for additional needs.

The promotion of Nacional cacao production in Ecuador has the potential to provide many positive environmental and development outcomes, but will need to be tempered by social programs for marginalized households.

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[1] We use this measure instead of present size in order to avoid endogeneity problems.

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Appendix

Table 1A. Regression analysis of preference for Nacional agroforestry system

Dependent: *Prefers Nacional*	Coef.		Std. err.
Access	-0.54		0.70
Perception biodiversity with Nacional	1.07	**	0.45
Land size when started farming	-0.01		0.02
Has a car	1.48	*	0.86
Main strategy to cope with shocks is diversifying, consuming products from the farm & selling trees or agricultural products	-3.16	**	0.90
Household health (perception 1-5 scale)	-1.95	**	0.60
Education (years) of household head	-0.64	**	0.33
Ethnicity (head of the household is Tsachila)	1.27	**	0.61
Age of household head	0.00		0.02
Size of the household	0.36		0.26
Number of kids between 0 and 5 years	0.37		0.54

Table 1A (cont.). Regression analysis of preference for Nacional agroforestry system

Dependent: *Prefers Nacional*	Coef.		Std. err.
Wage for day of labor	-0.32	*	0.17
Price of chemical fertilizer	0.12	**	0.05
Price of insecticide	0.17		0.12
Price of herbicide	-0.13		0.11
Constant	7.31	**	3.79
Probit regression	Nr. obs		61
(Std. error adjusted for 46 clusters in hhnr)	Wald $chi^2(15)$		52.22
	Prob > chi^2		0.000
Log pseudolikelihood = -16.178	Pseudo R^2		0.5318

Notes: ** Significant at 5% level. * Significant at 10% level.