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To cite this version:

Sylvaine Lemeilleur, Julie Subervie, Anderson Edilson Presoto, Roberta de Castro Souza, Maria Sylvia Macchione Saes. Eco-certified contract choice among coffee farmers in Brazil. 2017. hal-01512224

HAL Id: hal-01512224

https://hal.science/hal-01512224v1

Preprint submitted on 21 Apr 2017

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DOCUMENT de RECHERCHE

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Eco-certified contract choice among coffee farmers in Brazil

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Abstract

We survey Brazilian coffee farmers' preferences for attributes of voluntary sustainability standards using a choice experiment. We collected original data from 250 coffee farmers who live in the state of Minas Gerais who were asked to choose from several hypothetical buying contracts for eco-certified coffee. Our results suggest that both cash and non-cash payments may motivate farmers to participate in sustainability standard certification schemes that require improved agricultural practices. Preferences for non-cash rewards such as long-term formal contracts or technical assistance, however, appear highly heterogeneous. Results moreover show that the minimum willingness-to-accept for the adoption of composting is twice as high as the average price premium for certified coffee in the current context, which may partly explain why most coffee farmers continue to be reluctant to enter the most stringent eco-certification schemes such as the organic standard.

Keywords: voluntary sustainability standards, certification, coffee, choice experiment, Brazil, pesticides, compost, erosion.
JEL codes: Q01, Q15, Q57.

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1 Introduction

It is well known that cash crop production in tropical countries creates a range of serious potential environmental impacts. Coffee production is an emblematic case of environmental deterioration. In the 1990s, many coffee growers replaced traditional shade grown coffee cultivation methods with sun cultivation in order to increase the yield of their coffee. This shift has resulted in millions of acres of cleared forest. Additionally, sun plantations require greater amounts of fertilizer and pesticides, which damage the environment[1] and lead to topsoil erosion. Approximately 40 percent of Latin American shade coffee farms have been converted to low shade systems (Rice et al., 1996). Today, farming systems in Latin America have remained largely unchanged since the 1990s (Jha et al., 2011).

In many developing countries, the environmental impacts of cash crop production cannot usually be solved using conventional command-and-control regulation due to weak institutions and highly atomized production systems (Wehrmeyer and Mulugetta, 1999). The environmental problems that accompany coffee production would also be difficult to address using payment for environmental services (PES) schemes.[2] Although PES is an increasingly popular conservation and resource management tool in developing countries (Muradian et al., 2010), the uncertain future availability of land and resources that many poor farmers face remains a key obstacle to participation in these schemes. Moreover, the implementation of PES schemes is often complex, and the associated transaction costs are usually high. As governments alone cannot be relied upon to mitigate environmental issues, voluntary sustainability standards, also known as private standards, have emerged as a promising solution. Sustainability standards can encourage the internalization of environmental externalities by providing incentives to farmers for implementing environmentally friendly practices. Their ability to do so, however, depends on several factors,

[1] Indeed, sun-cultivated coffee often involves intensive pesticide use, which poses serious health and ecological concerns. Shade plantations, in contrast, rely less heavily on pesticides because the variety of plants that surround the coffee trees reduce the system's susceptibility to pests. Weed growth is also reduced with this method due to the shady exposure and fallen leaves that act as a natural mulch.

[2] PES are payments to farmers who have agreed to take certain actions to manage their land in such a way so as to provide an ecological service; in these schemes, payments are conditional on implementation of these favourable changes in land use. In this way, the program is similar to providing farmers a subsidy that depends on the amount of land under PES coverage.

including the stringency of the environmental requirements and the extent to which farmers are willing to comply with the requirement.

Sustainability standards define the principles and criteria that govern the production and processing methods for a product.[3] These initiatives rely mainly on labels and use a certification process. Most sustainability standards are enforced by third party auditors who monitor compliance with the criteria and examine product traceability. Labels are designed to enable consumers to differentiate between products based on environmental and/or social attributes, which facilitates the development of a market for products with premium prices (Giovannucci and Ponte, 2005). The coffee sector is generally regarded as a pioneering industry for sustainability standards and certification (Reinecke, Manning, and von Hagen, 2012). The very first certified coffees were Organic, Fair Trade, Bird Friendly and Rainforest Alliance. By the mid-2000s, sustainable coffees came to include certification initiatives such as UTZ Certified and Common Code for the Coffee Community (4C), as well as certifications used exclusively by individual firms (Starbucks and Nespresso). Environmental requirements vary highly from one standard to another.

There are a variety of reasons why voluntary sustainability standards and certifications may be effective in resolving the environmental issues that coffee production entails. First, there is growing consumer demand for coffee that has been produced in an environmentally friendly manner.[4] For example, the annual growth rate of coffee sold under the Rainforest Alliance (resp. UTZ) certification reached 28 % (resp. 25 %) in 2012 (Potts et al., 2014). Second, certification generates a price premium that can in some cases be quite high, which should create a financial incentive for farmers to participate in certification schemes (Giovannucci and Ponte, 2005; Blackman and Rivera, 2010). For the 2011-2012 period, for example, premiums for eco-certified coffee have been reported at : around +13% for Fairtrade, +10% to +15% for Organic (these premiums have declined

[3]Some sustainability standards encompass not only environmental protection but also social improvements such as better employment practices, as well as other economic criteria, in the selling contract. Given the increasing concern surrounding the environmental issues associated with coffee production, we focus here on environmental standards.

[4]Many studies have indeed shown that consumer's willingness to pay for eco-labelled products is often positive (Bougherara and Combris, 2009). There is, moreover, recent empirical evidence that eco-certification of coffee cultivation significantly improves environmental performance. Blackman and Naranjo (2012), for example, used detailed farm-level data in central Costa Rica to show that organic certification significantly reduces chemical input use and increases the adoption of several environmentally friendly management practices. Results such as these should further encourage consumer demand for eco-certified products.

compared to the +25 to +35% of the early to mid-2000s), +2.5% for UTZ Certified and +1% to +2% for 4C compliant (Potts et al., 2014). Premium data on Rainforest Alliance products are scarce, but premiums of around +8% were reported in 2009. Third, certification is often viewed as a strategy for strengthening the position of small coffee producers in the value chain.[5] In this regard, downstream operators often play a central role in determining market access for coffee producers by providing commercial stability through long-term contractual arrangements (Borrella, Mataix, and Carrasco-Gallego, 2015; Fitter and Kaplinksy, 2001; Vorley and Fox, 2004).

Table 1: Eco-certified coffee produced under 4C, UTZ, Rainforest and Organic

	2009		2012	
	tons	share (%)	tons	share(%)
4C	604,086	0.48	1,782,058	0.59
UTZ	365,009	0.29	715,648	0.24
Rainforest Alliance	168,114	0.13	265,565	0.09
Organic	132,058	0.10	248,767	0.08
Total	1,269,267	1.00	3,012,038	1.00

Source: Potts et al. (2014)

The production of certified coffee has increased significantly in recent years: approximately 1.3 million of metric tons of eco-certified coffee were produced in 2008 (nearly 18% of global coffee production) and more than 3 million of metric tons were produced in 2012 (nearly 40% of global coffee production). However, most newly-certified farmers opt for the least stringent standards (Table 1). Indeed, they often choose the new and prevalent standard 4C, which has moderate entry requirements and is widely perceived as a stepping-stone to existing standards. The 4C implementation process provides a transitional approach for producers and focuses mainly on traceability, efficiency and farmer training. No third party certification is required, as an external audit only occurs at the cooperative level. Conversely, farmers choose more stringent standards less frequently. One such standard is Organic, which prohibits all chemical products and encourages the use of organic compost; others are UTZ Certified and Rainforest Alliance, which require taking steps to prevent soil erosion and water contamination, planting native shade tree species,

[5] A wide range of literature aims to determine whether private standards tend to include or exclude small-scale farmers in markets for high-value food items (Asfaw, Mithöfer, and Waibel, 2010; Henson, Masakure, and Cranfield, 2011; Maertens and Swinnen, 2009; Minten, Randrianarison, and Swinnen, 2009; Subervie and Vagneron, 2013). Evidence is mixed.

and reducing reliance on pesticides through integrated pest management. Table 1 shows that Organic certified coffee comprised the lowest share of eco-certified coffee production worldwide in 2009, which declined again in 2012, while the share of the least stringent standard - 4C certification - increased dramatically during the same period. Additionally, growth in Organically certified coffee sales was the lowest over the 2004-2008 period and remained the lowest over the 2008-2012 period (Table 2). Moreover, it is worth noting that sustainable standard markets exhibit significant oversupply (standard-compliant sales volumes are far lower - nearly 25% lower - than standard-compliant production volumes). This oversupply indicates a downward pressure on prices and suggests that the development of the market for stringent eco-certified coffee may not, in the end, prove dynamic enough to solve the environmental problems caused by coffee production. In this paper, we investigate several possible impediments to farmer participation in certification schemes (such as stringency, knowledge, premiums, outlet uncertainty, etc.).

Table 2: Eco-certified coffee sold under 4C, UTZ, Rainforest and Organic

	Compound annual growth rate of sales	
	2004-2008	2008-2012
4C	153	48
UTZ	30	23
Rainforest Alliance	64	21
Organic	19	8

Source: Potts, van der Meer, and Daitchman (2010) and Potts et al. (2014)

While a vast literature discusses the efficiency of voluntary sustainability standards (Blackman and Rivera, 2010), studies that examine the acceptability of voluntary sustainability standards are rather scarce. It has been emphasized that in many cases, the price premiums paid to farmers under these standards may not be high enough to offset the costs of compliance (Giovannucci and Ponte, 2005; Blackman and Rivera, 2010). Despite this, the factors behind farmers' decisions to participate in certification schemes have seldom been the subject of empirical study. As a first step toward filling that gap, this paper explores coffee farmers' preferences for attributes of eco-certified coffee contracts in the Brazilian state of Minas Gerais. This region constitutes the main

area for coffee production in Brazil (50% of total Brazilian coffee production). Most of the production in this region is currently sun-cultivated, and farmers frequently use chemicals in the production process. Another originality of the paper is our focus on the motivations that underlie participation in voluntary sustainability standards through the use of a choice experiment. This methodology is often used for studying the acceptability of PES schemes, but surprisingly it has never been used for other well-developed market-based instruments such as sustainability standards. We ran a choice experiment (CE) among 250 coffee farmers who were asked to choose from several hypothetical contracts for eco-certified coffee. In the choice experiment, hypothetical contracts were represented as combinations of various contract attributes. In our framework, a contract for certified coffee combines a particular payment amount, payment method and environmentally friendly farming practice. The way in which farmers choose between several different contracts, each with varying levels of individual attributes, is used to quantify their preferences for these attributes, as well as to quantify overall willingness to accept (WTA) values, i.e. the amount of money an average farmer would require in order to adopt a particular contract. Our design allows us to examine farmers' preferences for three environmental practices, namely abandoning pesticides, composting, and erosion control. We moreover investigate the relevance of non-cash rewards such as technical assistance and long-term formal contracts. We analyse the data using a mixed logit regression as well as latent class models.

Consistent with economic theory, the results from the mixed logit model show that the inclusion of environmental requirements reduces the probability of choosing a certification contract, while all cash and non-cash rewards increase the probability that farmers enter into a certification contract. Overall, farmers prefer a high price premium, a long-term formal contract, as well as the provision of technical assistance in order to comply with the environmental requirements that the contract entails. However, as would be expected, results are not homogeneous among farmers. Results from the 2-class model show that a subset of farmers, about one third of the sample, behave quite differently from other farmers: they place a very low value on technical assistance and long-term contracts. On average, these farmers are less educated, own larger farms, and are less specialized in coffee production; they moreover have fewer family members who are also involved

in coffee production.

Overall, our findings suggest that the average farmer's willingness to enter the certified coffee sector depends heavily on the practices that he is required to adopt, and that most farmers consider composting to be the most stringent of the environmental requirements. We estimate that the average respondent is willing to accept a contract that involves a composting requirement for a 32 percentage point increase in the price premium, whereas they are willing to accept a contract stipulating zero pesticide use for only a 6 percentage point increase in the price premium. Given that the average price premium for certified coffee reaches at most 15% in the current context, the minimum WTA that is required by respondents for compost adoption appears to be quite high.

The remainder of this article is organized as follows. Section 2 reviews the main results of the literature that studies farmers' motivations to adopt sustainable agricultural practices through choice experiment methods. Section 3 describes the common practices used in the production of coffee and the emergence of sustainability standards in the Brazilian coffee sector. We then present the choice experiment design and the data used in Section 4 and the models used in Section 5. We then present and discuss the results of the choice experiment analysis in Section 6. We provide some robustness checks in Section 7, and Section 8 concludes.

2 Literature

There is a growing literature that studies farmers' motivations to adopt sustainable agricultural practices. A large number of these studies use choice experiments in which farmers are asked to state their preferences over hypothetical alternative PES contracts. Just as in the participation in sustainable standards, participation in PES programs is voluntary. Many studies focus on PES contracts that have been offered to farmers in order to encourage more eco-friendly practices in developed countries of the European Union, as farmers have shown less interest in these contracts than was anticipated (Lienhoop and Brouwer, 2015; Villanueva et al., 2015; Schulz, Breustedt, and Latacz-Lohmann, 2014; Beharry-Borg et al., 2013; Broch et al., 2013; Broch and Vedel, 2012; Christensen et al., 2011; Espinosa-Goded, Barreiro-Hurle, and Ruto, 2010; Ruto and Garrod,

2009). These studies tackle a variety of environmental issues (e.g. water quality, afforestation) that are likely to be solved by adjusting agricultural land management practices (such as establishing pest-free areas or adopting nitrogen fixing crops).

Other recent discrete-choice experiments examine the acceptability of biodiversity conservation contracts in tropical areas. Greiner (2016), for example, use a choice experiment to estimate the willingness of pastoralists and graziers to sign up for voluntary biodiversity conservation contracts in northern Australia. Pienaar, Jarvis, and Larson (2014) study the willingness of a sample of farming households to engage in anti-poaching enforcement, revegetation of wildlife habitat and wildlife monitoring in the framework of a natural resource management program in Botswana. Mulatu, van der Veen, and van Oel (2014) examine farmers' preferences for collective and individual actions to improve water-related ecosystem services in Kenya. Kaczan, Swallow, and Adamowicz (2013) study farmers' preferences for a hypothetical PES program to reduce deforestation in Tanzania, and Krishna et al. (2013) estimate the cost of farmer participation in a hypothetical PES scheme for agrobiodiversity conservation in India.

All of these studies are highly context-specific. Consequently, the design of choice experiments varies greatly from one study to another, making it difficult to infer general results from these analyses. However, we often observe a high heterogeneity in farmer preferences and minimum WTA requirements for participation in potential PES programs. Moreover, in many cases, the minimum WTA that is required by respondents varies greatly according to specific scheme requirements. We contribute to this literature by focusing on the environmental effects of coffee production in Brazil, which include the erosion of topsoil, biodiversity loss and water pollution due to the intensive use of synthetic pesticides and fertilizers. Note that our analysis differs slightly from previous studies in the sense that we explore the potential for the development of sustainability standards rather than a PES program. Both certification schemes and PES schemes belong to the family of market-based instruments for ecosystem services (Pirard and Lapeyre, 2014). From the point of view of many farmers, however, the reward provided by certification schemes (which depends on the quantity of standard-compliant coffee sold) is much more uncertain than the reward provided through PES schemes (which often offer farmers fixed payments on a per hectare basis).

3 Background

3.1 Coffee Agroecosystems in Brazil

Brazil is by far the world's largest coffee producer and exporter. Some 3.5 million people are involved in the coffee sector, mostly in rural areas (Rice, 2003). These farmers are heavily exposed to the volatility of world coffee prices. According to the International Coffee Organization, the average consumer price index of coffee was 1.27 USD per pound in the years 1980-1989 and fell to 0.54 USD per pound in the years 2000-2004. In order to compensate for decreases in their income, many farmers have abandoned their traditional coffee growing methods, in particular shaded cultivation.

Today, sun-grown farming methods continue to characterize agriculture in Brazil's coffee sector, as only a few producers, located in areas such as northern Sao Paulo or Pernambuco, maintain diverse canopies over their coffee (Jha et al., 2011). The predominant so-called Green Revolution approach used in the majority of coffee plantations in Brazil is a plantation model that uses high amounts of synthetic fertilizers and pesticides and grows coffee in full sun or in unshaded systems (Sales et al., 2013).

3.2 Eco-certified Coffee in Brazil

The 4C Association standard is the most widespread standard in Brazil. It represents over 30% of the total coffee production in Brazil in 2012.[6] However, the 4C Association standard has moderate entry requirements and should be considered a complementary initiative to existing standards. As such, the 4C implementation process offers a transitional approach to producers who are either unfamiliar with or not yet able to comply with more stringent sustainability standards. The standard generally focuses on traceability, efficiency and farmer training. There is no third-party certification, simply an external audit at the cooperative level, which may explain why many farmers are not aware of their own engagement in the standard. One of the objectives of the 4C Associa-

[6] We obtain this result by calculating the ratio of the quantity of 4C-compliant coffee sold in 2012 (977,096 tons according to Potts et al. (2014)) and the total quantity of coffee sold in Brazil in 2012 (2,952,000 tons according to the Agricultural Trade Office of Sao Paulo).

tion is therefore to prepare producers for possible compliance in the future, which explains why the association requirements appear much less stringent that those of other sustainable standards. Other common environmental standards in Brazil are UTZ Certified (nearly 8% of the total coffee production in 2012), Rainforest Alliance (nearly 3%) and the Organic Standard (0.4%).[7]

Among environmental standards, the most stringent is the Organic standard, since it prohibits all chemical products and encourages the use of organic compost, which helps eliminate the use of synthetic fertilizers. This fosters the proliferation of beneficial microorganisms that protect plants from diseases and pests, which in turn promotes healthy root systems that maintain soil structure, reducing the likelihood of erosion and decreasing runoff. Regular use of organic compost over an entire farm, however, can entail a significant amount of labour. Other environmental standards, such as the UTZ Certified and Rainforest Alliance certifications, appear to be less onerous. Nonetheless, these certifications also require coffee farmers to take steps to prevent soil erosion and water contamination, plant native shade tree species and reduce their reliance on pesticides through integrated pest management.

Although there is growing concern about the environmental impacts of coffee cultivation in Brazil, the adoption of organic agriculture is still perceived as a risky and very expensive option by most farmers, who continue to use conventional agriculture methods (Sales et al., 2013).

4 Choice Experiment Design and Data Collection

4.1 Choice Experiment Design

Stated preference methods involve asking individuals to repeatedly state their preferences over hypothetical alternatives. The choice experiment (CE), initially proposed by Louviere and Hensher (1983) and Louviere and Woodworth (1983), belongs to the group of stated preference methods.[8] In a CE, respondents are asked to undertake a sequence of choice tasks with two or more

[7] Note that certified farms are often compliant across multiple standards. For example, UTZ multi-certification data reports a 43% overlap with Rainforest Alliance among coffee farms (Potts et al., 2014).

[8] The major drawback of stated preference methods is their hypothetical nature, as people may not be sufficiently motivated to reveal their true preferences in such situations. We argue, however, that in our case this is less of a concern because we select attributes that are familiar to coffee farmers who are aware of the existence of sustainable

alternatives. Each alternative in a choice set is characterized by several attributes that can take on different levels. Variation across the alternatives that make up the choice sets is achieved by selecting different levels for each of the attributes. In our CE, we asked respondents to choose between two hypothetical buying contracts for certified products that are characterized by the attributes presented in Table 3.

Table 3: Certification scheme attributes and their levels

Attribute	Definition	Levels
Sustainable practice	The farmer who chooses to participate in the environmental certification scheme commits to integrate sustainability requirements into his practices	Zero pesticides Composting Erosion control
Technical assistance	The farmer who chooses to participate in the environmental certification scheme may receive technical assistance to meet the environmental requirements	No Yes
Contract length	The farmer who chooses to participate in the environmental certification scheme may sign a long-term contract with the buyer	1-year 3-years
Price premium	The farmer who chooses to participate in the environmental certification scheme may benefit from a price premium relative to the market price	+0 percent +5 percent +15 percent

The hypothetical contracts are characterized by the following four attributes: the environmental requirement, the contract length, the price premium and the provision of technical assistance from the buyer. The environmental attribute consists of three levels, that is, three sustainable farming practices that are often required in the context of environmental certifications. These environmental requirements are: “no pesticide use”, “composting” (instead of using chemical fertilizers, as in Organic requirements) and “erosion control”. These sustainable practices are all requirements that are encountered in existing certification schemes in Brazil. Each of these enhances compliance with the Forest Code, which requires the maintenance of at least 20 percent of land as forest.

Three payment attributes are used in the experiment. The primary payment vehicle is a price

standards.

premium, which takes on three levels that vary across scenarios: 0 percent, 5 percent or 15 percent of the market price. These levels were chosen according to the actual potential premiums that farmers are likely to encounter as payment for compliance with environmental standards. The second was the provision of technical assistance to help farmers adopt the sustainable practice required by the certification contract, which takes on two levels (zero or one). Indeed, ever since the privatization of extension services in Brazil, access to technical assistance has become difficult for many farmers. The third payment attribute is the provision of a formal contract for a period of 3 years (rather than a traditional annual contract), which is assumed to be a valuable option for farmers in a market currently characterized by high volatility and an oversupply of sustainability standards. An example of a choice set is shown in Table 4. The CE applies a fractional factorial design consisting of 10 choice sets. Indeed, we were unable to use a full factorial design that considers every possible choice set, i.e., each possible combination of the attribute levels, since this would have required too many sets. Indeed, including two alternative contracts, each characterized by two attributes with three levels each and two attributes with two levels each, would lead to 36 alternatives and 630 possible pairwise choices. Thus, we opted instead for a more practical fractional factorial design, in which each respondent is only shown a subset of 10 choice situations from the total number of possible choice situations.

Table 4: An example of a choice set

Which scheme would you prefer?	Scheme A	Scheme B
Requirements	Erosion control	No Pesticides
Tech. Assistance	Yes	No
Contract length	3 years	1 year
Premium	+15%	+5%
I would prefer (tick your choice)	[ ]	[ ]

In order to select this subset of choice situations, we used an orthogonal design that aims to minimize correlations between attribute levels in the choice situations. The orthogonality criterion requires that the levels of each attribute vary independently from each other so that the effect of each attribute may be estimated independently from all other effects. This design strategy also attempts to keep the alternatives within each choice set as different as possible. For example, if an

attribute's number of levels equals the number of alternatives in a choice set, each level appears exactly once. Complete enumeration moreover conforms to the level balance principle, which requires all levels of each attribute to appear with equal frequency across alternatives. The original choice set (in Portuguese) used in the experiment is displayed in Appendix 2.

4.2 Data Collection

We collected original data from a total of 249 farmers living in the state of Minas Gerais. In order to ensure that respondents would fully understand the questions and concepts used in the CE, a pilot questionnaire was tested in October 2013 with the help of volunteers from the Cooxupé coffee farmers' group in Minas Gerais. The CE was then implemented in face-to-face interviews with farmers in March 2014. Surveying took place in the municipality of Araguari during an agricultural fair. Visitors in the fair were randomly solicited to participate in the choice experiment. In order to increase participation, gifts were offered as prizes in a raffle for participants only. Interviewers were experienced research assistants from the University of Sao Paulo. Surveys were conducted in Portuguese.

Prior to the choice experiment, the respondents were informed about the attributes and their levels. The interviewers provided respondents with a 20-minute information session regarding the attributes and levels before presenting the choice experiment questions. The participants answered survey questions about themselves, their farm and their environmental perceptions, and then participated in the choice experiment. Each participant completed ten choice sets. A choice set consisted of two contract alternatives, as well as an option to decline both contracts (i.e. to choose the status quo).

4.3 Sample Characteristics

The descriptive statistics presented in Table 12 in Appendix 2 reveal that the sample is comprised of farmers that own an average of 380 hectares of land (although the median farmer owns less than

90 hectares).[9] They devote about 65 percent of their land to coffee production, and coffee is by far their primary source of income (70 percent on average). On average, they employ 10 permanent workers (while the median farmer only employs 3 permanent workers). The average number of family workers on the farm is 2. Average yields range between 30 and 70 bags of coffee per hectare. Most respondents (73 percent) are members of a cooperative, which is the main buyer for half of the sample.

A large number of respondents (40 percent) grow coffee on mountain slopes and may thus be causing excessive erosion on their plantation. Almost all respondents use pesticides. Most respondents (75 percent) state that they are accustomed to using organic compost, albeit on a small shares of their farmland. Indeed it is very common for farmers to use compost to encourage the growth of young coffee plants. As a result, they are often very familiar with the amount of effort required for this practice. The survey also consists of questions eliciting respondents' awareness of environmental issues. The majority of respondents believe that environmental issues are often taken into account in decisions regarding the cultivation of coffee and that pesticides are used in a controlled manner in their area. However, only 20 percent of farmers believe that forest biodiversity is threatened by coffee production.

At the time of the survey, some respondents (30 percent) declared that they were certified. More specifically, 15 percent of surveyed farmers declared that they were Certifica Minas certified and 8 percent declared that they were Cerrado certified (two kinds of Protected Geographical Indications), and 5 percent declared that they were 4C certified. Interestingly, some respondents were already engaged in some type of environmental certification scheme: 12 percent declared that they were UTZ Certified and 15 percent declared that they were Rainforest Alliance certified.

[9] This means that large coffee producers are over-represented in our sample compared to the population of Brazilian producers (Census of Agriculture 2006). This is not surprising given that we ran the choice experiment in an agricultural show and trade fair, an event that is likely to attract the largest producers. However, since large producers are also more likely to damage the environment through agricultural activity, focusing on these produces seems appropriate for our study.

5 Statistical Models

In our choice experiment, each of the 249 participants faces 10 choice sets (or choice occasions). A choice set consists of three alternatives: two alternative contracts and an option to decline both contracts (i.e. to choose the status quo). Each contract is characterized by four attributes, that is, one sustainable practice and three possible rewards (in the form of a price premium, free technical assistance and/or a long-term formal contract). It is assumed that farmers lose utility when adopting a sustainable practice required by a certification contract, and gain utility from the associated rewards.

We use the framework provided by Revelt and Train (1998), in which a sample of N respondents have the choice of J alternatives on T choice occasions. In our data, we have $N = 249$, $J = 3$ and $T = 10$. A farmer is assumed to choose a contract if the net utility from that choosing that contract is greater than choosing either no certification contract or any of the competing choices. The utility that farmer n derives from choosing alternative j on choice occasion t is given by $U_{njt} = \beta'_n x_{njt} + \epsilon_{njt}$, where β_n is a vector of individual-specific coefficients, x_{njt} is a vector of observed attributes relating to individual n and alternative j on choice occasion t, and ϵ_{njt} is a random term that is assumed to be an independently and identically distributed extreme value.

5.1 Standard Logit and Mixed Logit Models

Conditional on knowing β_n, the probability of farmer n choosing alternative j on choice occasion t is given by

$$L_{njt}(\beta_n) = \frac{\exp(\beta'_n x_{njt})}{\sum_{j=1}^{J} \exp(\beta'_n x_{njt})}$$

and the conditional probability that each farmer makes a particular sequence of choices d (with $d = d_1, d_2, ...d_T$) is given by

$$S_{nd}(\beta_n) = \prod_{t=1}^{T} L_{njt}(\beta_n)$$

These are the standard logit formulas (McFadden, 1974). In addition to the standard logit model, we use a mixed logit model to analyse our data. The mixed logit model overcomes three draw-

backs of the standard logit model by allowing for heterogeneity in tastes, correlation in unobserved factors over repeated choices made by each individual, and complete relaxation of the independence of irrelevant alternatives (IIA) assumption (Train, 1998). As β_n is unknown, the unconditional probability for a sequence of choices d can be expressed by integrating over all values of β weighted by the density of its distribution, denoted $f(\beta|\theta)$, where θ are the parameters of the distribution:

$$P_n(\theta) = \int S_{nd}(\beta_n) f(\beta|\theta) d\beta$$

Note that we assume that all the parameters except the premium attribute follow a normal distribution. The parameter of the premium attribute is treated as a fixed parameter, which allows us to easily derive the marginal willingness-to-accept (WTA) estimates. Finally, the log likelihood for the model is given by $LL(\theta) = \sum_{n=1}^{N} \ln P_n(\theta)$. This expression cannot be solved analytically, and it is therefore approximated using simulation methods (Hole, 2007).[10]

5.2 Latent Class Model

As encountered in previous literature, we expect a certain degree of heterogeneity in results across farmers. For this reason, we also employ a latent class model to analyse our data because we believe that identifying different classes of respondents - if there are any - could be of great practical use in policy design.[11] Unlike the mixed logit model that captures heterogeneity at the individual level, the latent class model accommodates preference heterogeneity at the group level. The latent class model can be interpreted as a semi-parametric version of the mixed logit model because it does not require any assumptions regarding the distributions of the random parameters (Greene and Hensher, 2003). In such models, each respondent is assumed to belong to a class, c, and farmers' preferences may vary across, but not within, these classes. Each farmer is assigned to a specific class based on his characteristics.

If farmer n is in class c, the probability of observing his sequence of choices is a product of

[10] We implement this model in Stata using the mixlogit command (Hole, 2007) that fits mixed logit models by employing maximum simulated likelihood using Halton draws.

[11] Moreover, several recent studies stress the potential gains that could be obtained by specifying a discrete rather than normal mixing distribution, as in the mixed logit model, including the ability to approximate the true parameter distribution more flexibly at lower computational costs (Pacifico and il Yoo, 2012).

conditional logit formulas:

$$P_n(\beta_c) = \prod_{t=1}^{T} \prod_{j=1}^{J} \left(\frac{\exp(\beta_c' x_{njt})}{\sum_{k=1}^{J} \exp(\beta_c' x_{nkt})} \right)^{y_{njt}}$$

where y_{njt} is a binary variable that equals 1 if farmer n chooses alternative j on choice occasion t. The unconditional likelihood of farmer n's choices equals the weighted average of $P_n(\beta_c)$ over all classes. The log likelihood is then obtained by summing each farmer's log unconditional likelihood:

$$\ln L(\beta, \theta) = \sum_{n=1}^{N} \ln \sum_{c=1}^{C} \pi_{nc}(\theta) P_n(\beta_c)$$

where $\pi_{nc}(\theta)$ denotes the weight for class c.[12] The β_c parameters can be estimated using the Expectation-Maximization (EM) algorithm (Pacifico and il Yoo, 2012).[13]

6 Results

6.1 Mixed Logit Model

In addition to the standard logit model, we estimate a mixed logit model in order to account for unobserved heterogeneity in the data. Results are displayed in Table 5. Both models provide coefficients that are very similar in size. More specifically, the results presented in Columns 1 and 2 show that all variables except one are significant at least at the 5% level.

Consistent with economic theory, requiring compliance with any type of environmental practice has a negative effect on the probability of choosing a certification, while all cash and non-cash rewards increase the probability that farmers enter a certification scheme. On average, farmers prefer higher price premiums, a longer contract length, and the provision of technical assistance designed to help them comply with environmental requirements. The result regarding technical assistance makes sense given that farmers generally have poor access to rural extension services,

[12] The weight for class c is the share of the total population that the class contains. It is modeled as $\pi_{nc} = \frac{\exp(\theta_c z_n)}{1+\sum_{l=1}^{C-1} \exp(\theta_l z_n)}$ where z_n is a vector of farmer-specific characteristics and $\theta = (\theta_1, \theta_2, .., \theta_l, .., \theta_{C-1})$ are the parameters of the class membership model.

[13] We estimate the β_c parameters in Stata using the *lclogit* command which estimates a latent class logit model via the Expectation-Maximization (EM) algorithm (Pacifico and il Yoo, 2012).

Table 5: Standard Logit and Mixed Logit Model Estimates

	Standard logit		Mixed logit			
	Coefficient		Mean		Std.Dev.	
Composting	-2.22	***	-3.25	***	1.98	***
	(0.18)		(0.36)		(0.30)	
No pesticide	-0.45	***	-0.60	**	1.48	***
	(0.17)		(0.29)		(0.20)	
Erosion control	-0.01		0.28		1.90	***
	(0.16)		(0.30)		(0.20)	
Tech. assistance	1.06	***	1.00	***	1.54	***
	(0.06)		(0.12)		(0.14)	
Long-term contract	0.20	***	0.21	**	0.80	***
	(0.06)		(0.09)		(0.11)	
Premium	0.09	***	0.10	***		
	(0.01)		(0.01)			
Log-likelihood	-3,715.92		-1,967.44			
Number of observations	7,452		7,452			
Number of respondents	249		249			

Notes: ***, ** and * indicate that the estimated coefficients are statistically significant at the 1%, 5%, and 10% levels, respectively. Standard errors are given in parentheses.

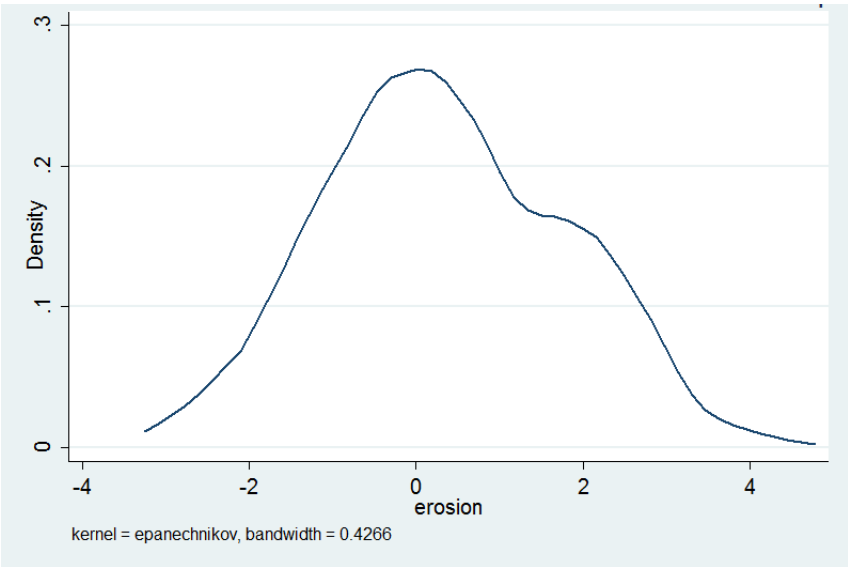
since the government no longer fulfils this function. The result regarding long-term contracts also seems appropriate given the highly volatile context of the international coffee market.[14]

We find that respondents tend to reject contracts that require composting more frequently than contracts that require eliminating pesticides. This result could be explained by the extra work that spreading compost can entail on large plantations. On average, we fail to detect any significant interest in the erosion control requirement. In order to further investigate this result, we estimate individual-level coefficients. We consider $E(\beta|y_n, X_n)$, which is the expected value of parameter β conditional on a given response pattern y_n and a set of alternatives characterized by X_n. Intuitively this can be thought of as the conditional mean of the distribution of these coefficients for the subgroup of individuals who face the same alternatives and make the same choices. We implement the approach suggested by Revelt and Train (2001). The distribution of the individual-level coefficients associated with the erosion control variable is displayed in Figure 1. The normal distribution

[14]The world coffee market is generally characterized by considerable instability, with a large crop in one year frequently followed by a smaller crop in the next.

demonstrates heterogeneity among farmers without over-scattered results: some farmers tend to *reject* the erosion control requirement, while others tend to systematically *choose* contracts that require erosion control. We study this issue further with a latent class model (Section 6.2).

Figure 1: Distribution of the individual-level coefficient for erosion attribute



Column 3 in Table 5 further suggests that there is significant preference heterogeneity for all of the attributes of the proposed eco-certified coffee contracts. A likelihood-ratio test for the joint significance of the standard deviations is reported at the bottom of the table. The associated p-value is small, which leads us to reject the null hypothesis that all standard deviations are equal to zero. From the magnitudes of the standard deviations relative to the mean coefficients, we calculate that the majority of respondents (77%) prefer certification contracts that provide technical assistance and that 62% prefer 3-year formal contracts. Moreover, whereas almost 37% of respondents prefer contracts that stipulate zero pesticides, only 5% of respondents prefer contracts with a composting requirement. These figures are given by $100 * \Phi(b_k/s_k)$ where Φ is the cumulative standard normal distribution, and b_k and s_k are the mean (Column 2) and standard deviation (Column 3), respectively, of the kth coefficient.

Because the price premium is assumed to be fixed in our model, we obtain the following result

regarding farmers' Willingness-To-Accept (WTA) for attribute k:

$$E(\text{WTA}^k) = -\frac{E(\beta^k)}{\beta^p}$$

where p refers to the price premium. The marginal WTA estimates provide insights on the relative importance of each attribute. Table 6 reports the estimated WTA associated with each attribute. The environmentally friendly agricultural practice with the highest WTA is the composting requirement. Results show that the average respondent requires a 32 percentage point increase in the price premium in order to accept a contract that includes a composting requirement, while an increase in the price premium of no greater that 6 percentage points will induce him to accept a contract with an environmental requirement stipulating zero pesticide use. Interestingly, farmers appear to value technical assistance as equivalent to a 10 percentage point increase in the price premium, and a 3-year contract as equivalent to a 2 percentage point increase in the price premium. Given that the average price premium for certified coffee rarely reaches 15% in the context considered, the minimum WTA that is required by respondents for compost adoption appears to be quite high. Nonetheless, our results suggest that non-cash payments such as technical assistance may be appropriate substitutes to a price premium to some extent.

Table 6: Willingness to Accept Estimates

Attribute	WTA	[95% Conf.Int.]	
Composting	31.91	24.70	39.11
No-pesticides	5.87	0.38	11.36
Erosion control	-2.75	-8.56	3.06
Tech. assistance	-9.86	-12.57	-7.16
Long-term contract	-2.04	-3.75	-0.33

The confidence intervals are constructed using the delta method. The WTA estimates are computed using the mixed logit model estimates.

Next we wish to investigate how the probability of choosing an alternative changes when a reward attribute changes. Focusing on the provision of technical assistance and a long-term formal contract, we calculate the difference between the predicted probability provided by the mixed logit model when the reward dummy equals one, and the predicted probability that we obtain

when the reward dummy equals zero. Results are displayed in Table 7. Results show that the probability of choosing a certification contract changes significantly when one shifts from no technical assistance to technical assistance (+11 percentage points), while the probability does not change significantly when one shifts from no contract to a 3-year contract (+2 percentage points). Results also suggest that the probability of choosing a certification contract can change dramatically if the price premium jumps from zero to 15% (+19 percentage points).

Table 7: Probability of choosing certification

		Prob. of choosing an alternative (%)		Change in prob.
Incentive	Obs.	With incentive	Without incentive	(%age point)
3-year contract	2490	34.5	32.1	2.4
Tech. assistance	2490	40.7	29.4	11.3
5% premium	2490	33.9	27.9	6.0
15% premium	2490	46.8	27.9	18.9
30% premium	2490	65.1	27.9	37.1

Note: The reference level of each simulation is 'no contract', 'no technical assistance', 'no premium', 'no premium' and 'no premium' respectively.

6.2 Latent Class Model

We have assumed thus far that the distribution of the coefficients in the model is continuous, however, given the heterogeneity in responses, identifying different classes of farmers based on their contract preferences could be of great practical use in policy design. Given our sample size, we opt for a two-class model.[15]

Following Pacifico and il Yoo (2012), we compute the average (over respondents) of the highest posterior probability of class membership in order to obtain a quantitative measure of how well the model performs in differentiating between the two classes of preferences.[16] The mean

[15]In empirical applications, it is common to choose the optimal number of latent classes by examining estimation criteria such as the Akaike information criterion (AIC), the Bayesian information criterion (BIC) and the consistent Akaike information criterion (CAIC). Table 13 in Appendix presents these statistics from a latent-class model in which the number of classes ranges from one to five. The case in which there is only one class corresponds to the standard logit model. Although the AIC, BIC and CAIC are minimized with 4 classes, the marginal improvement in the estimation criteria diminishes after the two-class model. Therefore, we select the two-class model as the best fit for the data.

[16]The posterior probability is the probability that the agent is in a particular class, taking into account his sequence of choices. Posterior probabilities are computed by evaluating the following equation using the final estimates for

highest posterior probability is about 0.98, meaning that the model does very well in distinguishing between different underlying taste patterns for the observed choice behaviour. The results of the two-class model estimation are displayed in Table 8. They show significant preference heterogeneity for attributes across classes. In particular, farmers from class 1 (which represents about one third of the sample) do not appear to place a high value on technical assistance and tend to reject long-term contracts more frequently than the other class. In addition, farmers in class 1 tend to choose contracts that require erosion control practices, while farmers in the other class are (in accordance with the theory) less likely to choose a contract that involves this environmental requirement. This last result can be explained by the fact that in our sample the odds that a farmer has already taken steps to preserve mountaintops are 0.67 for Class 1 and only 0.38 for Class 2. That is, the odds that farmers in Class 1 have already engaged in this practice are about 80% higher than the odds for farmers in Class 2.[17]

Examining the parameters of the class membership model helps to further interpret these results (Table 9). These parameters show that farmers from class 1 are on average less educated, own larger farms and are less specialized in coffee production. Moreover, they have a smaller number of family members who are also involved in coffee production. This suggests that providing farmers with technical assistance and formal contracts may increase participation in certification schemes only among certain farmers, namely those who are specialized in coffee production, well-educated, and who work on family farms. Other farmers seem to consider the issue not important enough to justify adopting a certification scheme.

7 Robustness checks

One concern with our findings is that they are biased by the subgroup of farmers who had already obtained one or more environmental certifications at the time we interviewed them. If this were

each class:

$$\frac{\pi_{nc}(\theta)P_n(\beta_c)}{\sum_{l=1}^{C}\pi_{nl}(\theta)P_n(\beta_l)}$$

[17] In Class 1, 840 farmers declare that they preserve mountaintops while 1,260 declare they do not ($840/1,260 = 0.67$). In Class 2, 1,050 farmers declare that they preserve mountaintops while 2,790 declare they do not ($1,050/2,790 = 0.38$).

Table 8: Latent Class Model Estimates

	Latent Class Model				Mixed Logit Model	
	Class 1		Class 2		Whole sample	
Composting	-1.76	***	-2.72	***	-3.25	***
	0.43		0.23		0.36	
No pesticide	-0.72	**	-0.93	***	-0.60	**
	0.34		0.20		0.29	
Erosion control	1.57	***	-1.19	***	0.28	
	0.35		0.19		0.30	
Tech. assistance	0.14		0.97	***	1.00	***
	0.15		0.07		0.12	
Long-term contract	-0.22	*	0.37	***	0.21	**
	0.13		0.07		0.09	
Premium	0.06	***	0.08	***	0.10	***
	0.01		0.01		0.01	
Nb. Respondents	86		163		249	
Uncond. Probability	0.43		0.47		-	
Cond. Probability	0.56		0.54		-	

Notes: ***, ** and * indicate that the estimated coefficients are statistically significant at the 1%, 5%, and 10% levels, respectively. Standard errors are given in parentheses. The first column displays the mixed logit model estimates.

Table 9: Class membership model estimates

Variable	Coef.	
The farmer's age	0.009	
	(0.012)	
The farmer has a bachelor degree (yes=1/no=0)	-0.883	**
	(0.386)	
Number of permanent family workers	-0.255	**
	(0.127)	
Family as percentage of permanent workers	0.586	
	(0.791)	
Total of hectares owned by the farmer	0.000	°
	(0.000)	
Share of total farm land allocated to coffee	-1.428	**
	(0.593)	
The farmer is certified (yes=1/no=0)	-0.184	
	(0.383)	
Share of harvest sold to the cooperative	0.000	
	(0.004)	
Constant term	0.361	
	(0.801)	

Notes: ***, **, * and ° indicate that the estimated coefficients are statistically significant at the 1%, 5%, 10% and 15% levels, respectively. Standard errors are given in parentheses. Estimates are obtained from the latent class model. Class 2 is the reference class.

the case, the elicited WTA of these farmers could be much lower for the sustainable practices that they already implement. To address this concern, we ran a robustness check by re-estimating the mixed logit and the latent class models after excluding the 47 farmers who indicated that they were Rainforest or UTZ Certified at the time of the survey. The results are displayed in Table 10. Our main results, as shown in Table 5, remain robust. That is, on average, farmers' WTA for composting appears high compared to other types of environmental requirements, and farmers appear to prefer a high price premium, a long-term formal contract, as well as the provision of technical assistance in order to comply with environmental requirements. Results from the 2-class model moreover show that farmers from one subset of the sample (Class 1, which represents about one third of the sample) behave quite differently from the others: specifically, they place a very low value on technical assistance and long-term contracts.

Table 10: Mixed Logit and Latent Class Model Estimates - Robustness check (I)

	Mixed Logit Model		Latent Class Model			
	Whole sample		Class 1		Class 2	
Composting	-3.16	***	-4.91	***	-1.82	***
	(0.40)		(1.10)		(0.25)	
No pesticide	-0.47	°	-3.05	***	-0.12	
	(0.32)		(0.68)		(0.23)	
Erosion control	0.29		-0.86		-0.35	*
	(0.33)		(0.63)		(0.21)	
Tech. assistance	0.97	***	0.06		0.89	***
	(0.14)		(0.19)		(0.08)	
Long-term contract	0.03		-0.51	***	0.23	***
	(0.10)		(0.17)		(0.08)	
Premium	0.10	***	0.05	***	0.08	***
	(0.01)		(0.01)		(0.01)	
Nb. Respondents	202		66		136	
Class share	-		0.33		0.67	

Notes: ***, **, * and ° indicate that the estimated coefficients are statistically significant at the 1%, 5%, 10% and 15% levels, respectively. Standard errors are given in parentheses. The first column displays the mixed logit model estimates. The sample does not include farmers who are already Rainforest certified or UTZ certified.

Another concern with our results is that they are biased by the subgroup of 33 farmers who were already engaged in a formal contract with their main buyer. Therefore, as a robustness check,

we excluded from the sample those individuals who were already involved in a long-term contact with their current buyer at the time they were interviewed. The results are displayed in Table 11. Again, our results remain robust.

Table 11: Mixed Logit and Latent Class Model Estimates - Robustness check (II)

	Mixed Logit Model		Latent Class Model			
	Whole sample		Class 1		Class 2	
Composting	-2.97	***	-1.65	***	-2.70	***
	(0.37)		(0.43)		(0.25)	
No pesticide	-0.31		-0.71	**	-0.89	***
	(0.29)		(0.33)		(0.21)	
Erosion control	0.61	**	1.57	***	-1.10	***
	(0.30)		(0.34)		(0.21)	
Tech. assistance	0.98	***	0.21		0.95	***
	(0.13)		(0.16)		(0.08)	
Long-term contract	0.16	*	-0.41	***	0.40	***
	(0.09)		(0.15)		(0.08)	
Premium	0.10	***	0.06	***	0.08	***
	(0.01)		(0.01)		(0.01)	
Nb. Respondents	216		76		140	
Class share	-		0.35		0.65	

Notes: ***, **, * and ° indicate that the estimated coefficients are statistically significant at the 1%, 5%, 10% and 15% levels, respectively. Standard errors are given in parentheses. The first column displays the mixed logit model estimates. The sample does not include farmers who are already involved in a long-term contact with their current buyer.

8 Conclusion

There are a growing number of certified farmers in the coffee sector. However, most of them comply with the least stringent environmental standards – as is the case with the 4C standard in Brazil. Despite the existence of price premiums, there is little consensus regarding how to best attract farmers to adopt certification schemes, and in particular to those with the most stringent standards. In order to provide new insight to this question, we ran a choice experiment in the state of Minas Gerais in Brazil, surveying 250 coffee farmers who were asked to choose from several hypothetical contracts for the production of eco-certified coffee. Our findings show that both cash

and non-cash payments are likely to motivate farmers' participation in a certification scheme. We estimate that the average respondent is willing to accept a contract that involves composting for a 32 percentage point increase in the price premium, whereas he is willing to accept a contract that involves zero pesticides for not more than a 6percentage point increase in the price premium. Given that the average price premium for certified coffee rarely reaches 15% in the current context, the minimum WTA necessary to induce respondents to adopt composting practices appears to be quite high. However, we also found that farmers prefer longer contract lengths as well as the provision of technical assistance designed to help them comply with environmental requirements. In particular, we estimated that the probability of choosing a certification contract changes significantly (+11 percentage points), when one shifts from no technical assistance to technical assistance. We also found that farmers from one subset of the sample, representing about two-thirds of respondents, behave quite differently from the others: specifically, they place a very high value on technical assistance and long-term contracts. Encouraging the spread of beneficial environmental practices in coffee agriculture via market-based instruments such as sustainability standards entails more than merely controlling compliance with particular sets of criteria. The fact that farmers place a high value on non-cash rewards also suggests that designing effective certification contracts is an important consideration for organizations that develop sustainability standards, and that public (re)intervention through technical assistance may become necessary when the market is unable to provide a price premium high enough to offset the compliance costs associated with the most stringent environmental requirements.

Acknowledgements

Funding for this research was provided by the French National Research Agency (ANR).

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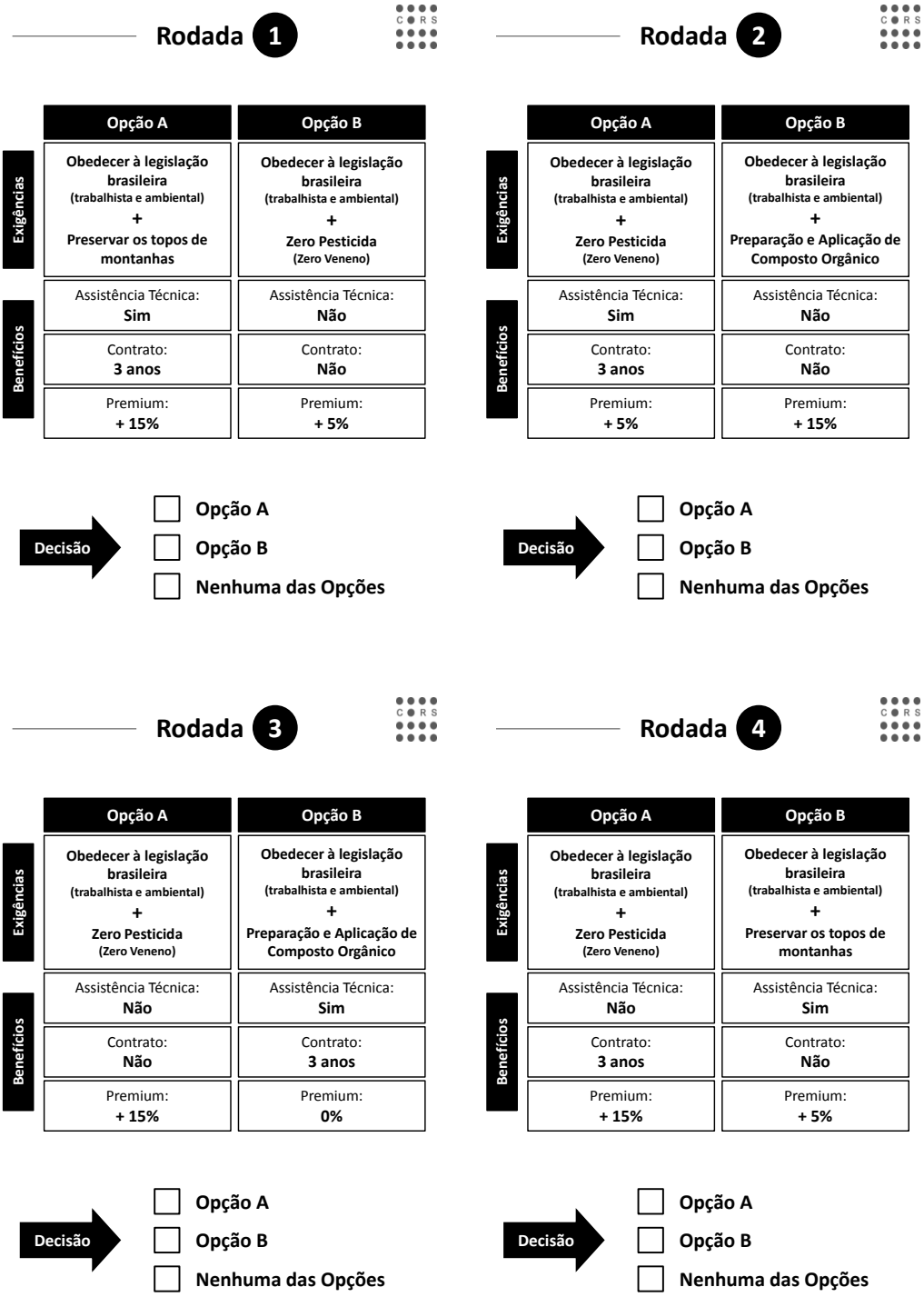
9 Appendix

Figure 2: Choice cards



Rodada 1

	Opção A	Opção B
Exigências	Obedecer à legislação brasileira (trabalhista e ambiental) + Preservar os topos de montanhas	Obedecer à legislação brasileira (trabalhista e ambiental) + Zero Pesticida (Zero Veneno)
Benefícios	Assistência Técnica: Sim	Assistência Técnica: Não
	Contrato: 3 anos	Contrato: Não
	Premium: + 15%	Premium: + 5%

Decisão
- ☐ Opção A
- ☐ Opção B
- ☐ Nenhuma das Opções

Rodada 2

	Opção A	Opção B
Exigências	Obedecer à legislação brasileira (trabalhista e ambiental) + Zero Pesticida (Zero Veneno)	Obedecer à legislação brasileira (trabalhista e ambiental) + Preparação e Aplicação de Composto Orgânico
Benefícios	Assistência Técnica: Sim	Assistência Técnica: Não
	Contrato: 3 anos	Contrato: Não
	Premium: + 5%	Premium: + 15%

Decisão
- ☐ Opção A
- ☐ Opção B
- ☐ Nenhuma das Opções

Rodada 3

	Opção A	Opção B
Exigências	Obedecer à legislação brasileira (trabalhista e ambiental) + Zero Pesticida (Zero Veneno)	Obedecer à legislação brasileira (trabalhista e ambiental) + Preparação e Aplicação de Composto Orgânico
Benefícios	Assistência Técnica: Não	Assistência Técnica: Sim
	Contrato: Não	Contrato: 3 anos
	Premium: + 15%	Premium: 0%

Decisão
- ☐ Opção A
- ☐ Opção B
- ☐ Nenhuma das Opções

Rodada 4

	Opção A	Opção B
Exigências	Obedecer à legislação brasileira (trabalhista e ambiental) + Zero Pesticida (Zero Veneno)	Obedecer à legislação brasileira (trabalhista e ambiental) + Preservar os topos de montanhas
Benefícios	Assistência Técnica: Não	Assistência Técnica: Sim
	Contrato: 3 anos	Contrato: Não
	Premium: + 15%	Premium: + 5%

Decisão
- ☐ Opção A
- ☐ Opção B
- ☐ Nenhuma das Opções

Table 12: Sample Characteristics

Variable	N	Mean	Std.Dev.	Min.	Med.	Max.
The farmer's age	232	41.9	14.2	17.0	41.5	80.0
The farmer stopped after elementary school (yes=1/no=0)	245	0.10	0.30	0	0	1
The farmer has a bachelor degree (yes=1/no=0)	245	0.37	0.48	0	0	1
The farmer has followed agricultural training (yes=1/no=0)	235	0.61	0.49	0	1	1
Total of hectares owned by the farmer	246	376.8	791.8	1.3	89.5	5500.0
Total of hectares cultivated as coffee	244	137.1	276.6	1.0	49.0	2300.0
Share of total farm land allocated to coffee	243	0.6	0.3	0.0	0.7	1.0
Coffee area is below 20 ha (yes=1/no=0)	244	0.20	0.40	0	0	1
Coffee area ranges between 20 and 50 ha (yes=1/no=0)	244	0.30	0.46	0	0	1
Coffee area ranges between 50 and 120 ha (yes=1/no=0)	244	0.24	0.43	0	0	1
Coffee area is above 120 ha (yes=1/no=0)	244	0.27	0.45	0.00	0.00	1.00
Number total of permanent employees	241	10.4	19.1	0.0	3.0	150.0
Number of permanent family workers	244	2.1	2.6	0.0	2.0	30.0
Family as percentage of permanent workers	234	0.3	0.3	0.0	0.3	1.0
Surface with mechanized harvest (%)	238	75.8	37.9	0.0	100.0	100.0
Higher productivity (bags/ha)	224	66.1	92.7	0.0	60.0	1400.0
Lower productivity (bags/ha)	225	28.3	47.5	0.0	24.0	700.0
Coffee revenue as share of total revenue (%)	231	70	34	0	80	100
The farmer is member of a cooperative (yes=1/no=0)	247	0.73	0.45	0	1	1
The farmer's most important buyer is the cooperative (yes=1/no=0)	249	0.48	0.50	0	0	1
The farmer sells his whole harvest to the cooperative (yes=1/no=0)	249	0.29	0.45	0	0	1
Share of harvest sold to the cooperative	249	41.4	45.0	0.0	20.0	100.0
The farmer has a long-term contract with the current buyer (yes=1/no=0)	249	0.13	0.34	0	0	1
The farmer uses organic compound (yes=1/no=0)	237	0.76	0.43	0	1	1
The farmer uses pesticides (yes=1/no=0)	241	0.98	0.16	0	1	1
The farmer grows coffee on mountain slopes (yes=1/no=0)	249	0.41	0.49	0	0	1
The farmer is certified (yes=1/no=0)	249	0.30	0.46	0	0	1
The farmer is 4C certified (yes=1/no=0)	249	0.05	0.21	0	0	1
The farmer is Certifica Minas certified (yes=1/no=0)	249	0.15	0.36	0	0	1
The farmer is Cerrado certified (yes=1/no=0)	249	0.08	0.27	0	0	1

The farmer is Rainforest certified (yes=1/no=0)	249	0.15	0.36	0	0	1
The farmer is UTZ certified (yes=1/no=0)	249	0.12	0.33	0	0	1
"Do you believe that:						
environmental problems are considered in coffee production decisions?" (yes=1/no=0)	249	0.70	0.46	0	1	1
pesticides are used in a controlled manner?" (yes=1/no=0)	249	0.59	0.49	0	1	1
forest biodiversity is threatened by coffee production?" (yes=1/no=0)	249	0.20	0.40	0	0	1

Table 13: Criteria for determining the optimal number of classes

Classes	LLF	BIC	AIC	CAIC
1	-3715.9	7485.3	7443.8	7443.8
2	-1720.0	3555.9	3482.0	3576.9
3	-1666.4	3531.3	3404.7	3567.3
4	-1595.7	3472.7	3293.3	3523.7
5	-1599.1	3562.3	3330.1	3628.3
6	-1561.8	3570.5	3285.6	3651.5

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