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Faculty of Social Sciences
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MASTER'S THESIS

Time Preferences of Ghanaian Cocoa Farmers

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Declaration of Authorship

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Prague, January 3, 2016

Signature

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Abstract

Agricultural technology adoption in developing countries is an interesting topic for two reasons: there is often a gap between the realized and potential hectare yields, and agriculture is an important source of livelihood for a significant part of the third world population. This thesis is attempting to analyze the relationships between time preferences of the Ghanaian cocoa farmers and their willingness to use fertilizers provided on a microcredit basis. It is using mainly basic statistical tests, contingent tables analysis and the logistic regression to find out whether the farmers who are patient and time consistent have different approach to technology adoption than the impatient and time inconsistent farmers. We also test for differences in time preferences between farmers with different gender, age and education, and we find that the younger farmers tend to be more impatient. The main conclusion of this work is that impatient and hyperbolic farmers are more likely to enter a microcredit program. We cannot present any significant inference about the link between the farmers' time preferences and their decision to leave a microcredit program.

JEL Classification	C12, C14, D9, G2, 013, Q14
Keywords	Technology adoption, time preferences, microcredit, developing economies, cocoa cultivation

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Abstrakt

Proces přijímání nové zemědělské technologie v rozvojových zemích je zajímavé sledovat ze dvou důvodů. Přetrvávající rozdíl mezi potenciálním a realizovaným hektarovým výnosem je prvním z nich, druhým důvodem je fakt, že zemědělství je významným zdrojem obživy pro podstatnou část obyvatel třetího světa. Tato práce se pokouší analyzovat vztah mezi časovými preferencemi u ghanských pěstitelů kakaa a jejich rozhodnutím používat hnojiva, která jim jsou poskytnuta na bázi mikropůjčky. V práci jsou použity hlavně základní statistické testy, analýza kontingenčních tabulek a logistická regrese k tomu, abychom odhalili, zda trpěliví a časově konzistentní farmáři přistupují k přijetí nové technologie jinak, než ti netrpěliví a časově nekonzistentní. Také testujeme, zda jsou rozdíly v časových preferencích mezi farmáři různého pohlaví, věku, nebo dosaženého vzdělání, a nalézáme, že mladší farmáři mají sklon k větší netrpělivosti. Hlavním závěrem této práce je, že farmáři, kteří jsou netrpěliví a mají hyperbolické preference, vstoupí do programu s větší pravděpodobností, nenašli jsme však žádný významný vztah mezi časovými preferencemi a rozhodnutím opustit program na bázi mikropůjček.

Klasifikace JEL	C12, C14, D9, G2, 013, Q14
Klíčová slova	Přijetí technologie, časové preference, mikropůjčka, rozvojové ekonomiky, pěstování kakaa

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Acronyms

CAA	Cocoa Abrabopa Association
CDF	Cumulative Distribution Function
COCOBOD	Ghana Cocoa Board
CSAE	The Centre for the Study of African Economies
DR	Discount Rate
GCFS	Ghana Cocoa Farmers' Survey
HYV	High-yielding Varieties
ICCO	International Cocoa Organization
MOFA	Ministry of Food and Agriculture (of Ghana)
OLS	Ordinary Least Squares
WCF	World Cocoa Foundation
WTO	World Trade Organization

Master's Thesis Proposal

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Proposed topic	Time Preferences of Ghanaian Cocoa Farmers

Topic characteristics Ghana is one of the fastest growing developing countries in the world and one of the five biggest cocoa producers. Cocoa is therefore an important commodity for the Ghanaian agriculture, its share of agricultural GDP has been increasing and its high world price suggests further growth potential. It was also recognized by Ghanaian government to be an important commodity and the driver of the growth and poverty reduction.. The importance of microcredit as an accessible source of money and an accessible financial institution has been discussed lately in developing economics surveys since its importance was emphasized by Nobel Peace Prize in 2006. In my thesis I would like to test hypothesis which combine personal characteristics as time preferences and cocoa farming, technology adoptions and microcredit. It is useful to understand time preferences of farmers and other people in developing countries, where lots of future aspects are uncertain and so their behavior might differ from what we experience in developed countries

Hypotheses

1. More patient farmers have higher cocoa output.
2. Farmers with hyperbolic preferences are less likely to use fertilizers.
3. Farmers with hyperbolic preferences have saving difficulties
4. Farmers who are more likely to trust people have higher cocoa output.
5. There is a significant difference between men and women preferences.

Methodology I will use data which were collected in October and November 2009 as a part of Ghana Cocoa Farmer Survey 2009 conducted by the Centre for the Study of African Economies of University of Oxford and Ghana Cocoa Board in 22 villages in southern cocoa-growing regions of Ghana. I would like to combine neoclassical approach with behavioral one and find the latest models used for developing economies. I would like to review articles with similar hypotheses and also those using models of time preferences reasonable for my hypotheses. After this model and literature review I will find the best proxy variable from available data set, I will sum up distribution of personal characteristic as in (2) and then use fixed effect model for panel data to test my hypotheses.

Outline

1. Introduction
2. Cocoa market
3. Time preferences
4. Survey
5. Methodology
6. Hypotheses testing
7. Conclusion

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Author	Supervisor

Chapter 1

Introduction

The question of technology adoption is an important part of economists' interests, because human welfare depends on increasing the productivity of existing stocks of land, labor and capital (Moser & Barrett (2006)). Technology adoption in developing countries has been a widely discussed topic lately, because agriculture is still the most important source of livelihood for a significant part of the population in the third world countries. Because the scope of agriculture is so substantial, the growth in this area implies an overall growth of the developing economy. There are many empirical studies that have proven the positive returns of fertilizer use (Opoku *et al.* (2009b), Conley & Udry (2010), Liu *et al.* (2008), Duflo *et al.* (2004), Bandiera & Rasul (2006)).

Cocoa is an important part of the Ghanaian economy for the two following reasons: it is one of the main exporting commodities, with the cocoa profits contributing 4% of GDP (Richman (2010)); it is also a crop that is cultivated mainly by small private farms, and therefore contributes to the overall employment and the quality of life in the countryside. Although Ghana is the world's second largest exporter of cocoa, there is still a gap between the potential and realized yields.

Behavioral aspects of technology adoption are often introduced in order to better understand the decisions that the individuals make (Tarozzi & Mahajan (2011), Jovanovic & Nyarko (1994), Karp & Lee (2001), Bauer & Chytilová (2010)). This thesis works with the concept of farmers' time preferences.

In 2006, Cocoa Abrabopa Association (CAA), a not-for-profit subsidiary of the fertilizers importer and distributor named Wienco (Ghana) Limited, introduced a microfinance program, which offered fertilizers, insecticides and pesticides on a loan, to overcome the low use of fertilizers and the credit constraints among the Ghanaian cocoa farmers. Records about the participation in this program, farmers' cocoa production and many of their other characteristics were elicited as a part of the Ghana Cocoa Farmers Survey (GCFS). GCFS is a long-running panel conducted by the Centre for the Study of African Economies, an economic research centre within the Department of Economics at the Oxford University, in collaboration with the Ghana Cocoa Board and the Ghana Statistical Service.

The aim of this work is fourfold. Firstly it is to review the relevant literature about technology adoption in developing countries and results of the surveys about other programs similar to the one by CAA. We also want to list some articles that link together time preferences, microcredit borrowing and technology adoption. The second objective is to analyze time preferences of the farmers in our sample. We compare these findings with the results from other existing samples that were also examined from the behavioral point of view (Harrison *et al.* (2002), Bauer & Chytilová (2010)). Thirdly, we link the participation in the program with the farmers' patience and time consistency. Following the work of Tarozzi & Mahajan (2011) and Karp & Lee (2001), Bauer & Chytilová (2010), we prioritize the technology-adoption nature of the CAA program, and thus hypothesize that time consistency and patience lead to a higher rate of participation in the CAA program. And lastly, we would like to find out whether there is any significant relationship between the decision to leave the CAA after the first year of participation and the time preferences that our farmers claim to have. The last objective is included in order to explain the empirical puzzle of giving up on technology adoption introduced by Zeitlin (2011). However, we would like to point out that fertilizer use does not necessarily imply CAA membership.

The thesis is organized as follows: the next chapter introduces cocoa, its cultivation in Ghana and the organizational scheme for the fertilizer distribution; Chapter 3 summarizes existing literature about technology adoption in agriculture in developing countries, its relationship with time preferences and other personal characteristics, relationship between microcredit and time preferences, and list some important findings of GCFS, Chapter 4 introduces our theoretical framework and suggests questions for further research; in Chapter 5 we outline statistical and econometric methods for the testing of our hypotheses. Empirical results are summarized in Chapter 6. Chapter 7 concludes.

Chapter 2

Cocoa and the survey description

2.1 Cocoa in the world and in Ghana

Cocoa originated from around the headwaters of the Amazon in South America. Its early cultivation has spread throughout the Central and Eastern Amazonian and northwards to Central America, with the beans being used by native Americans and later cultivated on a large scale by the Spanish in the Central American region. The trees can grow in a tropical environment within 15 to 20 degrees latitude from the equator, and the ideal climate for their cultivation is hot, rainy. Cocoa is a sensitive crop that must be protected from the wind, sun, pests and diseases, but when treated with care, it starts producing pods by the fifth year and can continue doing so for another ten years with the same level of yield (Opoko *et al.* (2009)). Cocoa became very popular, and its cultivation has spread around the world to Americas, Africa, India and Southeast Asia. Teteh Quashie brought its seeds to Ghana in 1879 and established a farm in the Eastern Region, but it took until at the end of the 19th century for the seedlings and seeds to spread among the farmers and start a large cultivation. From this brief history, we can see that cocoa is more of a new crop for the Ghanaians than a long-lasting livelihood spanning many generations. Currently there are seven cocoa growing regions namely Ashanti, Brong Ahafo, Eastern, Volta, Central, Western North and Western South regions (COCOBOD (2015)).

In 1947 the government of Ghana has established the Ghana Cocoa Board (COCOBOD), an agency responsible for the development of the cocoa industry. Its functions are production, research, extension, internal and external marketing and quality control, and its activities can be divided into a pre-harvest and post-harvest sectors (COCOBOD (2015)).

There are several Ghanaian companies producing cocoa products and preparations, mainly natural cocoa powder and drinking chocolate. Together with gold and crude oil, cocoa beans are one of the most important Ghanaian export commodities.

The agriculture sector is the largest contributor to the Ghanaian economy, making up on average 36% of GDP with the principal driver being the cocoa subsector contributing about 4.7% of GDP as of 2006 Richman (2010). The export of cocoa beans is the country's second largest earner of foreign exchange, with nearly USD 1.1 billion in value exported in 2006. Ghana is also an important international player, having produced 615,000 tonnes of cocoa beans in 2006/2007, supplying 20% of the total world production and occupying the second position in the world according to volume produced (Fiorello (2008)). Area planted to cocoa was 1,600,000 h and had an average yield of 0.4 Mt per hectare, giving Ghana the 16th position in the world according to average yield. As can be seen from Table 2.1, the highest yield per hectare in 2012 has been achieved by Guatemala with 2,7381 kg per hectare, and even though Guatemala is not one of the most important producers, this can lead us to some benchmark of possibilities. The world's largest producer Ivory Coast has achieved and average yield of 660 kg per hectare (Factfish (2015)). Experimental yields on cocoa farms in Ghana have been of the order of 2,471 kgs/ha, so technology adoption, such as fertilizers can play an important role in the future development. The recent growth in production was driven mainly by the land expansion and an increase use of labor (COCOBOD (2015), WCF (2015), CAA (2009)).

Ghana was the world's major exporter of cocoa beans in the middle of the 20th century until 1978, when it was surpassed by Ivory Coast. Since then it has been, for most of the time, the 2nd largest producer in the world. In the last three years the production of cocoa beans was 879 (2011/2012), 835 (2012/2013), 920 (2013/2014) thousands tonnes. According to Breisinger *et al.* (2008), cocoa is the driver of growth and poverty reduction. Existing yield gap between the actual output and an achievable output together with the rising, and already high, world prices suggest even further growth potential. In 2008 the goverment of Ghana has extended its development vision and declared the goals of reaching middle income by 2015 where cocoa should play an important role (WCF (2015), CAA (2009)).

Let us have a look at Table 2.2 where the world cocoa production is reviewed. The table shows us the production in thousands of tonnes for different

Table 2.1: Cocoa yield per hectare in representative countries [kg]

	Ivory Coast	Ghana	Indonesia	Cameroon	Ecuador	Guatemala
2000	700	291	561	331	247	513
2001	682	288	701	337	177	513
2002	672	285	797	370	242	518
2003	675	331	723	344	253	1257
2004	686	368	634	340	266	2000
2005	586	400	641	350	261	2750
2006	617	400	849	374	250	2915
2007	518	420	800	386	240	2551
2008	601	373	563	388	250	2488
2009	562	444	510	392	302	2499
2010	605	395	511	394	366	2689
2011	625	437	411	356	561	2692
2012	660	548	540	382	341	2738

Source: Factfish (2015)

continents and countries and their proportions. We can see that the whole world's yearly production is around 4 millions tonnes.

2.2 Ghana Cocoa Farmers' Survey and CAA

The Centre for the Study of African Economies (CSAE), an economic research centre within the Department of Economics at the Oxford University, in collaboration with COCOBOD and the Ghana Statistical Service, has conducted a general survey about the cocoa farmers in Ghana. The survey is called Ghana Cocoa Farmers' Survey, and from now on we will use the abbreviated form GCFS. The panel data were collected in 2002, 2004, 2006, 2008, 2009 and 2010, with the survey taking place in three regions of the country, namely Ashanti, Brong Ahafo and Western. The sampling unit within villages were farmers, asked various questions about their household, background, properties, cocoa farm, credit and collateral access, etc. In order to examine some personal characteristics and to understand the decisions about adopting a new technology, questions about time and social preferences and risk aversion were included later. Our interest focuses on the subsample of GCFS, which captures the characteristics of the cocoa farmers at the time when a new microcredit program for cocoa farmers was introduced.

Wienco (Ghana) Limited, established in 1979, is a Dutch and Ghanaian joint venture that imports and distributes fertilizers, pesticides and insecticides

Table 2.2: Cocoa production of representative countries in recent years [thousand tonnes]

	11/12		Est. 12/13		For. 13/14	
Africa	**2929**	**72%**	**2833**	**72%**	**3174**	**73%**
Cameroon	207		225		200	
Ivory Coast	1486		1449		1730	
Ghana	879		835		920	
Nigeria	245		235		240	
Others	113		89		84	
America	**655**	**16%**	**622**	**16%**	**666**	**15%**
Brazil	220		185		210	
Ecuador	198		192		200	
Others	237		245		256	
Asia and Oceania	**511**	**12%**	**487**	**12%**	**505**	**12%**
Indonesia	440		410		425	
Papua New Guinea	39		41		42	
Others	32		36		38	
World total	**4095**	**100%**	**3942**	**100%**	**4345**	**100%**

Source: ICCO Quarterly Bulletin of Cocoa Statistics, Vol. XLI, No. 3, Cocoa year 2013/14

for use in cocoa farming. In 2006, the Cocoa Abrabopa Association (CAA), a not-for-profit subsidiary of Wienco, began a program of distributing inputs on a seasonal credit. With the support of the COCOBOD, CAA provided farmers with access to two-acres-worth package of fertilizer, pesticides and fungicides. This specific bundle of inputs, known as the hi-tech package, has been promoted by the Cocoa Research Institute of Ghana since 2001, though problems with poor repayment rates have limited its distribution. Although the use of such broad categories of inputs is not new to the Ghanaian cocoa farmers, this particular configuration was. Evidence from a similar setup Duflo *et al.* (2008) shows that the economic returns can be highly sensitive to the precise quantities and combinations of inputs used.

Groups of 5 to 15 farmers were formed for the purpose of participation. These groups sign in and renew the contract with CAA every March and receive inputs to be applied by the beginning of April and May. The loans are repaid by December 15th, because by that time it is expected that the farmers will have harvested approximately three quarters of their annual production. The design of the program, that the repayment from the farmer groups is due after the harvest of their crops, helps the farmers who may not be financially sound to have access to the needed inputs. Groups that fail to repay in full are suspended for a minimum of one year, while those that repay successfully are given four-acres-worth of inputs in the following year. This credit is coupled with a training program to improve their farming and business skills. The membership is open to all the cocoa farmers who have a minimum of five acres of a mature cocoa farm, a farm plan establishing ownership of their farm, and at the same time are willing and able to adopt and follow the regime of the CAA package. CAA carefully screens all the potential farmers who could take place in their program and reaches them through promoter interactions, video shows, local radio interaction and the word of mouth among the farmers. However, the program also faces several challenges, such as an inefficient legal system of credit retrieval, uncoordinated similar schemes within the industry and prices of inputs (CAA (2009)). From Table 2.3, we can see the growing number of participants during the first few years but the biggest challenge seems to solve the puzzle why some farmers leave the program despite its proven payoffs and high recovery of the loans.

Technology adoption is a broad term which Foster & Rosenzweig (2010) define as a relationship between inputs and outputs, and by adoption of new technologies they mean both the use of new mappings between inputs and outputs and the corresponding allocations of inputs that exploit the new mappings. Agricultural technology can take various forms, such as new improved seeds, usage of fertilizers and machines. Feder *et al.* (1985) define final adoption at the individual farmer's level as the degree of use of a new technology in a long-run equilibrium when the farmer has full information about the new technology and its potential. Aggregate adoption is measured by the aggregate level of use of a specific new technology within a given geographical area or within a given population. However, we cannot test for a long-run decision and we cannot measure whether our farmers have full information. In this research, we focus mainly on the individual adoption and define it very specifically to serve our purpose - technology adoption is either the farmer's entry to the CAA or the use of fertilizers. The latter case is stated explicitly.

Time preferences dimension of the survey

The data about time preferences were collected in October and November 2009 in 22 villages in the southern cocoa-growing regions of Ghana. Eliciting farmers' subjective discount rate was done in a similar way as in Bauer *et al.* (2012).

The farmers were asked a question revealing their actual subjective discount

Table 2.3: Performance of CAA

Year	Number of farmers	Number of groups	Input	Recovery
2006	1,440	164	GHC 450,000	97%
2007	6,300	784	GHC 2,100,000	94%
2008	10,923	1,206	GHC 4,000,000	90%
2009	18,000	1,800	GHC 5,800,000	

Source: CAA (2009)

Table 2.4: Conversion of chosen amount into discount rate

Switching value	Switching value as DR	Approximate 3-months DR
<17	<13%	7%
17 - 20	13% - 33%	23%
20 - 25	33% - 67%	50%
25 - 32	67% - 113%	90%
32 - 41	113% - 173%	143%
41 - 52	173% - 247%	210%
52 - 65	247% - 333%	290%
>65	>333%	400%

Source: Author's computations

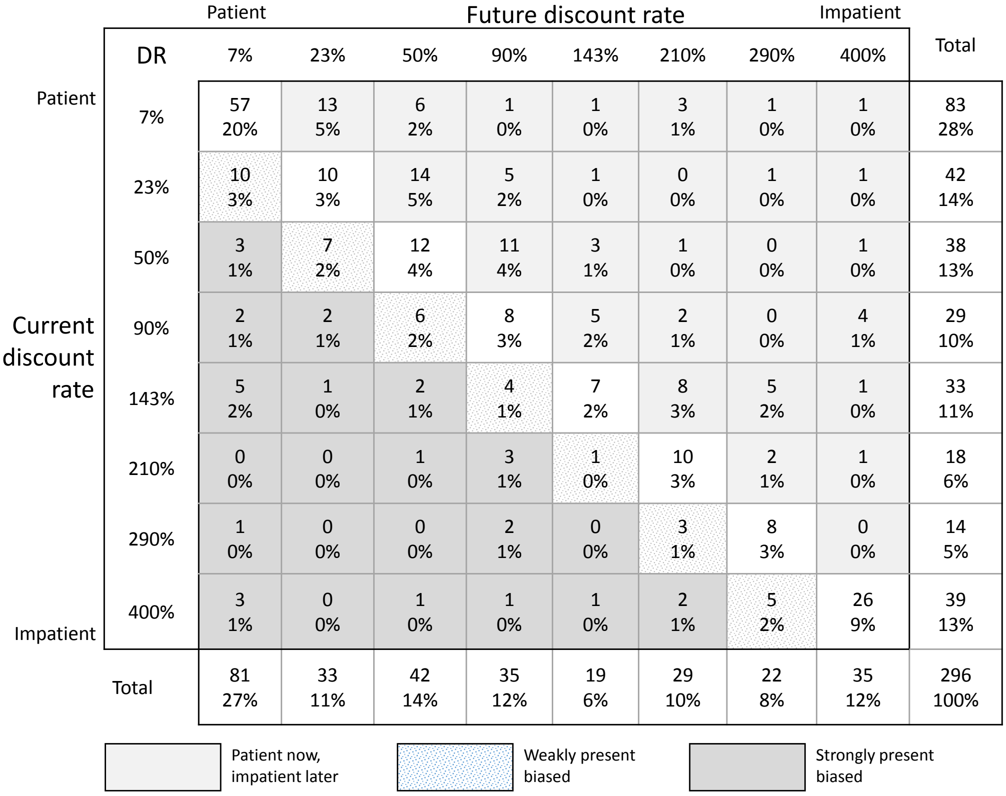
rate. The question was whether they would prefer to receive 15 Cedis the next day, or 17 Cedis in three months. If they selected the 15 Cedis, then they were gradually offered 20, 25, 32, 41, 52, 65 Cedis. According to the theory and the empirical observations, the individuals were expected to select the future option and wait for the money. The offered amount that made a farmer to switch from the current amount to the future amount provides the estimated of the personal discount rate.

A slight modification of this question can also reveal their future subjective discount rates. The choice is then whether the farmers prefer to receive 15 Cedis in a year, or 17, 20, 25, 32, 41, 52, 65 Cedis in one year and three months. Table 2.4 recalculates the answers into approximate 3-months discount rates (DR).

As in Bauer *et al.* (2012) we can determine five characteristics about one's time preferences, and see how many of our farmers have given DR in the Figure 2.1.

- We talk about **current patience** if the current DR is low. Current patience is an ordinal variable, the higher the DR is, the more impatient the farmers are. Later we choose the mean, median or fixed value of the DR as a benchmark to create a binary variable - current patience/current impatience.

Figure 2.1: Time preferences in our sample



		Patient			Future discount rate				Impatient	
	DR	7%	23%	50%	90%	143%	210%	290%	400%	Total
Patient	7%	57 20%	13 5%	6 2%	1 0%	1 0%	3 1%	1 0%	1 0%	83 28%
	23%	10 3%	10 3%	14 5%	5 2%	1 0%	0 0%	1 0%	1 0%	42 14%
	50%	3 1%	7 2%	12 4%	11 4%	3 1%	1 0%	0 0%	1 0%	38 13%
Current discount rate	90%	2 1%	2 1%	6 2%	8 3%	5 2%	2 1%	0 0%	4 1%	29 10%
	143%	5 2%	1 0%	2 1%	4 1%	7 2%	8 3%	5 2%	1 0%	33 11%
	210%	0 0%	0 0%	1 0%	3 1%	1 0%	10 3%	2 1%	1 0%	18 6%
	290%	1 0%	0 0%	0 0%	2 1%	0 0%	3 1%	8 3%	0 0%	14 5%
Impatient	400%	3 1%	0 0%	1 0%	1 0%	1 0%	2 1%	5 2%	26 9%	39 13%
	Total	81 27%	33 11%	42 14%	35 12%	19 6%	29 10%	22 8%	35 12%	296 100%

▢ Patient now, impatient later

▨ Weakly present biased

■ Strongly present biased

Source: Author's computations

- **Future patience** is similar to the current patience, with the only difference being that the future DR is taken as the measure. We construct the future patience/future impatience in a similar way as the current one.
- Farmers are **time consistent** when their future DR and the present DR are equal.
- **Present-biased time inconsistency** occurs when the farmers cannot wait for the remuneration now, but they believe that they would be able to wait the same time length in the future. Present-biased farmers have future DR < current DR.
- **Future-biased time inconsistency** is the opposite situation to the previous one. Farmers who are future biased time inconsistent have future DR > current DR.

Chapter 3

Literature review

3.1 Technology adoption in agriculture in developing countries

Agriculture technology adoption in developing countries has been a widely discussed topic since the time of the Green Revolution. We list here some representative, although general, academic works, starting with summarizing Feder *et al.* (1985). The following five are then examples of widely discussed issues influencing technology adoption, such as learning, social effects and social learning.

Feder *et al.* (1985) in their exhaustive survey about the adoption of agricultural innovation in developing countries discuss the theoretical models that have been used, as well as the results of some empirical studies analyzing the relationship between the technology adoption and the farms' or farmers' characteristics. The theoretical literature suggests that large fixed costs cause a reduced tendency to adopt, and a slower rate of adoption on smaller farms. However, this can be mitigated by the market for hired services (tractors. etc.). In empirical studies, this reduced tendency had often been found. Innovations also entail, in most cases, a subjective risk (that yield is more uncertain with an unfamiliar technique) and objective risks such as weather variations, pest susceptibility, uncertainty regarding the availability of inputs. Subjective risk may be hard to measure and relates to the availability of information, learning, etc. Education plays a role in technology adoption as well; more educated farmers can better understand the consequences of their choices and can adjust the quantity of the used fertilizer according to the external conditions. Access to capital in the form of either accumulated savings or capital markets is necessary in financing the adoption of many new agricultural technnologies, thus in practice the lack of capital is an important factor limiting adoption. Another barrier arises with a lower access to inputs or supplementary inputs.

One of the works exploring the implications of a model incorporating learning-by-doing and learning spillovers in technology adoption is Foster & Rosenzweig (1995). They conducted a survey in rural India, describing the adoption and profitability of rice and wheat high-yielding varieties (HYVs) seeds. They found that imperfect knowledge about the management of the new seeds is a significant barrier to adoption, with this barrier diminishing as the farmers' experience with the new technologies increases. Own experience and neighbors' experience with HYV significantly increase the HYV profitability, and the farmers do not fully incorporate the village returns to learning into their adoption decisions.

Moser & Barrett (2006) explore the puzzle of low rates of adoption and high rates of disadoption of a promising new technology among rice farmers in Madagascar. The authors find strong evidence supporting the hypothesis that the farmers' education, liquidity and labor availability matter to their willingness to try new, labor-intensive technologies. They also find that learning effects play a major role, not only in the farmers' initial decisions to try a new technology, but also in the subsequent decisions as to what proportion of their cultivated area to put under the new method and whether or not to continue with the method in future years. In sum, liquidity, labor and learning effects all matter.

Work of Conley & Udry (2010) presents evidence that social learning is important in the diffusion of knowledge regarding pineapple cultivation in Ghana. The authors traced the effect of farmers' successful experiment with fertilizer on the innovations in fertilizer use by other cultivators with whom the experimenter shared information, and came to several conclusions. The farmers are more likely to change their fertilizer use knowing that the information neighbors who use similar amounts of fertilizer have achieved lower than expected profits. They also increased (decreased) their use of fertilizer after their information neighbors have achieved unexpectedly high profits when using more (less) fertilizer than they did. The farmers' responsiveness to news about the productivity of the fertilizer in their information neighborhood is much greater if they have only recently begun cultivating pineapple, and lastly, response of farmers to news is stronger when the news is about the productivity of a fertilizer on plots cultivated by experienced farmers and farmers with similar wealth.

From their analysis of a dataset about technology adoption on sunflower farms in Mozambique, Bandiera & Rasul (2006) conclude that social effects are important determinants of individual's adoption decisions. They found that female-headed households are more likely to adopt than males. This seems in contrast to some of the earlier literature where female-headed households were often found to be amongst the last to embrace new technologies, but he offers a solution that that behavior had possibly been caused by greater credit constraints.

Dercon & Christiaensen (2011) investigated another reason for non-adoption among farmers in Ethiopia. Although fertilizers have higher yields and substantial returns on average, the impact of the risk of poor consumption outcomes on the adoption decision can be significant. As a costly input, when harvests are poor, for example due to poor weather conditions, the returns tend to be low given the sunk cost of the fertilizer, making it a high-risk activity with moderately higher returns compared to not using the fertilizer at all.

3.2 Relationship between technology adoption and time preferences and other personal characteristics

Strotz (1955) is a theoretical work and Harrison *et al.* (2002) is an empirical survey. Both can serve as a good introduction into the field of myopia, impatience and time preferences.

Strotz (1955) was the first one to bring a myopic behavior issue into the economic literature. Strotz concludes that the optimal plan of future behavior chosen as of a given time may be a plan which will be followed under conditions of certainty, or may be inconsistent with the optimizing future behaviour of the individual. In the latter case two possibilities exist: the conflict may not be recognized and his behavior will be inconsistent with his plans, or the conflict may be recognized and solved either by a strategy of precommitment or a strategy of consistent planning.

Harrison *et al.* (2002) analyzed personal discount rates elicited during an field experiment in Denmark on a representative sample of 268 people between

19 and 75 years of age. They found that the discount rates vary substantially with respect to several socio-demographic variables. The discount rates for men and women appear to be identical. Discount rates appear to decline with age, at least after middle age, and the length of education is associated with a lower discount rate. The richest households have discount rates lower than the poorest households.

Chabris *et al.* (2006) in their work review an enormous number of psychological studies about the intertemporal choice. We compare our suggested hypotheses with their findings in the next chapter.

The purpose of this work is to relate technology adoption with time preferences. Articles written on similar topic are Duflo *et al.* (2009), Yesuf & Köhlin (2009), Tarozzi & Mahajan (2011) and Karp & Lee (2001). Let us briefly introduce their hypotheses and findings.

Duflo *et al.* (2009) offered maize farmers in Kenya small discounts on fertilizer at a time when the farmers were relatively liquid due to a recent harvest season; the fertilizers were then delivered at the time of its use. The authors then observed that small, time-limited reductions in the fertilizer costs during the harvest period induce substantial increases in fertilizer use, comparable to those induced by much larger price reductions later in the season. This information can potentially help present-biased farmers commit to the fertilizer use and thus overcome procrastination problems.

Yesuf & Köhlin (2009) investigated the impacts and determinants of market and institutional imperfections on technology adoptions in Ethiopia. In their model, they consider fertilizer and soil conservation adoptions as joint decisions, and find that the household's decision to adopt fertilizers significantly and negatively depends on whether the same household adopts soil conservation. The reverse causality is insignificant. Concerning personal characteristics, households with relatively high personal discount rates and a higher degree of risk aversion are less likely to adopt soil conservation structures and modern fertilizers. As they are, the two technologies are substitutes to each other to the farm households, and hence any separate effort produces only a win-lose result, and subsequently wastes the potential gains. Poverty and capital market imperfections are often cited as important determinants of subjective discount rates and degrees of risk aversion of the households in developing countries.

Households with many dependents are more likely to be risk averse and high discounters. Households with relatively high subjective discount rates and a higher degree of risk aversion are less likely to adopt soil conservation structures and modern fertilizers respectively. In the short run, any effort that reduces poverty and asset scarcity helps to reduce the farm household's subjective discount rate and their degree of risk aversion and this subsequently leads to a rapid dissemination of new farm technologies.

Tarozzi & Mahajan (2011) examined the use of insecticide-treated nets against malaria. For time-inconsistent individuals, they distinguish between naive and sophisticated inconsistencies. Naive inconsistent agents do not take their future present-bias into consideration while formulating their dynamic plans, but sophisticated inconsistent agents do. They found that commitment products are not particularly appealing to the sophisticated agents and that the purchase of these products is in fact higher among the wealthier (and even naive) households.

Jovanovic & Nyarko (1994) wrote a theoretical work about learning by doing and the choice of technology. Their theory says that the more an agent uses a technology, the better s/he learns it, and the more productive s/he gets. This expertise is a form of human capital. Any given technology has bounded productivity, which therefore can grow in the long run only if the agent keeps switching to better technologies. But a switch in technologies temporarily reduces expertise - the bigger the technological leap, the bigger the loss in expertise. An agent may also be so skilled at some technology that he or she will never switch again, meaning he or she will experience no long-run growth. In contrast, someone who is less skilled (and therefore less productive) with that technology may find it optimal to switch technologies over and over again, and therefore enjoy a long-run growth in output. Thus the model can give rise to overtaking.

The theoretical work of Karp & Lee (2001) that relates time preferences with technology adoption and overtaking, extends the model of Jovanovic & Nyarko (1994). Their theory says that this kind of overtaking can occur even when the firms are forward-looking but never occurs if the firms are sufficiently patient. While the myopic firm's upgrade decision depends nontrivially on its skill level, a forward-looking firm decides to upgrade for a larger set of skill levels. In this sense, the forward-looking firms are more likely to upgrade, and they upgrade more frequently.

The above-listed studies are focused on the link between time preferences and technology adoption, but there are also other studies that examine time preferences in developing countries in different ways and are therefore relevant to our topic.

Bauer & Chytilová (2009) study the link between women's responsibility for children and their preferences on a large random sample in rural India. They find more patient choices among women who have a higher number of children. The age of the children matters, because the link with patience is specific for children below 18 years old, and the highest level of patience is associated with having three children. They do not observe the same link among men. Overall, they find significant gender differences in patience that are predicted by a higher number of children.

Bauer & Chytilová (2010) study the formation of time discounting as a possible explanation for the low savings and investments on a sample in Uganda. The authors study various socioeconomic characteristics that were suggested in earlier literature as possible determinants of time preference. The discount rate is significantly correlated with completed years of schooling: more educated respondents are more patient and thus more likely to make choices with delayed rewards. The sample shows a significant negative effect of education on men's discount rate. The reasoning comes from several sources: schooling may promote the creation of cognitive skills and the ability to simulate and plan for the future, education may play an important role in developing control mechanisms to manage the temptations of present consumption, education may enhance health prevention and reduce mortality risk, which might make individuals more willing to delay their spending, and more educated individuals are less likely to be income constrained and face lower pressures to spend money sooner.

Ashraf *et al.* (2006) brings an empirical evidence that women with hyperbolic preferences desire commitment savings devices. The authors designed a commitment savings product for a Philippine bank and implemented it using a randomized control methodology. The savings product was intended for individuals who want to commit now to restrict access to their savings, and who were sophisticated enough to engage in such a mechanism.

Behavioral aspects of technology adoptions form one chapter in Foster & Rosenzweig (2010). In this section, we also include gender (Doss & Morris

(2001), Venkatesh & Morris (2000)), age (Morris & Venkatesh (2000)) and risk aversion (Liu *et al.* (2008)) among the personal characteristics.

Foster & Rosenzweig (2010) wrote an overviewing survey about the microeconomics of technology adoption. They review what has been done in this field since Feder *et al.* (1985). Their work discusses studies about different topics such as returns, input use, optimal technology choice, heterogeneity, learning, education, risk and insurance, credit constraints,and at the end, they also include a chapter about behavioral economics and adoption behavior. They mention three works, one of them, Duflo *et al.* (2009), has been discussed earlier in this chapter. The other two focus on technology adoption as related to health and welfare.

Ashraf *et al.* (2007) used a randomized field experiment to study the adoption of packaged chlorine to purify drinking water. The intervention was designed to explore the idea that raising the cost of a technological device may increase the actual use of the device because agents are loss aversive, meaning sunk costs affect behavior, which should not be the case if agents are purely rational. Of course, in this experiment it is important to distinguish between a sunk cost effect and selection, arising from then fact that individuals who are more likely to use a device place a higher value on the device and thus are less sensitive to price. While the results show clear evidence of a selection effect, there is not clear evidence of the sunk cost effect.

Dupas (2009) asked whether people who knew that a bed net against malaria was sold to neighbors at a subsidized price would, ceteris paribus, be less likely to purchase the goods at a given price. The difficulty with this experiment is that people may also be influenced by a learning effect. It is clear from the results that the learning effects are far larger than any reference price effects, as the reduced-form effect of the neighbor prices on own adoption is negative, while the behavioral effect predicts a positive relationship.

Regarding gender, Doss & Morris (2001) used a Ghanaian maize farmers sample and found out that there is no significant association between the gender of the farmer and the probability of adopting fertilizer. Second, being a female farmer and living in a female-headed household affect the adoption decision in quite different ways. Therefore, although people living in female-headed households are less likely to adopt new technologies than people living in male-headed households, this does not necessarily mean that female farmers are less likely to adopt new technologies than male farmers. Third, the observed measures of access to land and number of extension contacts are clearly correlated with gender.

Venkatesh & Morris (2000) research investigated gender differences in the context of an individual's adoption and sustained usage of technology in the workplace: a new software system. Robust results were found that compared to women, men's technology usage decisions were more strongly influenced by their perceptions of usefulness. In contrast, women were more strongly influenced by the perceptions of ease of use. We admit that the attitude towards software technology may differ from the one to agricultural technology, but both the ease of use as well as the perceived usefulness can influence the overall utility function of an individual. We can assume that the new technology objectively increases output and thus also increases utility; but this personal utility can also be decreased by the effort to start using the new technology (women) or can be discounted by the lower belief in usefulness.

Morris & Venkatesh (2000) studied the dependency of technology adoption of a new software and age. Their sample has shown that age has an important influence on technology adoption and sustained usage decisions. Younger workers appeared to be more driven by underlying attitudinal factors, like effective evaluation of the costs and benefits, whereas older workers were motivated by social and process factors. Concerning age, Weinberg (2004) points out that economists generally argue that young workers are the primary adopters and beneficiaries of new technologies. On the other hand, research has indicated that technological progress is generally biased toward skill.

Liu *et al.* (2008) in his survey conducted among cotton farmers in China finds that farmers with higher risk aversion or higher loss aversion adopt Bt cotton later. Farmers who overweight small probabilities adopt Bt cotton earlier. Bt cotton is a cotton resistant to bollworms and is in fact no riskier and brings higher profits to the farmers than traditional cotton. An answer to the question why do risk-averse farmers adopt later is suggested by Yang *et al.* (2005) in a survey conducted on cotton farmers in Shandong - 78% of the farmers reported that they did not adopt Bt cotton in the first year of commercialization because they had doubts about the effectiveness of the resistance of the Bt cotton to bollworms. This therefore suggests that it is not the real risk, but rather the perceived risk, that influences their adoption decisions.

Heterogeneity in returns to adoption can be an explanation for not adopting new technology as following articles illustrate.

Rather than thinking of adoption decisions as based on learning and information externalities, Suri (2011) decided to focus on a framework that recognizes the large disparities in farming and input supply characteristics across the maize growing areas of Kenya. On the whole, the stagnation in hybrid maize adoption does not appear to be due to constraints or irrationalities. She found that even though these agricultural technologies have high average returns, the marginal farmer has low returns and switches easily in and out of adoption. Suri (2011) in fact concludes that there are three sets of farmers: a set of farmers for which there are small differences in the profitability of traditional and modern varieties who end up using both technologies, a set of farmers who have high returns to the modern variety but who do not adopt due to the difficulty of accessing the new technologies, and a third set with moderate returns to the new technology that always adopt it. A similar framework that allows for heterogeneity has also been adopted by Zeitlin (2011) in a paper we discuss later in this chapter.

Duflo *et al.* (2004), Duflo *et al.* (2008), Duflo *et al.* (2009) ran a number of field experiments with maize farmers in Western Kenya. There, despite the proven evidence from experimental farms that fertilizer substantially increases yield, just 45% had ever used them. The results suggest that fertilizer is profitable, and providing relevant information goes part of the way towards increasing its adoption. Moreover, programs that help the farmers commit at the point where they have money to use fertilizer in the future have a very large impact on its future adoption. Offering farmers the option to buy fertilizer immediately after the harvest leads to an increase the proportion of farmers using fertilizer. In contrast, there is no impact on fertilizer adoption from offering free delivery at the time the fertilizer is actually needed for top dressing. From the response to the different modifications of their program, the authors have concluded that farmers behave like hyperbolic discounters, and that they are impatient. Many farmers switch back and forth between using and not using fertilizer from season to season, and the return to fertilizer use is also sensitive to how it is used, meaning there can be heterogeneity in returns when the fertilizers are not used correctly.

3.3 Microcredit and time preferences

CAA program works on a microcredit basis, therefore in this literature review we also include sources which help to understand microcredit (Armendáriz & Morduch (2010)), see the limitations of CAA in this field (Andrews (2006), Weber & Musshoff (2012)). We also introduce (Bauer *et al.* (2012)) as an important source for us that connects microcredit with time preferences, although we discuss feature of our program and their program in the following chapter.

Armendáriz & Morduch (2010) explain in their exhaustive book the principles of microcredits which have been an emerging part of the capital markets and play now an unquestionable role in providing capital to the poor around the world.

Despite the vast diversity of agricultural microcredit projects around the world, Andrews (2006) in their overview study summarize some basic concepts and principles that help such microcredit work. We mention some that cannot be adopted by the CAA by definition, some that have already been adopted, and some that might be possibly adopted in the future.

The first group includes managing systemic risk in agriculture by three levels of diversification: (i) across rural and urban branches; (ii) across both the agricultural and non-agricultural activities in the rural branches; and (iii) across diverse household economic activities, in other words through managing the portfolio risk using a high level of diversification, meaning that the institution lends to a wide variety of farming households engaged in different activities and thus is better protected against the agricultural and natural risks. The second type of principle is the elegant part of CAA, e.g. the loan terms and conditions are adjusted to accommodate the cyclical cash flow. The third group suggests e.g. using various types of collateral, including a non-traditional collateral from the poorer households.

The results of Weber & Musshoff (2012), who performed an empirical study in Tanzania, reveal that agricultural firms face higher obstacles to get credit, but as soon as they have access to that credit, their loans are not differently volume-rationed than those of the non-agricultural firms. Furthermore, agricultural firms are less often delinquent when paying back their loans than non-agricultural firms.

Bauer *et al.* (2012) examine the link between microcredit loans and present-biased preferences of individuals. The survey took place in rural India and the authors found out that among the women who borrow, those with present-biased preferences are more likely to be microcredit borrowers. The finding is consistent with the hypothesis that the structure of microcredit loans can help the borrower with self-control.

3.4 Ghanaian cocoa and important findings of GCFS

Dormon *et al.* (2004) elicited among Ghanaian cocoa farmers their opinion about the possibilities of improvements. The other articles in this section are directly connected with GCFS and we used them while formulating our hypotheses in the next chapter, and also as a framework to work in.

Dormon *et al.* (2004) ran a field experiment in chosen villages in Ghana in order to identify the farmers' perspective and insights on the question of what causes the low productivity of cocoa. The research process started with a community meeting followed by a community mapping, participatory problem identification, analysis, prioritization and action planning. From this, study it can be concluded that the cocoa farmers recognized low yield as the major problem facing cocoa production in Ghana.

The farmers themselves stressed issues like the producer price paid to the farmers, the - in their view - exploitative behaviour of the government, the lack of social amenities like electricity, and the way these affect labor and non-investments and the lack of maintenance of the cocoa farms. The authors revealed that the current policy emphasis on increasing prices, introducing high-yielding varieties and stimulating specific pest control measures is likely to yield limited success since certain important social and technical issues are being overlooked. Such neglected issues include the problem with epiphytes, outmigration and labor shortages, and the diverging interpretations of the distribution of responsibilities and benefits of cocoa production between the farmers and the government.

Opoku *et al.* (2009b) found in his summarizing report an evidence of large agronomic and economic returns to participation in CAA. Gross increase in output was approximately 30% for the members, concerning labor inputs, increases in both the household and nnoboa labor appeared in response to the program. Fertilizer use among non-members in villages first visited by CAA in 2007/08 and 2006/07 was higher than the fertilizer use among non-members in villages first visited by CAA in 2008/09 - one of the explanations could be that this was a positive externality of the program.

Opoku also pointed out that despite high average returns in general and the successful repayment, there were farmers leaving the program after the first year of membership. Data analysis shows a negative relationship between the group size and retention. Groups with no female members - which constituted approximately 30% of all the groups - had by far the lowest probability of remaining within the program. However this does not prove any causality since there might have been unobserved variables correlated with the ones stated earlier. Those who experienced low returns were economically and statistically significantly less likely to remain within the program. One question that Opoku did not answer was which factors determined the high rate of dropout at the group level.

In response to Opoku *et al.* (2009b) Šteflová (2012) tried to answer the question of who the clients of microfinance are. She found that more non-participants than participants had no or only primary education. The probability of joining the CAA was lower among older farmers, while it increased with the number of adults in the household and the use of children for work. Females were less likely to participate in the program than males. Also the cocoa crop, the farm size or education seemed to have negative effects on the probability of joining the group. We would like to extend her research with the time preferences dimension.

Švenka (2013) examined how the farmers choose and learn about optimal the amounts of inputs. He did not confirm the hypothesis that Ghanaian cocoa farmers prefer the individual learning over the social one. His empirical evidence suggests that there is a significant difference between how the observed farmers learn about the non-labor and labor inputs. The power of the models inspecting the labor inputs appears to be significantly lower than the power of the non-labor models.

Zeitlin (2011) tries to answer three questions connected to the technology adoption: (1) How heterogeneous are the rates of return to agricultural technologies, such as fertilizer? (2) Does heterogeneity in returns affect the sustained adoption of such technologies, beyond farmers' initial experimentation? And (3) is this relationship between heterogeneity in realized returns and sustained technology adoption caused by prudence in response to transient shocks, or learning about persistent differences in the suitability of a technology across farms and farmers? Zeitlin challenges for other work to build on his findings. He provides an evidence that a learning mechanism as opposed to a precautionary savings drives the observed relationship between realized returns and subsequent adoption decisions and that even when the average returns are high, many farmers may stand to lose.

Chapter 4

Theoretical framework and research questions

4.1 Discount rates in our sample

Firstly, we want to hypothesize that time preferences of farmers in our sample are somehow similar to those of Harrison *et al.* (2002). Therefore we test for:

- Discount rates for men and women are identical.
- Discount rates for young and for old farmers differ.
- Discount rates for educated and not educated farmers differ and more educated farmers are more patient.

Bauer & Chytilová (2009) find that women with children below the age of 18 are more patient. The empirical part of the research is from rural India and the authors argue that women in their sample are typically housewives taking care of their families and that most of their activities are centered around their children. Unlike Bauer & Chytilová (2009), we do not interview housewives, but farmers, and moreover, we do not have detailed data about their children. That is why we do not expect any significant differences between the genders and hypothesize to obtain similar results as Harrison *et al.* (2002).

Chabris *et al.* (2006) conclude the rich psychological literature and say that patience appears to increase across the lifespan, with the young showing markedly less patience than the middle-aged, and the older adults are the most patient age group when delay horizons are only a year. However, this study also finds that the older adults are the least patient group when delay horizons are

3-10 years. This reversal probably reflects the fact that the 75-year-olds face a significant mortality/disability risk at the horizons of 3-10 years. Although it is beyond the scope of our work, it is interesting to point out that they list a number of studies consistent with the hypothesis that the area of brain essential for patient decision making is slow to mature.

We assume that more the educated individuals are more patient from the fact that the education itself is postponing the current reward for a higher one in the future. Like Bauer & Chytilová (2010), we can assume that education may promote cognitive skills and the ability to plan, and education can lead to a life of higher quality, where the individual does not suffer from the overall deficit and thus can wait for the future reward.

4.2 Time preferences and the CAA entry

Adoption of the new technology means changes to the way work has been done for a long time. This change may not be comfortable for someone who does not like to wait. The farmer's personal characteristics can play a significant role when deciding about the adoption despite the fact the mean yield when fertilizers are used is claimed by the authorities to be higher than the mean yield without fertilizers. As mentioned above, the CAA program works as a microcredit program. Let us explore in detail some features and advantages of microcredit in general and see which of them our program possesses or lacks.

We use the theory from Armendáriz & Morduch (2010). The farmers form small groups and receive the two-acre hi-tech package on a joint liability basis, which means that the whole group is responsible for the loan and when a member fails to repay, then the other members have to pay instead of him or her. This helps to mitigate the adverse selection bias as well as ex-ante and the ex-post moral hazard. Adverse selection bias arises when the lending institutions cannot distinguish between the risky and safe borrowers and thus impose high interest rates on the whole market, however, this can lead to a situation where only the risky borrowers stay in the market. The CAA does not need to know who is risky and who is a safe borrower because the farmers form themselves into groups where similar individuals find each other. However, CAA claims in CAA (2009) that they screen all the potential farmers interested in joining.

Ex-ante moral hazard occurs when the lender cannot observe the effort of the borrower to use the borrowed money productively, especially when the borrower is poor and has no own collateral that he or she would be putting into risk. In microfinance, peers from the group have interest in monitoring each other, because they want to avoid paying for the lazy members of their group.

The ex-post moral hazard is mitigated as well; the CAA does not need to monitor the borrowers' yield from the input package, which could be costly, because the members of the group monitor each other.

Dynamic incentives such as offering bigger loans after successful repayment are often used in microcredit for the following reasons: they increase the opportunity costs of not repaying the loan, they the reduce moral hazard, and they allow for the testing of clients through small loans first, thus building a better knowledge base about the borrowers. The CAA program also supports these dynamic incentives - the farmers who succesfully repay in the first year are offered the hi-tech package for four more acres in the next season.

In contrast to the previous characteristics that are typical for the microcredit loans, the farmers in our sample do not meet weekly to repay small instalments, which is a common practice in microcredit, but instead they repay their loan on the instant in December, after the majority of the cocoa is harvested and monetized.

We hypothesize that the absence of weekly meetings and instalments is crucial, and thus from the farmer's perspective, the microcredit character is being dominated by the technology adoption character.

An important feature of the CAA program is timing. The CAA is designed in a similar way as the experiment of Duflo *et al.* (2009) in the sense that it attempts to accommodate the farmers' needs; they receive fertilizers when they need them and they are supposed to pay for them when they have the liquidity. From the findings of Yesuf & Köhlin (2009) and from the theory of Karp & Lee (2001), we hypothesize that:

- Patient farmers are more likely to adopt a new technology.
- Present-biased farmers are less likely to enter the CAA program.

4.3 Time preferences and the CAA exit

The main outcome of Zeitlin (2011) is that the high average returns of the new technology mask a substantial, persistent heterogeneity in realized returns. Farmers at the low end of the of cocoa production distribution exhibit particularly low returns, therefore the zero economic return for the bottom quarter of the distribution cannot be rejected. Farmers experiencing low returns are less likely to continue using the technology. Besides this understandable reasons for leaving the CAA program, some farmers with positive returns from the distributed fertilizers, leave as well.

We extend the work of Zeitlin (2011) through the following hypotheses:

- Patient farmers are more likely to stay in the program.
- Farmers with hyperbolic preferences (present-biased) are more likely to leave.

From our perspective, the paper written by Bauer *et al.* (2012), which brings a behavioral aspect, namely time preferences, into the decision about microcredit, is an important study. As far as we know, it is a rare work that directly evaluates the relationship between time preferences of individuals and their willingness to apply for a credit through a microfinance institution. Conclusion of their work is a positive correlation between having present-biased preferences and selecting microcredit as the channel for borrowing, with this correlation holding only for women. This may lead us to form a hypothesis that farmers with present-biased preferences are more likely to stay in the program because they are looking for the support in their self-discipline in financial behavior. Nonetheless our farmers face slightly different conditions than the Indian women from the Bauer *et al.* (2012) sample, and thus we do not test for this hypothesis.

At the beginning of the second season, a subgroup of our farmers called the initial joiners, decides whether to stay in the CAA program or not- This means on one hand to take a new credit on the microcredit basis and on the second hand to continue adopting the new technology as well. Considering the former decision, let us recall that we aim to answer why do farmers leave the CAA program. This contains an implicit information that they have already been involved in it and have made the decision to have a debt at least once. Another difference from Bauer *et al.* (2012) is that the participants of the Indian program meet every week and repay part of the loan on this meeting, so the effect of social pressure to engage in the progran is stronger than the one our farmers face, because they repay the loan after the harvest in on instalment in December. The technology-adoption point of view at the decision would though suggest contradictory but very intuitive conclusion, which says that the more patient farmers stay in the program and continue with technology adoption which on average achieves high yields. There are studies like Duflo *et al.* (2009), Yesuf & Köhlin (2009), Tarozzi & Mahajan (2011) and Karp & Lee (2001) that suggest that technology adoption corresponds to patience and non-myopic behavior.

We can also point out that the initial joiner farmers have been involved in the whole CAA process and have participated in its education program as well. This education program includes the introduction and explanation of the proper use of the hi-tech package. There is a possibility that the farmers who decide to leave the CAA after the first year will continue using fertilizers on their own. This explains why, in the last chapter, we compare the second-year-fertilizer-users with the second-year-fertilizer-non-users, regardless if they are members of the CAA or not. We propose that

- Patient farmers are more likely to continue using fertilizers.
- Farmers with the hyperbolic preferences (present-biased) are more likely to give up on the technology adoption.

We also investigate the differences in time preferences between the farmers who left and used fertilizers on their own and those who left and gave up using fertilizers completely. This can tell us more about the technology adoption itself rather than the mixed effects of the technology adoption and the microcredit nature of the program.

Chapter 5

Methodology

In this chapter, we introduce the methodology that we would like to use to test our hypotheses. We use parametrical as well as non-parametrical approaches. Unpaired two-sample Student's t-test, χ^2 test and the odds ratio test help us gain an overall picture of the dependecies in our data, and the logit and probit regressions allow for a better specification. At the end of this chapter we briefly discuss robustness.

5.1 Unpaired two-sample Student's t-test

We use the unpaired two-sample Student's t-test to test whether two groups from our sample have the same mean of the current or future DR. Such groups are for example men and women, younger and older.

As in Anděl (2007), let $X_1, ..., X_n$ be a random sample from $N(\mu_1, \sigma^2)$ and $Y_1, ..., Y_m$ be a random sample from $N(\mu_2, \sigma^2)$. We assume that these two samples are independent. If we want to test the null hypothesis $H_0 : \mu_1 = \mu_2$, we calculate the test statistic

$$T = \frac{\bar{X} - \bar{Y}}{\sqrt{(n-1)S_X^2 + (m-1)S_Y^2}} \sqrt{\frac{nm(n+m-2)}{n+m}}, \tag{5.1}$$

where the sample means $\bar{X}$, $\bar{Y}$, and the sample variances S_X^2, S_Y^2 are computed in the standard way

$$\bar{X} = \frac{1}{n} \sum_{i=1}^{n} X_i,$$

$$\bar{Y} = \frac{1}{m}\sum_{i=1}^{m} Y_i,$$

$$S_X^2 = \frac{1}{n-1}\sum_{i=1}^{n}(X_i - \bar{X})^2,$$

$$S_Y^2 = \frac{1}{m-1}\sum_{i=1}^{m}(Y_i - \bar{Y})^2.$$

We reject the null hypothesis about the equality of means on the level α if $|T| \geq t_{n+m-2}(\alpha)$.

5.2 Contingent tables analysis

Our farmers are expected to choose a possibility or, in other words,to perform an action. They have to choose if they want to become initial joiners or not, they also decide whether they want to stay in the program, leave it, or use fertilizers on their own. On the other hand they also have some 0-1 characteristics. (Even though our characteristics do not have to be strictly binomial, we can impose some benchmark value and make them discrete.) Anděl (2007) suggests two ways how to test for dependency in a contingent table between having a characteristic and taking an action.

χ^2 test

Let us assume that we have two random vectors $Y \in \{0,1\}$ and $Z \in \{0,1\}$. Contingent tables are one of the ways that may help us determine whether Y and Z are independent or not. General contingent table has a form of 5.1, where n_{ij} is the number of observations where $Y = i$ and $Z = j$, $n_{i.} = \sum_j n_{ij}$, $n_{.j} = \sum_i n_{ij}$. The total number of observations is counted in the right lower corner to n.

In our case Y represents the decision which the farmer makes (become an initial adopter or not, stay in the CAA program or leave, etc.) and Z captures the time preference characteristics (patient now, not patient now, hyperbolic preferences, time consistent, etc.). We specify Y and Z for each of the hypotheses later.

Our null hypothesis H_0 says that random variables Z and Y are indepen-

Table 5.1: Example of a contingent table

		Z			
		1	...	c	$\sum$
Y	1	n_{11}	...	n_{1c}	$n_{1.}$
	...		...		...
	r	n_{r1}	...	n_{rc}	$n_{r.}$
	$\sum$	$n_{.1}$	...	$n_{.c}$	n

dent. Variable

$$\chi^2 = n \sum_{i=1}^{r} \sum_{j=1}^{c} \frac{n_{ij}^2}{n_{i.} n_{.j}} - n$$

has asymptotic χ^2-distribution with $(r-1)(c-1)$ degrees of freedom. We reject the null hypothesis on the α-level if our test statistic exceeds the $\chi^2 \geq \chi^2_{(r-1)(c-1)}(\alpha)$. This test is suitable if every cell of the contingent table contains a value higher or equal to 5. For more details and proofs see Anděl (2007).

The odds ratio

In Table 5.2 we can see an example. If a farmer does not possess a certain characteristic, his or her odds are $n_{10} : n_{00}$ to take a certain action. If the farmer has that characteristic then his or her odds to take this action are $n_{11} : n_{01}$. We want to inspect if these odds are significantly different and thus if having or not having the characteristic has an impact on the decision about taking the action. To do so, we construct the empirical odds ratio

$$b = \frac{n_{10} : n_{00}}{n_{11} : n_{01}} = \frac{n_{10} n_{01}}{n_{11} n_{00}},$$

which approximates the theoretical odds ratio

$$\beta = \frac{p_{10} p_{01}}{p_{11} p_{00}},$$

because n_{ij}/n is an empirical estimate of the probability that a farmer belongs to i and j groups. If $b = 1$ the chances to take the action are equal for both possibilities and having or not having a certain characteristic does not matter. However, the more b differs from 1, the higher is the influence of the inspected characteristic on the action. The odds ratio meets the condition $b \in (0, \infty)$. This asymmetry of β around 1 has led to the use of the logarithmic

Table 5.2: Odds to take an action

		Z does not have characteristic (0)	has characteristic (1)
Y	non action (0)	n_{00}	n_{01}
	action (1)	n_{10}	n_{11}

transformation of b and β; $d = ln(b)$ and $\delta = ln(\beta)$. Variable

$$D = \frac{d - \delta}{\sqrt{\frac{1}{n_{00}} + \frac{1}{n_{01}} + \frac{1}{n_{10}} + \frac{1}{n_{11}}}} \tag{5.2}$$

has $N(0,1)$ asymptotic distribution Anděl (2007). H_0 says that Y and Z are independent. This is the same as having equal chances $\beta = 1$ and $ln(\beta) = \delta = 0$. If we want to test for H_0, we plug $\delta = 0$ into the equation 5.2 and reject the null hypothesis on the α-level if $|D| \geq u(\frac{\alpha}{2})$.

Logit and probit models

We can use the above mentioned tests to see whether there are some statistically significant links between having certain characteristics (patient, present-biased) and taking an action (entry/exit of CAA), but now let us introduce the logit and probit models that allow us to specify the model better. In the next chapter, we also include some dummy variables for the village and for the survey wave. As in Greene (2003), we now introduce a brief theory of how to model binary choices.

Let us assume that we can observe the binary outcomes of a dependent variable Y. The probability of taking an action ($Y = 1$) or not taking an action ($Y = 0$), given a vector of observable explanatory variables $X = (X_1, X_2, ..., X_n)$, $n \in \mathbb{N}$ and a vector of parameters $\beta = (\beta_1, \beta_2, ..., \beta_n)$ that reflects the impact of changes in X on the probability, can be modeled as

$$\Pr(Y = 1|X) = F(\beta, X)$$

and

$$\Pr(Y = 0|X) = 1 - F(\beta, X),$$

where F is an increasing function that maps $\mathbb{R}$ to the $(0,1)$ interval. A cumulative distribution function is a good adept for F. When we use the CDF of the logistic distribution for $F(.)$, we obtain a model called the logistic regression or logit:

$$\Pr(Y = 1|X) = \frac{exp(X'\beta)}{1 + exp(X'\beta)} = \Lambda(X'\beta). \tag{5.3}$$

If we use Φ - the CDF of the normal distribution - we obtain the probit model

$$\Pr(Y = 1|X) = \int_{-\infty}^{X'\beta} \phi(t)\mathrm{d}t. = \Phi(X'\beta).$$

Logit and probit give in general similar results, so we use logit as the main estimation technique and then probit as a robustness check.

If we are interested in the marginal effect

$$\frac{d\Pr(Y = 1|X)}{dX_i},$$

that reflects how the probability of taking an action changes when one of the predictors changes by one unit, we can compute it for logit

$$\frac{d\Pr(Y = 1|X)}{dX_i} = \frac{d\Lambda(X'\beta)}{dX_i} = \Lambda(X'\beta)[1 - \Lambda(X'\beta)]\beta_i,$$

and for probit

$$\frac{d\Pr(Y = 1|X)}{dX_i} = \frac{d\Phi(X'\beta)}{dX_i} = \phi(X'\beta)\beta_i.$$

Let us explicitly state that the marginal effect of a predictor does not equal the corresponding parameter like in OLS.

The logit and probit estimations are based on the method of maximum likelihood.

5.3 Robustness check

We use two ways to check the robustness of our results.

The first one has already been mentioned and suggests the use of logit and probit at the same time.

The second one allows us to replace the measured and calculated DR by the rank of the choice that was made during the interview about the time preferences. Doing this, we do not stress the exact measured DR, but we rather point out that the farmer chooses the n-th given option. We designate this new metric as rank and it is given by the function

$$\text{rank} : \text{DR}_{\text{current/future}} \rightarrow \{1, ..., 8\}.$$

For example, rank(17%)=1, rank(23%)=2, rank(50%)=3, etc. The farmers who insist on receiving GHC 15 regardless of the offered amount in the future have our new metric equal to 8. Similar approach is in Bauer & Chytilová (2009). This robustness check can be done regardless of the technique we use: logit, t-test, etc.

Chapter 6

Empirical results

In this chapter, we first describe the data used for the empirical parts, and then we verify the hypotheses listed in Chapter 4. All calculations were done using the Stata statistical software.

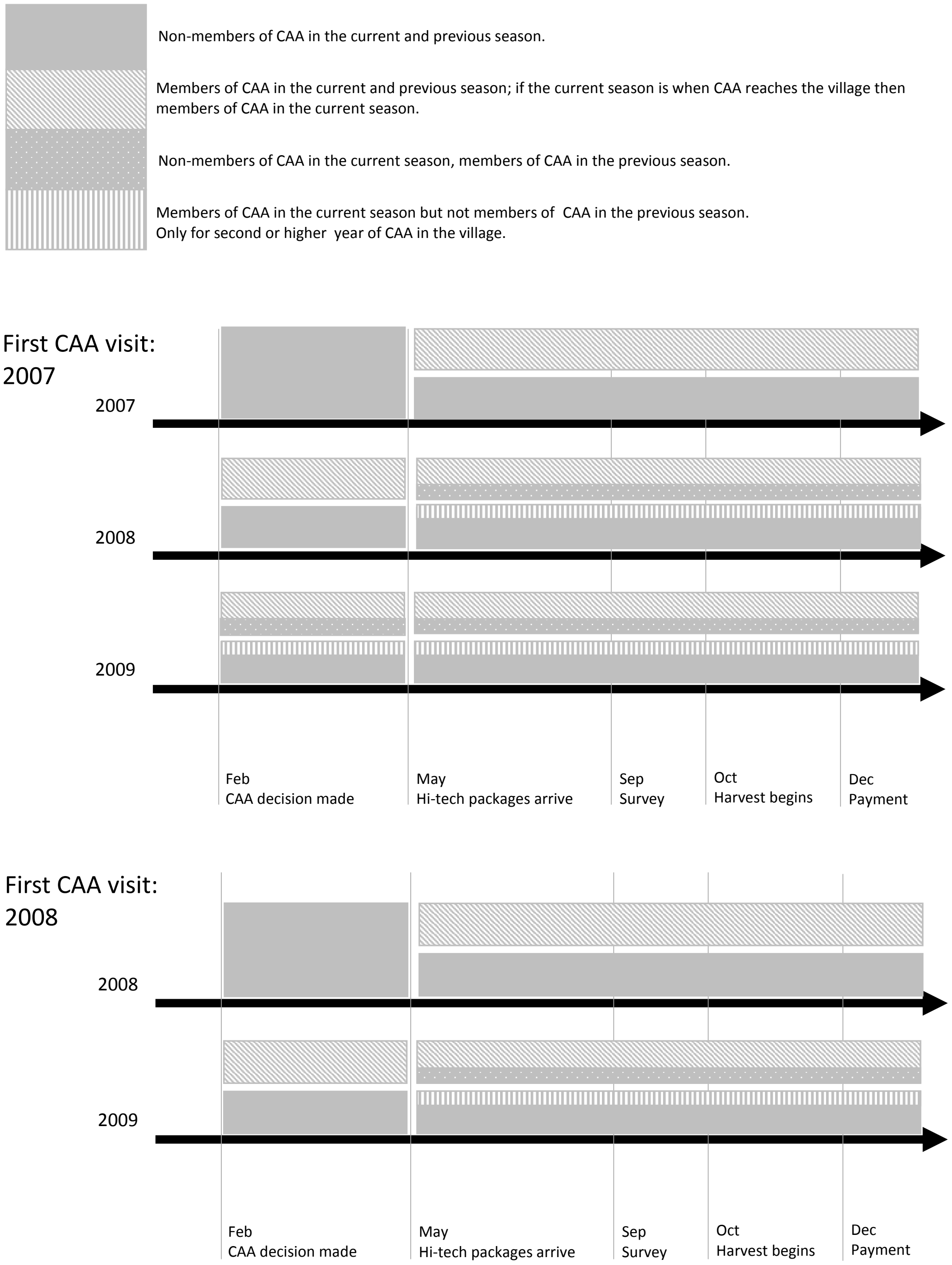
6.1 Data for the empirical part

We can see on Figure 6.1 part of the evolution of the membership status during years 2007, 2008 and 2009. We mark some important milestones for the CAA year and our survey, which repeat every year, on the timeline below. The survey took place in 2008, 2009 and 2010 and in each of these waves, the farmers were asked for details about their previous harvest, e.g. the first round of the survey was realized in 2008, and the season which started in May 2007 and ended at the beginning of 2008 was discussed.

Every year proceeds as follows: the CAA promoters enter the village at the begininng of the year, farmers decide about their own participation in February and they form groups in case they have chosen to join. Hi-tech inputs arrive at the villages in May. Our interviews were conducted in September, which is a time in the middle of the current cocoa year. The harvest starts in October, but it does not finish until the next year. However, the loans for the fertilizer, fungicides and insecticides are due in December, when approximately three quarters of all the cocoa have been harvested.

We divide our sample into three types according to the year when the CAA first entered the villages (2007, 2008 and 2009). There are four groups of farmers, explained in the legend in the upper part of the picture. We do not

Figure 6.1: Evolution of the CAA membership



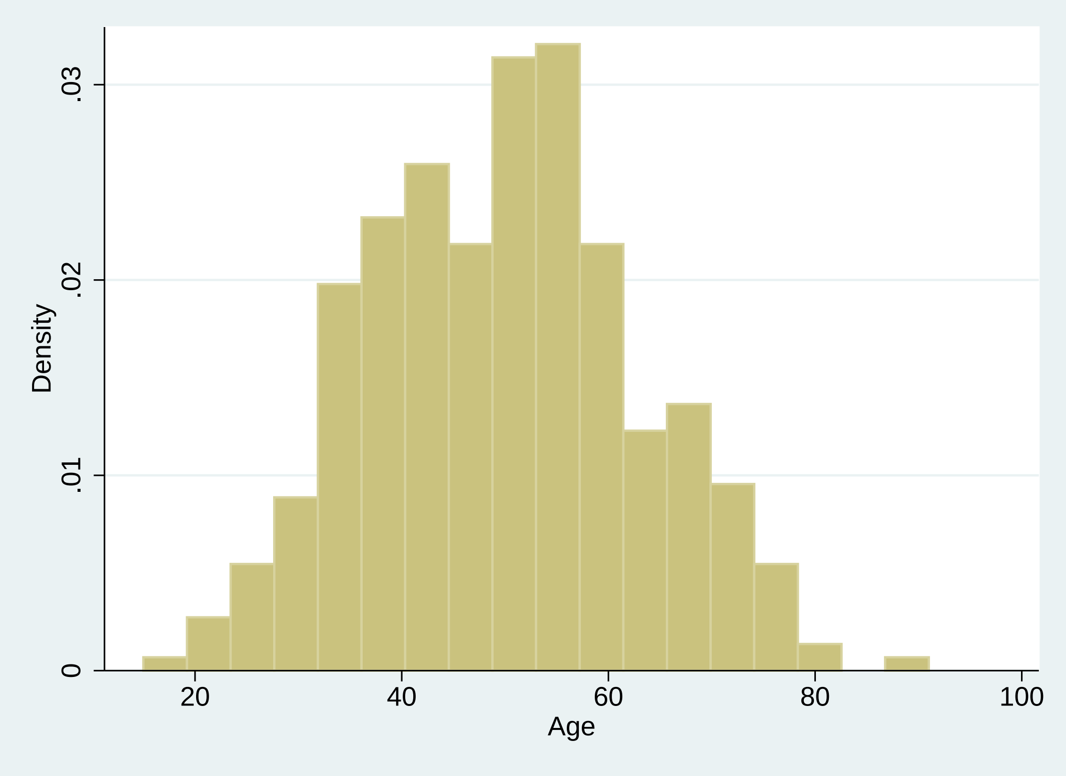
include into Figure 6.1 the last part of the 2009 season and the beginning of the 2010 season, and we also omit the illustration for villages reached by the CAA in 2009, as it is the same as for the two previous years. We explain the four groups for the villages that were reached for the first time by CAA in 2007 and the rest can be interpreted analogically.

There are only non-members (represented by the grey rectangle) until the CAA is introduced in the village for the first time. In May 2007, the first hi-tech packages arrive at the villages and they are distributed among the farmers who have agreed to participating in the CAA program. Since May, the 2007 non-members split into two groups: those who are members of the CAA, Zeitlin (2011) calls them initial joiners because they join the CAA as soon as it is possible, and those who remain non-members in the 2007/2008 season (initial non-joiners). In the following year 2008, the decisions about participating in the CAA program are made again. Some of the farmers remain in their group, which means that the members are still members and the non-members do not adopt, but also some of the non-members become members (see the vertically striped rectangle) and some members leave the program (white dotted rectangle). The last group is explored later in this work, because one of the most important questions for us is why the farmers leave the program that is on average successful.

Every wave of interviews included two types of villages. The first type were villages where the CAA had entered for the first time in the previous year, and such villages have experienced one full year of CAA's presence. Farmers in these villages have made the second CAA membership decision in the current year. The second group of villages are those where the CAA is currently new because the program had been introduced to them at the beginning of the current year. Moreover, in every village two types of farmers were interviewed: the initial adopters and initial non-adopters. Initial adopters are farmers who join the CAA in the first year of its availability, and initial non-adopters are those who do not join the CAA in the first year of exposure to it, even if they join in any of the following years, we still call them initial non-adopters (Zeitlin (2011)).

Personal characteristics were elicited from each farmer only once. This sub-survey of the GCFS was held in October and November 2009. We assume that time preferences do not change over time.

Figure 6.2: Age distribution of the farmers



6.2 Data exploration

We have described the principles of eliciting time preferences in Chapter 2 and extended the point of view on them in Chapter 5. Here we present some of the basic figures of our sample, such as the distribution of age (6.2), of the cocoa production in the year when the CAA program was introduced (6.3), and distribution of the current (6.4) and future (6.5) ranks of time preferences.

We select the appropriate subsamples of the above-described data to examine each of the hypotheses stated in Chapter 4.

We test for the first set of our hypotheses on a sample that includes all the available farmers and their time preferences. We restrict our dataset in a way that each farmer is present there just once, and thus we work with cross-sectional data.

The second set of our hypotheses investigates the decision to be an initial joiner or non-joiner. We restrict ourselves to the data where every farmer is confronted with the decision of becoming a member for the first time. We

Figure 6.3: Cocoa production in the first year of exposure

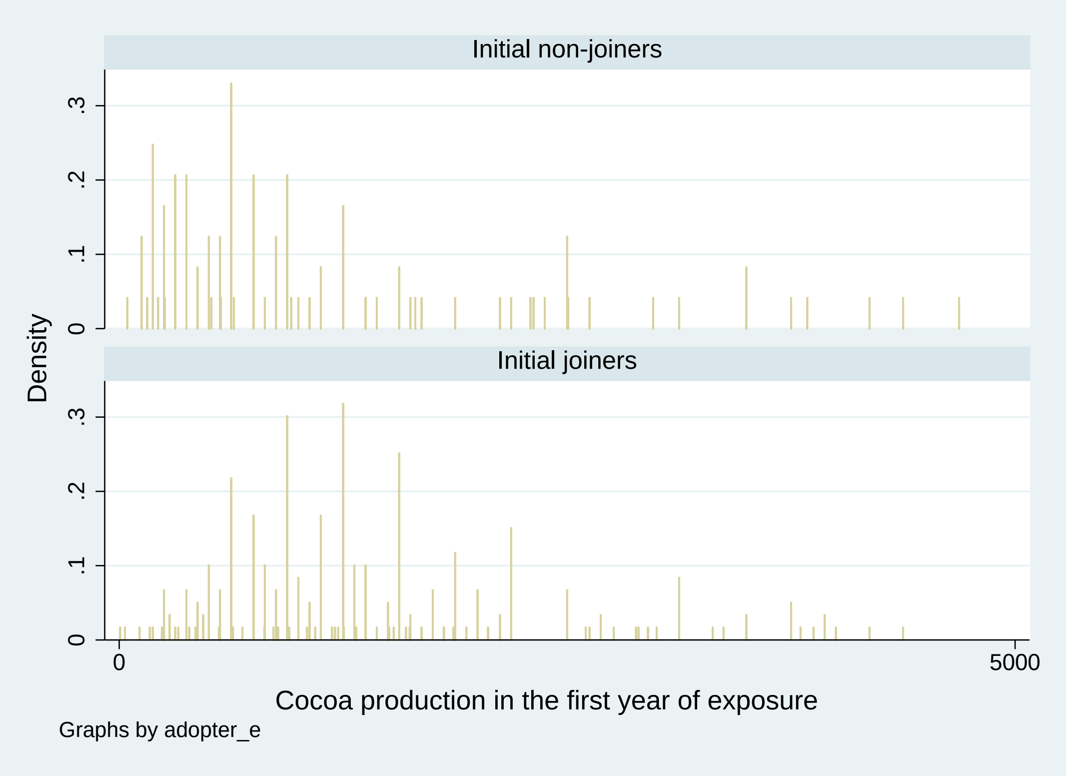


Figure 6.4: Distribution of the current rank time preferences

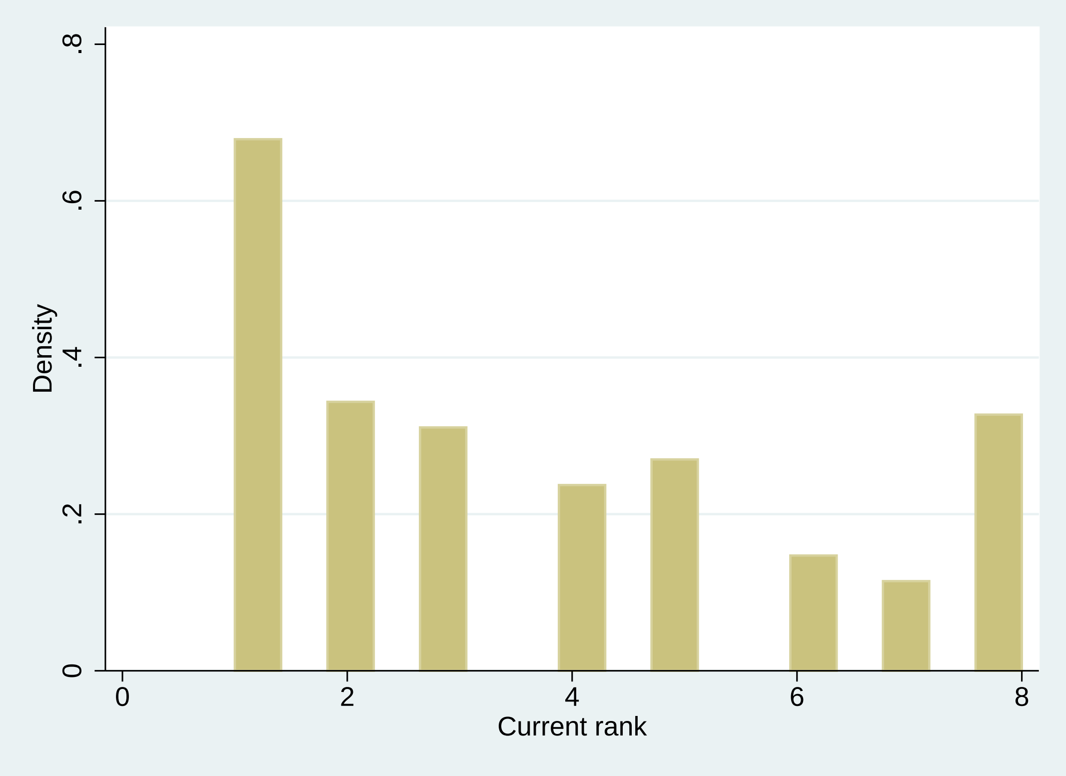
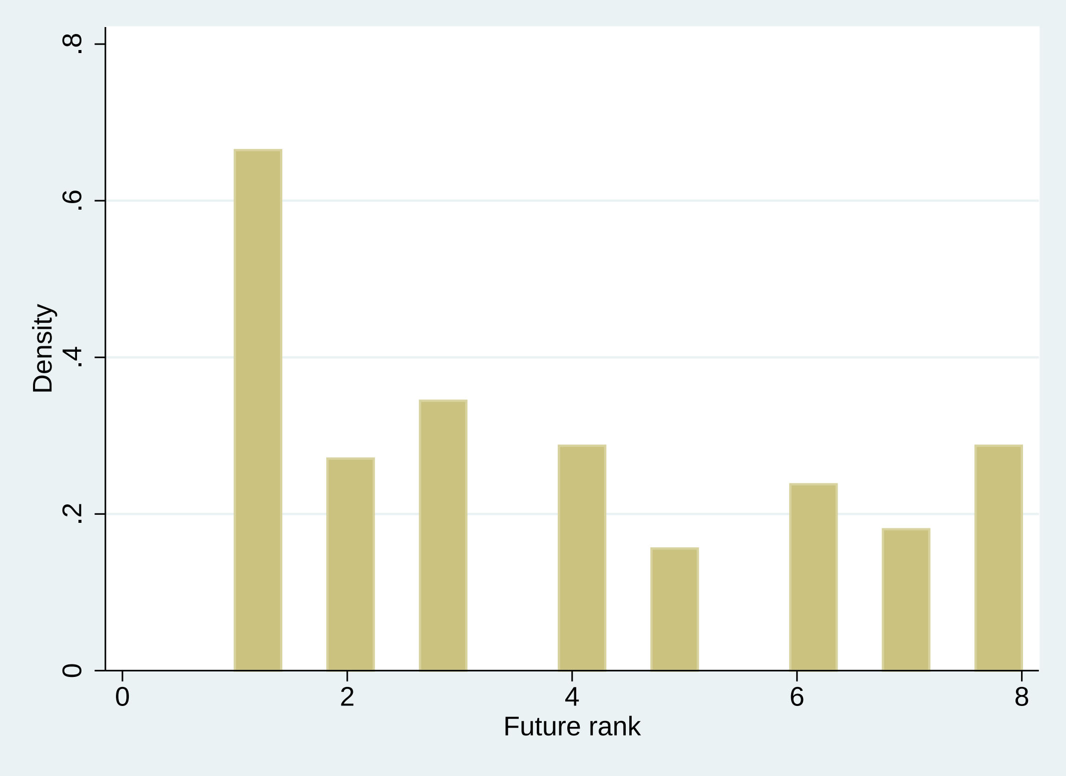


Figure 6.5: Distribution of the future rank time preferences



only use one set of observations about this farmer, which was recorded after he or she experienced the first CAA exposure. Therefore we work again with cross-sectional data.

Hypotheses that research any link between time preference characteristics and the exit from the CAA are tested on a restricted sample. Detailed description of this restriction is given next to the testing itself.

6.3 Discount rates in our sample

In our sample there are 59 women and 236 men. We can see the distribution of the current and future discount rates according to gender in Figures 6.6 and 6.7. These graphs have similar patterns for the current and future discount rates. Even though there are some variations between men and women, the figures do not suggest any significant difference. For example, there are relatively more men than women with the highest possible discount rate. This means that no matter how high was the offered amount for the future, their choice was always to take the reward now. However, besides this difference, we can see the p-value in the first row of Table 6.1 that does not allow us to reject the null hypothesis

Table 6.1: Results of t-tests on gender and age

P-values	Current DR	Future DR
Gender	0.3913	0.2388
Age	0.0829*	0.2008

Source: Author's computations

the about equivalence of means. The probability of finding a similar sample if the null hypothesis is true is quite high (30%).

In general, t-test is used under the assumption of normal distribution of both the random vectors. From the figures we can already see that this assumption is not fullfilled. We do not mind this problem though since Anděl (2007) allows us to use t-test for mean equality if the number of the observations is high enough in both vectors. He considers 30 to be such a sufficient number.

We face the non-normal distribution in the two following hypotheses as well (Figures 6.8, 6.9, 6.14, 6.15), but we can rely on the high number of observations, except for the 27 observations for the more educated farmers.

We divide our sample into 194 older and 102 younger farmers. A farmer is a member of the young group if he or she is less than 44 years old. (We do not exclude older people as the results of Chabris *et al.* (2006) suggest, because our farmers are looking into a future shorter than fifteen months). The mean for the older group is 106 (113) and the mean for the younger group is 135 (134) for the current DR (future DR). This seems to be in line with Harrison *et al.* (2002) who found in his sample that discount rates appear to decline with age, at least after middle age. Let us first have a look at Figures 6.8 and 6.9 and state that the patterns generally do not differ for the current and future DR distributions. There is a difference between the younger and older; the younger farmers are more likely to choose not waiting for the future reward, which is more obvious for the current DR. This difference influences the means of both groups and makes them significantly different for the current DR as we can read on the second line of Table 6.1. So we reject the hypothesis that the current DR mean of the younger farmers equals to the current DR mean of the older farmers on the level $\alpha = 0.1$. We do not reject the analogous hypothesis for the future DR.

Questioning why have we chosen 44 years as the benchmark for being older is more than justified right now. First we looked at Graph 6.10 of the current DR vs. age; we do not see any particular pattern there. Therefore we suggest

Table 6.2: P-values for current DR according to age

Less than	p-value
45 years	0.1976
44 years	0.0829*
43 years	0.0455 **
42 years	0.3544

Source: Author's computations

middle age (Harrison *et al.* (2002)) to be between 40 and 50 and then test for the different possibilities in this interval. We can see the results of this testing in Table 6.2. The results of regressing

$$\mathrm{DR} = \alpha + \beta \mathrm{age}$$

are very weak and not significant (p-value=0.4230, $R^2 = 0.0022$).

Overall, despite the fact that we reject the null hypothesis of equality, we do not find the results that older farmers in our sample are more patient than the young ones very robust.

The last hypothesis that we want to test for in this section, is that people with higher education are more patient. There are four groups of farmers based on education; those who have no official education, second those that completed primary school, third, the most numerous, are farmers who completed middle education, and the last one are those who have some form of higher education. Higher education can be either senior secondary school, some college or a university. We group them into one category because none of these higher education categories has enough members. We can see how many farmers are in each category on Figure 6.11.

Figures 6.12 and 6.13 show surprising information. Instead of more patient educated farmers, our farmers with higher education seem to be more impatient, for the current moment and also for the future.

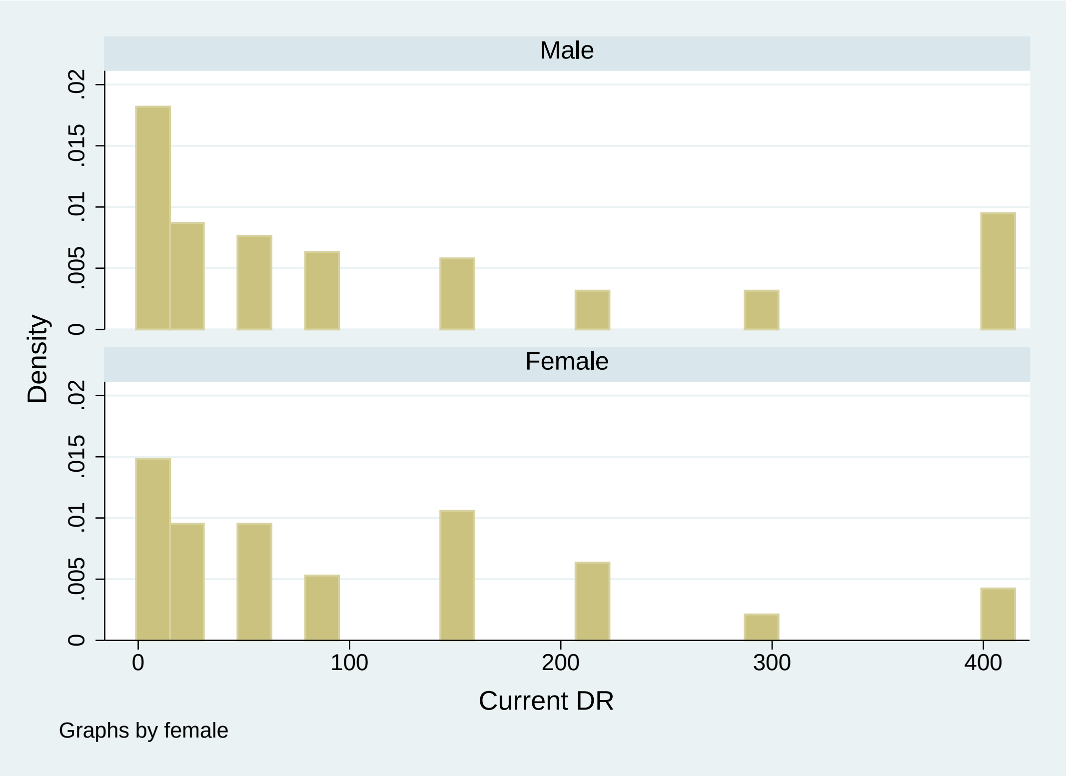
We use Kruskall-Wallis test for testing whether the distributions of current DR (future DR) are equal for all for all categories. The results from the Kruskall-Wallis tests are summarized in Table 6.3 and we conclude that these results do not allow us to reject the null hypothesis. Figures 6.14 and 6.15 capture the detailed distribution of the DR, where we also see the high proportion of the patient choices among the less educated people.

Table 6.3: P-values of Kruskall-Wallis test

	Current DR	Future DR
p-values	0.3037	0.1776

Source: Author's computations

Figure 6.6: Current DR and gender



We have to admit at this point that there is no relevant explanation for this observation. Moreover, the sample is too small to spot any specificity of the people who are extremely impatient and higher educated at the same time.

6.4 Time preferences and the CAA entry

Contingent table analysis

For the purpose of the following two sections, we define that current patient farmers are those who have $\mathrm{DR}_{\mathrm{current}} \leq 90\%$, and future patient farmers are analogically those who have $\mathrm{DR}_{\mathrm{future}} \leq 90\%$. Now we can count how many farmers are patient/not patient and initial joiners/not initial joiners and summarize the numbers in Table 6.4.

Figure 6.7: Future DR and gender

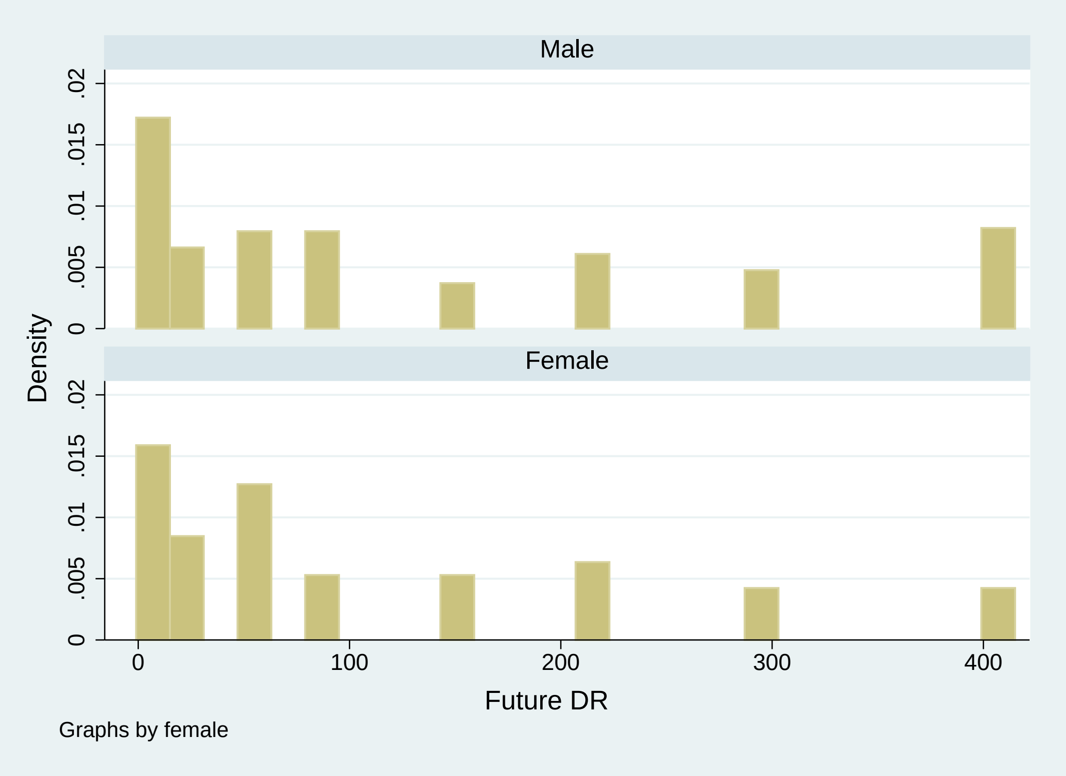


Figure 6.8: Current DR and age

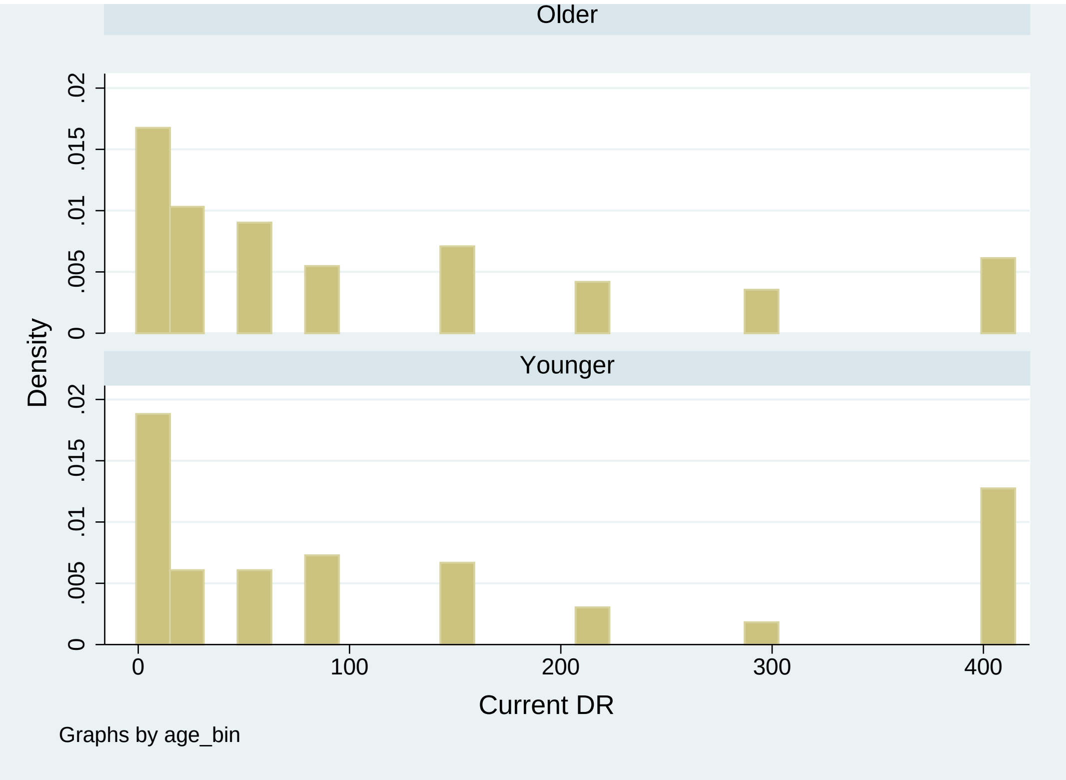


Figure 6.9: Future DR and age

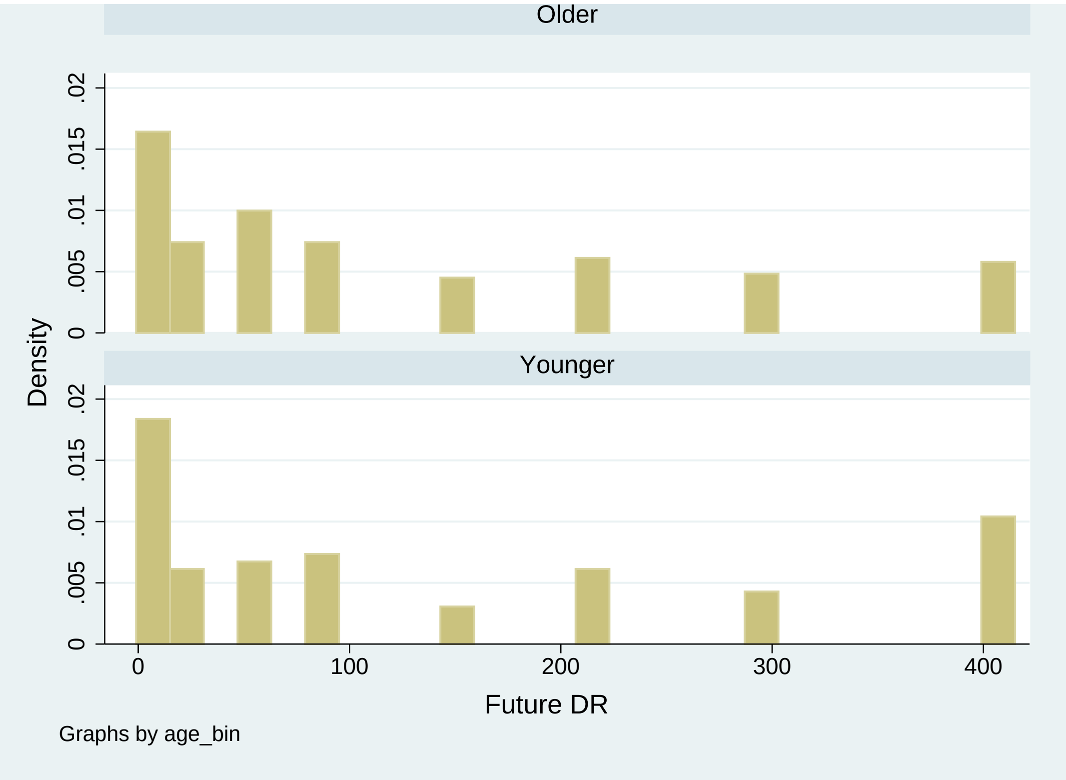


Figure 6.10: Current DR on age

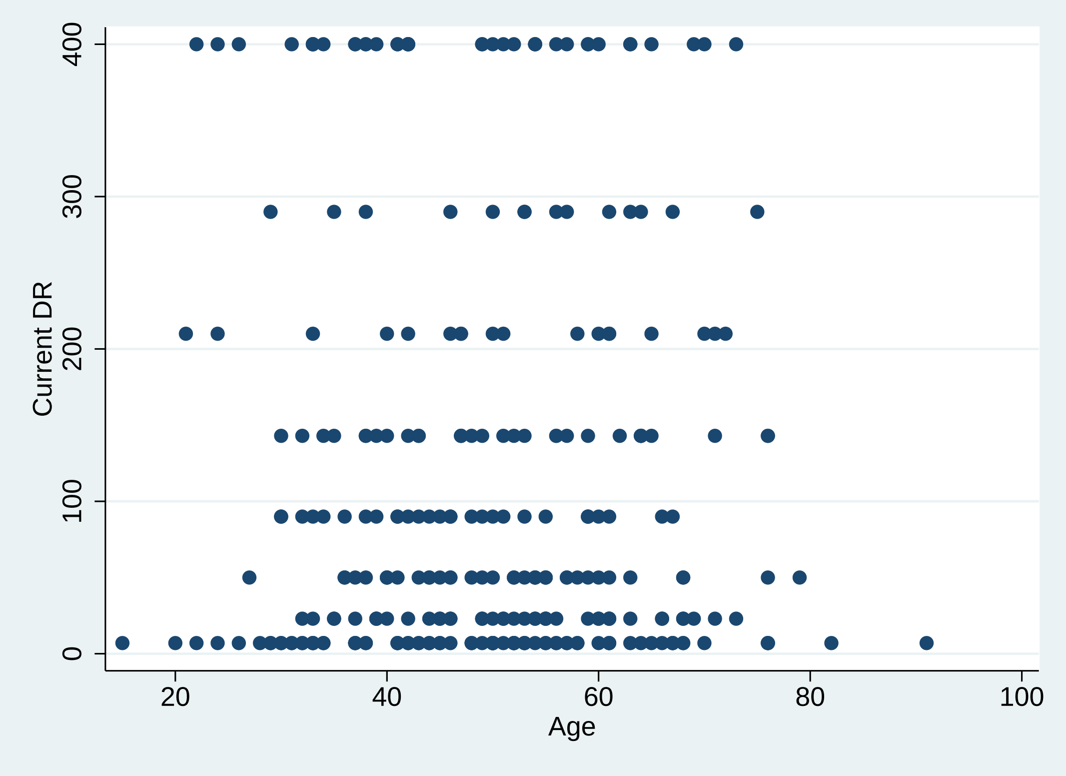


Figure 6.11: Number of farmers based on education

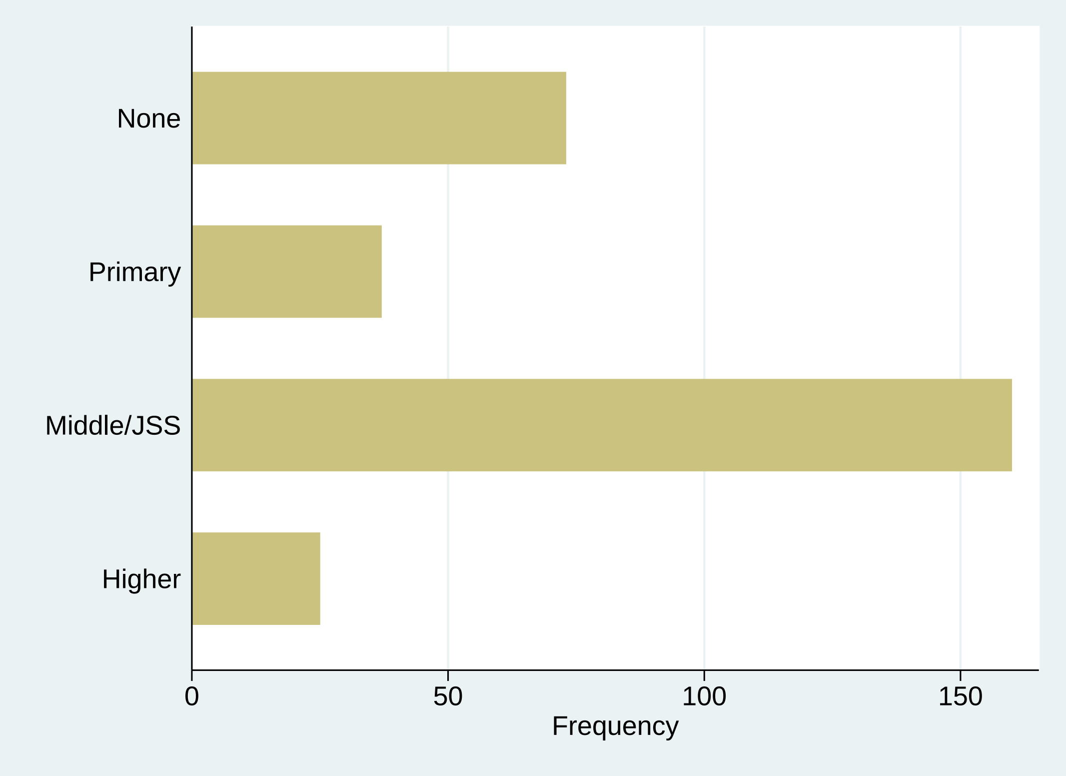


Figure 6.12: Mean of current DR based on education

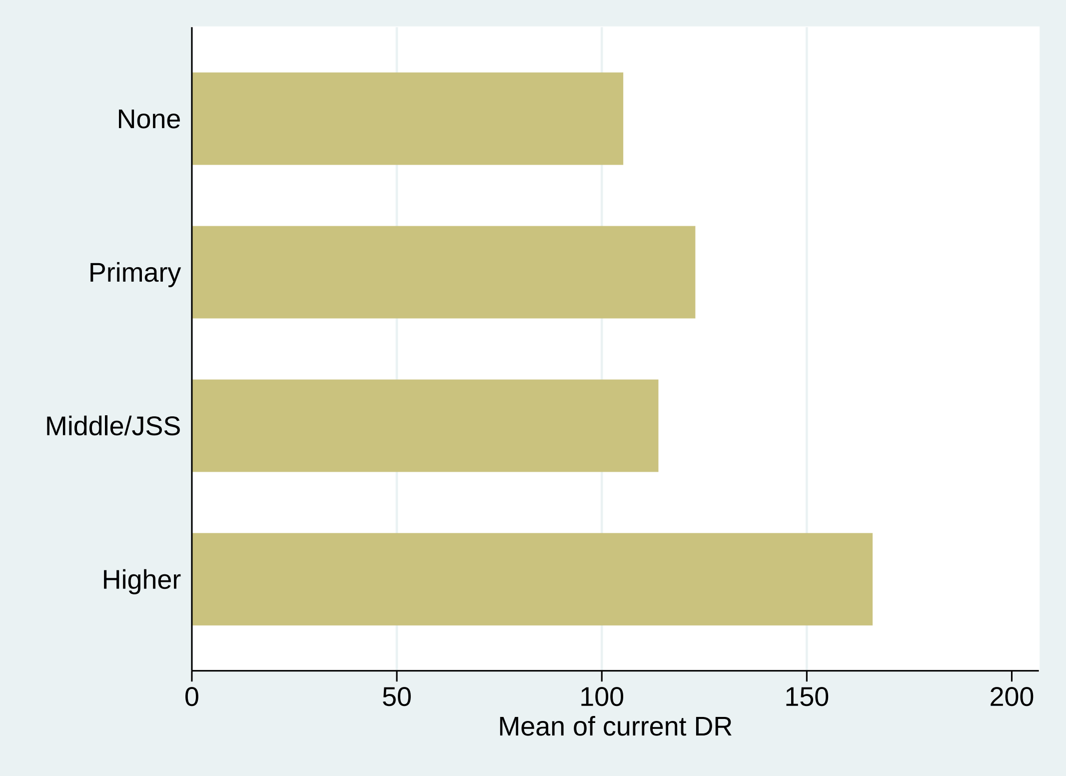


Figure 6.13: Mean of future DR based on education

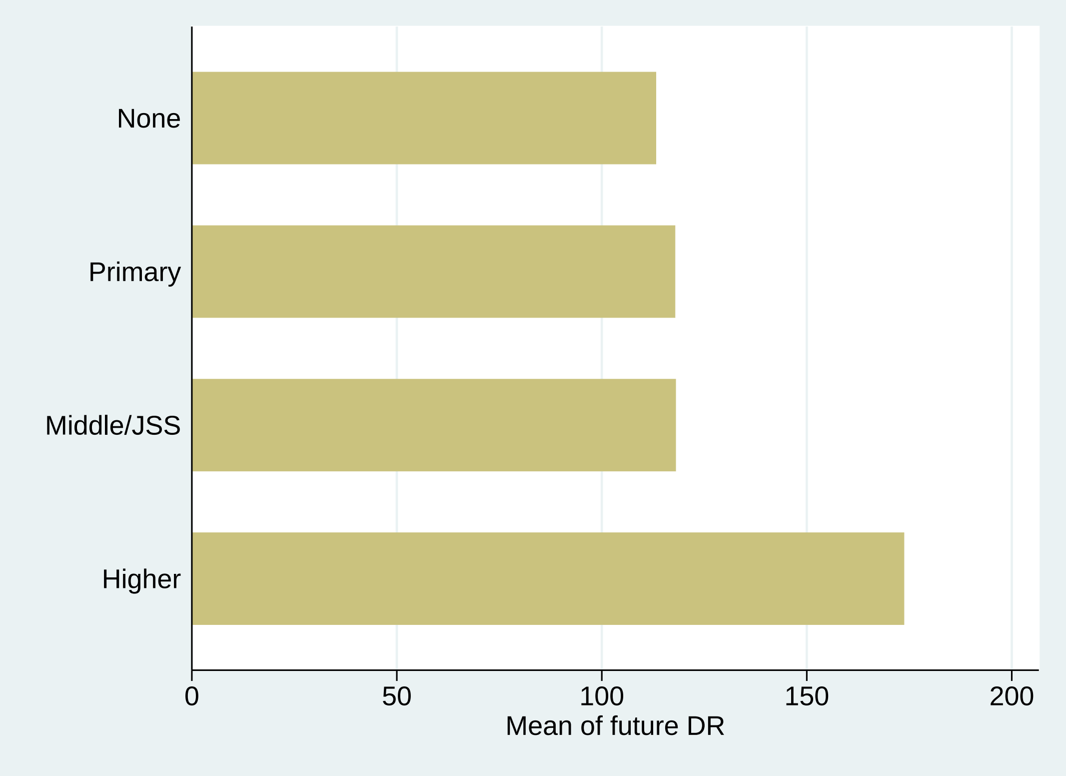


Figure 6.14: Current DR and education

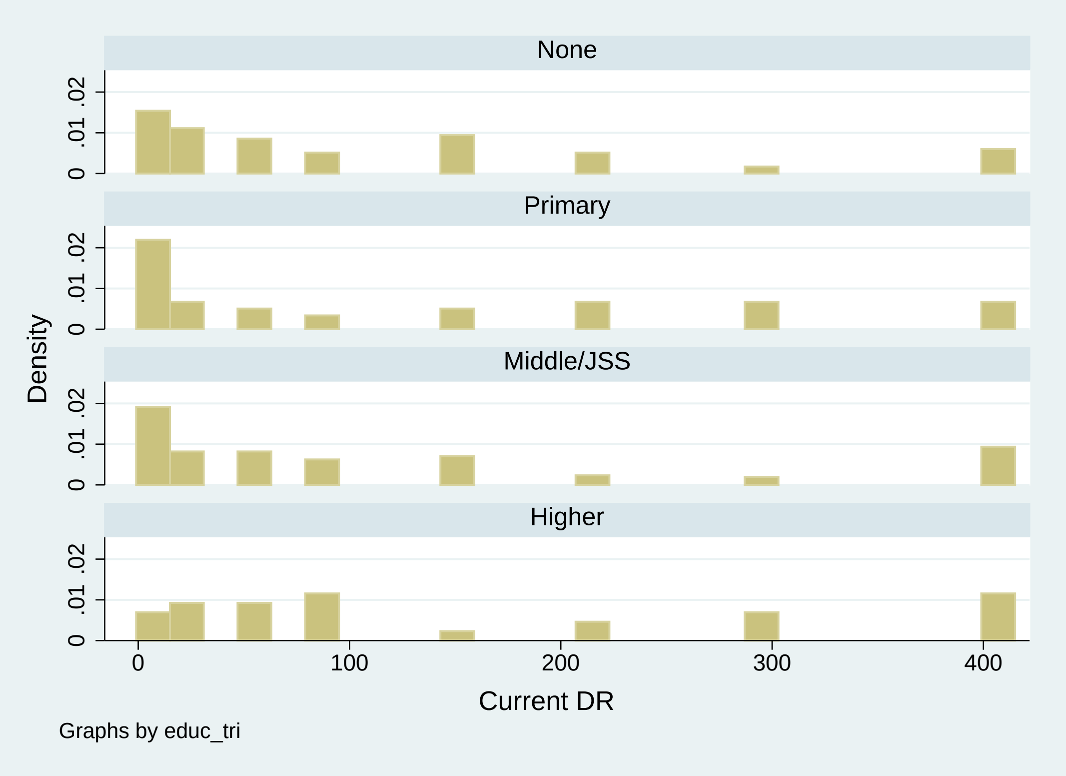
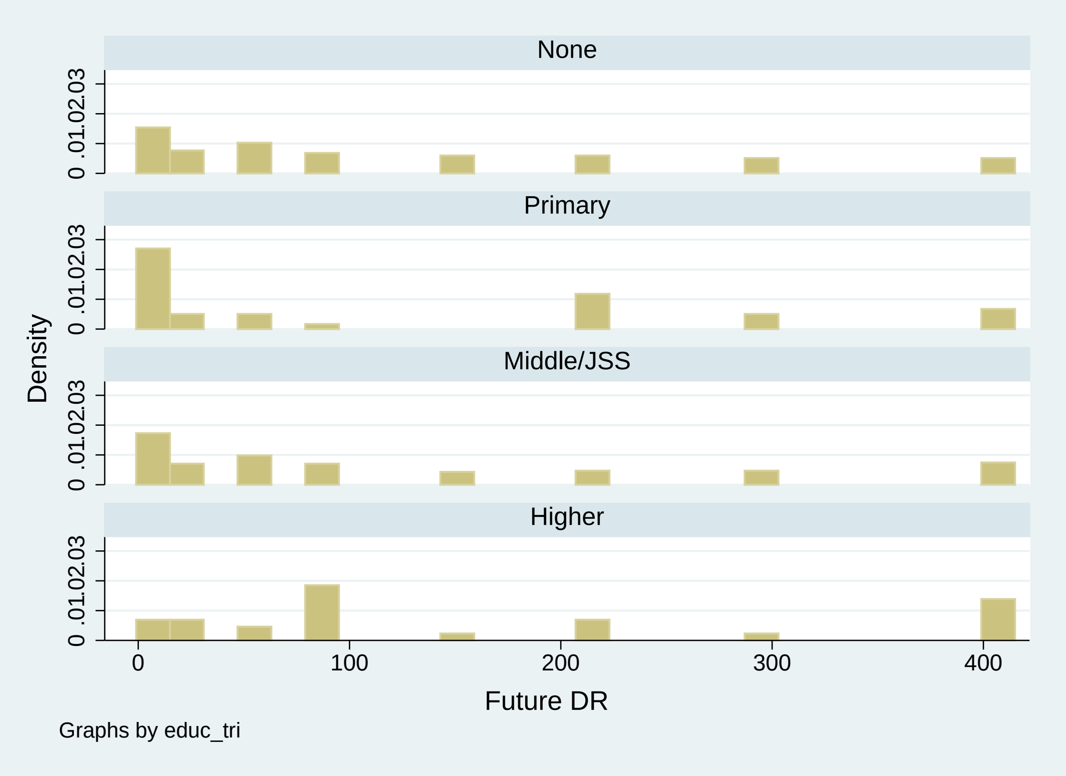


Figure 6.15: Future DR and education



We also define present-biased farmers as those who have

$$\text{rank}(\text{DR}_{\text{future}}) - \text{rank}(\text{DR}_{\text{future}}) \geq 2,$$

and future-biased with

$$\text{rank}(\text{DR}_{\text{future}}) - \text{rank}(\text{DR}_{\text{future}}) \leq -2.$$

Table 6.5 shows the number of present/future-biased farmers who decided to become initial joiners/non-joiners. Let us note that not being a present-biased farmer does not mean the same thing as being a future-biased one, because there are many time consistent farmers in our sample as well.

We can analyze these tables using the methods that have been listed in Chapter 5. The results of the χ^2 test and the odds ratio test are in Table 6.6. Being patient now or being patient later seems to have no influence on the 'initial joiner' decision. Though we cannot reject the null hypothesis on any standard level of α, we can state that if these facts are independent as the null hypothesis says, the probability that we find a similar sample is around 17%.

Table 6.4: Number of patient farmers and initial joiners

		Patient now			Patient in future		
		0	1	$\sum$	0	1	$\sum$
Initial joiner	0	24	58	82	24	58	82
	1	81	134	215	81	133	214
	$\sum$	105	192	297	105	191	296

Source: Author's computations

Table 6.5: Number of time inconsistent farmers and initial joiners

		Present-biased		Future-biased		
		0	1	0	1	$\sum$
Initial joiner	0	78	4	19	3	82
	1	188	26	200	14	214
	$\sum$	266	30	279	17	296

Source: Author's computations

Table 6.6: Results of χ^2 test and the odds ratio test for the entry decision

P-values	Patient now	Patient later	Present-biased	Future-biased
χ^2	0.176	0.167	–	–
Odds-ratio	0.177	0.168	0.073*	0.347

Source: Author's computations

χ^2 test assumes that the value in each cell is not lower than 5, but Table 6.5 does not fulfill this condition, therefore we use only the odds ratio test to analyze it. The odds ratio test allows us to reject the null hypothesis on the $\alpha = 0.1$ level, which says that being a present-biased farmer is an independent fact of the decision about the CAA entry in the first year of its exposure to the village. The direction of the dependency is as follows: it is more plausible that the farmers who are present-biased are also initial joiners. This is not in line with our hypothesis from Chapter 4 where we expect that the present-biased farmers are less likely to become initial joiners. This result may also suggest that in contrast to our assumption, the CAA program is more a microfinance program than a technology adoption promotion in the eyes of the farmers.

The last column in Table 6.6 shows that the probability of finding a similar sample of farmers that fulfill the null hypothesis about independence is very high, 35%, and therefore we do not expect any link between future-biased farmers and the decision to become an initial adopter.

Model specification

There are many factors that are typical for a given year and that can influence the joining decision. People might have heard about the CAA and formed an opinion about it. Meteorological conditions may vary over the years. Also the economic and political situation can be unstable; for example in 2007, a redenomination of the Ghanaian currency took place (four zeros were striked off). Situation on the global cocoa market which can affect the purchase price that COCOBOD pays to the farmers, as well as the prices of inputs can change.

We also control for village effects like Bauer *et al.* (2012) do. The specificity of villages comes from different sources, for example weather conditions, local political and local economy conditions. Social learning that has been proven by Conley & Udry (2010) can also play a role, because it can influence the 'village opinion' on fertilizers, or technology adoption in general.

The binary choice that the farmers face suggests that it is reasonable to use logistic regression with dummy variables to control for the year and village effects. However, we can omit the year effects, because the village effects capture both in this subsample, the year and the village. Every village in the subsample is present only one year, which is the year when the village was exposed to the CAA.

Table 6.7: Current DR

Model	Coef	Std. er.	Z	P-value	90% Conf. int.	95% Conf. int.
Logit (DR)	0.002	0.001	1.49	0.135	-0.000, 0.003	-0.000, 0.004
Logit (Rank)	0.116	0.061	1.89	0.058*	0.151, 0.216	-0.004, 0.235
Probit (DR)	0.001	0.001	1.37	0.169	-0.000, 0.002	-0.000, 0.002
Probit (Rank)	0.062	0.035	1.77	0.077*	0.004, 0.120	-0.007, 0.131

Table 6.8: Future DR

Model	Coef	Std. er.	Z	P-value	90% Conf. int.	95% Conf. int.
Logit (DR)	0.002	0.001	1.36	0.173	-0.000, 0.003	-0.001, 0.004
Logit (Rank)	0.074	0.058	1.26	0.207	-0.022, 0.170	-0.041, 0.188
Probit (DR)	0.001	0.001	1.19	0.234	-0.000, 0.002	-0.000, 0.002
Probit (Rank)	0.038	0.035	1.10	0.273	-0.0189, 0.095	-0.030, 0.106

The model specification thus has the following form that we use for modeling the probability of becoming an initial joiner

$$\Pr(\text{Initial joiner}|\text{DR}_{\text{current}}) = \frac{\exp(\beta_1 + \beta_2 \text{DR}_{\text{current}} + \sum_{v\in\{\text{set of villages}\}} D_v)}{1+\exp(\beta_1 + \beta_2 \text{DR}_{\text{current}} + \sum_{v\in\{\text{set of villages}\}} D_v)} \tag{6.1}$$

$$\Pr(\text{Initial joiner}|\text{DR}_{\text{future}}) = \frac{\exp(\beta_1 + \beta_2 \text{DR}_{\text{future}} + \sum_{v\in\{\text{set of villages}\}} D_v)}{1+\exp(\beta_1 + \beta_2 \text{DR}_{\text{future}} + \sum_{v\in\{\text{set of villages}\}} D_v)}, \tag{6.2}$$

for the current and future DR respectively, and for the dummy variable D that is $D = 1$ in case of present-bias and $D = 0$ otherwise:

$$\Pr(\text{Initial joiner}|\text{D}) = \frac{\exp(\beta_1 + \beta_2 \text{D} + \sum_{v\in\{\text{set of villages}\}} I_v)}{1+\exp(\beta_1 + \beta_2 \text{D} + \sum_{v\in\{\text{set of villages}\}} I_v)}, \tag{6.3}$$

where D_v is the dummy that a farmer lives in the village v.

We use the link test to detect any specification errors in 6.1, 6.2 and 6.3. The idea behind the link test is that if the model is properly specified, one should not be able to find any additional predictors that are statistically significant

Table 6.9: Present bias

Model	Coef	Std. er.	Z	P-value	90% Conf. int.	95% Conf. int.
Logit	1.043	0.582	1.79	0.073*	0.085, 2.001	-0.098, 2.184
Probit	0.591	0.318	1.86	0.063*	0.068, 1.113	-0.032, 0.213

except by chance. We do not include here the detailed results of these tests, we just say that the hat variable is significant and the hatsq is not significant for all of the above-mentioned cases (run the attached code for more details), and therefore we assume to have a valid specification.

Table 6.7 shows the results for the dependency between the farmers' current DR and their decision about entering the CAA. We ran the logit specified in 6.1 and the analogical probit model for both, DR and the rank variable. We can say that the farmers with a higher rank of current DR are also more likely to become initial joiners. We reject the hypothesis that the current DR term in the equation 6.1 is 0 on the level $\alpha = 0.1$. These results are robust. This corresponds to the inference in the previous section where we have found that the currently impatient farmers are more likely to join CAA.

Table 6.8 shows that there is no similar dependency for the future DR. The estimated coefficient is not significantly different from 0 in any of the four cases.

Table 6.9 also confirms the inference we have concluded in the previous section about the contingent tables. We reject the hypothesis about the zero value of the estimated coefficient on the level $\alpha = 0.1$.

Overall, we have found that the present-biased farmers are more likely to become the initial joiners. The same is valid for the farmers who claim to be more currently patient. The rank of the time preference choice during the experiment appears to be more important than the absolute value of the current DR.

6.5 Time preferences and the CAA exit

Zeitlin (2011) writes that despite the high average returns from the participation in the CAA program, and the indisputable heterogeneity among these returns, there are still farmers who leave, even though the CCA does yield positive results for them. Zeitlin (2011) also calculated that the farmers needed 230.8 kg of the cocoa output to repay the direct costs of inputs, so we exlude those who had achieved a lower one, because it is understandable why these farmers left. In this section, we focus on the leaving farmers and try to identify whether time preferences have any influence on such behavior. We divide our investigation into three parts; we compare the farmers who stay with those who leave, the farmers who use fertilizer with those who do not, and farmers who left and kept using fertilizers with the farmers who gave up using fertilizers altogether.

Table 6.10: Number of farmers: patient/impatient and leaving CAA

		Patient now			Patient in future		
		0	1	$\sum$	0	1	$\sum$
Left CAA	0	62	97	159	64	94	158
	1	17	34	51	16	35	51
	$\sum$	79	131	210	80	129	209

Source: Author's computations

Table 6.11: Number of farmers: time inconsistent and leaving CAA

		Present-biased			Future-biased		
		0	1	$\sum$	0	1	$\sum$
Left CAA	0	138	20	158	147	11	158
	1	46	5	51	48	3	51
	$\sum$	184	25	209	195	14	209

Source: Author's computations

Farmers who left CAA vs. farmers who remained

We restrict our data to the farmers who have become members in the first year of the CAA exposure to their village. Among these initial joiners, some farmers decided to stay and continue their CAA enrolment, and some of them left in the second year of exposure. In this section, we analyze the difference between these two groups.

Tables 6.10 and 6.11 are contingent tables showing how many current patient, future patient and time inconsistent farmers have chosen to stay for the second year and how many have decided to leave. None of the Tables is showing any clear pattern that would allow us to suggest dependency between time preferences and the leaving decision. This observation is confirmed in Table 6.12, where the p-values of the χ^2 test and the odds ratio test are listed.

Table 6.12: Results of χ^2 test and the odds ratio test for the staying-for-the-second-year decision

P-values	Patient now	Patient later	Present-biased	Future-biased
χ^2	0.468	0.243	0.585	–
Odds-ratio	0.468	0.245	0.586	0.789

Source: Author's computations

Table 6.13: Number of farmers: patient/impatient and fertilizer users

		Patient now			Patient in future		
		0	1	$\sum$	0	1	$\sum$
Fertilizer	0	9	10	19	6	13	19
	1	50	57	107	48	58	106
	$\sum$	59	67	126	54	71	125

Source: Author's computations

Table 6.14: Number of farmers: time inconsistent and fertilizer users

		Present-biased			Future-biased		
		0	1	$\sum$	0	1	$\sum$
Fertlizer	0	16	3	19	19	0	19
	1	92	14	106	100	6	106
	$\sum$	108	17	125	119	6	125

Source: Author's computations

Fertilizer users vs. fertilizer non-users

Another approach to understanding the leaving farmers is to observe the fertilizers use itself rather than the pure fact that the farmers are not members of the CAA anymore. This means that we do not distinguish between the farmers present in the CAA and those buying fertilizers on their own. After all, the technology adoption is claimed to be the thing that matters. We interviewed the farmers that joined CAA in 2007 (2008), in the following year 2008 (2009). We exclude the initial joiners of 2009, because we do not have full data about the farmers' fertilizer use in 2010.

Tables 6.13 and 6.14 are contingent tables that show how many farmers from the above-defined groups were using fertilizers. Table 6.15 concludes them with reporting the results of the χ^2 test and the odds ratio test. None of the binary time preferences characteristics has a significant link with the decision to use fertilizers for the second year.

Table 6.15: Results of χ^2 test and the odds ratio test for the fertilizers-use-for-the-second-year decision

P-values	Patient now	Patient later	Present-biased	Future-biased
χ^2	0.959	0.267	–	–
Odds-ratio	0.959	0.271	0.763	–

Source: Author's computations

Table 6.16: Number of farmers who left: patient and fertilizer users/non-users

		Patient now			Patient in future		
		0	1	$\sum$	0	1	$\sum$
Fertilizer	0	9	10	19	6	13	19
	1	7	10	17	7	10	17
	$\sum$	16	20	36	13	23	36

Source: Author's computations

Table 6.17: Number of patient farmers and initial joiners

		Present-biased			Future-biased		
		0	1	$\sum$	0	1	$\sum$
Fertilizer	0	16	3	19	19	0	19
	1	16	1	17	16	1	17
	$\sum$	32	4	36	35	1	36

Source: Author's computations

Fertilizer use among the farmers who left CAA

We restrict our sample for the last time, in the way that we use only the farmers who left CAA after one year of membership. We have 36 such farmers in our sample. We are curious to find out whether the farmers, who left and gave up fertilizers completely and the farmers who left, but continued to use fertilizers on their own, are different from the time preferences perspective.

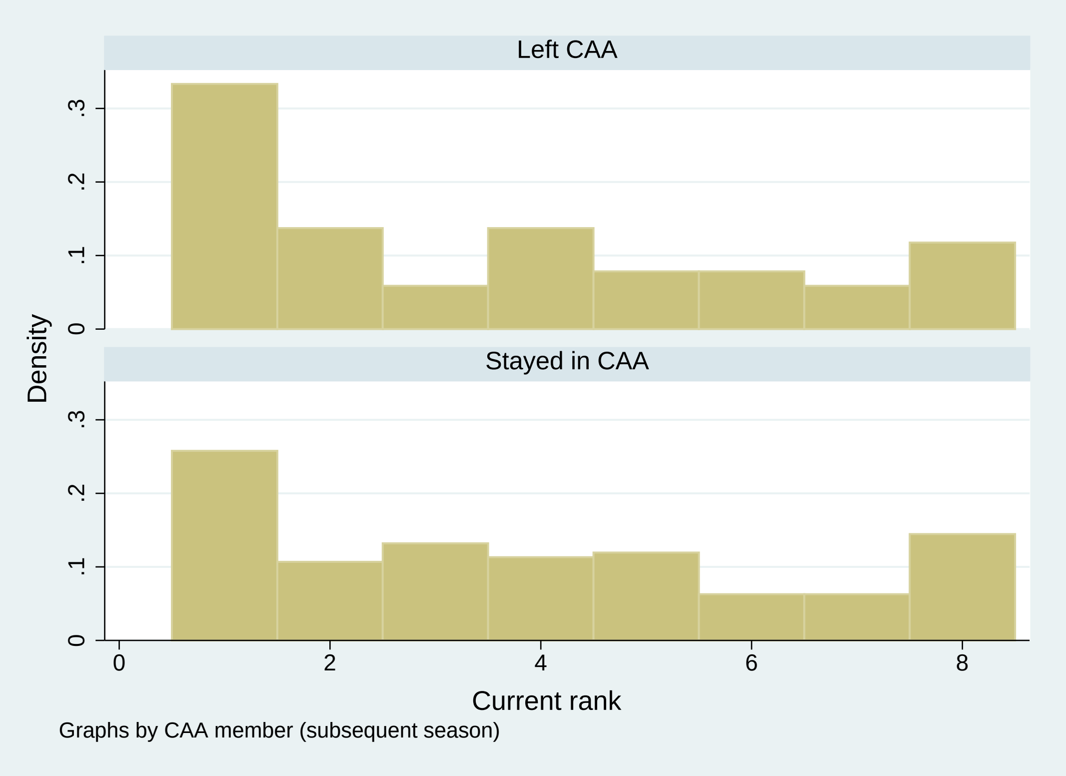
Tables 6.16 and 6.17 show the numbers in the particular groups. The results of the χ^2 tests and the odds ratio tests are in Table 6.18. We can see that due to the low number of farmers in the predefined groups, some tests cannot be calculated at all. From those that are able to be calculated, we cannot reject the dependency null hypothesis.

Table 6.18: Results of χ^2 test and the odds ratio test for the leaving-CAA-and-still-using-fertilizers decision

P-values	Patient now	Patient later	Present-biased	Future-biased
χ^2	0.709	0.549	–	–
Odds-ratio	0.709	0.550	0.363	–

Source: Author's computations

Figure 6.16: Current rank: Left vs. stayed



CAA exit and the rank distributions

The analysis of the contingent tables of the farmers' time preferences and their exit decision discussed in the previous pages does not offer any promising results. We also tried to apply the logit model, but specification analogous to 6.1, 6.2 and 6.3 are not even statistically significant, so we cannot draw any inference from the logit either.

Since we were not able to come up with any significant results about the link between time preferences and the decision to leave, we would like to present the current and future rank distributions here. We hope to provide the reader with at least some information about the time preferences of the farmers who left, but we recommend to check the numbers in the sample as some of them are very low. See Figures 6.16, 6.17, 6.18, 6.19, 6.20, 6.21

Figure 6.17: Future rank: Left vs. stayed

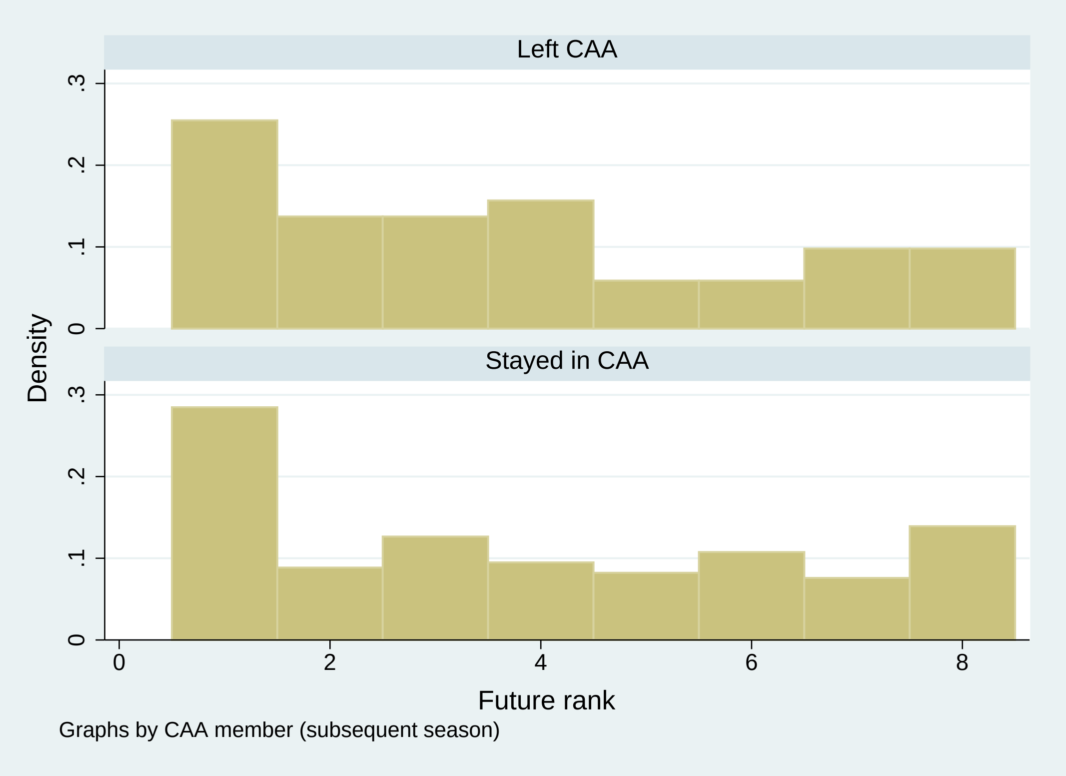


Figure 6.18: Current rank: Fertilizer users vs. non-users

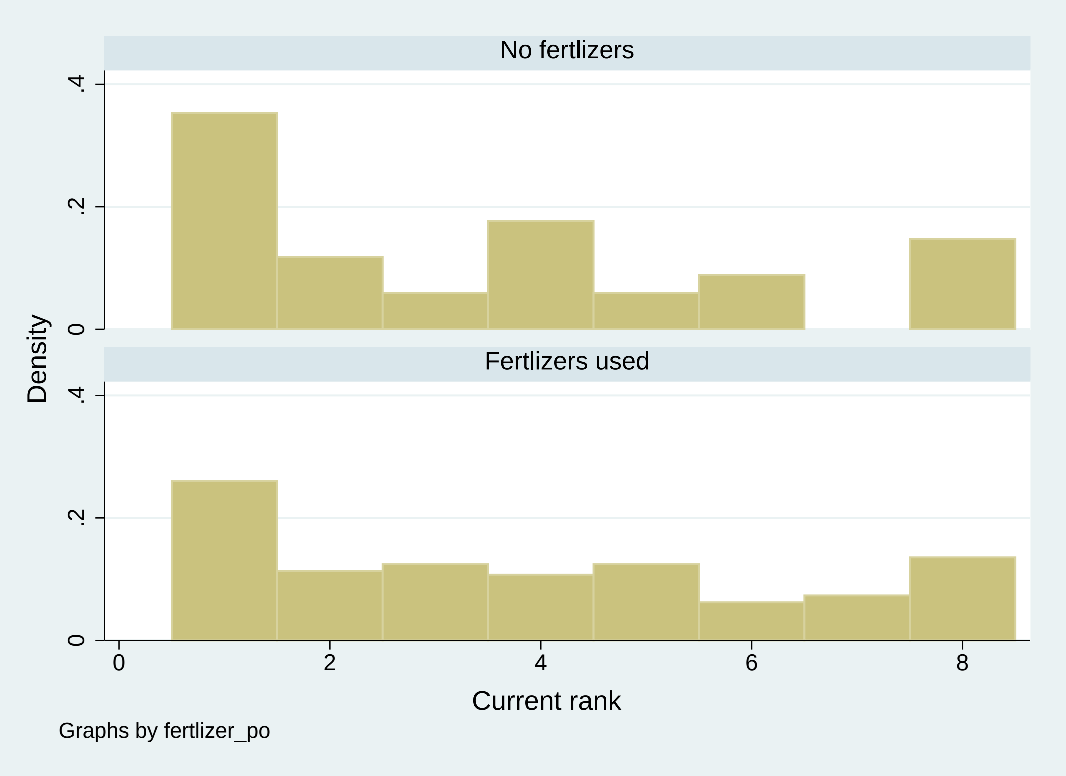


Figure 6.19: Future rank: Fertilizer users vs. non-users

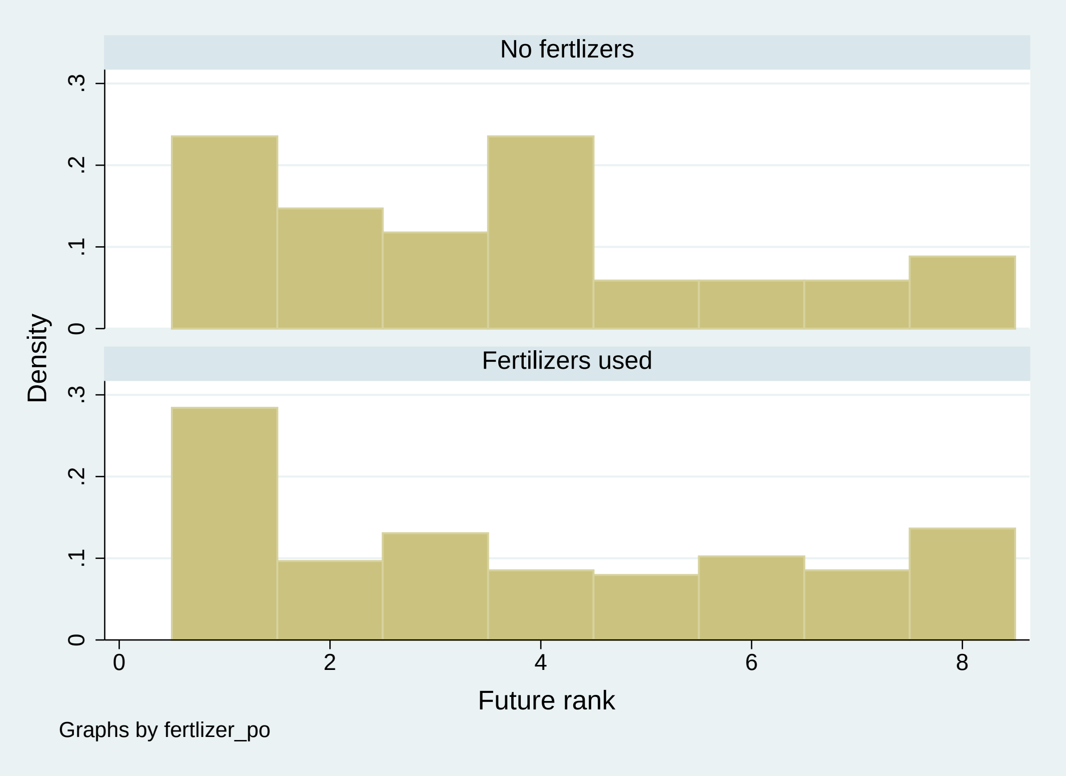


Figure 6.20: Future rank: Fertilizer users vs. non-users

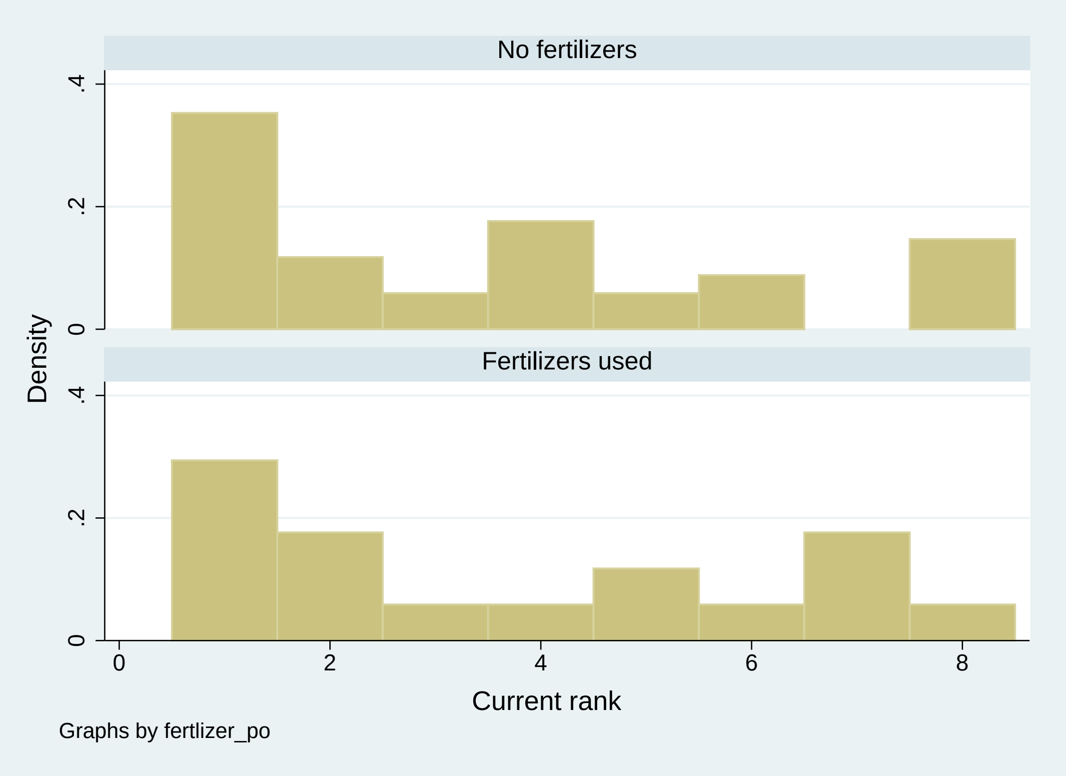
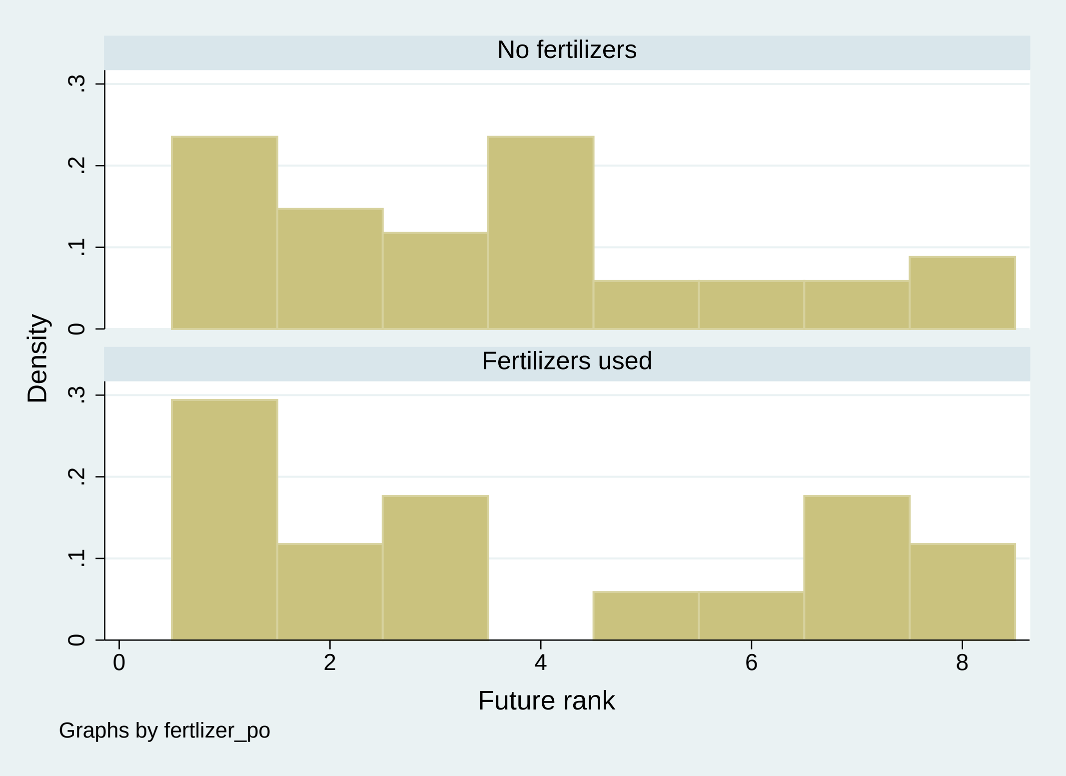


Figure 6.21: Current rank: Fertilizer users vs. non-users



Chapter 7

Conclusion

Cocoa is an important part of the Ghanaian economy and its increased hectare yield can play an important role for the agriculture sector. This work investigates mainly the links between the participation in a microcredit program, which offers cocoa fertilizers on a microcredit basis, and time preferences of individuals that have been offered the membership in this program. Our sample consists of cocoa farmers in Ghana who were offered the so-called hi-tech package that contains fertilizers, insecticides and pesticides, and which is proven to increase cocoa yields on average, on the microcredit basis. The participation in this program, which is ran by CAA, and the use of fertilizers are considered to be technology-adoption decisions.

We aimed to review the literature relevant to our survey, and thus we have included a chapter about the agriculture technology adoption, microcredit and time preferences articles.

One of the limitations of our analysis is that the sample does not have a purely experimental design, the survey was more of a quasi-experiment, and therefore the sample selection bias may occur. Having this limitations in mind, let us present the empiricial conclusions that our work brings.

Men and women in our sample do not have significantly different time preferences. We find out that the younger farmers have higher current discount rates and that the older farmers are more patient, however, these results are not robust. The more educated farmers from our sample seem to have on average higher discount rates, and thus are more impatient than the farmers with none or lower education, but this surprising fact is not statistically significant and therefore we cannot say that there is any connection between the farmers' time preferences and education.

The most interesting finding is the relationship between time preferences and the decision to enter the CAA program and adopt a new technology. Even though we have hypothesized that the CAA program is rather a way to adopt a new technology than to obtain a microcredit loan, and thus, that the more patient and time consistent farmers would become members, the contrary has been found; the impatient farmers and the farmers with hyperbolic time preferences are more likely to enter the CAA program.

Although we tried to search for dependecies between patience and time consistency and the decision to leave the CAA, we did not find any significant inference. We see a possibility for future research in this particular field. Having a longer and larger panel of data would allow us to track the behavior of the farmers and see whether those who left came back later. It would also allow us to use the logit model with proper specification. We also see a room for further research in distinguishing between the farmers who use fertilizers through the program, those who use fertilizers on their own, and those who do not use fertilizers at all. At the end, let us mention that a thing worthy an investigation is the possible relationship between the farmers' time preferences, cocoa yields and their technology adoption decision.

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Appendix A

Content of Enclosed DVD

There is a folder Sobkova_thesis.zip enclosed to this thesis which contains empirical data and Stata source codes. Read the 'read.txt' file for further explanation.