Time and risk preferences in economic development
Three essays

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Contents

1 Introduction

The thesis studies the role of time and risk preferences in the context of economic development, with particular focus on countries with lower income and less developed economic institutions. Wide range of important economic decisions is affected by individual willingness to postpone consumption and to bear risk. If people discount future pleasures heavily they are less likely to save, invest or send children to school. If they value future gratification intellectually but have difficulties to resist current temptations and suitable commitment devices are not available, they may ex post regret some of their decisions. If individuals or firms are averse to financial risk, they are less likely to make a profitable investment.

I have been motivated by a few simple questions. How are the individual attitudes to time and risk formed? Can the experimental measures developed for the lab environment and educated subject pools in rich countries be successfully applied in the field labs in low-income countries? Can we learn something new about why people remain poor if we complement the usual survey information with experimental measures of time and risk preferences? Shall we expect firms operating in environments with less developed economic institutions to be more or less risk averse than those producing in developed economies?

The thesis consists of three papers. In the first paper "The impact of education on subjective discount rate in Ugandan villages" we elicit a subjective discount rate for a varied sample of Ugandan villagers. In accordance with other studies, we have found the discount rate to decrease with education. In any cross-sectional study, it's difficult to infer the direction of causality from correlation. Does education make people more patient, or are more patient individuals more willing to invest in their human capital? The paper provides the first evidence for the causal effect of education on discount rate. We exploit two different sources of variation in education: school frequency across villages and the number of the respondents' school-going years that overlap with the era of the dictator Idi Amin's rule. For men, we find that education has a significant impact on their discount rate, similar in magnitude for both types of instruments and robust to observable characteristics. This finding highlights the importance of education in economic development.

The second paper "Behavioral foundations of microcredit: Experimental and survey evidence from rural India" draws a link between popularity of microcredit and desire for self-

discipline. We integrate experimental measures of time discounting and risk aversion for a sample of 573 villagers in south India with survey data on their financial activity. One third of participants made choices consistent with hyperbolic preferences (more impatient now than in the future), and would be made better off if they could discipline their time inconsistent preferences. While hyperbolic preferences have been often associated with difficulties to save and strategies to commit for saving, we describe links to borrowing as well. We find that "hyperbolic" women save a lower share of their savings at home and save less in total levels. Women with hyperbolic preferences are also more likely to borrow--and to do so through microcredit institutions specifically. The finding highlights the role of the fixed and frequent installment schedule ubiquitous in microcredit contracts. While microcredit contracts are celebrated for mitigating informational asymmetries, the evidence suggests that they also offer helpful, though costly, structure for people with self-discipline problems who seek to accumulate capital but who lack suitable contractual saving devices.

The third paper examines the determinants of firm's attitude to risk. The model developed in the paper is an extension of Greenwald and Stiglitz's model (1993a), which singly implies risk-averse behavior if a firm's production is financed by debt. Our model incorporates more general assumptions about a firm's financing: access to the equity market and the possibility of a soft budget constraint. Both features are closely associated with different stages of economic development. The model demonstrates several interesting implications. A soft-budget constraint, a feature that is typical primarily for developing or emerging economies, can lead to excessively risky production strategies. In the environment *without* soft-budget constraint, improving access to capital markets enhances the willingness of managers to bear risk up to the production level associated with risk-neutral firm. A degree of uncertainty about future prices may have opposite effect on production, depending on financial situation of the firm.

The first paper is a result of joint work with Julie Chytilová. It has been accepted for publication in Economic Development and Cultural Change. An earlier version of this paper received 2006 Young Economist Award of the Czech Economic Society. The paper was discussed during my research visit to STICERD at the London School of Economics (May and June 2006). It has been presented at the IES Annual Workshop (2006), the IES Young scholars conference (2006), the Education and Development Conference in Bangkok (2007), and the Seminar of the Czech Economic Society (2007, CERGE). An earlier version was published as the IES working paper 2007/10.

The second paper is co-authored by Julie Chytilová and Jonathan Morduch. It has been recently invited for resubmission to the American Economic Review. The paper was published as a Research Paper of the Financial Access Initiative (a consortium of NYU, Yale and Harvard Universities) and an IES working paper. It has been presented at Brown-bag seminar at Hunter College (CUNY), Empirical Microeconomics Workshop at Rutgers University and Hewlett/PRB Workshop on Innovations in Research Design at Duke University, 2008 NEUDC conference at Boston University, Nordic Conference on Behavioral and Experimental Economics in Copenhagen and will be presented at 2009 AEA conference in San Francisco.

The third paper is a substantially shortened version of my master thesis. The thesis received Karel Engliš Award of the Charles University Rector for the best Master thesis in social sciences in 2005. It has been published as the IES working paper 2005/71, in the working paper series of the Prague Social Science Studies 001/2006, and in the Czech Journal of Economics and Finance, 57(7-8), pp.382-399.

I deeply appreciate the lack of risk aversion of the Global Development Network, the IES research framework 2005-10 and the ETPM grant when making the decision to fund the Indian and the Ugandan projects. I would like to thank Caritas Prague, Uganda-Czech Development Trust and Bala Pragathi Kendra for their time consistent commitment to implement the data collection. I was pleased by the willingness of the people in Uganda and India to share their views and to reveal their time and risk preferences without personal aversion. The papers benefited greatly from many comments and helpful discussions. In particular, I would like to thank O. Bandiera, K. Basu, T. Cahlík, R. Filer, I. Gang, W. Greene, M. Ghatak, D. Karlan, O. Knot, M. Mejstřík, A. Morjaria, J. Morduch, D. Munich, S. Pratap, A. Ortmann, D. Ray, A. Schotter, M. Skořepa, P. Streblov, D. Thomas, F. Žikeš, anonymous referees and editors of the Economic Development and Cultural Change, participants of the IES research seminars and my advisor J. Hlaváček for their willingness to sacrifice tempting alternatives of their time for a prospect of uncertain and delayed benefits associated with the papers. Much of the thesis has been written during my research visit at the New York University. I am indebted to J. Conning, R. Filer, B. Forbes and J. Morduch for making it possible, to NYU for its hospitality and to the Fulbright Commission for assisting me with overcoming my aversion to risk of being financially indebted. I enjoyed the impatient curiosity of Julie when eliciting academic stories from discussions with local

people and collected data. I would also like to thank my family for patience with me during times when my thoughts were on the other side.

2 The Impact of Education on Subjective Discount Rate in Ugandan Villages

Abstract

Heterogeneity in time discounting may reinforce the existing barriers to save and invest faced by rural populations in developing countries. We elicit a subjective discount rate for a varied sample of Ugandan villagers. In accordance with other studies, we have found the discount rate to decrease with education. We examine this correlation further by testing the causal effect of education and exploit two different sources of its variation: school frequency across villages and the number of the respondents' school-going years that overlap with the era of the dictator Idi Amin's rule. For men, we find that education has a significant impact on their discount rate, similar in magnitude for both types of instruments and robust to observable characteristics. This finding highlights the importance of education in development.

Keywords: Time discounting, patience, education, economic development, Uganda

JEL classification: C93, D91, O12

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2.1 Introduction

The question why there is not more indigenous saving and investment in less developed countries lies at the core of many debates among development economists. Goldstein and Udry (1999) estimated rate of return to the production of pineapple in Ghana to be in excess of 1,200%. However, very few people decided to grow pineapple even though doing so requires only a moderate initial investment which could be covered by a loan collateralized by the farmers' land. Likewise, in Kenya, Duflo, Kremer and Robinson (2006) found that less than 20% of maize farmers in the area in which they conducted field trials on the profitability of fertilizer report that they had used fertilizer, despite an estimated rate of return in excess of 150%. The limited responsiveness to high marginal product in poor countries is usually attributed to market failures of various kinds (for a survey see Banerjee and Duflo 2004). Recently, growing attention has been directed towards behavioral issues and psychological barriers that limit saving and investment decisions not by affecting the constraints, but by changing the decision-making process (Duflo 2006; Mullainathan 2005).

An interaction between time discounting and individual characteristics such as education or wealth could also partially explain these observations. However, as noted by Anderson et al. (2004), we have surprisingly little empirical evidence regarding the process through which discount rates are formed, especially in countries with less developed economic institutions. In this paper we study the sample of Ugandan villagers. Most importantly, the study provides empirical evidence on the causal impact of education on the subjective discount rate.

There are good reasons as to why education may lower discount rate. In their model of the endogenous discount rate, Becker and Mulligan (1997) argue that education can be understood as an investment in patience. Education can help one to form a mental picture of one's future pleasures and difficulties in life and enhances the process of anticipation. In addition, through repeated practice at problem-solving, education helps one to learn the art of scenario simulation. In this way, education can be understood as a tool that helps people to perceive future pleasures as less remote. As Böhm-Bawerk (1891, p.244) writes: "*The present always gets its rights. It forces itself upon us through our senses. To cry for food when hungry occurs even to a baby. But future we must anticipate and picture…We must be able to form a mental picture of what will be the state of our wants, needs, feelings, at any particular point of time.*"

Psychological studies demonstrate that humans are born impatient (Mischel, Shoda and Rodriguez 1989; Metcalfe and Mischel 1999). Learning to be future-oriented and to choose actions with a postponed reward is an essential part of our upbringing and educational process. Without such learning, people would live solely within the present without much will to resist current temptations and would simply omit future pleasures from their decision-making process (Doepke and Zilibotti 2006; Shonkoff and Phillips 2000).

Studies that extend their samples beyond the usual pool of university students often find a correlation between education level and discount rate. In the major study that elicits discount rate in a developed country Harrison, Lau and Williams (2002) showed on a representative sample of Danish households that highly educated adults have subjective discount rates as low as two thirds of those less educated. [1] In less developed countries, the difference is likely to be even more profound, as there may be additional pathways through which education can increase patience. Kirby et al. (2002) studied discount rate in two remote villages in the Bolivian rain forest. They found high average discount rate and that a large proportion of its variance can be explained by years of schooling, parental education and measures of qualitative education achievements in terms of mathematics and language proficiency. Similar results were obtained in rural areas in India by Bauer and Chytilová (2008). In their study of subjective discount rates in Vietnam, Anderson et al. (2004) emphasize the importance of education although they do not specifically measure it. Pender (1996) and Tanaka et al. (2006) find a relationship between patience and income in India and Vietnam, respectively.

This paper should complement the earlier evidence in two ways. First, to our knowledge, the direction of causality between education and discount rate has not been addressed by any of the previous studies that have elicited discount rates. To estimate the impact of education on the discount rate, we use information on varying school frequency in different villages and the number of school-age years that overlap with the era of Idi Amin as reasonably exogenous sources of variation in education. Second, our sample was drawn from members of a rural society less influenced by modern market structures (e.g., credit markets) than undergraduates from affluent societies who are the usual subjects in this type of study. The environment is also very different compared to a few earlier studies from less developed countries.

[1] For a comprehensive survey of studies that elicit subjective discount rate in developed countries see Frederick, Loewenstein and O'Donoghue (2002). Cardenas and Carpenter (2005) survey studies from lower-income countries.

The paper proceeds as follows: In Section 2 we describe the survey design and discuss issues related to measuring discount rate. In Section 3, we show the relationship between the discount rate and individual characteristics and demonstrate the causal effect of education on discount rate. Section 4 concludes.

2.2 Survey Design

2.2.1 Measuring time discounting

Numerous methods have been used to measure individual discounting (Frederick et al. 2002). Before analyzing our results, we discuss the advantages and disadvantages of this type of study.

We used choice task method to elicit discount rate (Frederick et al. 2002). Individuals were asked to express their preference between receiving a smaller reward immediately and receiving a larger reward with some delay. Starting with the question, "Would you prefer to receive USh 200,000 today or USh 250,000 in one year?[2]" we posed five questions, each time increasing the amount offered in the future[3]. As we increased the future amount, we expected more individuals to select the future option. The point at which a respondent switches from the current amount to the future amount provides the range for his/her discount rate and the midpoint of the range is our best estimate of the person's discount rate. The amount in question was set relatively high so as to be relevant for important savings or investment choices. In particular, we had in mind the situation of many farmers in southern Uganda who were growing vanilla in 2004 and due to the boom in the international market had substantially higher income than they expected.[4]

Proper understanding of the time-discounting questions is particularly important in an environment with low average education levels. Two rounds of pre-testing with ten respondents were done to limit systematic misunderstanding, and the questionnaires were adjusted based on follow-up discussions.[5] The respondents' ability to understand the

[2] In November 2005, the exchange rate was 1,830 USh to USD.
[3] For the exact wording of the discount rate choices in the questionnaire see Appendix in Bauer and Chytilová (2007).
[4] As of 2005 Uganda numbered among the ten largest producers of vanilla, with Madagascar producing almost 60% of the overall world vanilla production. At the end of 1990s price of vanilla was around USD 40 per kg. The typhoon and political instability in Madagascar drove vanilla prices to USD 500 per kg at the beginning of 2004 (Uganda Export Promotion Board 2006).
[5] The major decision resulting from the pre-test was not to use the matching-task method for eliciting discount rate (used in e.g. Anderson et al. 2004), when respondents are asked to stipulate a monetary amount that equates

discount-rate questions based on binary choices was later checked by observing how many respondents from the whole sample switched back to the current income option after preferring future income in the previous binary choice. In the sample, less than 3% of respondents gave inconsistent answers. In addition, we test whether less-educated individuals are more likely to answer inconsistently and find that inconsistent responses are uncorrelated with education, and also with any other observed characteristics. As mentioned earlier, the inconsistent responses were not included into the analysis.

An important design choice is whether to use real or hypothetical rewards. In studies involving hypothetical rewards, respondents can be presented with a wider range of reward options, including relatively large gains, which are generally infeasible in studies involving real outcomes. As mentioned above, our aim was to approximate a financial decision of similar magnitude as unexpected income gains during the period of high vanilla prices in 2004. On the other hand, with hypothetical rewards there is a legitimate concern that respondents will have little incentive to work hard or thoughtfully on their responses (Harrison et al. 2005), in which case, our measure would yield a noisy estimate of discounting. Several experimenters have directly compared discount rates based on real and hypothetical rewards. While Kirby and Marakovic (1996) and Coller and Williams (1999) found lower discount rates for hypothetical choices than for real choices, Johnson and Bickel (2002), Madden et al. (2003) and Hamoudi and Thomas (2006) did not observe this difference in their experiments. There has also been considerable debate outside of the context of inter-temporal choice on this issue. The general conclusion from this debate is that the two methods typically yield qualitatively similar results, although financial incentives often decrease the variance of responses (Camerer and Hogarth 1999).

In traditional communities the person or institution that organizes an experiment is a particularly important parameter in terms of how local people approach the assigned tasks. The high social status of, and respect for, our instructors (social workers) within the village community should help to mitigate the possible problem of missing monetary incentives.[6]

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two intertemporal options. We found that the respondents participating in the pretest had difficulties understanding this task properly. Therefore, we opted for choice-task method, which is simpler although it generates less precise estimates of discount rate. On more detailed comparison of relative advantages between these two methods see Frederick et al. (2002).

[6] According to the feedback from the instructors the survey questions were a favourite topic for local people to discuss during their free time in the evenings after the survey. This deliberate expression of interest also suggests that the survey was a special event in the lives of local people and that respondents were serious in their responses.

A related question in terms of the validity of elicited discount rate is its relevance to economic decisions. For example, Binswanger (1980) experimentally measured aversion to risk in rural India and found that individuals with a higher degree of risk aversion choose more conservative agricultural strategies. In our sample we found that more patient respondents are more likely to use a mosquito net and assign higher importance to child schooling in their fertility decisions. The correlation with the discount rate is -0.089 (p-value = 0.010) and -0.086 (p-value = 0.012), respectively.

There are a few reliability issues related specifically to the choice task method for eliciting discount rate. Binary choices do not reveal a single indifference point that would allow a single discount rate to be inferred. Instead, they provide a range of inferred discount rate. The amounts offered in the questions may themselves communicate to respondents how much they should be discounting, resulting in a framing effect. The total range between the lowest and highest discount rate may not be sufficient to cover the preferences of some of the respondents. Although we increased the range upwards after pre-testing, the upper bound was still not high enough for many respondents, who chose the current option, even in the last pair in which the future option was highest. In the statistical analysis we employed 650% as a censoring value for these responses.

Lastly, researchers have found that the discount rate is not a constant and it may differ due to the effect of delay, size and sign of the amount in question (Frederick et al. 2002). The smaller the amount, the higher the discount rate is. Discount rates for losses seem to be smaller than discount rates for gains. Discount rates seem to be higher for short delays – e.g. three days – than for long delays – e.g. one year. Respondents in our study were deciding about a relatively high gain with alternative amount to be given one year later.

These caveats are particularly relevant for comparison of the absolute values of discount rates across different studies. For the purposes of this study, it is important to note that we are primarily interested in differences of discount rate across socioeconomic characteristics within our sample and not in particular absolute values. The respondents are facing the same protocol and it is plausible to assume that any biases in terms of effort and understanding are not systematic across different groups. In other words, we assume they do not depend on the examined explanatory variable and we therefore believe that the significance of observed relationships should be unaffected by the issues discussed above.

2.2.2 Sample

This study is based on data from a questionnaire survey that was conducted in ten village areas in the Mukono district, which is located in the southern part of Uganda. The district is primarily rural with an economy based on small-scale subsistence farming and local market trade. People usually grow maize, vegetables, plantain bananas, cassava, vanilla and coffee. The vast majority of households in this region are very poor by any standards, with an average per capita income of less than USD 300 a year and life expectancy at birth reaching only 46 years, largely due to the effects of malaria and HIV/AIDS (World Development Indicators 2005). 85% of Ugandan inhabitants live in rural areas with similar characteristics (Uganda Bureau of Statistics (UBOS) 2002). Uganda is a low-inflation country and its inflation levels do not differ significantly from those in developed economies.[7]

Data were collected in November 2005 in cooperation with UCDT, a Czech-Ugandan NGO in the ten village areas. Because there are no lists of area residents available to allow us to employ the random selection method we used a combination of the random walk method and quota sampling in our sampling procedure[8]. The target population was restricted to literate individuals above 15 years. Only a few selected individuals did not agree to participate.[9]

A total of 910 respondents participated. The respondents were not time-constrained when filling out the questionnaires. Most of them did not have previous experience with filling out such questionnaires and they approached the task very responsibly. On average they spent one and a half hours answering the questions. In all, 54 questionnaires were not filled out completely[10]. The incomplete questionnaires are excluded from the analysis and our sample size reduced from 910 to 856 respondents.

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[7] The average inflation rate for the period 2000–2004 was 4.3 percent (World Development Indicators 2005).

[8] Our assistants were requested to start a walk from a center of a village (usually school) and to continue towards the sun, outside of the village. They were asked to enter every second house or hut on the right hand side to ask for a participation in our survey. In addition, we stipulated four groups (quotas) in terms of age and education so that the proportion of participants within each of these groups corresponded to the overall rural statistics (UBOS 2002). By the approximate end of the village the assistants were instructed to turn right and continue the walk. The assistants were instructed to continue the random walk until they fulfilled the requested quotas of respondents. We should admit that the implementation of selection procedure was not perfect in every case, but it was still good enough to generate a very diverse sample.

[9] Since there were no lists of people selected to be invited, we do not know the exact number of people who did not agree to participate. We asked social workers who invited the respondents only after the selection was completed and they answered that in general people were willing to participate, considered their participation an interesting event and only exceptionally did not want to fill the questionnaire.

[10] 28 respondents either did not answer consistently the question on discount rate or they did not answer this question at all. Another 26 answered the question on discount rate but did not give information on one of the individual characteristics (usually age, as not knowing one's precise date of birth is quite common in the area).

We collected information on individual characteristics, specifically regarding age, education level, marital status, clan linkage and profession. Table 1 shows the summary statistics of the sample. The level of education was measured by the number of school classes completed by the respondent. The average educational attainment in our sample is higher than that of Uganda as a whole, where only 38% of children complete primary school (UBOS 2002), as compared to 70% in our sample. The questionnaires were bilingual – in English and Luganda – to allow us to approach less educated people who speak only Luganda[11]. Illiterate individuals could not participate. The Ugandan illiteracy rate among people aged over 15 years is 31% (World Development Indicators 2005). Illiteracy explains why our respondents are more educated and younger than the Ugandan averages.

Income is approximated by individual profession since, as we found during a pretest, respondents were generally uncomfortable with revealing their income. The sample is divided into four groups: self-employed farmers, self-employed non-farmers (shopkeepers and drivers), employees (mostly teachers and employees of NGOs) and others (students and those who did not fit any of the previous categories). Strength of clan is a binary variable that indicates self-reported embeddedness within family structures and is based on a survey question about clan influence on fertility decision-making.

The respondents were also asked about mosquito net usage and self-reported importance of child schooling. The purpose of these two variables is to cross-check the relevance of the elicited hypothetical discount rate to actual behavior in delayed-reward situations.

The respondents indicated their village of residence. This information, jointly with age, allows us to approximate access to educational facilities during the individual's school years. We match this information with data from UBOS and the Ugandan Ministry of Education to calculate the number of primary and secondary schools per thousand inhabitants in the given village area for different cohorts.

[11] The official language in Uganda is English. The different local languages reflect the tribal divisions within Uganda. Luganda is the language of the Baganda people – the largest tribe in Uganda.

2.3 Empirical Results

2.3.1 Correlates of discount rate

Although the discount rate is perhaps biologically determined to some degree, it is reasonable to regard it as not immutable. We will now explore how individual characteristics are able to predict the discount rate. In Table 2 we compare the mean discount rate for different sub-groups without controlling for other observable characteristics.

First, we find that more educated individuals have a lower discount rate. For example, men and women who studied at a secondary school have a significantly lower discount rate than those who did not. As described earlier, this correlation has been found in various studies in different contexts. The result is consistent with the proposition that education makes individuals more patient by enhancing their ability to plan and/or by increasing their permanent income (Becker and Mulligan 1997). Alternatively, more patient individuals might be more willing to delay gratification and invest in their human capital. In the next section we will address the issue of causation in detail and examine the impact of education on discount rate.

We find that self-employed farmers and non-farm workers (drivers, shopkeepers) are on average more impatient than employed individuals (teachers, employees of public bodies or NGOs) and students (a large part of the group marked as “other” in Table 2), although employed women have similar level of impatience as farmers. Although individual profession is likely to be an imprecise proxy of income, these results are broadly consistent with the hypothesis that individuals facing less income pressures discount less.

Note that similar concerns about causation discussed with regard to education are relevant to income as well. Becker and Mulligan (1997), for example, argue that wealth (and possibly income) should decrease discount rate because richer people can afford to delay consumption and invest more. Alternatively, a low income may be a result of a high discount rate and the selection of occupation with flat income profile that does not require learning and training (Lawrence 1991; Doepke and Zilibotti 2005). Pender (1996) and Tanaka et al. (2006) found a negative relation between income and the discount rate in India and Vietnam, respectively. Kirby et al. (2002) observed correlation with wealth, but not with income. Anderson et al. (2004) do not find correlation between these two variables, but they point out

that failure to identify it may be due to the difficulty of measuring income among the poor in the field.

Older individuals in our sample discount future income more heavily than their younger counterparts. This relationship accords with the traditional economic argument based on the permanent income hypothesis, in which people are assumed to reflect their current life expectancy in their inter-temporal decisions. The shorter the expected time to death, the higher the discount rate. On average we do indeed observe this pattern; age appears to be a significant predictor of discount rate and has a positive slope.

Numerous studies from low-income countries have reported that a higher share of income in the hands of women leads to less household expenditure on current consumption (e.g., Thomas 1990). There is new experimental evidence from Mexico and India showing that women have a lower discount rate than men (Hamoudi and Thomas 2006, Bauer and Chytilová 2008). As in Kirby et al (2002) and Anderson et al (2004), we have found no evidence for this pattern.

Social arrangements within a family or groups of families (clans) may also affect discount rate. Based on his observations of village institutions in Africa, Platteau (2000) argues that reciprocal claims to financial assistance among clan members may encourage individuals to spend money faster and lower their incentives to save. A similar argument is made in the context of intra-household relations, in which women facing spousal pressure are less likely to save (Anderson and Baland 2002). We have not found any significant difference in the discount rate between married and single respondents. Respondents who report strong clan linkage have a higher discount rate, in accordance with the findings of Platteau (2000). As shown below, this correlation has a rather low level of significance after controlling for other variables, education in particular.

We have identified a close association between education and discount rate. In the bivariate analysis in Table 2 we allowed educated individuals to “carry with them” other characteristics which they typically have, such as income or age, and which may also affect discount rate. To probe this relationship further, in Table 3 we run a series of OLS regressions. The dependent variable is the discount rate. Observations are clustered at the village level if not explicitly specified otherwise.

In Table 3, columns 1-3 we control only for cohort and life-cycle effects by including a set of twelve dummies into the regression, one dummy for each 5-year cohort starting from 1941-45. We find that more educated individuals have a lower discount rate at 1% level. Adding controls for individual profession and family ties leaves the education coefficient and

standard errors almost intact (columns 4-6). In columns 7-9 we also control for potential direct effects of village-area characteristics and include a set of village dummies into the regression, instead of clustering. The main result holds, although the coefficient for men is slightly lower.

Potentially, the results could be affected by our decision to calculate the discount rate values as the arithmetic means of the six inferred ranges. As a robustness check, we have repeated the same analysis as in Table 3 and applied an ordered probit regression instead of OLS. The results are qualitatively similar: a higher level of education predicts a lower discount rate (Appendix, Table A1).

This correlation does not help us determine the direction of the causal relationship between these two factors. Becker and Mulligan (1997) argue that investments in education reduce discount rate, a particularly important conclusion in terms of policy. It is also possible, of course, that people with lower – perhaps born - discount rate are more willing to invest in schooling, which has delayed payoffs, and study longer. Alternatively, there could be an omitted variable, such as intelligence, which would account for both the discount rate and the differences in education level. To our knowledge, as yet there has been no empirical study of discount rate that has tested causal direction in the observed correlation between education and discount rate. The next section estimates the impact of education on discount rate using the instrumental variable technique.

2.3.2 The impact of education on discount rate

A solution to the problem of causal inference requires an exogenous source of variation in education (Card 1999). Long distances to school and a lack of school capacities are widely regarded as major obstacles to higher school attendance in low-income countries, especially in sub-Saharan Africa (World Bank 2002). For example, Duflo (2001) and Duflo and Breierova (2004) have convincingly demonstrated a simultaneous change in education and other variables of interest (e.g., income, fertility or child mortality) resulting from a large scale school construction program in Indonesia.

In this paper we use two different sources of variation in education: different access to schools in different villages and the effect of instability during the Idi Amin era on respective school-age cohorts. Hence, the first instrument exploits primarily the variation by region and the second instrument is based on variation over time. We show that both types of instruments deliver very similar estimates of the effect of education on discount rate for men.

Number of primary and secondary schools

Our first type of instrumental variable is based on the observation that individuals belonging to village areas with better access to schools are more educated. We match our individual survey data with village-area-level data collected by the Ugandan Ministry of Education and Sports and UBOS. We then construct two variables to approximate access to schools: the number of primary schools and the number of secondary schools in a village area per one thousand inhabitants.

These instrumental variables are constructed as follows. We start with the information about the number of primary and secondary schools for each village area and the date on which they were established.[12] We calculate the average number of schools for each five-year period, starting with 1941-1945 and ending with 2001-2005. Due to the rapid population growth in Uganda during 1941-2005 and potential difference in the size of village areas,[13] it is more accurate to measure school access in terms of the number of schools per capita rather then the total number of schools. The number of schools is divided by the population size of the village area. Cohort specific population size of the village area is obtained by adjusting the number of inhabitants in 2002 (UBOS) for average population growth in Uganda (World Development Indicators 2006).[14] Finally, each respondent is assigned the number of primary schools in the village area when she was at the age to start primary school (7 years) and the availability of secondary schools when she was at the age to start secondary school (15 years).

Table 4 shows the average number of schools per thousand people during the period 1941-2005. We can observe substantial variation in secondary school access across village areas, but less so for primary schools. There is only a relatively small differential variation over time across villages. This prevents us from including village fixed effects to the regression analysis as these would capture the effect of varying school availability as we discuss below.

Table 5 illustrates the simple logic of our identification strategy. This table shows the means of education and the discount rate for individuals with above- and below-median

[12] Ideally, one would like to have panel data measuring the number of schools in village areas over time. According to our inquiries with the Ugandan Ministry of Education, these data do not exist, which is not surprising given the periods of instability in Ugandan history. As a consequence, there may be a measurement error in our constructs of school availability due to missing information about schools that were abolished before 2005.

[13] According to the detailed maps which we have received from UBOS, the village areas we study are not very different from each other in terms of geographical size.

[14] Historical statistics about population size in each village area are not available, with the exception of the year 2002. We need to assume that the population growth was the same in all village areas.

access to primary and secondary education facilities (the middle and left sections of the panel, respectively). Although the results are imprecise due to the fact that only a small part of the information is used, we can observe simultaneous change in education and discount rate. Men who live in villages with better access to secondary schools have both higher education and a lower discount rate. The pattern holds with greater uncertainty also for primary schools.

Note that this identification strategy is less suitable for women than it is for men. In southern Uganda, it is common practice for a wife to move to her husband's village following their wedding (Kaduuli 2006). The instrumental variables are based on access to schools in the village area in which the respondents lived at the time of the survey, not where they lived during their schooling age. The marriage-induced migration is likely to introduce a substantial measurement error into our estimates of the effects of schools on education for women, unless there is a strong matching of couples based on achieved education level. In further analysis we will compute the estimates for men and women separately. Indeed, the (non-)results for women showed below are consistent with the notion of substantial migration.

Table 6 presents the main set of results. The lower panel shows the results of the first stage regression, where the dependent variable is years of schooling. The upper panel reports the second stage with the discount rate as the dependent variable. In columns 1-4 the excluded instrumental variable is the number of secondary schools. We start with controlling for cohort effects only. For men, we observe that living in villages with a higher number of secondary schools leads to a higher individual level of education; this relationship is significant at 1% level. The underidentification and weak identification tests do not reject the relevance of the instrument, either. Further, the 2SLS estimates demonstrate a significant negative effect of education on discount rate. The estimated effect using 2SLS is above the corresponding OLS estimate (Table 3, column 2). For women, we observe a negative coefficient of education, though not statistically significant.

The evidence for the causal effect of education on men's discount rate is robust to alternative specifications. In columns 3-4 of Table 6 we add (potentially endogenous) variables that may also affect discount rate, such as income related to a particular profession, marital status and individual ties to his/her clan. The corresponding 2SLS estimate of the effect of education is larger than the one estimated without these controls, although it is not distinguishable statistically. In columns 5-8, primary schools -- instead of secondary schools -- are used as the excluded instrument for education. For men, we find similar results as those

with secondary schools, but with greater uncertainty. For women, we observe that primary schools have no explanatory power for their education, which is not surprising given the above-mentioned marriage migration. Using both primary and secondary schools as instruments delivers very similar estimates of the effect of education as those found in columns 1 and 3, both in terms of the size of the effect and its significance level.

A major threat to this identification strategy is the possibility that there are village-level unobservable characteristics that are correlated with the number of schools and affect discount rate (e.g., demand for education, access to health care). Ideally, we would like to include village fixed effects into our regressions to address this issue. However, our instruments for education in this section are largely based on the variation in schools across villages. To examine further, in the next section we use an instrumental variable that is based on variation over time and show that the results are robust to village fixed effects (similarly as the OLS estimates in Table 3).

Disorder during the era of Idi Amin

Parents are typically less motivated to send their children to school during periods of disorder. Our third instrument exploits the variation in education associated with the period during which the dictator Idi Amin was in power in Uganda (1971-1979). During that time, the country suffered enormous economic decline and it was inevitable that the education system would deteriorate as well (Furley 1988). Government expenditures per head fell to less than a quarter of pre-Amin levels and education expenditures further diminished as an increasing share of resources was diverted for military purposes (Stewart et al. 1997, Collier and Reinikka 2001). Amin, himself illiterate, and his regime is known for being highly suspicious of the loyalty of educated people, many of whom where targeted by the army or exiled (Furley 1988). When Amin declared an "economic war" in 1972 and expelled the Asian community out of the country, an exodus of European expatriate teachers followed, leaving enormous gaps in the teaching staff. The breakdown of contract enforcement mechanisms led to a high incidence of teachers' absenteeism (Collier and Reinikka 2001). The quality of education declined sharply as a result.[15] Appleton et al. (1996) use UNESCO estimates and report decreases in primary school enrollment between 1965 and 1975.

[15] There is only anecdotal evidence of the impacts on education infrastructure. Heyneman (1983) reports the effects on six schools in south Uganda (Mpigi district – close to Mukono district). In 1971 there was on average one chair for every 1.2 pupils; in 1981 there was one chair for every 8.8 pupils. Four out of the six schools did not have a single textbook in 1981, whereas these four schools had on average 84 textbooks in 1971.

To approximate the extent to which individual education is affected by this period of instability, we simply calculate the number of years of the respondent's primary schooling age (7-14 years of age) that overlap with the period 1971-1979. We expect that the higher the overlap, the lower the education level. In Figure 1 we show that before Amin the education of men had increasing trend, but the education of cohorts that were of primary-school age during Amin's era departs from this trend. Overall, as the exposure of respondents' schooling age to the Amin era increases, their level of education decreases. Those who were born in 1964-65 and therefore passed their entire primary school years during Amin's era seem to be the most affected. After this cohort, the level of education goes up again. For women, the education level continued to increase, even during the era of Amin's rule, which suggests that the years of exposure is not a valid instrument for them. Finding reasons for this differential pattern is rather a speculative exercise; perhaps it is due to the fact that cultural barriers against educating women gradually diminished over time and overweighed the economic factors that reduced the level of education for boys.

Table 7 shows the main results of this instrumental strategy. In columns 1-4 we cluster the standard errors at the village level. In columns 5-8 we control directly for village fixed effects. Exposure to Amin's era lowers the education of men, whereas it does not affect women's education. In the second stage, we find that a higher level of education reduces men's discount rate. Village fixed effects do not change the magnitude of the estimates, although they have now become only marginally significant (p-value=0.13). Interestingly, the magnitude of all these estimates is very similar to the magnitude of those we obtained when using the measures of school access as instruments (Table 6).

Our estimates could potentially be biased if the exposure to political instability during childhood affected time discounting via a channel other than schooling that persists over time (e.g., psychological trauma). Note that this type of threat to the identification strategy is orthogonal to the concerns discussed with respect to the former set of instruments.

2.4 Conclusions

The paper aims to contribute to the rich literature that studies the causes of the low levels of saving and investment in rural parts of low-income countries. The paper focuses on the formation of time discounting as a possible explanation of this important issue and it demonstrates a causal effect of education on subjective discount rate in ten village areas in southern Uganda.

First, we study various socioeconomic characteristics that were suggested in earlier literature as possible determinants of time preference. The discount rate emerged significantly correlated with completed years of schooling: more educated respondents are more patient. We also found several other intuitive relationships: the respondents with a lower discount rate are more likely to make choices with delayed rewards, such as using a mosquito net or assigning higher importance to schooling of their offspring.

To our knowledge, comparable studies that elicit discount rate have not attempted to depart from the observed correlation between education and discount rate by testing the impact of education on discount rate. In order to do so, we exploit two independent exogenous sources of variation in schooling: across villages and over time. The first set of instrumental variables is based on differential access to primary and secondary schools in different villages. The second type is based on the number of individual school-age years that overlap with the rule of Idi Amin (1971-79) -- a period of overall instability characterized by a drastic decline in quality of education. For men, both instrumental variables strongly predict individual education in the expected direction. The 2SLS estimates demonstrate a significant effect of education on men's discount rate. Both types of instrumental variables deliver estimates of similar magnitude. The results are robust to the inclusion of a set of dummies for cohort effects, individual characteristics such as profession, family status, and, in the case of the latter instrument, for village fixed effects.

This evidence is consistent with several specific channels through which education may affect discounting. First, schooling may promote the creation of cognitive skills and the ability to simulate and plan for the future (McClure et al. 2004, Becker and Mulligan 1997). Second, education may play an important role in developing control mechanisms to manage the temptations of present consumption. This understanding resonates with the increasingly loud calls among development economists for the exploration of not only the structural constraints that poverty imposes on the decision-making of the poor but for taking seriously also the internal barriers to saving and investing in the absence of suitable institutions (Duflo 2006; Armedáriz de Aghion and Morduch 2005). A recent study from rural India (Bauer et al. 2008), however, finds that education correlates with the level of discounting, but not with present-biased (or hyperbolic) discounting. Third, education may enhance health prevention and reduce mortality risk, which might make individuals more willing to delay their spending. Another explanation is that more educated individuals are less likely to be income constrained and face lower pressures to spend money sooner. Although the results are robust

to controlling for individual profession, it might be an imperfect proxy for income and education may capture the effect of income instead.

The capacity of education to reduce time discounting further emphasizes its prominent position in debates about economic development. It has been widely observed in cross-country analyses that standard estimates of the contribution of additional schooling to economic growth, based on productivity differences associated with differences in the level of schooling, cover only a relatively small portion of the total correlation between education and subsequent growth (Bils and Klenow 2000; Banerjee and Duflo 2004). Similarly, World Bank (2006) acknowledges that "*education impact on economic growth is well-established; precisely how this happens is less well-understood."* In addition to the role of education as a factor in the aggregate production function, there might be other effects of education that contribute to economic growth, such as its impact on fertility or health (Case 2006). The evidence from Ugandan villages may start teasing researchers and policy-makers with the proposition that there might be a new channel through which education promotes development – by shaping individual time discounting.

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Chart 1: Average education of men and year of birth

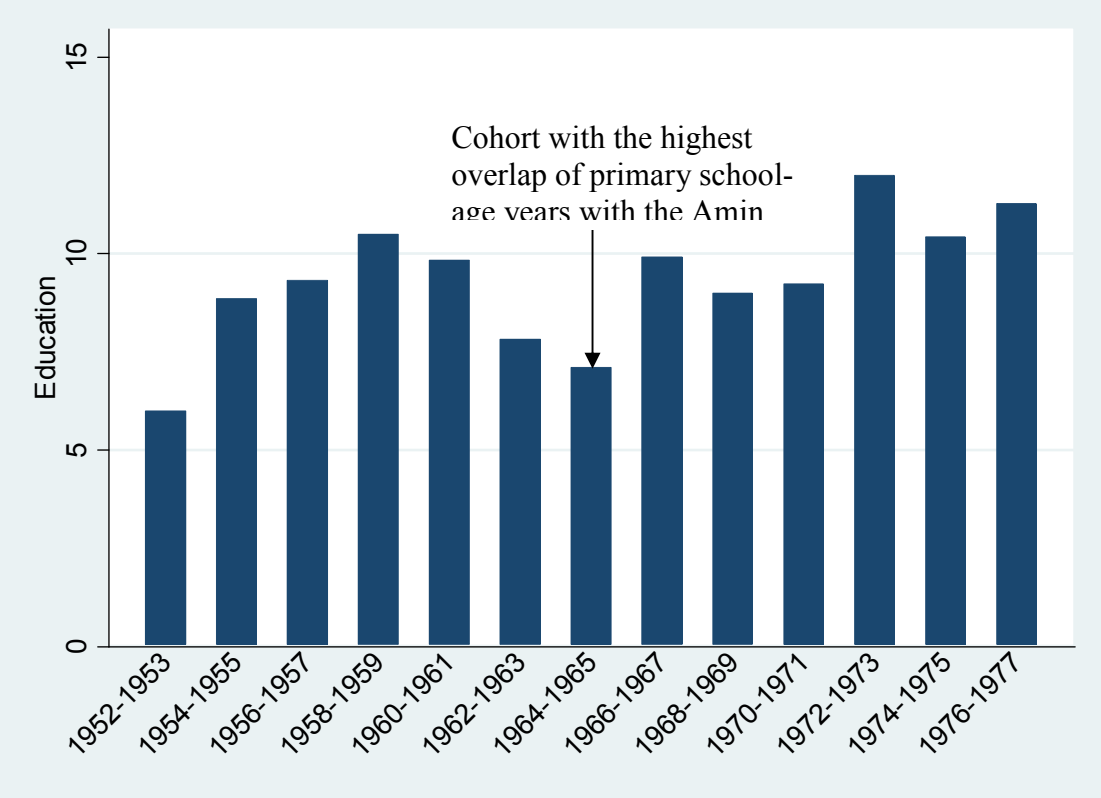

Table 1: Sample descriptive statistics (means)

	Total	Sex		Age group		
		Male	Female	15-19	20-29	30-74
Frequency:						
N	856	465	391	324	291	241
Sample	1.000	0.543	0.457	0.379	0.340	0.282
Rural Uganda[+]	1.000	0.475	0.525	0.222	0.314	0.464
Education:						
Completed PS - sample	0.701	0.740	0.655	0.799	0.742	0.519
Completed PS - rural Uganda[+]	0.382	0.426	0.336	0.440	0.459	0.301
Completed SS - sample	0.074	0.086	0.059	0.000	0.134	0.100
Completed SS - rural Uganda[+]	0.064	0.080	0.048	0.015	0.097	0.065
Age:						
Sample	25.811	26.112	25.453	16.935	24.017	39.909
Rural Uganda[+]	31.921	31.884	31.955	16.897	24.116	44.411
Family:						
Married	0.431	0.411	0.455	0.068	0.436	0.913
Strong clan linkage	0.188	0.252	0.113	0.179	0.141	0.257
Profession:						
Farmer	0.409	0.359	0.468	0.148	0.447	0.714
Non-farm self-employed	0.057	0.075	0.036	0.009	0.065	0.112
Employed	0.131	0.140	0.120	0.006	0.241	0.166
Other	0.403	0.426	0.376	0.836	0.247	0.008

NOTE.- [+] Source: Uganda Bureau of Statistics (2002), data for population of rural Uganda in the age group 15-74.

Table 2: Average discount rate across education levels (means and standard deviations)

	All	Men	Women
Education:			
Lower PS (1-4 classes)	4.598	3.643	5.303
	(2.715)	(3.039)	(2.280)
Higher PS (5-7 classes)	4.519	4.551	4.489
	(2.634)	(2.682)	(2.601)
Lower SS (8-9 classes)	3.911	4.106	3.625
	(2.914)	(2.837)	(3.020)
Higher SS (10-13 classes)	3.447	3.398	3.508
	(2.907)	(2.870)	(2.960)
Completed SS and higher education	3.218	2.850	3.859
	(2.787)	(2.828)	(2.652)
Age:			
Young (<19)	3.368	3.679	3.016
	(2.915)	(2.902)	(2.899)
Middle-aged (20-29)	3.989	3.701	4.312
	(2.805)	(2.810)	(2.773)
Old (>29)	4.339	4.020	4.775
	(2.757)	(2.876)	(2.536)
Clan linkage:			
Weak	3.718	3.614	3.823
	(2.899)	(2.899)	(2.900)
Strong	4.433	4.308	4.767
	(2.607)	(2.694)	(2.357)
Profession:			
Farmer	4.358	4.219	4.485
	(2.719)	(2.794)	(2.650)
Non-farm self-employed	4.020	3.907	4.304
	(2.655)	(2.651)	(2.742)
Employed	3.897	3.419	4.559
	(2.875)	(2.964)	(2.637)
Other	3.301	3.525	3.000
	(2.932)	(2.894)	(2.966)

Table 3: Correlates of discount rate: OLS

Dependent variable	Discount rate (%)								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	all	male	female	all	male	female	all	male	female
Education (years)	-0.171	-0.160	-0.172	-0.170	-0.168	-0.171	-0.156	-0.115	-0.182
	(0.045)***	(0.061)**	(0.032)***	(0.048)***	(0.066)**	(0.035)***	(0.045)***	(0.065)*	(0.067)***
Farmer				0.259	-0.318	0.705	0.433	-0.074	0.770
				(0.373)	(0.596)	(0.260)**	(0.349)	(0.493)	(0.530)
Non-farm self-employed				-0.051	-0.540	0.345	-0.126	-0.585	0.276
				(0.545)	(0.738)	(0.763)	(0.518)	(0.644)	(0.949)
Employed				0.507	-0.203	1.276	0.494	-0.306	1.300
				(0.389)	(0.460)	(0.539)**	(0.414)	(0.581)	(0.622)**
Married				-0.217	-0.090	-0.451	-0.253	-0.241	-0.391
				(0.244)	(0.309)	(0.334)	(0.296)	(0.449)	(0.416)
Clan linkage				0.470	0.465	0.580	0.364	0.409	0.526
				(0.275)	(0.351)	(0.465)	(0.254)	(0.322)	(0.468)
Constant	5.451	2.459	8.397	5.405	2.913	8.129	4.659	2.483	7.571
	(2.051)**	(0.368)***	(0.352)***	(2.107)**	(0.911)**	(0.426)***	(2.089)**	(2.968)	(3.030)**
Cohort effects	yes	yes	yes	yes	yes	yes	yes	yes	yes
Village fixed effects	no	no	no	no	no	no	yes	yes	yes
Observations	856	465	391	856	465	391	856	465	391
R-squared	0.06	0.06	0.10	0.06	0.06	0.11	0.10	0.12	0.13

NOTE. - The dependent variable is the discount rate calculated from the binary choices between amount now and after one year. In columns 1-6 standard errors are corrected for clustering at the village level. In columns 7-9 we control for village fixed effects. In all columns we control for age cohort effects by including 12 dummies, one for each 5-year cohort starting from 1941-45.

* Significant at 10%.

** Significant at 5%.

*** Significant at 1%.

Table 4: Average number of schools per thousand people in the period 1941-2005 (means and standard deviations)

	Primary Schools	Secondary Schools
Buikwe	0.814	0.017
	(0.274)	(0.041)
Busagazi	0.675	0.013
	(0.451)	(0.047)
Bweyogerere	0.938	0.102
	(0.329)	(0.197)
Kasolo	0.675	0.067
	(0.255)	(0.101)
Kateete	0.898	0.016
	(0.293)	(0.030)
Kigaya	0.592	0.030
	(0.296)	(0.073)
Kikube	0.694	0.005
	(0.211)	(0.018)
Kirugu	0.529	0.031
	(0.383)	(0.061)
Nakifuma	0.978	0.012
	(0.370)	(0.030)
Lugasa	1.107	0.144
	(0.365)	(0.131)

Table 5: Education and discount rate across secondary schools, primary schools and living during conflict era (means and standard deviations)

	SS accessibility			PS accessibility			At PS age during conflict		
	lower	higher	difference	lower	higher	difference	yes	no	difference
All									
Education	8.998	10.031	1.033**	9.421	9.599	0.178	8.717	9.645	0.928**
	(3.093)	(2.652)		(2.746)	(3.112)		(3.127)	(2.873)	
Discount rate	4.153	3.543	-0.610**	3.732	3.981	0.249	4.520	3.736	-0.784**
	(2.813)	(2.876)		(2.835)	(2.882)		(2.730)	(2.867)	
Men									
Education	9.276	10.356	1.080**	9.586	9.996	0.410	9.175	9.912	0.737**
	(3.276)	(2.381)		(2.830)	(3.037)		(3.306)	(2.842)	
Discount rate	4.118	3.418	-0.700**	3.840	3.733	-0.107	4.341	3.673	-0.668
	(2.813)	(2.877)		(2.812)	(2.929)		(2.855)	(2.854)	
Women									
Education	8.703	9.799	1.096**	9.227	9.122	-0.105	7.936	9.346	1.410**
	(2.719)	(2.991)		(2.638)	(3.142)		(2.649)	(2.881)	
Discount rate	4.005	3.930	-0.075	3.606	4.278	0.672**	4.824	3.807	-1.017**
	(2.874)	(2.840)		(2.875)	(2.803)		(2.503)	(2.884)	

NOTE. - ** significant at 5% level (t-test). Higher and lower level of accessility is divided according to the median value of the measures.

Table 6: The effect of education on discount rate: 2SLS (Instrumental variables: Access to primary and secondary schools)

	IV: Number of secondary schools				IV: Number of primary schools				IV: Number of primary and secondary schools			
Cohort effects	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observable characteristics	no	no	yes	yes	no	no	yes	yes	no	no	yes	yes
Village fixed effects	no	no	no	no	no	no	no	no	no	no	no	no
	2SLS: Discount rate (%)											
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	male	female	male	female	male	female	male	female	male	female	male	female
Education (years)	-0.600	-0.085	-0.948	-0.115	-0.702	17.132	-0.960	19.149	-0.591	-0.313	-0.948	-0.315
	(0.234)**	(0.166)	(0.320)***	(0.162)	(0.525)	(599.749)	(0.630)	(671.537)	(0.232)**	(0.180)*	(0.320)***	(0.169)*
	First stage: Education (years)											
Number of SS	4.949	2.684	3.125	3.096					5.611	4.335	3.398	5.022
	(0.728)***	(1.265)*	(0.759)***	(1.101)**					(1.032)***	(1.969)*	(1.123)**	(1.536)***
Number of PS					1.096	0.036	0.775	0.032	-0.679	-1.660	-0.274	-1.913
					(1.108)	(1.344)	(0.683)	(1.212)	(0.594)	(1.064)	(0.526)	(0.683)**
Underidentification test (p-value)	0.070	0.227	0.069	0.150	0.422	0.977	0.372	0.977	0.021	0.213	0.093	0.081
Weak identification test (F stat.)	46.273	4.504	16.933	7.905	0.978	0.001	1.288	0.001	18.405	2.562	9.348	6.399

NOTE. - Standard errors corrected for clustering at village level. The lower panel reports results from the first stage regression where the dependent variable is the years of schooling. The upper panel shows the results for the second stage where the dependent variable is the discount rate. In columns 1-4 the instrumental variable is the number of secondary schools per thousand of inhabitants in the particular village area when an individual was at the age of 15 years. In columns 5-8 the instrumental variable is the number primary schools per thousand of inhabitants in the particular village area when an individual was at the age of 7 years. In colums 9-12 both the number of primary and secondary schools are used as instrumental variables. In all regressions we control for cohort effects. In columns 3-4,7-8 and 11-12 we include also the other individual characteristics listed in Table 3.

* significant at 10%.

** significant at 5%.

*** significant at 1%.

Underidentification test statistic is Kleibergen-Paap rk LM statistic. The null hypothesis is that the equation is under-identified, i.e. that the excluded instruments are uncorrelated with the endogenous regressor. Weak identification test statistic is Kleibergen-Paap rk Wald F statistic. The null hypothesis is that excluded instruments are correlated with the endogeous regressor, but only weakly. A commonly used critical value for this test is approximately 10 (Baum et al. 2007).

Table 7: The effect of education on discount rate: 2SLS (Instrumental variable: number of years during Amin's era 1971-1979)

	IV: Number of school-age years during Amin era (1971-1979)							
Cohort effects	yes	yes	yes	yes	yes	yes	yes	yes
Observable characteristics	no	no	yes	yes	no	no	yes	yes
Village fixed effects	no	no	no	no	yes	yes	yes	yes
	2SLS: Discount rate (%)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	men	women	men	women	men	women	men	women
Education (years)	-0.653	-0.437	-0.623	-0.382	-0.588	-1.046	-0.581	-1.015
	(0.371)*	(1.239)	(0.369)*	(1.074)	(0.400)	(2.653)	(0.383)	(2.187)
	First stage: Education (years)							
At PS age during war (years)	-0.602	0.260	-0.602	0.268	-0.565	0.139	-0.575	0.157
	(0.218)**	(0.434)	(0.210)**	(0.309)	(0.203)***	(0.274)	(0.155)***	(0.231)
Underidentification test (p-value)	0.039	0.530	0.032	0.372	0.005	0.602	0.000	0.484
Weak identification test (F stat.)	7.611	0.360	8.259	0.751	7.736	0.257	13.833	0.458

NOTE. - In columns 1-4 the standard errors are corrected for clustering at village level, in columns 5-8 we control for village fixed effects. The lower panel reports results from the first stage regression where the dependent variable is the years of schooling. The upper panel shows the results for the second stage where the dependent variable is the discount rate. In all regressions the instrumental variable for education is the number of school-age years that overlap with the the era of Idi Amin (1971-1979). We control for age cohort effects and in columns 3-4,7-8 and 11-12 we include also the other individual characteristics listed in Table 3.
* significant at 10%.
** significant at 5%.
*** significant at 1%.

Underidentification test statistic is Kleibergen-Paap rk LM statistic. The null hypothesis is that the equation is under-identified, i.e. that the excluded instruments are uncorrelated with the endogenous regressor. Weak identification test statistic is Kleibergen-Paap rk Wald F statistic. The null hypothesis is that excluded instruments are correlated with the endogeous regressor, but only weakly. A commonly used critical value for this test is approximately 10 (Baum et al. 2007).

Table A1: Correlates of discount rate: Ordered probit

Dependent variable	Discount rate								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	all	male	female	all	male	female	all	male	female
Education (years)	-0.067	-0.051	-0.083	-0.066	-0.052	-0.086	-0.061	-0.033	-0.088
	(0.018)***	(0.027)*	(0.015)***	(0.022)***	(0.030)*	(0.017)***	(0.019)***	(0.027)	(0.029)***
Cohort effects	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observable characteristics	no	no	no	yes	yes	yes	yes	yes	yes
Village fixed effects	no	no	no	no	no	no	yes	yes	no
Observations	856	465	391	856	465	391	856	465	391

NOTE. - For female (columns 3,6 and 9) convergence was not achieved; the reported results are after fifth iteration. In columns 1-6, standard errors are corrected for clustering at the village level. In columns 7-9, village fixed effects are included. In all columns age cohort effects are controlled for (dummies for five-year period when an individual was 7 years old, i.e. at the age to start to attend primary school). In columns 4-9 observable characteristics are controlled for (dummies for farmer, non-farm self-employed, employed, married and strong clan linkage).
* Significant at 10%.
** Significant at 5%.
*** Significant at 1%.

Table A2: Distribution of choices in time preference question

Patient					Impatient	Total
200,000<X <250,000	250,000<X< 500,000	500,000<X< 800,000	800,000<X< 1200,000	1200,000<X <1500,000	1500,000< X	
137	113	73	72	35	426	856
16%	13%	9%	8%	4%	50%	100%

3 Behavioral Foundations of Microcredit: Experimental and Survey Evidence From Rural India

Abstract

Microcredit is celebrated as an innovative tool to reduce poverty. We integrate experimental measures of time discounting and risk aversion for a sample of 573 villagers in south India with survey data on their financial activity. The data show that the demand for microcredit loans is tied to time-inconsistent preferences. Women with hyperbolic preferences save less at home and save less in total levels. They are also more likely to borrow generally, but to do so through microcredit institutions specifically. The finding suggests that the structure of microcredit loan contracts helps people with self-discipline problems who lack suitable saving devices.

Keywords: time preference, hyperbolic discounting, loan contracts, microfinance

JEL classification: C93, D91, O12

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3.1 Introduction

The Nobel Peace Prize in 2006 celebrated the potential of microcredit to transform the lives of small-scale entrepreneurs by providing access to small loans. Microcredit advocates argue that such access to credit will unleash the productive potential of poor households (Yunus 2002). Microcredit providers are drawn together by shared commitments to offer small-scale transactions, serve the under-served, and use innovative contracts to compensate for the fact that most customers lack collateralizable assets that can be used to secure loans (Armendáriz and Morduch, 2005).

The success of microcredit, though, poses a puzzle: if the untapped economic returns to borrowing are so high, why don't households save their way out of credit constraints? New work in behavioral economics helps to answer that question by focusing on psychological conflicts that undermine efforts to save. The focus has been on self-discipline problems that persist in the absence of savings devices that foster regular deposits and that limit withdrawals. One of the hidden challenges faced by the poor is posed by the lack of access to such mechanisms.

These behavioral insights suggest a new view of microcredit, and they point to an often-overlooked feature of contracts that, in principle, provides a mechanism that substitutes for missing savings devices. This is the near-universal requirement that loans be repaid in regular, frequent, fixed installments over time (Rutherford 2000, Armendáriz and Morduch 2000). An unusual feature of microcredit contracts is that borrowers must typically repay loans in weekly or monthly installments beginning at the very start of the loan, well before investments can be expected to bear fruit. Money to pay installments must, of necessity, come at least in part from other income earned by households, such as from wage work. The repayment process thus looks and feels much like the process of saving in regular increments from earned income. To draw the link, Rutherford (2000) describes traditional saving behavior as "saving up" and borrowing in this form as "saving down." In a textbook loan contract, by contrast, the principal and interest are paid in a single, large payment after profits are reaped.[1]

In drawing the link between microcredit borrowing and saving, we focus on specific problems that emerge when, intellectually, people value future consumption but they nonetheless give in to the temptation to consume today. The internal tension is often depicted

[1] See Armendáriz and Morduch (2005) on the logic of microcredit repayment schedules, and Field and Pande (2007) for a field experiment from urban India.

as a conflict between a patient "future self" and an impatient "present self" (Schelling 1984, Strotz 1955, Ainslie 1992), a tension captured parametrically by "hyperbolic" discount rates rather than standard linear discounting (Laibson 1997). Our findings relate hyperbolic preferences to microcredit borrowing.

We study villagers in India who are the target customers of microcredit providers. The microcredit banks in the villages are run on a "self-help group" model promoted by the Government of India and inspired by Grameen Bank of Bangladesh, the co-winner of the 2006 Nobel Peace Prize. We conducted a series of "lab experiments in the field" designed to elicit measures of discounting and risk aversion for a random sample of 573 villagers spread across eighteen villages in two regions of Karnataka, a coastal state in South India. (These are "artefactual field experiments" in the classification scheme of Harrison and List, 2004.) The questions were not hypothetical: the experiments concerned choices over relatively large stakes, as large as a week's wage (as in Tanaka, et al 2006, and Binswanger 1980), and the structure of the questions allow us to infer intervals for discount rates and evidence of time inconsistency. We construct measures of hyperbolic discounting and relate the measures of time discounting and risk aversion to survey data on the economic and financial lives of the households, including participation in microcredit organizations.

The experiments identify roughly one third of the population as exhibiting choices consistent with hyperbolic discounting. Those in this group discount the future more heavily when asked a series of questions about the preference to consume now versus in three months, relative to the degree of discounting implicit in how they answer similar questions about consumption in twelve months versus fifteen months.

In our sample, women in the "hyperbolic" group tend to hold a smaller share of their overall savings at home, a finding consistent with a desire to avoid the everyday temptation of depleting cash on hand. Women in the hyperbolic group are also more likely than other women to join local microcredit organizations, and more likely to borrow from them (after controlling for their baseline degree of time discounting). While we find that women are generally interested in opportunities to borrow, women with hyperbolic preferences are especially likely to do so via microcredit. The results are robust to including a range of observable individual characteristics, evidence on seasonal income patterns, and measures of intra-family decision-making power.

The evidence is consistent with the notion that microcredit borrowing offers helpful structure for people with self-discipline problems who seek to accumulate capital but who lack convenient contractual saving devices. In a different world—one in which villagers

weren't vulnerable to time-inconsistent behavior and/or had attractive contractual saving devices—the households might only save (or at least would borrow less). But in an imperfect world, the nature of microcredit contracts makes borrowing an alternative way to steadily transfer money to a bank and end up with a "usefully large sum" (Rutherford 2000). In this sense, borrowing and saving are drawn together as substitute mechanisms used toward similar ends.

The next section describes self-help groups. Section 3 describes the economics of self-control. Section 4 describes the sample selection, experimental design for eliciting subjective discount rates, and the survey data. Section 5 presents the empirical results on determinants of patience and time inconsistencies. Section 6 discusses how the experimental choices correlate with observed financial behavior and describes alternative hypotheses. Section 7 concludes.

3.2 Self-help groups and microcredit

Self-help groups (SHGs) are the main source of microcredit in India. SHGs are the major providers of financial services in our sample, although moneylenders, banks, and postal savings schemes also operate in the communities. SHGs are based on groups formed endogenously in communities, sometimes facilitated by NGOs. The groups comprise 10-25 people, and groups gather regularly, typically every week, to pool their savings and lend from their accumulated pot to members at an interest rate designed to cover costs (Seibel 2005). SHG expansion has been driven by an initiative of the government's National Bank for Agriculture and Rural Development (NABARD) to encourage linkages between non-governmental organizations and commercial banks. The SHGs are permitted as informal entities to obtain bank loans and the whole group is responsible for the loan repayment. By March 2007, 2.92 million SHGs were providing services to 41 million members (NABARD 2007).

SHGs predominantly attract women, although no bias is built into the program design. In our sample, 76 percent of group members are women. The participation rate within our sample is 46 percent and this number is very similar in both regions we study. No village has fewer than 20 percent of individuals participating in an SHG.

All SHG members must deposit regularly into compulsory savings accounts (deposits average Rs. 40 per month[2]). These accounts have tight withdrawal restrictions: savings may only be

[2] At the time of our study the exchange rate was 40.6 Indian rupees per US dollar.

withdrawn when a member leaves a group or if there are exceptional circumstances. This kind of forced saving aids the SHG by creating collateral that can be tapped in times of trouble, but it is of limited immediate value as savings for customers.

Two thirds of SHG participants have a loan, with an average size of Rs. 6,708 (about $170). The interest rate charged by banks to SHGs is about 20 percent annually (which makes the real interest rate approximately 15 percent)[3]; the interest rate for individual loans is at the discretion of SHGs and varies. A recent survey of SHGs shows that 83 percent of loans were used for production or other purposes—notably agricultural production, animal husbandry, and microenterprise--rather than consumption (Consultative Group to Assist the Poor 2007).

3.3 Self-control and financial behavior

The degree of time discounting is essential in making saving and investment decisions. The behavioral economics literature has pushed further, based on experimental evidence that discount rates often vary with the time frame (Frederick et al. 2002). In particular, people are often more impatient for current trade-offs than for future tradeoffs (Strotz 1955, Ainslie 1992). This is captured parametrically by hyperbolic (or "quasi-hyperbolic") time discount functions (Laibson 1997). Hyperbolic preferences create a tension between future plans and current actions. If individuals are "sophisticated" enough to realize it, they may demand a commitment to "tie their hands" now. If they are "naïve" and do not address their inconsistencies, individuals may later regret their decisions (O'Donoghue and Rabin 1999). For sophisticated people with hyperbolic preferences, for example, savings rates should rise when given the choice to opt into savings devices that incorporate commitments to save regularly and that limit withdrawals. The cardinal feature of the devices is to keep present temptations at bay by contracting to deposit money in fixed increments at pre-specified times. These kinds of devices take many forms. In richer countries, the most common is direct-deposited pension accounts; in poorer communities, a range of informal devices share this feature, including community-run savings clubs and rotating savings and credit associations (Rutherford 2000).

Hyperbolic preferences have been invoked to explain a growing range of economic puzzles in poor countries. Duflo, Kremer and Robinson (2005) observe patterns consistent with sophisticated hyperbolic preferences in their field experiments on fertilizer adoption,

[3] India is a relatively low-inflation developing country. The annual rates of inflation were 4.3%, 5.8% and 6.4% in 2005, 2006 and 2007, respectively.

Mullainathan (2005) argues that time inconsistent preferences help explain erratic school attendance. Gugerty (2007) similarly interprets the widespread use of informal rotating savings and credit associations (ROSCAs) as a commitment device to overcome time inconsistencies faced by savers. She observes that participants value public pressure to make regular saving deposits; as some ROSCA participants put it, "you can't save alone." In keeping with this, Armendáriz and Morduch (2005) highlight difficulties saving at home, and they invoke savings difficulties as a rationale for why popular informal savings and borrowing institutions such as ROSCAs do not fall apart. By keeping money at a distance or by imposing rigidity to its access, spending may be much less tempting in the presence of immediate pressures (Mullainathan 2005). Basu (2007) uses hyperbolic preferences as the basis of a theoretical treatment that explains why individuals simultaneously save and borrow, a pattern commonly observed by microcredit practitioners. He argues that the existence of sanctions in the case of loan default provides incentives for discipline that make paying back a loan easier for individuals with hyperbolic preferences than regularly building up savings accounts. Self-control problems, although present around the world, may matter more in poor countries where immediate pressures are greater and mechanisms to help with self-control problems are more limited.

Ashraf et al. (2006) illustrate the link between time preference inconsistency and savings rigidity. They offered savers of a rural bank in the Philippines the opportunity to save using a new product that differed from the existing ones only by restricting access of savers to their deposits until either given maturity or given amount was achieved. They find that 28 percent of those being offered the commitment product accepted it. Women who demanded the "commitment" product were more likely to have hyperbolic time preferences—and access to such accounts notably increased their short-term saving.

We turn here to the link between hyperbolic preferences and borrowing decisions. As noted, savings with commitment and paying credit in installments are very similar in terms of the pressure to follow an intended course of action by taking regular steps. For example, Strotz (1955) and more recently Laibson (1997) highlight this similarity. Borrowing, though, is a roundabout way to save, and it is costly. While most people expect to earn interest on saving deposits, evidence shows that people are willing to pay to save when options are limited. The saving device tested in the Philippines, for example, was valued by the women although costly to them in that the accounts offer no extra compensation for the associated illiquidity. Similarly, in Ghana, local deposit collectors are a common part of the informal financial sector, charging customers a substantial fee for a simple, secure, disciplined ways to

save. One calculation shows that in South India, a similar form of deposit collector who takes savings from their customers each day, returning the accumulation after 220 days, charges depositors a fee equivalent to 30 percent of deposits on an annualized basis.[4] In parallel with such devices, microcredit borrowing can be an effective next-best accumulation device.

An alternative reason why the poor may demand commitments like these stem from household conflicts. In this case individuals do not seek to discipline their own preferences, but try instead to "discipline" the preferences of other household members (often spouses). Anderson and Baland (2002) show that the need to protect savings from their husbands triggers women's participation in ROSCAs in a Kenyan slum. They find a notable "inverted-U" shaped pattern in their data: women who have little autonomy from their husbands are unlikely to join ROSCAs, as are women with great autonomy (since they do not need the protections that ROSCAs afford). Women in a middle range, though, are particularly likely to be ROSCA participants. In the work below, we find that the effect of hyperbolic preferences is robust to including measures of individual autonomy and power within households.

3.4 Experimental and survey design

Although much has been written about time discounting, experimental evidence is largely limited to laboratory environments in developed countries. A significant contribution is Harrison et al. (2002) and Andersen et al. (2008) who estimate the subjective discount rate among a representative sample of the Danish population. Several innovative studies, typically in low-income countries, employ experimental tasks to predict behavior outside of labs to study motivations behind behavioral choices.[5] In our study we are primarily interested in whether people with time inconsistent preferences behave differently from those having consistent preferences.

3.4.1 Sample selection

The survey design generated a varied sample of the rural population of Karnataka. Data were collected in June 2007 in cooperation with BPKS, an Indian NGO in Honavar and Haliyal taluks (a taluk is an administrative unit akin to a county, part of a larger district within a state).

[4] See Rutherford (2000) and the discussion in Armendáriz and Morduch (2005).
[5] For example, Binswanger (1980) and Liu (2008) elicit individual attitudes to risk and observe correlations with agricultural behavior. Karlan (2005) uses the results of trust games to predict default among clients of FINCA. Tanaka et al (2007) take an approach similar to ours. Thomas and Hamoudi (2006) measure discounting, risk aversion, and altruism to study motivations behind inter-generational exchanges.

Honavar is a coastal region and, of the two, is more developed in terms of infrastructure, market access and access to education and financial facilities. Figure 1 provides a map and Table 1 compares the two taluks on a range of variables. Nine villages were selected from each taluk, and 35 people were selected in each village using a random walk method.[6] Those identified were invited to participate in the study, and 90 percent did. The total number of participants was 573, with no fewer than 25 participants per village.
We used village meeting halls, typically schools, as field labs. The very high response rate stemmed in part from the support of village heads. Self-selection concerns are limited by the high take-up rates.

Table 2 compares the sample characteristics with Karnataka averages from 2001, restricted to the population older than 15 years. The average age and education levels are not statistically different, but we have a slightly lower proportion of illiterate respondents in our sample (40 percent compared with 43 percent in the entire state). This may reflect increases in enrollment ratios in 1980s and 1990s. Age of marriage is typically higher in urban areas that are included in the Karnataka average, while our respondents are villagers and therefore more likely to be married. Although the selection strategy was not intended to generate a representative sample of rural population of Karnataka, the sample captures its variety.

3.4.2 Measuring discount rates and risk aversion

We used a simple protocol to elicit discount rates, drawing on practices common in developed and developing countries (e.g. Harrison et al. 2002; Tanaka et al. 2006).[7] Respondents were asked to choose between receiving smaller amount earlier in time or larger amounts with three months delay. We start with: "Do you prefer Rs. 250 tomorrow or Rs. 265 three months later?"

We posed five such questions to each individual, with each question increasing the future amount up to Rs. 375 while keeping the earlier amount constant. We thus made the

[6] The villages were randomly selected based on the 2001 Indian Census database; however, in three villages in each taluk the BPKS did not have a good access and knowledge of a village head. These were replaced with other villages that were similar in size, distance to town and educational facilities to the ones originally selected. The random walk method was designed in a standard way. Our assistants were requested to start a walk from a center of a village (usually school) and to continue towards the sun, outside of the village. They were asked to enter every second house or hut on the right hand side to ask for a participation in our survey. Only one individual from each household was allowed to participate in the survey. In cases when there were more individuals living in a house, the assistants were requested to write a list and randomly select one.

[7] In their surveying article Cardenas and Carpenter (2005) classify this methodology as the "choice task method." For a discussion on relative advantages of using "choices task method" vs. alternative "matching-task method" see Frederick et al. (2002). Our decision to use a "choice task method" was made largely on the basis of simplicity given the low education levels in the area and based on our negative previous experience with the matching-task method during a pre-testing for our study in Ugandan villages (section 2 of this dissertation).

choice to delay increasingly more attractive in each subsequent binary choice (Table 3, Panel A gives the choices). The point at which an individual switches from choosing the earlier reward to the future reward gives an interval of her discount rate. In the analysis we use the arithmetic means of these intervals to approximate individual discount rates (for specific values see Table 5). Five percent of respondents switched more than once, and nothing could be inferred about their discount rate. Such choices are uncorrelated with observable characteristics and the respondents were excluded from the analysis, reducing our sample to 544.

The same set of binary choices was also offered at a future time frame (as in Ashraf, et al. 2006). Here, we started with: "Do you prefer to receive Rs. 250 in one year's time or Rs. 265 in one year and three months?" (See Table 3, Panel B.) We denote the discount rate calculated from the current tradeoffs as the "current discount rate," and that calculated from the future tradeoffs as the "future discount rate." Inconsistencies provide evidence of hyperbolic preferences, as discussed in the next section.

Several design features in the elicitation methodology allow us to identify time preference reversals (differences between current and future discount rates) with greater confidence. First, we shifted the time frame by exactly one year to reduce the effects of seasonality of agricultural incomes and season-specific expenditures. Second, we introduced a short delay in the current income option in the earlier time frame. Participants were making choices between Rs. 250 delivered the next day and a higher amount delivered after three months. This "front end delay" method should control for potential confounds due to lower credibility and higher transaction costs associated with future payments (it is used, for example, by Harrison et al. 2002; Pender 1996). Third, the set of binary choices in the future time period (with a one year delay) were asked immediately after the set of choices offered in the earlier time frame. This sequencing should lead to a conservative estimate of the likelihood of time preference reversals since it biases toward consistency.

Individual attitudes to risk were also elicited in order to control for the curvature of utility function. We have used a near replication of the simple protocol designed by Binswanger (1980) in his study of villagers in South India and later used by Barr (2003) in Zimbabwe. Each participant was asked to select one out of six different gambles. Every gamble yielded either a high or a low payoff with a probability 0.5. In each subsequent gamble the expected value increased jointly with the variance. The sizes of the prize were set at the level of time discounting choices. The expected value of the least risky gamble was set

at Rs. 250, and the higher payoff in the most risky gamble was Rs. 1000. The prizes for all the gambles are in Table 4.[8]

Much care has been devoted to ensuring a correct understanding of experimental choices given the high proportion of illiterate respondents. Ten trained research assistants were on hand to help illiterate respondents. Before the experimental choices were made, the experimenter informed the participants that at the end of the session each of them would have a 20 percent chance of being paid according to one of their choices. He then explained the principle of future payments and simulated the randomization procedure - tossing numbered ping-pong balls from a bag – which would determine whether and according to which choice a participant would be paid.[10] Given the limited budgets, incentivization based on random probability of payment is common in much of the experimental work. In the context of discounting it was used, for example, by Botelho, Harrison et al. (2006) in a lab experiment conducted among students in Timor-Leste.

At the end of a session, randomly selected respondents were rewarded. Payments relating to risk aversion questions were disbursed immediately. For time discounting questions, winning participants received a cash certificate signed by the chief of the NGO, a local leader and a social worker familiar in the community. The prizes were deposited by the NGO and the social worker was responsible to deliver the amount specified in the cash certificate at the given date.[11]

3.4.3 Survey data

Table 5 describes definitions of variables used in the analysis. A wide range of information on individual characteristics was collected such as age, education, family background (marital status, household head, and woman's position in the household), economic conditions and

[8] We used two sets of prizes to elicit risk aversion. The relative proportions in the gambles were exactly the same, but amounts for the second set of gambles were lower, with the expected value of Rs. 30 for the least risky gamble and with the maximum payoff of Rs. 120 for the most risky gamble. In the analysis we control for risk aversion inferred from gambles with higher amounts, which were set on a level comparable to time discounting choices.

[10] In 12 villages, the experimenter was the director of the cooperating NGO, in six remaining villages the main instructor was the associate director who was also present at previous meetings as a research assistant. The results reported below do not change substantively after controlling for experimenter effect (not reported).

[11] In addition, everyone was given a participation fee amounting Rs. 60 to compensate for opportunity costs (daily income). One session lasted on average four hours and these payments were made upon completion of the entire session.

financial behavior. We constructed an index approximating wealth using principal components analysis based on information about items at home, characteristics of the house and land possession.[12] A set of questions on decision-making power and on attitudes about wife beating was used to approximate women's position within households (Jensen and Oster 2007). Again we used principle components to construct an index. Data on individual savings in a bank, a post office, at home and participation in SHGs together with information on borrowing indicate individual financial behavior.

3.5 Determinants of time discounting

We focus on four characteristics resulting from the experiments: current patience (based on Table 3, Panel A), future patience (based on Table 3, Panel B), present-biased time inconsistency (hyperbolic discounting) and future-biased time inconsistency ("patient now, impatient in the future"). In this section we examine how observable characteristics (gender, age, education, wealth, income fluctuations, family status) predict these traits. In Table 6 we compare means for different subgroups. In the regression analysis we use OLS for discount rates and probits for time preference reversals. Observations are clustered at the village level.[13]

3.5.1 Determinants of discount rates

We observe two clear relationships with respect to levels of patience as approximated by the level of discount rates. First, women make more patient choices than men.[14] Table 6 shows that the current three-months discount rate is 27.0 percent for men but only 21.8 percent for women. For the future discount rate the averages are 22.6 percent and 15.9 percent respectively. For both discount rates the differences are significant at the 1 percent level. The results accord with evidence on behavior from developing countries showing that income in the hands of women is more likely to be used for future-oriented activities like education and

[12] To generate a single summary measure for a multidimensional variable such as wealth, it is common to perform a statistical procedure called principal components analysis of variables. The first principál component of these variables captures the largest amount of variation common to all variables in the set. For more details see, for example, Filmer and Pritchett (2001) or Jensen and Oster (2007).

[13] Using an ordered probit instead of OLS yields comparable results. The results also do not change substantively after controlling for village fixed effects (not reported).

[14] Our anecdotal evidence about lunch consumption during experimental meetings suggests similar pattern. Lunch was a part of compensation for participation. We noticed that most women did not eat the meal, but waited until the end of the session and brought it home to share with their children. Men ate the lunch immediately. In a separate paper (Bauer and Chytilova 2008) we study gender heterogeneity in patience in bigger detail and show that much of the observed heterogeneity in patience is related to number of children.

health expenditures (Thomas 1990; Quisumbing and Maluccio 2003) rather than current consumption. Similarly, the positive experience of microfinance institutions with women is often attributed to women's greater patience (Yunus, 2002). Thomas and Hamoudi (2006) also find greater patience in women relative to men in a recent experimental study in rural Mexico.

Second, as in Kirby et al. (2002) and Bauer and Chytilová (2009), we find that more educated individuals are more patient, an effect that is particularly strong for men (Table 6). The mean of the current discount rate for men with above median education is 19.7 percent, while for below median education it is 33.8 percent. For women, the effect is only marginally significant, possibly due to the substantially lower variance in education of women (45 percent of women are illiterate in the sample).

In the first three columns of Table 7, the dependent variable is the current discount rate, and it is the future discount rate in the next three columns. The regression specifications yield similar conclusions as the table of means. Each additional year of schooling is associated with a decrease in the current discount rate of 1.3 percentage points and a decrease in the future rate of 1.5 percentage points. These are only associations, of course, since the relationship is in part endogenous: education can reduce income constraints or enhance planning skills and, all else the same, patient individuals are more likely to invest in education.

3.5.2 Determinants of time-inconsistent preferences

We interpret the choices as "hyperbolic" if the inferred current discount rate is higher than the future discount rate: an individual with hyperbolic preferences is more impatient now than in the future. We further distinguish between individuals with weakly hyperbolic preferences and strongly hyperbolic preferences. Weakly hyperbolic preferences reflect a difference between current and future discount rates that is relatively small, resulting from choosing the future reward only one binary choice earlier in future time frame (Table 3, Panel B) compared to earlier time frame (Panel A). If the difference is larger, a person is regarded as having strongly hyperbolic preferences. This distinction should allow us to exploit deeper the variation of the level of time inconsistency and to study if bigger difference between current and future patience gets translated into behavior in way that is predicted by behavioral economics. Note, however, that all key results about the financial behavior of hyperbolic women that are discussed below are robust to pooling the strongly and weakly hyperbolic individuals into one group (results are reported in Table A3).

Table 8 illustrates definitions of the time inconsistencies and describes their distribution. The current discount rate is on the vertical axis and the future rate is on the horizontal axis. Cells on the diagonal (where the current discount rate equals the future discount rate) represent individuals with time consistent preferences. Below the diagonal, the current discount rate is higher than the future discount rate. An individual is considered as "weakly hyperbolic" if she made a combination of choices that are next to the diagonal and as "strongly hyperbolic" if combinations lie further below the diagonal.[15] Above the diagonal are individuals with future-biased time inconsistency, in which individuals are more patient now than in the future.

Almost one third of individuals have hyperbolic time preferences (19.9 percent are strongly hyperbolic and 13.2 percent are weakly hyperbolic), whereas fewer than 10 percent of individuals are more patient now than in the future.

The first 6 columns of Table 9 show the determinants of hyperbolic preferences. Few observable characteristics explain hyperbolic time inconsistency. Women who are married or are household heads are more likely to have strongly hyperbolic preferences. The coefficients have an opposite sign and are not statistically significant for women having weakly hyperbolic preferences. None of the variables would predict time inconsistency of men with statistical significance. These (non-) results are similar to estimates of Ashraf et al (2006) and other psychological studies on impulsiveness that similarly find little association with observable characteristics.

There are two major concerns to consider before interpreting the observed reversals as indications of hyperbolic preferences. First, the preference reversals may mirror cash flow fluctuations between the earlier and the delayed time frame. Agricultural income is likely to fluctuate between seasons within a particular year. Similarly, local celebrations are organized on an annual basis with fixed dates. To address this concern, we deliberately shifted the time frame by exactly one year. The remaining concern then reduces to the role of income or expenditure fluctuations across years, such as those resulting from extremely adverse weather conditions. If farmers experienced or expected relatively bad harvest this year compared to

[15] Note that the inferred discount rates are not linearly increasing (to limit censoring for a given number of binary choices). Hence, the definition of being "weakly hyperbolic" includes individuals with changes in discount rates between the two time frames that vary by different absolute amounts. As a robustness check, we redefined the dividing line between strongly and weakly hyperbolic preferences. In the first variant, we define "strongly hyperbolic" individuals as those whose preferences change by more than 0.09 from the range of discount rates associated with time consistent choices. This variant makes very little difference both in terms of the number of observations defined as strongly hyperbolic and, not surprisingly, in the results. In the second variant, we define "strongly hyperbolic" individuals as having a current discount rate higher than the future discount rate by more than 0.16 units. Doing so decreases the size of the group by 26 observations and reduces the differences in behavior between strongly and weakly hyperbolic described in Section 6, but the basic results hold.

their usual harvest, they could become more impatient now than in the future. According to official standards and data from the Directorate of Economics and Statistics, Government of Karnataka, the cumulated rainfall since the monsoon until the end of the survey was "normal" in both Honavar and Haliyal Taluks, and when asked directly, most of local leaders indicated that the present rainfall did not substantially differ from previous years. Moreover, being a farmer does not predict a higher likelihood of having hyperbolic preferences. As a further check, participants were asked to select the major unexpected shock during the last five years; 42 percent selected low harvest due to bad weather, but this characteristic also fails to predict preference reversals.

Second, the reversals may reflect expected transaction costs and lower credibility of future rewards resulting in a higher discount rate now and lower discounting in the future. As noted earlier, we mitigate this concern by designing the binary choices so that there are no immediate payments and by putting the responsibility for future payments into the hands of respected individuals familiar to the participants. In order to test if the reversal is driven by lack of trust we also included three questions from the General Social Survey (GSS) on "trust", "fairness" and "helping" into our survey. An index from these questions is uncorrelated with both weakly and strongly hyperbolic preferences (p-value=0.39 and 0.34, respectively) as are the elements taken separately. Similarly, individuals with no previous interaction with the cooperating NGO -- and hence those presumably less inclined to trust it -- are not more likely to have hyperbolic preferences. Moreover, if the credibility issue was the driver of time preference reversal, the hyperbolic preferences should not be correlated with financial behavior, which contradicts our observations shown in the next section.

Columns 7, 8, and 9 of Table 9 show how individual characteristics predict being patient now and impatient in the future. Although men are more likely to have future-biased preferences than women (10.6 percent compared to 8.5 percent), no independent variable explains the reversal in their case. Women with less wealth are more likely to be more patient now than in the future. We show in the next section that people with this type of preferences are also substantially less financially active in terms of both borrowing and saving. The most plausible explanation is differential uncertainty about cash flow now and after one year. If a person near the subsistence level knows her cash flow is now above subsistence but feels uncertain about cash flow next year, she may become less impatient about her choices now than in the future. Unfortunately this is impossible to test without data on relative riskiness of individual income streams.

3.6 Discounting and financial decisions

The heart of the paper links the non-laboratory borrowing and savings decisions to the experimental choices observed in the field labs. We test several hypotheses. The first hypothesis is that more patient individuals save more and are more likely to favor long-term savings goals. Second, individuals with hyperbolic preferences have saving difficulties. They recognize the tension between their current and future levels of patience and adjust their financial strategies. Specifically, they reduce the share of savings held at home (where temptation is greatest) and they seek commitment devices like SHG loans. If contractual savings devices had been available in this sample, we would expect to demand for them as well.

Table 10 presents the summary statistics on saving and borrowing for individuals with varying degrees of patience and time consistency. We follow-up the analyses of means with regression analyses. The upper panel in Table 10 shows the results for women, the lower panel focuses on men. On average, the level of self-reported financial savings (in a bank, post office, SHG and at home) is Rs. 2,016 for women and 3,113 for men. Individual savings rise with patience as reflected by the discount rate in the later time frame (i.e., Table 3, panel B). The total savings of women with time-consistent preferences are Rs. 2,305, whereas women with strongly hyperbolic preferences save only Rs. 1,636, which suggests the existence of saving difficulties for women with hyperbolic preferences. For men, we observe no real difference, which suggests that men may have better mechanisms for addressing time inconsistencies. For both men and women, a lower proportion of savings is held at home if individuals have hyperbolic preferences, which accords with the hypothesis that "sophisticated" individuals will avoid keeping savings at home.

Levels of patience also help to predict the purpose of savings. We define the purpose of savings as being future-oriented if it is (self-reported) primarily motivated by desires to pay for agricultural investment, business, education, or medical procedures; it equals zero if savings are mainly for basic consumption (celebrations, personal items, household equipment). More patient individuals are, as expected, more likely to report a future-oriented savings goal. Women with a discount rate below the median future discount rate, for example, are 24.7 percentage points more likely to have future-oriented savings goal.

We observe sharp differences also for borrowing. For both men and women, the likelihood of borrowing rises with hyperbolic preferences and, in general, the level of future patience. The difference is particularly striking for women's borrowing from SHGs: 60.7

percent of women with strongly hyperbolic preferences have a loan from a SHG compared to only 35.9 percent when women are time consistent.[16]

Preference reversal in the opposite direction (more patient now than in the future) predicts low saving levels and low borrowing activity, which complies with our earlier observation that these individuals are very poor.

3.6.1 Savings and borrowing: regression results

In the textbook case of financial decision-making with time consistent preferences, the choices of individual *i* depend on her discount rate D_i^t, her level of risk aversion R_i, and both observed and unobserved conditioning factors, X_i and ε_i. Thus the outcome Y_i is a simple function:

$$Y_i = f(D_i^t, R_i, X_i, \varepsilon_i).$$

We capture these relationships in a linear regression specification, adding variables to capture departures from the textbook case:

$$(1) \qquad Y_i = \beta_0 + \beta_1 D_i^t + \beta_2 H_i^s + \beta_3 H_i^w + \beta_4 F_i + \beta_5 R_i + \beta_6 X_i + \varepsilon_i,$$

where Y_i is the financial behavior, D_i^t is a discount rate, H_i^s is a dummy indicating a strongly hyperbolic individual, H_i^w is a dummy for being weakly hyperbolic, F_i is a dummy for future-biased time inconsistency (dummy for time consistent preferences is omitted), R_i is a dummy for being risk averse, X_i is a vector of observable characteristics and ε_i is an error term for individual *i*. Standard errors are clustered at the village level. (Only minor changes in the results occur when we control for village fixed effects; Appendix, Table A1).

In general, more patient individuals are more likely to save. The behavioral economics literature complicates this notion by introducing multiple selves. We start by considering someone with hyperbolic preferences interested in saving. To capture the role of time inconsistencies, we run the specifications with two variations. In one, we use the current

[16] It could be argued that the link between experimental choices and financial behavior results from arbitrage behavior in which individuals make choices in the experiments predicated on their ability to borrow against the future expected income from the pay-outs. In other words, they engage in arbitrage between the lab and their outside opportunities to borrow. For example, an impatient person could choose to wait in the experiment and receive a higher expected pay-out, but then borrow outside and repay the loan after receiving the pay-out. If arbitraged perfectly, the discount rate inferred from the experimental choices should be equal to the market interest rate independently of the individual's level of patience. While theoretically possible, arbitrage is unlikely to drive our results. First, although the amounts in our experiments were relatively large, they are still well below the minimum loan size from SHGs or the formal sector. Second, arbitrage should eliminate time inconsistent choices for people with better opportunities to borrow, but a substantial proportion of individuals made time inconsistent choices in our experiments and these individuals are *more* likely to have a loan (and hence presumably have better access to borrowing), a result inconsistent with the arbitrage argument.

discount rate (based on questions in Table 3, Panel A) as a reference point, so $D_i^t = D_i^0$. In the second variant, we include the future discount rate (Table 3, Panel B), so $D_i^t = D_i^1$. When we control for the current discount rate, D_i^0, the coefficients β_2 and β_3 will estimate the difference in financial behavior for a hyperbolic person relative to the level predicted for a person with time consistent preferences and a similar level of patience in the current period. A large and significant coefficient on the hyperbolic indicators (β_2 and β_3) suggests that the current self does not prevail. Similarly, controlling for the future discount rate D_i^1 gives a comparison to a future self.

Ashraf et al. (2006) use a related specification in their analysis of a commitment savings product—with a slightly different interpretation. To see the difference, consider the case when there are only two values of each discount rate – high and low. There are then four types of individuals: patient and time consistent, impatient and time consistent, hyperbolic (current discount rate high, future discount rate low), and time inconsistent with a future bias (current discount rate low, future discount rate high).

Ashraf et al. (2006) apply the following specification:

(2) $$Y_i = \alpha_0 + \alpha_1 D_i^0 + \alpha_2 D_i^1 + \alpha_3 H_i + \alpha_6 X_i + \varepsilon_i .$$

The coefficient α_3 estimates the effect of being hyperbolic relative to time consistent or future biased individuals (here, it is not possible to also identify the coefficient on the dummy for being future-biased). A comparable version of our specification (1) can be written as $Y_i = \beta_0^{'} + \beta_1^{'} D_i^t + \beta_3^{'} H_i + \beta_4^{'} F_i + \beta_6^{'} X_i + \varepsilon_i$, where t=0,1. The difference is that we include only one of the discount rates and add the dummy for future biased individuals. When we control for current patience, the coefficient $\beta_3^{'}$ indicates a difference in behavior between the hyperbolic group and the time consistent impatient group, and it can be shown that $\beta_3^{'} = \alpha_3 - \alpha_2$. In the second version, where we control for future patience, the behavior of hyperbolic group is contrasted to the time consistent patient group and $\beta_3^{'} = \alpha_3 + \alpha_1$. Our specification generalizes this simple set-up.

In the analysis we compare how the behavior of the hyperbolic individuals departs from that of time consistent individuals, conditional on their level of patience. Two natural benchmarks arise: the level of patience associated with current patience (current self) and the level associated with future patience (future self). In equation (1) our two coefficients for hyperbolic preferences directly capture these departures, whereas the coefficient in Ashraf et

al (2006) compares hyperbolic individuals to the average behavior of the group of time consistent and future-biased individuals.[17]

If individuals completely give in to their immediate temptations—that is, they are "naïve" hyperbolics—saving behavior should follow their current discount rate (i.e., D_i^0). The indicator variable for being hyperbolic should not enter strongly in the regression (i.e., $\beta_2 = \beta_3 = 0$), since saving behavior will be captured by the discount rate. But households are unlikely to be completely naïve. If they are "sophisticated," they appreciate the implications of $D_i^0 \neq D_i^1$, and adjust their behavior to the extent they can given the available mechanisms. In this case, commitment mechanisms might lead them to a situation in which a regression that has the future discount rate in it (i.e., D_i^1), also yields that $\beta_2 = \beta_3 = 0$. In this case, temptations would be completely held at bay. The parallel regression with the current discount rate (D_i^0) would yield that $\beta_2 > \beta_3 > 0$. "Sophisticated" hyperbolics might also over-compensate by applying commitment devices that lead to even higher levels of saving than their future discount rates would suggest (a class of "sophisticated" behavior highlighted by O'Donoghue and Rabin 1999); here, $\beta_2 > \beta_3 > 0$ in the regression anchored by the future discount rate D_i^1.

An alternative situation, in which "sophisticated" individuals have no way to commit to saving, could result in their giving up and saving even less than the level predicted by current patience (i.e., $\beta_2, \beta_3 < 0$ when controlling for current patience). Here, individuals recognize that in the future they will have to permanently fight not to over-spend so they choose not to save so much in the first place (O'Donoghue and Rabin 1999).

The same patterns should hold for microcredit production loans, given the premise that they are investments and, due to the structure of microcredit contracts, entail delayed gratification.

As with saving, people with hyperbolic preferences who do not recognize the tension with their future selves (or who are powerless to act), will simply follow their current discount rate D_i^0. Sophisticated individuals, when armed with effective commitment devices, will diverge from the pattern suggested by D_i^0. In the villages we study, the structure of microcredit loans can make them useful commitment devices for individuals seeking better ways to accumulate. Using a similar argument as in the case of saving with commitment,

[17] See Appendix Table A2 for results from a specification in the spirit of Ashraf et al. (2006), in which both current and future discount rates are included instead of the dummy for future-biased preferences.

sophisticated hyperbolics would then be even more likely to borrow than predicted by the preferences of their future selves (i.e., $\beta_2 > \beta_3 > 0$ when controlling for D_i^1). The same pattern could reflect, directly, the need by hyperbolic borrowers to compensate for their saving difficulties. If this latter motivation drives behavior, then hyperbolic preferences should increase the demand for all loans, rather than microcredit loans specifically, a result we do not find for women.

3.6.2 Saving

Men and women who are more patient as predicted by the experiments save more. While for men hyperbolic preferences make little difference to overall saving levels (columns 2 and 4 of Table 11), they do for women. The evidence is consistent with men having better tools to cope with time inconsistencies. Specifically, hyperbolic women save substantially less than their future patience, as captured by D_i^1, suggests (Table 11, columns 3), a result that holds after controlling for observables. We see that via $\beta_2 < 0$. When controlling for current patience D_i^0, the coefficient for being hyperbolic is smaller and not statistically significant (column 1). This suggests that women's saving behavior follows their current patience level more closely than their future patience level. The results are qualitatively similar for weakly hyperbolic women, though measured with greater uncertainty. As expected, wealthier individuals report higher saving levels and more educated men also report significantly higher savings.

Preferences should also affect the purposes of saving. Table 12 turns to determinants of the self-reported purpose of savings. Similarly to Table 7, more patient men and women have more "future-oriented" savings goals, i.e. $\beta_1 < 0$. Having hyperbolic preferences matters relatively less. For hyperbolic women, future patience is a better predictor of the purpose of savings as indicated by positive significant coefficients on the hyperbolic indicators when controlling for current patience (column 1) and negative and not significant coefficients when controlling for future patience (columns 3). For hyperbolic men, current patience is a more accurate predictor of savings goals (columns 2 and 4). In general household heads and women are more likely to have future-oriented savings goals, as are married individuals and people with more education.

Hyperbolic preferences should, though, affect how people save. In Table 13 we examine home savings as a share of total savings. We hypothesize that people with self-

discipline problems are more likely to keep their money outside of the home.[18] More impatient individuals save a higher proportion of their savings at home and less outside of their household (such as in a bank, a post office, or SHG), in part because more impatient people save less overall (and saving less is associated with holding more at home). But the finding is also consistent with a higher priority placed on spending which diminishes the value of opening and using saving accounts.

Controlling for all of that, hyperbolic women adjust their savings practices to keep at home a lower proportion of their financial savings than the level predicted by their current selves (column 1). That is $\beta_2 < 0$. The future discount rate is a better predictor of their saving practices (column 3).

In sum, the experimentally-derived discount rates yield plausible predictions about saving behavior: patient people save more and have more "future-oriented" saving goals. Hyperbolic women save less than their future level of patience suggests they should. They do, though seem aware of the tension (and thus are not fully "naïve"). The clearest evidence thus far is seen in their systematically saving less at home.

3.6.3 Borrowing

The role of hyperbolic preferences continues to mark financial decisions when we turn to borrowing behavior. Hyperbolic people borrow more, a result consistent with both the greater need for borrowing to compensate for low saving levels and for workable commitment devices. As we show below, hyperbolic individuals have a particular demand for microcredit loans through SHGs, a finding that suggests the importance of commitment devices. As noted in the introduction, SHG loans have the advantages (in terms of disciplining mechanisms) of weekly loan installment schedules and public repayments within the villages.

In Table 14 we analyze the determinants of having a loan from any source: from a bank, a SHG or a moneylender. Patient women borrow more, a result in keeping with the working assumption that the loans are mainly taken for business investments and other

[18] There are 82 individuals who report not having any savings (see Table 10 for more details on their characteristics) and it is not clear how to treat the share of home saving among non-savers. In Table 13 they were excluded from the sample. In order to see the bounds of how important this exclusion is, we repeated the same analysis with non-savers treated as if (1) they saved 100% at home and (2) they saved nothing at home. In both cases the results are qualitatively similar to those observed in Table 13. In particular, strongly hyperbolic women save significantly less at home than predicted by their measured patience in the current period.

forward-looking investments.[19] For women, being married, middle-aged, less educated, and having recently experienced a shock at the harvest increases the likelihood of borrowing. Strongly hyperbolic women are 20 percentage points more likely to have a loan compared to the level predicted by the patience of their current self (column 1) and the coefficient on being hyperbolic is positive though not statistically significant when controlling for the preferences of the future self (column 3).

Although for men we also observe a positive correlation between being hyperbolic and having a loan, we can push the analysis further on the sample of women. First, borrowing by men is mainly restricted to banks, while there is substantial SHG borrowing activity among women in our sample (42.6 percent have an SHG loan versus only 13.9 percent of men). In addition, we didn't find lower savings for time-inconsistent men as we did for women, which suggests that they have other ways to cope with self-discipline problems not available to women.[20]

We begin by studying how being hyperbolic affects the choice between different types of loans. In Table 15 the dependent variable is equal to one if an individual has a loan from an SHG. We can see that the results for women's discounting and borrowing in Table14 were largely driven by SHG loans. Strongly hyperbolic women are 36.4 percentage points more likely to borrow from SHGs than predicted by their current level of patience (column 1). In columns 5-8, we restrict the sample only to individuals who have a loan (independently of its provider) and do the same analysis. This restriction thus conditions on the generic demand for a loan and places the focus on loan type. Importantly, we still observe similar results for hyperbolic discounting. Conditional on borrowing, strongly hyperbolic women are more inclined to borrow from SHGs, which is consistent with the hypothesis that features specific to SHG contracts and practices are desirable for individuals with hyperbolic preferences. (SHG loans may have other advantages relative to alternative loans types, such as lower interest rates, but our focus here is on features that are particularly appealing to hyperbolics.) When future patience levels, D_i^1, are included in the specification, strongly hyperbolic women

[19] Introductory economics tells us that patient individuals save more, and the impatient borrow more. That intuition fails, though, when we turn to the billions of people around the world, especially the poor, whose income derives largely from farming or small-scale business. As self-employed entrepreneurs, these households borrow often to support their farms and businesses.

[20] It is interesting to notice that – similar to our result -- Ashraf et al (2006) find the correlation between demand for their commitment savings product and hyperbolic preferences only for women and not for men. Similarly, in a recent field experiment from Kenya Dupas and Robinson (2008) find that demand for their interest-free savings account with commitment is driven mainly by women. Our women-specific result also fits into the larger picture on composition of microcredit clients. The vast majority of micro-credit borrowers in Asia and globally are women (Armendariz deAghion and Morduch 2005). The causes of these differential patterns between men and women should, we believe, be subject of further research.

borrow at a rate even higher than those discount rates suggest. The result is explained by the combination of the disciplining effect of SHG loans and the desire to compensate for lower savings levels.

The interpretation above centers on self-control issues, and the results are robust to extending the specifications to include a measure of women's position within a household (to capture "spousal control" issues). Spousal control can be another motivating factor for why women seek commitment mechanisms; i.e., to keep money from husbands whose spending preferences vary from those of their wives (Anderson and Baland 2002). Theory predicts that women who have little autonomy from their husbands are unlikely to use a commitment device, as are women with substantial autonomy (since they do not need the protection of commitment).

As found by Anderson and Baland (2002), the action here comes from women with a mid-level of autonomy. We find evidence supporting the spousal control motive for borrowing behavior, but not for savings behavior. Women in the third quartile of our measure of women's position are the most likely to have a loan from SHGs (Table 15). The result suggests that husbands or other family members respect women's autonomy over resources from SHG loans but less so for savings or other types of loans. The results on hyperbolics are little changed by this extension.

Time preference reversal and financial behavior: alternative explanation

So far we have treated hyperbolic preferences as an exogenous variable. A legitimate concern is that some other event is correlated both with the answer to the discounting choices in our experiments and the financial behavior of an individual. An individual may experience a negative income shock (due to weather, illness, etc.). Consequently, such an individual may express a greater preference for cash in the current time frame than in the future time frame during our experiments and she may reduce savings or increase borrowing in order to finance higher consumption now. If this is the case, we would spuriously conclude that a certain financial behavior is due to hyperbolicity, rather than just unobserved shock.

Although we cannot rule out this concern completely, since the sample is non-experimental in design, there are several reasons why we believe it should not play a major role for interpretation of our results. First, we have employed several features into the elicitation procedure to address this issue – as noted in section 3.5.2. Seasonal income shocks should be limited by our decision to shift the time frame for exactly one year. We don't observe any significant differences in our regressions after controlling for village fixed effect

which should eliminate a possible effect of community-level income shocks (Table A1). Controlling for self-reported major individual income shock in the last five years does not alter the results either. Similarly, less wealthy individuals – those who are presumably less able to absorb income shocks without a need to borrow – are not more likely to have hyperbolic preferences (Table 9).

Second, some of our results are consistent only with the hypothesis that microcredit is a disciplined (though costly) way to save for individuals with hyperbolic preferences, in contrast to the cash flow story. Being hyperbolic is correlated with the absolute level of saving and likelihood of borrowing as well as with their type. In Table 13 we observe that hyperbolic women hold lower proportion of savings at home. We would need to assume differential propensity to reduce different types of savings in response to an income shock to reconcile the observed pattern with the cash-flow story. Perhaps most importantly, women with hyperbolic preferences do not borrow more in general, but they borrow more specifically via SHGs using a microcredit type of contract. In Table 15 (columns 5-8) we restrict the sample on borrowers so that only individuals in the need of cash are included. Importantly, hyperbolic preferences still predict borrowing from SHGs. As we argued earlier, microcredit repayment structure is particularly suitable for individuals with limited discipline to save.

3.7 Conclusions

The textbook model of optimal consumption choice abstracts from self-discipline problems that households may face, limiting their ability to save. Behavioral economics has taken this as a focus, centering on ways that various contracting mechanisms can generate greater savings levels by promoting discipline. We draw a link between these kinds of disciplining mechanisms and the propensity to borrow from microcredit institutions.

The study is based on results from a series of "lab experiments in the field" designed to elicit measures of time discounting and risk aversion and survey data on financial behavior for a random sample of over 500 individuals in rural India. We show that women's choice to borrow in general, and the propensity to do so through local microcredit institutions specifically, is greater for women with hyperbolic preferences.

After controlling for the general preference for consuming today versus in the future, we find that women with time preferences exhibiting "strong" hyperbolic discounting save lower proportion of their savings at home (in keeping with self-discipline difficulties) and save less in total levels.

Borrowing through microcredit institutions can provide a partial solution to these problems. They provide a way to accumulate that is structured and regulated both by SHG loan officers and by fellow villagers.

The finding that hyperbolic women favor borrowing from SHGs can be partly explained by their difficulty saving, so they are less likely to be able to rely on their own resources for capital. Hence, the hyperbolic group is more likely to need to borrow than otherwise similar people undertaking comparable investments. Another explanation that has been a particular focus above, is that the structure of microcredit loans provides a way to convert income flows into large sums through a device that—for the hyperbolic group—is more effective than the alternative of saving up. A third explanation is that the hyperbolic group is giving in to their desire for current consumption, driving up loan demand. Our result, though, holds even after controlling for the baseline degree of time discounting; the time preference variable should capture aspects of loan demand associated with the desire for current consumption.

The analysis rests on the way that microcredit loans provide discipline and peer pressure absent in the textbook lending contract. Microcredit contracts have been celebrated by economic theorists for providing novel solutions to problems of moral hazard and adverse selection. The evidence here suggests that a key to their success may rest as well with their role in helping borrowers discipline their financial lives. The evidence helps to explain the puzzling existence of the regular repayment schedules used in nearly all microfinance loan contracts globally (Armendáriz and Morduch 2005). The evidence also helps to explain why microfinance institutions that drop the joint liability element of group lending from their contracts nonetheless have maintained regular repayment schedules and group meetings (Gine and Karlan 2008).

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Figure 1: Map of Karnataka and geographical location of Honavar and Haliyal Talukas

Table 1: Honavar and Haliyal Talukas - Descriptive Statistics

	Honavar	Haliyal
Total population	160,331	105,851
Number of villages	92	111
Rural literacy rate (%)	74	60
Total population/primary schools	629	868
Total population/secondary schools	5,529	15,122
Total population/bank facilities	4,581	26,463
Villages having post office (%)	63	28
Villages with paved road connection (%)	72	60

Note: Source: Indian Census 2001

Table 2: Sample characteristics, comparison with Karnataka averages (means, standard deviations)

	Total	**Male**	**Female**	**Honavar**	**Haliyal**	**Karnataka+**
Age (years)	36.822	38.128	35.496	36.759	36.885	36.300
	(11.756)	(12.091)	(11.274)	(11.060)	(12.443)	
Education (classes)	4.256	5.004	3.496	5.967	2.519	4.200
	(4.442)	(4.684)	(4.051)	(4.487)	(3.658)	
Illiterate	0.395	0.339	0.452	0.204	0.589	0.425
	(0.489)	(0.474)	(0.499)	(0.404)	(0.493)	
Married	0.786	0.796	0.777	0.729	0.844	0.670
	(0.410)	(0.404)	(0.417)	(0.445)	(0.363)	
Farmer	0.702	0.739	0.664	0.632	0.772	0.750++
	(0.458)	(0.440)	(0.473)	(0.483)	(0.420)	
Sample size	544	274	270	274	270	

Note: [+] Source: Indian Census 2001: data for the Karnataka population above 15. [++] only rural population.

Table 3: Eliciting discount rates (payoffs)

	Panel A (current discount rate)	
	Tomorrow **Earlier reward**	After three months **Delayed reward**
choice 1	250	265
choice 2	250	280
choice 3	250	300
choice 4	250	330
choice 5	250	375
	Panel B (future discount rate)	
	After one year **Earlier reward**	After one year and three months **Delayed reward**
choice 1	250	265
choice 2	250	280
choice 3	250	300
choice 4	250	330
choice 5	250	375

Table 4: Eliciting attitude to risk (payoffs)

Prospect	Bad luck payoff (50%)	Good luck payoff (50%)
1	250	250
2	225	475
3	200	600
4	150	750
5	50	950
6	0	1000

Table 5: Definition of variables

Variables	Definition	Mean	Std dev
Experimental choices			
Current discount rate	6 values approximating 3-months discount rate in earlier time frame: 0.03 = if discount rate < 6%; 0.09= if 6% < discount rate < 12%; 0.16 if 12% < discount rate < 20%; 0.26 = if 20% < discount rate < 32%, 0.14 if 32% < discount rate < 50%; 0.6= if 50% < discount rate	0.244	0.228
Future discount rate	6 values approximating 3-months discount rate in delayed time frame: 0.03 = if discount rate < 6%; 0.09= if 6% < discount rate < 12%; 0.16 if 12% < discount rate < 20%; 0.26 = if 20% < discount rate < 32%, 0.14 if 32% < discount rate < 50%; 0.6= if 50% < discount rate	0.193	0.221
Strongly hyperbolic	dummy; 1= current discount rate >> future discount rate, as defined in Table 9	0.199	0.399
Weakly hyperbolic	dummy; 1= current discount rate > future discount rate, as defined in Table 9	0.132	0.339
Patient now, impatient in the future	dummy, 1= current discount rate < future discount rate	0.096	0.294
Risk aversion	dummy, 1= if risk aversion above median (i.e. selects gamble (250,250) or (225,475) or (200,600)), 0= if risk aversion below median (i.e. if selects (150,750) or (50,950) or (0,1000))	0.452	0.498
Financial behavior			
Loan	Dummy; 1 = has an outstanding loan; 0 = doesn't have an outstanding loan	0.597	0.491
SHG loan	Dummy; 1 = has an outstanding loan from SHG; 0 = doesn't have an outstanding loan from SHG	0.281	0.450
Total savings	Rs. th. (savings in bank + savings in post office + SHG monthly contribution*average length of participation + home savings)	2.569	5.454
Share of home savings	Home savings /Total savings (%, only those who save)	0.333	0.386
Future oriented purpose of savings	Dummy; 1 = if the major purpose of savings is future-oriented (agricultural investment, business, education, doctor); 0 = if it focuses on current consumption (celebration, personal items, household equipment)	0.546	0.498
Socioeconomic characteristics			
Female	Dummy; 1 = female; 0 = male	0.496	0.500
Age	Age in years	36.822	11.756
Education	Years of schooling completed	4.256	4.442
Married	Dummy; 1 = married, divorced or widow; 0 = single	0.851	0.357
Household head	Dummy; 1 = household head; 0 = non household head	0.397	0.490
Position in the family	Position of a woman in a family. Index calculated by principal component analyses from seven questions on decision-making and five questions on wife's beating. Minimum of the index is set to zero. The higher the index value, the better the position.	3.617	1.887
Wealth index	Wealth index calculated by principal component analyses from questions on type of house, electricity connection, land ownership and dummies for possesion of 14 types of household equipment	0.000	1.893
Income in June < income in Sept.	Dummy; 1 = if income in June < income in September; 0 = if income in June >= income in September	0.496	0.500

Table 6: Experimental questions and individual characteristics (means, standard deviations)

	All	Female							Male						
	Total	Total	Education		Age		Wealth		Total	Education		Age		Wealth	
			Low	High	Young	Old	Low	High		Low	High	Young	Old	Low	High
Patience															
Current discount rate	0.244	0.218	0.241	0.191	0.205	0.234	0.236	0.197	0.270	0.338	0.197	0.259	0.281	0.307	0.232
	(0.228)	(0.212)	(0.223)	(0.195)	(0.207)	(0.218)	(0.219)	(0.202)	(0.239)	(0.254)	(0.199)	(0.242)	(0.237)	(0.248)	(0.225)
Future discount rate	0.193	0.159	0.180	0.135	0.164	0.154	0.186	0.133	0.226	0.294	0.152	0.230	0.221	0.267	0.184
	(0.221)	(0.193)	(0.209)	(0.170)	(0.202)	(0.183)	(0.209)	(0.173)	(0.240)	(0.267)	(0.182)	(0.247)	(0.234)	(0.259)	(0.213)
Time consistency															
Strongly hyperbolic preferences	0.199	0.207	0.223	0.189	0.192	0.226	0.222	0.187	0.190	0.204	0.174	0.164	0.216	0.188	0.191
	(0.399)	(0.406)	(0.418)	(0.393)	(0.395)	(0.420)	(0.417)	(0.391)	(0.393)	(0.405)	(0.381)	(0.372)	(0.413)	(0.392)	(0.395)
Weakly hyperbolic preferences	0.132	0.141	0.128	0.156	0.123	0.161	0.148	0.134	0.124	0.085	0.167	0.121	0.127	0.101	0.147
	(0.339)	(0.348)	(0.336)	(0.364)	(0.330)	(0.369)	(0.357)	(0.342)	(0.330)	(0.279)	(0.374)	(0.328)	(0.334)	(0.303)	(0.355)
Patient now, impatient in future	0.096	0.085	0.095	0.074	0.103	0.065	0.111	0.060	0.106	0.099	0.114	0.129	0.082	0.101	0.110
	(0.294)	(0.280)	(0.294)	(0.262)	(0.305)	(0.247)	(0.315)	(0.238)	(0.308)	(0.299)	(0.319)	(0.336)	(0.276)	(0.303)	(0.314)
Attitude to risk															
Risk averse	0.452	0.470	0.446	0.500	0.493	0.444	0.511	0.425	0.434	0.479	0.386	0.421	0.448	0.449	0.419
	(0.498)	(0.500)	(0.499)	(0.502)	(0.502)	(0.499)	(0.502)	(0.496)	(0.497)	(0.501)	(0.489)	(0.496)	(0.499)	(0.499)	(0.495)

Table 7: Determinants of discount rates

Dependent variable	Current discount rate			Future discount rate		
	All	Male	Female	All	Male	Female
	(1)	(2)	(3)	(4)	(5)	(6)
Female	-0.070			-0.095		
	(0.033)**			(0.031)***		
Age	-0.013	-0.019	-0.007	-0.009	-0.017	-0.001
	(0.007)*	(0.013)	(0.010)	(0.006)	(0.007)**	(0.008)
$(Age)^2$	1.5e-04	2.2e-04	7.7e-05	8.4e-05	1.7e-04	-3.6e-06
	(8.0e-05)*	(1.4e-04)	(1.2e-04)	(6.0e-05)	(7.6e-05)**	9.4e-05
Education	-0.013	-0.018	-0.007	-0.015	-0.022	-0.007
	(0.003)***	(0.004)***	(0.005)	(0.003)***	(0.003)***	(0.005)
Wealth	8.5e-04	2.2e-05	0.004	0.002	0.006	5.5e-04
	(0.006)	(0.009)	(0.007)	(0.005)	(0.007)	(0.008)
Income in June < income in Sept	-0.011	-0.041	0.018	-0.020	-0.051	0.012
	(0.024)	(0.031)	(0.028)	(0.023)	(0.028)*	(0.029)
Farmer	-0.008	-0.035	0.017	-0.021	-0.029	-0.012
	(0.019)	(0.028)	(0.032)	(0.017)	(0.027)	(0.024)
Negative shock from harvest	0.032	0.036	0.032	0.045	0.035	0.056
	(0.027)	(0.028)	(0.041)	(0.028)	(0.036)	(0.036)
Married	0.032	0.048	0.042	0.031	0.076	0.005
	(0.035)	(0.073)	(0.065)	(0.041)	(0.062)	(0.061)
Household head	-7.4e-05	-0.020	0.034	-0.014	-0.036	-0.022
	(0.032)	(0.042)	(0.070)	(0.037)	(0.056)	(0.063)
Constant	0.547	0.717	0.306	0.483	0.693	0.201
	(0.117)***	(0.217)***	(0.150)*	(0.079)***	(0.111)***	(0.102)*
Observations	538	272	266	538	272	266
R-squared	0.09	0.15	0.03	0.11	0.17	0.04

Note: OLS, standard errors corrected for clustering at the village level. For columns 1, 2, 3 the dependent variable is the "current discount rate" calculated from the binary choices between amount next day and after three months. It has 6 values calculated as arithmetic means of inferred ranges of discount rate. For columns 4, 5, 6 the dependent variable is the "future discount rate" calculated from the binary choices between amount after one year or amount after one year and three months.

* significant at 10%.

** significant at 5%.

*** significant at 1%.

Table 8: Distribution of responses to time preference questions (number of observations, %)

		Future discount rate						
		Patient					Impatient	Total
		DR=0.03	DR=0.06	DR=0.16	DR=0.26	DR=0.41	DR=0.60	
Patient	DR=0.03	126 23%	8 1%	6 1%	2 0%	2 0%	9 2%	**153** **28%**
	DR=0.09	37 7%	41 8%	3 1%	1 0%	4 1%	0 0%	**86** **16%**
Current discount rate	DR=0.16	27 5%	18 3%	41 8%	4 1%	5 1%	0 0%	**95** **17%**
	DR=0.26	14 3%	7 1%	12 2%	11 2%	3 1%	3 1%	**50** **9%**
	DR=0.41	1 0%	6 1%	2 0%	4 1%	4 1%	2 0%	**19** **3%**
Impatient	DR=0.60	34 6%	1 0%	11 2%	5 1%	1 0%	89 16%	**141** **26%**
Total		**239** **44%**	**81** **15%**	**75** **14%**	**27** **5%**	**19** **3%**	**103** **19%**	**544** **100%**

13.2% of individuals	"Weakly hyperbolic": More patient over future tradeoffs than current tradeoffs (next to the diagonal)
19.9% of individuals	"Strongly hyperbolic": More patient over future tradeoffs than current tradeoffs (further off the diagonal)
9.6% of individuals	"Patient now, impatient later": Less patient over future tradeoffs than current tradeoffs

Table 9: Determinants of time preference reversals

Dependent variable	Strongly hyperbolic preferences			Weakly hyperbolic preferences			Patient now, impatient in the future		
	All	Male	Female	All	Male	Female	All	Male	Female
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Female	0.005			0.052			-0.058		
	(0.050)			(0.064)			(0.034)*		
Age	0.014	0.008	0.020	-0.010	-0.004	-0.019	0.007	0.011	0.001
	(0.010)	(0.013)	(0.017)	(0.007)	(0.013)	(0.013)	(0.006)	(0.010)	(0.013)
$(Age)^2$	-1.3e-04	-6.7e-05	-2.1e-04	1.3e-04	7.1e-05	2.1e-04	-1.2e-04	-1.8e-04	-3.1e-05
	(1.1e-04)	(1.4e-04)	(2.1e-04)	(8.1e-05)	(1.3e-04)	(1.4e-04)	(7.6e-05)	(1.3e-04)	(1.7e-04)
Education	0.003	0.005	0.001	-1.2e-04	0.003	-0.003	-0.001	-0.003	0.002
	(0.004)	(0.005)	(0.006)	(0.006)	(0.008)	(0.010)	(0.004)	(0.005)	(0.008)
Wealth	0.002	0.005	-0.002	-0.006	-0.011	0.001	-0.010	-6.2e-04	-0.030
	(0.008)	(0.011)	(0.012)	(0.013)	(0.019)	(0.016)	(0.005)*	(0.010)	(0.009)***
Income in June < income in Sept.	0.026	0.037	0.015	-0.003	-0.043	0.036	-0.020	-0.049	-0.005
	(0.034)	(0.051)	(0.049)	(0.033)	(0.051)	(0.038)	(0.024)	(0.039)	(0.044)
Farmer	-0.060	-0.047	-0.077	0.061	0.046	0.079	-0.006	0.005	-0.032
	(0.030)**	(0.045)	(0.037)**	(0.046)	(0.056)	(0.064)	(0.030)	(0.049)	(0.046)
Negative shock from harvest	0.030	0.033	0.027	-0.052	-0.052	-0.055	-0.008	-0.002	-0.023
	(0.038)	(0.044)	(0.053)	(0.044)	(0.065)	(0.064)	(0.024)	(0.042)	(0.034)
Married	-0.077	-0.029	-0.141	0.027	-0.018	0.133	0.033	-0.109	
	(0.070)	(0.076)	(0.112)	(0.030)	(0.119)	(0.054)**	(0.033)	(0.096)	
Household head	-0.037	-0.027	-0.074	0.071	0.036	0.294	-0.047	0.040	
	(0.046)	(0.090)	(0.052)	(0.059)	(0.081)	(0.160)*	(0.036)	(0.044)	
Observations	538	272	266	538	272	266	538	272	203

Note: * significant at 10%; ** significant at 5%; *** significant at 1%. Probit, marginal effects reported, standard errors corrected for clustering at the village level. In column 1,2,3 the dependent variable "strongly hyperbolic preferences" equals to one if the current discount rate is higher than the future discount rate and the difference is "large" (see Table 8). Hence, these individuals exhibit hyperbolic time preferences. In column 4,5,6 the dependent variable "weakly hyperbolic preferences" equals to one if the current discount rate is higher than the future discount rate and the difference is "small" (see Table 8). In column 7, 8, 9 the dependent variable equals to one if the future discount rate is higher than the current discount rate. Hence, these individuals exhibit time inconsistency, but not in the direction associated with hyperbolicity.

Table 10: Time discounting and financial behavior (means, standard deviations)

	Total	Future discount rate		Time consistency			
		Low	High	Strongly hyperbol.	Weakly hyperbol.	Consist.	Pat. now, impat. in future
WOMEN							
Borrowing							
Loan	0.641	0.688	0.557	0.768	0.632	0.621	0.478
	(0.481)	(0.465)	(0.499)	(0.426)	(0.489)	(0.487)	(0.511)
SHG loan	0.426	0.457	0.371	0.607	0.447	0.359	0.391
	(0.495)	(0.500)	(0.486)	(0.493)	(0.504)	(0.481)	(0.499)
SHG loan (conditional on borrowin	0.665	0.664	0.667	0.791	0.708	0.579	0.818
	(0.473)	(0.474)	(0.476)	(0.412)	(0.464)	(0.496)	(0.405)
Saving							
Having any savings	0.863	0.884	0.825	0.857	0.842	0.876	0.826
	(0.345)	(0.321)	(0.382)	(0.353)	(0.370)	(0.331)	(0.388)
Total savings (Rs. th.)	2.016	2.198	1.691	1.636	2.069	2.305	0.936
	(2.736)	(2.646)	(2.875)	(1.788)	(3.808)	(2.849)	(0.952)
Share of home savings	0.191	0.182	0.208	0.164	0.148	0.194	0.306
only those having any savings	(0.303)	(0.291)	(0.326)	(0.278)	(0.260)	(0.307)	(0.388)
Future-oriented purpose of saving:	0.591	0.680	0.433	0.589	0.632	0.579	0.609
	(0.493)	(0.468)	(0.498)	(0.496)	(0.489)	(0.495)	(0.499)
Number of observations	270	173	97	56	38	153	23
MEN							
Borrowing							
Loan	0.555	0.585	0.520	0.654	0.559	0.541	0.448
	(0.498)	(0.494)	(0.502)	(0.480)	(0.504)	(0.500)	(0.506)
SHG loan	0.139	0.163	0.110	0.173	0.059	0.157	0.069
	(0.346)	(0.371)	(0.314)	(0.382)	(0.239)	(0.365)	(0.258)
Saving							
Having any savings	0.836	0.884	0.780	0.827	0.794	0.855	0.793
	(0.371)	(0.321)	(0.416)	(0.382)	(0.410)	(0.353)	(0.412)
Total savings (Rs. th.)	3.113	3.350	2.839	3.221	3.206	3.267	1.967
	(7.154)	(6.375)	(7.979)	(5.148)	(5.093)	(8.539)	(2.682)
Share of home savings	0.479	0.442	0.527	0.440	0.375	0.500	0.546
only those having any savings	(0.407)	(0.399)	(0.415)	(0.432)	(0.353)	(0.414)	(0.376)
Future-oriented purpose of saving:	0.502	0.517	0.484	0.346	0.559	0.516	0.643
	(0.501)	(0.501)	(0.502)	(0.480)	(0.504)	(0.501)	(0.488)
Number of observations	274	147	127	52	34	159	29

Table 11: Total savings (Rs. th.)

Dependent variable	Total savings (Rs. th.)			
	Female	Male	Female	Male
	(1)	(2)	(3)	(4)
Strongly hyperbolic	-0.422	0.333	-0.933	0.058
	(0.413)	(0.731)	(0.447)*	(0.791)
Weakly hyperbolic	-0.679	-0.618	-0.843	-0.983
	(0.628)	(1.008)	(0.650)	(1.153)
Current discount rate	-1.309	0.479		
	(0.740)*	(1.520)		
Future discount rate			-2.036	-1.622
			(0.882)**	(1.978)
Patient now, impatient in future	-1.165	-0.860	-0.768	-0.727
	(0.438)**	(0.719)	(0.390)*	(0.664)
Risk averse	-0.088	0.718	-0.071	0.706
	(0.281)	(0.765)	(0.287)	(0.761)
Age	0.265	0.351	0.262	0.316
	(0.090)***	(0.185)*	(0.091)**	(0.194)
$(Age)^2$	-0.003	-0.004	-0.003	-0.003
	(0.001)**	(0.002)*	(0.001)**	(0.002)*
Education	-0.020	0.226	-0.025	0.185
	(0.057)	(0.087)**	(0.057)	(0.077)**
Wealth	0.406	1.131	0.409	1.141
	(0.164)**	(0.385)***	(0.161)**	(0.395)**
Income in June < income in Sept.	0.279	-0.480	0.298	-0.574
	(0.264)	(0.735)	(0.268)	(0.777)
Farmer	0.153	0.109	0.144	0.038
	(0.392)	(1.116)	(0.379)	(1.101)
Negative shock from harvest	-0.097	-0.170	-0.038	-0.097
	(0.412)	(0.874)	(0.418)	(0.865)
Married	0.280	4.218	0.277	4.358
	(0.481)	(2.344)*	(0.495)	(2.385)*
Household head	0.721	-5.230	0.732	-5.302
	(0.704)	(1.881)**	(0.670)	(1.878)**
Position in the family	0.069		0.069	
	0.240		0.240	
$(Position\ in\ the\ family)^2$	-0.008		-0.007	
	(0.025)		(0.025)	
Constant	-2.881	-5.203	-2.670	-3.702
	(1.238)**	(3.754)	(1.271)**	(3.926)
Observations	249	272	249	272
R-squared	0.17	0.24	0.18	0.24

Note: OLS, standard errors corrected for clustering at village level. Total savings are calculated as a sum of savings on a bank account, in a post office, contributions to SHGs and financial savings held at home.
* significant at 10%.
** significant at 5%.
*** significant at 1%.

Table 12: Future-oriented purpose of savings

Dependent variable	Future oriented purpose of savings			
	Female	Male	Female	Male
	(1)	(2)	(3)	(4)
Strongly hyperbolic	0.130	-0.106	-0.068	-0.252
	(0.078)*	(0.080)	(0.081)	(0.101)**
Weakly hyperbolic	0.014	-0.011	-0.037	-0.027
	(0.077)	(0.107)	(0.075)	(0.111)
Current discount rate	-0.615	-0.479		
	(0.142)***	(0.160)***		
Future discount rate			-0.591	-0.389
			(0.176)***	(0.189)**
Patient now, impatient in future	-0.048	0.059	0.087	0.194
	(0.134)	(0.119)	(0.128)	(0.114)*
Risk averse	-0.073	-0.075	-0.085	-0.077
	(0.098)	(0.083)	(0.101)	(0.085)
Age	0.044	-0.029	0.044	-0.027
	(0.021)**	(0.022)	(0.021)**	(0.022)
$(Age)^2$	-6.5e-04	3.4e-04	-6.5e-04	3.2e-04
	(2.8e-04)**	(2.4e-04)	(2.8e-04)**	(2.4e-04)
Education	0.024	0.005	0.024	0.006
	(0.013)*	(0.011)	(0.013)*	(0.011)
Wealth	0.029	0.009	0.028	0.010
	(0.025)	(0.028)	(0.025)	(0.028)
Income in June < income in Sept.	0.121	0.034	0.121	0.034
	(0.055)**	(0.075)	(0.061)**	(0.076)
Farmer	0.077	0.101	0.073	0.110
	(0.074)	(0.122)	(0.072)	(0.121)
Negative shock from harvest	0.039	0.197	0.050	0.184
	(0.096)	(0.084)**	(0.096)	(0.083)**
Married	0.236	0.008	0.225	0.022
	(0.133)*	(0.114)	(0.134)*	(0.116)
Household head	0.369	0.180	0.373	0.174
	(0.087)***	(0.093)*	(0.084)***	(0.092)*
Position in the family	0.246		0.250	
	(0.098)**		(0.100)**	
$(Position\ in\ the\ family)^2$	-0.030		-0.030	
	(0.014)**		(0.015)**	
Observations	248	271	248	271

Note: Probit, marginal effects reported, standard errors corrected for clustering at village level. Future-oriented purpose of savings is a dummy variable equal to 1, if the major purpose of savings is future-oriented (agricultural investment, business, education, doctor), and equal to 0, if it focuses on current consumption (celebration, personal items, household equipment).

* significant at 10%.

** significant at 5%.

*** significant at 1%.

Table 13: Share of home savings

Dependent variable	Share of home savings			
	Female	Male	Female	Male
	(1)	(2)	(3)	(4)
Strongly hyperbolic	-0.313	-0.147	-0.089	-0.045
	(0.146)**	(0.124)	(0.079)	(0.108)
Weakly hyperbolic	-0.056	-0.010	-0.003	0.029
	(0.090)	(0.097)	(0.085)	(0.096)
Current discount rate	0.655	0.187		
	(0.235)***	(0.342)		
Future discount rate			0.605	0.358
			(0.265)**	(0.369)
Patient now, impatient in future	0.273	0.061	0.129	-0.022
	(0.123)**	(0.134)	(0.113)	(0.143)
Risk averse	-0.169	-0.046	-0.155	-0.042
	(0.088)*	(0.086)	(0.091)*	(0.086)
Age	-0.058	-0.001	-0.060	0.002
	(0.022)***	(0.030)	(0.023)***	(0.030)
$(Age)^2$	6.2e-04	2.3e-06	6.5e-04	-2.9e-05
	(2.6e-04)**	(3.5e-04)	(2.7e-04)**	(3.5e-04)
Education	-0.006	-0.041	-0.006	-0.038
	(0.010)	(0.013)***	(0.010)	(0.013)***
Wealth	0.017	-0.086	0.018	-0.087
	(0.021)	(0.022)***	(0.020)	(0.022)***
Income in June < income in Sept.	0.116	-0.069	0.119	-0.060
	(0.059)*	(0.113)	(0.059)**	(0.116)
Farmer	0.094	0.284	0.098	0.286
	(0.101)	(0.130)**	(0.100)	(0.128)**
Negative shock from harvest	-0.158	0.032	-0.164	0.032
	(0.114)	(0.117)	(0.116)	(0.115)
Married	0.278	-0.424	0.283	-0.441
	(0.138)**	(0.151)***	(0.136)**	(0.150)***
Household head	0.336	0.085	0.327	0.094
	(0.187)*	(0.152)	(0.182)*	(0.149)
Position in the family	0.006		-0.003	
	(0.081)		(0.084)	
$(Position\ in\ the\ family)^2$	0.003		0.003	
	(0.010)		(0.011)	
Constant	0.896	0.895	0.937	0.769
	(0.558)	(0.622)	(0.582)	(0.638)
Observations	213	227	213	227

Note: Tobit (lower limit = 0; upper limit =1), standard errors corrected for clustering at village level. Share of home savings is equal to home savings divided by total savings. Only respondents with positive total savings are included.

* significant at 10%.

** significant at 5%.

*** significant at 1%.

Table 14: Having loan

Dependent variable	Loan			
	Female	Male	Female	Male
	(1)	(2)	(3)	(4)
Strongly hyperbolic	0.203	0.142	0.085	0.168
	(0.075)***	(0.074)*	(0.086)	(0.078)**
Weakly hyperbolic	-0.007	0.071	-0.050	0.100
	(0.082)	(0.060)	(0.085)	(0.060)*
Current discount rate	-0.340	-0.021		
	(0.133)**	(0.147)		
Future discount rate			-0.514	0.149
			(0.188)***	(0.164)
Patient now, impatient in future	-0.246	-0.070	-0.143	-0.087
	(0.120)**	(0.123)	(0.107)	(0.130)
Risk averse	0.052	0.212	0.061	0.213
	(0.068)	(0.061)***	(0.067)	(0.063)***
Age	0.068	0.017	0.067	0.020
	(0.019)***	(0.018)	(0.020)***	(0.018)
$(Age)^2$	-8.7e-04	-2.1e-04	-8.7e-04	-2.4e-04
	(2.4e-04)***	(2.0e-04)	(2.6e-04)***	(2.0e-04)
Education	-0.021	0.003	-0.023	0.006
	(0.010)**	(0.013)	(0.010)**	(0.014)
Wealth	0.013	0.026	0.014	0.025
	(0.033)	(0.017)	(0.034)	(0.017)
Income in June < income in Sept.	-0.049	0.005	-0.043	0.013
	(0.063)	(0.063)	(0.062)	(0.066)
Farmer	0.081	0.180	0.079	0.186
	(0.071)	(0.051)***	(0.071)	(0.053)***
Negative shock from harvest	0.102	0.124	0.121	0.119
	(0.056)*	(0.096)	(0.056)**	(0.097)
Married	0.379	0.173	0.385	0.162
	(0.141)***	(0.133)	(0.140)***	(0.137)
Household head	0.119	-0.123	0.121	-0.117
	(0.157)	(0.115)	(0.150)	(0.113)
Position in the family	0.138		0.143	
	(0.065)**		(0.064)**	
$(Position\ in\ the\ family)^2$	-0.012		-0.012	
	(0.008)		(0.008)	
Observations	249	272	249	272

Note: Probit, marginal effects reported, standard errors corrected for clustering at village level. The dependent variable equals to one, if an individual has an outstanding loan from a bank, SHG or moneylender.
* significant at 10%.
** significant at 5%.
*** significant at 1%.

Table 15: Having SHG loan

Dependent variable	SHG loan							
	Whole sample				Conditional on having a loan			
	Female (1)	Male (2)	Female (3)	Male (4)	Female (5)	Male (6)	Female (7)	Male (8)
Strongly hyperbolic	0.364	0.048	0.225	0.014	0.285	0.029	0.212	-0.018
	(0.082)***	(0.037)	(0.088)**	(0.043)	(0.081)***	(0.062)	(0.085)**	(0.071)
Weakly hyperbolic	0.064	-0.099	0.019	-0.100	0.070	-0.205	0.041	-0.211
	(0.087)	(0.041)**	(0.085)	(0.042)**	(0.104)	(0.074)***	(0.108)	(0.075)***
Current discount rate	-0.365	-0.104			-0.270	-0.129		
	(0.145)**	(0.106)			(0.147)*	(0.174)		
Future discount rate			-0.596	-0.069			-0.397	-0.149
			(0.201)***	(0.095)			(0.205)*	(0.169)
Patient now, impatient in future	-0.046	-0.090	0.073	-0.073	0.236	-0.137	0.255	-0.104
	(0.113)	(0.035)**	(0.112)	(0.045)	(0.073)***	(0.087)	(0.068)***	(0.106)
Risk averse	0.056	0.042	0.061	0.041	0.016	-0.005	0.012	-0.007
	(0.073)	(0.047)	(0.073)	(0.048)	(0.083)	(0.087)	(0.085)	(0.086)
Age	0.072	-0.009	0.072	-0.008	0.041	-0.024	0.044	-0.024
	(0.026)***	(0.015)	(0.026)***	(0.015)	(0.036)	(0.024)	(0.036)	(0.024)
$(Age)^2$	-9.1e-04	7.2e-05	-9.1e-04	6.2e-05	-5.1e-04	2.5e-04	-5.5e-04	2.5e-04
	(3.1e-04)***	(1.7e-04)	(3.2e-04)***	(1.7e-04)	(4.4e-04)	(2.6e-04)	(4.5e-04)	(2.7e-04)
Education	-0.021	0.002	-0.022	0.003	-0.008	0.004	-0.009	0.004
	(0.011)*	(0.006)	(0.011)**	(0.006)	(0.012)	(0.008)	(0.012)	(0.008)
Wealth	-0.003	0.012	-0.001	0.012	-0.015	0.014	-0.014	0.014
	(0.026)	(0.010)	(0.027)	(0.009)	(0.023)	(0.020)	(0.023)	(0.020)
Income in June < income in Sept	-0.060	0.048	-0.054	0.048	-0.080	0.087	-0.077	0.084
	(0.080)	(0.049)	(0.081)	(0.050)	(0.097)	(0.081)	(0.099)	(0.084)
Farmer	-0.027	-0.060	-0.035	-0.058	-0.078	-0.222	-0.081	-0.223
	(0.067)	(0.045)	(0.066)	(0.044)	(0.096)	(0.110)**	(0.096)	(0.110)**
Negative shock from harvest	0.170	0.066	0.194	0.062	0.133	0.079	0.140	0.075
	(0.086)**	(0.054)	(0.089)**	(0.054)	(0.093)	(0.089)	(0.095)	(0.089)
Married	0.271	0.087	0.273	0.086	0.269	0.109	0.289	0.113
	(0.102)***	(0.070)	(0.108)**	(0.072)	(0.270)	(0.124)	(0.270)	(0.125)
Household head	0.141	-0.008	0.152	-0.009	0.175	-0.004	0.188	-0.008
	(0.191)	(0.077)	(0.187)	(0.077)	(0.162)	(0.142)	(0.157)	(0.142)
Position in the family	0.220		0.229		0.228		0.232	
	(0.064)***		(0.065)***		(0.085)***		(0.088)***	
$(Position\ in\ the\ family)^2$	-0.022		-0.023		-0.024		-0.025	
	(0.009)**		(0.009)**		(0.012)**		(0.012)**	
Observations	249	272	249	272	159	152	159	152

Note: Probit, marginal effects reported, standard errors corrected for clustering at village level. The dependent variable equals to one, if an individual has an outstanding loan from SHG. In columns 1-4 the whole sample is included, in columns 5-8 only those with some loan are included.

* significant at 10%.

** significant at 5%.

*** significant at 1%

Table A1: Hyperbolic preferences and financial behavior with village fixed effects

	Relative to current patience		Relative to future patience	
	Female	Male	Female	Male
	(1)	(2)	(3)	(4)
Dependent variable	**Total savings (Rs. th.)**			
Strongly hyperbolic	-0.418	0.745	-0.944	0.116
	(0.449)	(1.122)	(0.440)**	(1.187)
Weakly hyperbolic	-0.342	-0.704	-0.490	-1.119
	(0.529)	(1.322)	(0.529)	(1.351)
Dependent variable	**Future oriented purpose of savings**			
Strongly hyperbolic	0.126	-0.040	-0.038	-0.210
	(0.096)	(0.100)	(0.103)	(0.098)**
Weakly hyperbolic	0.012	0.089	-0.026	0.069
	(0.123)	(0.115)	(0.127)	(0.119)
Dependent variable	**Share of home savings**			
Strongly hyperbolic	-0.184	-0.136	0.009	-0.036
	(0.087)**	(0.126)	(0.082)	(0.127)
Weakly hyperbolic	0.014	-0.044	0.067	-0.008
	(0.099)	(0.144)	(0.100)	(0.146)
Dependent variable	**Loan**			
Strongly hyperbolic	0.225	0.171	0.094	0.222
	(0.087)**	(0.090)*	(0.101)	(0.090)**
Weakly hyperbolic	-0.027	0.126	-0.063	0.162
	(0.121)	(0.104)	(0.124)	(0.103)
Dependent variable	**SHG loan**			
Strongly hyperbolic	0.386	0.055	0.209	0.026
	(0.098)***	(0.051)	(0.105)**	(0.045)
Weakly hyperbolic	0.045	-0.063	-0.005	-0.064
	(0.125)	(0.022)***	(0.124)	(0.022)***
Dependent variable	**SHG loan (conditional on having a loan)**			
Strongly hyperbolic	0.314	0.038	0.238	-0.021
	(0.078)***	(0.092)	(0.095)**	(0.087)
Weakly hyperbolic	-0.007	-0.183	-0.049	-0.187
	(0.162)	(0.050)***	(0.169)	(0.050)***
Current discount rate	yes	yes	no	no
Future discount rate	no	no	yes	yes
Patient now, impatient in future	yes	yes	yes	yes
Observable characteristics	yes	yes	yes	yes
Village fixed effects	yes	yes	yes	yes

Note: Probit for dependent variables Future oriented purpose of savings, Loan, SHG loan and SHG loan (conditional on having a loan); marginal effects reported. OLS for Total savings. Tobit (lower limit = 0; upper limit =1) for Share of home savings. In columns 1 and 2 the current discount rate is controlled for. In columns 3 and 4 the future discount rate is controlled for. In all columns we also control for dummy for having future-biased preferences, risk aversion, all other observable characteristics used in Tables 11-15 and village fixed effects.

* significant at 10%.

** significant at 5%.

*** significant at 1%

Table A2: Hyperbolic preferences and financial behavior: alternative specification

	Saving					
Dependent variable	Total savings (Rs. th.)		Future-oriented purpose of savings		Share of home savings	
	Female	Male	Female	Male	Female	Male
Strongly hyperbolic	-1.777	-1.763	0.080	-0.036	-0.185	0.154
	(0.640)**	(1.451)	(0.201)	(0.143)	(0.188)	(0.203)
Weakly hyperbolic	-1.247	-2.314	-0.033	-0.012	-0.004	0.273
	(0.890)	(1.752)	(0.130)	(0.116)	(0.136)	(0.182)
	Borrowing					
Dependent variable	Loan		SHG loan		SHG loan	
	Female	Male	Female	Male	Female	Male
Strongly hyperbolic	0.030	0.241	0.289	-0.043	0.365	-0.117
	(0.124)	(0.138)*	(0.132)**	(0.058)	(0.113)***	(0.119)
Weakly hyperbolic	-0.079	0.148	0.023	-0.075	0.134	-0.172
	(0.138)	(0.078)*	(0.129)	(0.044)*	(0.102)	(0.071)**

Note: Standard errors corrected for clustering at village level. Probit for dependent variables Future oriented purpose of savings, Loan, SHG loan and SHG loan (conditional on having a loan); marginal effects reported. OLS for Total savings. Tobit (lower limit = 0; upper limit =1) for Share of home savings. Table reports the coefficients after controlling for dummies for each level of current discount rate, dummies for each level of future discount rate (as in Ashraf et al. 2006), risk aversion and all other observable characteristics used in Tables 11-15.

* significant at 10%.

** significant at 5%.

*** significant at 1%.

Table A3: Hyperbolic preferences and financial behavior (individuals with strongly and weakly hyperbolic preferences pooled)

	Relative to current patience	Relative to future patience
	Female	Female
	(1)	(2)
Dependent variable	**Total savings (RS. th.)**	
Hyperbolic	-0.532	-0.898
	(0.400)	(0.440)*
Dependent variable	**Future oriented purpose of savings**	
Hyperbolic	0.080	-0.055
	(0.067)	(0.057)
Dependent variable	**Share of home savings**	
Hyperbolic	-0.201	-0.056
	(0.107)*	(0.063)
Dependent variable	**Having loan**	
Hyperbolic	0.115	0.030
	(0.054)**	(0.055)
Dependent variable	**SHG loan (whole sample)**	
Hyperbolic	0.232	0.143
	(0.067)***	(0.061)**
	SHG loan (conditional on having loan)	
Hyperbolic	0.243	0.122
	(0.088)***	(0.088)
Current discount rate	yes	no
Future discount rate	no	yes
Patient now, impatient in the future	yes	yes
Observable characteristics	yes	yes
village fixed effects	no	no

Note: Probit for dependent variables Future oriented purpose of savings, Loan, SHG loan and SHG loan (conditional on having a loan); marginal effects reported. OLS for Total savings. Tobit (lower limit = 0; upper limit =1) for Share of home savings. In the first column the current discount rate is controlled for. In the second column the future discount rate is controlled for. In all columns we also control for dummy for having future-biased preferences, risk aversion, all other observable characteristics used in Tables 11-15. Standard errors corrected for clustering at village level.

* significant at 10%.

** significant at 5%.

*** significant at 1%

4 An Endogenous Attitude to Risk of a Firm: A Model

Abstract

The paper examines the risk behavior of a competitive firm under price uncertainty. The model developed in the paper is an extension of Greenwald and Stiglitz's model (1993a), which implies risk-averse behavior if a firm's production is financed by debt. Our model incorporates more general assumptions about a firm's financing: access to the equity market and the possibility of a soft budget constraint. Both features are closely associated with different stages of economic development. The model demonstrates several interesting implications. A soft-budget constraint, a feature that is typical primarily for developing or emerging economies, can lead to adoption of excessively risky production strategies. In the environment *without* soft-budget constraint, improving access to capital markets enhances the willingness of managers to bear risk up to the production level associated with risk-neutral firm. A degree of uncertainty about future prices may have ambiguous effect on production, depending on financial situation of the firm.

JEL Classification: D21, D81, G32.

Keywords: attitude to risk, bankruptcy, financing, firm, soft budget constraint, uncertainty.

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4.1 Introduction

In the previous decades there has been a tendency to remove the traditional assumption in the theory of the firm that the demand for products is known with certainty at the time when the output decision is made. The uncertain character of the environment has become a critical component in the theories of the firm. It was shown originally by Sandmo (1971) and Leland (1972) that a firm's attitude to bear the inherent risk of production has important effects on the firm's willingness to produce.

Various authors link the firm's attitude to risk to firm' financing. Greenwald and Stiglitz (1993a) argue that a firm's risk-averse behavior is a result of financial market imperfections and they demonstrate its link to business cycles. The risk-seeking behavior of firms resulting from too easy access to debt-financing due to soft budget constraint was a central policy issue in the transition economies (Kornai, Maskin and Roland, 2003) and during the collapse of the banking sector in Asia in the 1990s (Krugman, 1998). However interesting they are, these models of firm behavior are components of theories with the primary focus on explaining certain phenomena on the macroeconomic level (business cycles, troubles of the banking sector in the transition countries, the nature of the Asian crises). They capture important patterns of a firm's risk behavior, but they focus on the specific conditions of a firm's financing. As a result, they do not provide a complete picture of the determinants of the firm's attitude to risk.

The aim of this paper is to complement this literature and develop a more comprehensive model of a firm, which would encompass a broader scope of important parameters, which may have an effect on how a firm behaves – in a risk-averse, risk-neutral or risk-seeking manner. In particular, we are interested in the characteristics of environment that are closely associated with different stages of economic development. We will focus on the role of softness of budget constraint and constraints to access capital markets in determining firm's attitude to risk, since both are characteristics primarily relevant for developing countries.[1]

The interplay between uncertainty related to the productive activity of firms and financing arises from a simple fact: most production takes time and future markets are missing for most of the products (Magill and Quinzii 1996). The cost of investment or inputs

[1] I must admit that recent policy choices in response to the financial crisis in developed countries question the traditional perception that soft budget constraint is characteristic for developing countries.

must be incurred before the revenue is obtained from the sale of its output. The traditional theory of the firm under uncertainty (Sandmo, 1971; Coes, 1977; Quiggin, 2001; Hau, 2003) models a firm as having a von Neumann-Morgenstern utility function, which, besides other properties, is increasing and concave in its profit. The firm is therefore assumed to be risk-averse.[2] The principal result of this approach is the demonstration that (1) optimal output for a risk-averse firm facing an uncertain demand is lower than it would be in the case in which the firm faced a certain price of the same expected value and (2) with riskier distribution of prices the risk-averse firm reduces output. However, the attitude to risk is not explained within the model and risk aversion is only assumed and not specifically related to financing decisions.

For Greenwald and Stiglitz (1990, 1993a, 1993b) capital structure is a central issue for the firm's attitude to risk and the following logical framework is utilized for explaining behavior: financing - attitude to risk - optimal level of output. It is argued that as a consequence of severely limited access to the capital market due to information asymmetries and negative signals associated with issuing equity, the reliance on debt-financing is the prevailing phenomenon. Greenwald and Stiglitz (1993a) use a simple model to illustrate how risk considerations affect firms' production decisions. It is assumed that the firm cannot raise equity and it is financed by debt. The debt imposes a risk of bankruptcy on the firm and there are personal costs of bankruptcy for managers. Their value and reputation on the managers' market may be harmed, because it is usually not possible to distinguish whether the bankruptcy is caused by bad management or adverse market conditions. Firms thus take the bankruptcy costs into account in their production decisions, which translates into lower output and high sensitivity of firms to any changes in the market prices. Consequently, severe business cycles are more likely to happen.

Although the model of Greenwald and Stiglitz (1993a) lucidly relates the financing and attitude to risk, it is very restrictive about the firm's capital structure possibilities when assuming that bond-financing is the only feasible option for additional financing. Most of the financial theorists understand the information asymmetries as an explanation for conditions when a firm may refuse to issue equity and prefer debt (Myers and Majluf, 1984). As Myers (2001, p.81) points out: "There is no universal theory of the debt-equity choice, and no reason to expect one." Agency theory and the incentive argument originally suggested by

[2] This shift from expected profit to the expected utility of profit in the theory of the firm resembles the shift in consumer theory from the expected value to the expected utility originally suggested by Daniel Bernoulli almost three centuries ago via his so-called Petersburg's Paradox.

Jensen and Meckling (1976), Grossmann and Hart (1982) and Fama and Jensen (1983) provide a rationale for a mix between debt and equity as too much debt may imply excessive risk for managers, while too little will encourage misuse of funds. Therefore it is more realistic to assume that a firm is financed by both – by debt and by issuing new equity shares.

The soft budget constraint (SBC) literature may add another piece to the picture as it provides a theoretical justification for, among other things, the risk-seeking behavior of a firm[3]. It has been shown in extensive literature that the SBC concept is relevant in an economic environment dominated by state as well as private ownership (e.g. Schaffer, 1998; Djankov and Murrel, 2002). An important softening instrument in the market economy is some form of credit. Relaxed repayment terms to banks may have the form of governmental guarantees (Krugman, 1998). State-owned banks, which are characteristic for emerging economies, may apply paternalistic economic policy and give firms easy access to credit even if they are in a troublesome financial situation. Or the banks might not require full repayment and they might provide refinancing for investment projects which in the first period turn out to be unprofitable and rely on the second period's results to be higher than the costs of bankruptcy proceedings (Dewatripont and Maskin, 1995).

As a consequence of all these forms, managers may "discount" the value of debt because they expect that they will not be forced to repay it in the event that the firm gets into financial difficulties. The ability of firms to buy inputs without fully repaying them can significantly alter demand for these inputs and the level of output produced. As pointed out in Kornai, Maskin and Roland (2003) and Krugman (1998) the SBC induces firms towards a higher level of investment and production levels by reducing the downside risk to firms.

In the remaining part of this paper we will extend the Greenwald and Stiglitz model (1993a) for the usage of equity and the possibility of the SBC and thus we will try to capture other important determinants of the attitude to risk and output behavior under uncertainty. The following model should be a generalization of the preceding ones.

This paper is organized as follows. In the next section the assumptions will be described and a new model constructed. Section 3 discusses the resulting firm's supply under uncertainty. In Section 4 it will be demonstrated that changes in financing (net worth position, possibility to raise new equity, softness of the budget constraint) and the perception of risk

[3] For a surveying article which defines the term "soft budget constraint" and provides a comprehensive account of contexts in which the SBC concept is relevant, see Kornai, Maskin and Roland (2003).

faced by a firm can explain all types of attitudes to risk and can potentially have large effects on the optimal output level. Section 5 concludes.

4.2 Model

4.2.1 Assumptions

A.1. We will assume that a firm can partially finance its expansion of production through new equity shares and the remaining part through debt-financing. Hence $T_t^i = B_t^i + S_t^i$, where T_t is the total level of external financing that a firm needs, B_t^i is the level of bond-financing and S_t^i is the total issuing price for new shares at time *t*. At the same time we will assume that the proportion of new equity is given by parameter $s \in \langle 0;1 \rangle$ so that $S_t^i = sT_t^i$. This differs from the assumption of Greenwald and Stiglitz (1993a), who consider only a bond-financed firm and thus $s = 0$. The parameter *s* represents the level of access to the capital market and it is considered as exogenous since we are particularly interested in how overall access to equity financing affects behavior of firms in an economy. A possible extension of this model would be to make the parameter *s* endogenous based on one of many theories of optimal capital structure.

A.2 Firms will be assumed to make decisions at discrete intervals: t = 1,…., T. We will assume that future markets for products do not exist and that there is one period lag between the use of inputs and the availability of output.

A.3 The decision variable is the level of production q_t^i . The output decisions of firms are made by managers who take into account not only profit maximization criteria (relevant for owners), but also the risk related to financing the production through bonds and limited predictability of future prices. As it is usually impossible to distinguish whether financial bankruptcy was caused by bad luck with investment projects or by bad management, managers inevitably suffer a stigma associated with bankruptcy and assign personal costs to bankruptcy (Eaton, Gersovitz and Stiglitz 1986; Greenwald and Stiglitz, 1993a).

A.4 The technology of the firm is represented by the standard real cost function $c = c(q)$ where q is the level of production, with $c'(q) > 0$ and $c''(q) \geq 0$. The firm's costs increase with the level of production and technology has increasing marginal costs.

A.5 The firm faces sectoral price level $\widetilde{P}_t^i$, which is randomly determined around the overall price level. The uncertain price of output of the firm $\widetilde{P}_t^i$ is i.i.d. with a distribution

function F(.) and density f(.). The expected price of output is assumed to be equal to the overall price level so that $E(\widetilde{P}_t^i) = P$. The relative prices are important for the firm due to the fact that expenditures on inputs are assumed to be dependent on the price level P, whereas the revenues from the produced output depend on specific sector price P_t^i. The firm operates in a competitive market and it is a price-taker.

A.6 Following Greenwald and Stiglitz (1993a) it is assumed that if the nominal net worth position of the firm is negative ($A_t < 0$) the firm will go bankrupt and all revenues from the sale of q_{t-1}^i will be distributed to creditors[4].

A.7 All forms of the SBC with respect to a bank result in some form of partial or late repayment of the credit or at least they create the expectation of managers that the firm will have the freedom not to fully repay. In our model we will associate the degree to which the budget constraint related to debt is soft with the parameter I_t. The softness of the budget constraint is exogenous in our model – a feature of an economic system - and the value of the parameter I_t ranges between zero and unity, $I_t \in \langle 0;1 \rangle$. The parameter I_t can be also understood as a "discount" factor, which managers associate to debt due to the SBC. $I_t B_t^i$ represents the value of debt B_t^i, which the firm expects that it will be forced to repay.

The decrease in I_t will simulate the increase in the degree of softness of the budget constraint. Under standard market conditions I_t is equal to one and the more moral hazard there is in the firm's decision-making due to the SBC, the closer the parameter I_t will be to zero.

As the net worth position depends on the level of debt which the firm has to repay (see the equation (1) below), a lower I_t may artificially keep the net worth positive and the company will not go into bankruptcy. The A.5 therefore still holds, even though under standard market conditions ($I_t = 1$) the firm would go bankrupt.

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[4] In theory, negative net worth may not necessarily imply negative net present value of future profits compared to losses which should be the ultimate criteria for owners to enter bankruptcy. I thank R. Filer for this point.

[6] The model could be further extended by making the $r_t^{i,BT}$ dependent on other parameters determining firm value during bankruptcy procedure such as random price, level of debt and output level. This extension would not alter the main results of the model and for the sake of simplicity it is assumed that $r_t^{i,BT}$ is a constant.

A.8 For the sake of simplicity we assume that the overall price level does not change between the periods $P_t = P_{t+1}$ and we will denote the price level P as independent of time. The only source of risk is the uncertain price of output $\tilde{P}_t^i$.

A.9 We assume that output q_{t-1}^i has zero supply elasticity and must be sold in its entirety at the beginning of the following period t, in which it becomes available.

4.2.2 Bankruptcy conditions

The nominal net worth position A_t^i is defined as all assets minus all liabilities. It determines the solvency of a firm and it results from the production and financing decisions made in period t-1.

$$A_t^i = P_t^i q_{t-1}^i - (1 + r_{t-1}^i) B_{t-1}^i I_t^i \quad (1)$$

The nominal level of debt B_{t-1}^i was utilized to pay for the inputs that were required for producing q_{t-1}^i. The contractual interest rate of debt is r_{t-1}^i, the contractual repayment owed to debt-holders is $(1 + r_{t-1}^i) B_{t-1}^i$ and the degree to which the budget constraint is soft is I_t. The nominal net worth position is also affected by the price P_t^i at which the firm sells the inherited output q_{t-1}^i.

The level of external financing T_t^i needed for production in period t depends on the difference between the level of costs and net worth position. Since the cost function is defined in real terms we can write

$$T_t^i = Pc(q_t^i) - A_t^i \quad (2)$$

The firm has two options for supplementing its own resources (net worth) in financing the production: through debt B_t^i or through issuing new equity S_t^i. As noted earlier in A.1, the proportion of new shares in total external financing (and thus of bonds) is given by the parameter *s*.

In the second stage, after the prices in period *t+1* are revealed, the firm will go bankrupt if it is obliged to repay more than its income allows it to repay. Using assumption A.6 and equation (1), we get:

$$P_{t+1}^i q_t^i < (1 + r_t^i) B_t^i I_t \quad (3)$$

By rewriting and using A.1, A.5 and equation (2) we get the same condition as:

$$\tilde{P}^i_{t+1} q^i_t < (1 + r^i_t) I^i_t (Pc(q^i_t) - A^i_t - S^i_t) \quad (4)$$

Dividing the equation by q^i_t we get:

$$\tilde{P}^i_{t+1} < \frac{(1 + r^i_t) I_t \, (Pc(q^i_t) - A^i_t - S^i_t)}{q^i_t} = \overline{P}^i_{t+1} \quad (5)$$

where $\overline{P}^i_{t+1}$ is the lowest sectoral price in period *t+1* at which the firm is solvent and it shows the extent of changes of relative prices the company is able to absorb without becoming bankrupt. The company is more resistant to bankruptcy risk (i.e. it has lower $\overline{P}^i_{t+1}$) with an increase of its net worth position and the level of new shares issued in period t, and a decrease in I_t and in the contractual interest rate.

4.2.3 Probability of Bankruptcy

A.10 We assume that firms can borrow as much as they wish as long as the lender gets the expected return amounting to $1 + r^f_t$, where r^f_t is the risk-free interest rate. The lender takes into account not only the regular repayments amounting to $1 + r^i_t$ in the situations when a firm is solvent - if $\tilde{P}^i_{t+1} \geq \overline{P}^i_{t+1}$ -, but also a return $1 + r^{i,BT}_t$ when a firm is insolvent - if $\tilde{P}^i_{t+1} < \overline{P}^i_{t+1}$.

Therefore the contractual interest rate is given by the following equation:

$$1 + r^f_t = (1 + r^i_t)(1 - F(\overline{P}^i_{t+1})) + F(\overline{P}^i_{t+1})(1 + r^{i,BT}_t) \quad (6),$$

where *F(.)* is the probability distribution of the sectoral price and $F(\overline{P}^i_{t+1})$ is defined as the probability of bankruptcy. The individual firm pays via its contractual interest rate not only the opportunity costs (risk-free interest rate), but it also pays to the lender for the risk that the firm will go bankrupt and that the bondholder will get only the return $(1 + r^{i,BT}_t)$, where $r^{i,BT}_t \in < -1; r^i_t >$. As a consequence, the contractual interest rate is higher than, and increases with, the risk-free interest rate, increasing with the probability of bankruptcy and decreasing with the amount the lender can get during the bankruptcy procedure $r^{i,BT}_t$. Notice that both $r^{i,BT}_t$ and r^f_t are exogenous in this model.[6]

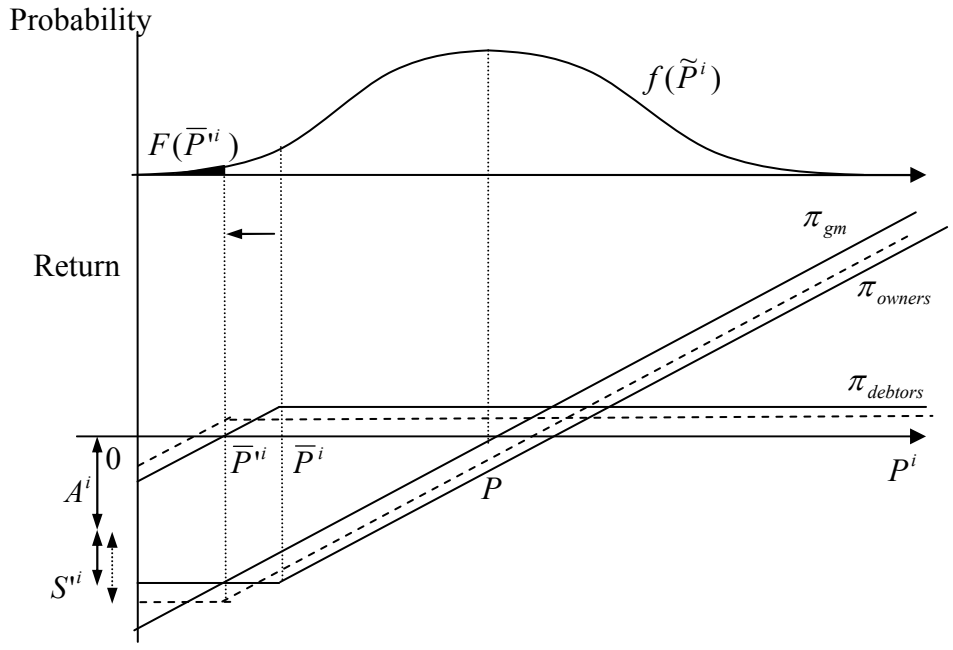
The probability of bankruptcy $F(\overline{P}^i_{t+1}) = F(\overline{P}(q^i_t, A^i_t, S^i_t, I_t, r^f_t))$ is positively dependent on $\overline{P}^i_{t+1}$, which causes it to increase along with the increase of the interest rate and decrease with the initial net worth position, the amount of new shares and softness of the budget constraint.

The shape of the distribution function *F(.)* expresses the degree of uncertainty concerning future prices. The relationship between these parameters and probability of bankruptcy can be easily graphically illustrated (Figure 1). On the horizontal axis is the uncertain sectoral price $\widetilde{P}^i_{t+1}$ and on the vertical axis we plot:

- the firm's gross margin defined as $\pi_{gm} = P^i_{t+1} q^i_t - Pc(q^i_t)$,
- the return of owners defined as $\pi_{owners} = P^i_{t+1} q^i_t - Pc(q^i_t) - r^i_t B^i_t$, if $\widetilde{P}^i_{t+1} \geq \overline{P}^i_{t+1}$ (the firm is solvent) or as $\pi_{owners} = -A^i_t - S^i_t$, if $\widetilde{P}^i_{t+1} < \overline{P}^i_{t+1}$ (the firm is bankrupt),
- the return to bondholders defined as $\pi_{debtor} = r^i_t B^i_t$, if $\widetilde{P}^i_{t+1} \geq \overline{P}^i_{t+1}$ or as $\pi_{debtor} = P^i_{t+1} q^i_t - Pc(q^i_t) + A^i_t + S^i_t$, if $\widetilde{P}^i_{t+1} < \overline{P}^i_{t+1}$.

In the upper part of Figure 1 we have plotted the probability density *f(.)* of the sectoral price, which illustrates the uncertainty. [7] The area under the density function up to the solvency price $\overline{P}^i_{t+1}$ measures the probability of bankruptcy $F(\overline{P}^i_{t+1})$. For illustrative purposes, let's examine the effect of new shares and increased uncertainty for a given q^i_t.

Figure 1: The effect of new shares on the probability of bankruptcy

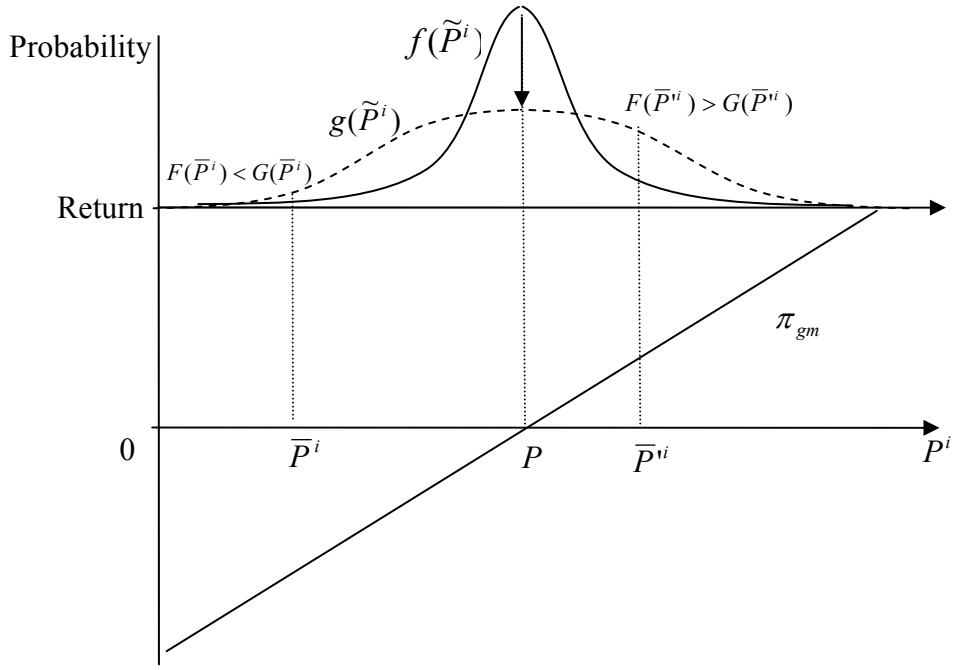


[7] The distribution function of output prices is assumed to have a shape similar to normal distribution with the mean equal to the overall price level, the lower bound equal to zero and the upper bound equal to double the mean price level.

An increase of new shares S_t^i has two effects. It increases the owner's liabilities and it works as a substitute for bond-financing, which is reduced. Consequently, the contractual interest rate and thus repayments to debtors decrease for all levels of relative prices – π_{debtor} shifts down, π_{owners} shifts to the left. Both effects lead to a decrease of the probability of bankruptcy.

The shape of density function *f(.)* influences the size of the area illustrating the probability of bankruptcy $F(\overline{P}_{t+1}^i)$. Let us define an increase in price uncertainty as a "stretching" of the probability distribution around a constant mean (Sandmo, 1971). In Figure 2 the probability function *g(.)* corresponds to the riskier distribution of prices. We can observe opposite effects of uncertainty depending on the firm's financial situation. If the solvency level of the output price is lower than the overall price level, then riskier distribution increases the probability of bankruptcy; $F(\overline{P}) < G(\overline{P})$. In other words, if a firm is more likely to survive than it is to go bankrupt, then price uncertainty reduces the likelihood of the firm's survival. In the opposite situation, when $\overline{P}'$ is very high and the firm has a poor chance of survival, the increase in price uncertainty may help the firm out of troubles via the increased probability of extremely high prices. The probability of bankruptcy thus decreases for riskier distribution of prices; $F(\overline{P}) > G(\overline{P})$.

Figure 2: The impact of increased price uncertainty on the probability of bankruptcy



4.2.4 The firm's objective function and first order conditions

We focus on a firm with divided ownership and control and therefore consider managers as the primary decision-makers in the firm. In each period the managers select output level so as to maximize expected profit of the firm (i.e., total sales revenues minus repayments to lenders and opportunity costs of new equity capital) minus the personal costs of possible bankruptcy.

The objective function with these features can be expressed in the following way:

$$\underset{q\geq 0}{MAX}[P_{t+1}^{i,E} q_t^i - (1+r_t^i) I_t B_t^i - (1+r_t^f) S_t^i - K_t^i F(\bar{P}_{t+1}^i)] \qquad (7)$$

In compliance with Greenwald and Stiglitz (1993a) the bankruptcy costs are defined as the costs of bankruptcy K_t^i multiplied by the probability of bankruptcy. Bankruptcy costs represent the negative attitude of managers towards bankruptcy. They are subject to an agency agreement that rewards them with a share of profits, but they have to bear a large penalty in the event of bankruptcy (stigma of an unsuccessful manager).

A.11 We assume that the bankruptcy costs increase with the size of the firm. The bigger the firm is, the more managers (and employees) are involved, whose loss of position and income would increase with the firm's size. We will use the quantity of output as the proxy variable for the firm's size as it is the only scale variable in the model and thus the bankruptcy costs are defined as follows:

$$K_t^i = Kq_t^i \tag{8}$$

The bankruptcy costs are linearly related to the firm's level of production, where K is the sensitivity of managers to bankruptcy.[8]

We can rewrite the objective function as:

$$\underset{q\geq 0}{MAX}[P_{t+1}^{i,E} q_t^i - (1+r_t^i)I_t\,(Pc(q_t^i) - A_t^i - S_t^i) - (1+r_t^f)S_t^i - Kq_t^i F(\overline{P}_{t+1}^i)] \tag{9}$$

If the above-stated assumptions are fulfilled, then the firm's behavior in terms of its real output is determined by interest rates, softness of the budget constraint, technology, the firm's ability to issue new shares, equity, real bankruptcy costs and relative price uncertainty.

After derivation of equation (9) with respect to q we get the first order equilibrium condition

$$P_{t+1}^{i,E} - (1+r_t^i)I_t\,(Pc'(q_t^{i^*}) - s\frac{\partial T_t^i}{\partial q_t^i}) - (1+r_t^f)s\frac{\partial T_t^i}{\partial q_t^i} - \eta_t^i = 0$$

(10)

where η_t^i is the marginal bankruptcy costs of the firm i in the period t:

$$\eta_t^i = KF(\overline{P}_{t+1}^i) + Kq_t^i f(\overline{P}_{t+1}^i)\frac{\partial \overline{P}_{t+1}^i}{\partial q_t^i} \tag{11}$$

$\eta_t^i = \eta(K, q_t^i, A_t^i, S_t^i, I_t, r_t^i)$ can be understood as risk premium for additional production.

4.2.5 The firm's supply under uncertainty

The equilibrium condition (12) below is the central outcome of our model. First we will try to show that the resulting behavior is a generalization of the existing concepts of a firm under uncertainty. Then we will perform a sensitivity analysis of the optimal output on the major parameters. This exercise will allow us to devise nine propositions about the determinants of the firm's attitude to risk and the impact on the firm's behavior.

Using derivative of equation (2) $\frac{\partial T_t^i}{\partial q_t^i} = Pc'(q_t^i)$ we can rewrite the equilibrium condition (11) so that:

$$P_{t+1}^{i,E} = Pc'(q_t^{i^*})[(1-s)I_t^i(1+r_t^i) + s(1+r_t^f)] + \eta_t^i \tag{12}$$

[8] Besides this reasoning, the dependence of bankruptcy costs on the size of a firm is important from the technical point of view of this model as with bankruptcy costs having been fixed, they could be easily mitigated through expansion of production.

The output is selected so as to equalize price with (1) marginal costs that include the costs of financing weighted for the relative proportion of new shares and debt and (2) the personal bankruptcy costs.

The first question which is naturally raised by the introduction of price uncertainty and financing issues is how the optimal output compares with the well-known neoclassical solution. The traditional neoclassical analysis says a firm produces up to the point when the market price is equal to the present value of the marginal costs. In terms of our model it is the situation when:

- the firm faces a hard budget constraint ($I_t = 1$) and
- the costs of production expansion can be fully financed through new shares ($s = 1$).

Since the event of bankruptcy is possible only when the company is at least partially financed by debt, the risk premium η_t^i is equal to zero. We can write:

$$P_{t+1}^{i,E} = Pc'(q_t^{i^*})(1 + r_t^f) \tag{13}$$

This outcome is the traditional neoclassical result taking into account the fact that the costs are paid one period before the output is received and opportunity costs must be included.

The second situation of interest is when a firm faces a hard budget constraint (HBC, $I_t = 1$) and it is partly financed through debt. The managers choose the level of output according to the following equation:

$$P_{t+1}^{i,E} = Pc'(q_t^{i^*})[(1-s)(1 + r_t^i) + s(1 + r_t^f)] + \eta_t^i \tag{14}$$

The costs of debt r_t^i and the opportunity costs of new shares r_t^f are weighted according to their relative proportion to give the total costs of financing. As the contractual interest rate related to debt is higher than the risk-free interest rate (equation 6), better access to the capital market approximated by the exogenous parameter s reduces the costs of financing. It is interesting to notice that to the extent a firm can issue new shares on the capital market ($s \rightarrow 1$) in order to finance its additional production, the marginal costs of production and financing move towards the level of marginal costs related to a traditional risk-neutral firm as we have shown above.

The item η_t^i is another departure from the traditional risk-neutral neoclassical equilibrium. The bond-financed or co-financed firm has to face the risk of bankruptcy. As

a consequence, the marginal bankruptcy costs η_t^i (risk premium) are positive. Hence bankruptcy risk reduces optimal output level.

Greenwald and Stiglitz (1993a) model a situation when a firm is solely bond-financed ($s = 0$), faces an HBC and pays a higher contractual interest rate for the overall financial needs $T_t^i = B_t^i$. At the same time the risk premium with solely bond-financing is the maximum of the risk premiums associated with co-financing (bonds and new shares). Both of these effects lead to a firm having the highest possible risk aversion and lowest optimal level of output (supply curve S_B^i in Figure 3) compared to our model. Here, new shares work as a buffer to absorb risks. The more the firm has access to equity financing, the less risk-averse it will be and the supply curve will shift to the right towards the supply curve associated with a risk-neutral firm.

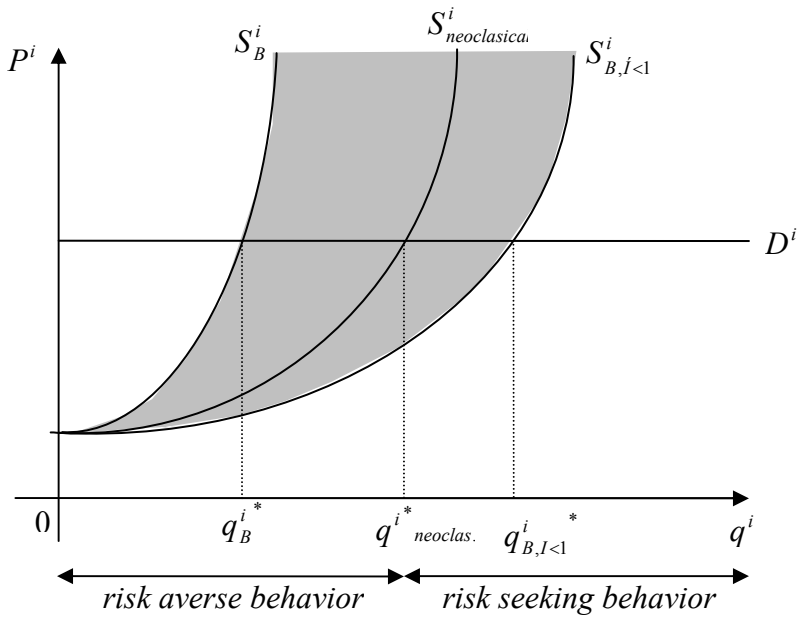
Let's look at the behavior of a firm which faces a SBC, in which case the probability of fully repaying its debt obligations is lower than unity ($I_t < 1$). So far we have assumed it is desirable for managers to search for funding on the capital market relative to loans and that they are constrained by the parameter *s*. If, however, $I_t < \frac{1+r_t^f}{1+r_t^i}$, it is preferable for managers to finance production completely via loans, because doing so reduces the costs of financing. Managers also feel less threatened by the firm's debt obligations and thus the bankruptcy risk premium associated with bonds decreases with the softness of the budget constraint.

We can rewrite the equation (12) so that:

$$P_{t+1}^{i,E} = Pc'(q_t^{i^*})I_t\,(1 + r_t^i) + \eta_t^i \qquad (15)$$

The softer the budget constraint is, the more the costs of production are "discounted" and the closer the bankruptcy premium is to zero. In an extreme case, when the firm has certainty that it will not have to repay its debt ($I_t = 0$), the managers do not include the costs into their considerations about optimal output. Consequently, the supply curve of a firm facing an SBC ($S_{B,I<1}^i$) is shifted to the right and the optimal level of production ($q_{B,I<1}^{i\,*}$) may become even higher than for a neoclassical risk-neutral firm. Figure 3 graphically illustrates the three situations discussed above.

Figure 3: Firm's supply under uncertainty



S^i_B is the supply curve of a firm as understood by Greenwald and Stiglitz (1993a). It is only bond-financed, very risk-averse and produces low levels of output. The inclusion of the possibility of equity financing creates a continuous interval for the firm's supply curve with the upper extreme being a neoclassical risk-neutral firm. The introduction of the SBC has further broadened the model for risk-seeking behavior. The managers may put greater weight on the favorable development of prices because they are less motivated to reduce the chance of failure and, as a result, the firm may produce even more than the risk-neutral producer. When the degree of softness I_t is switched for unity due to, for example, privatization of state banks, the optimization issue changes rapidly. The firm starts to face an HBC and it may cause substantial shrinkage in the firm's supply.

4.3 The determinants of firm's attitude to risk and optimal output

In this section we will elaborate algebraically how the major parameters influence the firm's attitude to risk and its optimal output.

4.3.1 Net worth position, interest rate and sensitivity to bankruptcy

By differentiating the optimality condition (12) with respect to the net worth position we get:

$$[(1-s)I_t^i(1+r_t^i)+s(1+r_t^f)]Pc''(q_t^{i*})\frac{\partial q_t^{i*}}{\partial A_t^i}=-Pc'(q_t^{i*})(1-s)I_t^i\frac{\partial r_t^i}{\partial A_t^i}-\frac{\partial \eta_t^i}{\partial A_t^i} \qquad (16)$$

The first item on the right-hand side represents the change in costs of financing due to the change in net worth. The contractual interest rate required by banks is negatively dependent on the net worth position and the proportion of debt on the value of marginal costs is non-negative, and thus the whole first item is positive. The second item on the right-hand side is also positive as the change in the risk premium associated with bankruptcy depends negatively on the net worth position, because a stronger net worth position decreases the probability of bankruptcy. Since we assume that marginal costs increase with quantity, we can conclude that the optimal output has to increase with the net worth position ($\frac{\partial q_t^{i*}}{\partial A_t^i}\geq 0$).

Result 1: Under price uncertainty stronger net worth position decreases the costs of production financing, decreases risk premium associated with bankruptcy and therefore increases the optimal level of production.

The lower boundary of the contractual interest rate is the risk-free interest rate and the minimum risk premium is zero. There is thus a level of A_t^i above which the decrease of the interest rate and bankruptcy premium due to the increase in A_t^i will be close to zero.

Result 2: There is certain level of net worth above which the impact of increased net worth has a negligible positive impact on the optimal level of production.

The positive relationship between net worth and the level of production is determined also in Greenwald and Stiglitz (1990, 1993a). Using the differentiating exercise with respect to the risk-free interest rate and the sensitivity of managers to bankruptcy *K* we can obtain two more results which are also very similar to those of the Greenwald and Stiglitz model.

Result 3: Under price uncertainty the increase of the risk-free interest rate increases the costs of financing and increases the risk premium associated with bankruptcy and therefore decreases the optimal level of production. Moreover, the optimal output decreases faster than that of a risk-neutral firm.

Result 4: Under price uncertainty the increase of the sensitivity of managers to bankruptcy increases the risk premium associated with bankruptcy and therefore decreases the optimal level of production.

The results that follow are products of additional features of our model.

4.3.2 New shares and optimal output

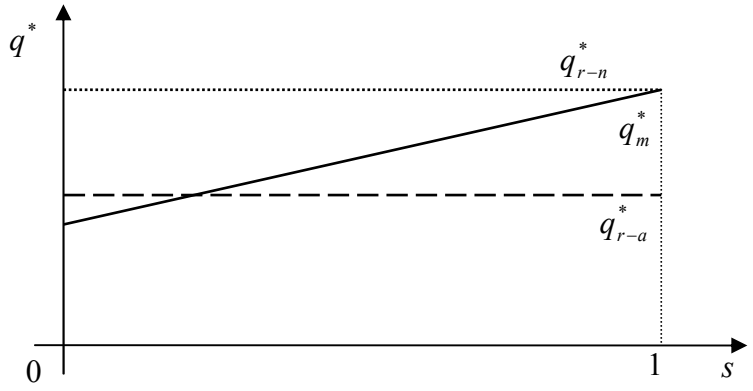
The effect of new shares resembles the situation for the net worth position with one exception. The equation (17) shows that the negative relationship between new shares and costs of financing is conditional on the existence of the HBC. If a firm faces the SBC, the effect of increased s is ambiguous. On one hand, the interest rate required from lenders decreases up to risk-free interest rate. On the other hand, if a firm faces an SBC it may be cheaper to rely on loans, because they may not be fully repaid. In such a situation we cannot determine a sign of a change in the costs of financing. In any case, the risk premium decreases with the level of new shares. Thus, for a firm that faces an HBC the optimal level of production is positively dependent on the proportion of new shares in its financing $\frac{\partial q_t^{i*}}{\partial s} \geq 0$.

$$[(1-s)I_t^i(1+r_t^i)+s(1+r_t^f)]Pc''(q_t^{i*})\frac{\partial q_t^{i*}}{\partial s} = -Pc'(q_t^{i*})[(1-s)I_t^i\frac{\partial r_t^i}{\partial s}-(1+r_t^i)I_t^i+(1+r_t^f)]-\frac{\partial \eta_t^i}{\partial s} \qquad (17)$$

Result 5: Under price uncertainty and the existence of a hard budget constraint, the increase in financing through new shares decreases the costs of financing and decreases the risk premium associated with bankruptcy, and therefore increases the optimal level of production.

Figure 4 illustrates these relationships and the independence of output from financing in the theory of a risk-neutral firm (q_{r-n}^*) and the traditional theory of a firm under uncertainty (q_{r-a}^*; Sandmo, 1971). In our model the optimal output q_m^* increases up to the level of production associated with a risk-neutral firm for $s = 1$. We can easily observe that if we take the extreme case used in the models of Greenwald and Stiglitz, where $s = 0$, the level of production under uncertainty will be the lowest possible.

Figure 4: New shares and optimal output



4.3.3 Price uncertainty and optimal output

The determinants we have analyzed so far influence first the minimal sectoral price level when a firm is solvent $\overline{P}_t^i$ and through the probability of bankruptcy $F(\overline{P}_t^i)$ they change the contractual interest rate and the risk premium. This time we keep the solvency level of the sectoral price constant and we model the impact of the changes in the variance of the distribution function *F(.)*.

It is not straightforward how the effect of increased variance can be formalized in a manner similar to that by which we demonstrated the changes in a firm's risk behavior for other parameters. Let's define a function $X(\overline{P}_t^i,\sigma)$, which represents the distribution function for different levels of $\overline{P}_t^i$ and different levels of uncertainty represented by σ. We can imagine the departure from $F(\overline{P}_t^i)$ to $X(\overline{P}_t^i,\sigma)$ as adding another dimension σ, where the probability of bankruptcy depends not only on the solvency level of price $\overline{P}_t^i$ as is the case for $F(\overline{P}_t^i)$, but also on its variance. Therefore, $X(\overline{P}_t^i,\sigma) = F(\overline{P}_t^i)$, if the "varying" variance in the new function of probability of bankruptcy is the same as the given variance behind our original probability of bankruptcy.

Let's substitute the two and let's differentiate the optimality condition with respect to variance. We get:

$$[(1-s)I_t^i(1+r_t^i)+s(1+r_t^f)]Pc''(q_t^{i*})\frac{\partial q_t^{i*}}{\partial\sigma} = -Pc'(q_t^{i*})(1-s)I_t^i\frac{\partial r_t^i}{\partial X(\overline{P}_t^i,\sigma)}\frac{\partial X(\overline{P}_t^i,\sigma)}{\partial\sigma} - \frac{\partial \eta_t^i}{\partial X(\overline{P}_t^i,\sigma)}\frac{\partial X(\overline{P}_t^i,\sigma)}{\partial\sigma}$$

(18)

We have already analyzed the relationship between increased uncertainty and the probability of bankruptcy in Section 3 (Figure 2). There is a positive relationship between the probability of bankruptcy and uncertainty ($\frac{\partial X(\overline{P}_t^i,\sigma)}{\partial\sigma} > 0$) if the firm's solvency price is lower than the overall price level ($\overline{P}_t^i < P$). A negative relationship is present if $\overline{P}_t^i > P$, because its probability of survival[9] is low and a big variance of prices may help the firm out of trouble.

The increased probability of bankruptcy increases both the interest rate $\frac{\partial r_t^i}{\partial X(\overline{P}_t^i,\sigma)} > 0$ and the risk premium associated with bankruptcy $\frac{\partial \eta_t^i}{\partial X(\overline{P}_t^i,\sigma)} > 0$. Therefore the overall impact of uncertainty on the optimal output $\frac{\partial q_t^{i*}}{\partial\sigma}$ depends on the financial situation of the firm.

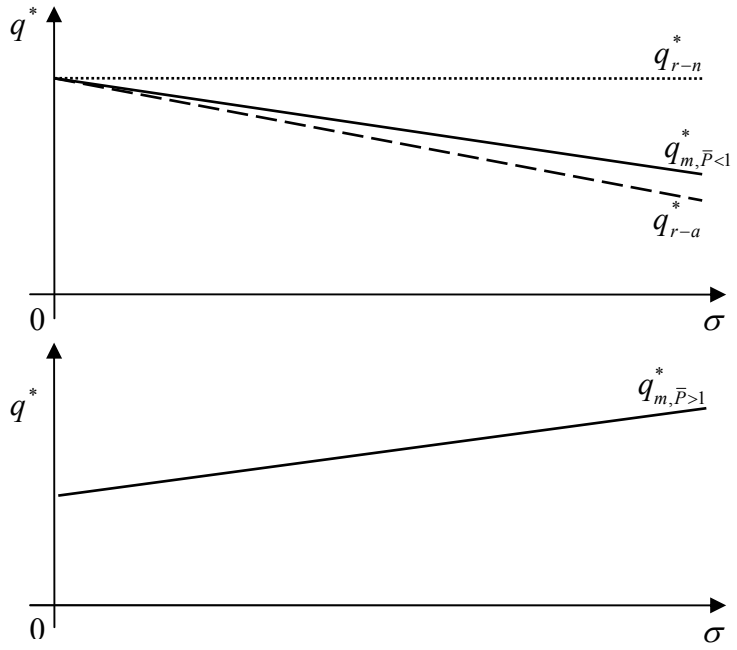
Result 7: If the probability of bankruptcy is lower than the probability of the firm's survival, then the increase in the price uncertainty increases the costs of financing and the risk premium associated with bankruptcy and therefore decreases the optimal level of production.

Result 8: If the probability of bankruptcy is higher than the probability of the firm's survival, then the increase in the price uncertainty increases the optimal level of production.

In other words, under usual circumstances when a firm would go bankrupt only in the case of extremely adverse market conditions (low prices), the increased price uncertainty induces the firm to reduce its output level. On the other hand, if the firm has financial troubles, then the managers may welcome the increased uncertainty of its output prices and increase the optimal output in order to increase the chance that the firm will get of financial troubles. In such a situation the managers have an incentive to gamble their way out of the coming insolvency through risky investments and risky levels of production.

[9] Probability of survival is defined as one minus the probability of bankruptcy.

Figure 5: Price uncertainty and optimal output



Note: Although we plot q^*_{r-a} steeper than $q^*_{m,\bar{u}<1}$ in the first chart, the sensitivities of optimal output on price uncertainty are not comparable. We show only the negative relationship for both cases.

Traditional theories of the firm under price uncertainty demonstrate a decline in production q^*_{r-a} due to uncertainty. The Greenwald and Stiglitz's model (1993a) determines a negative relationship between the degree of uncertainty and the optimal output as well. However, in other places Stiglitz (1994) highlights the incentives of insolvent banks to make high-risk loans in order to avoid insolvency and uses the similar logic we explained for the case of our firm. This phenomenon is theoretically explained also in a number of other places. For example, Hlaváček (1999, pp. 106-110) uses his model of a firm which maximizes the probability of its survival instead of profit, and he argues that there are situations which force the firm to behave in a risk-seeking manner even though normally the firm would behave in a risk-averse manner. The immediate threat of a firm's liquidation is taken as an example of such a situation.

4.3.4 SBC and output behavior

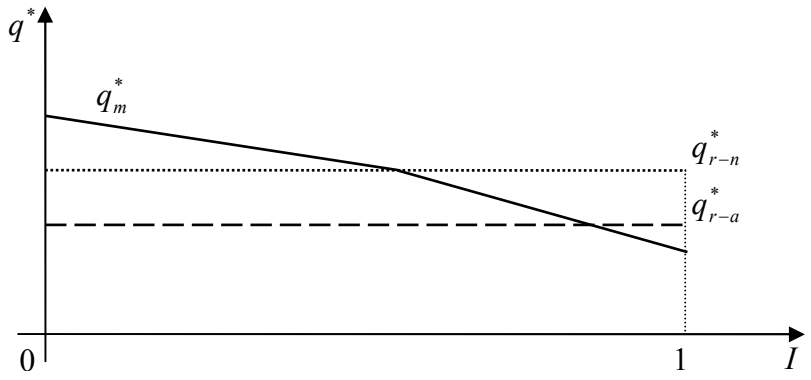
As the final parameter we will analyze the impact of an SBC. There are two effects similar to the preceding variables: the change in financing costs and the change in the risk premium. These two effects will push a firm to the level of production of a risk-neutral firm (similarly

as new shares and net worth position). In addition, in an SBC environment managers "discount" the value of costs financed by debt. This effect is represented by the third item on the right-hand side, which is constantly negative. This third effect can push a firm into production levels even higher than those of a risk-neutral firm and ex-post this production expansion can be considered as excessively risky. All three effects lead to a positive relationship between the softness of the budget constraint and the optimal level of production ($\frac{\partial q_t^{i*}}{\partial I_t} \leq 0$).

$$[(1-s)I_t^i(1+r_t^i)+s(1+r_t^f)]Pc''(q_t^{i*})\frac{\partial q_t^{i*}}{\partial I_t^i} = -Pc'(q_t^{i*})(1-s)I_t^i\frac{\partial r_t^i}{\partial I_t^i} - \frac{\partial \eta_t^i}{\partial I_t^i} - Pc'(q_t^{i*})(1-s)(1+r_t^i) \qquad (19)$$

Result 9: Under price uncertainty, an increase in the softness of the budget constraint decreases the costs of financing, decreases the risk premium associated with bankruptcy and discounts the value of debt perceived by managers, and therefore increases the optimal level of production.

Figure 6: SBC and optimal output



The increase in optimal output q_m^* with the softness of the budget constraint is faster below the level of production of a risk-neutral firm, because all three effects are present. Above q_{r-n}^* the output q_m^* grows at a slower pace as only the third effect (managers discounting production costs financed by debt) is at work.

4.4 Conclusions

The attitude to risk directly influences a firm's willingness to produce in the environment of uncertainty. The presence of uncertainty thus changes many of the predictions of the neoclassical theory of the firm under certainty, where the only important determinants of the firm's optimal output are technology and relative prices. This paper aimed to answer the following question: What are the major determinants of the firm's attitude to risk and therefore of the firm's willingness to produce under uncertainty? In doing so, we have used the following logical framework: financing, attitude to risk and optimal output. A model of a firm has been developed, where the managers are the primary decision-makers and include personal costs of bankruptcy into the profit maximization as originally suggested by Greenwald and Stiglitz (1993a).

Unique to our model is more general approach to the firm's financing possibilities and conditions. Our firm is not restricted to debt-financing as in Greenwald and Stiglitz (1993a), which implies only risk-averse behavior of a firm. We have incorporated other plausible assumptions about a firm's financing, most importantly partial access to the equity market and the possibility of the soft budget constraint related to debt-financing. The resulting firm's attitude to risk can range from strongly risk-averse behavior to risk-seeking behavior. From the perspective of our core question, the benchmark models can be understood as special cases of this model as illustrated in the following matrix.

	Financing	*Attitude to risk*	*Output behavior*
Neoclassical firm	Ø	A: certainty A': risk neutral	P: $p = MC(q^*_{r-n})$
Traditional theory of firm under uncertainty	Ø	A: risk averse	P: $q^*_{r-a} < q^*_{r-n}$
Greenwald and Stiglitz (1993a)	A: B>0 S=0	P: risk averse	P: $q^*_B < q^*_{r-n}$
Soft budget constraint concepts	A: B>0 ∃ SBC	P: risk seeking	P: $q^*_{r-n} < q^*_{SBC}$
This model	A: B>0 S>0 ∃ SBC	P: risk averse risk neutral risk seeking	P: $q^*_m \in < q^*_B ; q^*_{SBC} >$

Note: We denote the assumptions as "A" and the results of the models as "P" (propositions).

Nine propositions about the determinants of the firm's behavior under uncertainty were derived. For example, higher net worth leads to more production and its impact is

concave with the maximum being at the level associated with the traditional risk-neutral firm. Second, the price uncertainty has a dual effect depending on the financial condition of the given firm. Under normal circumstances, when the probability of bankruptcy is relatively low, an increase in the price uncertainty will lead to a reduction of output. On the other hand, a firm teetering on the edge of bankruptcy will be tempted by the increased uncertainty towards higher levels of production.

There are several results that are particularly relevant in the context of economic development. In developing countries firms need to rely on debt-financing since capital markets are missing or under-developed. The model shows that firms without an opportunity to issue equity are more risk-averse, unless they face soft budget constraint. Improving access to capital markets shifts the production up to the level associated with a risk-neutral firm. On the other hand, an environment with poor institutional framework and paternalistic state may lead to excessively risky behavior of firms. The optimal output of the firm facing the soft budget constraint may be even higher that the optimal output level for risk-neutral firm.

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